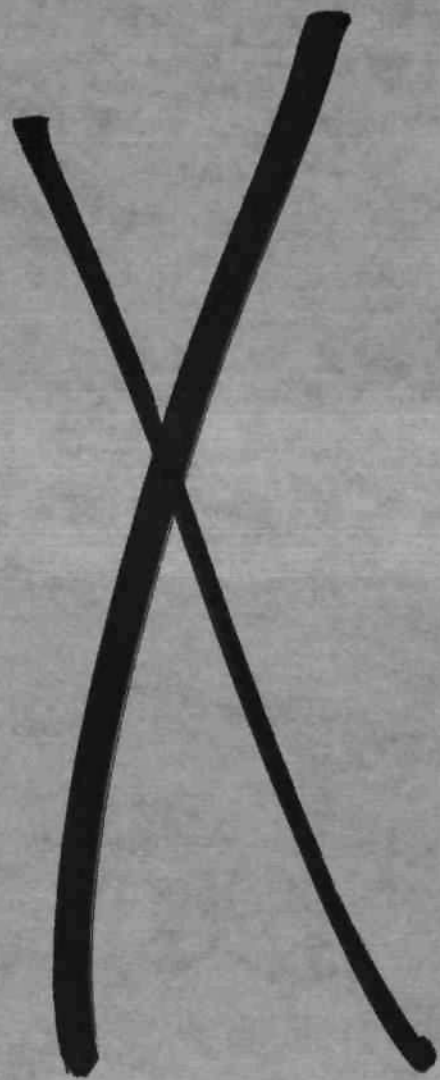

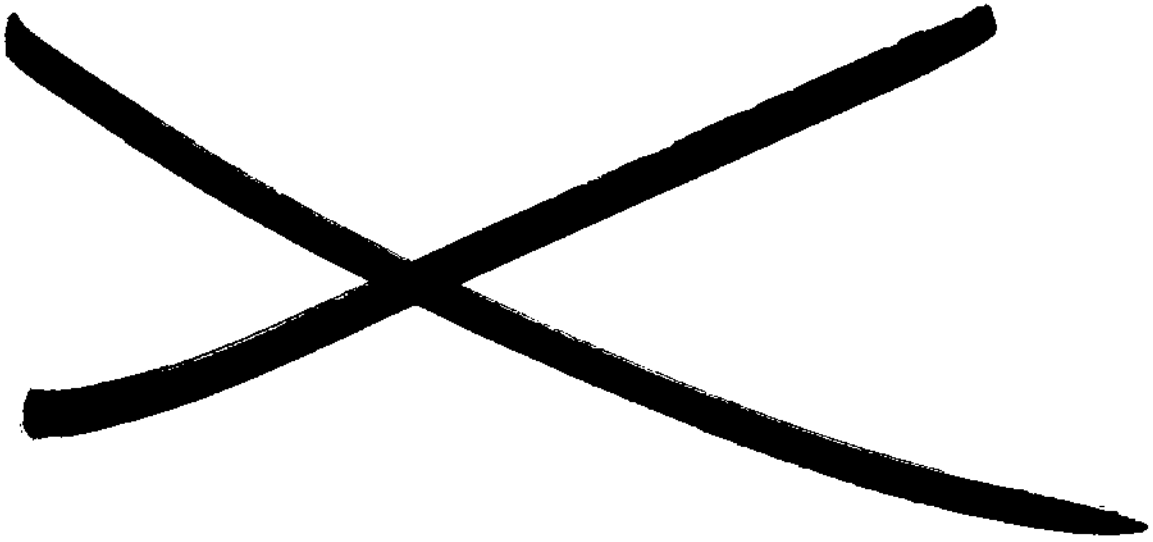

SRAM Regional Consumption

INTRODUCTION

Estimates of regional consumption can be used to determine the size of a total available market (TAM) in a particular region for a specific density of SRAM. These data can be used by both suppliers and users to enhance their understanding of the potential a product may have within a region and to better appreciate the competition among regions for the availability of product.

We define consumption as the point at which the manufacturer sells the device for the first time. For example, if a Japanese supplier transfers the product to its American marketing subsidiary, which in turn sells the product in the United States, the product is considered consumed in North America. However, if the Japanese supplier sells the product in Japan to a multinational systems manufacturer that ships it to the United States for actual use, we would count this as Japanese consumption because that was the point at which the manufacturer sold the product for the first time.

To review the regional consumption of SRAMs, Dataquest offers the following tables and charts:

Figure 1—1989 SRAM Regional Consumption (Millions of Dollars)

Table 1—Slow SRAM Regional Consumption By Density (Millions of Units)

Table 2—Slow SRAM Regional Consumption By Density (Millions of Dollars)

Table 3—Fast SRAM Regional Consumption By Density (Millions of Dollars)

Table 4—Fast SRAM Regional Consumption By Density (Millions of Units)

Figure 2—Slow SRAM Regional Consumption (Millions of Dollars)

Figure 3—Fast SRAM Regional Consumption (Millions of Dollars)

Figure 4—Slow SRAM Regional Product Mix 1989 (Millions of Units)

Figure 5—Fast SRAM Regional Product Mix 1989 (Millions of Units)

HIGHLIGHTS

In 1989, the consumption of fast and slow SRAMs were divided as shown in Figure 1. In terms of the slow SRAM market, the Japan-based users dominate because many of the systems that they manufacture demand the low-power and low-cost characteristics of slow SRAMs. On a worldwide basis, electronic equipment products such as video games, compact disc players, laptop computers, and computer peripherals gobble up large amounts of slow SRAMs. Because these are among the focal industries in Japan, it is logical that consumption of slow SRAMs would be focused in this region also. Conveniently, in 1988, 9 of the top 10 suppliers of slow SRAMs also were based in Japan. This closeness in proximity facilitated the suppliers' ability to meet the needs of their users and could give them an edge over offshore competition.

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The majority of fast SRAMs still are consumed in North America; however, Japan represents a large portion of the total number. Because fast SRAMs are mainly used in systems such as large computers, workstations, and high-end PCs, the regional consumption is mainly in North America, the traditional leader in these markets. However, as the Japanese play a more influential role in these end markets, they also are using a large portion of the fast SRAMs produced.

SRAMs consumption over time is illustrated in Figures 2 and 3. Figure 2 shows just how the presence of Japan-based OEMs has grown in terms of slow SRAM consumption. Because of emphasis on lower-end electronic products, the Rest of World (ROW) countries consume mostly slow SRAMs and use only a small amount of fast SRAMs. We expect to see ROW increase its focus on high-speed memories as its domestic demand for such systems increases and as it begins to apply knowledge it has gained in low-end systems to the manufacture of higher-performance systems.

Along with the different rates at which regions consume SRAMs, each region also has a slightly different product mix. The 1989 product mix for both types of SRAMs are shown in Figures 4 and 5. In 1989, the 16K slow SRAM represented more than one-third of slow SRAM units consumed in Japan. Again, this consumption is based on products that are produced in Japan. Video games, compact disc players, and point-of-sale cash registers ate up a good portion of 16K slow SRAMs in Japan. Because of the new sales tax implemented in Japan in 1989, a large number of retailers required new cash registers, and many of these new registers used SRAMs of 16K or larger to store daily sales totals.

In North America there is a tendency to lag behind other regions in phasing out lower densities of fast SRAMs. The long system life cycles of military products require that memories be supported long after the commercial market for the devices tails off. Also, because American computer manufacturers have been in existence for awhile, there exists a large installed base of machines and a number of older designs that require some support from dated technologies. However, because they are on the leading edge of new system designs, American (and Japanese) manufacturers also lead in the acceptance of new technologies.

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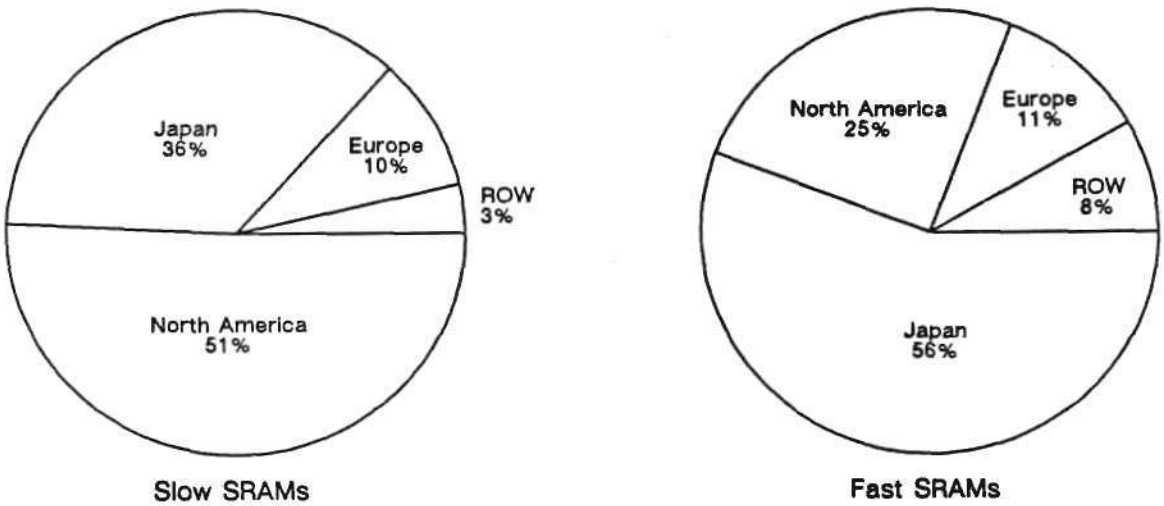
Figure 1

1989 SRAM Regional Consumption
(Millions of Dollars)



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Source: Dataquest
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Table 1

Slow SRAM Regional Consumption by Density
(Millions of Units)

Region	Density	1986	1987	1988	1989	1990
Europe	Others	2.2	1.2	0.3	0	0
	16K	23.9	16.3	21.7	20.7	12.6
	64K	17.5	20.3	22.4	18.4	18.6
	256K	0.6	4.4	8.6	11.3	18.1
	1Mb	0	0	0	0.2	0.9
Total		44.1	42.2	53.0	50.5	50.2
Japan	Others	4.8	2.4	0.8	0.1	0.3
	16K	39.8	59.2	95.1	100.5	58.0
	64K	41.9	78.1	91.5	93.2	79.7
	256K	3.3	27.3	53.1	77.6	110.2
	1Mb	0	0.2	0.9	3.4	10.0
Total		89.7	167.2	241.4	274.8	258.2
North America	Others	5.9	3.4	0.9	0.1	0.2
	16K	33.7	20.4	24.0	23.9	13.4
	64K	30.9	34.7	33.7	32.8	26.7
	256K	2.1	12.6	21.3	30.4	39.1
	1Mb	0	0.2	1.2	3.1	7.3
Total		72.6	71.3	81.1	90.4	86.7
ROW	Others	1.8	1.1	0.4	0	0
	16K	10.7	6.1	13.9	14.4	9.1
	64K	8.7	11.6	17.0	16.6	17.1
	256K	0.2	2.3	6.0	8.6	13.6
	1Mb	0	0	0	0	0.4
Total		21.4	21.1	37.2	39.6	40.1
Worldwide Total	Others	14.7	8.1	2.4	0.2	0.5
	16K	108.1	102.1	154.7	159.5	93.0
	64K	99.0	144.7	164.6	161.0	142.1
	256K	6.2	46.6	89.0	127.9	181.0
	1Mb	0	0.3	2.1	6.7	18.6
Total		228.0	301.8	412.8	455.3	435.2

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

Source: Dataquest
February 1990

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Table 2

Slow SRAM Regional Consumption by Density
(Millions of Dollars)

Region	Density	1986	1987	1988	1989	1990
Europe	Others	4	2	1	0	0
	16K	29	22	54	50	27
	64K	34	43	77	74	65
	256K	11	31	77	108	129
	1Mb	0	0	2	19	34
Total		77	98	210	251	254
Japan	Others	8	4	1	0	15
	16K	47	75	214	228	117
	64K	75	148	258	311	242
	256K	51	172	361	564	706
	1Mb	0	4	39	180	237
Total		181	404	873	1,283	1,317
North America	Others	12	8	2	0	11
	16K	42	30	67	60	29
	64K	64	79	108	123	88
	256K	46	89	178	283	281
	1Mb	0	4	35	106	147
Total		164	209	392	572	556
ROW	Others	3	2	1	0	0
	16K	13	8	34	33	19
	64K	16	23	56	63	58
	256K	4	15	50	76	93
	1Mb	0	0	0	5	13
Total		35	48	141	177	182
Worldwide Total	Others	27	16	5	0	27
	16K	131	135	369	372	191
	64K	188	293	499	570	452
	256K	111	307	667	1,030	1,209
	1Mb	0	8	76	309	431
Total		458	759	1,616	2,283	2,309

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

Source: Dataquest February 1990

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Table 3

Fast SRAM Regional Consumption by Density
(Millions of Dollars)

Region	Density	1986	1987	1988	1989	1990
Europe	Others	7	6	4	3	1
	16K	20	20	21	20	17
	64K	14	23	43	57	54
	256K	0	1	7	26	35
	1Mb	0	0	0	0	4
Total		41	50	75	106	111
Japan	Others	17	13	8	4	2
	16K	57	55	56	50	42
	64K	39	64	123	160	147
	256K	0	8	64	156	202
	1Mb	0	0	0	4	31
Total		113	140	250	374	424
North America	Others	30	28	19	12	7
	16K	85	85	88	85	72
	64K	52	91	168	238	225
	256K	0	9	75	193	250
	1Mb	0	0	0	4	35
Total		167	212	350	532	590
ROW	Others	2	2	1	1	0
	16K	5	6	7	7	6
	64K	2	5	11	16	15
	256K	0	0	3	9	12
	1Mb	0	0	0	0	0
Total		9	12	22	33	35
Worldwide Total	Others	55	49	33	19	11
	16K	167	166	172	163	138
	64K	107	182	344	470	441
	256K	0	17	149	384	499
	1Mb	0	0	0	9	70
Total		330	414	698	1,044	1,159

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

Source: Dataquest February 1990

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Table 4

Fast SRAM Regional Consumption by Density
(Millions of Units)

Region	Density	1986	1987	1988	1989	1990
Europe	Others	2.4	2.2	1.5	0.9	0.5
	16K	5.8	6.3	6.3	5.7	5.1
	64K	1.0	2.8	5.2	7.6	8.8
	256K	0	0	0.2	0.9	2.2
	1Mb	0	0	0	0	0
Total		9.2	11.3	13.1	15.2	16.7
Japan	Others	6.1	4.8	2.8	1.3	0.7
	16K	17.1	17.7	17.2	14.9	13.2
	64K	3.1	8.2	15.3	21.9	24.7
	256K	0	0.2	1.8	6.0	13.7
	1Mb	0	0	0	0	0.3
Total		26.2	30.8	37.1	44.2	52.6
North America	Others	9.8	8.9	6.2	3.8	2.2
	16K	21.2	22.8	22.6	21.0	18.8
	64K	3.5	9.9	17.9	28.2	32.7
	256K	0	0.2	1.7	6.2	14.3
	1Mb	0	0	0	0	0.3
Total		34.5	41.8	48.4	59.3	68.4
ROW	Others	0.6	0.6	0.5	0.3	0.2
	16K	1.3	1.7	2.1	2.2	2.0
	64K	0.2	0.6	1.4	2.3	2.7
	256K	0	0	0.1	0.3	0.8
	1Mb	0	0	0	0	0
Total		2.1	3.0	4.0	5.1	5.7
Worldwide Total	Others	18.9	16.5	11.0	6.4	3.6
	16K	45.3	48.6	48.1	43.8	39.1
	64K	7.7	21.5	39.8	60.1	68.9
	256K	0	0.3	3.8	13.5	31.1
	1Mb	0	0	0	0	0.7
Total		71.9	86.9	102.7	123.8	143.4

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

Source: Dataquest February 1990

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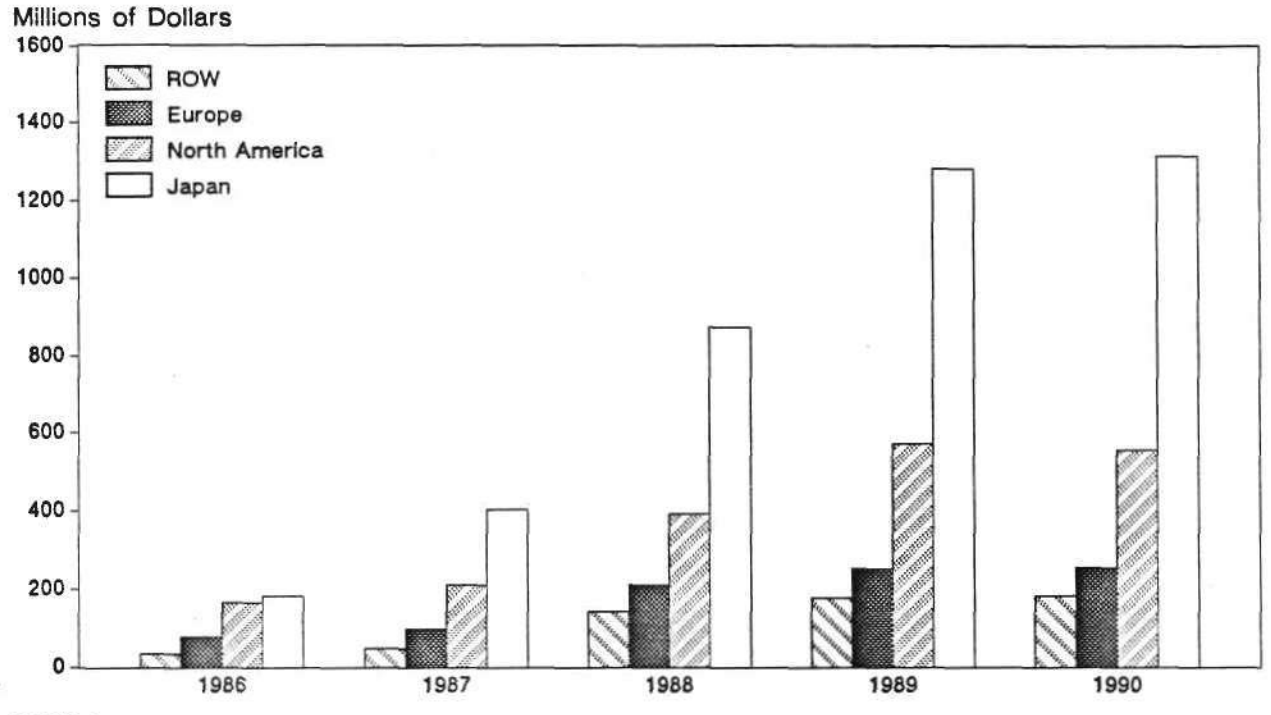
Figure 2

Slow SRAM Regional Consumption (Millions of Dollars)



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Source: Dataquest
February 1990

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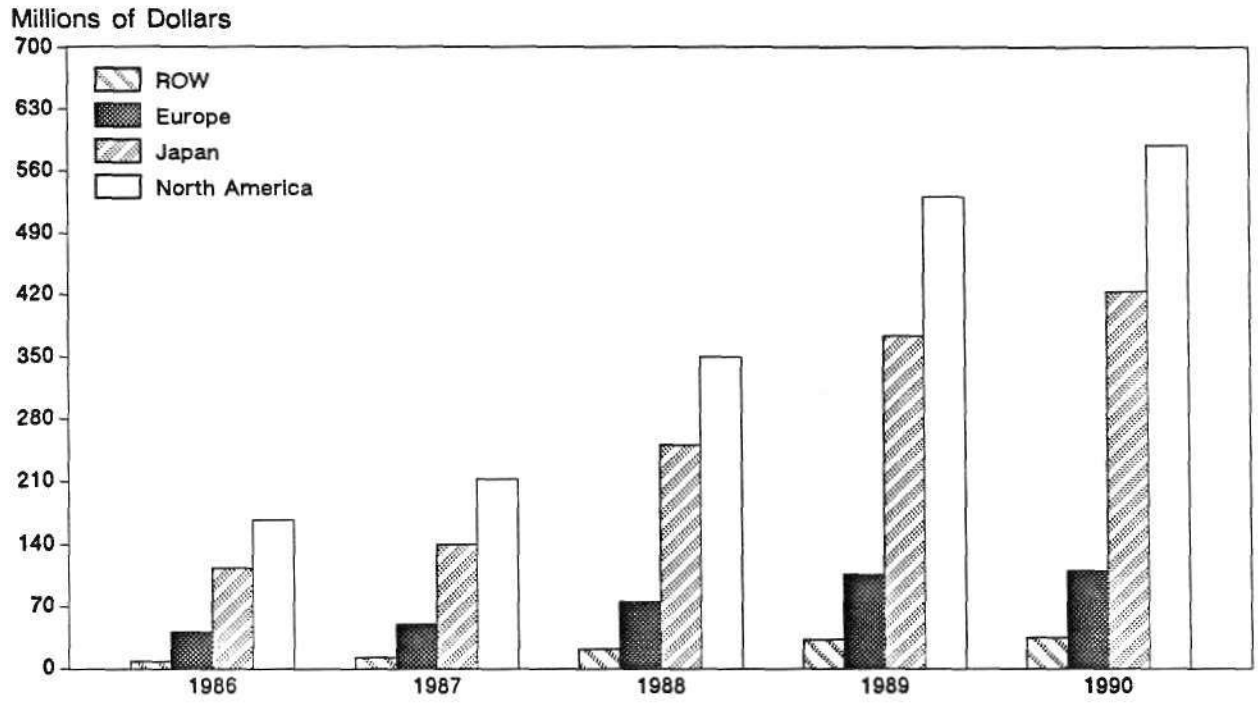
Figure 3

Fast SRAM Regional Consumption (Millions of Dollars)



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Source: Dataquest
February 1990

Source: Dataquest
February 1990

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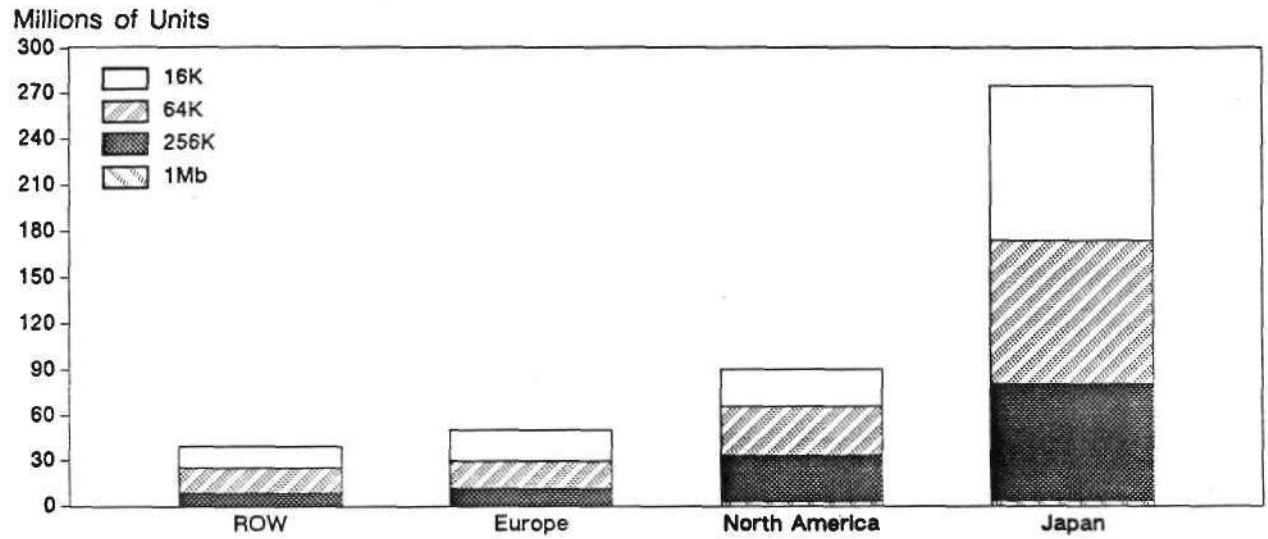
Figure 4

Slow SRAM Regional Product Mix 1989
(Millions of Units)



Source: Dataquest
February 1990

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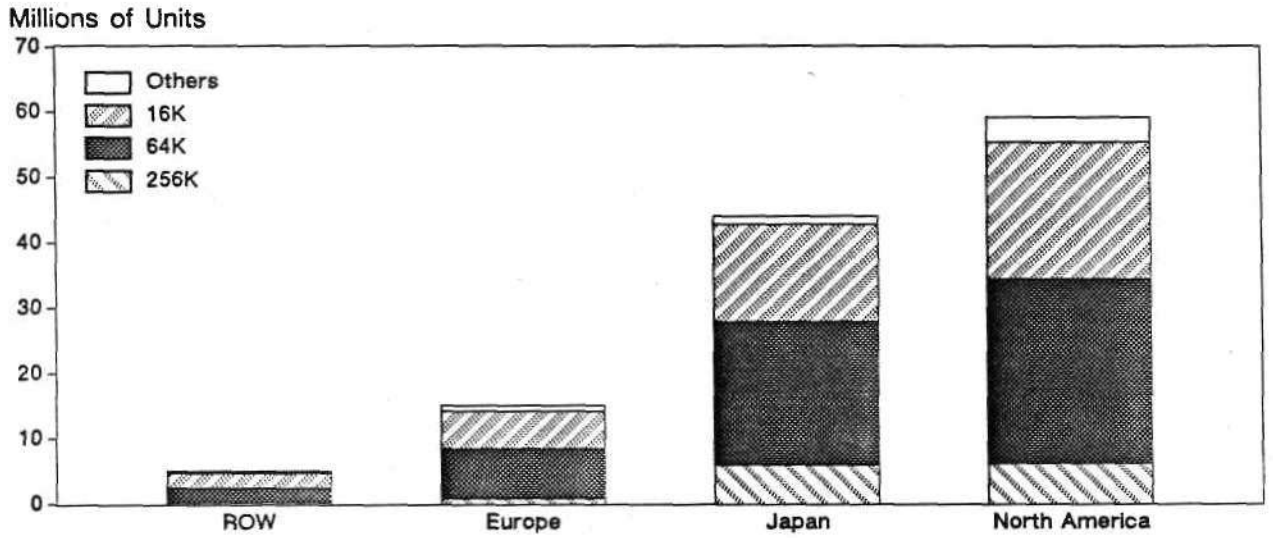
Figure 5

Fast SRAM Regional Product Mix 1989
(Millions of Units)



DATAQUEST ANALYSIS

As mentioned previously, there is a close tie between what is consumed in a region and what devices are produced in a region. This key trend appears obvious, but is worth noting nevertheless. Regardless of a suppliers' nationality, it is good business sense to build fabrication facilities as close as possible to the end users, because it makes technical support easier, supply channels shorter, and improves communications between supplier and user. This method is contrary to how things were done in the past, when large manufacturing facilities were concentrated in one area. The choice of where to place a fab should depend as much on the demand in a given region as on other factors such as low labor rates.

Beyond 1990, Dataquest expects to see some gradual shifting of consumption among the regions. High-end systems and consumer products will start to drift away from their existing regional strongholds of North America and Japan and move toward Europe and ROW. The move toward Europe will also be facilitated by that region's push for domestic manufacturing of electronic equipment. In addition, the further development of advanced computer production and the improvement of Asia/Pacific countries' telecommunications systems by domestic manufacturers will be an impetus for increased consumption of SRAMs in the ROW regions.

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MOS SRAM—Forecast

OVERVIEW OF THE MOS STATIC RAM MARKET

The MOS static RAM, or SRAM, is becoming an increasingly important member of the memory family. SRAMs are displacing DRAMs and nonvolatile memories in some applications because of their high speed, low power consumption, and the ease with which they can be designed into a system. Many companies have turned to using SRAMs as a vehicle to monitor and prove the feasibility of new processes and packaging. High performance, complexity of process, and reasonable profit margins make SRAMs, especially fast SRAMs, ideal as process drivers for specialty memory, ASIC, processor, and standard memory companies alike.

SRAMs can be divided into two distinct markets: slow SRAMs, which include parts with access times of more than 70ns and fast SRAMs, which consist of those RAMs with an access time at or less than 70ns. These must be treated as separate markets because of the differences in end uses and design. Slow SRAMs are designed for volume production and for use in a wide variety of low-cost applications. Fast SRAMs, on the other hand, are designed primarily to fill the high-performance demands of systems and are less cost sensitive.

This section reviews the dynamics of the SRAM market through the following topics:

- Historical growth
- MOS SRAM market forecast
- Comparison with earlier forecasts
- Short-term outlook
- Long-term outlook

Historical Growth

- In 1988, the SRAM market reached $2.3 billion. SRAMs represented 19.2 percent of the total MOS memory market that year, a slight decrease from 19.5 percent in 1987.
- Total SRAM revenue grew at a compound annual growth rate (CAGR) of 24.2 percent between 1983 and 1988. This growth is slightly higher than that of the MOS memory market, which had a CAGR of 24.1 percent during the same period.
- The slow SRAM market revenue reflected a 21.2 percent CAGR from 1983 to 1988, and the fast SRAM revenue CAGR was 33.2 percent for the same period. The growth of the fast SRAM market is due to its maturation and the strength of its 16K and 64K densities.

Figure 1 shows the MOS SRAM revenue growth in comparison with the total MOS memory market. Figure 2 depicts the historical revenue of the fast and slow SRAMs since 1977 and forecast revenue through 1993.

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Figure 1

Estimated MOS Memory and SRAM Market Growth
1977-1988

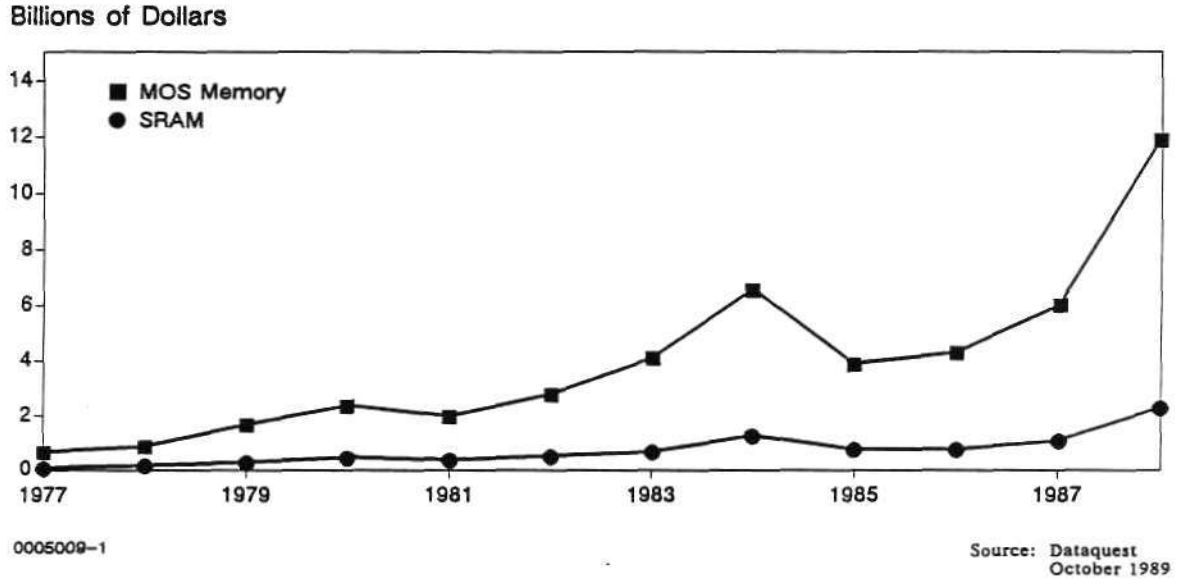
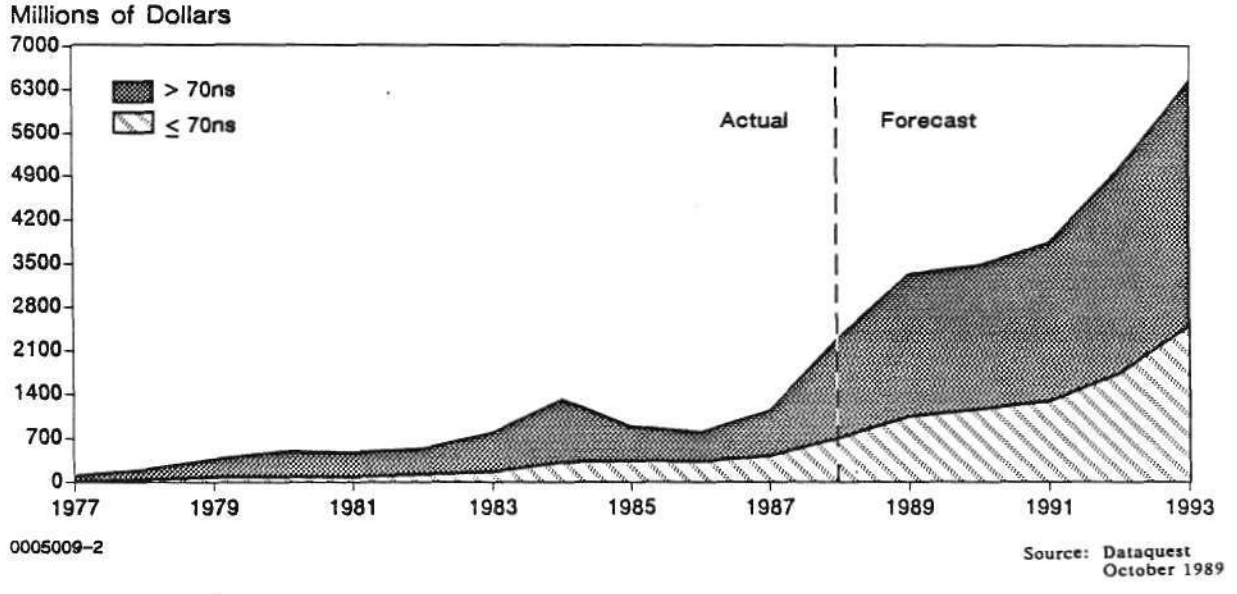


Figure 2

Estimated MOS SRAM Market Growth
1977-1993



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MOS SRAM Market Forecast

Dataquest describes the MOS SRAM forecast and historical shipments from 1986 to 1993 in the following tables:

- Table 1—Worldwide MOS SRAM Forecast (Revenue, Units, and Average Selling Prices)
- Table 2—Worldwide NMOS SRAM Forecast (Revenue, Units, and Average Selling Prices)
- Table 3—Worldwide Other MOS SRAM Forecast—Includes CMOS and BiCMOS (Revenue, Units, and Average Selling Prices)
- Table 4—Worldwide Fast SRAM Forecast (Revenue, Units, and Average Selling Prices)
- Table 5—Worldwide Slow SRAM Forecast (Revenue, Units, and Average Selling Prices)

In 1988, the MOS memory market demonstrated tremendous growth over 1987, and Dataquest expects this growth to continue between 1988 and 1993. Dataquest believes that the expansion of the SRAM market will be spurred on by a number of factors: continued cost-per-bit reductions, introduction of larger densities, further reduction of access times, development of new processes, and the emergence of new applications, to name a few. The key elements to the forecast are as follows:

- In 1988, the SRAM market showed healthy growth; it grew 97.2 percent over its 1987 position. This growth was mainly due to the developments in the 256K slow SRAM, which experienced a 13.7 percent increase in price and a 91.0 percent increase in units.
- The growth during 1988 and 1989 is mainly due to the increase in average selling prices (ASPs), which is especially true for the slow SRAMs.
  - From 1988 to 1989, units for slow SRAMs grew only 10.3 percent while revenue grew 41.3 percent.
  - ASPs were driven up as the SRAM shortage continued, the result of SRAM manufacturing capacity being channeled toward the building of DRAMs to help fulfill the growing demands of this market.
- The market is experiencing a slowdown in SRAM demand in the third quarter of 1989. Dataquest expects this to continue through the second quarter of 1990, at which time the end markets that consume SRAMs should start to pick up again.
  - The slowdown will have more impact on SRAM selling prices than on unit shipments.
  - A small discrepancy in the supply/demand situation will have a drastic effect on prices as suppliers and users react to the uncertainty.
  - Slow SRAMs will be affected more than fast SRAMs due to their consumption by more price-sensitive commodity-type products.

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- The fast SRAM market is expected to grow at a CAGR of 28.7 percent between 1988 and 1993. It will slightly outpace the slow SRAM market, which is expected to grow at a 19.6 percent CAGR.
  - The anticipated greater growth rate of fast SRAMs will be a result of the continual speed improvements within each density, resulting in slower price degradation and longer product life cycles.
  - The fast SRAM growth rate will also be due to the usage of the fast devices in a wider spectrum of applications; to meet increasing processor and CPU speed demands, a wider variety of systems will call on fast SRAMs to help meet the requirements for faster data rates.
- The next boom year in the electronics industry is expected to be 1993. The anticipated growth rate in 1993 is based on a number of factors:
  - The introduction of larger wafer fabrication facilities that will feed the 4Mb DRAM and 1Mb SRAM markets
  - The development of new applications that will consume large amounts of electronics in the consumer, data processing, and telecommunication markets
  - The extrapolation of historical market and economic cycles

Table 1

Worldwide MOS SRAM Forecast

	Revenue (Millions of Dollars)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (Fast)	$ 16	$ 11	$ 5	0	0	0	0	0
1K (Slow)	3	2	0	0	0	0	0	0
4K (Fast)	39	38	28	$ 19	$ 11	$ 6	$ 4	$ 3
4K (Slow)	24	14	5	0	0	0	0	0
8K (Slow)	0	0	0	0	0	0	0	0
16K (Fast)	167	166	172	162	138	132	126	111
16K (Slow)	131	135	368	372	191	132	79	51
64K (Fast)	107	182	344	470	441	416	402	399
64K (Slow)	188	292	499	570	452	316	266	226
256K (Fast)	0	17	149	384	499	575	781	978
256K (Slow)	111	307	667	1,031	1,209	1,050	942	851
1Mb (Fast)	0	0	0	9	70	158	397	964
1Mb (Slow)	0	8	76	309	431	965	1,775	2,307
4Mb (Fast)	0	0	0	0	0	0	15	50
4Mb (Slow)	0	0	0	0	27	83	221	706
Total	$787	$1,173	$2,313	$3,326	$3,467	$3,831	$5,008	$6,645
Percent Change from Previous Year		49.1%	97.2%	43.8%	4.2%	10.5%	30.7%	32.7%

(Continued)

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Table 1 (Continued)

Worldwide MOS SRAM Forecast

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (Fast)	5.0	3.5	1.5	0	0	0	0	0
1K (Slow)	1.0	0.6	0.1	0	0	0	0	0
4K (Fast)	13.9	13.0	9.5	6.4	3.6	2.0	1.4	0.9
4K (Slow)	13.7	7.5	2.3	0.2	0	0	0	0
8K (Slow)	0	0	0	0	0	0	0	0
16K (Fast)	45.3	48.6	48.1	43.8	39.1	35.1	31.6	27.6
16K (Slow)	108.1	102.1	154.7	159.5	93.0	58.0	32.0	19.0
64K (Fast)	7.7	21.5	39.8	60.1	68.9	71.1	69.4	66.7
64K (Slow)	99.0	144.7	164.6	161.0	142.1	115.2	96.0	80.0
256K (Fast)	0	0.3	3.8	13.5	31.1	52.5	76.5	99.1
256K (Slow)	6.2	46.6	89.0	127.9	181.0	216.0	227.0	210.0
1Mb (Fast)	0	0	0	0	0.7	3.5	14.8	45.6
1Mb (Slow)	0	0.3	2.1	6.7	18.6	65.9	152.0	217.0
4Mb (Fast)	0	0	0	0	0	0	0.1	0.6
4Mb (Slow)	0	0	0	0	0.5	2.1	6.0	20.0
Total	299.9	388.7	515.5	579.1	578.6	621.4	706.8	786.5

Average Selling Price (Dollars/Units)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (Fast)	$ 3.16	$ 3.27	$ 3.40	0	0	0	0	0
1K (Slow)	$ 3.36	$ 3.41	$ 3.50	0	0	0	0	0
4K (Fast)	$ 2.83	$ 2.90	$ 2.90	$ 2.91	$ 2.95	$ 3.00	$ 3.05	$ 3.15
4K (Slow)	$ 1.74	$ 1.93	$ 2.07	$ 2.10	0	0	0	0
8K (Slow)	0	0	0	0	0	0	0	0
16K (Fast)	$ 3.69	$ 3.41	$ 3.58	$ 3.71	$ 3.53	$ 3.75	$ 3.98	$ 3.50
16K (Slow)	$ 1.21	$ 1.32	$ 2.38	$ 2.33	$ 2.05	$ 2.27	$ 2.47	$ 1.60
64K (Fast)	$13.94	$ 8.48	$ 8.65	$ 7.82	$ 6.40	$ 5.85	$ 5.79	$ 4.35
64K (Slow)	$ 1.90	$ 2.02	$ 3.03	$ 3.54	$ 3.18	$ 2.74	$ 2.77	$ 2.58
256K (Fast)	$78.75	$49.83	$39.34	$ 28.44	$16.05	$10.96	$ 10.21	$ 6.00
256K (Slow)	$17.96	$ 6.59	$ 7.49	$ 8.06	$ 6.68	$ 4.86	$ 4.15	$ 3.55
1Mb (Fast)	N/A	N/A	N/A	$218.75	$99.29	$45.10	$ 26.85	$11.00
1Mb (Slow)	N/A	N/A	$36.34	$ 46.19	$23.15	$14.64	$ 11.68	$ 5.00
4Mb (Fast)	N/A	N/A	N/A	N/A	N/A	N/A	$163.13	$14.00
4Mb (Slow)	N/A	N/A	N/A	N/A	N/A	$40.24	$ 36.75	$14.00
Overall ASP	$ 2.62	$ 3.02	$ 4.49	$ 5.74	$ 5.99	$ 6.17	$ 7.09	$ 8.45

N/A = Not Available
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
October 1989

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Table 2

Worldwide NMOS SRAM Forecast

	Revenue (Millions of Dollars)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Types)	$ 5	$ 3	$ 2	0	0	0	0	0
4K (Fast, 4Kx1)	25	25	16	$ 10	$ 6	$ 3	$ 2	$ 2
4K (Fast, 1Kx4)	12	9	4	4	2	1	1	1
4K (Slow, 4Kx1)	1	1	0	0	0	0	0	0
4K (Slow, 1Kx4)	11	7	3	0	0	0	0	0
8K (Slow, 1Kx8)	0	0	0	0	0	0	0	0
16K (Fast, 16Kx1)	23	11	7	4	3	2	1	1
16K (Fast, 4Kx4)	31	24	18	12	10	8	6	4
16K (Fast, 2Kx8)	18	17	14	12	9	7	5	3
16K (Slow, 2Kx8)	41	38	72	57	22	10	5	3
64K (Slow, 8Kx8)	8	14	2	1	0	0	0	0
64K (Fast, All Orgs.)	4	2	1	0	0	0	0	0
Total	$180	$153	$138	$101	$52	$31	$20	$13
Percent Change from Previous Year	(44.5%)	(15.1%)	(9.4%)	(26.9%)	(48.2%)	(40.3%)	(36.7%)	(35.1%)

	Units (Millions)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Types)	2.0	1.2	0.6	0	0	0	0	0
4K (Fast, 4Kx1)	8.9	8.8	5.7	3.5	2.0	1.0	0.7	0.5
4K (Fast, 1Kx4)	4.0	3.2	1.4	1.2	0.7	0.4	0.3	0.2
4K (Slow, 4Kx1)	0.7	0.6	0.1	0	0	0	0	0
4K (Slow, 1Kx4)	8.5	5.0	1.7	0.2	0	0	0	0
8K (Slow, 1Kx8)	0	0	0	0	0	0	0	0
16K (Fast, 16Kx1)	6.6	4.0	2.3	1.5	1.0	0.7	0.4	0.2
16K (Fast, 4Kx4)	9.1	7.9	5.6	4.0	3.5	2.8	2.2	1.5
16K (Fast, 2Kx8)	4.2	4.9	4.1	3.5	3.0	2.2	1.5	1.0
16K (Slow, 2Kx8)	38.7	31.7	31.1	26.0	12.0	5.0	2.0	1.0
64K (Slow, 8Kx8)	4.5	7.6	0.7	0.3	0.1	0	0	0
64K (Fast, All Orgs.)	0.3	0.2	0.2	0.1	0	0	0	0
Total	87.5	75.1	53.3	40.3	22.3	12.1	7.1	4.4

(Continued)

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Table 2 (Continued)

Worldwide NMOS SRAM Forecast

	Average Selling Price (Dollars/Units)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Types)	$ 2.60	$2.60	$2.60	0	0	0	0	0
4K (Fast, 4Kx1)	$ 2.80	$2.86	$2.86	$2.87	$2.90	$2.95	$3.00	$3.12
4K (Fast, 1Kx4)	$ 2.91	$2.98	$2.98	$3.01	$3.05	$3.10	$3.15	$3.23
4K (Slow, 4Kx1)	$ 1.78	$2.00	$2.16	0	0	0	0	0
4K (Slow, 1Kx4)	$ 1.25	$1.40	$1.57	$2.10	0	0	0	0
8K (Slow, 1Kx8)	0	0	0	0	0	0	0	0
16K (Fast, 16Kx1)	$ 3.55	$2.82	$3.02	$2.87	$2.65	$2.69	$2.74	$2.76
16K (Fast, 4Kx4)	$ 3.40	$3.02	$3.17	$3.09	$2.85	$2.87	$2.92	$2.93
16K (Fast, 2Kx8)	$ 4.40	$3.56	$3.48	$3.31	$3.03	$3.07	$3.10	$3.11
16K (Slow, 2Kx8)	$ 1.07	$1.20	$2.30	$2.20	$1.85	$2.07	$2.32	$2.57
64K (Slow, 8Kx8)	$ 1.80	$1.90	$2.90	$3.35	$2.90	0	0	0
64K (Fast, All Orgs.)	$12.50	$7.38	$6.91	$5.57	$4.50	0	0	0
Overall ASP	$ 2.05	$2.03	$2.59	$2.51	$2.34	$2.58	$2.80	$2.92

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

Source: Dataquest
October 1989

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Table 3

Worldwide Other MOS SRAM Forecast
Includes CMOS and BiCMOS

	Revenue (Millions of Dollars)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (All types)	$ 14	$ 10	$ 4	0	0	0	0	0
4K (Fast)	3	3	7	$ 5	$ 3	$ 2	$ 1	$ 1
4K (Slow)	12	6	2	0	0	0	0	0
16K (Fast, 16Kx1)	35	38	30	25	21	21	17	13
16K (Fast, 4Kx4)	42	52	65	66	58	58	61	56
16K (Fast, 2Kx8)	17	24	39	43	37	37	35	34
16K (Slow, 2Kx8)	89	97	297	314	168	121	74	48
64K (Fast, 64Kx1)	58	87	143	154	129	112	102	92
64K (Fast, 16Kx4)	22	45	108	198	203	202	203	209
64K (Fast, 8Kx8/9)	23	49	92	118	109	102	97	98
64K (Slow, 8Kx8)	180	278	497	569	452	316	266	226
256K (Fast, 256Kx1)	0	6	60	146	173	181	207	232
256K (Fast, 64Kx4)	0	8	68	144	204	258	375	487
256K (Fast, 32Kx8/9)	0	3	20	94	122	136	199	259
256K (Slow, 32Kx8)	111	307	667	1,031	1,209	1,050	942	851
1Mb (Fast, 1Mx1)	0	0	0	2	19	48	133	266
1Mb (Fast, 256Kx4)	0	0	0	4	29	58	143	392
1Mb (Fast, 128Kx8/9)	0	0	0	3	22	52	121	306
1Mb (Slow, All Orgs)	0	8	76	309	431	965	1,775	2,307
4Mb (Fast, 4Mx1)	0	0	0	0	0	0	4	11
4Mb (Fast, 1Mx4)	0	0	0	0	0	0	5	24
4Mb (Fast, 512Kx8/9)	0	0	0	0	0	0	6	15
4Mb (Slow, All Orgs)	0	0	0	0	27	83	221	706
Total	$607	$1,021	$2,175	$3,225	$3,415	$3,800	$4,988	$6,632
Percent Change from Previous Year	8.5%	68.2%	113.1%	48.3%	5.9%	11.3%	31.3%	32.9%

	Units (Millions)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (All types)	4.0	2.9	1.0	0	0	0	0	0
4K (Fast)	1.0	1.0	2.4	1.7	0.9	0.6	0.4	0.2
4K (Slow)	4.5	1.9	0.5	0	0	0	0	0
16K (Fast, 16Kx1)	10.5	11.6	8.7	6.9	5.9	5.2	4.2	3.2
16K (Fast, 4Kx4)	11.3	14.7	18.0	17.4	15.7	14.5	14.1	13.1
16K (Fast, 2Kx8)	3.6	5.5	9.6	10.5	10.0	9.7	9.2	8.6

(Continued)

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Table 3 (Continued)

Worldwide Other MOS SRAM Forecast
Includes CMOS and BiCMOS

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
16K (Slow, 2Kx8)	69.4	70.4	123.6	133.5	81.0	53.0	30.0	18.0
64K (Fast, 64Kx1)	4.4	11.0	17.8	22.4	22.6	21.8	20.3	18.1
64K (Fast, 16Kx4)	1.6	5.1	11.4	21.8	27.7	30.0	30.7	30.6
64K (Fast, 8Kx8/9)	1.4	5.1	10.4	15.8	18.6	19.3	18.4	18.0
64K (Slow, 8Kx8)	94.5	137.1	163.9	160.7	142.0	115.2	96.0	80.0
256K (Fast, 256Kx1)	0	0.1	1.5	4.8	10.4	16.3	21.4	25.5
256K (Fast, 64Kx4)	0	0.2	1.8	5.3	12.7	23.0	35.3	47.5
256K (Fast, 32Kx8/9)	0	0	0.5	3.4	8.0	13.2	19.8	26.1
256K (Slow, 32Kx8)	6.2	46.6	89.0	127.9	181.0	216.0	227.0	210.0
1Mb (Fast, 1Mx1)	0	0	0	0	0.2	1.0	4.8	13.2
1Mb (Fast, 256Kx4)	0	0	0	0	0.3	1.4	5.5	18.6
1Mb (Fast, 128Kx8/9)	0	0	0	0	0.2	1.1	4.5	13.8
1Mb (Slow, All Orgs)	0	0.3	2.1	6.7	18.6	65.9	152.0	217.0
4Mb (Fast, 4Mx1)	0	0	0	0	0	0	0	0.1
4Mb (Fast, 1Mx4)	0	0	0	0	0	0	0	0.3
4Mb (Fast, 512Kx8/9)	0	0	0	0	0	0	0	0.2
4Mb (Slow, All Orgs)	0	0	0	0	0.5	2.1	6.0	20.0
Total	212.4	313.7	462.2	538.9	556.3	609.3	699.7	782.1

Average Selling Price (Dollars/Units)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All types)	$ 3.49	$ 3.58	$ 3.89	0	0	0	0	0
4K (Fast)	$ 2.82	$ 2.95	$ 2.94	$ 2.94	$ 2.97	$ 3.00	$ 3.06	$ 3.17
4K (Slow)	$ 2.67	$ 3.29	$ 3.65	0	0	0	0	0
16K (Fast, 16Kx1)	$ 3.32	$ 3.24	$ 3.46	$ 3.61	$ 3.57	$ 3.95	$ 4.08	$ 4.04
16K (Fast, 4Kx4)	$ 3.74	$ 3.54	$ 3.63	$ 3.82	$ 3.69	$ 3.99	$ 4.34	$ 4.30
16K (Fast, 2Kx8)	$ 4.75	$ 4.30	$ 4.04	$ 4.08	$ 3.72	$ 3.77	$ 3.84	$ 3.91
16K (Slow, 2Kx8)	$ 1.29	$ 1.37	$ 2.40	$ 2.36	$ 2.08	$ 2.29	$ 2.48	$ 2.68
64K (Fast, 64Kx1)	$13.14	$ 7.85	$ 8.04	$ 6.87	$ 5.72	$ 5.13	$ 5.03	$ 5.11
64K (Fast, 16Kx4)	$13.92	$ 8.85	$ 9.50	$ 9.08	$ 7.32	$ 6.73	$ 6.60	$ 6.82
64K (Fast, 8Kx8/9)	$16.89	$ 9.53	$ 8.80	$ 7.44	$ 5.87	$ 5.29	$ 5.27	$ 5.46
64K (Slow, 8Kx8)	$ 1.90	$ 2.03	$ 3.03	$ 3.54	$ 3.18	$ 2.74	$ 2.77	$ 2.82
256K (Fast, 256Kx1)	$85.00	$45.06	$39.88	$ 30.32	$ 16.66	$11.08	$ 9.69	$ 9.09
256K (Fast, 64Kx4)	$75.00	$50.92	$37.73	$ 27.20	$ 16.04	$11.23	$ 10.63	$10.25
256K (Fast, 32Kx8/9)	$85.00	$60.59	$43.92	$ 27.73	$ 15.29	$10.34	$ 10.03	$ 9.94

(Continued)

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Table 3 (Continued)

Worldwide Other MOS SRAM Forecast
Includes CMOS and BiCMOS

	Average Selling Price (Dollars/Units)							
	1986	1987	1988	1989	1990	1991	1992	1993
256K (Slow, 32Kx8)	$17.96	$ 6.59	$ 7.49	$ 8.06	$ 6.68	$ 4.86	$ 4.15	$ 4.05
1Mb (Fast, 1Mx1)	N/A	N/A	N/A	$187.00	$ 94.36	$48.01	$ 27.71	$20.15
1Mb (Fast, 256Kx4)	N/A	N/A	N/A	$215.00	$ 95.94	$41.47	$ 26.03	$21.07
1Mb (Fast, 128Kx8/9)	N/A	N/A	N/A	$258.00	$109.25	$47.06	$ 26.94	$22.18
1Mb (Slow, All Orgs)	N/A	N/A	$36.34	$ 46.19	$ 23.15	$14.64	$ 11.68	$10.63
4Mb (Fast, 4Mx1)	N/A	N/A	N/A	N/A	N/A	N/A	$136.00	$94.53
4Mb (Fast, 1Mx4)	N/A	N/A	N/A	N/A	N/A	N/A	$160.00	$87.40
4Mb (Fast, 512Kx8/9)	N/A	N/A	N/A	N/A	N/A	N/A	$192.00	$96.75
4Mb (Slow, All Orgs)	N/A	N/A	N/A	N/A	N/A	$40.24	$ 36.75	$35.28
Overall ASP	$ 2.86	$ 3.25	$ 4.71	$ 5.99	$ 6.14	$ 6.24	$ 7.13	$ 8.48

N/A = Not Available

Source: Dataquest
October 1989

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Table 4

Worldwide Fast SRAM Forecast

Revenue (Millions of Dollars)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	$ 16	$ 11	$ 5	0	0	0	0	0
4K (4Kx1)	27	26	18	$ 13	$ 7	$ 4	$ 3	$ 2
4K (1Kx4)	12	12	9	6	3	2	2	1
16K (16Kx1)	58	49	37	29	24	22	18	13
16K (4Kx4)	73	76	83	79	68	66	68	61
16K (2Kx8)	36	41	53	54	46	43	40	37
64K (64Kx1)	62	87	143	154	129	112	102	92
64K (16Kx4)	22	45	108	198	203	202	203	209
64K (8Kx8/9)	23	50	93	118	109	102	97	98
256K (256Kx1)	0	6	60	146	173	181	207	232
256K (64Kx4)	0	8	68	144	204	258	375	487
256K (32Kx8/9)	0	3	20	94	122	136	199	259
1Mb (1Mx1)	0	0	0	2	19	48	133	266
1Mb (256Kx4)	0	0	0	4	29	58	143	392
1Mb (128Kx8/9)	0	0	0	3	22	52	121	306
4Mb (4Mx1)	0	0	0	0	0	0	4	11
4Mb (1Mx4)	0	0	0	0	0	0	5	24
4Mb (512Kx8/9)	0	0	0	0	0	0	6	15
Total	$330	$414	$698	$1,044	$1,159	$1,287	$1,725	$2,506
Percent Change from Previous Year		25.8%	68.4%	49.5%	11.0%	11.1%	34.1%	45.2%

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	5.0	3.5	1.5	0	0	0	0	0
4K (4Kx1)	9.7	9.1	6.4	4.4	2.5	1.4	0.9	0.6
4K (1Kx4)	4.2	3.9	3.1	2.0	1.1	0.6	0.5	0.3
16K (16Kx1)	17.1	15.6	10.9	8.4	6.9	5.9	4.6	3.4
16K (4Kx4)	20.4	22.6	23.6	21.4	19.2	17.3	16.3	14.6
16K (2Kx8)	7.8	10.4	13.6	14.0	13.0	11.9	10.7	9.6
64K (64Kx1)	4.7	11.1	17.8	22.4	22.6	21.8	20.3	18.1
64K (16Kx4)	1.6	5.1	11.4	21.8	27.7	30.0	30.7	30.6
64K (8Kx8/9)	1.4	5.3	10.6	15.9	18.6	19.3	18.4	18.0
256K (256Kx1)	0	0.1	1.5	4.8	10.4	16.3	21.4	25.5
256K (64Kx4)	0	0.2	1.8	5.3	12.7	23.0	35.3	47.5

(Continued)

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Table 4 (Continued)

Worldwide Fast SRAM Forecast

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
256K (32Kx8/9)	0	0	0.5	3.4	8.0	13.2	19.8	26.1
1Mb (1Mx1)	0	0	0	0	0.2	1.0	4.8	13.2
1Mb (256Kx4)	0	0	0	0	0.3	1.4	5.5	18.6
1Mb (128Kx8/9)	0	0	0	0	0.2	1.1	4.5	13.8
4Mb (4Mx1)	0	0	0	0	0	0	0	0.1
4Mb (1Mx4)	0	0	0	0	0	0	0	0.3
4Mb (512Kx8/9)	0	0	0	0	0	0	0	0.2
Total	71.9	86.9	102.7	123.8	143.4	164.2	193.8	240.5

Average Selling Price (Dollars/Units)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	$ 3.16	$ 3.27	$ 3.40	0	0	0	0	0
4K (4Kx1)	$ 2.80	$ 2.86	$ 2.86	$ 2.87	$ 2.90	$ 2.95	$ 3.00	$ 3.12
4K (1Kx4)	$ 2.91	$ 2.98	$ 2.98	$ 3.01	$ 3.05	$ 3.10	$ 3.15	$ 3.23
16K (16Kx1)	$ 3.41	$ 3.13	$ 3.37	$ 3.48	$ 3.44	$ 3.80	$ 3.96	$ 3.96
16K (4Kx4)	$ 3.59	$ 3.36	$ 3.52	$ 3.68	$ 3.54	$ 3.81	$ 4.15	$ 4.16
16K (2Kx8)	$ 4.56	$ 3.95	$ 3.87	$ 3.89	$ 3.56	$ 3.64	$ 3.74	$ 3.83
64K (64Kx1)	$13.10	$ 7.85	$ 8.04	$ 6.87	$ 5.72	$ 5.13	$ 5.03	$ 5.11
64K (16Kx4)	$13.92	$ 8.85	$ 9.50	$ 9.08	$ 7.32	$ 6.73	$ 6.60	$ 6.82
64K (8Kx8/9)	$16.76	$ 9.46	$ 8.77	$ 7.43	$ 5.87	$ 5.29	$ 5.27	$ 5.46
256K (256Kx1)	N/A	$45.06	$39.88	$ 30.32	$ 16.66	$11.08	$ 9.69	$ 9.09
256K (64Kx4)	$75.00	$50.92	$37.73	$ 27.20	$ 16.04	$11.23	$ 10.63	$10.25
256K (32Kx8/9)	$85.00	$60.59	$43.92	$ 27.73	$ 15.29	$10.34	$ 10.03	$ 9.94
1Mb (1Mx1)	N/A	N/A	N/A	$187.00	$ 94.36	$48.01	$ 27.71	$20.15
1Mb (256Kx4)	N/A	N/A	N/A	$215.00	$ 95.94	$41.47	$ 26.03	$21.07
1Mb (128Kx8/9)	N/A	N/A	N/A	$258.00	$109.25	$47.06	$ 26.94	$22.18
4Mb (4Mx1)	N/A	N/A	N/A	N/A	N/A	N/A	$136.00	$94.53
4Mb (1Mx4)	N/A	N/A	N/A	N/A	N/A	N/A	$160.00	$87.40
4Mb (512Kx8/9)	N/A	N/A	N/A	N/A	N/A	N/A	$192.00	$96.75
Overall ASP	$ 4.58	$ 4.77	$ 6.80	$ 8.43	$ 8.08	$ 7.84	$ 8.90	$10.42

N/A = Not Available
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
October 1989

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Table 5

Worldwide Slow SRAM Forecast

Revenue (Millions of Dollars)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	$ 3	$ 2	0	0	0	0	0	0
4K (4Kx1)	3	2	0	0	0	0	0	0
4K (1Kx4)	21	12	4	0	0	0	0	0
8K (1Kx8)	0	0	0	0	0	0	0	0
16K (2Kx8)	131	135	$ 368	$ 372	$ 191	$ 132	$ 79	$ 51
64K (8Kx8)	188	292	499	570	452	316	266	226
256K (32Kx8)	111	307	667	1,031	1,209	1,050	942	851
1Mb (All Orgs.)	0	0	30	223	310	777	1,540	2,151
1Mb PSRAM	0	8	47	86	121	188	235	156
4Mb (All Orgs.)	0	0	0	0	0	13	135	513
4Mb PSRAM	0	0	0	0	27	70	86	193
Total	$457	$759	$1,615	$2,282	$2,309	$2,544	$3,283	$4,139
Percent Change from Previous Year		65.8%	112.9%	41.3%	1.2%	10.2%	29.0%	26.1%

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	1.0	0.6	0.1	0	0	0	0	0
4K (4Kx1)	1.3	0.9	0.1	0	0	0	0	0
4K (1Kx4)	12.4	6.6	2.2	0.2	0	0	0	0
8K (1Kx8)	0	0	0	0	0	0	0	0
16K (2Kx8)	108.1	102.1	154.7	159.5	93.0	58.0	32.0	19.0
64K (8Kx8)	99.0	144.7	164.6	161.0	142.1	115.2	96.0	80.0
256K (32Kx8)	6.2	46.6	89.0	127.9	181.0	216.0	227.0	210.0
1Mb (All Orgs.)	0	0	0.1	2.0	8.6	40.9	110.0	187.0
1Mb PSRAM	0	0.3	2.0	4.7	10.0	25.0	42.0	30.0
4Mb (All Orgs.)	0	0	0	0	0	0.1	1.5	9.0
4Mb PSRAM	0	0	0	0	0.5	2.0	4.5	11.0
Total	228.0	301.8	412.8	455.3	435.2	457.2	513.0	546.0

Average Selling Price (Dollars/Units)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	$ 3.36	$ 3.41	$ 3.50	0	0	0	0	0
4K (4Kx1)	$ 2.25	$ 2.50	$ 2.55	0	0	0	0	0
4K (1Kx4)	$ 1.69	$ 1.85	$ 2.04	$ 2.10	0	0	0	0

(Continued)

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Table 5 (Continued)

Worldwide Slow SRAM Forecast

	Average Selling Price (Dollars/Units)							
	1986	1987	1988	1989	1990	1991	1992	1993
8K (1Kx8)	0	0	0	0	0	0	0	0
16K (2Kx8)	$ 1.21	$ 1.32	$ 2.38	$ 2.33	$ 2.05	$ 2.27	$ 2.47	$ 2.67
64K (8Kx8)	$ 1.90	$ 2.02	$ 3.03	$ 3.54	$ 3.18	$ 2.74	$ 2.77	$ 2.82
256K (32Kx8)	$17.96	$ 6.59	$ 7.49	$ 8.06	$ 6.68	$ 4.86	$ 4.15	$ 4.05
1Mb (All Orgs.)	N/A	N/A	$298.17	$111.50	$36.00	$ 19.00	$14.00	$11.50
1Mb PSRAM	N/A	$26.86	$ 23.25	$ 18.40	$12.10	$ 7.50	$ 5.60	$ 5.20
4Mb (All Orgs.)	N/A	N/A	N/A	N/A	N/A	$250.00	$90.00	$57.00
4Mb PSRAM	N/A	N/A	N/A	N/A	$53.00	$ 35.00	$19.00	$17.50
Overall ASP	$ 2.01	$ 2.51	$ 3.91	$ 5.01	$ 5.30	$ 5.57	$ 6.40	$ 7.58

N/A = Not Available
Note: Columns may not add to totals shown because of rounding. The 1Mb and 4Mb pseudostatic RAMs are separated: they are combined with standard RAMs at the 64K and 256K densities.

Source: Dataquest October 1989

Comparison With Earlier Forecasts

The major difference between the current SRAM forecast and the one previously published is the strength of the 1989 market. This fact is especially true for the slow SRAM market. At present, Dataquest forecasts the growth of 1989 over 1988 to be 43.8 percent; in our earlier forecast, we estimated the growth to be 5.9 percent. This large difference is due to the continued DRAM shortage and the delay of the market slowdown from a predicted start of early 1989 to the second half of 1989.

This DRAM shortage plagued the SRAM market throughout 1988 and into the first half of 1989. Because production capacity and engineering resources were being focused on 1Mb DRAM production, SRAMs were unable to meet the market demand, resulting in a shortage of supply and higher prices.

In early 1988, Dataquest forecast that the market slowdown would occur in the first half of 1989. However, due to the overall health of the economy and the strong demand for memories as a result of the previous quarters of shortage the SRAM market, slowdown did not start until the second half of 1989. Because of the continued demand and relatively high prices, the MOS memory market as a whole should maintain a robust growth through 1989, while other semiconductor products may not perform nearly as well.

From a product standpoint, some important differences between our current and previous forecasts need to be noted. We have added a new product category to our current forecast and adjusted the magnitude of two key developing trends.

In previous forecasts we included the BiCMOS ECL I/O level product with the bipolar ECL I/O product because they function with the same I/O interface levels. However, because BiCMOS is an outgrowth of a MOS process and BiCMOS TTL I/O was counted under the MOS memory

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forecast, we decided to combine all of BiCMOS into the MOS forecast. In the short term, this change had only a minor impact on the fast SRAM forecast; the effects become apparent in the forecast for 1991 and beyond.

Magnitude adjustments to the forecast were made to the 16K slow SRAM and to the 1Mb pseudostatic RAM. The 16K slow SRAM market went through severe changes in both demand and supply during the second half of 1988 and the first half of 1989. From the demand side, a number of new applications for the 2Kx8 devices were introduced late in the product's life cycle. Compact disc players, video games, point-of-sale (POS) cash registers, disk drives, and even personal computers all started to use the 2Kx8 in volume production. During this time, the traditional suppliers of the 2Kx8 were de-emphasizing the device to make way for newer generations of memories. The increased demand resulted in a second peak in the product's unit life cycle, and the short supply resulted in very high selling prices.

The 1Mb pseudostatic RAM (PSRAM) introduced by Hitachi and Toshiba had a stronger-than-anticipated presence in 1988. Traditionally the PSRAM, which is based on DRAM core technology, appears later in the slow SRAM's life cycle. However, because 1Mb PSRAMs are used in laptop computers as main memory, and fax machines and printers as buffers, the 1Mb was introduced and ramped into production much earlier than in previous generations. For increased detail of this phenomenon we separated the 1Mb and 4Mb PSRAM product lines in the slow SRAM forecast.

Short-Term Outlook

Dataquest forecasts a slight downturn in the SRAM market from the third quarter of 1989 through the second quarter of 1990. During the second half of 1990, we expect the market to pull out of its slump and return to more traditional growth trends. We believe the slowdown will be minor compared with the 1985 recession because the market is in a better state of control than in 1985, there is improved communication between vendors and OEMs, users have better control over inventories, and manufacturing capacity is not growing at unreasonable rates. From our present view, there appears to be a slight buildup in capacity and inventory levels, but not to the degree of misalignment that occurred in 1985. The SRAM market is expected to grow 4.2 percent in 1990 over 1989.

For the fast SRAM market in the short term, applications will continue to develop in more commodity-oriented products. Caches made from high-speed SRAM will become almost a necessity in the workstation market and will develop as a desired feature for PCs. BiCMOS will begin to be more widely used because of its ability to offer faster speeds at more conservative line geometries and its capability of operating at both ECL and TTL I/O levels. In the slow SRAM market, the 1Mb will begin its production ramp and the 4Mb will start to be sampled. For both slow and fast SRAMs, surface-mount packaging will become increasingly critical to help reduce the size of end products, to increase the number of memories that can be packed on a board, and to improve system speed.

Long-Term Outlook

As mentioned earlier, Dataquest expects 1993 to be the next boom market, which will result in increased sales for both types of SRAMs. Also, due to the increased demand, a possible shortage may develop resulting in higher ASPs. Although we believe that these factors will prevail

in 1993, Dataquest still anticipates a conservative boom scenario, albeit with market growth less than that of the 1988 boom year. We also speculate that 1994 will be a recovery year and revenue growth will be flat to slightly down.

During the next three to five years, Dataquest expects the products to experience an evolutionary change. We foresee emitter-coupled logic (ECL) interface levels becoming more important as systems push for faster speeds. A number of standard microprocessor and RISC processor manufacturers are planning ECL I/O versions of their products to increase speed and drive capabilities. As mentioned previously, BiCMOS will be in a unique position to take advantage of this development with its ability to operate in both interface worlds. TTL I/O device also will start migrating toward the 3.3V power supply to avoid problems associated with high-power and smaller line geometries. We have seen a few overtures in this direction already; however, it is not expected to become a standard until the 4Mb level.

Dataquest believes that the development of specialty and custom memories is a trend that will blossom during the next few years. As it becomes increasingly difficult to achieve faster system speed through pushing for smaller-line geometries, system architects and chip designers will have to combine their talents to improve overall system speed. It will be too expensive to force speed through simple reduction—especially when reducing feature sizes below 0.8 micron; alternatives such as improved integration will have to used. Bringing the cache on-chip for microprocessors is an example of movement in this direction; we expect this trend to continue as the drive for faster and less expensive systems persists.

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MOS SRAM--Forecast

OVERVIEW OF THE MOS STATIC RAM MARKET

The MOS static RAM, or SRAM, is becoming an increasingly important member of the memory family. SRAMs are displacing DRAMs and nonvolatile memories in some applications because of their high speed, low power consumption, and the ease with which they can be designed into a system. Many companies have turned to using SRAMs as a vehicle to monitor and prove the feasibility of new processes and packaging. High performance, complexity of process, and reasonable profit margins make SRAMs, especially fast SRAMs, ideal as process drivers for specialty memory, ASIC, processor, and standard memory companies alike.

SRAMs can be divided into two distinct markets: slow SRAMs, which include parts with access times of more than 70ns and fast SRAMs, which consist of those RAMs with an access time at or less than 70ns. These must be treated as separate markets because of the differences in end uses and design. Slow SRAMs are designed for volume production and for use in a wide variety of low-cost applications. Fast SRAMs, on the other hand, are designed primarily to fill the high-performance demands of systems and are less cost sensitive.

This section reviews the dynamics of the SRAM market through the following topics:

- Historical growth
- MOS SRAM market forecast
- Comparison with earlier forecasts
- Short-term outlook
- Long-term outlook

Historical Growth

- In 1988, the SRAM market reached $2.3 billion. SRAMs represented 19.2 percent of the total MOS memory market that year, a slight decrease from 19.5 percent in 1987.
- Total SRAM revenue grew at a compound annual growth rate (CAGR) of 24.2 percent between 1983 and 1988. This growth is slightly higher than that of the MOS memory market, which had a CAGR of 24.1 percent during the same period.
- The slow SRAM market revenue reflected a 21.2 percent CAGR from 1983 to 1988, and the fast SRAM revenue CAGR was 33.2 percent for the same period. The growth of the fast SRAM market is due to its maturation and the strength of its 16K and 64K densities.

Figure 1 shows the MOS SRAM revenue growth in comparison with the total MOS memory market. Figure 2 depicts the historical revenue of the fast and slow SRAMs since 1977 and forecast revenue through 1993.

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Figure 1

Estimated MOS Memory and SRAM Market Growth
1977-1988

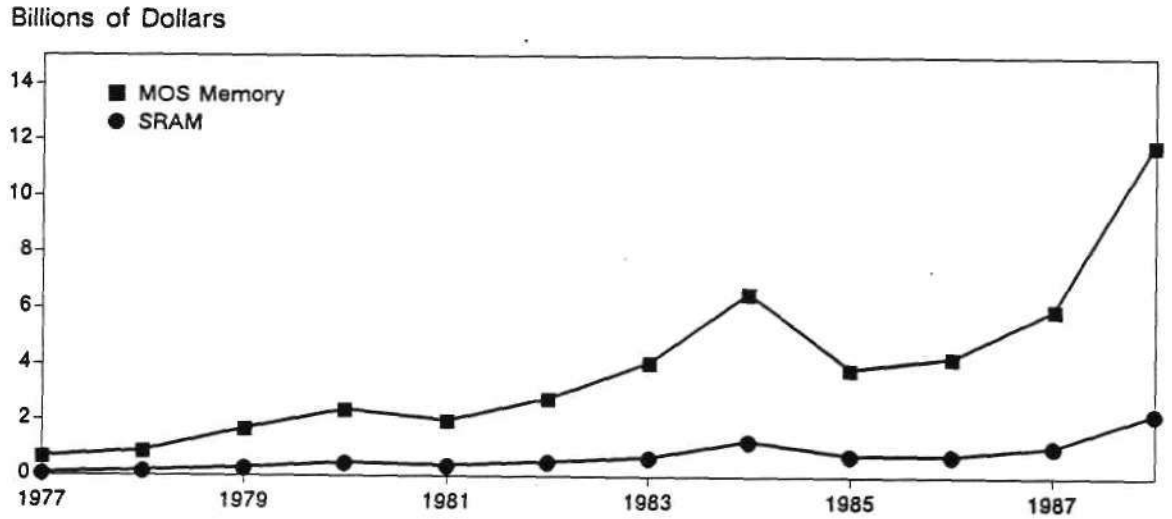
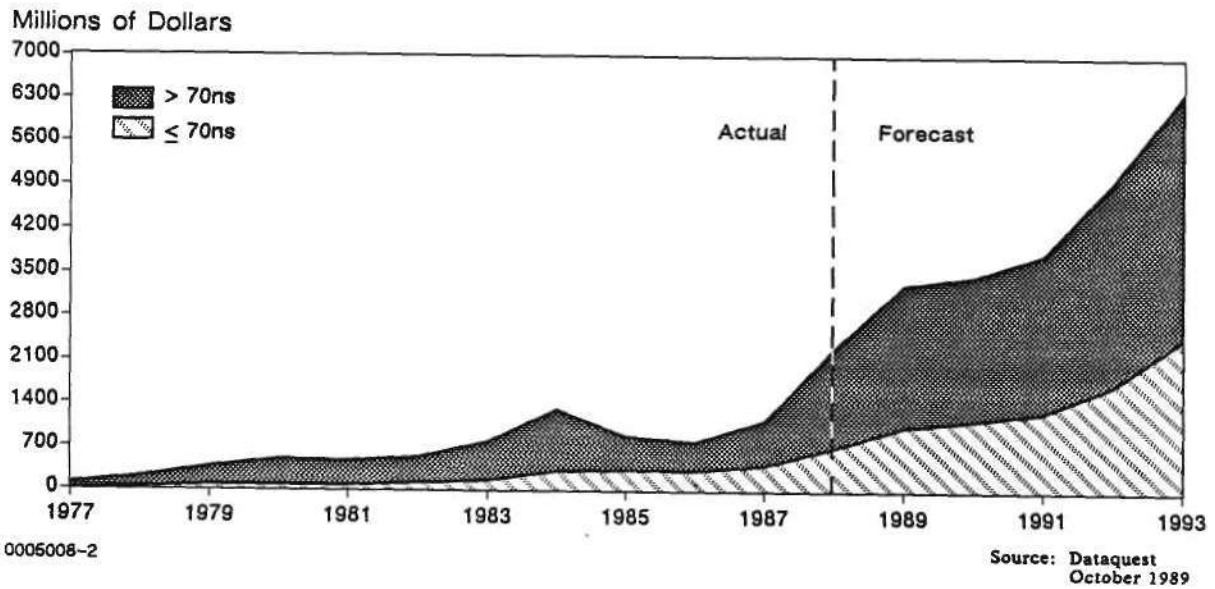


Figure 2

Estimated MOS SRAM Market Growth
1977-1993



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MOS SRAM Market Forecast

Dataquest describes the MOS SRAM forecast and historical shipments from 1986 to 1993 in the following tables:

- Table 1—Worldwide MOS SRAM Forecast (Revenue, Units, and Average Selling Prices)
- Table 2—Worldwide NMOS SRAM Forecast (Revenue, Units, and Average Selling Prices)
- Table 3—Worldwide CMOS SRAM Forecast (Revenue, Units, and Average Selling Prices)
- Table 4—Worldwide BiCMOS SRAM TTL I/O Forecast (Revenue, Units, and Average Selling Prices)
- Table 5—Worldwide BiCMOS SRAM ECL I/O Forecast (Revenue, Units, and Average Selling Prices)
- Table 6—Worldwide Fast SRAM Forecast (Revenue, Units, and Average Selling Prices)
- Table 7—Worldwide Slow SRAM Forecast (Revenue, Units, and Average Selling Prices)

In 1988, the MOS memory market demonstrated tremendous growth over 1987, and Dataquest expects this growth to continue between 1988 and 1993. Dataquest believes that the expansion of the SRAM market will be spurred on by a number of factors: continued cost-per-bit reductions, introduction of larger densities, further reduction of access times, development of new processes, and the emergence of new applications, to name a few. The key elements to the forecast are as follows:

- In 1988, the SRAM market showed healthy growth; it grew 97.2 percent over its 1987 position. This growth was mainly due to the developments in the 256K slow SRAM, which experienced a 13.7 percent increase in price and a 91.0 percent increase in units.
- The growth during 1988 and 1989 is mainly due to the increase in average selling prices (ASPs), which is especially true for the slow SRAMs.
  - From 1988 to 1989, units for slow SRAMs grew only 10.3 percent while revenue grew 41.3 percent.
  - ASPs were driven up as the SRAM shortage continued, the result of SRAM manufacturing capacity being channeled toward the building of DRAMs to help fulfill the growing demands of this market.
- The market is experiencing a slowdown in SRAM demand in the third quarter of 1989. Dataquest expects this to continue through the second quarter of 1990, at which time the end markets that consume SRAMs should start to pick up again.
  - The slowdown will have more impact on SRAM selling prices than on unit shipments.
  - A small discrepancy in the supply/demand situation will have a drastic effect on prices as suppliers and users react to the uncertainty.
  - Slow SRAMs will be affected more than fast SRAMs due to their consumption by more price-sensitive commodity-type products.

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- The fast SRAM market is expected to grow at a CAGR of 28.7 percent between 1988 and 1993. It will slightly outpace the slow SRAM market, which is expected to grow at a 19.6 percent CAGR.
  - The anticipated greater growth rate of fast SRAMs will be a result of the continual speed improvements within each density, resulting in slower price degradation and longer product life cycles.
  - The fast SRAM growth rate will also be due to the usage of the fast devices in a wider spectrum of applications; to meet increasing processor and CPU speed demands, a wider variety of systems will call on fast SRAMs to help meet the requirements for faster data rates.
- The next boom year in the electronics industry is expected to be 1993. The anticipated growth rate in 1993 is based on a number of factors:
  - The introduction of larger wafer fabrication facilities that will feed the 4Mb DRAM and 1Mb SRAM markets
  - The development of new applications that will consume large amounts of electronics in the consumer, data processing, and telecommunication markets
  - The extrapolation of historical market and economic cycles

Table 1

Worldwide MOS SRAM Forecast

	Revenue (Millions of Dollars)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (Fast)	$ 16	$ 11	$ 5	0	0	0	0	0
1K (Slow)	3	2	0	0	0	0	0	0
4K (Fast)	39	38	28	$ 19	$ 11	$ 6	$ 4	$ 3
4K (Slow)	24	14	5	0	0	0	0	0
8K (Slow)	0	0	0	0	0	0	0	0
16K (Fast)	167	166	172	162	138	132	126	111
16K (Slow)	131	135	368	372	191	132	79	51
64K (Fast)	107	182	344	470	441	416	402	399
64K (Slow)	188	292	499	570	452	316	266	226
256K (Fast)	0	17	149	384	499	575	781	978
256K (Slow)	111	307	667	1,031	1,209	1,050	942	851
1Mb (Fast)	0	0	0	9	70	158	397	964
1Mb (Slow)	0	8	76	309	431	965	1,775	2,307
4Mb (Fast)	0	0	0	0	0	0	15	50
4Mb (Slow)	0	0	0	0	27	83	221	706
Total	$787	$1,173	$2,313	$3,326	$3,467	$3,831	$5,008	$6,645
Percent Change from Previous Year		49.1%	97.2%	43.8%	4.2%	10.5%	30.7%	32.7%

(Continued)

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Table 1 (Continued)

Worldwide MOS SRAM Forecast

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (Fast)	5.0	3.5	1.5	0	0	0	0	0
1K (Slow)	1.0	0.6	0.1	0	0	0	0	0
4K (Fast)	13.9	13.0	9.5	6.4	3.6	2.0	1.4	0.9
4K (Slow)	13.7	7.5	2.3	0.2	0	0	0	0
8K (Slow)	0	0	0	0	0	0	0	0
16K (Fast)	45.3	48.6	48.1	43.8	39.1	35.1	31.6	27.6
16K (Slow)	108.1	102.1	154.7	159.5	93.0	58.0	32.0	19.0
64K (Fast)	7.7	21.5	39.8	60.1	68.9	71.1	69.4	66.7
64K (Slow)	99.0	144.7	164.6	161.0	142.1	115.2	96.0	80.0
256K (Fast)	0	0.3	3.8	13.5	31.1	52.5	76.5	99.1
256K (Slow)	6.2	46.6	89.0	127.9	181.0	216.0	227.0	210.0
1Mb (Fast)	0	0	0	0	0.7	3.5	14.8	45.6
1Mb (Slow)	0	0.3	2.1	6.7	18.6	65.9	152.0	217.0
4Mb (Fast)	0	0	0	0	0	0	0.1	0.6
4Mb (Slow)	0	0	0	0	0.5	2.1	6.0	20.0
Total	299.9	388.7	515.5	579.1	578.6	621.4	706.8	786.5

Average Selling Price (Dollars/Units)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (Fast)	$ 3.16	$ 3.27	$ 3.40	0	0	0	0	0
1K (Slow)	$ 3.36	$ 3.41	$ 3.50	0	0	0	0	0
4K (Fast)	$ 2.83	$ 2.90	$ 2.90	$ 2.91	$ 2.95	$ 3.00	$ 3.05	$ 3.15
4K (Slow)	$ 1.74	$ 1.93	$ 2.07	$ 2.10	0	0	0	0
8K (Slow)	0	0	0	0	0	0	0	0
16K (Fast)	$ 3.69	$ 3.41	$ 3.58	$ 3.71	$ 3.53	$ 3.75	$ 3.98	$ 3.50
16K (Slow)	$ 1.21	$ 1.32	$ 2.38	$ 2.33	$ 2.05	$ 2.27	$ 2.47	$ 1.60
64K (Fast)	$13.94	$ 8.48	$ 8.65	$ 7.82	$ 6.40	$ 5.85	$ 5.79	$ 4.35
64K (Slow)	$ 1.90	$ 2.02	$ 3.03	$ 3.54	$ 3.18	$ 2.74	$ 2.77	$ 2.58
256K (Fast)	$78.75	$49.83	$39.34	$ 28.44	$16.05	$10.96	$ 10.21	$ 6.00
256K (Slow)	$17.96	$ 6.59	$ 7.49	$ 8.06	$ 6.68	$ 4.86	$ 4.15	$ 3.55
1Mb (Fast)	N/A	N/A	N/A	$218.75	$99.29	$45.10	$ 26.85	$11.00
1Mb (Slow)	N/A	N/A	$36.34	$ 46.19	$23.15	$14.64	$ 11.68	$ 5.00
4Mb (Fast)	N/A	N/A	N/A	N/A	N/A	N/A	$163.13	$14.00
4Mb (Slow)	N/A	N/A	N/A	N/A	N/A	$40.24	$ 36.75	$14.00
Overall ASP	$ 2.62	$ 3.02	$ 4.49	$ 5.74	$ 5.99	$ 6.17	$ 7.09	$ 8.45

N/A = Not Available
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
October 1989

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Table 2

Worldwide NMOS SRAM Forecast

	Revenue (Millions of Dollars)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Types)	$ 5	$ 3	$ 2	0	0	0	0	0
4K (Fast, 4Kx1)	25	25	16	$ 10	$ 6	$ 3	$ 2	$ 2
4K (Fast, 1Kx4)	12	9	4	4	2	1	1	1
4K (Slow, 4Kx1)	1	1	0	0	0	0	0	0
4K (Slow, 1Kx4)	11	7	3	0	0	0	0	0
8K (Slow, 1Kx8)	0	0	0	0	0	0	0	0
16K (Fast, 16Kx1)	23	11	7	4	3	2	1	1
16K (Fast, 4Kx4)	31	24	18	12	10	8	6	4
16K (Fast, 2Kx8)	18	17	14	12	9	7	5	3
16K (Slow, 2Kx8)	41	38	72	57	22	10	5	3
64K (Slow, 8Kx8)	8	14	2	1	0	0	0	0
64K (Fast, All Orgs.)	4	2	1	0	0	0	0	0
Total	$180	$153	$138	$101	$52	$31	$20	$13
Percent Change from Previous Year	(44.5%)	(15.1%)	(9.4%)	(26.9%)	(48.2%)	(40.3%)	(36.7%)	(35.1%)

	Units (Millions)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Types)	2.0	1.2	0.6	0	0	0	0	0
4K (Fast, 4Kx1)	8.9	8.8	5.7	3.5	2.0	1.0	0.7	0.5
4K (Fast, 1Kx4)	4.0	3.2	1.4	1.2	0.7	0.4	0.3	0.2
4K (Slow, 4Kx1)	0.7	0.6	0.1	0	0	0	0	0
4K (Slow, 1Kx4)	8.5	5.0	1.7	0.2	0	0	0	0
8K (Slow, 1Kx8)	0	0	0	0	0	0	0	0
16K (Fast, 16Kx1)	6.6	4.0	2.3	1.5	1.0	0.7	0.4	0.2
16K (Fast, 4Kx4)	9.1	7.9	5.6	4.0	3.5	2.8	2.2	1.5
16K (Fast, 2Kx8)	4.2	4.9	4.1	3.5	3.0	2.2	1.5	1.0
16K (Slow, 2Kx8)	38.7	31.7	31.1	26.0	12.0	5.0	2.0	1.0
64K (Slow, 8Kx8)	4.5	7.6	0.7	0.3	0.1	0	0	0
64K (Fast, All Orgs.)	0.3	0.2	0.2	0.1	0	0	0	0
Total	87.5	75.1	53.3	40.3	22.3	12.1	7.1	4.4

(Continued)

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Table 2 (Continued)

Worldwide NMOS SRAM Forecast

	Average Selling Price (Dollars/Units)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Types)	$ 2.60	$2.60	$2.60	0	0	0	0	0
4K (Fast, 4Kx1)	$ 2.80	$2.86	$2.86	$2.87	$2.90	$2.95	$3.00	$3.12
4K (Fast, 1Kx4)	$ 2.91	$2.98	$2.98	$3.01	$3.05	$3.10	$3.15	$3.23
4K (Slow, 4Kx1)	$ 1.78	$2.00	$2.16	0	0	0	0	0
4K (Slow, 1Kx4)	$ 1.25	$1.40	$1.57	$2.10	0	0	0	0
8K (Slow, 1Kx8)	0	0	0	0	0	0	0	0
16K (Fast, 16Kx1)	$ 3.55	$2.82	$3.02	$2.87	$2.65	$2.69	$2.74	$2.76
16K (Fast, 4Kx4)	$ 3.40	$3.02	$3.17	$3.09	$2.85	$2.87	$2.92	$2.93
16K (Fast, 2Kx8)	$ 4.40	$3.56	$3.48	$3.31	$3.03	$3.07	$3.10	$3.11
16K (Slow, 2Kx8)	$ 1.07	$1.20	$2.30	$2.20	$1.85	$2.07	$2.32	$2.57
64K (Slow, 8Kx8)	$ 1.80	$1.90	$2.90	$3.35	$2.90	0	0	0
64K (Fast, All Orgs.)	$12.50	$7.38	$6.91	$5.57	$4.50	0	0	0
Overall ASP	$ 2.05	$2.03	$2.59	$2.51	$2.34	$2.58	$2.80	$2.92

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

Source: Dataquest
October 1989

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Table 3

Worldwide CMOS SRAM Forecast

	1986	1987	1988	1989	1990	1991	1992	1993
	Revenue (Millions of Dollars)							
1K (All types)	$ 14	$ 10	$ 4	0	0	0	0	0
4K (Fast)	3	3	7	$ 5	$ 3	$ 2	$ 1	$ 1
4K (Slow)	12	6	2	0	0	0	0	0
16K (Fast, 16Kx1)	35	38	30	24	17	14	10	8
16K (Fast, 4Kx4)	42	52	63	61	48	42	39	37
16K (Fast, 2Kx8)	17	24	37	41	34	32	31	29
16K (Slow, 2Kx8)	89	97	297	314	168	121	74	48
64K (Fast, 64Kx1)	53	61	85	90	62	49	47	45
64K (Fast, 16Kx4)	22	29	59	98	88	73	62	56
64K (Fast, 8Kx8/9)	23	49	91	116	105	91	77	71
64K (Slow, 8Kx8)	180	278	497	569	452	316	266	226
256K (Fast, 256Kx1)	0	6	42	65	71	73	94	113
256K (Fast, 64Kx4)	0	8	67	102	115	115	146	184
256K (Fast, 32Kx8/9)	0	3	20	94	119	119	146	170
256K (Slow, 32Kx8)	111	307	667	1,031	1,209	1,050	942	851
1Mb (Fast, 1Mx1)	0	0	0	2	11	17	44	117
1Mb (Fast, 256Kx4)	0	0	0	4	25	39	68	200
1Mb (Fast, 128Kx8/9)	0	0	0	3	22	46	101	232
1Mb (Slow, All Orgs.)	0	8	76	309	431	965	1,775	2,307
4Mb (Fast, 4Mx1)	0	0	0	0	0	0	4	4
4Mb (Fast, 1Mx4)	0	0	0	0	0	0	5	19
4Mb (Fast, 512Kx8/9)	0	0	0	0	0	0	6	15
4Mb (Slow, All Orgs.)	0	0	0	0	27	83	221	706
Total	$602	$978	$2,042	$2,928	$3,006	$3,245	$4,159	$5,435
Percent Change from Previous Year	7.5%	62.6%	108.7%	43.4%	2.7%	8.0%	28.2%	30.7%
	Units (Millions)							
	1986	1987	1988	1989	1990	1991	1992	1993
1K (All types)	4.0	2.9	1.0	0	0	0	0	0
4K (Fast)	1.0	1.0	2.4	1.7	0.9	0.6	0.4	0.2
4K (Slow)	4.5	1.9	0.5	0	0	0	0	0
16K (Fast, 16Kx1)	17.1	15.6	10.9	8.3	6.4	4.9	3.6	2.6
16K (Fast, 4Kx4)	20.4	22.6	23.0	20.2	17.4	14.8	13.3	12.1
16K (Fast, 2Kx8)	7.8	10.4	13.3	13.5	12.3	10.9	9.8	8.8
16K (Slow, 2Kx8)	69.4	70.4	123.6	133.5	81.0	53.0	30.0	18.0

(Continued)

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Table 3 (Continued)

Worldwide CMOS SRAM Forecast

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
64K (Fast, 64Kx1)	4.1	9.6	14.5	17.5	16.0	14.1	12.6	11.3
64K (Fast, 16Kx4)	1.6	4.2	8.9	16.5	19.6	18.6	16.1	14.0
64K (Fast, 8Kx8/9)	1.4	5.1	10.4	15.7	18.2	18.3	16.3	15.0
64K (Slow, 8Kx8)	94.5	137.1	163.9	160.7	142.0	115.2	96.0	80.0
256K (Fast, 256Kx1)	0	0.1	1.3	3.2	6.6	10.0	13.5	16.0
256K (Fast, 64Kx4)	0	0.2	1.8	4.6	9.7	15.5	21.0	26.0
256K (Fast, 32Kx8/9)	0	0.0	0.5	3.4	7.8	12.3	17.0	20.5
256K (Slow, 32Kx8)	6.2	46.6	89.0	127.9	181.0	216.0	227.0	210.0
1Mb (Fast, 1Mx1)	0	0	0	0	0.1	0.6	2.3	6.6
1Mb (Fast, 256Kx4)	0	0	0	0	0.3	1.2	3.4	10.5
1Mb (Fast, 128Kx8/9)	0	0	0	0	0.2	1.1	4.0	11.2
1Mb (Slow, All Orgs.)	0	0	2.1	6.7	18.6	65.9	152.0	217.0
4Mb (Fast, 4Mx1)	0	0	0	0	0	0	0	0.1
4Mb (Fast, 1Mx4)	0	0	0	0	0	0	0	0.3
4Mb (Fast, 512Kx8/9)	0	0	0	0	0	0	0	0.2
4Mb (Slow, All Orgs.)	0	0	0	0	0.5	2.1	6.0	20.0
Total	232.0	328.0	467.1	533.4	538.6	575.0	644.3	700.3

Average Selling Price (Dollars/Units)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All types)	$ 3.49	$ 3.58	$ 3.89	0	0	0	0	0
4K (Fast)	$ 2.82	$ 2.95	$ 2.94	$ 2.94	$ 2.97	$ 3.00	$ 3.06	$ 3.17
4K (Slow)	$ 2.67	$ 3.29	$ 3.65	0	0	0	0	0
16K (Fast, 16Kx1)	$ 2.04	$ 2.41	$ 2.73	$ 2.86	$ 2.71	$ 2.78	$ 2.91	$ 3.03
16K (Fast, 4Kx4)	$ 2.07	$ 2.30	$ 2.74	$ 3.02	$ 2.78	$ 2.83	$ 2.94	$ 3.08
16K (Fast, 2Kx8)	$ 2.19	$ 2.27	$ 2.80	$ 3.00	$ 2.80	$ 2.96	$ 3.14	$ 3.28
16K (Slow, 2Kx8)	$ 1.29	$ 1.37	$ 2.40	$ 2.36	$ 2.08	$ 2.29	$ 2.48	$ 2.68
64K (Fast, 64Kx1)	$12.86	$ 6.35	$ 5.84	$ 5.19	$ 3.85	$ 3.48	$ 3.71	$ 3.95
64K (Fast, 16Kx4)	$13.92	$ 7.07	$ 6.54	$ 5.92	$ 4.52	$ 3.91	$ 3.83	$ 3.97
64K (Fast, 8Kx8/9)	$16.76	$ 9.50	$ 8.75	$ 7.40	$ 5.79	$ 5.00	$ 4.71	$ 4.74
64K (Slow, 8Kx8)	$ 1.90	$ 2.03	$ 3.03	$ 3.54	$ 3.18	$ 2.74	$ 2.77	$ 2.82
256K (Fast, 256Kx1)	$85.00	$43.39	$32.46	$ 19.94	$ 10.79	$ 7.25	$ 7.00	$ 7.03
256K (Fast, 64Kx4)	$75.00	$50.92	$37.17	$ 22.32	$ 11.81	$ 7.40	$ 6.96	$ 7.06
256K (Fast, 32Kx8/9)	$85.00	$60.59	$43.92	$ 27.73	$ 15.12	$ 9.64	$ 8.61	$ 8.30
256K (Slow, 32Kx8)	$17.96	$ 6.59	$ 7.49	$ 8.06	$ 6.68	$ 4.86	$ 4.15	$ 4.05
1Mb (Fast, 1Mx1)	N/A	N/A	N/A	$187.00	$ 78.95	$28.02	$ 19.01	$17.86

(Continued)

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Table 3 (Continued)

Worldwide CMOS SRAM Forecast

	Average Selling Price (Dollars/Units)							
	1986	1987	1988	1989	1990	1991	1992	1993
1Mb (Fast, 256Kx4)	N/A	N/A	N/A	$215.00	$ 92.31	$33.14	$ 20.25	$19.01
1Mb (Fast, 128Kx8/9)	N/A	N/A	N/A	$258.00	$109.25	$44.06	$ 24.98	$20.80
1Mb (Slow, All Orgs.)	N/A	N/A	$36.34	$ 46.19	$ 23.15	$14.64	$ 11.68	$10.63
4Mb (Fast, 4Mx1)	N/A	N/A	N/A	N/A	N/A	N/A	$136.00	$51.34
4Mb (Fast, 1Mx4)	N/A	N/A	N/A	N/A	N/A	N/A	$160.00	$75.49
4Mb (Fast, 512Kx8/9)	N/A	N/A	N/A	N/A	N/A	N/A	$192.00	$96.75
4Mb (Slow, All Orgs.)	N/A	N/A	N/A	N/A	N/A	$40.24	$ 36.75	$35.28
Overall ASP	$ 2.59	$ 2.98	$ 4.37	$ 5.49	$ 5.58	$ 5.64	$ 6.46	$ 7.76

N/A = Not Available
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
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Table 4

Worldwide BiCMOS TTL I/O SRAM Forecast

		Revenue (Millions of Dollars)							
		1986	1987	1988	1989	1990	1991	1992	1993
16K	16Kx1	0	0	0	0	0	0	0	0
16K	4Kx4	0	0	$ 2	$ 4	$ 5	$ 5	$ 4	$ 2
16K	2Kx8	0	0	1	2	3	4	3	2
64K	64Kx1	$5	$22	34	35	39	33	29	23
64K	16Kx4	0	12	24	29	37	37	39	40
64K	8Kx8/9	0	0	1	2	4	6	10	14
256K	256Kx1	0	0	3	12	19	20	23	25
256K	64Kx4	0	0	0	16	35	56	82	101
256K	32Kx8/9	0	0	0	0	3	10	22	37
1Mb	1Mx1	0	0	0	0	3	11	27	59
1Mb	245Kx4	0	0	0	0	4	16	46	102
1Mb	128Kx8/9	0	0	0	0	0	3	12	44
4Mb	4Mx1	0	0	0	0	0	0	0	3
4Mb	1Mx4	0	0	0	0	0	0	0	4
4Mb	512Kx8/9	0	0	0	0	0	0	0	0
Total		$5	$35	$66	$100	$151	$201	$296	$455
Percent Change from Previous Year			584.4%	87.3%	52.7%	51.4%	32.9%	47.1%	53.6%

		Units (Millions)							
		1986	1987	1988	1989	1990	1991	1992	1993
16K	16Kx1	0	0	0	0	0.1	0.1	0.1	0.1
16K	4Kx4	0	0	0.6	1.1	1.4	1.4	1.0	0.5
16K	2Kx8	0	0	0.3	0.5	0.7	1.0	0.8	0.6
64K	64Kx1	0.2	1.3	2.5	3.8	4.8	5.5	5.2	4.3
64K	16Kx4	0	0.7	1.6	2.9	4.4	5.8	6.7	7.0
64K	8Kx8/9	0	0	0.1	0.1	0.4	0.8	1.5	2.2
256K	256Kx1	0	0	0	0.4	1.1	1.7	2.4	3.0
256K	64Kx4	0	0	0	0.4	1.8	4.3	7.8	11.0
256K	32Kx8/9	0	0	0	0	0.2	0.7	1.8	3.5
1Mb	1Mx1	0	0	0	0	0	0.2	1.1	3.6
1Mb	256Kx4	0	0	0	0	0	0.2	1.6	5.7
1Mb	128Kx8/9	0	0	0	0	0	0	0.4	2.0
4Mb	4Mx1	0	0	0	0	0	0	0	0
4Mb	1Mx4	0	0	0	0	0	0	0	0
4Mb	512Kx8/9	0	0	0	0	0	0	0	0
Total		0.2	2.1	5.0	9.2	14.8	21.6	30.5	43.5

(Continued)

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Table 4 (Continued)

Worldwide BiCMOS TTL I/O SRAM Forecast

		Average Selling Price (Dollars/Units)							
		1986	1987	1988	1989	1990	1991	1992	1993
16K	16Kx1	N/A	N/A	N/A	$ 3.66	$ 3.11	$ 3.18	$3.29	$ 3.40
16K	4Kx4	N/A	$ 4.64	$ 3.96	$ 3.95	$ 3.33	$ 3.37	$3.45	$ 3.54
16K	2Kx8	N/A	$ 5.48	$4.65	$ 4.64	$ 3.92	$ 3.98	$4.08	$ 4.18
64K	64Kx1	$25.55	$16.08	$13.77	$ 9.42	$ 8.01	$ 6.12	$5.53	$ 5.41
64K	16Kx4	N/A	$17.53	$14.87	$10.08	$ 8.49	$ 6.46	$5.81	$ 5.65
64K	8Kx8/9	N/A	$20.58	$17.35	$11.68	$ 9.77	$ 7.34	$6.53	$ 6.28
256K	256Kx1	N/A	$89.46	$60.61	$32.20	$ 17.78	$11.84	$9.61	$ 8.56
256K	64Kx4	N/A	N/A	$68.49	$36.06	$ 19.74	$13.02	$10.47	$ 9.24
256K	32Kx8/9	N/A	N/A	$80.61	$42.18	$ 22.94	$15.04	$12.01	$ 10.53
1Mb	1Mx1	N/A	N/A	N/A	N/A	$104.22	$72.91	$24.79	$ 16.20
1Mb	245Kx4	N/A	N/A	N/A	N/A	$118.81	$82.39	$27.76	$ 17.98
1Mb	128Kx8/9	N/A	N/A	N/A	N/A	$143.82	$99.16	$33.22	$ 21.38
4Mb	4Mx1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$125.00
4Mb	1Mx4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$180.00
4Mb	512Kx8/9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Overall ASP		$25.55	$16.57	$13.02	$10.88	$ 10.21	$ 9.32	$9.70	$ 10.46

N/A = Not Available

Source: Dataquest
October 1989

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Table 5

Worldwide BiCMOS ECL I/O SRAM Forecast

		Revenue (Millions of Dollars)						
		1987	1988	1989	1990	1991	1992	1993
16K	16Kx1	0	0	$ 1	$ 3	$ 7	$ 6	$ 5
16K	4Kx4	0	0	1	5	11	19	17
16K	2Kx8	0	0	0	0	0	1	2
64K	64Kx1	$4	$25	28	29	29	26	25
64K	16Kx4	3	26	71	77	92	102	114
64K	8Kx8/9	0	0	0	0	5	10	14
256K	256Kx1	0	15	69	84	88	90	94
256K	64Kx4	0	1	27	54	88	147	202
256K	32Kx8/9	0	0	0	0	8	31	52
1Mb	1Mx1	0	0	0	4	20	62	90
1Mb	245Kx4	0	0	0	1	3	30	90
1Mb	128Kx8/9	0	0	0	0	2	8	30
4Mb	4Mx1	0	0	0	0	0	0	5
4Mb	1Mx4	0	0	0	0	0	0	2
4Mb	512Kx8/9	0	0	0	0	0	0	0
Total		$7	$67	$197	$258	$353	$533	$741
Percent Change from Previous Year			815.5%	193.8%	30.6%	37.1%	51.0%	39.1%

		Units (Millions)						
		1987	1988	1989	1990	1991	1992	1993
16K	16Kx1	0	0	0.1	0.4	0.9	0.9	0.7
16K	4Kx4	0	0	0.1	0.4	1.1	2.0	2.0
16K	2Kx8	0	0	0	0	0	0.1	0.2
64K	64Kx1	0.1	0.9	1.2	1.8	2.2	2.5	2.5
64K	16Kx4	0.1	0.7	2.3	3.7	5.6	7.9	9.6
64K	8Kx8/9	0	0	0	0	0.2	0.6	0.9
256K	256Kx1	0	0.2	1.2	2.8	4.6	5.5	6.5
256K	64Kx4	0	0	0.3	1.2	3.2	6.5	10.5
256K	32Kx8/9	0	0	0	0	0.2	1.0	2.1
1Mb	1Mx1	0	0	0	0	0.3	1.4	3.0
1Mb	256Kx4	0	0	0	0	0	0.5	2.4
1Mb	128Kx8/9	0	0	0	0	0	0.1	0.6
4Mb	4Mx1	0	0	0	0	0	0	0
4Mb	1Mx4	0	0	0	0	0	0	0
4Mb	512Kx8/9	0	0	0	0	0	0	0
Total		0.1	1.7	5.2	10.3	18.3	29.0	41.0

(Continued)

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Table 5 (Continued)

Worldwide BiCMOS ECL I/O SRAM Forecast

		Average Selling Price (Dollars/Units)						
		1987	1988	1989	1990	1991	1992	1993
16K	16Kx1	$16.85	$ 11.83	$ 9.72	$ 8.57	$ 7.34	$ 6.98	$ 6.72
16K	4Kx4	N/A	$ 18.20	$14.51	$ 12.42	$ 10.20	$ 9.31	$ 8.62
16K	2Kx8	N/A	N/A	N/A	N/A	$ 14.28	$12.85	$ 11.64
64K	64Kx1	$44.90	$ 29.00	$23.40	$ 16.24	$ 13.25	$10.59	$ 9.82
64K	16Kx4	$64.14	$ 39.17	$30.79	$ 20.82	$ 16.36	$12.91	$ 11.83
64K	8Kx8/9	N/A	N/A	N/A	N/A	$ 22.90	$17.43	$ 15.38
256K	256Kx1	N/A	$ 92.68	$57.78	$ 29.97	$ 19.16	$16.33	$ 14.42
256K	64Kx4	N/A	$115.85	$88.89	$ 44.73	$ 27.37	$22.68	$ 19.22
256K	32Kx8/9	N/A	N/A	N/A	$ 64.86	$ 38.32	$30.62	$ 24.99
1Mb	1Mx1	N/A	N/A	N/A	$165.00	$ 80.00	$44.38	$ 29.94
1Mb	245Kx4	N/A	N/A	N/A	$190.00	$110.00	$59.17	$ 37.43
1Mb	128Kx8/9	N/A	N/A	N/A	N/A	$154.00	$82.84	$ 50.53
4Mb	4Mx1	N/A	N/A	N/A	N/A	N/A	N/A	$175.00
4Mb	1Mx4	N/A	N/A	N/A	N/A	N/A	N/A	$200.00
4Mb	512Kx8/9	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Overall ASP		$50.57	$ 39.48	$37.92	$ 24.91	$ 19.26	$18.38	$ 18.07

N/A = Not Available

Source: Dataquest
October 1989

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Table 6

Worldwide Fast SRAM Forecast

Revenue (Millions of Dollars)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	$ 16	$ 11	$ 5	0	0	0	0	0
4K (4Kx1)	27	26	18	$ 13	$ 7	$ 4	$ 3	$ 2
4K (1Kx4)	12	12	9	6	3	2	2	1
16K (16Kx1)	58	49	37	29	24	22	18	13
16K (4Kx4)	73	76	83	79	68	66	68	61
16K (2Kx8)	36	41	53	54	46	43	40	37
64K (64Kx1)	62	87	143	154	129	112	102	92
64K (16Kx4)	22	45	108	198	203	202	203	209
64K (8Kx8/9)	23	50	93	118	109	102	97	98
256K (256Kx1)	0	6	60	146	173	181	207	232
256K (64Kx4)	0	8	68	144	204	258	375	487
256K (32Kx8/9)	0	3	20	94	122	136	199	259
1Mb (1Mx1)	0	0	0	2	19	48	133	266
1Mb (256Kx4)	0	0	0	4	29	58	143	392
1Mb (128Kx8/9)	0	0	0	3	22	52	121	306
4Mb (4Mx1)	0	0	0	0	0	0	4	11
4Mb (1Mx4)	0	0	0	0	0	0	5	24
4Mb (512Kx8/9)	0	0	0	0	0	0	6	15
Total	$330	$414	$698	$1,044	$1,159	$1,287	$1,725	$2,506
Percent Change from Previous Year		25.8%	68.4%	49.5%	11.0%	11.1%	34.1%	45.2%

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	5.0	3.5	1.5	0	0	0	0	0
4K (4Kx1)	9.7	9.1	6.4	4.4	2.5	1.4	0.9	0.6
4K (1Kx4)	4.2	3.9	3.1	2.0	1.1	0.6	0.5	0.3
16K (16Kx1)	17.1	15.6	10.9	8.4	6.9	5.9	4.6	3.4
16K (4Kx4)	20.4	22.6	23.6	21.4	19.2	17.3	16.3	14.6
16K (2Kx8)	7.8	10.4	13.6	14.0	13.0	11.9	10.7	9.6
64K (64Kx1)	4.7	11.1	17.8	22.4	22.6	21.8	20.3	18.1
64K (16Kx4)	1.6	5.1	11.4	21.8	27.7	30.0	30.7	30.6
64K (8Kx8/9)	1.4	5.3	10.6	15.9	18.6	19.3	18.4	18.0
256K (256Kx1)	0	0.1	1.5	4.8	10.4	16.3	21.4	25.5
256K (64Kx4)	0	0.2	1.8	5.3	12.7	23.0	35.3	47.5

(Continued)

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Table 6 (Continued)

Worldwide Fast SRAM Forecast

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
256K (32Kx8/9)	0	0	0.5	3.4	8.0	13.2	19.8	26.1
1Mb (1Mx1)	0	0	0	0	0.2	1.0	4.8	13.2
1Mb (256Kx4)	0	0	0	0	0.3	1.4	5.5	18.6
1Mb (128Kx8/9)	0	0	0	0	0.2	1.1	4.5	13.8
4Mb (4Mx1)	0	0	0	0	0	0	0	0.1
4Mb (1Mx4)	0	0	0	0	0	0	0	0.3
4Mb (512Kx8/9)	0	0	0	0	0	0	0	0.2
Total	71.9	86.9	102.7	123.8	143.4	164.2	193.8	240.5

Average Selling Price (Dollars/Units)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	$ 3.16	$ 3.27	$ 3.40	0	0	0	0	0
4K (4Kx1)	$ 2.80	$ 2.86	$ 2.86	$ 2.87	$ 2.90	$ 2.95	$ 3.00	$ 3.12
4K (1Kx4)	$ 2.91	$ 2.98	$ 2.98	$ 3.01	$ 3.05	$ 3.10	$ 3.15	$ 3.23
16K (16Kx1)	$ 3.41	$ 3.13	$ 3.37	$ 3.48	$ 3.44	$ 3.80	$ 3.96	$ 3.96
16K (4Kx4)	$ 3.59	$ 3.36	$ 3.52	$ 3.68	$ 3.54	$ 3.81	$ 4.15	$ 4.16
16K (2Kx8)	$ 4.56	$ 3.95	$ 3.87	$ 3.89	$ 3.56	$ 3.64	$ 3.74	$ 3.83
64K (64Kx1)	$13.10	$ 7.85	$ 8.04	$ 6.87	$ 5.72	$ 5.13	$ 5.03	$ 5.11
64K (16Kx4)	$13.92	$ 8.85	$ 9.50	$ 9.08	$ 7.32	$ 6.73	$ 6.60	$ 6.82
64K (8Kx8/9)	$16.76	$ 9.46	$ 8.77	$ 7.43	$ 5.87	$ 5.29	$ 5.27	$ 5.46
256K (256Kx1)	N/A	$45.06	$39.88	$ 30.32	$ 16.66	$11.08	$ 9.69	$ 9.09
256K (64Kx4)	$75.00	$50.92	$37.73	$ 27.20	$ 16.04	$11.23	$ 10.63	$10.25
256K (32Kx8/9)	$85.00	$60.59	$43.92	$ 27.73	$ 15.29	$10.34	$ 10.03	$ 9.94
1Mb (1Mx1)	N/A	N/A	N/A	$187.00	$ 94.36	$48.01	$ 27.71	$20.15
1Mb (256Kx4)	N/A	N/A	N/A	$215.00	$ 95.94	$41.47	$ 26.03	$21.07
1Mb (128Kx8/9)	N/A	N/A	N/A	$258.00	$109.25	$47.06	$ 26.94	$22.18
4Mb (4Mx1)	N/A	N/A	N/A	N/A	N/A	N/A	$136.00	$94.53
4Mb (1Mx4)	N/A	N/A	N/A	N/A	N/A	N/A	$160.00	$87.40
4Mb (512Kx8/9)	N/A	N/A	N/A	N/A	N/A	N/A	$192.00	$96.75
Overall ASP	$ 4.58	$ 4.77	$ 6.80	$ 8.43	$ 8.08	$ 7.84	$ 8.90	$10.42

N/A = Not Available
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
October 1989

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Table 7

Worldwide Slow SRAM Forecast

Revenue (Millions of Dollars)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	$ 3	$ 2	0	0	0	0	0	0
4K (4Kx1)	3	2	0	0	0	0	0	0
4K (1Kx4)	21	12	4	0	0	0	0	0
8K (1Kx8)	0	0	0	0	0	0	0	0
16K (2Kx8)	131	135	$ 368	$ 372	$ 191	$ 132	$ 79	$ 51
64K (8Kx8)	188	292	499	570	452	316	266	226
256K (32Kx8)	111	307	667	1,031	1,209	1,050	942	851
1Mb (All Orgs.)	0	0	30	223	310	777	1,540	2,151
1Mb PSRAM	0	8	47	86	121	188	235	156
4Mb (All Orgs.)	0	0	0	0	0	13	135	513
4Mb PSRAM	0	0	0	0	27	70	86	193
Total	$457	$759	$1,615	$2,282	$2,309	$2,544	$3,283	$4,139
Percent Change from Previous Year		65.8%	112.9%	41.3%	1.2%	10.2%	29.0%	26.1%

Units (Millions)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	1.0	0.6	0.1	0	0	0	0	0
4K (4Kx1)	1.3	0.9	0.1	0	0	0	0	0
4K (1Kx4)	12.4	6.6	2.2	0.2	0	0	0	0
8K (1Kx8)	0	0	0	0	0	0	0	0
16K (2Kx8)	108.1	102.1	154.7	159.5	93.0	58.0	32.0	19.0
64K (8Kx8)	99.0	144.7	164.6	161.0	142.1	115.2	96.0	80.0
256K (32Kx8)	6.2	46.6	89.0	127.9	181.0	216.0	227.0	210.0
1Mb (All Orgs.)	0	0	0.1	2.0	8.6	40.9	110.0	187.0
1Mb PSRAM	0	0.3	2.0	4.7	10.0	25.0	42.0	30.0
4Mb (All Orgs.)	0	0	0	0	0	0.1	1.5	9.0
4Mb PSRAM	0	0	0	0	0.5	2.0	4.5	11.0
Total	228.0	301.8	412.8	455.3	435.2	457.2	513.0	546.0

Average Selling Price (Dollars/Units)

	1986	1987	1988	1989	1990	1991	1992	1993
1K (All Orgs.)	$ 3.36	$ 3.41	$ 3.50	0	0	0	0	0
4K (4Kx1)	$ 2.25	$ 2.50	$ 2.55	0	0	0	0	0
4K (1Kx4)	$ 1.69	$ 1.85	$ 2.04	$ 2.10	0	0	0	0
8K (1Kx8)	0	0	0	0	0	0	0	0

(Continued)

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Table 7 (Continued)

Worldwide Slow SRAM Forecast

	Average Selling Price (Dollars/Units)							
	1986	1987	1988	1989	1990	1991	1992	1993
16K (2Kx8)	$ 1.21	$ 1.32	$ 2.38	$ 2.33	$ 2.05	$ 2.27	$ 2.47	$ 2.67
64K (8Kx8)	$ 1.90	$ 2.02	$ 3.03	$ 3.54	$ 3.18	$ 2.74	$ 2.77	$ 2.82
256K (32Kx8)	$17.96	$ 6.59	$ 7.49	$ 8.06	$ 6.68	$ 4.86	$ 4.15	$ 4.05
1Mb (All Orgs.)	N/A	N/A	$298.17	$111.50	$36.00	$ 19.00	$14.00	$11.50
1Mb PSRAM	N/A	$26.86	$ 23.25	$ 18.40	$12.10	$ 7.50	$ 5.60	$ 5.20
4Mb (All Orgs.)	N/A	N/A	N/A	N/A	N/A	$250.00	$90.00	$57.00
4Mb PSRAM	N/A	N/A	N/A	N/A	$53.00	$ 35.00	$19.00	$17.50
Overall ASP	$ 2.01	$ 2.51	$ 3.91	$ 5.01	$ 5.30	$ 5.57	$ 6.40	$ 7.58

N/A = Not Available
Note: Columns may not add to totals shown because of rounding. The 1Mb and 4Mb pseudostatic RAMs are separated: they are combined with standard RAMs at the 64K and 256K densities.

Source: Dataquest
October 1989

Comparison with Earlier Forecasts

The major difference between the current SRAM forecast and the one previously published is the strength of the 1989 market. This fact is especially true for the slow SRAM market. At present, Dataquest forecasts the growth of 1989 over 1988 to be 43.8 percent; in our earlier forecast, we estimated the growth to be 5.9 percent. This large difference is due to the continued DRAM shortage and the delay of the market slowdown from a predicted start of early 1989 to the second half of 1989.

This DRAM shortage plagued the SRAM market throughout 1988 and into the first half of 1989. Because production capacity and engineering resources were being focused on 1Mb DRAM production, SRAMs were unable to meet the market demand, resulting in a shortage of supply and higher prices.

In early 1988, Dataquest forecast that the market slowdown would occur in the first half of 1989. However, due to the overall health of the economy and the strong demand for memories as a result of the previous quarters of shortage the SRAM market, slowdown did not start until the second half of 1989. Because of the continued demand and relatively high prices, the MOS memory market as a whole should maintain a robust growth through 1989, while other semiconductor products may not perform nearly as well.

From a product standpoint, some important differences between our current and previous forecasts need to be noted. We have added a new product category to our current forecast and adjusted the magnitude of two key developing trends.

In previous forecasts we included the BiCMOS ECL I/O level product with the bipolar ECL I/O product because they function with the same I/O interface levels. However, because BiCMOS is an outgrowth of a MOS process and BiCMOS TTL I/O was counted under the MOS memory

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forecast, we decided to combine all of BiCMOS into the MOS forecast. In the short term, this change had only a minor impact on the fast SRAM forecast; the effects become apparent in the forecast for 1991 and beyond.

Magnitude adjustments to the forecast were made to the 16K slow SRAM and to the 1Mb pseudostatic RAM. The 16K slow SRAM market went through severe changes in both demand and supply during the second half of 1988 and the first half of 1989. From the demand side, a number of new applications for the 2Kx8 devices were introduced late in the product's life cycle. Compact disc players, video games, point-of-sale (POS) cash registers, disk drives, and even personal computers all started to use the 2Kx8 in volume production. During this time, the traditional suppliers of the 2Kx8 were de-emphasizing the device to make way for newer generations of memories. The increased demand resulted in a second peak in the product's unit life cycle, and the short supply resulted in very high selling prices.

The 1Mb pseudostatic RAM (PSRAM) introduced by Hitachi and Toshiba had a stronger-than-anticipated presence in 1988. Traditionally the PSRAM, which is based on DRAM core technology, appears later in the slow SRAM's life cycle. However, because 1Mb PSRAMs are used in laptop computers as main memory, and fax machines and printers as buffers, the 1Mb was introduced and ramped into production much earlier than in previous generations. For increased detail of this phenomenon we separated the 1Mb and 4Mb PSRAM product lines in the slow SRAM forecast.

Short-Term Outlook

Dataquest forecasts a slight downturn in the SRAM market from the third quarter of 1989 through the second quarter of 1990. During the second half of 1990, we expect the market to pull out of its slump and return to more traditional growth trends. We believe the slowdown will be minor compared with the 1985 recession because the market is in a better state of control than in 1985, there is improved communication between vendors and OEMs, users have better control over inventories, and manufacturing capacity is not growing at unreasonable rates. From our present view, there appears to be a slight buildup in capacity and inventory levels, but not to the degree of misalignment that occurred in 1985. The SRAM market is expected to grow 4.2 percent in 1990 over 1989.

For the fast SRAM market in the short term, applications will continue to develop in more commodity-oriented products. Caches made from high-speed SRAM will become almost a necessity in the workstation market and will develop as a desired feature for PCs. BiCMOS will begin to be more widely used because of its ability to offer faster speeds at more conservative line geometries and its capability of operating at both ECL and TTL I/O levels. In the slow SRAM market, the 1Mb will begin its production ramp and the 4Mb will start to be sampled. For both slow and fast SRAMs, surface-mount packaging will become increasingly critical to help reduce the size of end products, to increase the number of memories that can be packed on a board, and to improve system speed.

Long-Term Outlook

As mentioned earlier, Dataquest expects 1993 to be the next boom market, which will result in increased sales for both types of SRAMs. Also, due to the increased demand, a possible shortage may develop resulting in higher ASPs. Although we believe that these factors will prevail

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in 1993, Dataquest still anticipates a conservative boom scenario, albeit with market growth less than that of the 1988 boom year. We also speculate that 1994 will be a recovery year and revenue growth will be flat to slightly down.

During the next three to five years, Dataquest expects the products to experience an evolutionary change. We foresee emitter-coupled logic (ECL) interface levels becoming more important as systems push for faster speeds. A number of standard microprocessor and RISC processor manufacturers are planning ECL I/O versions of their products to increase speed and drive capabilities. As mentioned previously, BiCMOS will be in a unique position to take advantage of this development with its ability to operate in both interface worlds. TTL I/O device also will start migrating toward the 3.3V power supply to avoid problems associated with high-power and smaller line geometries. We have seen a few overtures in this direction already; however, it is not expected to become a standard until the 4Mb level.

Dataquest believes that the development of specialty and custom memories is a trend that will blossom during the next few years. As it becomes increasingly difficult to achieve faster system speed through pushing for smaller-line geometries, system architects and chip designers will have to combine their talents to improve overall system speed. It will be too expensive to force speed through simple reduction—especially when reducing feature sizes below 0.8 micron; alternatives such as improved integration will have to used. Bringing the cache on-chip for microprocessors is an example of movement in this direction; we expect this trend to continue as the drive for faster and less expensive systems persists.

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MOS SRAM--Forecast

OVERVIEW OF THE MOS STATIC RAM MARKET

MOS static RAMs (SRAMs) are playing an increasingly important role in the memory market. Because of improvements in their price-to-performance ratio and their ease of use, they are becoming a threat to some applications that traditionally have belonged to DRAMs. Many companies have turned to SRAMs as a vehicle to prove the feasibility of new processes and packaging. The high performance requirements and the reasonable profit margins of high-speed SRAMs make them an ideal process driver, especially for ASIC manufacturers.

SRAMs can be divided into two distinct markets: slow SRAMs, including parts above a 70ns access time; and fast SRAMs, consisting of those at and below a 70ns access time. These must be treated as different markets because of the differences in end uses and design. The slow SRAMs are designed for volume production and for use in a wide variety of low-cost applications. The fast SRAMs, on the other hand, are driven by speed, and are used in applications where performance is crucial, but cost sensitivity is minimal.

This section reviews the dynamics of the SRAM market through the following topics:

- Historical growth
- Market forecast and the factors driving future growth
- Comparison with earlier forecasts
- Short-term outlook
- Long-term outlook

Historical Growth

- For 1987, the MOS static RAM market reached $1.14 billion. SRAMs represented 19.4 percent of the total MOS memory market in that year.
- Total SRAM revenue grew at a compound annual growth rate (CAGR) of 17.4 percent from 1982 to 1987. This growth slightly exceeded that of the total MOS memory market, which had a 15.6 percent CAGR during the same period.
- The slow SRAM market revenue reflected a 12.7 percent CAGR from 1982 through 1987, and the fast SRAM revenue CAGR was 29.4 percent. The fast SRAM growth was due mainly to the development and maturing of its market. During this period, three very popular fast SRAM densities were introduced, along with speed improvements on the existing SRAMs.

Figure 1 shows the MOS SRAM revenue growth in comparison to the total MOS memory market. Figure 2 depicts the revenue of the fast and slow SRAMs since 1977.

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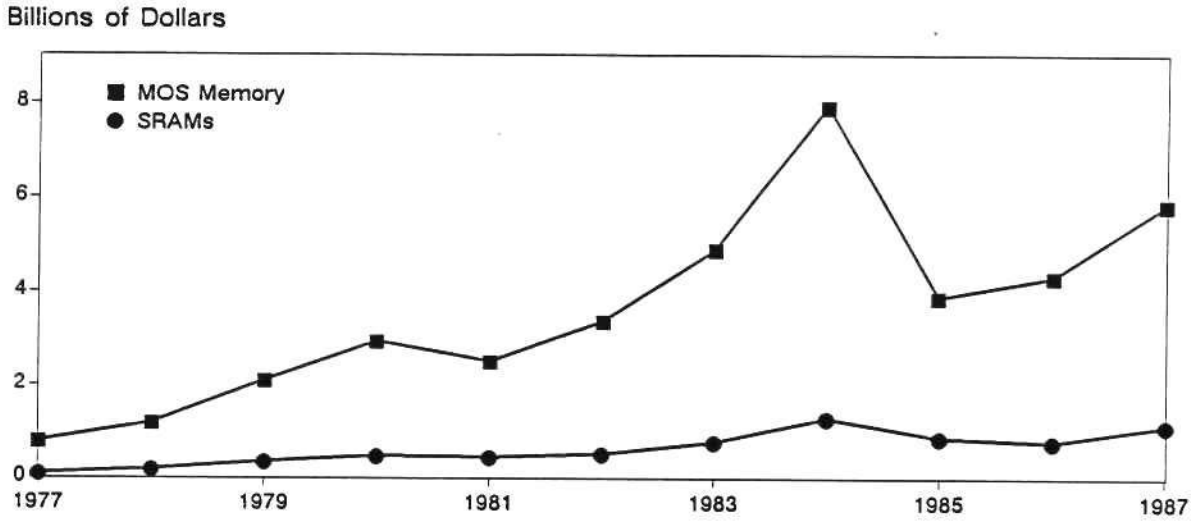
Figure 1

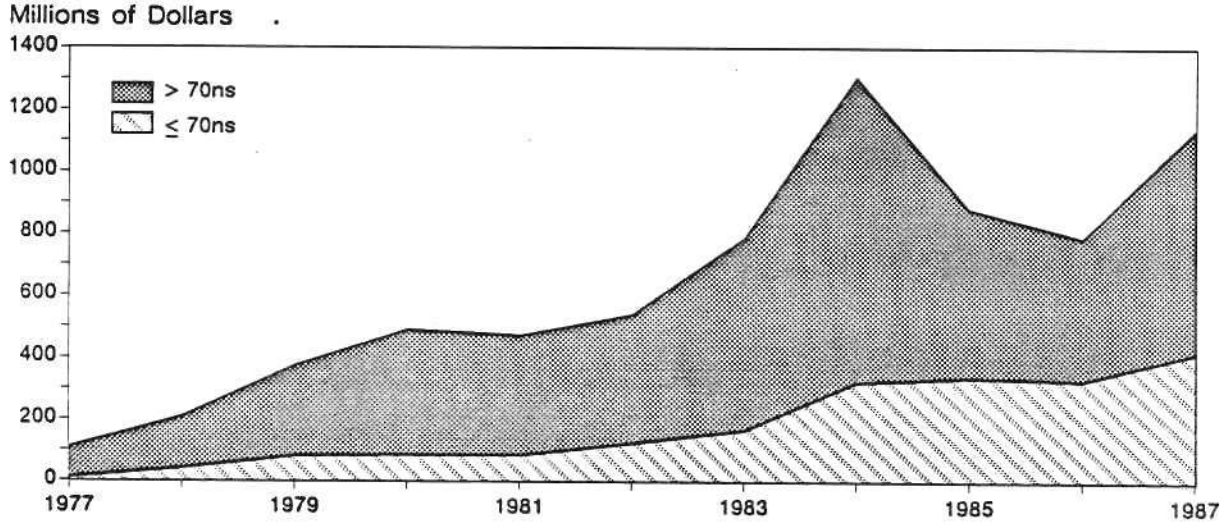
Estimated MOS Memory and SRAM Market Growth
1977–1987



Source: Dataquest
July 1988

Figure 2

Estimated MOS SRAM Market Growth
1977–1987



Source: Dataquest
July 1988

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MOS SRAM--Forecast

The MOS SRAM Market Forecast

Dataquest presents the MOS SRAM forecast from 1987 to 1992 in the following tables:

- Table 1 — Worldwide MOS SRAM Market Forecast (Revenue, Units, and Average Selling Prices)
- Table 2 — Worldwide NMOS SRAM Market Forecast (Revenue, Units, and Average Selling Prices)
- Table 3 — Worldwide CMOS SRAM Market Forecast (Revenue, Units, and Average Selling Prices)
- Table 4 — Worldwide Fast SRAM Market Forecast (Revenue, Units, and Average Selling Prices)
- Table 5 — Worldwide Slow SRAM Market Forecast (Revenue, Units, and Average Selling Prices)

In 1987, the MOS SRAM market recovered from the 1986 slowdown, and Dataquest is forecasting that growth in this market should continue for the next five years. The expansion is driven by reduced price erosion, introduction of larger densities, faster access times, and new applications. The key elements of the forecast are:

- The growth in the MOS SRAM market is expected to climb from $1.14 billion in 1987 to $2.82 billion in 1992. The slow SRAMs will constitute 65.4 percent of the total revenue in 1992, up slightly from 63.4 percent in 1987.
- The weakening of the U.S. dollar against the Japanese yen, coupled with the concern over profitability brought on the U.S./Japanese trade agreement, will keep average selling prices (ASPs) from eroding as quickly as they have in the past.
- Dataquest is expecting a slowdown in the unit growth rates of some key electronic equipment markets, which will affect the amount of SRAM consumed. As an example, between 1982 and 1986 the personal computer market had a CAGR of 33 percent and the business computer market had a CAGR of 23 percent. However, the expected CAGR for both personal computers and business computers between 1987 and 1992 is only 10 percent. The slower growth is due to the large established base already existing. Slow SRAMs are used in personal computer disk controllers, and both fast and slow SRAMs are used in business computers. Therefore, this slowdown in computer market growth probably will have a negative effect on SRAM development.

MOS SRAM—Forecast

- A large portion of the 1988 total MOS SRAM revenue growth will be due to the slight increase of the 256K slow SRAM ASP. This absence of the usual price erosion is a result of a product shortage. Supply of the 256K slow SRAMs did not meet the demand, because manufacturing capacity is being transferred to the ramping of the 1Mb DRAM.

- Slow SRAMs have a revenue CAGR from 1987 to 1992 of 20.6 percent, which is slightly greater than the fast SRAMs' 18.5 percent CAGR. The growth in the slow SRAM market is primarily due to the ramp and maturation of the 256K and the introduction and development of the 1Mb SRAM.

- Dataquest is predicting a slight downturn in the total semiconductor market in the second half of 1989. This forecast is based on projections of historical industry trends. The downturn probably will affect ASPs more than it will affect unit shipments.

- The unit life cycle of the 256K slow SRAM should peak in 1991. This peak is expected a year after the price-per-bit crossover with the 1Mb slow SRAM. The 64K fast SRAM's unit life cycle should peak in 1990, which probably will coincide with the early production of 15ns 256K fast SRAMs. If 15ns 256K SRAMs are delayed, the peak of the 64K SRAM may also be delayed.

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MOS SRAM--Forecast

Table 1

Worldwide MOS SRAM Market Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (Fast)	$ 16	$ 16	$ 11	$ 5	0	0	0	0
1K (Slow)	6	3	2	0	0	0	0	0
4K (Fast)	58	39	30	17	$ 12	$ 9	$ 6	$ 4
4K (Slow)	39	24	14	6	2	0	0	0
8K (Slow)	3	0	0	0	0	0	0	0
16K (Fast)	203	167	172	166	142	123	111	100
16K (Slow)	232	131	129	130	75	54	42	34
64K (Fast)	65	107	184	325	297	282	256	221
64K (Slow)	258	188	278	428	350	279	258	219
256K (Fast)	0	0	20	88	190	289	360	416
256K (Slow)	5	111	299	505	619	660	658	585
1Mb (Fast)	0	0	0	0	4	37	106	235
1Mb (Slow)	0	0	0	28	107	186	523	851
4Mb (Slow)	0	0	0	0	0	0	6	154
Total	$884	$787	$1,140	$1,698	$1,798	$1,919	$2,326	$2,818
Percent Change from Previous Year		(11.0%)	44.8%	49.0%	5.9%	6.7%	21.2%	21.2%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (Fast)	5.4	5.0	3.5	1.5	0	0	0	0
1K (Slow)	2.0	1.0	0.6	0.1	0	0	0	0
4K (Fast)	20.1	13.9	10.4	5.9	4.0	2.9	2.0	1.4
4K (Slow)	23.0	13.7	7.4	3.0	1.0	0	0	0
8K (Slow)	1.0	0	0	0	0	0	0	0
16K (Fast)	40.1	45.3	50.5	49.0	43.5	37.3	32.6	29.3
16K (Slow)	144.9	108.1	97.4	81.5	55.1	40.1	29.0	21.9
64K (Fast)	2.2	7.7	22.4	45.0	53.6	58.5	55.5	50.7
64K (Slow)	59.0	99.0	139.1	168.7	159.1	133.0	108.8	86.4
256K (Fast)	0	0	0.4	2.6	9.6	26.1	44.5	61.1
256K (Slow)	0.1	6.2	45.3	73.4	115.2	164.3	176.5	162.0
1Mb (Fast)	0	0	0	0	0.05	0.7	3.2	12.3
1Mb (Slow)	0	0	0	0.5	4.3	18.2	72.7	144.2
4Mb (Slow)	0	0	0	0	0	0	0.1	5.7
Total	297.7	299.9	377.0	431.2	445.5	481.1	524.9	575.0

(Continued)

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Table 1 (Continued)

Worldwide MOS SRAM Market Forecast

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (Fast)	$ 3.02	$ 3.16	$ 3.27	$ 3.40	0	0	0	0
1K (Slow)	$ 3.13	$ 3.36	$ 3.41	$ 3.50	0	0	0	0
4K (Fast)	$ 2.89	$ 2.84	$ 2.90	$ 2.89	$ 2.91	$ 2.94	$ 2.99	$ 3.04
4K (Slow)	$ 1.68	$ 1.74	$ 1.93	$ 2.04	$ 2.10	0	0	0
8K (Slow)	$ 2.75	0	0	0	0	0	0	0
16K (Fast)	$ 5.05	$ 3.69	$ 3.42	$ 3.38	$ 3.27	$ 3.29	$ 3.40	$ 3.42
16K (Slow)	$ 1.60	$ 1.21	$ 1.32	$ 1.59	$ 1.37	$ 1.35	$ 1.45	$ 1.54
64K (Fast)	$29.99	$13.94	$ 8.22	$ 7.21	$ 5.55	$ 4.82	$ 4.60	$ 4.35
64K (Slow)	$ 4.37	$ 1.90	$ 2.00	$ 2.54	$ 2.20	$ 2.10	$ 2.37	$ 2.53
256K (Fast)	N/A	$78.75	$50.06	$33.67	$19.79	$11.09	$ 8.10	$ 6.81
256K (Slow)	$46.00	$17.96	$ 6.60	$ 6.88	$ 5.37	$ 4.02	$ 3.73	$ 3.61
1Mb (Fast)	N/A	N/A	N/A	N/A	$82.95	$52.49	$33.26	$19.13
1Mb (Slow)	N/A	N/A	N/A	$56.29	$24.81	$10.22	$ 7.20	$ 5.90
4Mb (Slow)	N/A	N/A	N/A	N/A	N/A	N/A	$55.00	$27.00
Overall ASP	$ 2.97	$ 2.62	$ 3.02	$ 3.94	$ 4.04	$ 3.99	$ 4.43	$ 4.90

N/A = Not Available

Source: Dataquest
July 1988

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MOS SRAM--Forecast

Table 2

Worldwide NMOS SRAM Market Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Types)	$ 8	$ 5	$ 3	$ 2	0	0	0	0
4K (Fast, 4Kx1)	35	25	19	11	$ 7	$ 5	$ 4	$ 2
4K (Fast, 1Kx4)	20	12	9	5	3	2	1	1
4K (Slow, 4Kx1)	2	1	1	1	0	0	0	0
4K (Slow, 1Kx4)	14	11	7	3	0	0	0	0
8K (Slow, 1Kx8)	3	0	0	0	0	0	0	0
16K (Fast, 16Kx1)	52	23	16	12	7	3	1	1
16K (Fast, 4Kx4)	66	31	22	15	12	9	6	3
16K (Fast, 2Kx8)	19	18	21	21	15	10	7	5
16K (Slow, 2Kx8)	83	41	38	36	13	5	1	0
64K (Slow, 8Kx8)	9	8	14	14	6	3	1	0
64K (Fast, All Orgs)	13	4	3	2	1	0	0	0
Total	$324	$180	$154	$121	$64	$36	$21	$13
Percent Change from Previous Year		(44.5%)	(14.3%)	(21.4%)	(47.4%)	(43.5%)	(40.9%)	(39.0%)

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Types)	3.0	2.0	1.2	0.6	0	0	0	0
4K (Fast, 4Kx1)	12.4	8.9	6.8	3.7	2.5	1.8	1.2	0.8
4K (Fast, 1Kx4)	6.6	4.0	3.0	1.6	0.9	0.6	0.4	0.3
4K (Slow, 4Kx1)	1.0	0.7	0.6	0.3	0	0	0	0
4K (Slow, 1Kx4)	12.0	8.5	5.0	2.0	0.1	0	0	0
8K (Slow, 1Kx8)	1.0	0	0	0	0	0	0	0
16K (Fast, 16Kx1)	10.7	6.6	5.3	4.0	2.5	1.0	0.5	0.5
16K (Fast, 4Kx4)	13.3	9.1	7.0	5.0	4.0	3.0	2.0	1.0
16K (Fast, 2Kx8)	3.0	4.2	5.5	6.0	4.5	3.0	2.0	1.5
16K (Slow, 2Kx8)	57.2	38.7	31.7	24.0	11.0	4.0	1.0	0
64K (Slow, 8Kx8)	2.3	4.5	7.6	6.0	3.0	1.5	0.5	0
64K (Fast, All Orgs)	0.4	0.3	0.5	0.3	0.2	0	0	0
Total	122.8	87.5	74.2	53.5	28.7	14.9	7.6	4.1

(Continued)

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Table 2 (Continued)

Worldwide NMOS SRAM Market Forecast

	Average Selling Price (Dollars/Units)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Types)	$ 2.60	$ 2.60	$2.60	$2.60	0	0	0	0
4K (Fast, 4Kx1)	$ 2.85	$ 2.80	$2.86	$2.86	$2.87	$2.90	$2.95	$3.00
4K (Fast, 1Kx4)	$ 2.96	$ 2.91	$2.98	$2.98	$3.01	$3.05	$3.10	$3.15
4K (Slow, 4Kx1)	$ 1.75	$ 1.78	$2.00	$2.25	0	0	0	0
4K (Slow, 1Kx4)	$ 1.20	$ 1.25	$1.40	$1.50	$2.10	0	0	0
8K (Slow, 1Kx8)	$ 2.75	0	0	0	0	0	0	0
16K (Fast, 16Kx1)	$ 4.90	$ 3.55	$3.00	$2.95	$2.78	$2.80	$2.84	$2.86
16K (Fast, 4Kx4)	$ 5.00	$ 3.40	$3.10	$3.05	$2.95	$2.98	$3.10	$3.11
16K (Fast, 2Kx8)	$ 6.15	$ 4.40	$3.80	$3.55	$3.25	$3.25	$3.40	$3.40
16K (Slow, 2Kx8)	$ 1.45	$ 1.07	$1.20	$1.50	$1.22	$1.15	$1.20	0
64K (Slow, 8Kx8)	$ 4.00	$ 1.80	$1.90	$2.40	$2.00	$1.90	$2.10	0
64K (Fast, All Orgs)	$37.00	$12.50	$6.75	$5.75	$4.10	0	0	0
Overall ASP	$ 2.64	$ 2.05	$2.08	$2.26	$2.22	$2.42	$2.82	$3.17

Source: Dataquest
July 1988

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Table 3

Worldwide CMOS SRAM Market Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Types)	$ 15	$ 14	$ 10	$ 4	0	0	0	0
4K (Fast)	3	3	2	2	$ 2	$ 1	$ 1	$ 1
4K (Slow)	23	12	6	2	0	0	0	0
16K (Fast, 16Kx1)	33	35	37	35	31	29	27	24
16K (Fast, 4Kx4)	25	42	56	52	44	39	36	35
16K (Fast, 2Kx8)	7	17	21	31	34	33	33	31
16K (Slow, 2Kx8)	149	89	91	94	62	50	41	34
64K (Fast, 64Kx1)	46	58	83	124	101	85	73	62
64K (Fast, 16Kx4)	4	22	47	96	102	106	98	87
64K (Fast, 8Kx8/9)	1	23	50	103	93	91	85	71
64K (Slow, 8Kx8)	249	180	264	414	344	276	257	219
256K (Fast, 256Kx1)	0	0	6	27	51	71	85	95
256K (Fast, 64Kx4)	0	0	10	37	78	120	157	183
256K (Fast, 32Kx8)	0	0	3	24	62	98	118	138
256K (Slow, 32Kx8)	5	111	299	505	619	660	658	585
1Mb (Fast, 1Mx1)	0	0	0	0	1	9	21	57
1Mb (Fast, 245Kx4)	0	0	0	0	2	16	45	90
1Mb (Fast, 128Kx8)	0	0	0	0	2	12	41	89
1Mb (Slow, All Orgs)	0	0	0	28	107	186	523	851
4Mb (Slow, All Orgs)	0	0	0	0	0	0	6	154
Total	$559	$607	$986	$1,577	$1,732	$1,883	$2,305	$2,805
Percent Change from Previous Year		8.5%	62.5%	60.0%	9.8%	8.7%	22.4%	21.7%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Types)	4.4	4.0	2.9	1.0	0	0	0	0
4K (Fast)	1.1	1.0	0.6	0.6	0.6	0.5	0.4	0.3
4K (Slow)	10.0	4.5	1.8	0.7	0	0	0	0
16K (Fast, 16Kx1)	7.5	10.5	11.5	10.8	9.9	9.4	8.6	7.6
16K (Fast, 4Kx4)	4.6	11.3	16.0	15.2	13.0	11.6	10.4	10.1
16K (Fast, 2Kx8)	1.0	3.6	5.2	8.0	9.6	9.3	9.2	8.6
16K (Slow, 2Kx8)	87.7	69.4	65.7	57.5	44.1	36.1	28.0	21.9
64K (Fast, 64Kx1)	1.6	4.4	11.0	18.9	20.2	19.3	17.2	15.2
64K (Fast, 16Kx4)	0.1	1.6	5.7	13.4	18.5	22.2	21.6	20.3
64K (Fast, 8Kx8/9)	0	1.4	5.2	12.4	14.7	17.0	16.7	15.2
64K (Slow, 8Kx8)	56.7	94.5	131.5	162.7	156.1	131.5	108.3	86.4
256K (Fast, 256Kx1)	0	0	0.1	0.9	2.9	7.3	11.7	15.3
256K (Fast, 64Kx4)	0	0	0.2	1.1	4.0	11.1	19.8	27.5
256K (Fast, 32Kx8)	0	0	0.1	0.6	2.7	7.7	13.0	18.3
256K (Slow, 32Kx8)	0.1	6.2	45.3	73.4	115.2	164.3	176.5	162.0
1Mb (Fast, 1Mx1)	0	0	0	0	0	0.2	0.7	3.3
1Mb (Fast, 245Kx4)	0	0	0	0	0	0.3	1.4	4.8
1Mb (Fast, 128Kx8)	0	0	0	0	0	0.2	1.1	4.2
1Mb (Slow, All Orgs)	0	0	0	1.0	4.3	18.2	72.7	144.2
4Mb (Slow, All Orgs)	0	0	0	0	0	0	0.1	5.7
Total	174.9	212.4	302.8	377.7	415.9	466.2	517.4	570.9

(Continued)

Table 3 (Continued)

Worldwide CMOS SRAM Market Forecast

	Average Selling Price (Dollars/Units)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Types)	$ 3.35	$ 3.49	$ 3.58	$ 3.89	0	0	0	0
4K (Fast)	$ 3.00	$ 2.86	$ 2.88	$ 2.88	$ 2.89	$ 2.93	$ 2.99	$ 3.05
4K (Slow)	$ 2.25	$ 2.67	$ 3.37	$ 3.51	0	0	0	0
16K (Fast, 16Kx1)	$ 4.40	$ 3.32	$ 3.22	$ 3.24	$ 3.09	$ 3.09	$ 3.18	$ 3.22
16K (Fast, 4Kx4)	$ 5.50	$ 3.74	$ 3.47	$ 3.40	$ 3.36	$ 3.36	$ 3.43	$ 3.43
16K (Fast, 2Kx8)	$ 6.90	$ 4.75	$ 4.11	$ 3.87	$ 3.59	$ 3.57	$ 3.65	$ 3.65
16K (Slow, 2Kx8)	$ 1.70	$ 1.29	$ 1.38	$ 1.63	$ 1.41	$ 1.37	$ 1.46	$ 1.54
64K (Fast, 64Kx1)	$28.00	$13.14	$ 7.55	$ 6.55	$ 5.02	$ 4.39	$ 4.22	$ 4.11
64K (Fast, 16Kx4)	$33.60	$13.92	$ 8.30	$ 7.20	$ 5.52	$ 4.78	$ 4.52	$ 4.27
64K (Fast, 8Kx8/9)	$37.80	$16.89	$ 9.67	$ 8.27	$ 6.32	$ 5.35	$ 5.11	$ 4.70
64K (Slow, 8Kx8)	$ 4.37	$ 1.90	$ 2.01	$ 2.55	$ 2.20	$ 2.10	$ 2.37	$ 2.53
256K (Fast, 256Kx1)	N/A	$85.00	$45.06	$29.93	$17.47	$ 9.77	$ 7.27	$ 6.22
256K (Fast, 64Kx4)	N/A	$75.00	$50.92	$33.52	$19.39	$10.85	$ 7.92	$ 6.66
256K (Fast, 32Kx8)	N/A	$85.00	$60.59	$39.55	$22.88	$12.69	$ 9.11	$ 7.53
256K (Slow, 32Kx8)	$46.00	$17.96	$ 6.60	$ 6.88	$ 5.37	$ 4.02	$ 3.73	$ 3.61
1Mb (Fast, 1Mx1)	N/A	N/A	N/A	N/A	$76.74	$46.30	$29.41	$17.17
1Mb (Fast, 245Kx4)	N/A	N/A	N/A	N/A	$88.25	$51.86	$32.35	$18.72
1Mb (Fast, 128Kx8)	N/A	N/A	N/A	N/A	$80.75	$59.64	$36.88	$21.15
1Mb (Slow, All Orgs)	N/A	N/A	N/A	$56.29	$24.81	$10.22	$ 7.20	$ 5.90
4Mb (Slow, All Orgs)	N/A	N/A	N/A	N/A	N/A	N/A	$55.00	$27.00
Overall ASP	$ 3.20	$ 2.86	$ 3.26	$ 4.18	$ 4.17	$ 4.04	$ 4.46	$ 4.91

N/A = Not Available

Source: Dataquest
July 1988

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Table 4

Worldwide Fast SRAM Market Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Orgs)	$ 16	$ 16	$ 11	$ 5	0	0	0	0
4K (4Kx1)	38	27	21	12	$ 9	$ 6	$ 4	$ 3
4K (1Kx4)	20	12	9	5	3	2	2	1
16K (16Kx1)	85	58	53	47	38	32	29	26
16K (4Kx4)	92	73	77	67	55	48	42	38
16K (2Kx8)	26	36	42	52	49	43	40	36
64K (64Kx1)	56	62	84	124	101	85	73	62
64K (16Kx4)	4	22	47	96	102	106	98	87
64K (8Kx8/9)	1	23	53	104	94	91	85	71
256K (256Kx1)	0	0	6	27	51	71	85	95
256K (64Kx4)	0	0	10	37	78	120	157	183
256K (32Kx8)	0	0	3	24	62	98	118	138
1Mb (1Mx1)	0	0	0	0	1	9	21	57
1Mb (245Kx4)	0	0	0	0	2	16	45	90
1Mb (128Kx8)	0	0	0	0	2	12	41	89
Total	$339	$330	$418	$600	$645	$739	$839	$976
Percent Change from Previous Year		(2.7%)	26.7%	43.8%	7.4%	14.6%	13.5%	16.4%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Orgs)	5.4	5.0	3.5	1.5	0	0	0	0
4K (4Kx1)	13.3	9.7	7.3	4.2	3.0	2.2	1.5	1.0
4K (1Kx4)	6.8	4.2	3.1	1.7	1.0	0.7	0.5	0.4
16K (16Kx1)	18.2	17.1	16.8	14.8	12.4	10.4	9.1	8.1
16K (4Kx4)	17.9	20.4	23.0	20.2	17.0	14.6	12.4	11.1
16K (2Kx8)	4.0	7.8	10.7	14.0	14.1	12.3	11.1	10.1
64K (64Kx1)	2.0	4.7	11.1	18.9	20.2	19.3	17.2	15.2
64K (16Kx4)	0.1	1.6	5.7	13.4	18.5	22.2	21.6	20.3
64K (8Kx8/9)	0	1.4	5.6	12.7	14.9	17.0	16.7	15.2
256K (256Kx1)	0	0	0.1	0.9	2.9	7.3	11.7	15.3
256K (64Kx4)	0	0	0.2	1.1	4.0	11.1	19.8	27.5
256K (32Kx8)	0	0	0.1	0.6	2.7	7.7	13.0	18.3
1Mb (1Mx1)	0	0	0	0	0	0.2	0.7	3.3
1Mb (245Kx4)	0	0	0	0	0	0.3	1.4	4.8
1Mb (128Kx8)	0	0	0	0	0	0.2	1.1	4.2
Total	67.7	71.9	87.2	104.0	110.8	125.5	137.8	154.8

(Continued)

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Table 4 (Continued)

Worldwide Fast SRAM Market Forecast

	Average Selling Price (Dollars/Units)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Orgs)	$ 3.02	$ 3.16	$ 3.27	$ 3.40	0	0	0	0
4K (4Kx1)	$ 2.86	$ 2.80	$ 2.86	$ 2.86	$ 2.87	$ 2.90	$ 2.95	$ 3.00
4K (1Kx4)	$ 2.96	$ 2.92	$ 2.98	$ 2.98	$ 3.01	$ 3.05	$ 3.10	$ 3.15
16K (16Kx1)	$ 4.69	$ 3.41	$ 3.15	$ 3.16	$ 3.03	$ 3.06	$ 3.16	$ 3.20
16K (4Kx4)	$ 5.13	$ 3.59	$ 3.36	$ 3.31	$ 3.26	$ 3.28	$ 3.38	$ 3.40
16K (2Kx8)	$ 6.34	$ 4.56	$ 3.95	$ 3.73	$ 3.48	$ 3.49	$ 3.61	$ 3.61
64K (64Kx1)	$28.29	$13.10	$ 7.55	$ 6.55	$ 5.02	$ 4.39	$ 4.22	$ 4.11
64K (16Kx4)	$33.60	$13.92	$ 8.30	$ 7.20	$ 5.52	$ 4.78	$ 4.52	$ 4.27
64K (8Kx8/9)	$37.80	$16.76	$ 9.46	$ 8.21	$ 6.29	$ 5.35	$ 5.11	$ 4.70
256K (256Kx1)	N/A	N/A	$45.06	$29.93	$17.47	$ 9.77	$ 7.27	$ 6.22
256K (64Kx4)	N/A	$75.00	$50.92	$33.52	$19.39	$10.85	$ 7.92	$ 6.66
256K (32Kx8)	N/A	$85.00	$60.59	$39.55	$22.88	$12.69	$ 9.11	$ 7.53
1Mb (1Mx1)	N/A	N/A	N/A	N/A	$68.44	$46.30	$29.41	$17.17
1Mb (245Kx4)	N/A	N/A	N/A	N/A	$78.71	$51.86	$32.35	$18.72
1Mb (128Kx8)	N/A	N/A	N/A	N/A	$94.45	$59.64	$36.88	$21.15
Overall ASP	$ 5.00	$ 4.58	$ 4.79	$ 5.77	$ 5.82	$ 5.89	$ 6.09	$ 6.31

N/A = Not Available

Source: Dataquest
July 1988

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MOS SRAM--Forecast

Table 5

Worldwide Slow SRAM Market Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Orgs)	$ 6	$ 3	$ 2	0	0	0	0	0
4K (4Kx1)	10	3	2	$ 1	0	0	0	0
4K (1Kx4)	29	21	12	5	$ 2	0	0	0
8K (1Kx8)	3	0	0	0	0	0	0	0
16K (2Kx8)	232	131	129	130	75	$ 54	$ 42	$ 34
64K (8Kx8)	258	188	278	428	350	279	258	219
256K (32Kx8)	5	111	299	505	619	660	658	585
1Mb (All Orgs)	0	0	0	28	107	186	523	851
4Mb (All Orgs)	0	0	0	0	0	0	6	154
Total	$542	$457	$722	$1,098	$1,153	$1,180	$1,487	$1,842
Percent Change from Previous Year		(15.6%)	57.8%	52.0%	5.0%	2.3%	26.0%	23.8%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Orgs)	2.0	1.0	0.6	0.1	0	0	0	0
4K (4Kx1)	4.5	1.3	0.9	0.4	0	0	0	0
4K (1Kx4)	18.5	12.4	6.5	2.6	1.0	0	0	0
8K (1Kx8)	1.0	0	0	0	0	0	0	0
16K (2Kx8)	144.9	108.1	97.4	81.5	55.1	40.1	29.0	21.9
64K (8Kx8)	59.0	99.0	139.1	168.7	159.1	133.0	108.8	86.4
256K (32Kx8)	0.1	6.2	45.3	73.4	115.2	164.3	176.5	162.0
1Mb (All Orgs)	0	0	0	0.5	4.3	18.2	72.7	144.2
4Mb (All Orgs)	0	0	0	0	0	0	0.1	5.7
Total	230.0	228.0	289.8	327.2	334.7	355.6	387.1	420.2

	Average Selling Price (Dollars/Units)							
	1985	1986	1987	1988	1989	1990	1991	1992
1K (All Orgs)	$ 3.13	$ 3.36	$ 3.41	$ 3.50	0	0	0	0
4K (4Kx1)	$ 2.14	$ 2.25	$ 2.50	$ 2.65	0	0	0	0
4K (1Kx4)	$ 1.57	$ 1.69	$ 1.85	$ 1.95	$ 2.10	0	0	0
8K (1Kx8)	$ 2.75	0	0	0	0	0	0	0
16K (2Kx8)	$ 1.60	$ 1.21	$ 1.32	$ 1.59	$ 1.37	$ 1.35	$ 1.45	$ 1.54
64K (8Kx8)	$ 4.37	$ 1.90	$ 2.00	$ 2.54	$ 2.20	$ 2.10	$ 2.37	$ 2.53
256K (32Kx8)	$46.00	$17.96	$ 6.60	$ 6.88	$ 5.37	$ 4.02	$ 3.73	$ 3.61
1Mb (All Orgs)	N/A	N/A	N/A	$56.29	$24.81	$10.22	$ 7.20	$ 5.90
4Mb (All Orgs)	N/A	N/A	N/A	N/A	N/A	N/A	$55.00	$27.00
Overall ASP	$ 2.36	$ 2.01	$ 2.49	$ 3.35	$ 3.44	$ 3.32	$ 3.84	$ 4.38

N/A = Not Available

Source: Dataquest
July 1988

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MOS SRAM--Forecast

Comparison with Earlier Forecasts

Dataquest has an optimistic outlook for the SRAM market and has increased the current forecast to reflect this. Revenue for 1987 finished the year 14 percent above the previous estimations. The growth has come from the slow SRAM area, where unforeseen demand for 2Kx8 and 8Kx8 brought revenue up by 31 percent over the last forecast. One of the reasons for the revival of the 2Kx8 was its use in compact disk players. In 1987 the fast SRAMs, on the other hand, had a decrease of 6 percent. The decline was mainly due to slower than expected introduction of the 256K SRAM.

This robust growth in the slow SRAM market is expected to extend into the following years. The continued demand of the 16K and 64K densities should result in longer life cycles that will contribute to the overall SRAM growth. Also, because of market factors resulting from the DRAM shortage and the trade issues, Dataquest foresees slow SRAM ASPs decreasing less rapidly than in past forecasts. These same issues, along with the high costs of working in submicron processes, are expected to have a similar effect on fast SRAM ASPs.

Some of the 1986 unit shipments have been revised after a reevaluation of the market and the performance of some suppliers. The greatest change was in the 16K fast SRAM market. The 4Kx4 and the 16Kx1 shipments were substantially lower, while the 2Kx8 performed above expectations. The lower unit shipments of the x1 and x4 were due to a greater than anticipated displacement by the 2Kx8, 64Kx1, 16Kx4, and specialty memories. The unit shipments of the slow SRAM were also changed slightly. The 4K shipments did not decline as quickly as was expected, and the 256K production was better than the manufacturers had forecasted. Both of these factors resulted in a stronger fourth quarter for slow SRAMs than Dataquest had previously foreseen.

The Short-Term Outlook

Dataquest expects the next couple of years to be characterized by slower price deterioration, maturation of existing products, introductions of new products, and the development of advanced processes.

- Through 1988, SRAM prices probably will remain high, especially for the 64K and 256K slow SRAMs. These high prices are a result of the shortage of SRAM manufacturing capacity, caused by the ramping of the 1-Megabit DRAM. In the middle of 1989, as the supply of DRAMs reaches parity with demand, production capacity probably will be transferred to SRAMs. Then the prices should once again resume their usual decline within the bounds of the U.S./Japanese trade agreement.

- Dataquest expects that in late 1989 prices will start to drop more quickly, as the forecasted slowdown in the electronics market reduces demand.

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MOS SRAM--Forecast

- During 1988 and into 1989, the 16K slow SRAM is expected to be in short supply as the major suppliers phase out the product and other suppliers ramp their production.

- The 1Mb slow SRAM will go into early production in 1989 while the fast 1Mb SRAM will start its production ramp next year.

- The specialty memory market should continue to grow and develop new applications, especially in the high-performance areas. These applications will become possible through the speed, integration, and cost benefits of new devices. These devices include dual port RAMs, memories that can be accessed from two directions simultaneously; FIFOs, first-in-first-out memories; color look-up tables, for color graphics terminals; and cache and cache tag RAMs, for use in work stations and high-end personal computers.

- Several BICMOS fast SRAMs will be introduced during the next two years. BICMOS will offer speed improvements over CMOS and lower power consumption than bipolar at the 64K and 256K densities at both the ECL and TTL I/O levels.

The Long-Term Outlook

Dataquest foresees long-term trends influencing SRAMs centering on evolution of the product and the growth of applications. Some of the key trends expected are:

- Specialty memories will most likely play a more important role in SRAM development. System designers probably will turn toward specialty memories as they look for ways to increase performance, reduce cost, shorten design time, differentiate their products, and reduce chip count. Further improvements in chip architectures and processes, will make it feasible to bring even more features onto the memory chips at reasonable prices, thus providing the means to meet expanding market needs.

- Dataquest expects BICMOS to play an influential role in the growth of the fast SRAM market. We believe that BICMOS will be a helpful tool to reach the required high speeds at densities of 256K and above.

- Dataquest also foresees growth in the ECL I/O market, as a result of BICMOS. BICMOS can offer system designers the speed and drive of ECL I/O without having to pay the power penalties associated with pure bipolar processes.

- Packaging will become a critical issue. As die sizes get larger and as every nanosecond becomes more crucial, innovative packaging techniques will have to be implemented. Silicon interconnect, waferscale integration, tap automated bonding, and chip on board, are some of the avenues being explored today.

MOS SRAM--Forecast

- As existing applications of SRAMs become more complex, and as they demand higher performance, they will consume increasing amounts of SRAM bits. Examples of some key areas of growth are: Laptop PCs using more slow SRAMs for main memory; graphics systems requiring increased numbers of fast SRAMs for real-time processing; computers with parallel architectures consuming additional fast SRAMs for multiple caches; and portable electronic equipment that utilizes growing amounts of low-power slow SRAMs for battery-operated memory.

- Dataquest sees new applications emerging that will also drive the growth of the SRAM market. As examples, neural networks and speech recognition systems will require large quantities of SRAM memory to store and manipulate massive amounts of data as they try to mimic human functions. Also, as the automotive industry incorporates more complex electronic features into its designs, such as electronic rode maps and trip computers, it will consume increasing numbers of SRAMs.

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MOS SRAM--Forecast

OVERVIEW OF THE MOS STATIC RAM MARKET

The MOS static RAM (SRAM) market has gained prominence in recent years. Traditionally, the dynamic RAM (DRAM) has been the preferred memory device because of its low cost and high density. However, MOS static RAMs have spurred the growth of CMOS memories, sub-100ns access times, and surface-mount packages, leading to a healthy expansion of the MOS SRAM market.

The MOS SRAM market is divided into two distinct parts: the fast SRAM market and the slow SRAM market. Dataquest defines fast access time as being 70ns and faster, while slow access time is defined as speeds slower than 70ns. With the advances in submicron technology, access times are increasing in such a way that the next forecast may necessitate a third very fast SRAM category for devices at 35ns and faster.

- In 1986, the MOS static RAM market achieved total revenue of $803 million, which translates to 18 percent of the MOS memory market.

- This market grew at a compound annual growth rate (CAGR) of 8.5 percent from 1980 to 1986 versus a MOS memory CAGR of 10.3 percent. The MOS SRAM market is actually more attractive, hitting $1.2 billion in 1984; however, it has declined recently due to severe price pressures.

- The phenomenal market expansion for fast SRAMs and the increased density of slow SRAMs have fueled the growth of this market. Fast SRAM revenue grew at a CAGR of 26.5 percent. The contribution of slow SRAMs to total MOS SRAM revenue increased from 8 percent in 1980 to 44 percent in 1986. Slow SRAM bit revenue has grown grew at a CAGR of 77.6 percent since 1980, hitting 10,000 billion bits in 1986.

Figure 1 shows the growth of MOS SRAM revenue relative to the total MOS memory market. Figure 2 shows the contributions of the fast and slow SRAM markets.

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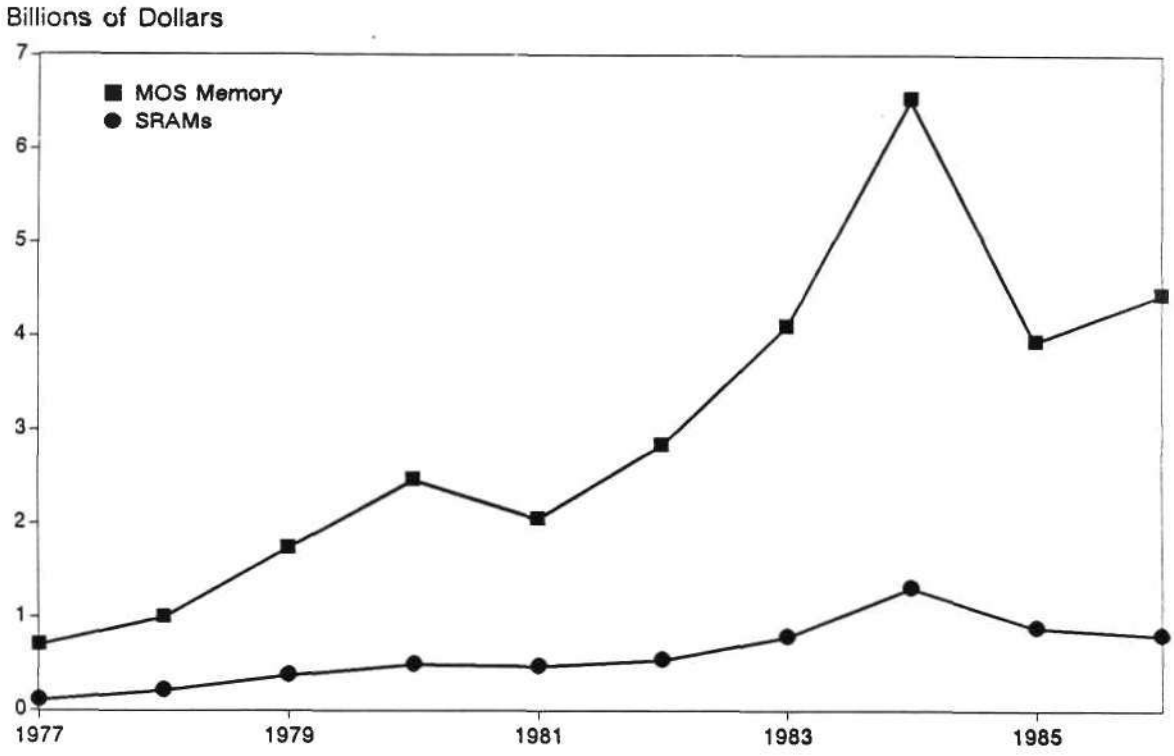
Figure 1

MOS MEMORY AND SRAM MARKET GROWTH COMPARISON
1977-1986



Source: Dataquest
June 1987

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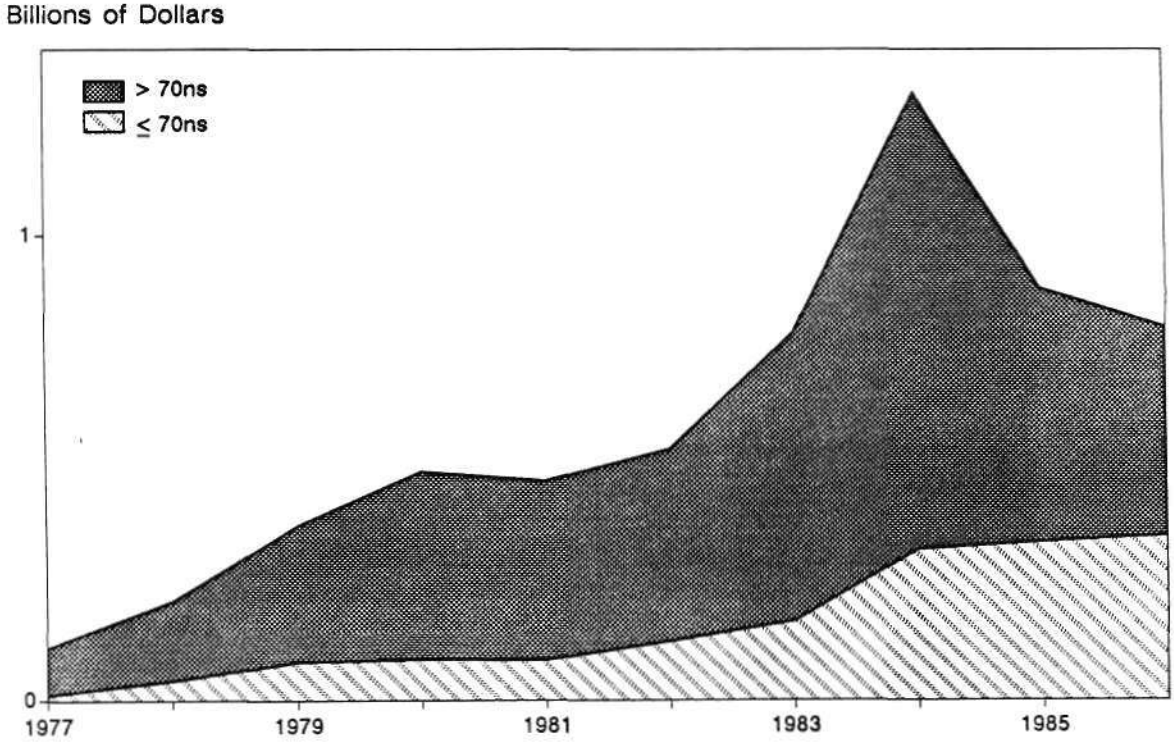
Figure 2

ESTIMATED MOS SRAM MARKET GROWTH
1977-1988



Source: Dataquest
June 1987

THE MOS SRAM MARKET FORECAST

Dataquest presents the MOS SRAM market forecast from 1987 to 1991 with the following tables:

- Table 1--Worldwide MOS SRAM Market Forecast (Revenue, Units, and Average Selling Prices)
- Table 2--Worldwide NMOS SRAM Market Forecast (Revenue, Units, and Average Selling Prices)

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- Table 3--Worldwide CMOS SRAM Market Forecast (Revenue, Units, and Average Selling Prices)
- Table 4--Worldwide Fast SRAM Market Forecast (Revenue, Units, and Average Selling Prices)
- Table 5--Worldwide Slow SRAM Market Forecast (Revenue, Units, and Average Selling Prices)

Despite the decline from record revenue in 1984, Dataquest expects the MOS SRAM market to be robust in the coming years, with the introduction of higher densities and faster-speed devices and the emergence of new applications. The highlights of this forecast are:

- The MOS SRAM market is expected to reach $1.6 billion by 1991 from its present level of $803 million in 1986. The fast SRAM segment will contribute 47 percent of MOS SRAM revenue.
- The MOS SRAM market is expected to grow at a CAGR of 15.3 percent, equivalent to MOS memory CAGR forecast for the same period.
- The fast SRAM market will be the main source of growth, with a CAGR of 15.7 percent, primarily due to the increased acceptance of specialty memories such as FIFOs, dual-port RAMs, and cache tag RAMs and the need for access times faster than 35ns.
- The slow SRAM market will still have a healthy CAGR of 14.3 percent, primarily due to the growth of 256K, 1Mb, and 4Mb SRAMs. These devices will contribute 96 percent of total MOS SRAM revenue in 1991 and 63 percent in 1988.
- Dataquest anticipates a mild downturn in overall semiconductor business in 1989, based on projections of historical business cycles in the industry.
- The price per bit of the slow 32kx8 SRAM has crossed over that of the 8kx8, making it the most cost-effective SRAM in 1987. The price per bit of the slow 1Mb SRAM is expected to cross over that of the 256K in 1989.

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MOS SRAM--Forecast

Table 1

TOTAL MOS SRAM MARKET FORECAST

Value (Millions of Dollars)

	1984	1985	1986	1987	1988	1989	1990	1991
1K (Fast)	$ 15	$ 16	$ 16	$ 11	$ 5	0	0	0
1K (Slow)	9	6	2	1	0	0	0	0
4K (Fast)	75	58	39	29	17	$ 8	$ 2	0
4K (Slow)	82	39	22	4	0	0	0	0
8K	8	3	0	0	0	0	0	0
16K (Fast)	227	203	188	186	161	118	96	$ 69
16K (Slow)	465	232	131	74	38	24	16	8
64K (Fast)	8	65	109	181	220	228	226	240
64K (Slow)	421	258	187	207	165	98	39	28
256K (Fast)	0	0	1	39	117	165	265	257
256K (Slow)	3	5	108	260	340	240	328	228
1Mb (Fast)	0	0	0	0	0	6	87	197
1Mb (Slow)	0	0	0	4	3	60	193	333
4Mb (Slow)	0	0	0	0	0	0	13	280
Total	$1,310	$884	$803	$996	$1,067	$946	$1,264	$1,639
Percent Change from Previous Year	67%	(33%)	(9%)	24%	7%	(11%)	34%	30%

Units (Millions)

	1984	1985	1986	1987	1988	1989	1990	1991
1K (Fast)	5.5	5.4	5.0	3.5	1.5	0	0	0
1K (Slow)	3.2	2.0	0.6	0.3	0	0	0	0
4K (Fast)	23.0	20.1	13.7	10.0	5.9	2.7	0.8	0
4K (Slow)	47.0	23.0	11.6	2.0	0	0	0	0
8K	2.5	1.0	0	0	0	0	0	0
16K (Fast)	31.1	40.1	52.6	59.0	53.0	40.0	33.0	23.5
16K (Slow)	150.0	144.9	109.0	62.0	32.0	20.0	12.5	6.0
64K (Fast)	0.1	2.2	7.8	19.9	32.2	50.0	67.0	73.0
64K (Slow)	29.0	59.0	98.0	115.0	100.0	75.0	30.0	20.0
256K (Fast)	0	0	0	1.5	8.7	18.8	39.6	56.0
256K (Slow)	0	0.1	5.5	40.0	85.0	120.0	160.0	130.0
1Mb (Fast)	0	0	0	0	0	0.1	2.9	13.5
1Mb (Slow)	0	0	0	0	0.1	6.0	35.0	95.0
4Mb (Slow)	0	0	0	0	0	0	0.1	7.0
Total	291.4	297.7	303.8	313.2	318.4	332.6	380.9	424.0

Average Selling Price (Dollars/Unit)

	1984	1985	1986	1987	1988	1989	1990	1991
1K (Fast)	$ 2.73	$ 3.02	$ 3.16	$ 3.27	0	0	0	0
1K (Slow)	$ 2.89	$ 3.13	$ 3.36	$ 3.41	0	0	0	0
4K (Fast)	$ 3.24	$ 2.89	$ 2.89	$ 2.89	$ 2.89	0	0	0
4K (Slow)	$ 1.75	$ 1.68	$ 1.86	$ 1.98	0	0	0	0
8K	$ 3.00	$ 2.75	0	0	0	0	0	0
16K (Fast)	$ 7.29	$ 5.05	$ 3.58	$ 3.16	$ 3.04	$ 2.94	$ 2.92	$ 2.93
16K (Slow)	$ 3.10	$ 1.60	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.25	$ 1.29
64K (Fast)	$ 60.00	$29.99	$14.01	$ 9.08	$ 6.84	$ 4.56	$ 3.37	$ 3.29
64K (Slow)	$ 14.50	$ 4.37	$ 1.91	$ 1.80	$ 1.65	$ 1.30	$ 1.30	$ 1.40
256K (Fast)	0	0	$78.75	$ 26.68	$13.43	$ 8.77	$ 6.70	$ 4.58
256K (Slow)	$125.00	$46.00	$19.70	$ 6.50	$ 4.00	$ 2.00	$ 2.05	$ 1.75
1Mb (Fast)	0	0	0	0	0	$76.88	$ 29.90	$14.62
1Mb (Slow)	0	0	0	$125.00	$32.00	$10.00	$ 5.50	$ 3.50
4Mb (Slow)	0	0	0	0	0	0	$125.00	$40.00
Overall ASP	$ 4.50	$ 2.97	$ 2.64	$ 3.18	$ 3.35	$ 2.84	$ 3.32	$ 3.86

Source: Dataquest
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MOS SRAM--Forecast

Table 2

NMOS SRAM MARKET FORECAST

	Value (Millions of Dollars)							
	1984	1985	1986	1987	1988	1989	1990	1991
1K (All types)	$ 11	$ 8	$ 5	$ 3	$ 1	0	0	0
4K (Slow, 1Kx4)	45	14	6	0	0	0	0	0
4K (Slow, 4Kx1)	4	2	0	0	0	0	0	0
4K (Fast, 1Kx4)	27	20	12	8	5	$ 2	$ 1	0
4K (Fast, 4Kx1)	42	35	25	18	11	5	1	0
8K (Slow, 1Kx8)	8	3	0	0	0	0	0	0
16K (Fast, 2Kx8)	15	19	18	22	16	9	6	$ 3
16K (Slow, 2Kx8)	159	83	45	14	8	6	3	1
16K (4Kx4)	85	66	51	26	16	7	4	3
16K (16Kx1)	81	52	31	26	17	13	10	7
64K (Fast, All Orgs)	4	13	5	10	11	6	4	2
Total	$481	$315	$198	$126	$84	$47	$28	$15
Percent Change from Previous Year	44%	(35%)	(37%)	(35%)	(34%)	(44%)	(40%)	(47%)

	Units (Millions)							
	1984	1985	1986	1987	1988	1989	1990	1991
1K (All types)	4.5	3.0	2.0	1.2	0.5	N/A	N/A	N/A
4K (Slow, 1Kx4)	30.0	12.0	4.5	N/A	N/A	N/A	N/A	N/A
4K (Slow, 4Kx1)	2.0	1.0	N/A	N/A	N/A	N/A	N/A	N/A
4K (Fast, 1Kx4)	8.3	6.6	3.9	2.8	1.6	0.6	0.2	N/A
4K (Fast, 4Kx1)	13.0	12.4	8.8	6.3	3.8	1.7	0.4	N/A
8K (Slow, 1Kx8)	2.5	1.0	N/A	N/A	N/A	N/A	N/A	N/A
16K (Fast, 2Kx8)	1.7	3.0	4.0	6.0	5.0	3.0	2.0	1.0
16K (Slow, 2Kx8)	53.1	57.2	42.0	12.0	7.0	5.0	2.5	1.0
16K (4Kx4)	11.0	13.3	15.1	9.0	6.0	3.0	1.5	1.0
16K (16Kx1)	11.6	10.7	8.8	8.5	6.0	5.0	4.0	2.5
64K (Fast, All Orgs)	0.1	0.4	0.3	1.0	1.5	1.2	1.1	0.6
Total	137.7	120.5	89.4	46.8	31.4	19.5	11.7	6.1

	Average Selling Price (Dollars/Unit)							
	1984	1985	1986	1987	1988	1989	1990	1991
1K (All types)	$ 2.50	$ 2.60	$ 2.60	$ 2.60	$2.60	N/A	N/A	N/A
4K (Slow, 1Kx4)	$ 1.50	$ 1.20	$ 1.25	N/A	N/A	N/A	N/A	N/A
4K (Slow, 4Kx1)	$ 1.75	$ 1.75	N/A	N/A	N/A	N/A	N/A	N/A
4K (Fast, 1Kx4)	$ 3.30	$ 2.96	$ 2.96	$ 2.99	$2.99	$2.99	$3.10	N/A
4K (Fast, 4Kx1)	$ 3.20	$ 2.85	$ 2.85	$ 2.85	$2.85	$2.85	$2.95	N/A
8K (Slow, 1Kx8)	$ 3.00	$ 2.75	N/A	N/A	N/A	N/A	N/A	N/A
16K (Fast, 2Kx8)	$ 8.95	$ 6.15	$ 4.40	$ 3.65	$3.20	$3.10	$2.85	$2.75
16K (Slow, 2Kx8)	$ 3.00	$ 1.45	$ 1.07	$ 1.20	$1.20	$1.20	$1.25	$1.25
16K (4Kx4)	$ 7.75	$ 5.00	$ 3.40	$ 2.90	$2.65	$2.40	$2.40	$2.50
16K (16Kx1)	$ 7.00	$ 4.90	$ 3.55	$ 3.05	$2.75	$2.50	$2.60	$2.60
64K (Fast, All Orgs)	$60.00	$37.00	$16.00	$10.00	$7.00	$4.75	$3.50	$3.50
Overall ASP	$ 3.49	$ 2.61	$ 2.21	$ 2.73	$2.68	$2.43	$2.43	$2.48

N/A = Not Available

Source: Dataquest
June 1987

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Table 3

CMOS SRAM MARKET FORECAST

	Value (Millions of Dollars)							
	1984	1985	1986	1987	1988	1989	1990	1991
1K	$ 13	$ 15	$ 13	$ 9	$ 4	0	0	0
4K (Fast)	6	3	3	3	1	$ 1	$ 1	0
4K (Slow)	34	23	16	4	0	0	0	0
16K (Fast, 16Kx1)	35	33	37	40	36	27	23	$ 17
16K (Fast, 4Kx4)	7	25	40	61	53	42	38	27
16K (Fast, 2Kx8)	3	7	12	12	24	20	16	13
16K (Slow, 2Kx8)	305	149	86	60	30	18	13	7
64K (Fast, 64Kx1)	4	46	59	78	87	88	78	83
64K (Fast, 16Kx4)	0	4	22	53	70	77	84	90
64K (Fast, 8Kx8)	0	1	23	40	52	57	61	65
64K (Slow, 8Kx8)	421	258	187	207	165	98	39	28
256K (Fast, 256Kx1)	0	0	0	2	38	55	80	86
256K (Fast, 64Kx4)	0	0	0	34	43	61	100	104
256K (Fast, 32Kx8)	0	0	0	2	36	49	85	68
256K (Slow, 32Kx8)	3	5	108	260	340	240	328	228
1Mb (Fast, 1Mbx1)	0	0	0	0	0	2	29	59
1Mb (Fast, 256Kx4)	0	0	0	0	0	2	41	87
1Mb (Fast, 64Kx8)	0	0	0	0	0	2	17	52
1Mb (Slow)	0	0	0	4	3	60	193	333
4Mb (Slow)	0	0	0	0	0	0	13	280
Total	$830	$569	$606	$869	$982	$898	$1,236	$1,623
Percent Change from Previous Year	83%	(31%)	6%	43%	13%	(9%)	38%	31%

	Units (Millions)							
	1984	1985	1986	1987	1988	1989	1990	1991
1K	4.2	4.4	3.6	2.6	1.0	0	0	0
4K (Fast)	1.7	1.1	1.0	0.9	0.5	0.4	0.2	0
4K (Slow)	15.0	10.0	7.1	2.0	0	0	0	0
16K (Fast, 16Kx1)	5.7	7.5	11.4	13.5	12.0	9.0	8.0	6.0
16K (Fast, 4Kx4)	0.9	4.6	10.8	19.0	17.0	14.0	12.5	9.0
16K (Fast, 2Kx8)	0.3	1.0	2.5	3.0	7.0	6.0	5.0	4.0
16K (Slow, 2Kx8)	96.9	87.7	67.0	50.0	25.0	15.0	10.0	5.0
64K (Fast, 64Kx1)	0.1	1.6	4.5	9.2	13.4	20.0	24.0	25.0
64K (Fast, 16Kx4)	0	0.1	1.6	5.8	10.3	17.0	25.0	28.0
64K (Fast, 8Kx8)	0	0	1.4	3.9	7.0	11.8	16.9	19.4
64K (Slow, 8Kx8)	29.0	59.0	98.0	115.0	100.0	75.0	30.0	20.0
256K (Fast, 256Kx1)	0	0	0	0.1	2.9	6.5	12.3	18.0
256K (Fast, 64Kx4)	0	0	0	1.3	3.5	7.3	15.4	23.0
256K (Fast, 32Kx8)	0	0	0	0.1	2.3	5.0	11.9	15.0
256K (Slow, 32Kx8)	0	0.1	5.5	40.0	85.0	120.0	160.0	130.0
1Mb (Fast, 1Mbx1)	0	0	0	0	0	0	1.0	4.2
1Mb (Fast, 256Kx4)	0	0	0	0	0	0	1.4	6.1
1Mb (Fast, 64Kx8)	0	0	0	0	0	0	0.5	3.2
1Mb (Slow)	0	0	0	0	0.1	6.0	35.0	95.0
4Mb (Slow)	N/A	N/A	N/A	N/A	N/A	N/A	0.1	7.0
Total	153.7	177.2	214.4	266.4	287.0	313.1	369.2	417.9

(Continued)

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Table 3 (Continued)

CMOS SRAM MARKET FORECAST

	Average Selling Price (Dollars/Unit)							
	1984	1985	1986	1987	1988	1989	1990	1991
1K	$ 3.10	$ 3.35	$ 3.50	$ 3.60	$ 3.60	N/A	N/A	N/A
4K (Fast)	$ 3.25	$ 3.00	$ 3.00	$ 2.90	$ 2.90	$ 2.90	$ 2.90	N/A
4K (Slow)	$ 2.25	$ 2.25	$ 2.25	$ 1.98	N/A	N/A	N/A	N/A
16K (Fast, 16Kx1)	$ 6.25	$ 4.40	$ 3.20	$ 2.95	$ 3.00	$ 3.00	$ 2.90	$ 2.90
16K (Fast, 4Kx4)	$ 8.00	$ 5.50	$ 3.70	$ 3.20	$ 3.10	$ 3.00	$ 3.00	$ 3.00
16K (Fast, 2Kx8)	$ 9.95	$ 6.90	$ 4.60	$ 3.95	$ 3.40	$ 3.25	$ 3.20	$ 3.15
16K (Slow, 2Kx8)	$ 3.15	$ 1.70	$ 1.28	$ 1.20	$ 1.20	$ 1.20	$ 1.25	$ 1.30
64K (Fast, 64Kx1)	$ 60.00	$28.00	$13.00	$ 8.50	$ 6.50	$ 4.40	$ 3.25	$ 3.33
64K (Fast, 16Kx4)	N/A	$33.60	$14.00	$ 9.10	$ 6.83	$ 4.53	$ 3.35	$ 3.20
64K (Fast, 8Kx8)	N/A	$37.80	$16.90	$ 10.20	$ 7.48	$ 4.85	$ 3.58	$ 3.36
64K (Slow, 8Kx8)	$ 14.50	$ 4.37	$ 1.91	$ 1.80	$ 1.65	$ 1.30	$ 1.30	$ 1.40
256K (Fast, 256Kx1)	N/A	N/A	$85.00	$ 29.00	$13.00	$ 8.50	$ 6.50	$ 4.75
256K (Fast, 64Kx4)	N/A	N/A	$75.00	$ 26.10	$12.35	$ 8.33	$ 6.50	$ 4.50
256K (Fast, 32Kx8)	N/A	N/A	$85.00	$ 34.80	$15.60	$ 9.77	$ 7.15	$ 4.50
256K (Slow, 32Kx8)	$125.00	$46.00	$19.70	$ 6.50	$ 4.00	$ 2.00	$ 2.05	$ 1.75
1Mb (Fast, 1Mbx1)	N/A	N/A	N/A	N/A	N/A	$80.00	$ 28.50	$14.00
1Mb (Fast, 256Kx4)	N/A	N/A	N/A	N/A	N/A	$70.00	$ 29.36	$14.28
1Mb (Fast, 64Kx8)	N/A	N/A	N/A	N/A	N/A	$80.00	$ 34.20	$16.10
1Mb (Slow)	N/A	N/A	N/A	$125.00	$32.00	$10.00	$ 5.50	$ 3.50
4Mb (Slow)	N/A	N/A	N/A	N/A	N/A	N/A	$125.00	$40.00
Overall ASP	$ 5.40	$ 3.21	$ 2.82	$ 3.26	$ 3.42	$ 2.87	$ 3.35	$ 3.88

N/A = Not Available

Source: Dataquest
June 1987

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Table 4

FAST SRAM MARKET FORECAST

Value (Millions of Dollars)

	1984	1985	1986	1987	1988	1989	1990	1991
1K (All Orgs)	$ 15	$ 16	$ 16	$ 11	$ 5	0	0	0
4K (4Kx1)	46	38	27	20	12	$ 6	$ 2	0
4K (1Kx4)	28	20	12	9	5	2	1	0
16K (16Kx1)	116	85	68	66	53	40	34	$ 24
16K (4Kx4)	92	92	91	87	69	49	41	30
16K (2Kx8)	19	26	29	34	40	29	22	15
64K (64Kx1)	7	56	63	78	87	88	78	83
64K (16Kx4)	0	4	22	53	70	77	84	90
64K (8Kx8)	0	1	24	50	63	63	64	67
256K (256Kx1)	0	0	0	2	38	55	80	86
256K (64Kx4)	0	0	0	34	43	61	100	104
256K (32Kx8)	0	0	0	2	36	49	85	68
1Mb (1Mbx1)	0	0	0	0	0	2	29	59
1Mb (256Kx4)	0	0	0	0	0	2	41	87
1Mb (64Kx8)	0	0	0	0	0	2	17	52
Total	$323	$339	$353	$446	$520	$524	$677	$763
Percent Change from Previous Year	90.8%	4.9%	4.3%	26.3%	16.5%	0.8%	29.1%	12.7%

Units (Millions)

	1984	1985	1986	1987	1988	1989	1990	1991
1K (All Orgs)	5.5	5.4	5.0	3.5	1.5	0	0	0
4K (4Kx1)	14.4	13.3	9.6	7.0	4.2	2.0	0.6	0
4K (1Kx4)	8.6	6.8	4.1	3.0	1.7	0.7	0.2	0
16K (16Kx1)	17.2	18.2	20.2	22.0	18.0	14.0	12.0	8.5
16K (4Kx4)	11.8	17.9	25.9	28.0	23.0	17.0	14.0	10.0
16K (2Kx8)	2.0	4.0	6.5	9.0	12.0	9.0	7.0	5.0
64K (64Kx1)	0.1	2.0	4.8	9.2	13.4	20.0	24.0	25.0
64K (16Kx4)	0	0.1	1.6	5.8	10.3	17.0	25.0	28.0
64K (8Kx8)	0	0	1.4	4.9	8.5	13.0	18.0	20.0
256K (256Kx1)	0	0	0	0.1	2.9	6.5	12.3	18.0
256K (64Kx4)	0	0	0	1.3	3.5	7.3	15.4	23.0
256K (32Kx8)	0	0	0	0.1	2.3	5.0	11.9	15.0
1Mb (1Mbx1)	0	0	0	0	0	0	1.0	4.2
1Mb (256Kx4)	0	0	0	0	0	0	1.4	6.1
1Mb (64Kx8)	0	0	0	0	0	0	0.5	3.2
Total	59.7	67.7	79.0	93.8	101.3	111.6	143.3	166.0

Average Selling Price (Dollars/Unit)

	1984	1985	1986	1987	1988	1989	1990	1991
1K (All Orgs)	$ 2.73	$ 3.02	$ 3.16	$ 3.27	0	0	0	0
4K (4Kx1)	$ 3.20	$ 2.86	$ 2.86	$ 2.86	$ 2.85	$ 2.86	$ 2.94	0
4K (1Kx4)	$ 3.30	$ 2.96	$ 2.96	$ 2.98	$ 2.98	$ 2.98	$ 3.07	0
16K (16Kx1)	$ 6.75	$ 4.69	$ 3.35	$ 2.99	$ 2.92	$ 2.82	$ 2.80	$ 2.81
16K (4Kx4)	$ 7.77	$ 5.13	$ 3.53	$ 3.10	$ 2.98	$ 2.89	$ 2.94	$ 2.95
16K (2Kx8)	$ 9.12	$ 6.34	$ 4.48	$ 3.75	$ 3.32	$ 3.20	$ 3.10	$ 3.07
64K (64Kx1)	$53.76	$28.29	$13.17	$ 8.50	$ 6.50	$ 4.40	$ 3.25	$ 3.33
64K (16Kx4)	0	$33.60	$14.00	$ 9.10	$ 6.83	$ 4.53	$ 3.35	$ 3.20
64K (8Kx8)	N/A	$37.80	$16.86	$10.16	$ 7.40	$ 4.84	$ 3.58	$ 3.36
256K (256Kx1)	0	0	0	$29.00	$13.00	$ 8.50	$ 6.50	$ 4.75
256K (64Kx4)	0	0	$75.00	$26.10	$12.35	$ 8.33	$ 6.50	$ 4.50
256K (32Kx8)	0	0	$85.00	$34.80	$15.60	$ 9.77	$ 7.15	$ 4.50
1Mb (1Mbx1)	N/A	N/A	N/A	N/A	N/A	$80.00	$28.50	$14.00
1Mb (256Kx4)	N/A	N/A	N/A	N/A	N/A	$70.00	$29.36	$14.28
1Mb (64Kx8)	N/A	N/A	N/A	N/A	N/A	$80.00	$34.20	$16.10
Overall ASP	$ 5.41	$ 5.00	$ 4.47	$ 4.76	$ 5.13	$ 4.70	$ 4.72	$ 4.60

N/A = Not Available

Source: Dataquest June 1987

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MOS SRAM--Forecast

Table 5

SLOW SRAM MARKET FORECAST

Value (Millions of Dollars)

	1984	1985	1986	1987	1988	1989	1990	1991
1K (All Orgs)	$ 9	$ 6	$ 2	$ 1	0	0	0	0
4K (4Kx1)	15	10	4	2	0	0	0	0
4K (1Kx4)	67	29	17	2	0	0	0	0
8K (1Kx8)	8	3	0	0	0	0	0	0
16K (2Kx8)	465	232	131	74	$ 38	$ 24	$ 16.0	$ 8
64K (8Kx8)	421	258	187	207	165	98	39.0	28
256K (32Kx8)	3	5	108	260	340	240	328.0	228
1Mb (All Orgs)	0	0	0	4	3	60	193.0	333
4Mb (All Orgs)	0	0	0	0	0	0	12.5	280
Total	$987	$542	$450	$550	$547	$422	$588.0	$876
Percent Change from Previous Year	59.7%	(45.1%)	(17.0%)	22.3%	(0.7%)	(22.9%)		39.4%
49.0%								

Units (Millions)

	1984	1985	1986	1987	1988	1989	1990	1991
1K (All Orgs)	3.2	2.0	0.6	0.3	0	0	0	0
4K (4Kx1)	7.3	4.5	2.0	0.7	0	0	0	0
4K (1Kx4)	39.8	18.5	9.6	1.3	0	0	0	0
8K (1Kx8)	2.5	1.0	0	0	0	0	0	0
16K (2Kx8)	150.0	144.9	109.0	62.0	32.0	20.0	12.5	6.0
64K (8Kx8)	29.0	59.0	98.0	115.0	100.0	75.0	30.0	20.0
256K (32Kx8)	0	0.1	5.5	40.0	85.0	120.0	160.0	130.0
1Mb (All Orgs)	0	0	0	0	0.1	6.0	35.0	95.0
4Mb (All Orgs)	0	0	0	0	0	0	0.1	7.0
Total	231.7	230.0	224.7	219.4	217.1	221.0	237.6	258.0

Average Selling Price (Dollars/Unit)

	1984	1985	1986	1987	1988	1989	1990	1991
1K (All Orgs)	$ 2.89	$ 3.13	$ 3.36	$ 3.41	0	0	0	0
4K (4Kx1)	$ 2.11	$ 2.14	$ 2.25	$ 2.49	0	0	0	0
4K (1Kx4)	$ 1.68	$ 1.57	$ 1.78	$ 1.71	0	0	0	0
8K (1Kx8)	$ 3.00	$ 2.75	0	0	0	0	0	0
16K (2Kx8)	$ 3.10	$ 1.60	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.25	$ 1.29
64K (8Kx8)	$ 14.50	$ 4.37	$ 1.91	$ 1.80	$ 1.65	$ 1.30	$ 1.30	$ 1.40
256K (32Kx8)	$125.00	$46.00	$19.70	$ 6.50	$ 4.00	$ 2.00	$ 2.05	$ 1.75
1Mb (All Orgs)	0	0	0	$125.00	$32.00	$10.00	$ 5.50	$ 3.50
4Mb (All Orgs)	N/A	N/A	N/A	N/A	N/A	N/A	$125.00	$40.00
Overall ASP	$ 4.26	$ 2.36	$ 2.00	$ 2.51	$ 2.52	$ 1.91	$ 2.47	$ 3.39

N/A = Not Available

Source: Dataquest June 1987

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MOS SRAM--Forecast

Comparison with Earlier Forecasts

The 1986 MOS SRAM market ended up 15 percent lower than previously forecast, due to a more severe price decline. Actual 1986 units were 4 percent higher than the previous forecast, but the ASP was 18 percent lower. Although all devices in volume production experienced price declines, the most severe came from the slow 8kx8 SRAM, where prices dropped in Japan by as much as 40 percent in the fourth quarter.

The outlook through 1991 for static RAMs has also been tempered. The market for the popular 32kx8 slow SRAM is not expected to take off as aggressively as previously forecast but will show marked improvement over the 8kx8 slow SRAM market. Production shipments of the 1Mb DRAM are not likely to occur until the first half of 1988, instead of 1987 as previously forecast.

The Short-Term Outlook

Both the fast and slow SRAM markets are expected to grow in 1987 by a substantial 24 percent over 1986. Competition will be intense, however, with more than 30 vendors competing in the fast SRAM market and approximately 24 vendors in the slow SRAM market. Prices of standard product are expected to encounter heavy pressure. Nevertheless, we expect 1987 to see an increased proliferation of specialty memories, which are being spawned in the SRAM market. These specialty memories will have above-average prices and will compensate for those of standard products. Success will depend on the broadness of a company's SRAM portfolio, its identification of applications to suit the wide portfolio, and its ability to compete with others in price.

The Long-Term Outlook

Prospects for MOS SRAMs are bright. Battery backup applications are increasing, and SRAMs are expected to be strong DRAM alternatives as main memory devices for desktop computer applications because of their access time and low power. The market for specialty memories is expected to increase as standardization efforts begin and as available products broaden. The already fragmented SRAM market is fragmenting even more.

Alternatives to pushing technology to achieve faster access times are likely to emerge through new technologies such as BICMOS or novel memory cell structures. The present distinction between the slow and fast SRAM markets will change as megabit SRAMs achieve fast access times below 70ns and access times of lower-density SRAMs encroach into current bipolar territory. With the attractiveness of the market and its reputation as a haven from Japanese competition, we expect the SRAM vendor base to increase and competition to intensify.

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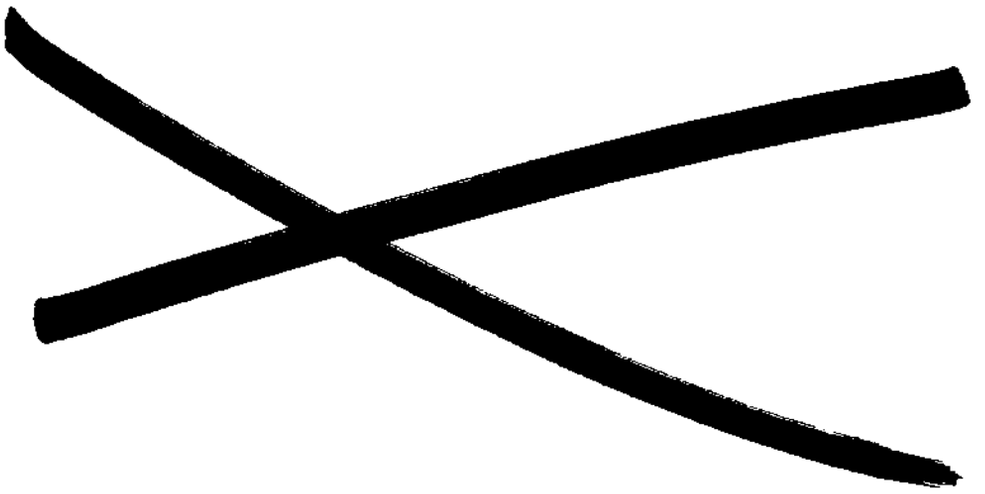

Fast MOS SRAM—Products/Suppliers

INTRODUCTION

The product matrix in Table 1 can be used to evaluate fast static RAM (SRAM) products currently being manufactured by SRAM suppliers. The matrix includes the organizational structure, pertinent specifications, and major suppliers for the 4K, 16K, 64K, and 256K SRAM densities. This lot is not meant to be all-inclusive, but it is meant to indicate the general trends. It must also be noted that the high-speed versions of each density may in actuality be one or two life-cycle stages behind the slower versions. As an example, the CMOS 4Kx4 55ns is in the decline stage of its life cycle, but the 15ns version of the same device is in its ramping stage, so we chose the maturity stage to represent this entire type of SRAM. For more information on the life cycles of SRAMs, please refer to the "Product Life Cycle" section for each specific type.

Table 1

Fast SRAM Suppliers and Product Mix

Density	Process	Org.	Max. Access Time (ns)	No. of Pins	Package*	Stage in Life Cycle
4K	NMOS	4Kx1	70 to 25ns	18	DIP/CLCC	Decline
	NMOS	1Kx4	70 to 25ns	18	DIP/CLCC	Decline
	(NMOS Top Suppliers: AMD, Intel, NEC, and SGS-Thomson)					
	CMOS	4Kx1	45 to 10ns	18	DIP/CLCC	Decline
	CMOS	1Kx4	45 to 10ns	18	DIP/CLCC	Decline
	(CMOS Top Suppliers: Cypress, Inmos, Performance, UMC, and Vitelic)					
	BiCMOS/TTL	4Kx1	25 to 15ns	18	DIP	Decline
	BiCMOS/ECL	4Kx1	10 to 15ns	18	DIP	Maturity
	BiCMOS/ECL	1Kx4	15 to 8ns	24	DIP	Maturity
	(BiCMOS Top Supplier: Saratoga)					
16K	NMOS	16Kx1	70 to 35ns	20	DIP/CLCC	Decline
	NMOS	4Kx4	70 to 35ns	20	DIP/CLCC	Decline
	NMOS	2Kx8	70 to 35ns	24	DIP/SOG	Decline
	(NMOS Top Suppliers: AMD, Fujitsu, Inmos, NEC, STC, and Toshiba)					
	CMOS	16Kx1	70 to 15ns	20	DIP/CLCC	Maturity
	CMOS	4Kx4	70 to 15ns	20	DIP/CLCC	Maturity
	CMOS	2Kx8	70 to 20ns	24	DIP/SOG	Maturity
	(CMOS Top Suppliers: Cypress, Fujitsu, Hitachi, IDT, Inmos, Intel, Matra-Harris, Micron, Mitsubishi, Mosel, Motorola, NEC, Performance, Seiko, SGS-Thomson, Sharp, UMC, Vitelic, and VLSI)					

(Continued)

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Table 1 (Continued)

Fast SRAM Suppliers and Product Mix

Density	Process	Org.	Max. Access Time (ns)	No. of Pins	Package*	Stage in Life Cycle
16K	BiCMOS/TTL	4Kx4	25 to 12ns	20/24	DIP/PLCC/SOG/SOJ	Maturity
	BiCMOS/TTL	2Kx8	25 to 12ns	24	DIP/PLCC/SOG/SOJ	Maturity
	BiCMOS/ECL	16Kx1	15 to 12ns	20	DIP	Ramp
	BiCMOS/ECL	4Kx4	15 to 12ns	28	DIP	Ramp
	(BiCMOS Top Supplier: Saratoga)					
64K	NMOS	64Kx1	70 to 45ns	22	DIP/CLCC	Decline
	NMOS	8Kx9	70 to 45ns	28	DIP	Decline
	(NMOS Top Suppliers: Fujitsu and Toshiba)					
	CMOS	64Kx1	70 to 15ns	22	DIP/CLCC/SOJ	Maturity
	CMOS	16Kx4	70 to 15ns	22/24	DIP/SOJ	Maturity
	CMOS	8Kx8/9	70 to 15ns	28	DIP/SOG/SOJ	Maturity
	(CMOS Top Suppliers: AMD, Cypress, Fujitsu, Hitachi, IDT, Inmos, Intel, Micron, Mitsubishi, Mosel, Motorola, National, NEC, Oki, Performance, Seiko, SGS-Thomson, Sharp, TI, Toshiba, Vitelic, and VLSI)					
	BiCMOS/TTL	64Kx1	25 to 15ns	22	DIP/SOJ	Ramp
	BiCMOS/TTL	16Kx4	25 to 15ns	22/24	DIP/SOJ	Ramp
	BiCMOS/TTL	8Kx8	25 to 15ns	28	DIP/SOJ	Ramp
	BiCMOS/ECL	64Kx1	20 to 8ns	22	DIP/CLCC/FPK/SOJ	Ramp
	BiCMOS/ECL	16Kx4	20 to 8ns	28	DIP/CLCC/FPK	Ramp
	(BiCMOS Top Suppliers: Fujitsu, Hitachi, IDT, and Saratoga)					
256K	CMOS	256Kx1	70 to 20ns	24	DIP/SOJ	Ramp
	CMOS	64Kx4	70 to 20ns	24	DIP/SOJ	Ramp
	CMOS	32Kx8/9	70 to 20ns	28	DIP/SOJ	Ramp
	(CMOS Top Suppliers: AMD, Cypress, EDI, Fujitsu, Hitachi, IDT, Inmos, Micron, Mitsubishi, Mosel, Motorola, NEC, Performance, Samsung, Sharp, Toshiba, and VLSI)					
	BiCMOS/TTL	256Kx1	25 to 15ns	24	DIP/SOJ	Ramp
	BiCMOS/TTL	64Kx4	25 to 15ns	24	DIP/SOJ	Ramp
	BiCMOS/ECL	256Kx1	20 to 12ns	24	DIP/FPK	Ramp
	BiCMOS/ECL	64Kx4	20 to 12ns	32	DIP/FPK	Intro
	(BiCMOS Top Suppliers: Fujitsu, Hitachi, and National)					

*CLCC: Ceramic Leadless Chip Carrier
DIP: Dual-In-Line Package
FPK: Flatpack
PLCC: Plastic Leaded Chip Carrier
SOG: Small-Outline Gullwing Package
SOJ: Small-Outline J-Bend Package

Source: Dataquest
October 1989

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Slow MOS SRAM—Products/Suppliers

INTRODUCTION

The product matrix in Table 1 can be used to evaluate slow static RAM (SRAM) products currently being manufactured by SRAM suppliers. The matrix includes the density, pertinent specifications, and suppliers for the 16K, 64K, 256K, and 1Mb SRAM densities. This list is not meant to be all-inclusive, but it is meant to indicate the general trends. For more information on the life cycles of SRAMs, please refer to the "Product Life Cycle" section for each specific type.

Table 1

Slow SRAM Suppliers and Product Mix

Density	Process	Org.	Max. Access Time (ns)	No. of Pins	Package*	Stage in Life Cycle
16K	NMOS	2Kx8	250 to 100ns	24	DIP/SOG	Decline
	(NMOS Top Suppliers: AMD, Mitsubishi, NEC, SGS-Thomson, Toshiba)					
	CMOS	2Kx8	250 to 80ns	24	DIP/SOG	Decline
	(CMOS Top Suppliers: Fujitsu, Harris, Hitachi, Hyundai, Matra-Harris, Mosel, Motorola, NEC, Oki, Rohm, Sanyo, Seiko, SGS-Thomson, Sharp, Sony, and UMC)					
64K	CMOS	8Kx8	250 to 80ns	28	DIP/SOG	Maturity
	(CMOS Top Suppliers: Fujitsu, Hitachi, Hyundai, Matra-Harris, Matsushita, Mitsubishi, Mosel, Motorola, NEC, Oki, Rohm, Samsung, Sanyo, Seiko, SGS-Thomson, Sharp, Sony, and Toshiba)					
256K	CMOS	32Kx8	200 to 80ns	28	DIP/SOG	Ramp
	(CMOS Top Suppliers: Fujitsu, Hitachi, Hyundai, Matra-Harris, Matsushita, Mitsubishi, Motorola, NEC, Oki, Samsung, Seiko, Sharp, Sony, and Toshiba)					
1Mb	CMOS	128Kx8	150 to 70ns	32	DIP/SOG/VSOP	Intro
	(CMOS Top Suppliers: Fujitsu, Hitachi, Inova, Mitsubishi, Motorola, NEC, Sony, and Toshiba)					

DIP = Dual-in-Line Package
SOG = Small-Outline Gullwing Package
VSOP = Very Small Outline Package

Source: Dataquest
October 1989

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Fast MOS SRAM--Products/Suppliers

INTRODUCTION

The product matrix shown in Table 1 can be used to evaluate fast static RAM (SRAM) products currently being manufactured by SRAM suppliers. The matrix includes the organizational structures for the 4K, 16K, 64K, and 256K SRAM densities.

Table 1

FAST MOS SRAM PRODUCT MATRIX

Density	Process	Org'n	Max. Acc. Time (ns)	No. of Pins	Package	Special Features
4K	NMOS	4Kx1	35	18	DIP	CS Power Down
				18	LCC	
		1Kx4	35	18	DIP	CS Power Down
				18	LCC	
	CMOS	4Kx1	25	18	DIP	CS Power Down
				18	LCC	
		1Kx4	25	18	DIP	CS Power Down
				18	LCC	
16K	NMOS	16Kx1	35	20	DIP	
				20	LCC	
		4Kx4	35	20	DIP	
				20	LCC	
		2Kx8	70	24	DIP	
				32	LCC	
	CMOS	16Kx1	15	20	DIP	
				20	LCC	
		4Kx4	20	20	DIP	
				20	LCC	
		2Kx8	30	24	DIP	
				28	LCC	
				32	LCC	

(Continued)

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Fast MOS SRAM--Products/Suppliers

Table 1 (Continued)

FAST MOS SRAM PRODUCT MATRIX

Density	Process	Org'n	Max. Acc. Time (ns)	No. of Pins	Package	Special Features
16K	BICMOS	16Kx1	20	20	DIP	
		4Kx4				
64K	CMOS	64Kx1	25	22	DIP	
				22	LCC	
		16Kx4	25	22	DIP	
				22	LCC	
				28	LCC	
		8Kx8	30	28	DIP	
				32	LCC	
	BICMOS	64Kx1	20	22	DIP	
		16Kx4	20	22	DIP	
256K	CMOS	256Kx1	35	24	DIP	
		64Kx4	35	24	DIP	
		32Kx8	35	28	DIP	

Source: Dataquest
May 1987

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Fast MOS SRAM--Price Learning Curves

OVERVIEW

Price learning curves can be a useful aid in forecasting and interpreting reasons for price fluctuations. Price learning curves illustrate both the relationship between the reduction of average selling prices (ASPs) as production volume increases, and how prices are influenced by extraneous market conditions. External forces in the marketplace can take the form of government intervention, competition, substitute technology, supply and demand, and general economic conditions.

The purpose of this section is to demonstrate the use of price learning curves for the fast MOS Static RAM (SRAM) market, Figure 1, and the 4K, 16K, and 64K fast SRAM densities, Figures 2, 3, and 4, respectively. These curves are generated by plotting the accumulated bits shipped against the millicents per bit on a log-log scale. The accumulated bits are derived from unit shipments, and millicents per bit is a reflection of ASPs and density.

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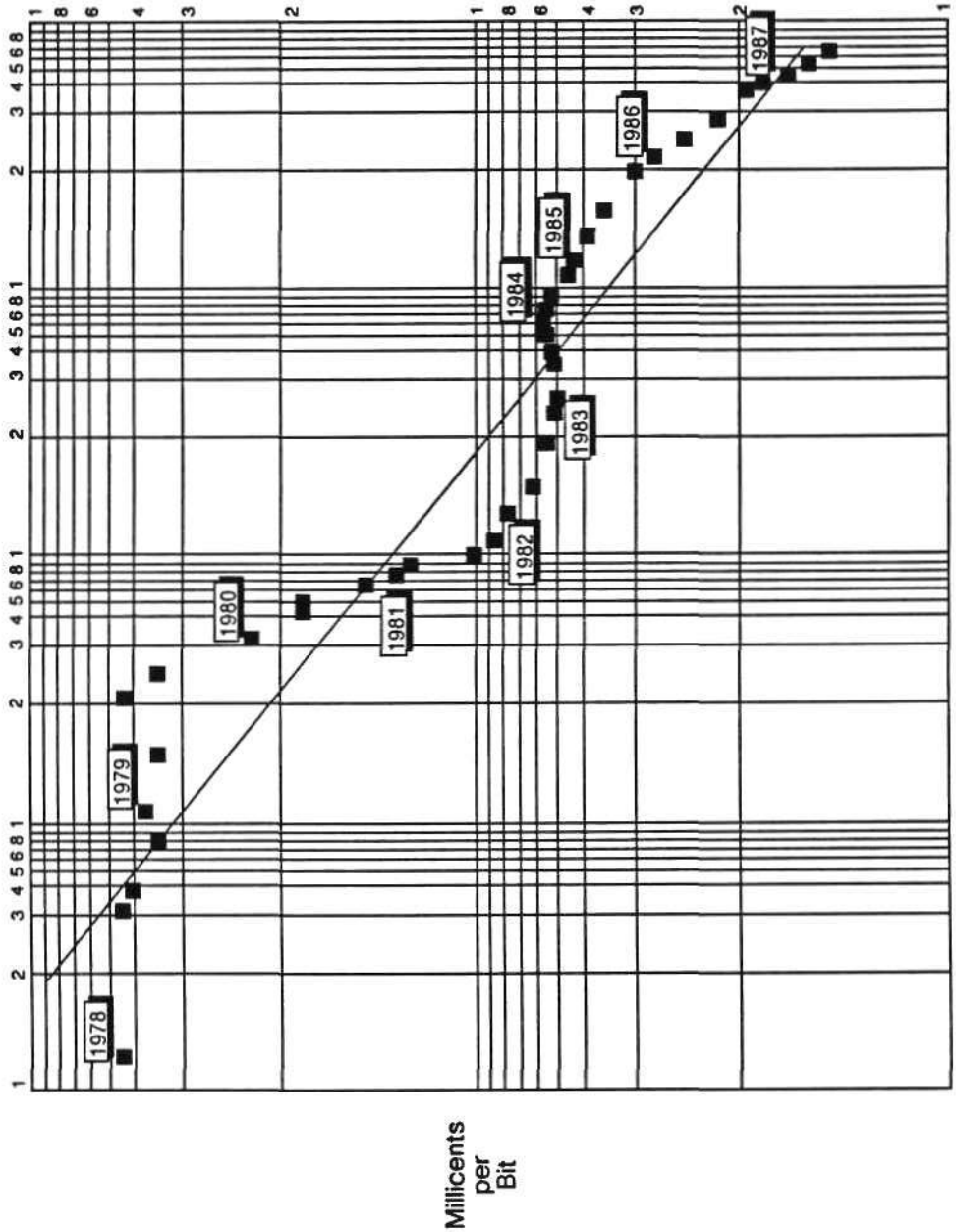
Fast MOS SRAM--Price Learning Curves

Figure 1
Fast MOS SRAM
Price Learning Curve



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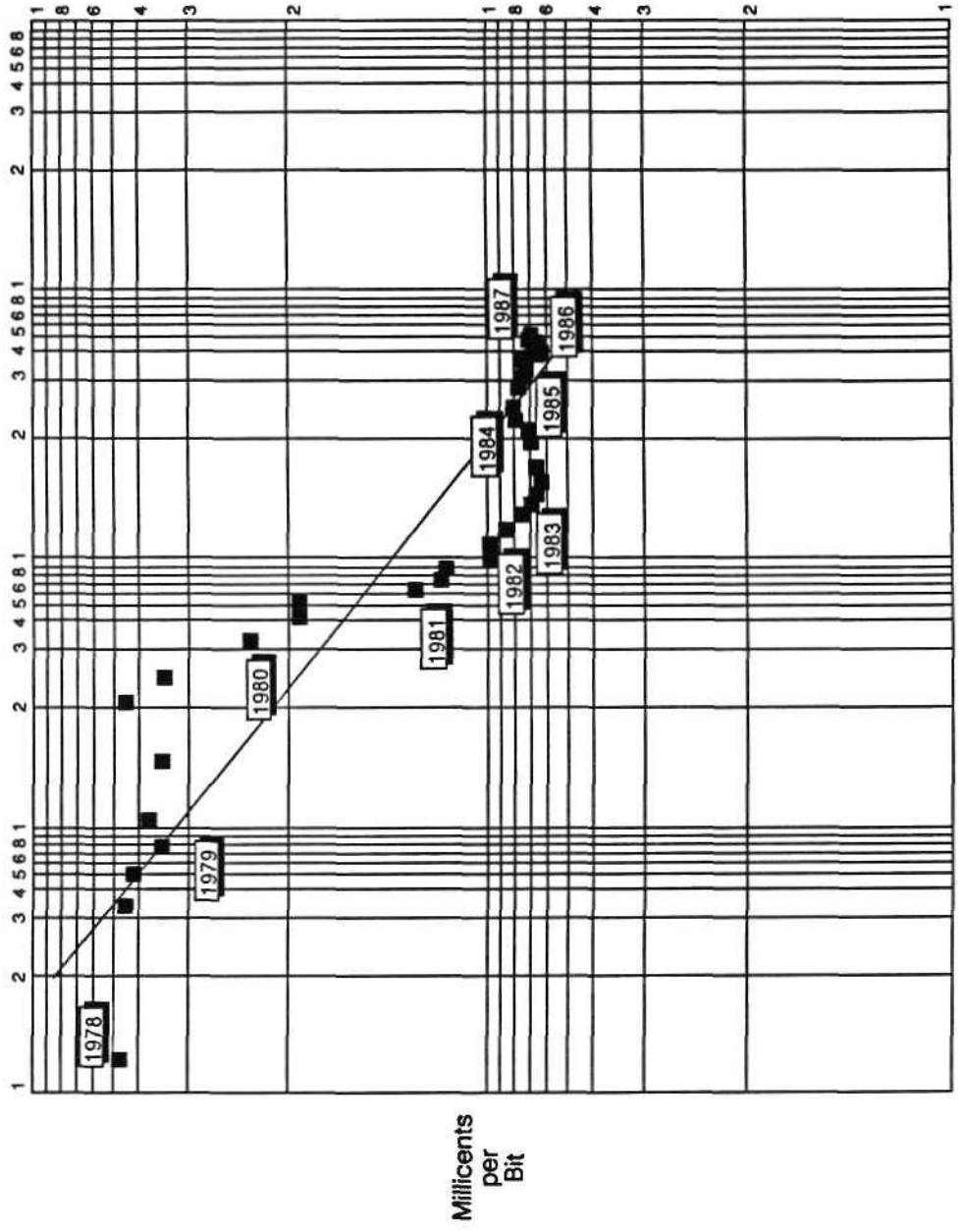
Fast MOS SRAM--Price Learning Curves

Figure 2
4K Fast MOS SRAM
Price Learning Curve



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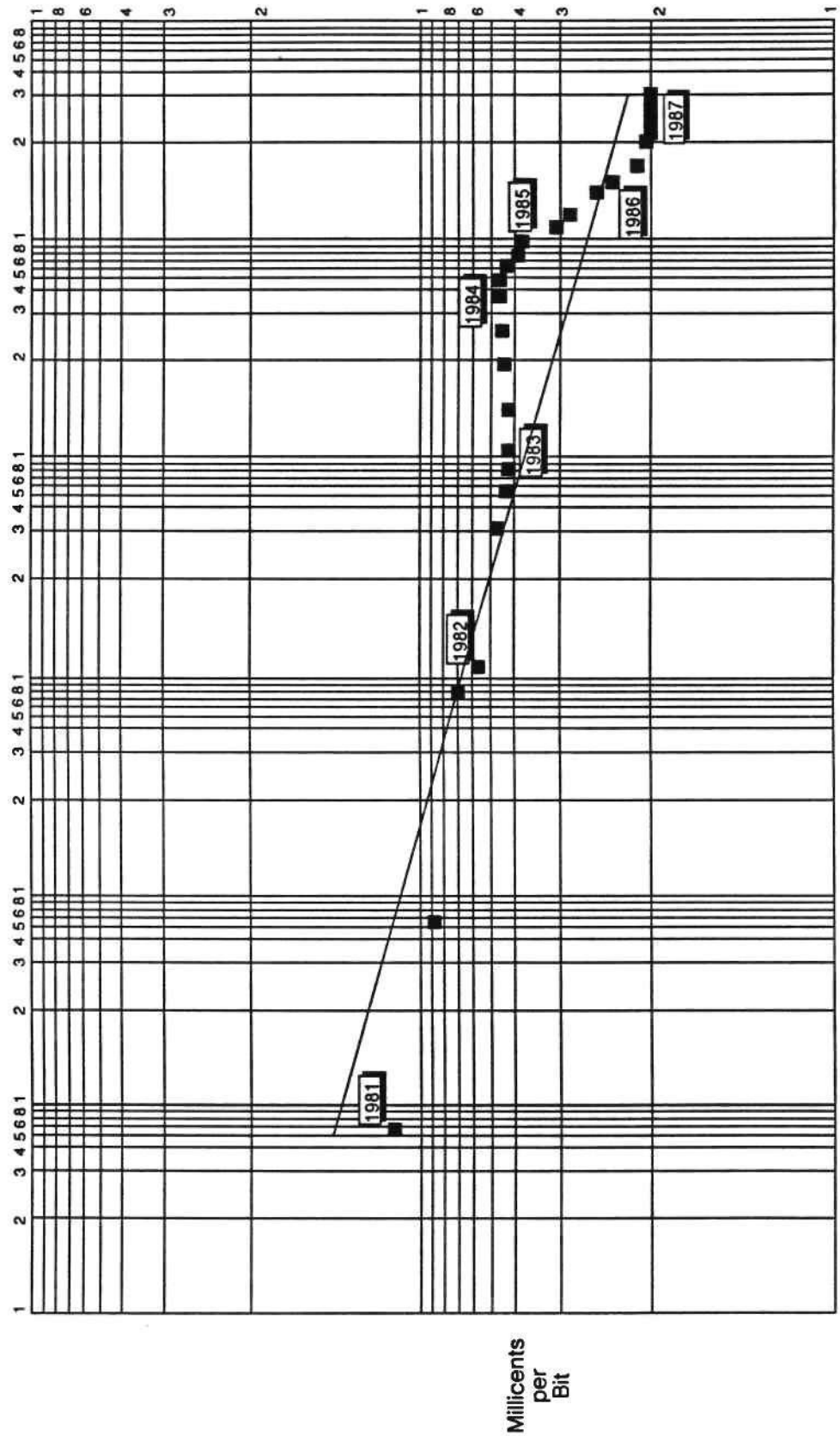
Fast MOS SRAM--Price Learning Curves

Figure 3
16K Fast MOS SRAM
Price Learning Curve



Source: Dataquest September 1988

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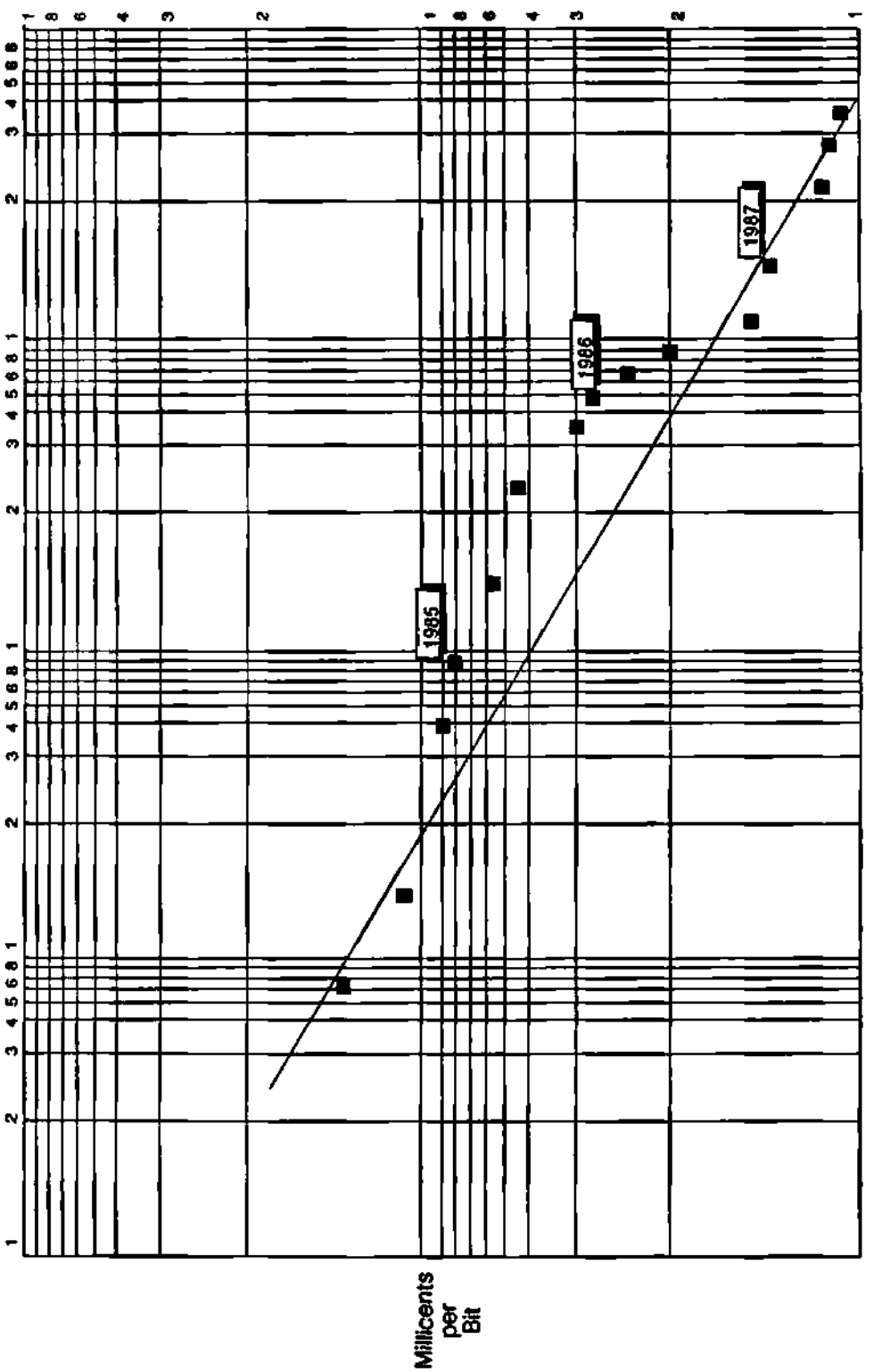
Fast MOS SRAM--Price Learning Curves

Figure 4
64K Fast MOS SRAM
Price Learning Curve



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Fast MOS SRAM--Price Learning Curves

HIGHLIGHTS

The slope of the average curve illustrates the typical price reductions that take place over time. For the fast SRAM market, consisting of the 4K through the 256K densities, the average price learning curve slope is 72.4 percent. The slope is calculated by dividing the price per bit at a given volume by the price per bit at half that volume. A slope of 72.4 percent means that as the volume doubles, the price of fast SRAMs is reduced by 27.6 percent. The typical slope for a memory product usually falls between 70 and 80 percent. The fast SRAM market has a steep slope because of the heavy influence of the 4K density. The 4K, which dominated the fast SRAM market until 1981, had a slightly different cost structure because its manufacturing process had been proven and established for the most part by the 16K DRAM and 4K slow SRAM, allowing it to fall down the learning curve more quickly. Also, the competitive environment during the 4K's ramping phase, from the second half of 1979 through 1982, contributed to the steepness of the slope. As a comparison, fast SRAMs without the 4K density has a more shallow price learning curve slope of 88.2 percent.

The price learning curve for the fast SRAM market, shown in Figure 1, can be broken down into four segments, with the first segment beginning in 1978 and continuing through the first half of 1979. During this time the slope was a shallow 91.4 percent. Intel controlled the market and had very little competition, so there was no need to be price aggressive. In the next segment, through 1982, the price learning curve had a slope of 53.1 percent. During this time, other suppliers began to grab the 4K market share and the 16K began to be a real threat to the 4K's dominance. Both of these factors resulted in increased price competition.

The next two segments were influenced by the 1983 boom and the following slowdown. Starting in 1983, the total fast SRAM market cost per bit remained almost constant because of the increased demand and the dominance of the 16K density. In the second half of 1984, the supply of fast SRAMs began to outstrip demand and prices decrease quickly. Prices continued to decline at a rapid rate though 1987, spurred on by the introduction of the 64K density and the increased number of suppliers. The slope from the second half of 1984 through 1987 was a steep 64.1 percent.

The 16K, Figure 3, is characterized by a much shallower slope of 88.8 percent. This obtuse slope results from a few suppliers dominating the 16K market in its early development. From 1981 through 1983 the top three suppliers controlled over 85 percent of the market, lessening the necessity for price competition. The 64K density, Figure 4, has a more acute slope, measuring 73.7 percent. Being introduced in 1984 when market prices were quickly deteriorating, plus the higher number of suppliers, helped drive the 64K price down faster than the 16K.

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Fast MOS SRAM--Price Learning Curves

DATAQUEST ANALYSIS

Because of the fast SRAM's relatively high ASPs and the diversity of supplier nationality, Dataquest believes that the United States/Japan trade agreement, and the strengthening of the Japanese yen on the world market, will have only a limited effect on fast SRAM prices. Most fast SRAMs have not experienced the drastic increases in ASPs as the DRAMs and slow SRAMs have as a result of the trade agreement. But the agreement may influence the future rate of price decline and the depths to which fast SRAM prices will fall.

For the most part, extra costs associated with manufacturing in a single region will have to be absorbed by the supplier to maintain a competitive market price. The older, less cost-efficient technologies (like the 70 to 45ns 16K density) have been affected the most by the aforementioned market conditions. Because there is less profit margin to absorb any cost increase, prices of 16K fast SRAMs from Japan-based companies have been forced upward.

Through 1988, we see fast SRAM prices stabilizing and not falling as quickly as they did in 1987. This trend is expected to continue until the second half of 1989, at which time we expect a slowdown in the market to cause prices to decrease at a quicker rate.

Fast SRAM pricing is more resistant than other commodity memories to fluctuations in the market because it is technology driven. Constant speed improvements extend product life cycles and keep the average price per density from falling quickly. We foresee technological improvements (like the reduction of line geometries) and advanced process techniques (like BICMOS) becoming increasingly important to suppliers that want to maintain a leading edge position. Building of facilities and the installation of new equipment needed to manufacture in submicron geometries, and solving the technical and reliability problems involved in high performance processes, carry a very heavy price tag. These extra costs will have to be passed on to users in the form of higher prices, especially for devices at the very fast 25ns and below access times.

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Fast MOS SRAM--Product Life Cycles

OVERVIEW

Product and product line life cycles are important elements of a company's strategic planning. The value of this planning extends to both semiconductor memory manufacturers and users alike, in the following ways:

- Memory manufacturers can match the planned product life cycles (for instance, a 64K SRAM) with the cycles of the market to determine if their introduction and phase-out timetables maximize their revenue and profits.
- Memory users can match their system life and redesign schedules with those of the memory components to develop a plan for purchasing and design engineering that maximizes availability and minimizes costs.
- Semiconductor manufacturers can use life cycles to evaluate the strength of, or make plans for, their product portfolios.
- Vendors can also control and alter the life cycles, given a thorough understanding of their behavior.

Dataquest analyzes three versions of the product life cycle and the product line bit growth. These four are derived from the same pool of data, but each presents a different insight. In this section, we will be reviewing the following:

- The standard fast MOS SRAM life cycle
- The product life cycle by density
- The product life cycle through time
- The bit-growth analysis

The Standard Fast MOS SRAM Life Cycle

The typical life cycle of the fast MOS SRAM is shown in Figure 1. Compared with the cycles of other memory devices, the fast MOS SRAM market is resilient. Lower-density devices have extended lives as well as longer maturity and decline stages.

Reasons exist for this long life cycle. Dataquest believes that a significant portion of the market needs the faster access time available in small devices more crucially than it needs density. A difference of 10 nanoseconds (10ns) is valuable to many speed-sensitive users, and the market has shown a propensity to forego the higher density and pay the premium for such a difference. There are also abundant applications, especially in writable control store, that do not require more density. Finally, the lives of many systems that use fast SRAMs (such as supercomputers) are also long, and the length of time to support these systems with service, repair, and replacement is even longer. The manufacturers of these systems are not likely to spend time and money to redesign these mature products.

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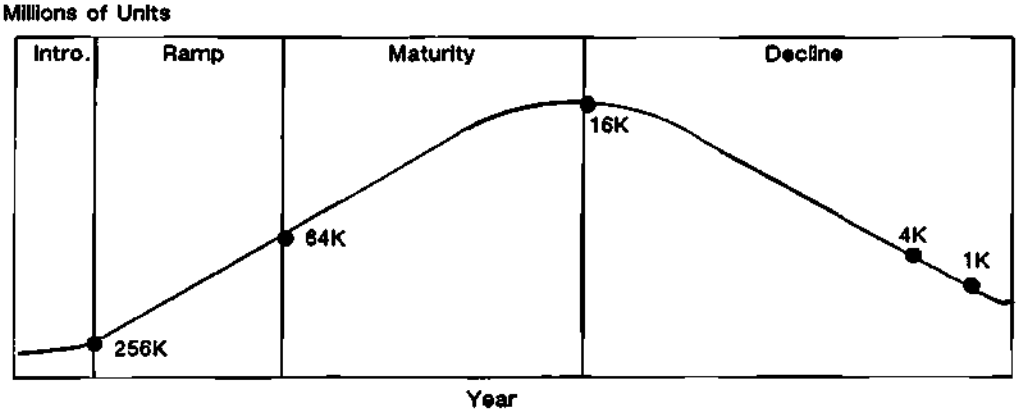
Fast MOS SRAM--Product Life Cycles

Figure 1

Typical Fast MOS SRAM Product Life Cycles



Stage	Intro.	Ramp	Maturity	Decline
Typical Number of Years	2	3	3	10
1988 Products	256K	64K	16K	4K 1K
1989 Products	1Mb	256K	64K	16K 4K
1992 Products	—	1Mb	256K	64K 16K 4K

Source: Dataquest June 1988

In 1988, the 256K is in its introduction stage after a slower start than expected. The 64K is in the latter part of its ramping phase, and the 16K has passed its unit peak. By 1992, the 1Mb will be in the first year of its ramping phase as the 256K reaches maturity and the 64K and 16K are in their decline, as shown in Figure 1.

The Product Life Cycle by Density

The actual life cycle curves, and how they vary by density, are presented in Figure 2. The curves show some distinct trends; their highlights are as follows:

- The 16K and the 64K are expected to peak in the seventh year. We also expect the 1Mb to follow the same pattern and peak in 1993.

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Fast MOS SRAM--Product Life Cycles

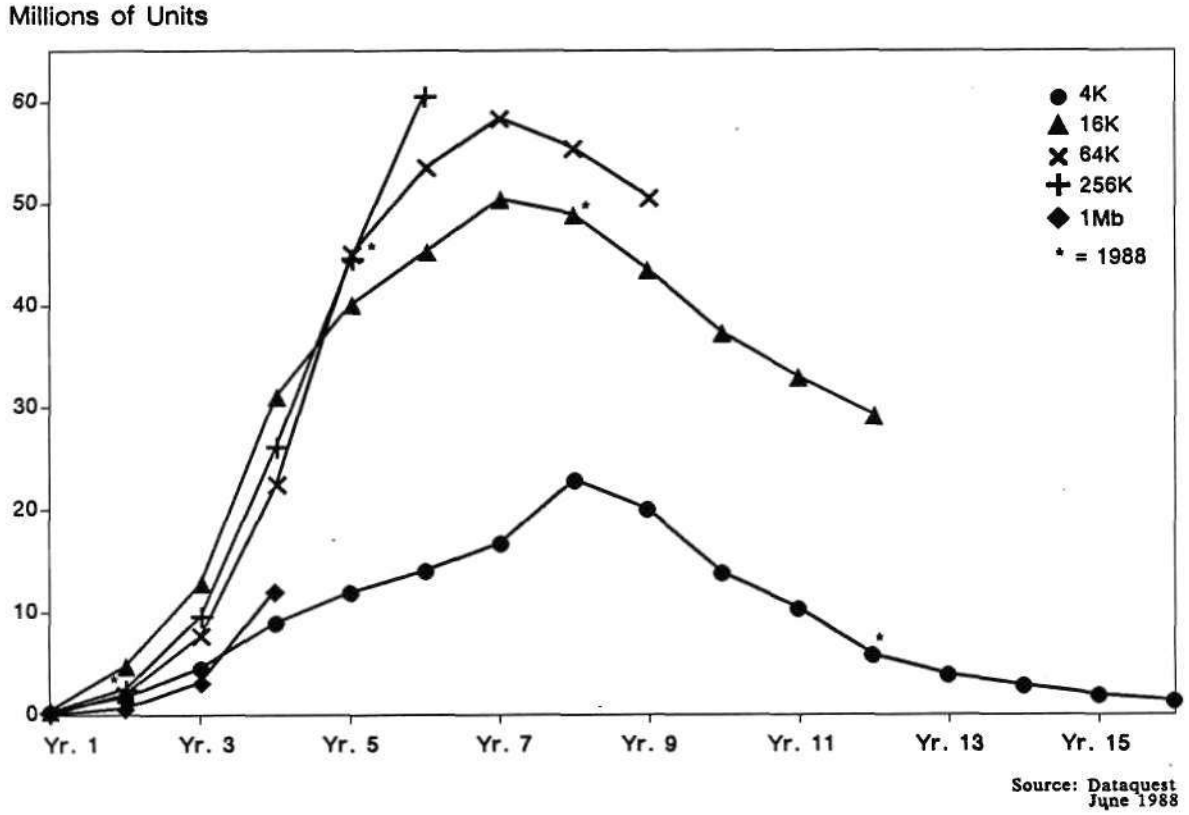
- The peaks of fast SRAMs are much more rounded in comparison with slow SRAMs or DRAMs. These flatter peaks are a result of each fast SRAM density being made up of a variety of speeds. Each density's life cycle consists of overlapping and smaller life cycles of different speeds. Thus each density's peak is an aggregate of smaller markets, not dependent on a single market like other memories.

- With each increasing density, Dataquest believes that the unit peak will rise. This increase is caused by the development of new fast SRAM applications as the price-to-performance ratio improves and as systems demand more high-speed memory.

- As finer line geometries are required to manufacture fast SRAMs at each generation, the development of larger densities will become more difficult and costly, resulting in slower growth rates at introduction as densities increase.

Figure 2

Fast MOS SRAM Product Life Cycles by Density



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Fast MOS SRAM—Product Life Cycles

The Product Life Cycle through Time

The behavior of each density's life cycle through time is shown in Figure 3. We believe that the fast SRAM market is speed driven. To show the influence of speed on each density's life, we have annotated the graph with the time at which speed improvements reach early production. The model of process, line geometry, and timing that we used to generate the production schedule of access time reductions will be discussed at more length in the "Technology Trends" section. Some key points that this life cycle illustrates are the following:

- A density's life cycle peak will occur around the same time as the next density's fastest speed equals its own fastest speed. As an example, the 16K peaked in 1987 with its fastest speed in volume production of 15ns, which is a year before the 64K had its 15ns version go into early production. Also, we expect the 64K to peak in 1990—the year that the 256K is expected to be able to match the 64K's fastest speed.

- Dataquest expects that there will be a continuation of the three-year gap between life cycle peaks through the 1Mb level.

- The time between the actual introduction of each new density varies from two to four years. However, because production quantities are sometimes difficult to achieve, a more consistent pattern to note is the one represented by three-year intervals between densities passing the 2 million unit level. This pattern is expected to hold true for the 16K through 1Mb densities.

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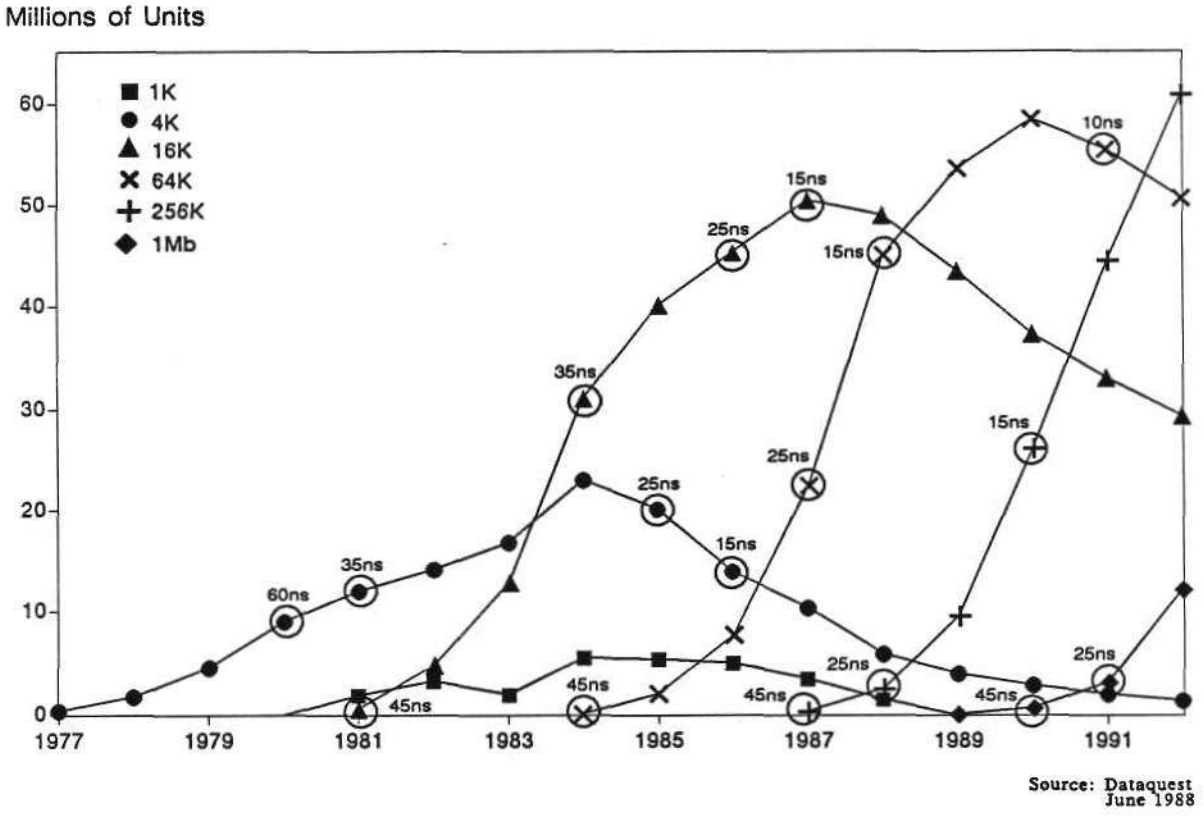
Fast MOS SRAM--Product Life Cycles

Figure 3

Fast MOS SRAM Product Life Cycles through Time



Source: Dataquest
June 1988

Bit-Growth Analysis

Bit growth is a measure of the life cycle of the whole fast MOS SRAM product line. So far, discussion has been limited to life cycles of densities within the fast SRAM family. Although the life cycle of each individual density fluctuates wildly, the bit consumption of fast SRAMs is very stable and consistent. Figure 4 indicates the actual and projected growth in bits from 1977 through 1992.

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Fast MOS SRAM—Product Life Cycles

The fast MOS SRAM bit use increases 10 times every 4 to 5 years. Bit growth is spurred on primarily by the introduction of newer densities. Figure 4 also shows that the market's average density use has increased by four times about every four years. The 4K density was the most popular device from 1977 to 1981; in 1985 the 16K became the most-used density; in 1989 we expect it to be the 64K; and the 256K will most likely be the most frequently used density in 1993. This trend means that although the lower densities play an important role in the fast SRAM market, the newer densities will continue to play the most influential part.

Fast SRAMs will be gaining bits from the slow SRAM category as systems demand more performance and as high-volume manufacturing processes yield faster speeds at lower prices. However, we are expecting the development of the specialty memory devices such as FIFOs, dual-port RAMs, and cache RAMs, to encroach on some of the bit growth of standard fast SRAMs. We also expect bit growth to be affected by a slowdown in the unit growth rates of some systems that use fast SRAMs. (For more details on this subject, refer to the "MOS SRAM—Forecast" section.) The transfer of bits from the slow SRAM category is not enough to compensate for the loss of bits to the specialty memory market and the slower unit growth of end-use systems. The result of these factors is the reduced bit-growth rate for the fast SRAM category depicted in Figure 4.

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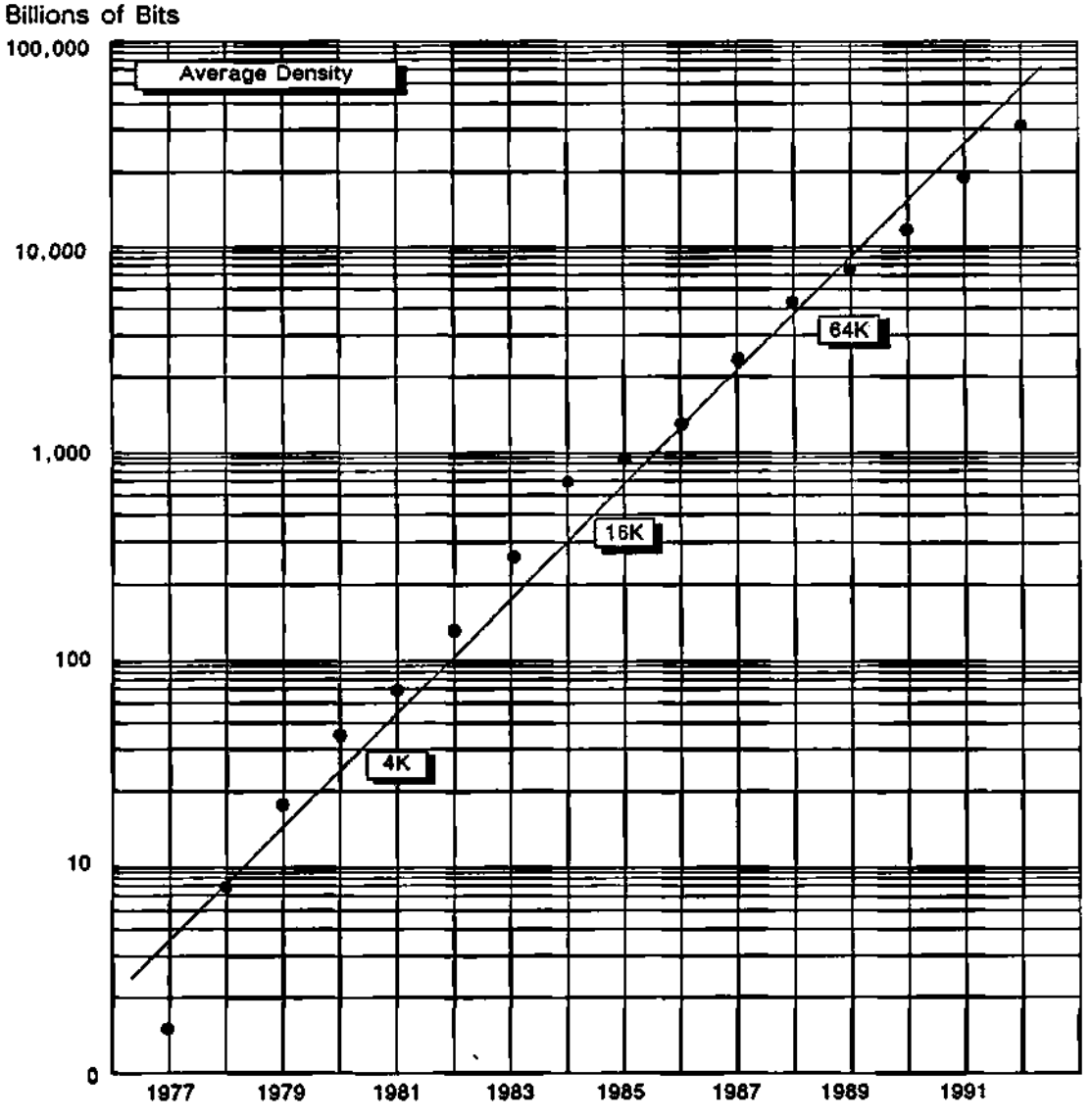
Fast MOS SRAM--Product Life Cycles

Figure 4

Estimated Fast MOS SRAM Bit Growth



Source: Dataquest
June 1988

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Fast MOS SRAM--Product Life Cycles

OVERVIEW OF PRODUCT LIFE CYCLES

Product life cycles are an important element of a company's strategic planning. The value of this planning extends to both semiconductor memory manufacturers and users alike, in the following ways:

- Manufacturers match their planned product life cycles (say, for a 16K high-speed SRAM) with the cycles of the market to determine if the timing of their entry and departure maximizes their revenue and profits.

- Memory users match their system's life with that of its memory components to develop a commodity plan for purchasing and design engineering that maximizes availability of vital components and minimizes cost.

- Manufacturers use life cycles to evaluate the strength of or make plans for their product portfolios.

- Vendors can also control and alter the life cycle, given a thorough understanding of its behavior. The 4K high-speed SRAM, for example, has had an extended life and two peaks in its life cycle.

THE FAST MOS SRAM PRODUCT LIFE CYCLES

Dataquest analyzes three versions of the product life cycle, all derived from the data pool but each presenting a different insight, as follows:

- The stage of each group of fast SRAM devices in the standard product life cycle and the typical interval of each stage

- The actual behavior of the life cycles and how they vary as density increases

- The behavior of the life cycles of each density through time

An analysis of bit growth is also presented and reflects whether total use of fast MOS SRAMs is still increasing or is beginning to saturate.

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Fast MOS SRAM--Product Life Cycles

The Standard Fast MOS SRAM Life Cycle

The typical life cycle for fast MOS SRAMs is shown in Figure 1. Compared to the cycles of other memory devices, the fast MOS SRAM market is resilient. Lower-density devices have extended lives as well as longer maturity and decline stages.

There are reasons for this long life cycle. Dataquest believes that a significant portion of the market needs the faster access time, available in lower densities, more crucially than it needs density. A difference of 10 nanoseconds (ns) is material to many speed-sensitive users, and the market has shown a propensity to forego the higher density and pay a premium for such a difference. There are also abundant applications, especially in control storage, that do not require more density. Finally, the lives of many systems that use fast SRAMs, such as supercomputers, are also long, and the time to support these systems with service repair and replacements is even longer. The manufacturers of these systems are not likely to spend time and money to redesign these mature products.

By 1991, the 1Mb SRAM will be in the ramp stage while the 64K and 256K SRAMs will be in maturity, as shown in Figure 1.

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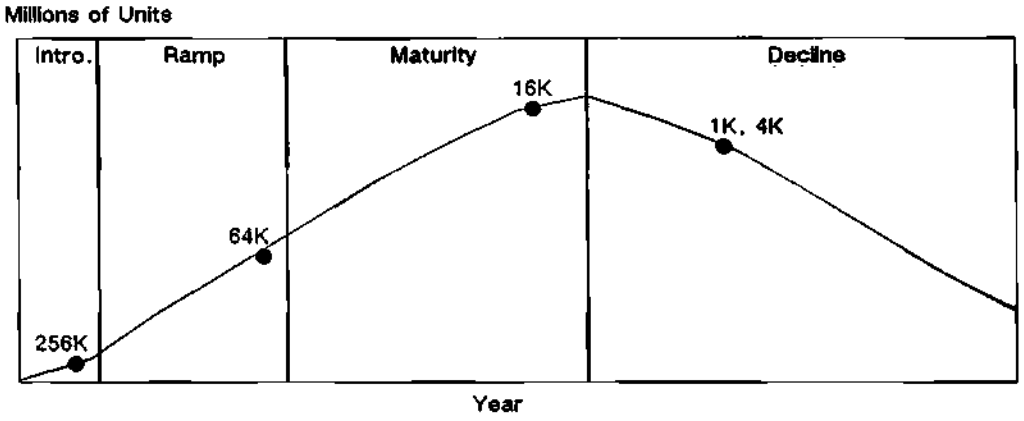
Fast MOS SRAM--Product Life Cycles

Figure 1

TYPICAL FAST MOS SRAM PRODUCT LIFE CYCLES



Stage	Intro.	Ramp	Maturity	Decline
Typical Number of Years	2	3	4	5-6
1986 Products	256K	64K	16K	4K 1K
1987 Products	256K	64K	16K	4K 1K
1991 Products	—	1Mb	256K 64K	16K

Source: Dataquest
April 1987

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Fast MOS SRAM--Product Life Cycles

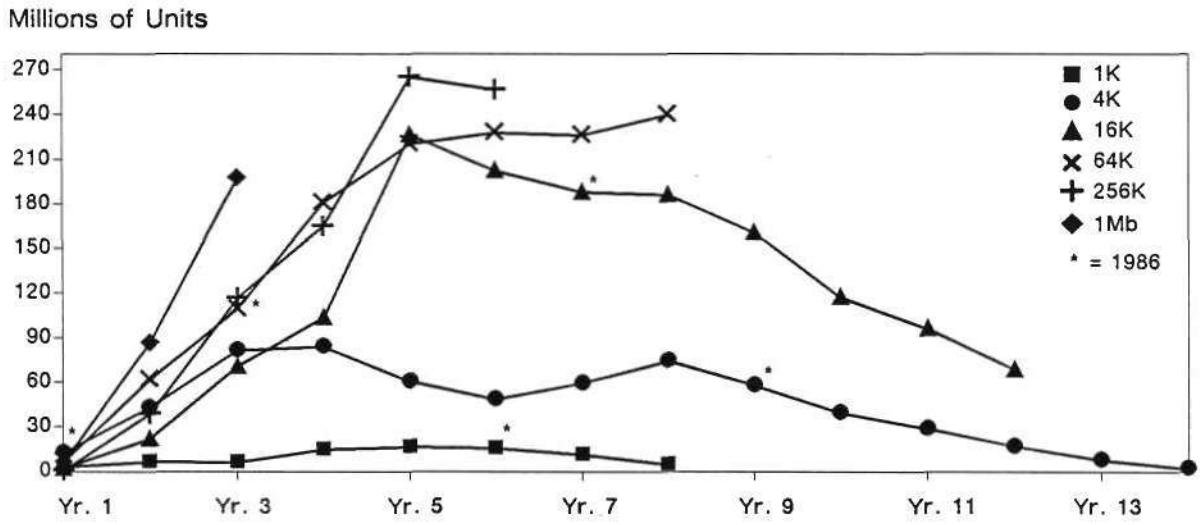
The Product Life Cycles by Density

The actual life cycle curves and how they vary by density are presented in Figure 2. The highlights of these curves include:

- It is possible for the life of a fast SRAM to be extended as in the case of the 4K SRAM. We believe that the second upturn was a result of the availability of faster access times relative to other densities.
- The high peak of 16K SRAMs was not typical; the peak occurred in the boom year of 1984.
- From the 1K SRAM to the 16K SRAM, we can see a long maturity stage of about four years.
- The curves are not as orderly as those for other memory devices because this is a speed-driven market rather than a density-driven market.

Figure 2

FAST MOS SRAM PRODUCT LIFE CYCLES BY DENSITY



Source: Dataquest
April 1987

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Fast MOS SRAM--Product Life Cycles

The Product Life Cycles through Time

The behavior of each density's life cycle through time is shown in Figure 3. Highlights include:

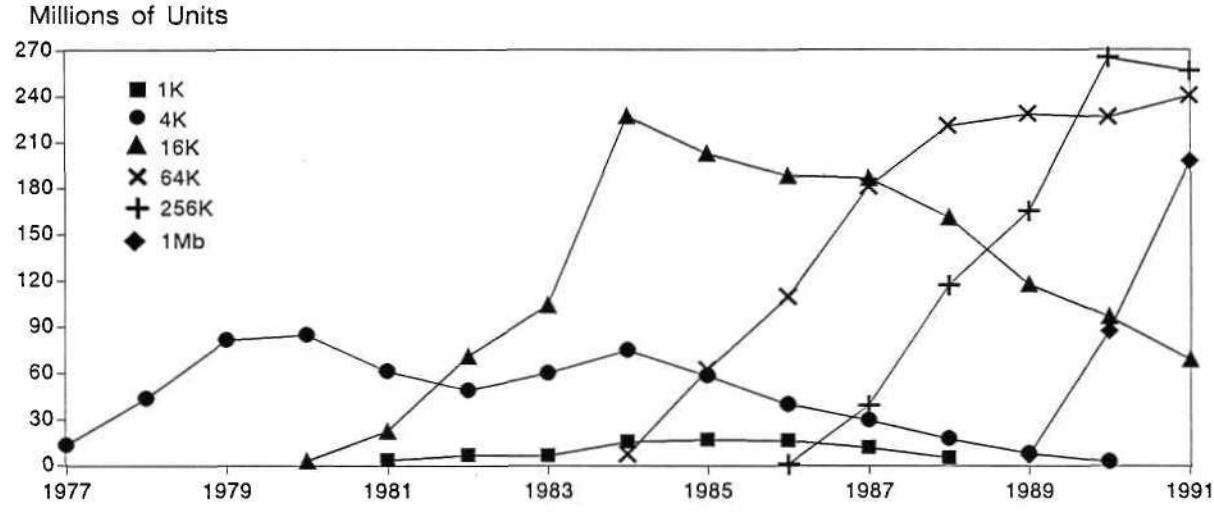
- The intervals between new density introductions are shrinking. As more U.S. companies join the fast SRAM market, the drive to introduce newer products intensifies.

- The ramp of newer products is expected to come sooner because access times of newer densities are close to those of preceding densities early in the life cycle. Many vendors, for example, are expected to release 35ns 256K SRAMs in 1987.

- The peak of each succeeding density is not increasing as substantially because of the large residual market that does not need to upgrade to the next density as quickly as in slow SRAMs or DRAMs.

Figure 3

FAST MOS SRAM PRODUCT LIFE CYCLES THROUGH TIME



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April 1987

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Fast MOS SRAM—Product Life Cycles

- The emergence of BICMOS and novel memory cell structures that are projected to near bipolar speeds at CMOS power dissipation levels is expected to cause the steeper ramps of the 256K and the 1Mb SRAMs. These densities are not likely to be achieved with pure bipolar technology.

BIT-GROWTH ANALYSIS

Bit-growth analysis looks at the life cycle of the whole fast MOS SRAM product line. So far, discussions have been limited to life cycles of devices within the fast SRAM family. Figure 4 shows the actual and projected growth in bits from 1977 to 1991.

Fast MOS SRAM bits are increasing by more than 10 times every four years, which is an impressive growth and does not show signs of weakening through 1991. The nature of this bit growth is changing, however. Figure 4 shows how the market's average density is increasing along the bit curve. From 1977 to 1981, 4K SRAMs were the major products used; the bit growth came from the increased use of this density. The next five years show the influence of 16K SRAMs. We expect the average density to hit 64K in a shorter interval of three years.

Dataquest believes that the coming years will see an acceleration in the use of higher densities and that these new densities will have faster introductory speeds than their predecessors. The future bit growth will accelerate slightly because it will come both from increased use of individual densities and from a faster acceptance of higher ones.

There are dark horses in the fast SRAM forecast and this life cycle analysis. They are the emergence of BICMOS and other novel memory cells and the growing market for specialty memories that are currently proliferating in this market. Although they have been incorporated into the forecast and life cycle curves, they possess a potential for increased contribution to this market.

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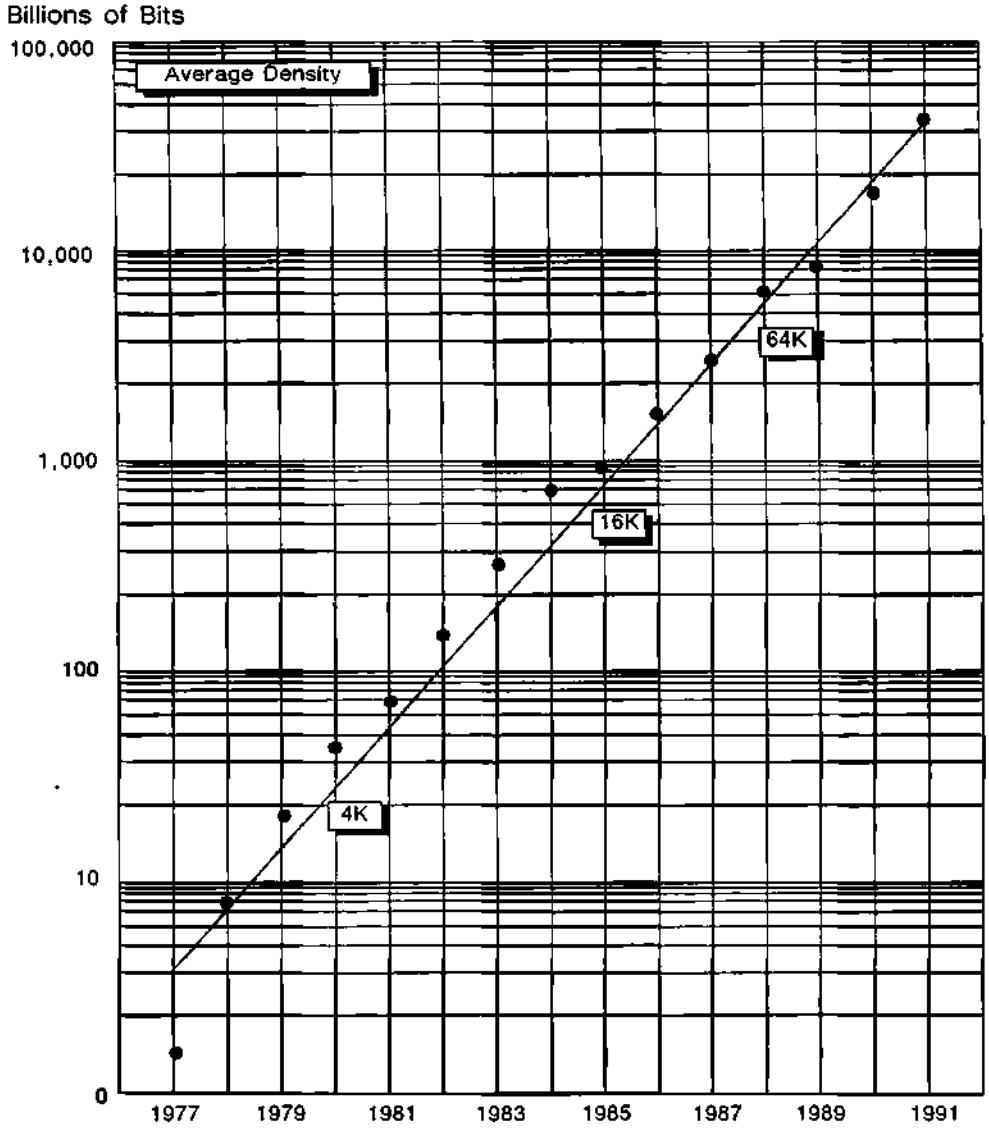
Fast MOS SRAM--Product Life Cycles

Figure 4

ESTIMATED FAST MOS SRAM BIT GROWTH



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Fast MOS SRAM--Product Life Cycles

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Fast MOS SRAM--Price Learning Curves

OVERVIEW

Price learning curves can be a useful aid in forecasting and interpreting reasons for price fluctuations. Price learning curves illustrate both the relationship between the reduction of average selling prices (ASPs) as production volume increases, and how prices are influenced by extraneous market conditions. External forces in the marketplace can take the form of government intervention, competition, substitute technology, supply and demand, and general economic conditions.

The purpose of this section is to demonstrate the use of price learning curves for the fast MOS Static RAM (SRAM) market, Figure 1, and the 4K, 16K, and 64K fast SRAM densities, Figures 2, 3, and 4, respectively. These curves are generated by plotting the accumulated bits shipped against the millicents per bit on a log-log scale. The accumulated bits are derived from unit shipments, and millicents per bit is a reflection of ASPs and density.

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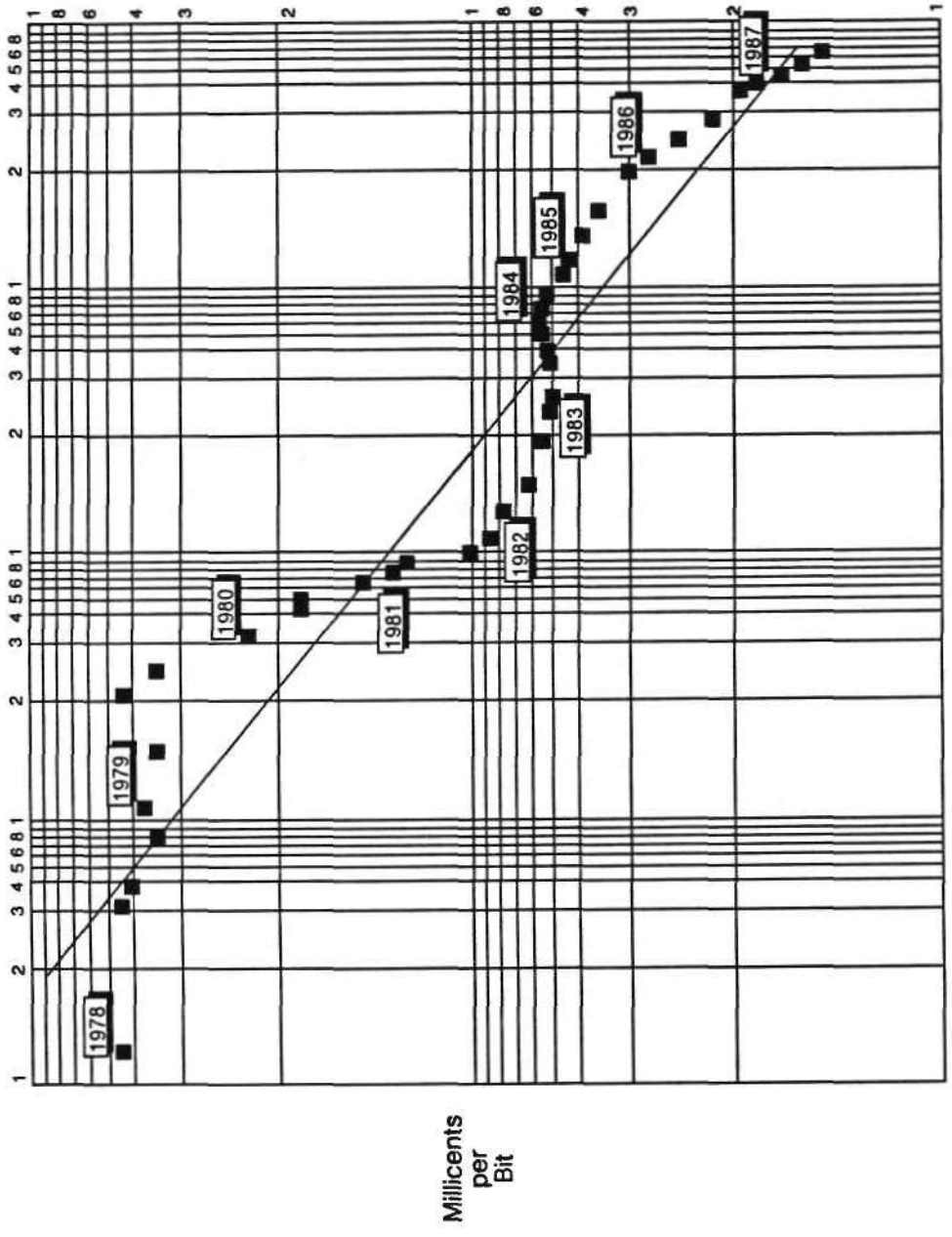
Fast MOS SRAM--Price Learning Curves

Figure 1

Fast MOS SRAM
Price Learning Curve



Source: Dataquest September 1988

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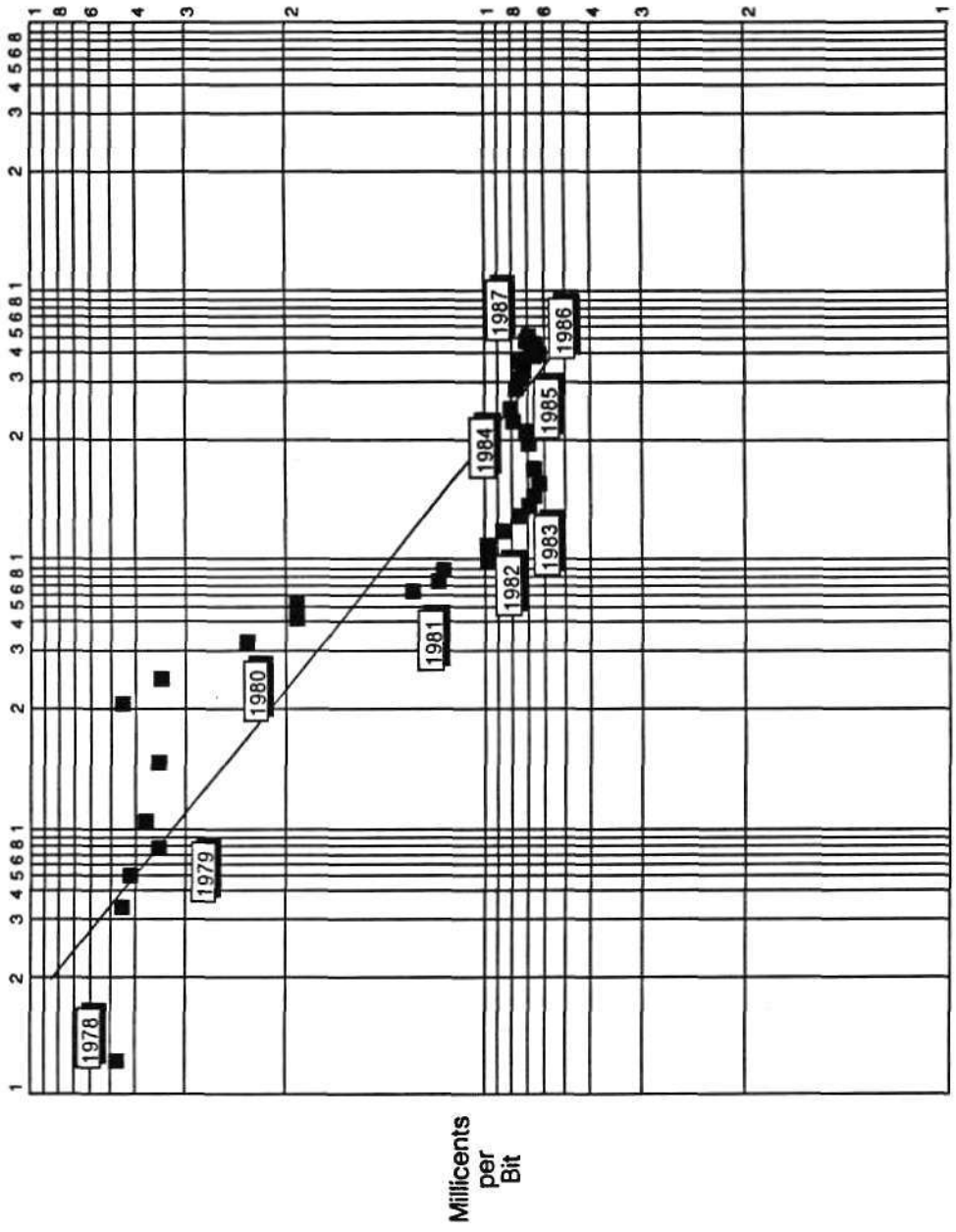
Fast MOS SRAM--Price Learning Curves

Figure 2
4K Fast MOS SRAM
Price Learning Curve



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Fast MOS SRAM--Price Learning Curves

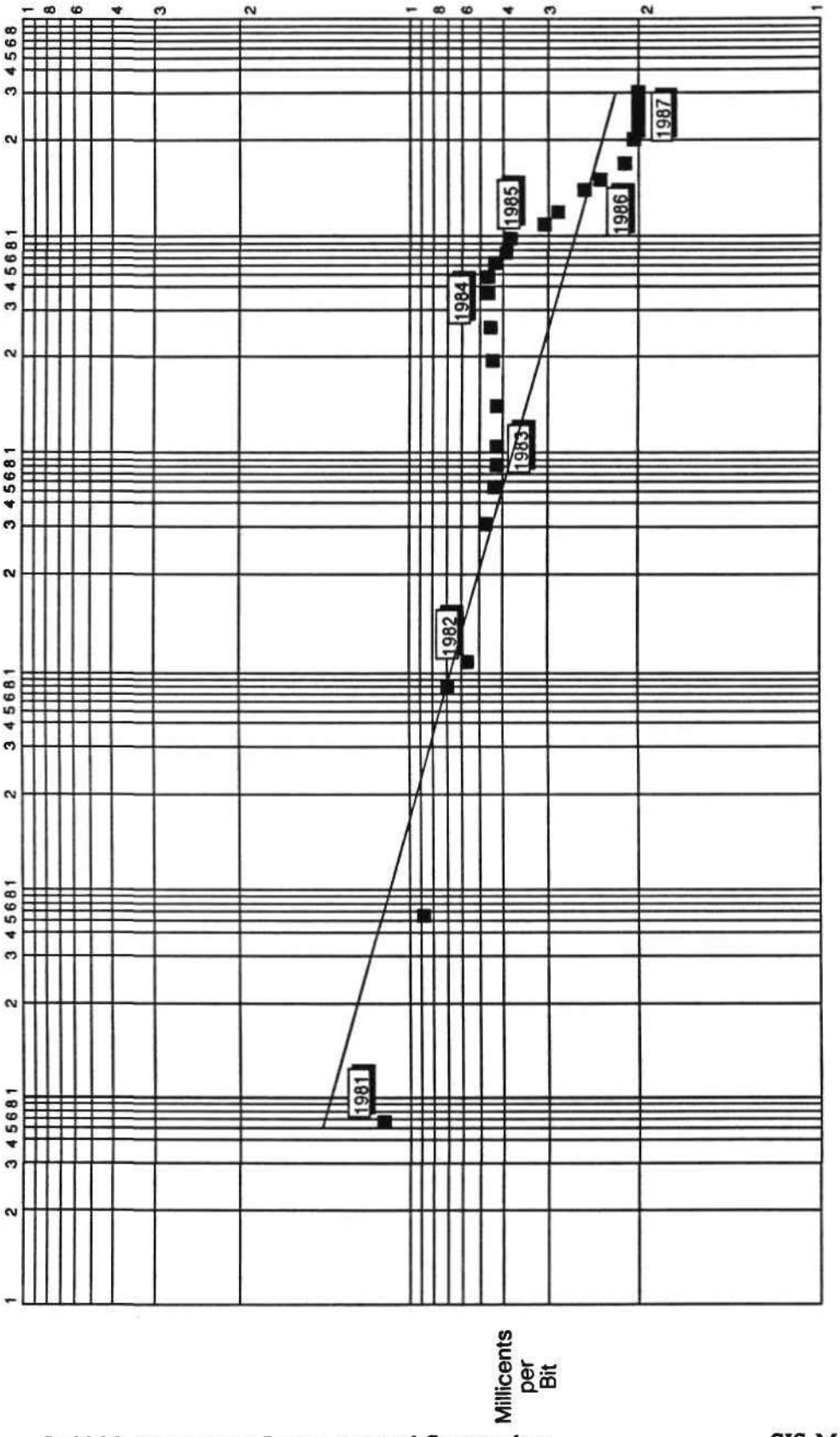

Figure 3
16K Fast MOS SRAM
Price Learning Curve

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Fast MOS SRAM--Price Learning Curves

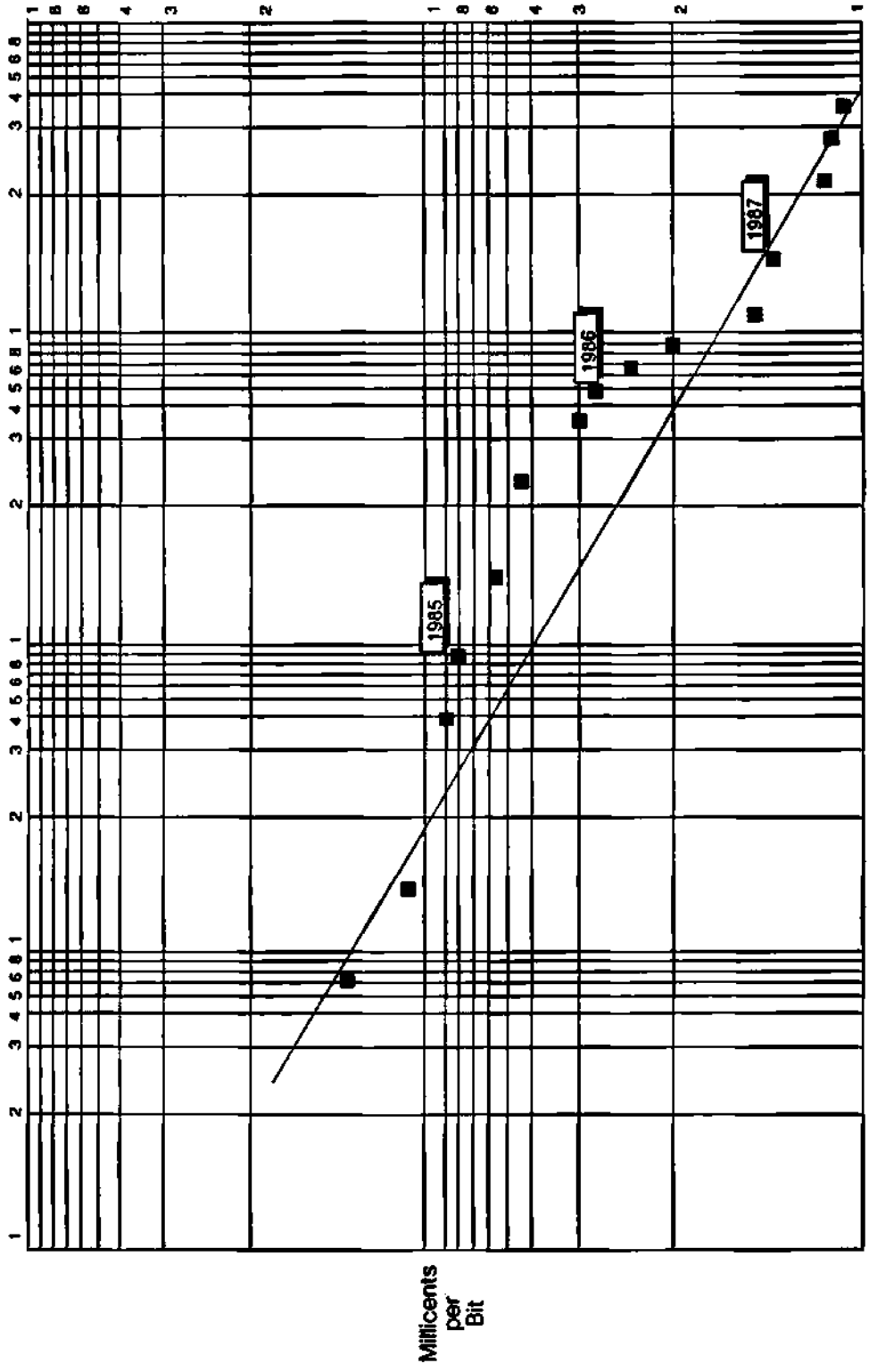

Figure 4
64K Fast MOS SRAM
Price Learning Curve

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Fast MOS SRAM--Price Learning Curves

HIGHLIGHTS

The slope of the average curve illustrates the typical price reductions that take place over time. For the fast SRAM market, consisting of the 4K through the 256K densities, the average price learning curve slope is 72.4 percent. The slope is calculated by dividing the price per bit at a given volume by the price per bit at half that volume. A slope of 72.4 percent means that as the volume doubles, the price of fast SRAMs is reduced by 27.6 percent. The typical slope for a memory product usually falls between 70 and 80 percent. The fast SRAM market has a steep slope because of the heavy influence of the 4K density. The 4K, which dominated the fast SRAM market until 1981, had a slightly different cost structure because its manufacturing process had been proven and established for the most part by the 16K DRAM and 4K slow SRAM, allowing it to fall down the learning curve more quickly. Also, the competitive environment during the 4K's ramping phase, from the second half of 1979 through 1982, contributed to the steepness of the slope. As a comparison, fast SRAMs without the 4K density has a more shallow price learning curve slope of 88.2 percent.

The price learning curve for the fast SRAM market, shown in Figure 1, can be broken down into four segments, with the first segment beginning in 1978 and continuing through the first half of 1979. During this time the slope was a shallow 91.4 percent. Intel controlled the market and had very little competition, so there was no need to be price aggressive. In the next segment, through 1982, the price learning curve had a slope of 53.1 percent. During this time, other suppliers began to grab the 4K market share and the 16K began to be a real threat to the 4K's dominance. Both of these factors resulted in increased price competition.

The next two segments were influenced by the 1983 boom and the following slowdown. Starting in 1983, the total fast SRAM market cost per bit remained almost constant because of the increased demand and the dominance of the 16K density. In the second half of 1984, the supply of fast SRAMs began to outstrip demand and prices decrease quickly. Prices continued to decline at a rapid rate though 1987, spurred on by the introduction of the 64K density and the increased number of suppliers. The slope from the second half of 1984 through 1987 was a steep 64.1 percent.

The 16K, Figure 3, is characterized by a much shallower slope of 88.8 percent. This obtuse slope results from a few suppliers dominating the 16K market in its early development. From 1981 through 1983 the top three suppliers controlled over 85 percent of the market, lessening the necessity for price competition. The 64K density, Figure 4, has a more acute slope, measuring 73.7 percent. Being introduced in 1984 when market prices were quickly deteriorating, plus the higher number of suppliers, helped drive the 64K price down faster than the 16K.

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Fast MOS SRAM--Price Learning Curves

DATAQUEST ANALYSIS

Because of the fast SRAM's relatively high ASPs and the diversity of supplier nationality, Dataquest believes that the United States/Japan trade agreement, and the strengthening of the Japanese yen on the world market, will have only a limited effect on fast SRAM prices. Most fast SRAMs have not experienced the drastic increases in ASPs as the DRAMs and slow SRAMs have as a result of the trade agreement. But the agreement may influence the future rate of price decline and the depths to which fast SRAM prices will fall.

For the most part, extra costs associated with manufacturing in a single region will have to be absorbed by the supplier to maintain a competitive market price. The older, less cost-efficient technologies (like the 70 to 45ns 16K density) have been affected the most by the aforementioned market conditions. Because there is less profit margin to absorb any cost increase, prices of 16K fast SRAMs from Japan-based companies have been forced upward.

Through 1988, we see fast SRAM prices stabilizing and not falling as quickly as they did in 1987. This trend is expected to continue until the second half of 1989, at which time we expect a slowdown in the market to cause prices to decrease at a quicker rate.

Fast SRAM pricing is more resistant than other commodity memories to fluctuations in the market because it is technology driven. Constant speed improvements extend product life cycles and keep the average price per density from falling quickly. We foresee technological improvements (like the reduction of line geometries) and advanced process techniques (like BICMOS) becoming increasingly important to suppliers that want to maintain a leading edge position. Building of facilities and the installation of new equipment needed to manufacture in submicron geometries, and solving the technical and reliability problems involved in high performance processes, carry a very heavy price tag. These extra costs will have to be passed on to users in the form of higher prices, especially for devices at the very fast 25ns and below access times.

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Slow MOS SRAM--Products/Suppliers

INTRODUCTION

The product matrix shown in Table 1 can be used to evaluate slow static RAM (SRAM) products currently being manufactured by SRAM suppliers. The matrix includes the organizational structures for the 16K, 64K, and 256K SRAM densities.

Table 1

SLOW MOS SRAM PRODUCT MATRIX

Density	Process	Org'n	Max. Acc. Time (ns)	No. of Pins	Package	Special Features
16K	NMOS	2Kx8	70	24	DIP	
				32	LCC	
	CMOS	2Kx8	70	24	DIP	300 mil skinny DIP
				32	LCC	available
				24	SOP	
64K	CMOS	8Kx8	70	28	DIP	400 mil thin and
				28	SOP	300 mil skinny DIP
				32	LCC	available
				32	PLCC	
256K	CMOS	32Kx8	85	28	DIP	400 mil thin or
				28	SOP	skinny DIP
				32	LCC	available

Source: Dataquest
May 1987

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Slow MOS SRAM--Products/Suppliers

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Slow MOS SRAM--Product Life Cycles

OVERVIEW

Product and product line life cycles are important elements of a company's strategic planning. The value of this planning extends to both semiconductor memory manufacturers and users alike, in the following ways:

- Memory manufacturers can match the planned product life cycles (for instance, a 256K SRAM) with the cycles of the market to determine if their introduction and phase-out timetables maximize their revenue and profits.
- Memory users can match their system's life and redesign schedules with that of its memory components to develop a plan for purchasing and design engineering that maximizes availability and minimizes costs.
- Semiconductor manufacturers can use life cycles to evaluate the strength of, or make plans for, their product portfolios.
- Vendors can also control and alter the life cycle, given a thorough understanding of its behavior.

Dataquest analyzes three versions of the product life cycle and the product line bit growth. All four are derived from the same pool of data, but each presents a different insight. In this section we will review the following:

- The standard slow MOS SRAM life cycle
- The product life cycle by density
- The product life cycle through time
- The bit-growth analysis

The Standard Slow MOS SRAM Life Cycle

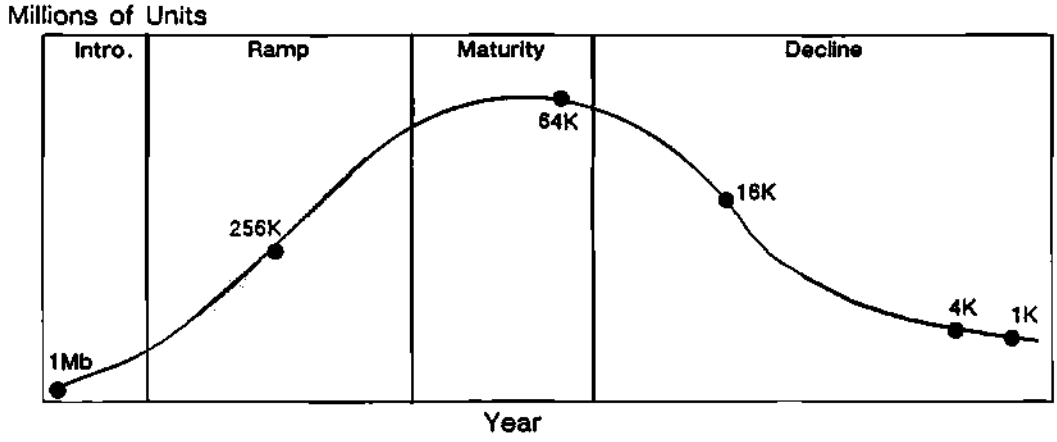
The typical life cycle of the slow MOS SRAM is shown in Figure 1. The slow SRAM market, like the DRAM market, is density driven. The introduction of a new density accelerates the maturity and decline of current generations. Therefore, the maturity stage is typically short—approximately two years.

Lower densities tend to linger in the decline stage for several years because of the long life of the systems using them. Also, package size differences can constrain users from upgrading. For example, the 256K is currently being supplied in a 28-pin DIP, while the 1Mb will be in a 32-pin DIP. To migrate to the 1Mb, it will be necessary to redesign the memory boards to accept a larger pin count. Users are not likely to shoulder the expense of redesigning mature systems to accept the larger packages. Instead they will leave the older memories designed in, thus lengthening the product's life.

Slow MOS SRAM--Product Life Cycles

Figure 1

Typical Slow MOS SRAM Product Life Cycle



Stage	Intro.	Ramp	Maturity	Decline
Typical Number of Years	2	3	3	2
1988 Products	1Mb	256K	64K	16K 4K 1K
1989 Products	1Mb	256K		64K 16K 4K
1992 Products	4Mb	1Mb		256K 64K 16K

Source: Dataquest June 1988

In 1988, the 256K will reach the middle of its ramping phase and the 64K will achieve the peak of its unit life cycle. The 1Mb will begin sampling in the second half of 1988, while the 4K and the 1K will continue to slide farther down the decline phase of their life cycles.

Dataquest expects that by 1992, the 4Mb will be in its second year of introduction and the 256K will enter its first year of the decline phase. By that time, the 4K and the 1K are expected to be completely phased out of volume production.

The Product Life Cycle by Density

The actual life cycle curves and how they vary by density are presented in Figure 2. The curves show the following distinct trends:

- Dataquest believes that the 16K SRAM peaked earlier than it normally should have, due to the 1984 boom year. Under normal circumstances, the part would have peaked the following year, in 1985.

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Slow MOS SRAM--Product Life Cycles

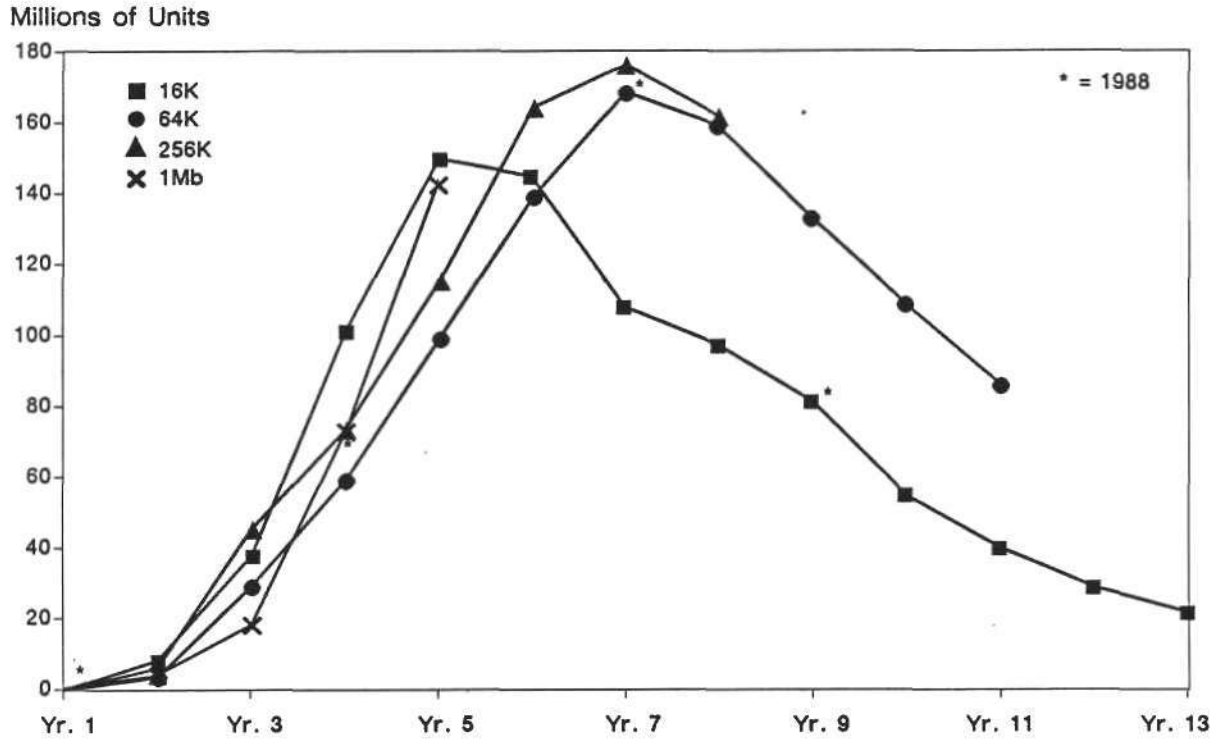
- The 64K is expected to peak in the seventh year because of continued demand. The strong demand is caused by both a shortage of 256K slow SRAMs and a healthy market for the systems in which they are used.

- The 256K devices are also expected to peak in the seventh year. The product shortages in the early stages of their development and increased demand have lengthened their life cycle. The product shortages are the result of manufacturing capacity being transferred away from the 256K slow SRAM and toward the ramping of the 1Mb DRAM. The increased demand for the 256K is due to its use in high-growth markets, such as laptop PCs.

- Dataquest believes that the unit life cycle peak will rise with each increasing density. This is caused by the development of new slow SRAM applications as their price-to-performance ratio improves and as systems demand more memory.

Figure 2

Slow MOS SRAM Product Life Cycles by Density



Source: Dataquest
June 1988

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Slow MOS SRAM--Product Life Cycles

The Product Life Cycle through Time

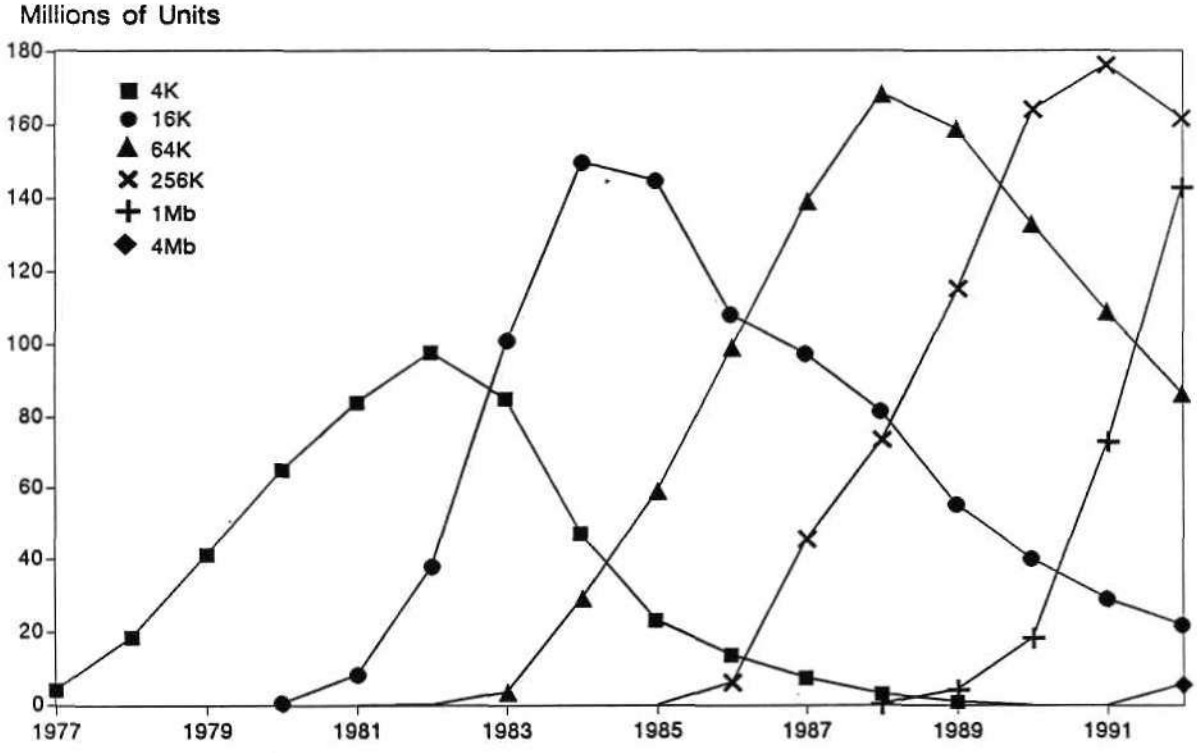
The behavior of each density's life cycle through time is shown in Figure 3. Some of the key points to note are:

- There was a two-year delay between the introductions of the 16K and the 64K densities. However, the gap between the introduction of the 256K and the 1Mb densities has stretched to three years, and we expect the 4Mb to follow the same pattern. The reason for the increased time between generations is that it is becoming more difficult and costly to make the reductions in line geometries necessary for the fourfold jumps in density.

- Dataquest expects that the three-year span between life cycle peaks will continue through the 1Mb level. If the 16K had not peaked a year early due to market conditions, the cycle would remain unbroken from the 4K to the 1Mb.

Figure 3

Slow MOS SRAM Product Life Cycles through Time



Source: Dataquest June 1988

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Slow MOS SRAM--Product Life Cycles

Bit-Growth Analysis

Bit growth is a measure of the life cycle of the whole slow MOS SRAM product line. So far, discussion has been limited to life cycles of densities within the slow SRAM family. Although the life cycle of each individual density fluctuates wildly, the bit consumption of total slow SRAM market is very stable and consistent. Figure 4 indicates the actual and projected growth in bits from 1977 to 1992.

The slow MOS SRAM bit usage increases 10 times every 4 to 5 years. Bit growth is spurred on primarily by the introduction of newer densities. Figure 4 also shows the market's average density usage has increased by fourfold every three years from the 1K to the 64K densities. However, between the 64K and the 256K density, the gap has lengthened to four years. This longer delay between the changing of average densities is a result of the increasing number of lower-density devices remaining in the market.

Dataquest expects that as systems demand more performance and as high-volume manufacturing processes yield faster speeds at lower prices, slow SRAM bits will begin to be transferred into the fast SRAM category. We also expect bit growth to be affected by a slowdown in the unit growth rates of some systems that use slow SRAMs. (For more details on this subject, refer to the "MOS SRAM Forecast" section.) This transfer of bits and the slower unit growth of end-use systems is the reason for the reduced bit-growth rate of the slow SRAM category depicted in Figure 4.

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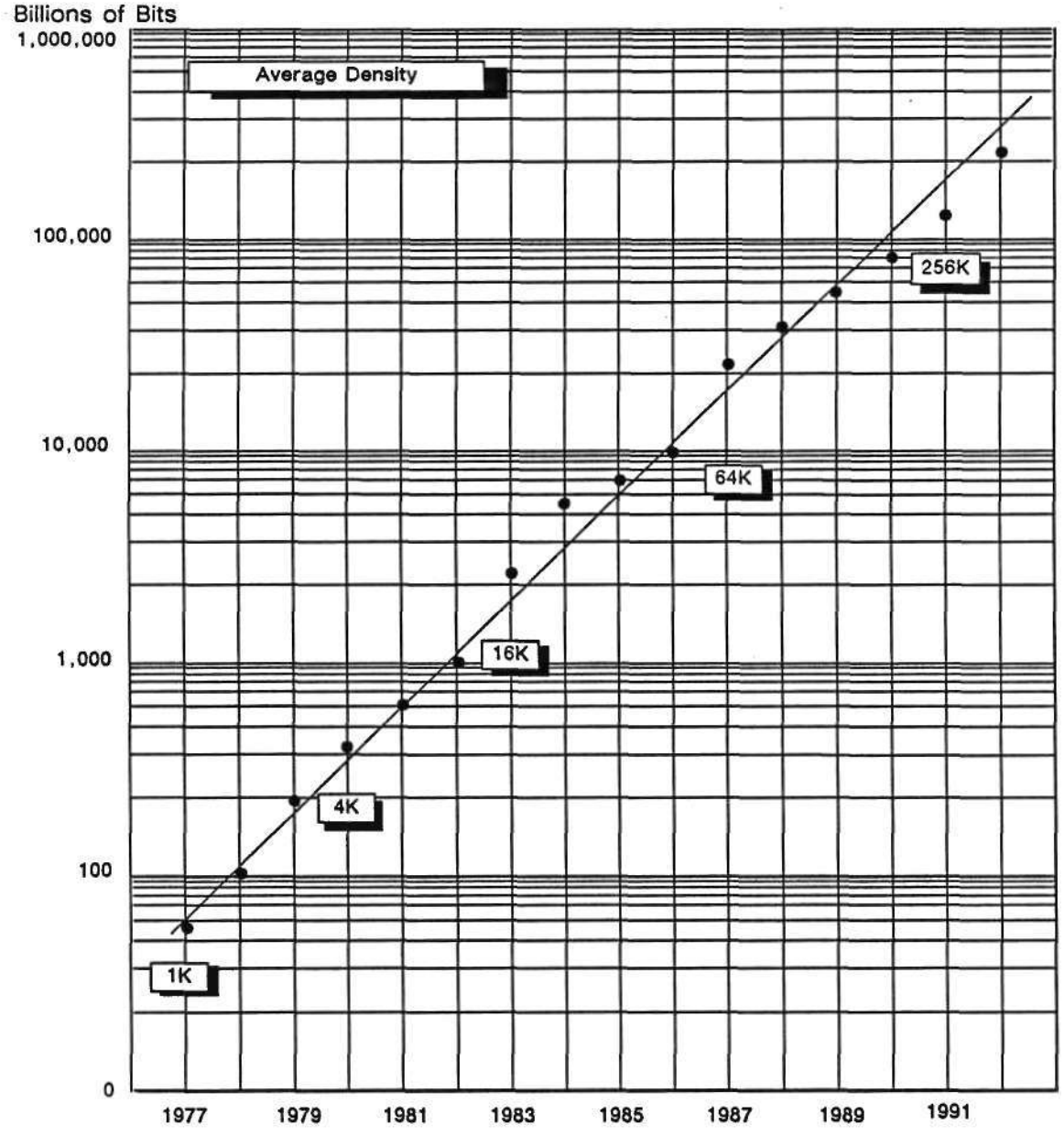
Slow MOS SRAM--Product Life Cycles

Figure 4

Estimated Slow MOS SRAM Bit Growth



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Slow MOS SRAM--Product Life Cycles

OVERVIEW OF PRODUCT LIFE CYCLES

Product life cycles are an important element of a company's strategic planning. The value of this planning extends to both semiconductor memory manufacturers and users alike, in the following ways:

- Manufacturers match their planned product life cycles (say, for a 64K slow SRAM) with the cycles of the market to determine if the timing of their entry and departure maximizes their revenue and profits.
- Memory users match their system life with that of its memory components to develop a commodity plan for purchasing and design engineering that maximizes availability of vital components and minimizes cost.
- Manufacturers use life cycles to evaluate the strength of or make plans for their product portfolios.
- Vendors can also control and alter the life cycle, given a thorough understanding of its behavior.

THE SLOW MOS SRAM PRODUCT LIFE CYCLES

Dataquest analyzes three versions of the product life cycle, all derived from the same data pool but each presenting a different insight, as follows:

- The stage of each group of slow SRAM devices in a standard product life cycle and the typical interval of each stage
- The actual behavior of the life cycles and how they vary as density increases
- The behavior of the life cycles of each density through time

An analysis of bit growth is also presented and reflects whether total use of slow MOS SRAMs is still increasing or beginning to saturate.

The Standard Slow MOS SRAM Life Cycle

The typical life cycle for slow MOS SRAMs is shown in Figure 1. The slow SRAM market is density driven, similar to DRAMs. The introduction of new densities accelerates the maturity and decline of current densities. Therefore, the maturity stage is short--approximately two years.

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Slow MOS SRAM--Product Life Cycles

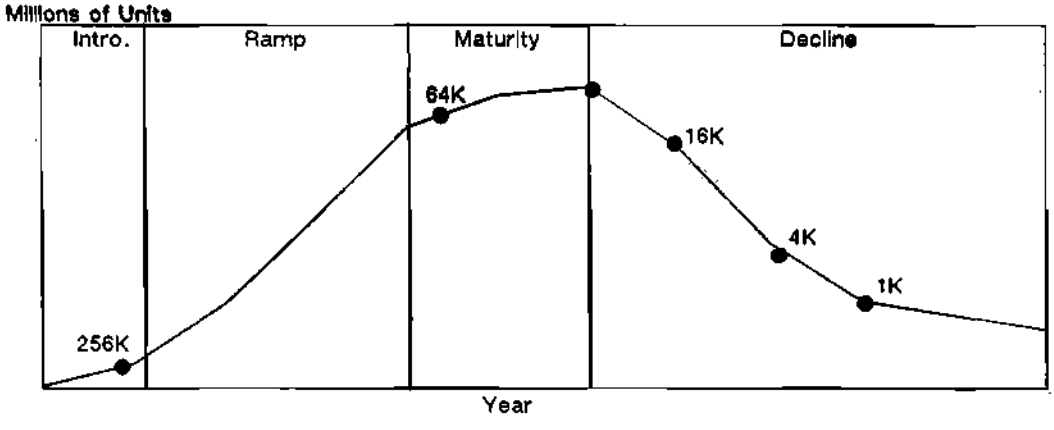
Lower densities tend to linger in the decline stage for several years because of the long life of the systems using them. Package differences between densities also constrain users from upgrading. For example, the 16K SRAM has a 24-pin DIP package while the 64K SRAM has a 28-pin DIP package. To move to the 64K will necessitate a board redesign, which users are not likely to shoulder for their mature systems.

It is interesting to note that there was no product in the ramping up stage in 1986. Manufacturers were attempting to bring the 256K SRAM in sooner, but schedules fell below expectation. High-volume productions only began to accelerate in the second half of the year. This has caused a drop in overall average selling price (ASP) of slow MOS SRAMs in 1986.

Dataquest expects 1987 to have better balance in the life cycle, with the 256K in the ramp stage. We expect 1991 to be a well-balanced year, with every stage loaded properly: the 4Mb SRAM in its introductory phase, the 1Mb SRAM ramping, and the 256K SRAM at maturity.

Figure 1

TYPICAL SLOW MOS SRAM PRODUCT LIFE CYCLES



Stage	Intro.	Ramp	Maturity	Decline
Typical Number of Years	2	3	2	5
1986 Products	256K	—	64K	16K 4K 1K
1987 Products	—	256K	64K	16K 4K
1991 Products	4Mb	1Mb	256K	64K 16K

Source: Dataquest April 1987

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Slow MOS SRAM--Product Life Cycles

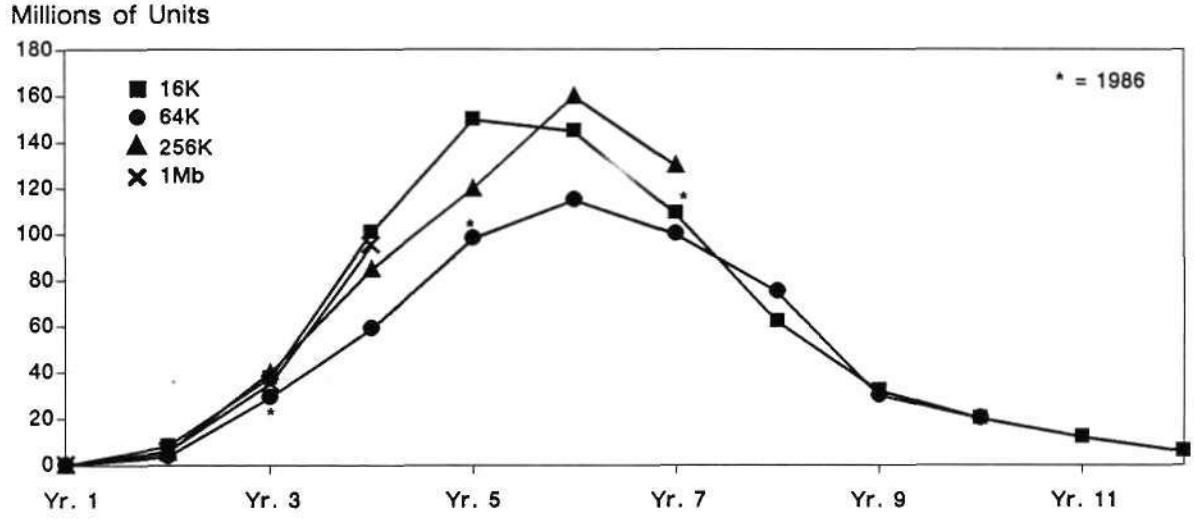
The Product Life Cycles by Density

The actual life cycle curves and how they vary by density are presented in Figure 2. The curves do not show clear trends. Highlights include:

- Dataquest believes that the 16K SRAM peaked sooner because of the boom year of 1984; otherwise, the part would have peaked the year after, in 1985.
- The 64K SRAM, a previously high-priced device, entered the ramp phase during the industry recession of 1985 and 1986, constraining its growth. It is not likely that this density will pick up since the 256K SRAM is already ramping and has crossed over the 64K SRAM on a price-per-bit basis.
- The 256K SRAM and future devices are expected to grow at more normal patterns. We anticipate gradual improvement in the semiconductor industry in 1987 and 1988, which will be the major ramp years of the 256K SRAM.

Figure 2

SLOW MOS SRAM PRODUCT LIFE CYCLES BY DENSITY



Source: Dataquest April 1987

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Slow MOS SRAM--Product Life Cycles

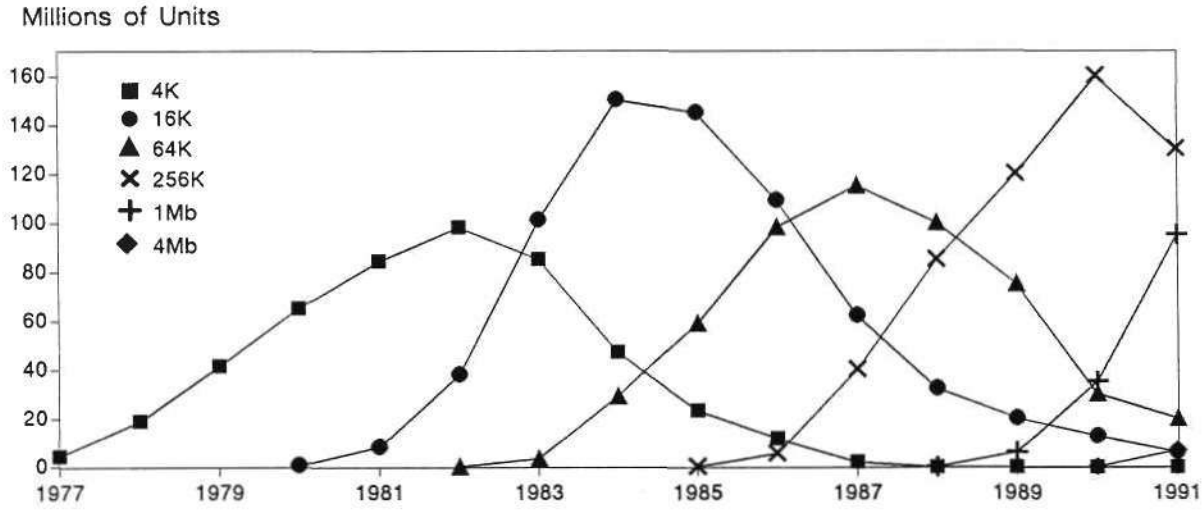
The Product Life Cycles through Time

The behavior of each density's life cycle through time is shown in Figure 3. Highlights include:

- The historically consistent interval of two years between density introductions was cut at the 256K SRAM.
  - The 256K SRAM achieved true production levels three years after the 64K SRAM.
  - The 1Mb SRAM is also expected to be delayed, picking up production in 1988.
  - Dataquest expects the two-year intervals to return at the 4Mb SRAM level.
- The series shows the excessive growth of the 16K SRAM adjacent to the stunted ramp of the 64K SRAM, as explained earlier.

Figure 3

SLOW MOS SRAM PRODUCT LIFE CYCLES THROUGH TIME



Source: Dataquest April 1987

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Slow MOS SRAM--Product Life Cycles

BIT-GROWTH ANALYSIS

Bit growth is a measure of the life cycle of the whole slow MOS SRAM product line. So far, discussion has been limited to life cycles of devices within the slow SRAM family. Figure 4 shows the actual and projected growth in bits from 1977 to 1991.

The slow MOS SRAM bit usage increases 10 times every four years and does not show signs of saturation or weakening. This bit growth is spurred primarily by the introduction of newer densities. The market's average density usage is consistently increasing by 4 times every three years, as shown in Figure 4. Although the life cycle of each density fluctuates wildly, the bit consumption of slow SRAMs is very stable and consistent.

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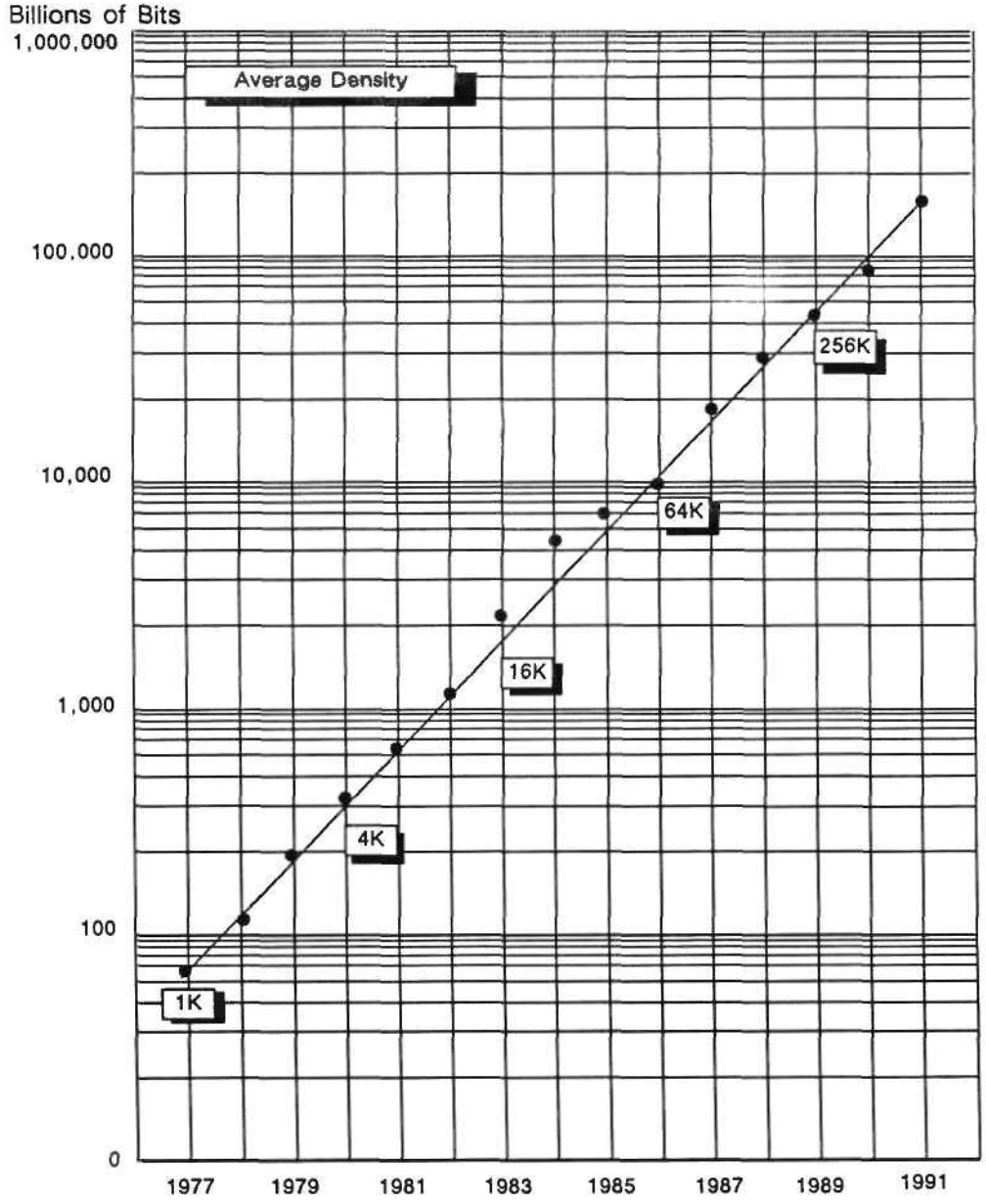
Slow MOS SRAM--Product Life Cycles

Figure 4

ESTIMATED SLOW MOS SRAM BIT GROWTH



Source: Dataquest
April 1987

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Slow MOS SRAM--Price Learning Curves

OVERVIEW

Price learning curves can be a useful aid in forecasting and interpreting reasons for price fluctuations. Price learning curves illustrate both the relationship between the reduction of average selling prices (ASPs) as production volume increases, and how prices are influenced by extraneous market conditions. External forces in the marketplace can take the form of government intervention, competition, substitute technology, supply and demand, and general economic conditions.

The purpose of this section is to demonstrate the use of price learning curves for the slow MOS static RAMs (SRAMs) market, Figure 1, and the 16K and 64K densities, Figures 2 and 3, respectively. These curves are generated by plotting the accumulated bits shipped against the millicents per bit on a log-log scale. Accumulated bits are derived from unit shipments, and millicents per bit are a reflection of ASPs and density.

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Slow MOS SRAM--Price Learning Curves

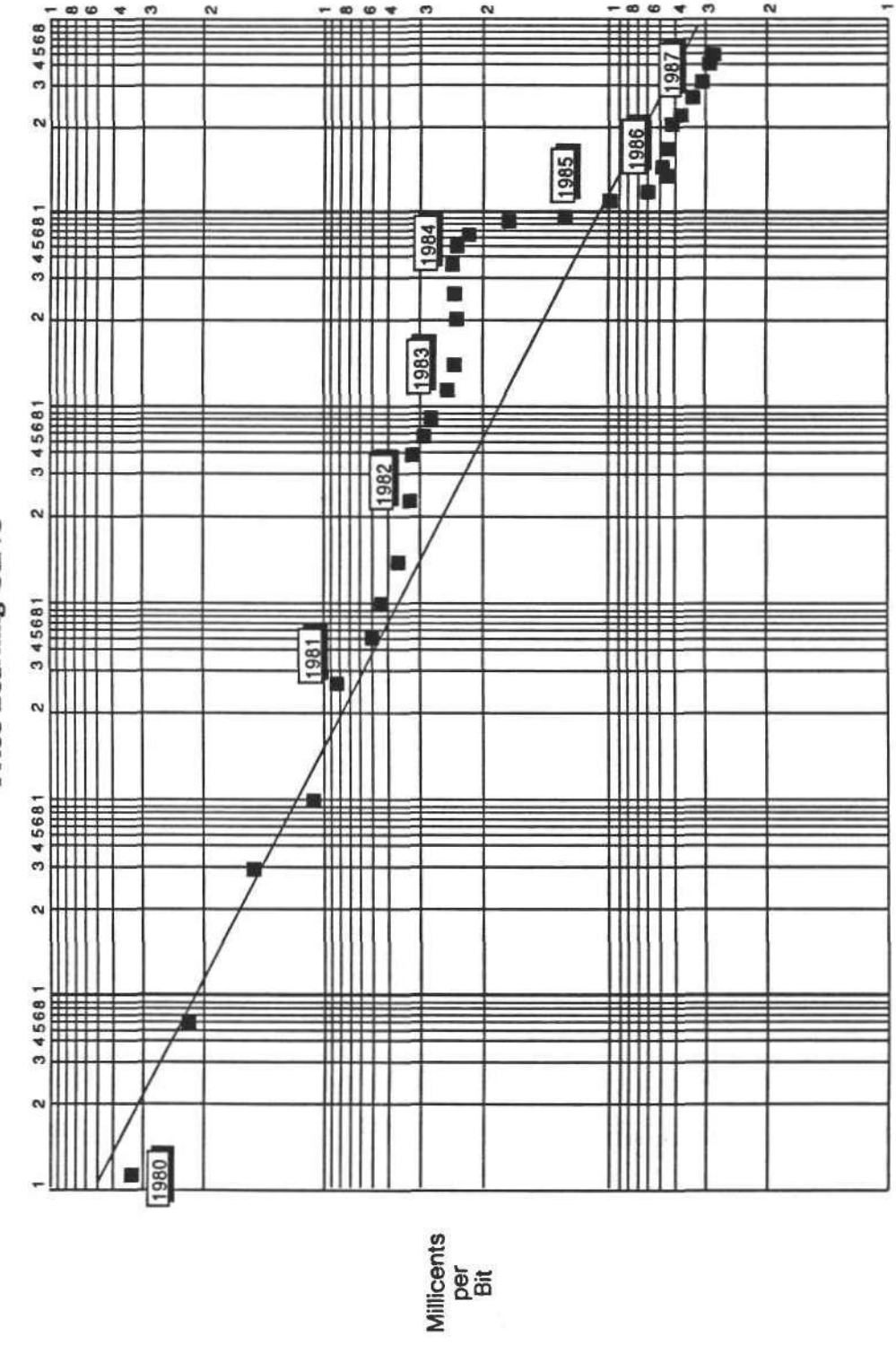

Figure 1

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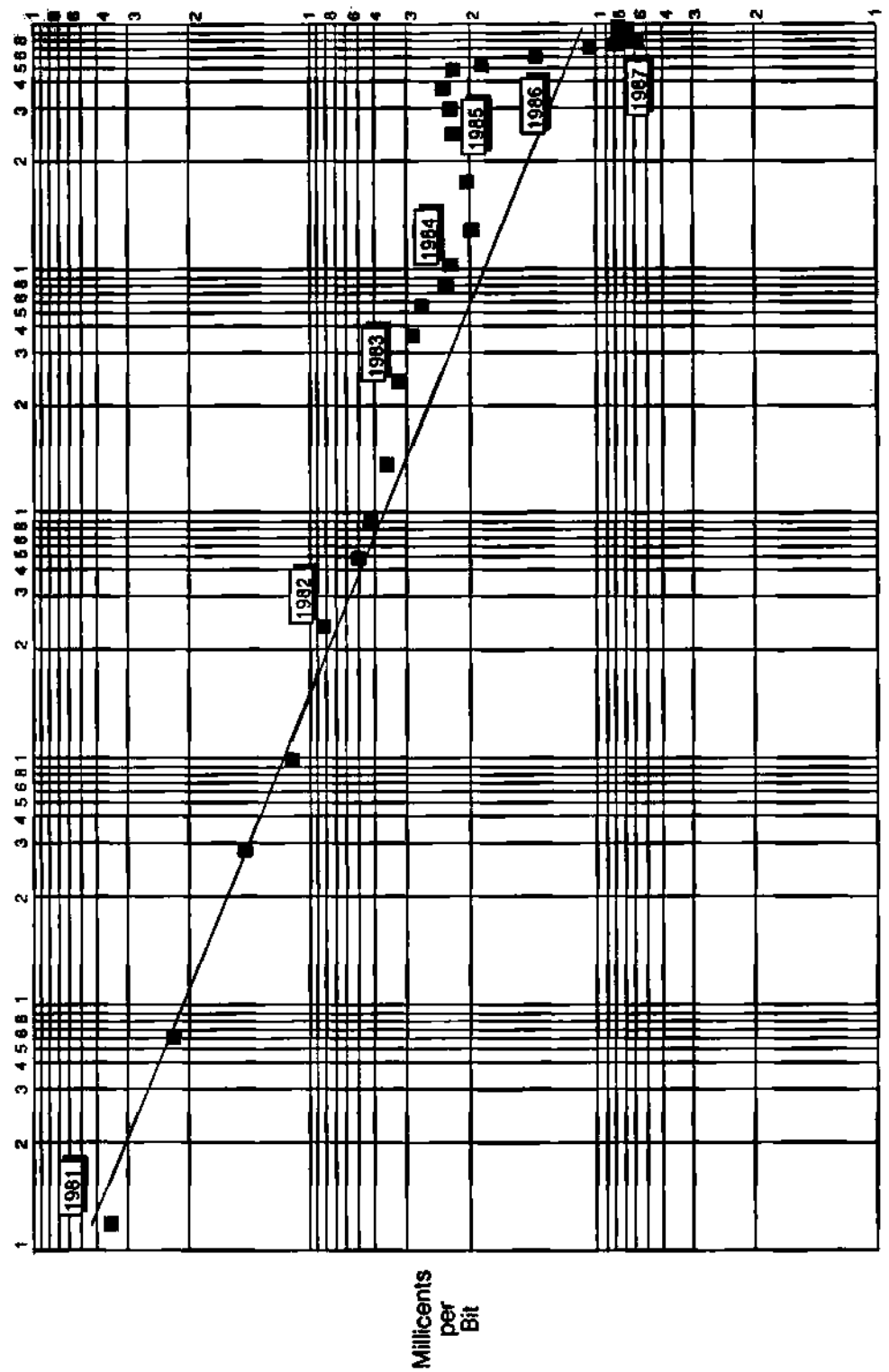
Slow MOS SRAM--Price Learning Curves



Source: Dataquest September 1988

Figure 2
16K Slow MOS SRAM Price Learning Curve

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Slow MOS SRAM--Price Learning Curves

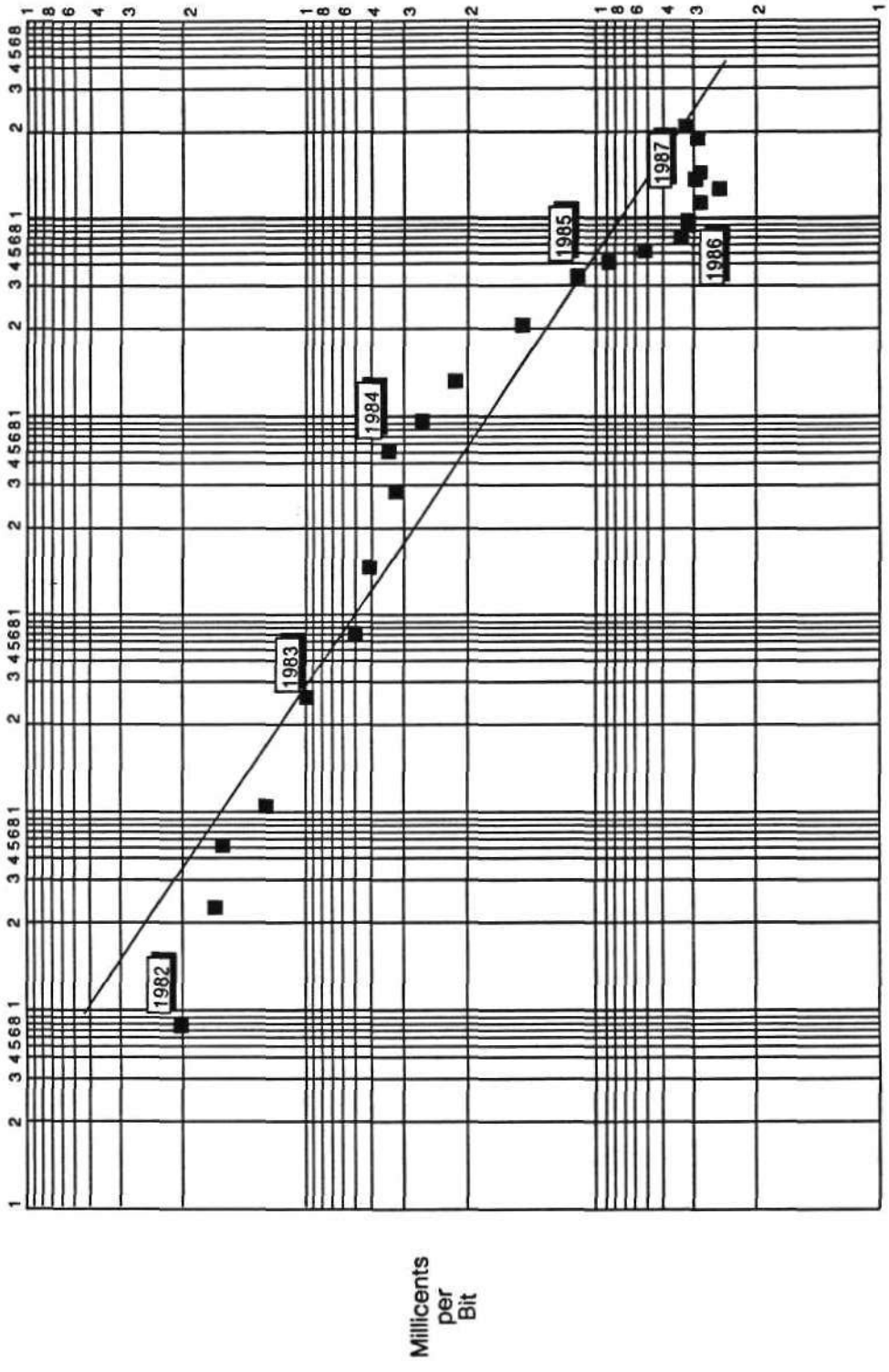

Figure 3
64K Slow MOS SRAM
Price Learning Curve

Source: Dataquest September 1988

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Slow MOS SRAM--Price Learning Curves

HIGHLIGHTS

The slope of the average curve illustrates the typical price reductions that take place over time. For the slow SRAM market, consisting of the 16K through the 256K densities, the average price learning curve slope is 77.4 percent. Smaller densities were not included in this study because their life cycles and pricing structures do not follow the same patterns as the larger ones. The slope is calculated by dividing the price per bit at a given volume by the price per bit at half that volume. The price learning curve slope of 77.4 percent means that as the volume doubles, the price of slow SRAMs is reduced by 22.6 percent. Memory devices typically have a slope of 70 to 80 percent. As a comparison, DRAMs have a steeper slope of 73 percent because their market is more price competitive than the slow SRAM market.

The price learning curve for the slow SRAM market is characterized by four segments. The first segment encompasses 1980 through 1982 and has a shallow slope of 80.8 percent. During this time, the market was dominated by two suppliers, and the technology and acceptance of the 16K density was developing. Both of these factors resulted in a slow rate of decline for market ASPs. The second and third breaks in the curve occur between 1983 and the first half of 1986. Prices during these two segments were affected greatly by fluctuations in demand, resulting from the 1983 market boom, and the following slowdown. Through 1983, the price per bit for slow SRAMs remained almost flat. Between 1984 and the first half of 1986, the slope of the price learning curves steepened to 40.8 percent. The acute slope was caused by the slowdown in consumption, which resulted in an overabundance of slow SRAMs in the market. The fourth break occurred during the last six quarters, when prices normalized below the average market slope, at a pitch of 74.3 percent.

The 16K slow SRAM, Figure 2, has a price learning curve slope of 79.2 percent. The rise of data points in late 1987 is caused by increasing ASPs due to a product shortage. The 16Ks were in short supply because major suppliers were phasing out this product, and other manufactures lagged behind in ramping up production.

The 64K market, Figure 3, is much more price competitive and has a slope of 71.7 percent. Dataquest believes that this price learning curve slope, generated by data collected between 1982 and 1987, is not a good indicator of future pricing. Because of the concerns over profitability brought on in all regional markets by the United States/Japan trade agreement, we believe that prices will rise above the projected average from 1988 on.

DATAQUEST ANALYSIS

In the short term, Dataquest believes that a combination of external market forces will cause prices to decrease at a slower rate than they have during the last 6 quarters. One of the key reasons for the reduced rate of decline is higher prices, resulting from the product shortages currently plaguing the slow SRAM industry in the aforementioned 16K density and higher densities. Since most of the suppliers of slow SRAMs are also

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participants in the DRAM market, their efforts to increase output of 1Mb DRAMs is decreasing their available capacity for the manufacture of slow SRAMs, and is subsequently causing a shortage of the 64K and 256K densities. The rate at which prices decline, and the levels to which they fall, will also be affected by the trade agreement between the United States and Japanese governments. Although slow SRAM prices are not formally controlled under the trade agreement, product shipments to all regional markets are being closely monitored by the Japanese government to ensure that they will not provide grounds for future trade problems. The fact that all of the leaders in the slow SRAM industry are based in Japan, and the recent strengthening of the Japanese yen on the world market, only compounds the problem.

We expect that prices will continue to decrease at a slower rate until the second half of 1989, at which time we believe there will be a slowdown in the electronics market. The slowdown will reduce demand for commodity products and will result in lower prices.

In the long term, Dataquest believes that the previously mentioned trade issues and increasing manufacturing costs will have a heavy influence on prices. To make the four-fold jumps in density it is necessary to reduce the feature size and the line geometries that are used to manufacture slow SRAMs. High-volume production facilities, and overcoming the technical issues that are involved, will require a large capital investment. These costs will be passed on to the consumer in the form of higher average selling prices.

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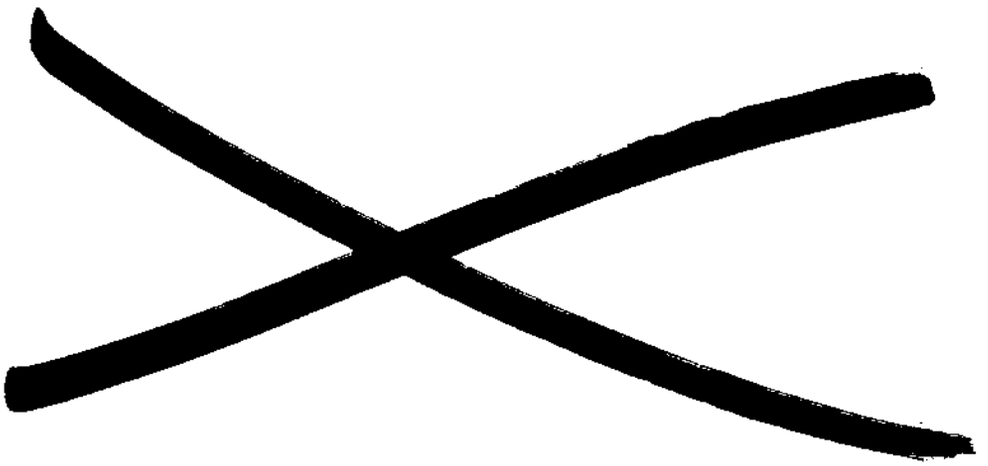

Fast MOS SRAM--Market Shares

OVERVIEW OF THE FAST MOS SRAM MARKET

This section presents an analysis of the fast static RAM (SRAM) market share by company, region, and the top 5 and 10 vendors. In order to interpret our data correctly, it is important to understand the following about how Dataquest defines the market:

- Fast MOS SRAMs are static RAMs with access times equal to or less than 70 nanoseconds (ns).

- All of the fast MOS SRAM market shares are based on the number of bits shipped. The overall company and regional shares, shown in Tables 1 through 4 and Figure 1, are a combination of all densities supplied. To derive a company's or a region's market share, the bit shipments at each density offered are combined with those of the other densities, resulting in the total fast SRAM bits shipped. Percentage of market share then is generated from the number of bits each company or region supplies.

Dataquest chose to base our market shares on bits shipped rather than dollarized units as with the other memories because of the inconsistency of fast SRAM average selling prices (ASPs). ASPs within a single density can vary as much as four times from the slowest to the fastest speed. Also, selling prices for military products, which consume approximately 11 percent of all fast SRAM bits, can be five times the commercial price. Therefore, in order to strip out any ties to company revenue and to provide a uniform basis of comparison, we elected to use bit shipment data.

OVERALL FAST MOS SRAM MARKET SHARES

The following tables present the fast MOS SRAM market share data:

- Table 1—Fast MOS SRAM Market Shares (in Percentages)
- Table 2—Fast MOS SRAM Market Shares (in Bits)
- Figure 1—Fast MOS SRAM Regional Shares (in Percentages)
- Table 3—Fast MOS SRAM Regional Shares (in Bits)
- Table 4—Fast MOS SRAM Top 5 and Top 10 Vendors (in Percentages)
- Table 5—16K Fast MOS SRAM Market Shares (in Percentages)
- Table 6—64K Fast MOS SRAM Market Shares (in Percentages)
- Table 7—256K Fast MOS SRAM Market Shares (in Percentages)

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Fast MOS SRAM--Market Shares

Market Share Highlights

Japan-based suppliers continue to maintain the majority share of the fast SRAM market, as they have since 1982. However, North America- and Europe-based suppliers have been able to maintain a larger presence in fast SRAMs than they have in slow SRAMs or DRAMs. Figure 1 shows how the regional market share has changed over time. The share of Japanese suppliers has grown from 0.3 percent in 1978 to 64.7 percent in 1988; this is down slightly from its high of 67.0 percent in 1987. Dataquest believes that the loss of 2.3 percent of market share was due to the preoccupation the majority of Japanese suppliers had with DRAMs in 1988.

While Japanese suppliers have been gaining market share since 1978, North American suppliers' share has dropped to less than one-fourth its 1978 high. However, since 1984, North American vendor market share has grown from a low of 17.1 percent to 24.4 percent in 1988. This growth is mostly the result of smaller North American companies that built their business by servicing niche markets.

The European supplier base is marked by the consolidation of two of its major players. SGS-Thomson purchased Inmos from Thorn EMI and with SGS-Thomson's previous acquisition of Mostek in 1986, its position was greatly strengthened in the fast SRAM market. In 1988, the European market share increased for the first time since 1983, mostly due to Inmos' presence in the 64K and 16K densities.

Table 4 depicts the positioning of the top 5 and top 10 suppliers over time. In 1988, the market share of the top five suppliers reversed a trend that has held fast since we started tracking the market by supplier in 1978. The share of the top 5 increased; it moved in the direction of a more consolidated market. If this trend continues, it could result in a market that is less amiable to the entry of new and smaller players.

The top position in high-speed SRAMs has changed five times since 1981. Because historically, this market is centered on technological expertise and not volume production, it does not have the long running dynasties of top suppliers that exist in the slow SRAM market. It is difficult to maintain technological leadership in an area that comprises such diverse products. To be number one, a supplier must not only invest on progressing to the next density, but it must also develop speed improvements on existing densities.

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Fast MOS SRAM—Market Shares

Table 1

Fast MOS SRAM Market Shares
(Percentage of Bits)

Company	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
AMD	0	0	0.1%	2.9%	5.0%	5.5%	5.9%	5.9%	4.2%	4.9%	1.8%
AMI	0	0.6%	0	0	0	0	0	0	0	0	0
Cypress	0	0	0	0	0	0	0.2	0.9	5.1	5.1	4.9
EDI	0	0	0	0	0	0	0	0	0	0	0.1
Fujitsu	0	1.7	10.7	13.1	19.9	24.5	27.6	27.4	18.0	19.7	23.3
Hitachi	0	0	0	0	8.4	14.9	15.0	18.0	24.1	17.6	14.5
IDT	0	0	0	0	0.3	1.9	1.7	2.9	4.7	5.5	5.8
Inmos	0	0	0	5.7	25.0	26.8	24.5	15.7	8.4	6.2	9.5
Intel	99.7%	79.5	55.1	42.3	18.9	8.5	5.6	3.1	1.6	0.8	0.2
Intersil	0	0.5	2.4	1.1	0	0	0	0	0	0	0
Lattice	0	0	0	0	0	0	0	0.3	1.4	1.2	0.3
Matra-Harris	0	0	0	0	0	0.6	1.1	1.7	1.8	1.7	0.5
Micron	0	0	0	0	0	0	0	0	0	0	1.1
Mitsubishi	0	0	0	0	0.8	2.1	3.0	3.7	3.9	6.2	9.5
MOSel	0	0	0	0	0	0	0	0	0.3	1.6	3.5
Motorola	0	1.8	2.9	1.9	0.6	1.0	1.6	2.0	4.0	3.5	3.6
National	0	2.2	17.0	15.1	5.9	3.3	1.3	0.9	0.3	0	0.6
NEC	0.3	13.3	7.6	10.7	8.5	5.1	3.8	7.1	5.8	7.2	3.8
Oki	0	0	0	0	0	0	0	0	0.9	0.1	0.2
Performance	0	0	0	0	0	0	0	0	0.1	0.6	1.1
Samsung	0	0	0	0	0	0	0	0	0	0	0
Saratoga	0	0	0	0	0	0	0	0	0	0.1	0.5
Seiko	0	0	0	0	0	0	0	0.1	2.3	4.7	1.4
SGS-Thomson	0	0	0	0	0	0	0	0	0	0	0.3
Sharp	0	0	0	0	0	0	0.4	0.6	0.9	1.5	2.3
Sony	0	0	0	0	0	0	0	0	0	0	0
STC (ITT)	0	0	0	0	0	0.6	2.6	2.7	1.0	0.7	0.2
Synertek	0	0	0	1.1	1.6	1.6	0.5	0	0	0	0
TCMC	0	0	0.2	0	1.4	1.3	0.6	0.7	0.6	0.6	0
Texas Instruments	0	0.1	2.9	3.8	2.1	1.1	0.3	0	0	0	0
Toshiba	0	0.3	1.2	2.1	1.5	1.3	4.2	6.1	8.9	10.0	9.6
UMC	0	0	0	0	0	0	0	0	0	0.2	0.4
Visic	0	0	0	0	0	0	0	0	0.3	0	0
Vitelic	0	0	0	0	0	0	0	0	0	0.1	0.7
VLSI	0	0	0	0	0	0	0	0.1	1.4	0.2	0.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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

Source: Dataquest
January 1990

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Fast MOS SRAM--Market Shares

Table 2

Fast MOS SRAM Market Shares
(Billions of Bits)

Company	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
AMD	0	0	0	1.6	5.9	13.7	36.3	52.2	55.1	115.7	81.0
AMI	0	0.1	0	0	0	0	0.0	0	0	0	0
Cypress	0	0	0	0	0	0	1.2	8.0	67.2	120.9	216.6
EDI	0	0	0	0	0	0.0	0	0	0	0	2.4
Fujitsu	0	0.3	3.7	6.9	23.2	61.4	169.7	242.7	235.7	463.2	1,037.0
Hitachi	0		0	0	9.8	37.4	92.2	159.4	315.2	412.9	645.3
IDT	0	0	0	0	0.3	4.8	10.5	25.6	61.2	130.3	257.1
Inmos	0	0	0	3.0	29.2	67.2	150.8	139.1	109.6	145.0	421.9
Intel	7.4	14.5	19.0	22.3	22.1	21.3	34.3	27.6	20.5	18.4	7.7
Intersil	0	0.1	0.8	0.6	0	0	0	0	0	0	0
Lattice	0	0	0	0	0	0	0	2.3	18.2	27.5	14.9
Matra-Harris	0	0	0	0	0	1.4	6.6	15.0	23.9	39.4	24.2
Micron	0	0	0	0	0	0	0	0	0	0	47.8
Mitsubishi	0	0	0	0	1.0	5.2	18.8	32.8	50.3	145.0	422.2
MOSel	0	0	0	0	0	0	0	0	4.0	37.4	156.9
Motorola	0	0.3	1.0	1.0	0.7	2.5	9.9	18.2	51.8	82.1	158.5
National	0	0.4	5.8	8.0	6.8	8.4	8.2	8.4	3.5	0.2	25.2
NEC	0	2.4	2.6	5.7	10.0	12.8	23.6	63.0	75.5	168.0	169.7
Oki	0	0	0	0	0	0	0	0	11.1	1.9	10.0
Performance	0	0	0	0	0	0	0	0	1.0	14.6	49.4
Samsung	0	0	0	0	0	0	0	0	0	0	1.0
Saratoga	0	0	0	0	0	0	0	0	0	2.4	23.1
Seiko	0	0	0	0	0	0	0	1.3	30.5	111.2	62.7
SGS-Thomson	0	0	0	0	0	0	0	0	0	0	13.8
Sharp	0	0	0	0	0	0	2.5	5.7	12.4	36.1	103.9
Sony	0	0	0	0	0	0	0	0	0	0	0
STC (ITT)	0	0	0	0	0	1.5	16.1	23.9	13.2	15.4	8.7
Synertek	0	0	0	0.6	1.9	4.0	3.2	0	0	0	0
TCMC	0	0	0.1	0	1.6	3.3	3.9	6.3	8.4	13.3	0
Texas Instruments	0	0	1.0	2.0	2.5	2.9	1.8	0	0	0	1.5
Toshiba	0	0.1	0.4	1.1	1.8	3.2	25.7	54.0	115.8	235.4	426.1
UMC	0	0	0	0	0	0	0	0	0	4.9	16.3
Visic	0	0	0	0	0	0	0	0.3	3.6	0	0
Vitelic	0	0	0	0	0	0	0	0	0	3.1	31.0
VLSI	0	0	0	0	0	0	0	1.3	18.7	4.6	12.0
Total	7.4	18.3	34.4	52.8	116.7	251.0	615.1	887.2	1,306.3	2,349.1	4,448.3

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

Source: Dataquest
January 1990

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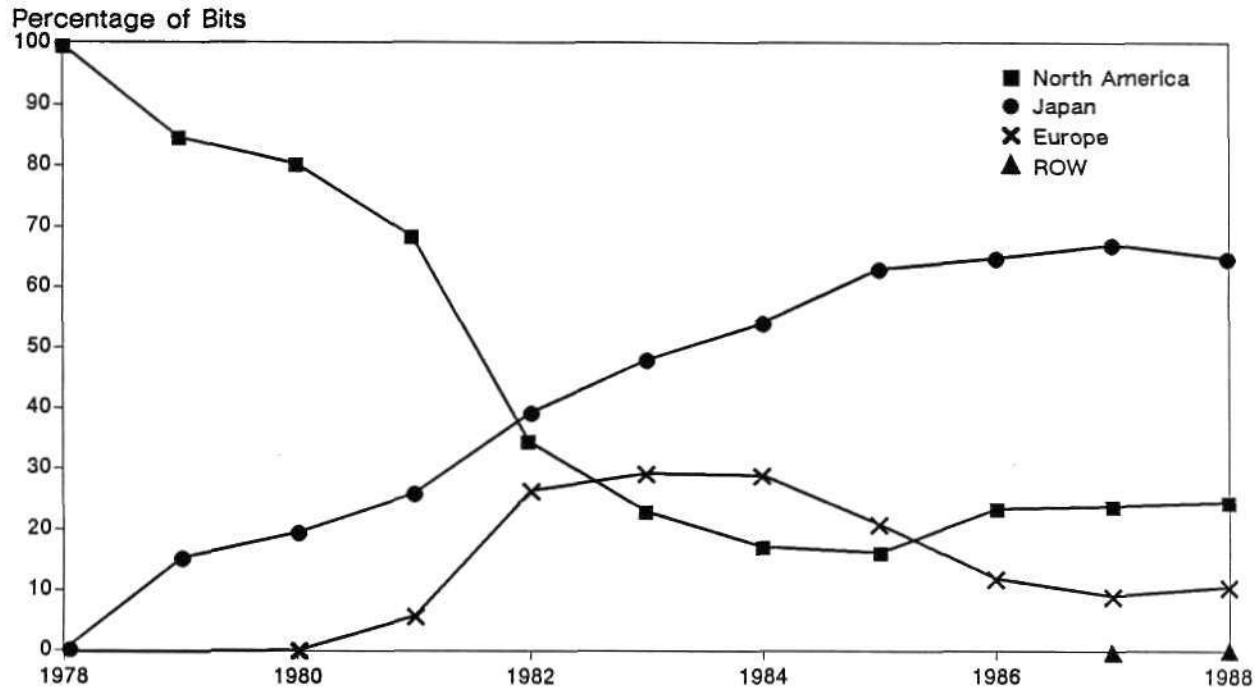
Fast MOS SRAM--Market Shares

Figure 1

Fast MOS SRAM Regional Shares
(in Percentages)



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Source: Dataquest
January 1990

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Fast MOS SRAM—Market Shares

Table 3

Fast MOS SRAM Regional Market Shares
(Billions of Bits)

Company	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
North America	7.4	15.5	27.6	36.1	40.1	57.5	105.3	143.9	304.8	557.4	1,085.3
Japan	0	2.8	6.7	13.7	45.8	120.2	332.4	559.0	846.5	1,573.7	2,877.0
Europe	0	0	0.1	3.1	30.8	73.3	177.3	184.4	155.1	213.1	468.6
ROW	0	0	0	0	0	0	0	0	0	4.9	17.4
Total	7.4	18.3	34.4	52.8	116.7	251.0	615.1	887.2	1,306.3	2,349.1	4,448.3

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

Source: Dataquest
January 1990

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Fast MOS SRAM--Market Shares

Table 4

Fast MOS SRAM Top Vendor Shares
(Percentage of Bits)

Company	1981	1982	1983	1984	1985	1986	1987	1988
Top Five	87.0%	80.8%	80.6%	78.5%	74.2%	65.2%	60.6%	66.3%
North America	66.1%	23.4%	17.9%	14.6%	0	0	0	0
Japan	27.3%	45.6%	48.9%	54.2%	78.9%	87.1%	100.0%	85.7%
Europe	6.6%	31.0%	33.2%	31.2%	12.1%	12.9%	0%	14.3%
ROW	0	0	0	0	0	0	0	0
Next Five	11.9%	16.2%	14.0%	15.4%	18.3%	21.9%	26.5%	21.6%
North America	82.4%	90.4%	48.7%	11.1%	65.0%	82.4%	58.9%	82.3%
Japan	17.6%	9.6%	51.3%	72.0%	20.2%	17.6%	17.8%	17.7%
Europe	0	0	0	17.0%	14.8%	0	23.3%	0
ROW	0	0	0	0	0	0	0	0
Top Ten	98.9%	97.0%	94.6%	93.9%	92.5%	87.1%	87.2%	87.9%
North America	68.0%	34.6%	22.4%	14.0%	12.9%	20.7%	17.9%	20.2%
Japan	26.2%	39.6%	49.3%	57.1%	67.3%	69.7%	75.0%	69.0%
Europe	5.8%	25.8%	28.3%	28.9%	19.9%	9.6%	7.1%	10.8%
ROW	0	0	0	0	0	0	0	0

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

Source: Dataquest
January 1990

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Fast MOS SRAM--Market Shares

Table 5

16K Fast MOS SRAM Market Shares
(Percentage of Bits)

Company	1980	1981	1982	1983	1984	1985	1986	1987	1988
AMD	0	0	0	0.1%	1.7%	2.9%	3.7%	3.8%	3.2%
Cypress	0	0	0	0	0	0.7	8.3	11.6	15.0
Fujitsu	0	29.4%	29.2%	30.4	31.8	32.5	17.4	16.3	6.0
Hitachi	0	0	14.5	20.2	17.9	19.1	25.9	21.8	14.9
IDT	0	0	0.5	2.6	2.1	3.1	4.0	4.6	7.7
Inmos	0	38.9	43.0	36.2	29.7	18.2	10.8	6.9	12.9
Intel	100.0%	5.5	0.1	0	0	0.1	0.4	0.5	0.2
Matra-Harris	0	0	0	0.7	1.3	2.3	3.2	4.9	3.1
Mitsubishi	0	0	1.4	2.8	3.7	5.0	5.5	5.5	7.5
MOSel	0	0	0	0	0	0	0.2	1.2	2.3
Motorola	0	0	0	0	0.5	2.2	5.7	5.2	3.7
NEC	0	26.3	10.6	4.6	2.7	1.3	1.0	0.8	0.5
Saratoga	0	0	0	0	0	0	0	0.1	1.8
Seiko	0	0	0	0	0	0	0.5	1.1	1.2
SGS-Thomson	0	0	0	0	0	0	0	0	1.1
Sharp	0	0	0	0	0.5	0.9	1.2	1.6	0.8
STC (ITT)	0	0	0	0.8	3.2	3.6	1.8	1.9	1.1
TCMC	0	0	0.6	0.2	0	0	0.1	0.6	0
Toshiba	0	0	0	1.4	5.0	8.2	10.2	10.8	10.3
UMC	0	0	0	0	0	0	0	0.3	1.7
Vitelic	0	0	0	0	0	0	0	0.4	3.9
VLSI	0	0	0	0	0	0	0	0	1.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
January 1990

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Fast MOS SRAM--Market Shares

Table 6

16K Fast MOS SRAM Market Shares
(Percentage of Bits)

Company	1984	1985	1986	1987	1988
AMD	0	0	1.4%	4.6%	1.4%
Cypress	0	0	0.3	1.8	3.5
Fujitsu	52.0%	18.3%	20.8	21.4	20.7
Hitachi	20.0	24.1	24.7	16.8	16.5
IDT	0	3.7	6.3	6.5	5.8
Inmos	4.0	13.9	5.9	6.2	12.2
Lattice Semi	0	1.6	3.6	2.0	0.6
Micron	0	0	0	0	0.4
Mitsubishi	0	0	2.0	4.3	3.6
MOSel	0	0	0.4	1.6	2.7
Motorola	0	0	1.3	2.3	4.9
National	0	2.8	0.4	0	0.1
NEC	24.0	33.3	12.2	11.3	6.3
Oki	0	0	2.2	0.1	0.4
Performance	0	0	0.2	1.0	1.9
Saratoga	0	0	0	0.1	0.3
Seiko	0	0.9	5.3	7.3	2.0
Sharp	0	0	0.7	1.7	3.6
Texas Inst	0	0	0	0	0.1
Toshiba	0	0.2	8.0	10.6	13.1
Visic	0	0.2	0.7	0	0
Vitelic	0	0	0	0	0
VLSI	0	0.9	3.7	0.3	0.1
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
January 1990

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Fast MOS SRAM--Market Shares

Table 7

256K Fast MOS SRAM Market Shares
(Percentage of Bits)

Company	1986	1987	1988
AMD	0	5.2%	0.4%
Cypress	0	0	0
EDI	0	0	0.2
Fujitsu	62.5%	36.4	44.9
Hitachi	0	2.9	9.5
IDT	0	1.7	4.5
Inmos	0	2.9	0
Micron	0	0	3.8
Mitsubishi	0	44.5	27.0
Mosel	37.5	6.4	6.9
Motorola	0	0	0.1
National	0	0	2.4
NEC	0	0	0
Peformance	0	0	0
Samsung	0	0	0.1
Sharp	0	0	0.2
Sony	0	0	0
Toshiba	0	0	0
VLSI	0	0	0
Total	100.0%	100.0%	100.0%

Source: Dataquest
January 1990

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Fast MOS SRAM--Market Shares

DATAQUEST ANALYSIS

Two trends are likely to affect the market position of fast SRAM suppliers during the next few years. The first is the usage of high-speed SRAMs in more volume-oriented applications. The second is the increasing number of small and large suppliers that are entering the market.

Fast SRAMs traditionally have been used mostly in large systems, where the high ASP of RAMs could be justified because of their benefit to overall system speed and the price tag of large systems could easily absorb the extra cost. However, increased microprocessor clock speed has dictated that a cache memory is necessary for systems such as PCs and workstations to operate at peak efficiency. The use of fast SRAMs to make up these cache memories in these commodity-oriented markets will not only increase the demand for fast SRAMs but will also require a set of priorities that are different from what fast SRAM suppliers typically are used to. In these applications, especially those targeted for use with cache controllers such as the Intel 82385, the ASPs will have to be more aggressive because of the cost sensitivity of the end systems; production volumes will have to be higher to meet mass market needs; and product differentiation will be limited by the specifications of the popular processors and controllers.

Today, caches for single-user systems only represent a small portion of the total fast SRAM market; however, by 1992 we expect this type of cache to consume more than 20 percent of all fast SRAM bits. Because of the potential represented by this application, a large number of traditional and new suppliers are developing product lines to meet the upcoming demand. Suppliers that will maintain success in this market will be the ones that can continually offer low prices and ready product availability, characteristics that, for the most part, favor larger suppliers.

We are seeing current and would-be suppliers focus on fast SRAMs more and more. Attention is being drawn to high-speed SRAMs because of their move toward larger volume arenas and because they represent a good alternative for compensating a company's revenue as DRAM, ASIC, and microprocessor sales are being squeezed by falling prices, increased competition, or market softness. Fast SRAMs have become a popular haven for semiconductor suppliers across all regions. Large and small companies are building fast SRAM product lines: Hyundai and Samsung in South Korea; UMC in Taiwan; Sony and Sharp in Japan; Philips and SGS-Thomson in Europe; and Alliance, AT&T, Intel, ISSI, Logic Devices, Paradigm, Quality, and Synergy in North America, to name a few. As a whole, fast SRAMs offers a reasonably stable market, relatively high ASPs, and do not require an expansive production facility to allow suppliers to participate. Because of their high-performance requirements, fast SRAMs also can be a process driver for other devices. Motorola uses fast SRAMs to drive its manufacturing process for its microprocessors; VLSI Technology uses them to help develop ASICs; and several companies use fast SRAMs as a core technology for specialty memories. For North America-based suppliers, there also is the lure of high ASPs and long-run rates from the military market.

Fast MOS SRAM--Market Shares

The increasing number of entrants into the fast SRAM market could present a problem. The market may not be large enough to sustain a number of full-time, dedicated suppliers as well as a myriad of part-time suppliers that are only using fast SRAMs as a vehicle to reach other markets. A large influx—and then exodus—of suppliers could have a devastating effect.

All participants will have to reanalyze their fast SRAM marketing strategies in the light of the number of new entrants and the changing market segment dynamics and demands.

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SLOW MOS SRAM--Market Shares

OVERVIEW OF THE SLOW MOS SRAM MARKET

This section presents an analysis of the historical market shares of slow MOS SRAM vendors in order to predict future competitive patterns and market opportunities. The following should be noted:

- Slow MOS SRAMs are NMOS and CMOS static RAMs with access times greater than 70 nanoseconds (ns).
- Each density's market share percentages are based on unit shares. Dataquest believes that unit shares are a more accurate measure of overall competitiveness because they reflect a company's cost and manufacturing strengths.
- The overall slow MOS SRAM market shares, all densities combined, are based on "dollarized" units. Each density's units are multiplied by that density's overall average selling price (ASP) for that year. The product is then added to those of other densities, resulting in a company's total slow MOS SRAM dollarized units on which market share percentages will be based. Although this number is in dollars, it is not related to the company's true revenue. It is another expression of units, although weighted by ASPs, used to arrive at a summary of overall slow MOS SRAM market shares.

SLOW MOS SRAM MARKET SHARES

Tables

The following tables present the slow MOS SRAM market share data:

- Table 1--Overall Slow MOS SRAM Market Shares (in Percentages)
- Table 2--Overall Slow MOS SRAM Market Shares (in Dollarized Units)
- Table 3--Slow MOS SRAM Regional Market Shares (in Percentages)
- Table 4--Slow MOS SRAM Regional Market Shares (in Dollarized Units)
- Table 5--Slow MOS SRAM Top 10 Vendors' Shares (in Percentages)
- Table 6--16K Slow MOS SRAM Market Shares (in Percentages)
- Table 7--64K Slow MOS SRAM Market Shares (in Percentages)
- Table 8--256K Slow MOS SRAM Market Shares (in Percentages)

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SLOW MOS SRAM--Market Shares

Market Share Highlights

The top three vendors--Hitachi, Toshiba, and NEC--have dominated the market since 1979. In fact, their combined market shares have climbed from 43 percent in 1979 to 71 percent in 1986. Table five pictures a market that is growing increasingly more concentrated in the top five vendors. The share of the top five vendors has grown from 68 percent in 1981 to 86 percent in 1986.

From a regional perspective, Japan-based companies clearly control the market for slow MOS SRAMs. Their share of the market has rapidly grown from 46 percent in 1978 to 92 percent in 1986, taking the shares of U.S. companies in 1980 and expanding since then. In 1986, the five market share leaders were all based in Japan.

Advances in CMOS technology and surface-mount packaging developed the portable and battery backup applications that have increased the slow MOS SRAM market in the past years. Hitachi and Toshiba drove these technologies in the SRAM arena. Hitachi, in particular, introduced the production of mix-MOS devices. These devices combine CMOS peripheral circuits and NMOS memory arrays with the proper balance of power dissipation, access time, and cost, and they have driven the market. Hitachi and Toshiba were first in the market for both 16K and 64K SRAMs, leading to their market leadership.

U.S.-based suppliers have backed away from this market and have concentrated their efforts on the fast MOS SRAM arena, where prices are relatively higher and more stable. The slow MOS SRAM market share of U.S.-based suppliers has decreased from 54 percent in 1978 to 7 percent in 1986.

DATAQUEST ANALYSIS

Dataquest expects the Japan-based companies to continue their domination of this market. The major slow CMOS SRAM applications are in consumer systems built primarily in Japan and other Asian countries. Furthermore, the Japanese firms continue to establish de facto industry standards for these devices. Last, the market has become very price driven, akin to the DRAM market, an area in which the Japanese have proven their strength.

Nevertheless, opportunities still abound for U.S.-based suppliers. Many companies, such as Dallas Semiconductors and EDI, have developed fruitful businesses in resold SRAMs with innovative packaging. As U.S suppliers continue to penetrate the popular fast SRAM market, their eventual participation in slow SRAMs may be inevitable because of their need for a market for their slower speed yields.

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SLOW MOS SRAM--Market Shares

We also believe that more Japanese firms, in addition to Hitachi, Toshiba, and NEC, will increase their presence in this market. Mitsubishi, Fujitsu, and Seiko have started volume production of 256K SRAMs early. The market shares of these companies have been slowly increasing since 1983, threatening the leadership of the top three vendors.

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SLOW MOS SRAM--Market Shares

Table 1

SLOW MOS SRAM MARKET SHARES
(Percentage of Market)

Companies	1978	1979	1980	1981	1982	1983	1984	1985	1986
AMD	0	2.8%	2.5%	3.4%	2.5%	2.9%	1.8%	1.7%	1.0%
AMI	0	0.4	0	0	0	0	0	0	0
Commodore	0	0.5	1.2	0.4	0	0	0	0	0
Fairchild	0	1.5	1.7	1.5	0.5	0.1	0	0	0
Fujitsu	0	1.0	3.5	1.9	3.0	5.5	8.2	8.7	9.8
GTE (EMM prior to 1980)	0	4.7	6.4	3.1	0.3	0	0	0	0
Harris	13.2%	4.2	5.3	2.8	2.2	0.8	0.6	0.5	0.3
Hitachi	12.3	10.6	14.9	17.3	25.3	34.1	31.7	27.0	26.8
IDT	0	0	0	0	0.2	0.4	0.2	0.2	0.2
Intel	0	6.8	4.6	4.8	2.8	2.9	4.2	2.2	1.6
Intersil	0	2.6	1.4	0.3	0.1	0	0	0	0
Matra-Harris	0	0	0	0.8	1.6	1.4	1.1	0.4	0.7
Matsushita	0	0.2	0.3	0.3	0.1	0	0	0	0.3
Mitsubishi	0	2.0	3.5	7.9	5.3	2.9	2.2	3.2	3.0
Motorola	0	2.5	2.1	3.1	2.4	1.4	1.1	1.0	0.7
National	18.0	7.5	9.5	7.8	6.1	4.6	2.5	2.3	1.6
NEC	0	17.2	17.2	16.5	13.8	8.8	13.0	17.5	22.2
Oki Electric	0	0	0.9	1.8	2.3	3.5	1.4	0.8	1.5
RCA	22.7	2.5	2.3	0.8	0.2	1.3	1.8	1.9	1.3
Seiko/SMOS	0	0	0	0	0	0.3	1.4	3.1	4.8
Sharp	0	0	0	0	0	0	0	0	0
Solid State Scientific	0	0	0	0.1	0.3	0.2	0.1	0.1	0.1
Sony	0	0	0	0	0	0	0.1	0.5	0.7
Synertek	0	5.3	3.6	3.2	2.0	2.3	1.8	1.5	0
TCMC	0	5.1	2.5	1.5	0.4	0.5	0.8	0.8	0.6
Texas Instruments	0	6.4	2.9	2.3	1.2	1.0	0.7	0.4	0.2
Toshiba	33.6	15.4	13.7	18.2	27.4	24.8	25.2	26.0	22.4
Zilog	0	0.7	0	0	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
April 1987

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SLOW MOS SRAM--Market Shares

Table 2

SLOW MOS SRAM MARKET SHARES
(Dollarized Unit Shares in Thousands)

Companies	1978	1979	1980	1981	1982	1983	1984	1985	1986
AMD	0	6,493	6,834	9,334	8,468	17,439	19,760	9,384	4,378
AMI	0	987	13	0	0	0	0	0	0
Commodore	0	1,204	3,281	1,201	0	0	0	0	0
Fairchild	0	3,355	4,669	4,002	1,759	656	4	0	0
Fujitsu	0	2,289	9,561	5,278	10,171	33,925	88,736	48,822	43,251
GTE (EMM prior to 1980)	0	10,914	17,271	8,606	1,147	89	0	0	0
Harris	2,320	9,591	14,486	7,650	7,576	4,848	6,462	2,959	1,342
Hitachi	2,160	24,267	40,505	47,234	86,370	208,559	343,146	151,204	118,513
IDT	0	0	0	0	749	2,543	2,325	1,244	1,030
Intel	0	15,647	12,401	13,137	9,660	17,876	45,267	12,120	7,240
Intersil	0	5,988	3,928	933	406	0	0	0	0
Matra-Harris	0	0	0	2,155	5,429	8,424	12,384	2,354	3,034
Matsushita	0	572	804	811	265	0	0	0	1,257
Mitsubishi	0	4,620	9,533	21,720	17,984	17,461	24,095	17,763	13,190
Motorola	0	5,807	5,744	8,383	8,296	8,622	12,373	5,813	3,285
National	3,200	17,341	25,729	21,274	20,709	28,270	26,725	12,771	7,205
NEC	0	39,489	46,734	45,250	47,062	54,082	140,877	98,120	98,269
Oki Electric	0	0	2,491	4,930	7,796	21,701	14,892	4,640	6,772
RCA	4,000	5,770	6,172	2,248	622	8,238	18,993	10,765	5,649
Seiko/SMOS	0	0	0	0	45	2,100	14,634	17,309	21,324
Sharp	0	0	0	0	0	0	0	0	0
Solid State Scientific	0	0	0	285	1,164	1,492	959	693	413
Sony	0	0	0	0	0	0	871	3,056	3,246
Synertek	0	12,076	9,650	8,675	6,979	13,871	19,689	8,118	0
TCMC	0	11,775	6,698	4,174	1,397	3,289	8,786	4,603	2,718
Texas Instruments	0	14,683	7,821	6,390	4,002	6,413	7,472	2,200	904
Toshiba	5,920	35,364	37,356	49,789	93,592	151,616	272,913	145,375	98,995
Zilog	0	1,656	0	0	0	0	0	0	0
Total	17,600	229,889	271,683	273,460	341,650	611,514	1,081,365	559,312	442,014

Source: Dataquest
April 1987

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SLOW MOS SRAM--Market Shares

Table 3

SLOW MOS SRAM REGIONAL SHARES
(Percentage of Market)

Regions	1978	1979	1980	1981	1982	1983	1984	1985	1986
United States	54.1%	48.5%	43.4%	33.7%	20.9%	18.0%	14.8%	11.8%	7.1%
Japan	45.9	46.4	54.1	64.0	77.1	80.0	83.2	86.9	91.6
Europe	0	5.1	2.5	2.3	2.0	1.9	2.0	1.2	1.3
Asia-Pacific	-	-	-	-	-	-	-	-	-
ROW	-	-	-	-	-	-	-	-	-
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
April 1987

Table 4

SLOW MOS SRAM REGIONAL SHARES
(Dollarized Unit Shares in Thousands)

Regions	1978	1979	1980	1981	1982	1983	1984	1985	1986
United States	9,520	111,512	118,001	92,119	71,537	110,357	160,031	66,067	31,444
Japan	8,080	106,602	146,984	175,012	263,287	489,444	900,163	486,288	404,818
Europe	0	11,775	6,698	6,329	6,826	11,714	21,171	6,957	5,752
Asia-Pacific	-	-	-	-	-	-	-	-	-
ROW	-	-	-	-	-	-	-	-	-
Total	17,600	229,889	271,683	273,460	341,650	611,514	1,081,365	559,312	442,014

Source: Dataquest
April 1987

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SLOW MOS SRAM--Market Shares

Table 5

SLOW MOS SRAM TOP 5/10 VENDOR SHARES
(Percentage of Market)

Top Vendors by Region	1981	1982	1983	1984	1985	1986
Top 5	67.7%	77.8%	77.9%	82.4%	82.5%	86.0%
United States	11.5%	7.8%	5.9%	5.1%	0	0
Japan	88.5%	92.2%	94.1%	94.9%	100.0%	100.0%
Europe	-	-	-	-	-	-
ROW	-	-	-	-	-	-
Next 5	17.6%	13.0%	14.4%	10.1%	10.4%	8.4%
United States	100.0%	59.5%	55.7%	77.9%	70.3%	46.3%
Japan	0	40.5%	44.3%	22.1%	29.7%	53.7%
Europe	-	-	-	-	-	-
ROW	-	-	-	-	-	-
Top 10	85.4%	90.8%	92.4%	92.5%	92.9%	94.5%
United States	25.4%	13.8%	12.7%	12.1%	7.3%	3.9%
Japan	60.0%	77.0%	79.7%	80.4%	85.6%	90.6%
Europe	-	-	-	-	-	-
ROW	-	-	-	-	-	-

Source: Dataquest
April 1987

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SLOW MOS SRAM--Market Shares

Table 6

SLOW MOS 16K SRAM MARKET SHARES
(Percentage of Market)

Companies	1980	1981	1982	1983	1984	1985	1986
AMD	0	0	0.5%	2.7%	2.6%	2.6%	2.7%
Fairchild	0	0	0	0	0	0	0
Fujitsu	0	3.9%	5.8	7.0	7.6	7.5	8.3
Harris	0	0.4	0.1	0.2	0.7	0.6	0.5
Hitachi	70.7%	36.9	33.9	33.8	30.2	26.6	25.0
IDT	0	0	0.5	0.7	0.4	0.5	0.8
Matra-Harris	0	0	0.7	1.5	1.7	0	0
Matsushita	0	0	0	0	0	0	1.0
Mitsubishi	2.0	12.6	6.5	4.0	3.7	3.8	4.2
Motorola	0	0	0	0.2	0.2	0.1	0.5
National	0	0	0.2	1.3	2.4	2.8	3.2
NEC	0	2.0	9.2	8.6	9.6	12.4	14.7
Oki Electric	5.2	2.4	3.4	5.5	2.6	1.3	2.5
RCA	0	0	0	2.1	3.2	3.4	2.2
Seiko	0	0	0	0.5	1.7	2.4	2.7
Sharp	0	0	0	0	0	0	0
Synertek	0	0.1	1.9	3.3	3.1	3.2	0
TCMC	0.8	2.2	0.3	0.6	1.4	1.7	2.1
Texas Instruments	2.0	0.8	1.2	1.4	1.2	0.7	0.7
Toshiba	19.2	38.9	35.8	26.5	27.7	30.4	29.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
April 1987

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SLOW MOS SRAM--Market Shares

Table 7

SLOW MOS 64K SRAM MARKET SHARES
(Percentage of Market)

Companies	1982	1983	1984	1985	1986
AMD	0	0	0	0	0
Fujitsu	0	6.7%	10.7%	10.6%	9.4%
Hitachi	71.0%	59.0	39.2	31.0	31.7
Intel	6.5	12.0	10.2	4.1	3.5
Matra-Harris	0	0	0	0.2	1.0
Mitsubishi	0	0	0.5	2.9	3.1
Motorola	0	0	0	0	
National	0	0	0	0.7	1.2
NEC	0	0.2	15.8	22.6	22.9
Oki Electric	0	0	0	0.5	1.1
RCA	0	0	0	0.6	1.3
Seiko/SMOS	0	0.2	1.2	4.4	6.1
Sony	0	0	0.2	1.2	1.7
Toshiba	22.6	21.7	22.1	21.2	16.9
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
April 1987

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SLOW MOS SRAM--Market Shares

Table 8

SLOW MOS 256K SRAM MARKET SHARES
(Percentage of Market)

Companies	1985	1986
Fujitsu	35.5%	13.8%
Hitachi	25.8	23.7
Mitsubishi	0	1.6
NEC	25.8	31.9
Oki Electric	0	1.3
Seiko-Epson	0	5.8
Toshiba	12.9	21.9
Total	100.0%	100.0%

Source: Dataquest
April 1987

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Slow MOS SRAM: Market Shares

OVERVIEW OF SLOW MOS SRAM MARKET SHARES

This section presents Dataquest's analysis of the slow static RAM (SRAM) market share by company, region, and the top 5 and top 10 vendors. In order to interpret our data correctly, it is important to understand the following about how we define the market:

- Slow MOS SRAMs are NMOS and CMOS static RAMs with access times greater than 70 nanoseconds (ns).
- The overall company and regional market shares, shown in Tables 1 through 4 and Figure 1, are a combination of all densities and are based on dollarized units. Dollarized units are calculated by multiplying the units in each density offered by that density's average selling price (ASP) for that year. The product of the two numbers is added to those of the other densities, resulting in the total slow MOS SRAM dollarized units. Percentage of market share is then based on a company's or region's total dollarized units.
- Each individual density's market share, shown in Tables 5 through 8, also are based on dollarized unit shares. On a product basis, Dataquest believes that this method is a more accurate measure of overall competitiveness because it reflects a company's ability to compete on the basis of cost and manufacturing.

Although the final numbers are in dollars, they are not related to a company's true revenue. They are another expression of units, weighted by ASPs, used to generate a summary of overall slow MOS SRAM market shares.

Overall Slow MOS SRAM Market Shares

The following tables present the slow MOS SRAM market share data:

- Table 1—Slow MOS SRAM Regional Market Shares (in Percentages)
- Table 2—Slow MOS SRAM Market Shares (in Dollarized Units)
- Figure 1—Slow MOS SRAM Regional Shares (in Percentages)
- Table 3—Slow MOS SRAM Regional Market Shares (in Dollarized Units)
- Table 4—Slow MOS SRAM Top Vendor Shares (in Percentages)
- Table 5—16K Slow MOS SRAM Market Shares (in Percentages)
- Table 6—64K Slow MOS SRAM Market Shares (in Percentages)
- Table 7—256K Slow MOS SRAM Market Shares (in Percentages)
- Table 8—1Mb Slow MOS SRAM Market Shares (in Percentages)

Because of the lack of accurate historical data at the supplier level, Tables 1 through 4 and Figure 1 do not include data from the 1K and 8K slow SRAM markets.

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MARKET SHARE HIGHLIGHTS

The dominance of the top five slow SRAM suppliers slipped from 82.9 percent in 1987 to 67.3 percent in 1988. The details of this decline are shown in Table 5. The reason for this dramatic change is the focus that major suppliers had on the 1Mb DRAM in 1988. DRAMs and slow SRAMs are very similar from a manufacturing standpoint, and slow SRAMs often are used to counterbalance a fabrication facility's production with DRAMs. During the 1988 DRAM shortage, manufacturing and engineering resources were directed toward the production of DRAMs to the detriment of the slow SRAM supply. Despite this recent change in the share of the top five, the slow SRAM market continues to be dominated by the few top suppliers. Hitachi, NEC, and Toshiba have held the top three positions in this market since 1979.

As an example of the effect that DRAM preoccupation has had on the slow SRAM market, Hitachi, NEC, and Toshiba held a combined market share of 69.1 percent in 1987—before the DRAM shortage. In 1988, their combined share shrank to 52.9 percent while they attempted to maintain a strong presence in the DRAM market. The DRAM shortage, however, did help the suppliers that were not as reliant on DRAMs, and those that could concentrate on supplying the slow SRAM market increased their market share. Sanyo, Sharp, and Sony, which focus strongly on SRAMs, moved up substantially in the rankings. Their combined market share went from 8.1 percent in 1987 to 17.5 in 1988.

The regional breakdown of market share shown in Figure 1 illustrates the strength of the Japanese suppliers in this market. Their market share has grown from 23.5 percent in 1978 to a peak of 95.6 percent in 1987. During the last four years, the top six slow SRAM market share leaders all have been based in Japan.

Although the Japan-based companies have what appears to be a stranglehold on the slow SRAM market, their heavy concentration on DRAMs opened the door for new competition. While the North America- and Europe-based companies trained their sights on other markets, companies such as Hyundai, Samsung, and UMC capitalized on the opportunity and increased the Rest of World (ROW) market share from 0.2 percent in 1987 to 5.4 percent in 1988.

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Table 1

Slow MOS SRAM Regional Market Shares
(Percentage of Dollarized Units)

Company	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
AMD	5.0%	2.8%	2.5%	3.4%	2.5%	2.9%	1.8%	1.7%	1.6%	0.5%	0.7%
AMI	0.1	0.4	0	0	0	0	0	0	0	0	0
Commodore	0	0.5	1.2	0.4	0	0	0	0	0	0	0
Fairchild	0.1	1.5	1.7	1.5	0.5	0.1	0	0	0	0	0
Fujitsu	1.5	1.0	3.5	1.9	3.0	5.5	8.2	8.7	8.0	7.5	6.7
GTE (EMM prior to 1980)	19.0	4.7	6.4	3.1	0.3	0	0	0	0	0	0
Harris	1.9	4.2	5.3	2.8	2.2	0.8	0.6	0.5	0.3	0.1	0
Hitachi	5.1	10.6	14.9	17.3	25.3	34.1	31.7	27.0	27.8	26.7	24.3
Hyundai	0	0	0	0	0	0	0	0	0	0.1	2.4
IDT	0	0	0	0	0.2	0.4	0.2	0.2	0.2	0	0
Inova	0	0	0	0	0	0	0	0	0	0	0.2
Intel	10.3	6.8	4.6	4.8	2.8	2.9	4.2	2.2	0.6	0.2	0
Intersil	2.1	2.6	1.4	0.3	0.1	0	0	0	0	0	0
Matra-Harris	0	0	0	0.8	1.6	1.4	1.1	0.4	0.8	0.6	1.0
Matsushita	0	0.2	0.3	0.3	0.1	0	0	0	0.3	0.4	1.1
Mitsubishi	0	2.0	3.5	7.9	5.3	2.9	2.2	3.2	4.3	5.0	4.8
MOSel	0	0	0	0	0	0	0	0	0	0	0.1
Motorola	3.4	2.5	2.1	3.1	2.4	1.4	1.1	1.0	1.0	0.7	1.1
National	6.1	7.5	9.5	7.8	6.1	4.6	2.5	2.3	0.7	0.5	0.1
NEC	11.7	17.2	17.2	16.5	13.8	8.8	13.0	17.5	22.5	23.5	14.0
Oki	0	0	0.9	1.8	2.3	3.5	1.4	0.8	1.5	1.7	1.7
RCA	3.3	2.5	2.3	0.8	0.2	1.3	1.8	1.9	1.1	1.1	0.7
Rohm	0	0	0	0	0	0	0	0	0	0	0.6
Samsung	0	0	0	0	0	0	0	0	0	0	0.5
Sanyo	0	0	0	0	0	0	0	0	0	0.7	3.0

(Continued)

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Table 1 (Continued)

Slow MOS SRAM Regional Market Shares
(Percentage of Dollarized Units)

Company	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Seiko	0	0	0	0	0	0.3	1.4	3.1	2.8	3.9	5.1
SGS-Thomson	0	0	0	0	0	0	0	0	0	0	0.4
Sharp	0	0	0	0	0	0	0	0	0	1.0	6.8
Solid State Scientific	0	0	0	0.1	0.3	0.2	0.1	0.1	0.1	0	0
Sony	0	0	0	0	0	0	0.1	0.5	1.0	6.4	7.7
Synertek	5.7	5.3	3.6	3.2	2.0	2.3	1.8	1.5	0	0	0
TCMC	3.7	5.1	2.5	1.5	0.4	0.5	0.8	0.8	0.8	0.4	0
Texas Instruments	13.7	6.4	2.9	2.3	1.2	1.0	0.7	0.4	0.2	0	0
Toshiba	5.3	15.4	13.7	18.2	27.4	24.8	25.2	26.0	24.4	18.9	14.6
Zilog	2.2	0.7	0	0	0	0	0	0	0	0	0
UMC	0	0	0	0	0	0	0	0	0	0.1	2.5
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
February 1990

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Table 2

Slow MOS SRAM Market Shares
(Dollarized Units in Thousands)

Company	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
AMD	6,133	6,493	6,834	9,334	8,468	17,439	19,760	9,384	7,202	3,854	11,874
AMI	84	987	13	0	0	0	0	0	0	0	0
Commodore	0	1,204	3,281	1,201	0	0	0	0	0	0	0
Fairchild	111	3,355	4,669	4,002	1,759	656	4	0	0	0	0
Fujitsu	1,812	2,289	9,561	5,278	10,171	33,925	88,736	48,822	36,787	56,695	108,043
GTE (EMM prior to 1980)	23,147	10,914	17,271	8,606	1,147	89	0	0	0	0	0
Harris	2,320	9,591	14,486	7,650	7,576	4,848	6,462	2,959	1,491	779	541
Hitachi	6,174	24,267	40,505	47,234	86,370	208,559	343,146	151,204	127,378	202,443	391,968
Hyundai	0	0	0	0	0	0	0	0	0	898	38,974
IDT	0	0	0	0	749	2,543	2,325	1,244	1,041	264	0
Inova	0	0	0	0	0	0	0	0	0	0	2,982
Intel	12,550	15,647	12,401	13,137	9,660	17,876	45,267	12,120	2,868	1,188	274
Intersil	2,565	5,988	3,928	933	406	0	0	0	0	0	0
Matra-Harris	0	0	0	2,155	5,429	8,424	12,384	2,354	3,884	4,376	15,700
Matsushita	0	572	804	811	265	0	0	0	1,271	2,969	18,520
Mitsubishi	0	4,620	9,533	21,720	17,984	17,461	24,095	17,763	19,671	38,247	76,614
MOSel	0	0	0	0	0	0	0	0	0	32	881
Motorola	4,182	5,807	5,744	8,383	8,296	8,622	12,373	5,813	4,445	5,411	17,918
National	7,382	17,341	25,729	21,274	20,709	28,270	26,725	12,771	3,025	3,914	958
NEC	14,224	39,489	46,734	45,250	47,062	54,082	140,877	98,120	102,942	178,556	225,296
Oki	0	0	2,491	4,930	7,796	21,701	14,892	4,640	6,675	12,756	27,006
RCA	4,000	5,770	6,172	2,248	622	8,238	18,993	10,765	5,112	8,714	11,021
Rohm	0	0	0	0	0	0	0	0	0	350	9,639
Samsung	0	0	0	0	0	0	0	0	0	0	8,014
Sanyo	0	0	0	0	0	0	0	0	0	4,950	47,600

(Continued)

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Table 2 (Continued)

Slow MOS SRAM Market Shares
(Dollarized Units in Thousands)

Company	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Seiko	0	0	0	0	45	2,100	14,634	17,309	12,608	29,702	82,158
SGS-Thomson	0	0	0	0	0	0	0	0	0	0	7,116
Sharp	0	0	0	0	0	0	0	0	49	7,303	108,888
Solid State Scientific	0	0	0	285	1,164	1,492	959	693	504	213	74
Sony	0	0	0	0	0	0	871	3,056	4,680	48,502	123,254
Synertek	6,913	12,076	9,650	8,675	6,979	13,871	19,689	8,118	0	0	0
TCMC	4,465	11,775	6,698	4,174	1,397	3,289	8,786	4,603	3,507	3,158	0
Texas Instruments	16,734	14,683	7,821	6,390	4,002	6,413	7,472	2,200	818	0	0
Toshiba	6,422	35,364	37,356	49,789	93,592	151,616	272,913	145,375	111,638	143,133	234,557
Zilog	2,623	1,656	0	0	0	0	0	0	0	0	0
UMC	0	0	0	0	0	0	0	0	0	384	40,718
Total	121,841	229,889	271,683	273,460	341,650	611,514	1,081,365	559,312	457,595	758,790	1,610,586

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

Source: Dataquest
February 1990

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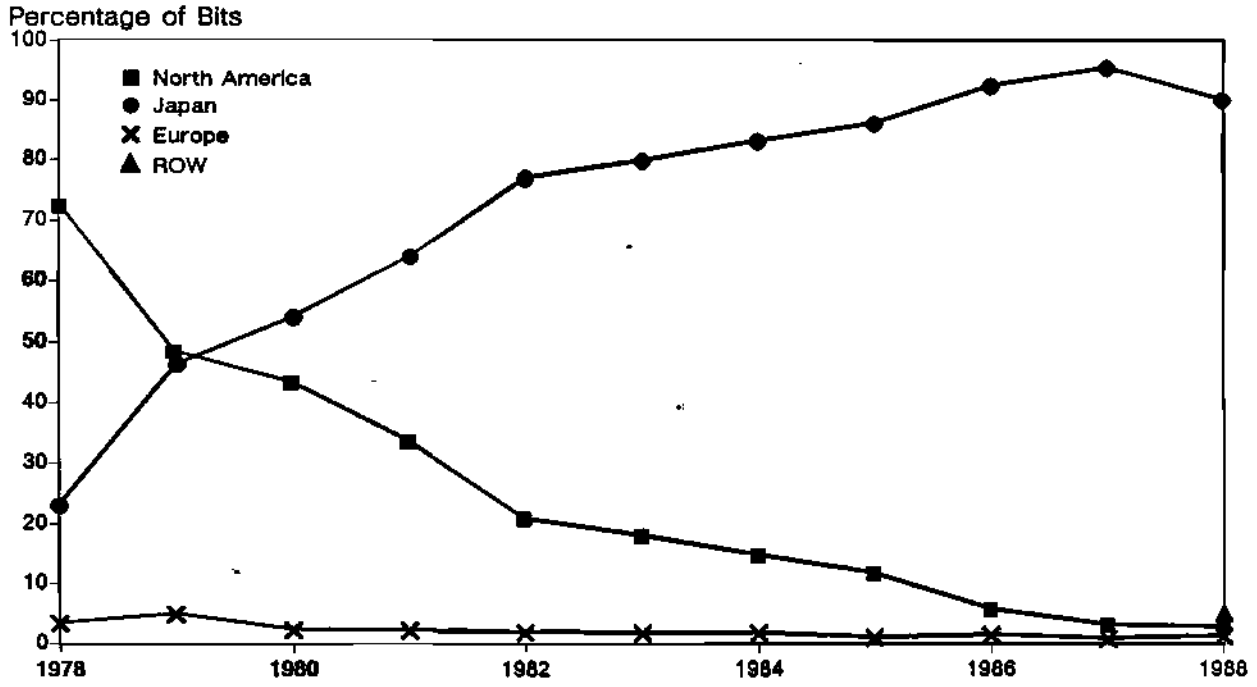
Figure 1

Slow MOS SRAM Regional Shares (in Percentages)



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Source: Dataquest
February 1989

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Table 3

Slow MOS SRAM Regional Market Shares
(Dollarized Units in Thousands)

Region	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
North America	88,744	111,512	118,001	92,119	71,537	110,357	160,031	66,067	26,505	24,369	46,522
Japan	28,632	106,602	146,984	175,012	263,287	489,444	900,163	486,288	423,699	725,606	1,453,541
Europe	4,465	11,775	6,698	6,329	6,826	11,714	21,171	6,957	7,391	7,533	22,816
ROW	0	0	0	0	0	0	0	0	0	1,282	87,707
Total	121,841	229,889	271,683	273,460	341,650	611,514	1,081,365	559,312	457,595	758,790	1,610,586

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

Source: Dataquest February 1990

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Table 4

Slow MOS SRAM Top Vendor Shares
(Percentage of Dollarized Units)

Top Vendors by Region	1981	1982	1983	1984	1985	1986	1987	1988
Top 5	67.7%	77.8%	77.9%	82.4%	83.6%	88.1%	82.9%	67.3%
North America	11.5%	7.8%	5.9%	5.1%	0	0	0	0
Japan	88.5%	92.2%	94.1%	94.9%	100.0%	100.0%	100.0%	100.0%
Europe	0	0	0	0	0	0	0	0
ROW	0	0	0	0	0	0	0	0
Next 5	17.6%	13.0%	14.4%	10.1%	10.4%	7.6%	12.7%	22.0%
North America	100.0%	59.5%	55.7%	77.9%	70.3%	30.7%	9.0%	0
Japan	0	40.5%	44.3%	22.1%	29.7%	69.3%	91.0%	88.5%
Europe	0	0	0	0	0	0	0	0
ROW	0	0	0	0	0	0	0	11.5%
Top 10	85.3%	90.8%	92.3%	92.5%	94.0%	95.7%	95.7%	89.4%
North America	29.7%	15.2%	13.7%	13.0%	7.8%	2.4%	1.2%	0
Japan	70.3%	84.8%	86.3%	87.0%	92.2%	97.6%	98.8%	97.2%
Europe	0	0	0	0	0	0	0	0
ROW	0	0	0	0	0	0	0	2.8%

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

Source: Dataquest February 1990

Table 5

16K Slow MOS SRAM Market Shares
(Percentage of Dollarized Units)

Company	1980	1981	1982	1983	1984	1985	1986	1987	1988
AMD	0	0	0.5%	2.7%	2.6%	2.6%	2.5%	1.4%	3.0%
Fairchild	0	0	0	0	0	0	0	0	0
Fujitsu	0	3.9%	5.8	7.0	7.6	7.5	4.4	2.6	0.6
Harris	0	0.4	0.1	0.2	0.7	0.6	0.5	0.3	0.1
Hitachi	70.7%	36.9	33.9	33.8	30.2	26.6	25.3	14.1	8.6
Hyundai	0	0	0	0	0	0	0	0.7	4.3
IDT	0	0	0.5	0.7	0.4	0.5	0.8	0.2	0
Matra-Harris	0	0	0.7	1.5	1.7	0	0	0.2	0.5
Matsushita	0	0	0	0	0	0	1.0	0.7	0.1
Mitsubishi	2.0	12.6	6.5	4.0	3.7	3 8	1.2	0.1	0.1
MOSel	0	0	0	0	0	0	0	0	0.2
Motorola	0	0	0	0.2	0.2	0.1	0.5	1.7	1.2
National	0	0	0.2	1.3	2.4	2.8	0	0	0

(Continued)

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Table 5 (Continued)

16K Slow MOS SRAM Market Shares
(Percentage of Dollarized Units)

Company	1980	1981	1982	1983	1984	1985	1986	1987	1988
NEC	0	2.0	9.2	8.6	9.6	12.4	14.8	13.3	6.3
Oki	5.2	2.4	3.4	5.5	2.6	1.3	2.5	3.4	2.2
RCA	0	0	0	2.1	3.2	3.4	2.2	2.9	0.9
Rohm	0	0	0	0	0	0	0	0.3	2.6
Sanyo	0	0	0	0	0	0	0	3.7	12.9
Seiko	0	0	0	0.5	1.7	2.4	2.8	2.6	4.2
SGS-Thomson	0	0	0	0	0	0	0	0	1.3
Sharp	0	0	0	0	0	0	0	2.0	7.4
Sony	0	0	0	0	0	0	1.9	11.5	16.2
Synertek	0	0.1	1.9	3.3	3.1	3.2	0	0	0
TCMC	0.8	2.2	0.3	0.6	1.4	1.7	2.1	1.4	0
Texas Instruments	2.0	0.8	1.2	1.4	1.2	0.7	0.6	0	0
Toshiba	19.2	38.9	35.8	26.5	27.7	30.4	36.9	36.9	16.1
UMC	0	0	0	0	0	0	0	0.3	10.9
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
February 1990

Table 6

64K Slow MOS SRAM Market Shares
(Percentage of Dollarized Units)

Company	1982	1983	1984	1985	1986	1987	1988
AMD	0	0	0	0	0	0	0
Fujitsu	0	6.7%	10.7%	10.6%	9.3%	6.7%	5.4%
Hitachi	71.0%	59.0	39.2	31.0	31.2	25.2	19.9
Hyundai	0	0	0	0	0	0	4.6
Intel	6.5	12.0	10.2	4.1	0.4	0	0
Matra-Harris	0	0	0	0.2	1.0	0.6	1.2
Matsushita	0	0	0	0	0	0.2	1.2
Mitsubishi	0	0	0.5	2.9	6.9	4.3	6.0
Motorola	0	0	0	0	0	0.2	1.1
National	0	0	0	0.7	0	0	0
NEC	0	0.2	15.8	22.6	22.6	25.8	17.4
Oki	0	0	0	0.5	1.1	1.0	1.3

(Continued)

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Table 6 (Continued)

64K Slow MOS SRAM Market Shares
(Percentage of Dollarized Units)

Company	1982	1983	1984	1985	1986	1987	1988
RCA	0	0	0	0.6	1.0	1.6	1.5
Samsung	0	0	0	0	0	0	1.3
Seiko	0	0.2	1.2	4.4	2.0	3.4	4.3
SGS-Thomson	0	0	0	0	0	0	0.4
Sharp	0	0	0	0	0	1.2	11.0
Sony	0	0	0.2	1.2	0.9	8.1	6.9
TCMC	0	0	0	0	0.4	0.4	0
Toshiba	22.6	21.7	22.1	21.2	23.1	21.2	16.4
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest February 1990

Table 7

256K Slow MOS SRAM Market Shares
(Percentage of Dollarized Units)

Company	1985	1986	1987	1988
Fujitsu	35.5%	12.2%	10.9%	11.8%
Hitachi	25.8	30.7	32.9	30.3
Matra-Harris	0	0	0.3	1.1
Matsushita	0	0	0.4	1.8
Mitsubishi	0	4.1	8.3	7.0
Motorola	0	0	0	1.1
NEC	25.8	34.7	27.7	17.0
Oki	0	1.1	1.7	1.9
RCA	0	0	0	0
Samsung	0	0	0	0.2
Seiko	0	4.7	5.3	6.8
Sharp	0	0	0.3	4.0
Sony	0	0.5	3.1	4.4
Toshiba	12.9	12.1	9.1	12.6
Total	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest February 1990

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Table 8

1Mb Slow MOS SRAM Market Shares
(Percent of Dollarized Units)

Company	Type	1988
Hitachi	-	22.9%
	PSRAM	58.5
Inova	-	4.2
NEC	-	2.1
Toshiba	-	5.0
	PSRAM	7.3
Total		100.0%

Source: Dataquest
February 1990

DATAQUEST ANALYSIS

Dataquest believes that Japanese companies will continue to dominate this market in the foreseeable future because the majority of slow SRAM applications are found in consumer systems and office equipment that, for the most part, are built in Japan and other Asian countries. Furthermore, the market has become price driven, very much like the DRAM market where the Japanese have proven their strength. Finally, Japanese companies continue to establish de facto industry standards for these devices. For example, the acceptance of the small outline gull-wing (SOG) package as the standard surface-mount package for slow SRAMs was driven by Japanese suppliers and users.

Nevertheless, opportunities still exist in the long term for non-Japanese suppliers. As discussed previously, South Korean and Taiwanese companies are developing a strong foothold in the market. Motorola has formed a technology exchange agreement with Toshiba in which it will have access to Toshiba's slow SRAM products and designs, and Texas Instruments is working with Hitachi to develop its slow SRAM product line. In addition, Dallas Semiconductor, EDI, and SGS-Thomson have developed a lucrative business in resold SRAMs with innovative packaging and value-added features.

The DRAM oversupply situation that started in the latter part of 1989 is likely to thrust additional capacity toward the slow SRAM market and should cause short-term price degradation. This situation will make it more difficult for new, smaller companies to enter the market in the near future. However, because of their usage in a wide variety of high-volume systems and their process commonality with DRAMs, slow SRAMS are a beneficial product line for many to consider in the long term.

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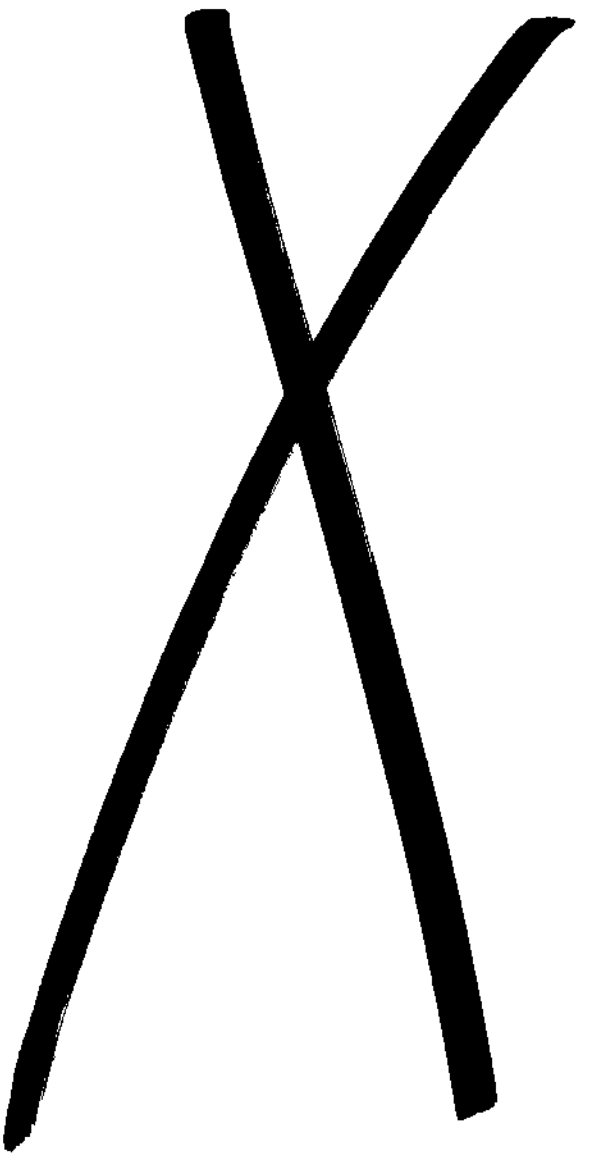

Fast MOS SRAM--Data Update

INTRODUCTION

This section contains complete historical unit shipments for fast MOS static RAMs (SRAMs) for 1988. For each quarter, we list estimates of unit shipments by supplier for the 4K, 16K, 64K, and 256K densities; worldwide quarterly prices; and the resulting revenue. Also, at the bottom of each table, we list the unit market share of suppliers based in the North America, Japan, Europe, and Rest of World (ROW) region. The tables are organized as follows:

- Table 1—4K SRAM (1988)
- Table 2—16K SRAM (1988)
- Table 3—64K SRAM (1988)
- Table 4—256K SRAM (1988)

DEFINITIONS

Speeds

Slow SRAMs are defined as parts that have access times greater than 70ns. These most often come in x8 organizations. Fast SRAMs, on the other hand, have access times of 70ns or less; they are commonly organized as either x1, x4, or x8.

A more general definition is based on applications. Fast SRAMs generally go into markets where use of the fastest device available can improve the system performance. Examples of applications for fast SRAMs would be cache memory in computing systems or writable control store for high-speed bit-slice processors. Slow SRAMs are often used as I/O buffers and in other applications where the limiting factor to system performance is not the memory access time. Because of the differentiation in applications, Dataquest treats the fast and slow SRAM markets separately.

Prices

Dataquest estimates the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and speed mixes (within the fast and slow categories). This information includes devices sold into both commercial and military markets.

Quarterly Revenue

Quarterly revenue is calculated by multiplying the units shipped by the average billing price during the quarter.

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Fast MOS SRAM--Data Update

Table 1

Estimated Worldwide Fast 4K Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		1,100	1,040	840	900	3,880
Cypress	CMOS	4Kx1	20	80	150	200	450
	CMOS	1Kx4	150	200	275	350	975
Inmos	CMOS	4Kx1	5	1	1	1	8
	CMOS	1Kx4	15	18	17	17	67
Intel	NMOS		600	450	350	200	1,600
Matra-Harris	CMOS	4Kx1	0	0	0	0	0
	CMOS	1Kx4	0	0	0	0	0
Motorola	NMOS	4Kx1	0	0	0	0	0
	NMOS	1Kx4	0	0	0	0	0
National	NMOS		0	0	0	0	0
NEC	NMOS	4Kx1	20	10	13	12	55
	NMOS	1Kx4	120	100	70	40	330
Performance	CMOS	4Kx1	S	10	15	25	50
	CMOS	1Kx4	0	0	0	S	0
Saratoga	BiCMOS	4Kx1	6	3	3	2	14
	BiCMOS	1Kx4	15	8	7	7	37
SGS-Thomson	NMOS	4Kx1	450	360	250	150	1,210
UMC	CMOS	4Kx1	61	187	5	15	268
	CMOS	1Kx4	183	140	93	125	541
Vitelic	CMOS	1Kx4	2	2	3	3	10
Total			2,747	2,609	2,092	2,047	9,495
Percentage Change from Previous Quarter			(40%)	(5%)	(20%)	(2%)	
Cumulative Total			98,025	100,634	102,726	104,773	
Average Selling Price			$2.90	$2.90	$2.90	$2.91	$2.90
Revenue ($M)			8.0	7.6	6.1	6.0	27.6

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share						
North America		68.9%	68.7%	78.5%	82.4%	73.9%
Japan		5.1	4.2	4.0	2.5	4.1
Europe		17.1	14.5	12.8	8.2	13.5
ROW		8.9	12.5	4.7	6.8	8.5
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
April 1990

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Table 2

Estimated Worldwide Fast 16K Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1	320	320	320	220	1,180
	NMOS	4Kx4	110	100	80	50	340
Cypress	CMOS	16Kx1	250	200	150	100	700
	CMOS	4Kx4	575	675	800	900	2,950
	CMOS	2Kx8	770	850	930	1,025	3,575
Fujitsu	NMOS	16Kx1	60	40	20	10	130
	NMOS	4Kx4	130	110	95	70	405
	CMOS	16Kx1	310	280	255	230	1,075
	CMOS	4Kx4	350	330	310	280	1,270
Hitachi	CMOS	16Kx1	750	700	650	625	2,725
	CMOS	4Kx4	1,300	1,150	1,050	950	4,450
IDT	CMOS	16Kx1	215	215	220	220	870
	CMOS	4Kx4	200	220	240	250	910
	CMOS	2Kx8	300	450	550	650	1,950
Inmos	NMOS	16Kx1	131	50	18	30	229
	NMOS	4Kx4	139	69	95	95	398
	CMOS	4Kx4	750	911	1,159	945	3,765
	CMOS	16Kx1	501	298	389	370	1,558
	CMOS	2Kx8	59	71	75	50	255
Intel	CMOS	16Kx1	18	8	3	2	31
	CMOS	4Kx4	21	11	5	5	42
Matra-Harris	CMOS	16Kx1	162	130	104	73	468
	CMOS	4Kx4	137	109	88	61	395
	CMOS	2Kx8	212	169	135	95	611
Mitsubishi	CMOS	16Kx1	120	150	190	50	510
	CMOS	4Kx4	1,000	1,100	800	200	3,100
MOSel	CMOS	16Kx1	21	23	25	26	95
	CMOS	4Kx4	26	31	150	150	357
	CMOS	2Kx8	100	100	150	300	650
Motorola	NMOS	16Kx1	2	1	1	0	4
	CMOS	4Kx4	541	242	400	609	1,792
	NMOS	2Kx8	0	0	0	0	0
NEC	NMOS	16Kx1	30	40	30	10	110
	CMOS	16Kx1	37	26	13	6	83
	CMOS	4Kx4	12	8	4	2	27

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Saratoga	BiCMOS 16Kx1	2	1	3	9	15
	BiCMOS 4Kx4	35	121	152	292	599
	BiCMOS 2Kx8	18	51	65	124	258
Seiko	CMOS 16Kx1	56	50	40	30	176
	CMOS 4Kx4	121	110	90	80	401
SGS-Thomson	CMOS 16Kx1	40	45	55	70	210
	CMOS 4Kx4	60	80	90	100	330
Sharp	CMOS 16Kx1	175	123	74	37	408
STC (ITT)	NMOS 16Kx1	40	28	17	8	93
	NMOS 4Kx4	188	132	79	39	438
Toshiba	NMOS 4Kx4	300	250	200	150	900
	NMOS 2Kx8	1,200	1,100	950	800	4,050
UMC	CMOS 16Kx1	8	11	75	75	169
	CMOS 4Kx4	29	44	53	75	201
	CMOS 2Kx8	50	75	100	200	425
Vitelic	CMOS 16Kx1	5	10	15	20	50
	CMOS 4Kx4	10	30	50	100	190
	CMOS 2Kx8	100	180	600	750	1,630
VLSI	CMOS 4Kx4	5	30	100	250	385
	CMOS 2Kx8	5	20	75	125	225
Total		12,105	11,677	12,385	11,994	48,162
Percentage Change from Previous Quarter		1%	(4%)	6%	(3%)	
Cumulative Total		12,117	23,795	36,180	48,174	
Average Selling Price		$3.48	$3.55	$3.63	$3.71	$3.59
Revenue ($M)		42.1	41.5	45.0	44.5	173.0

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share						
North America		30.1%	33.3%	41.0%	51.5%	39.0%
Japan		49.2	47.7	38.5	29.4	41.2
Europe		20.0	17.9	18.6	16.1	18.2
ROW		0.7	1.1	1.8	2.9	1.7
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
April 1990

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Table 3

Estimated Worldwide Fast 64K Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		Fastest Speed (ns)	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	C	64Kx1	45	150	90	25	3	268
	C	8Kx8	70	170	100	15	5	290
Cypress	C	64Kx1	25	45	50	50	55	200
	C	16Kx4	25	115	140	165	190	610
	C	8Kx8	35	90	130	170	210	600
Fujitsu	N	64Kx1	45	0	0	0	0	0
	C	64Kx1	25	772	811	851	826	3,260
	C	16Kx4	25	420	462	485	500	1,867
	C	8Kx8	35	436	480	504	529	1,950
	C	8Kx9	35	248	273	287	301	1,110
	BiC	64Kx1	15	S	S	2	6	8
	BiC	16Kx4	15	5	15	25	80	125
Hitachi	C	64Kx1	25	309	293	264	238	1,103
	C	16Kx4	25	10	20	40	70	140
	BiC	64Kx1	15	632	758	900	1,000	3,290
	BiC	16Kx4	15	399	480	550	650	2,079
IDT	C	64Kx1	25	116	139	153	168	575
	C	16Kx4	25	262	288	317	348	1,215
	C	8Kx8	30	108	124	137	150	519
	BiC	64Kx1	10	S	S	1	1	.2
Inmos	C	64Kx1	35	529	675	710	762	2,676
	C	16Kx4	25	268	224	261	275	1,028
	C	8Kx8	45	43	312	279	540	1,174
Lattice Semi	C	64Kx1	45	13	10	5	3	31
	C	16Kx4	35	65	52	42	21	179
	C	8Kx8	35	6	5	4	2	18
Micron	C	16Kx4	15	0	S	50	100	150
Mitsubishi	C	64Kx1	25	30	60	30	80	200
	C	16Kx4	25	120	240	200	160	720
	C	8Kx8	35	80	150	160	150	540
Mosel	C	64Kx1	45	0	0	0	0	0
	C	16Kx4	45	0	0	0	0	0
	C	8Kx8	45	165	214	300	400	1,079
Motorola	C	64Kx1	25	32	19	48	211	310
	C	16Kx4	25	114	51	230	494	889
	C	8Kx8	35	109	55	197	402	763

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		Fastest Speed (ns)	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
National	C	64Kx1	25	S	S	2	8	10
	C	16Kx4	25	S	S	4	10	14
NEC	C	64Kx1	45	280	300	440	520	1,540
	C	16Kx4	45	70	250	300	350	970
Oki	C	16Kx4	45	17	27	44	65	153
Performance	C	64Kx1	15	0	S	4	8	12
	C	16Kx4	17	150	180	198	208	736
	C	8Kx8	15	0	0	S	2	2
Saratoga	BiC	16Kx4	20	20	20	21	12	73
	BiC	8Kx8	25	16	16	18	10	60
Seiko	C	64Kx1	35	182	200	210	221	813
	C	16Kx4	35	0	0	0	0	0
	C	8Kx8	35	0	0	0	0	0
Sharp	C	8Kx8	35	297	356	392	411	1,456
Texas Instruments	C	64Kx1	25	S	1	2	4	7
	C	16Kx4	25	S	1	3	6	10
	C	8Kx8	25	0	S	1	3	4
	C	8Kx9	25	0	S	1	1	2
Toshiba	C	64Kx1	25	800	850	900	950	3,500
	C	16Kx4	20	100	150	200	275	725
	C	8Kx8	20	0	0	10	30	40
	C/N	8Kx9	20	250	250	250	250	1,000
Vitelic	C	8Kx8	25	0	S	S	5	5
VLSI	C	16Kx4	35	5	5	6	14	30
	C	8Kx8	35	0	0	0	0	0
Total				8,049	9,327	10,461	12,294	40,131
Percent Change From Previous Quarter				9%	16%	12%	18%	
Cumulative Total				39,415	48,743	59,204	71,498	

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization	Fastest Speed (ns)	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Average Selling Price			$8.35	$8.65	$8.95	$9.15	$8.82
Revenue ($M)			67.2	80.7	93.6	112.5	354.0
Market Share							
North America			21.8%	18.1%	20.7%	24.8%	21.6%
Japan			67.8	68.9	67.3	62.3	66.3
Europe			10.4	13.0	11.9	12.8	12.2
Total			100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
April 1990

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Table 4

Estimated Worldwide Fast 256K MOS Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		Fastest Speed (ns)	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	32Kx8	45	5	4	3	2	14
Cypress	CMOS	256Kx1		0	0	0	S	0
	CMOS	64Kx4		0	0	0	S	0
	CMOS	32Kx8		0	0	0	S	0
EDI	CMOS	32Kx8	45	S	1	3	5	9
Fujitsu	CMOS	256Kx1	35	90	170	220	260	740
	CMOS	64Kx4	35	80	150	260	337	827
	CMOS	32Kx8	35	0	0	S	3	3
	BiCMOS	256Kx1	15	5	15	30	60	110
	BiCMOS	64Kx4	15	S	1	5	10	16
Hitachi	CMOS	256Kx1	35	2	3	5	10	20
	CMOS	64Kx4	35	30	50	100	150	330
	BiCMOS	256Kx1	20	0	0	S	10	10
	BiCMOS	64Kx4	20	0	0	0	S	0
IDT	CMOS	64Kx4	0	0	0	0	0	0
	CMOS	32Kx8	35	15	25	50	80	170
Inmos	CMOS	256Kx1	45	0	0	0	0	0
	CMOS	64Kx4	45	1	0	0	0	1
	CMOS	32Kx8	45	0	0	0	0	0
Micron	CMOS	256Kx1	25	S	5	40	60	105
	CMOS	64Kx4	25	0	S	10	30	40
	CMOS	32Kx8	25	0	0	0	S	0
Mitsubishi	CMOS	256Kx1	35	50	100	130	150	430
	CMOS	64Kx4	35	60	110	200	220	590
Mosel	CMOS	32Kx8	45	20	40	80	120	260
Motorola	CMOS	256Kx1	35	0	0	0	0	0
	CMOS	64Kx4	35	0	0	0	0	0
	CMOS	32Kx8	35	0	S	1	1	2
National	BiCMOS	256Kx1	15	S	10	30	50	90
NEC	CMOS	256Kx1		0	0	0	S	0
	CMOS	64Kx4		0	0	0	S	0
Performance	CMOS	256Kx1	25	0	0	0	S	0
	CMOS	64Kx4		0	0	0	0	0
Samsung	CMOS	256Kx1	45	0	0	S	4	4

(Continued)

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Table 4 (Continued)

Estimated Worldwide Fast 256K MOS Static RAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		Fastest Speed (ns)	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Sharp	CMOS	64Kx4	35	0	S	2	5	7
	CMOS	32Kx8	35	0	0	0	S	0
Sony	CMOS	32Kx8	45	0	0	0	S	0
Toshiba	CMOS	64Kx4	20	0	0	0	S	0
	CMOS	32Kx8	20	0	0	0	S	0
	CMOS	32Kx9	20	0	0	0	S	0
Total				358	684	1,169	1,567	3,778
Percent Change From Previous Quarter				108%	91%	71%	34%	
Cumulative Total				711	1,395	2,564	4,131	
Average Selling Price				$43.00	$41.00	$39.80	$39.00	$39.99
Revenue ($M)				15.4	28.0	46.5	61.1	151.1
Market Share								
North America				11.2%	12.4%	18.6%	22.2%	18.3%
Japan				88.5	87.6	81.4	77.5	81.6
Europe				0.3	0	0	0	0
ROW				0	0	0	0.3	0.1
Total				100.0%	100.0%	100.0%	100.0%	100.0%

S = Sample
N/A = Not Available
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
April 1990

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Fast MOS SRAM--Data

INTRODUCTION

This section contains complete historical unit shipments for fast MOS static RAMs (SRAMs) from 1977 through 1987. For each quarter, we list estimates of unit shipments by supplier for the 4K, 16K, 64K, and 256K densities; worldwide quarterly prices; and the resulting revenue. Also, at the bottom of each table, we list the unit market share of suppliers based in North America, Japan, Europe, and Rest of World (ROW) region. The tables are organized as follows:

- Table 1—4K SRAM (1977–1987)
- Table 2—16K SRAM (1980–1987)
- Table 3—64K SRAM (1984–1987)
- Table 4—256K SRAM (1986 and 1987)

DEFINITIONS

Speeds

Slow SRAMs are defined as parts that have access times greater than 70ns. These most often come in x8 organizations. Fast SRAMs, on the other hand, have access times of 70ns or less; they are commonly organized as either x1, x4, or x8.

A more general definition is based on applications. Fast SRAMs generally go into markets where use of the fastest device available can improve the system performance. Examples of applications for fast SRAMs would be cache memory in computing systems or writable control store for high-speed bit-slice processors. Slow SRAMs are often used as I/O buffers and in other applications where the limiting factor to system performance is not the memory access time. Because of the differentiation in applications, Dataquest treats the fast and slow SRAM markets separately.

Prices

Dataquest estimates the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and speed mixes (within the fast and slow categories). This information includes devices sold into both commercial and military markets.

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Fast MOS SRAM--Data

Unit Shipments

Historical shipment data are as published in earlier service sections, with occasional restatements, additions, and deletions based on later availability of other information. Portions of the 1987 data have been updated to reflect new information.

Quarterly Revenue

Quarterly revenue is calculated by multiplying the units shipped by the average billing price during the quarter.

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Fast MOS SRAM--Data

Table 1

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1977 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS						0
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS						0
Intel	NMOS		S	S	100	300	400
Intersil	NMOS						0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS						0
	CMOS	4Kx1					0
National	NMOS						0
NEC	NMOS						0
Synertek	NMOS						0
TCMC	NMOS	4Kx1					0
Texas Instruments	NMOS						0
Toshiba	NMOS		-	-	---	---	0
Total			S	S	100	300	400
Percentage Change From Previous Quarter						200%	
Cumulative Total			S	S	100	400	
Average Selling Price			$28.00	$25.00	$22.00	$21.00	$21.25
Revenue ($M)			0	0	2.2	6.3	8.5
Market Share							
North America			0	0	100.0%	100.0%	100.0%
Japan			0	0	0	0	0
Europe			0	0	0	0	0
Total			0	0	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1978 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS						0
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS						0
Intel	NMOS		300	500	350	650	1,800
Intersil	NMOS						0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS						0
	CMOS	4Kx1					0
National	NMOS						0
NEC	NMOS				$	$	5
Synertek	NMOS						0
TCMC	NMOS	4Kx1					0
Texas Instruments	NMOS						0
Toshiba	NMOS						0
Total			300	500	350	655	1,805
Percentage Change From Previous Quarter			0	67%	(30%)	87%	
Cumulative Total			700	1,200	1,550	2,205	
Average Selling Price			$20.00	$20.00	$18.00	$15.00	$17.80
Revenue ($M)			6.0	10.0	6.3	9.8	32.1
Market Share							
North America			100.0%	100.0%	100.0%	99.2%	99.7%
Japan			0	0	0	0.8	0.3
Europe			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Fast MOS SRAM--Data

Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1979 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS						0
AMI	NMOS		5	10	5	5	25
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS			S	15	60	75
Intel	NMOS		800	1,200	650	900	3,550
Intersil	NMOS				3	20	23
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		S	10	20	50	80
	CMOS	4Kx1					0
National	NMOS			10	25	65	100
NEC	NMOS		25	70	250	250	595
Synertek	NMOS						0
TCMC	NMOS	4Kx1				S	0
Texas Instruments	NMOS					5	5
Toshiba	NMOS				S	15	15
Total			830	1,300	968	1,370	4,468
Percentage Change From Previous Quarter			27%	57%	(26%)	42%	
Cumulative Total			3,035	4,335	5,303	6,673	
Average Selling Price			$16.00	$15.00	$19.00	$15.00	$16.05
Revenue ($M)			13.3	19.5	18.4	20.6	71.7
Market Share							
North America			97.0%	94.6%	72.6%	76.3%	84.7%
Japan			3.0	5.4	27.4	23.7	15.3
Europe			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		S	S	S	5	5
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS		150	200	250	300	900
Intel	NMOS		1,125	1,100	1,200	1,200	4,625
Intersil	NMOS		35	40	65	60	200
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		70	70	70	30	240
	CMOS	4Kx1					0
National	NMOS		200	325	450	450	1,425
NEC	NMOS		200	150	140	150	640
Synertek	NMOS						0
TCMC	NMOS	4Kx1	S	S	5	10	15
Texas Instruments	NMOS		30	40	75	100	245
Toshiba	NMOS		15	20	25	40	100
Total			1,825	1,945	2,280	2,345	8,395
Percentage Change From Previous Quarter			33%	7%	17%	3%	
Cumulative Total			8,498	10,443	12,723	15,068	
Average Selling Price			$10.00	$8.00	$8.00	$5.50	$7.74
Revenue ($M)			18.3	15.6	18.2	12.9	64.9
Market Share							
North America			80.0%	81.0%	81.6%	78.7%	80.3%
Japan			20.0	19.0	18.2	20.9	19.5
Europe			0	0	0.2	0.4	0.2
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Fast MOS SRAM--Data

Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		5	25	50	75	155
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS		350	275	250	250	1,125
Intel	NMOS		1,200	1,300	1,300	1,300	5,100
Intersil	NMOS		35	45	45	20	145
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		60	70	50	40	220
	CMOS	4Kx1			10	10	20
National	NMOS		400	500	550	500	1,950
NEC	NMOS		180	300	250	150	880
Synertek	NMOS		S	10	50	80	140
TCMC	NMOS	4Kx1	5	0	S	S	5
Texas Instruments	NMOS		120	120	125	130	495
Toshiba	NMOS		50	65	75	80	270
Total			2,405	2,710	2,755	2,635	10,505
Percentage Change From Previous Quarter			3%	13%	2%	(4%)	
Cumulative Total			17,473	20,183	22,938	25,573	
Average Selling Price			$5.00	$5.00	$4.00	$4.00	$4.49
Revenue ($M)			12.0	13.6	11.0	10.5	47.1
Market Share							
North America			75.7%	76.4%	79.1%	81.8%	78.3%
Japan			24.1	23.6	20.9	18.2	21.7
Europe			0.2	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		100	230	280	320	930
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS		200	200	200	220	820
Intel	NMOS		1,200	1,250	1,300	1,300	5,050
Intersil	NMOS		5	0	0	0	5
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		40	15	0	0	55
	CMOS	4Kx1	10	10	10	80	110
National	NMOS		350	450	470	400	1,670
NEC	NMOS		150	160	215	150	675
Synertek	NMOS		80	100	130	150	460
TCMC	NMOS	4Kx1	20	20	100	150	290
Texas Instruments	NMOS		140	150	150	160	600
Toshiba	NMOS		100	120	120	100	440
Total			2,395	2,705	2,975	3,030	11,105
Percentage Change From Previous Quarter			(9%)	13%	10%	2%	
Cumulative Total			27,968	30,673	33,648	36,678	
Average Selling Price			$3.60	$3.20	$3.00	$2.80	$3.12
Revenue ($M)			8.6	8.7	8.9	8.5	34.7
Market Share							
North America			80.4%	81.5%	78.7%	79.5%	80.0%
Japan			18.8	17.7	18.0	15.5	17.4
Europe			0.8	0.7	3.4	5.0	2.6
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		525	725	800	1,000	3,050
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS		250	300	300	350	1,200
Intel	NMOS		1,300	1,250	1,250	1,150	4,950
Intersil	NMOS						0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS						0
	CMOS	4Kx1	60	80	150	300	590
National	NMOS		400	400	600	650	2,050
NEC	NMOS		200	250	300	300	1,050
Synertek	NMOS		170	200	250	350	970
TCMC	NMOS	4Kx1	150	170	200	200	720
Texas Instruments	NMOS		175	175	175	175	700
Toshiba	NMOS		60	40	30	20	150
Total			3,290	3,590	4,055	4,495	15,430
Percentage Change From Previous Quarter			9%	9%	13%	11%	
Cumulative Total			39,968	43,558	47,613	52,108	
Average Selling Price			$2.70	$2.75	$2.80	$3.00	$2.83
Revenue ($M)			8.9	9.9	11.4	13.5	43.6
Market Share							
North America			79.9%	78.8%	79.5%	80.6%	79.8%
Japan			15.5	16.4	15.5	14.9	15.6
Europe			4.6	4.7	4.9	4.4	4.7
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		1,200	1,400	1,550	1,650	5,800
AMI	NMOS						0
Cypress	CMOS	1Kx4	S	5	10	25	40
Fujitsu	NMOS		300	280	265	245	1,090
Intel	NMOS		1,620	1,920	2,450	2,250	8,240
Intersil	NMOS						0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS						0
	CMOS	4Kx1	355	375	780	260	1,770
National	NMOS		650	500	450	400	2,000
NEC	NMOS		450	500	500	520	1,970
Synertek	NMOS		250	200	180	150	780
TCMC	NMOS	4Kx1	180	210	250	270	910
Texas Instruments	NMOS		150	130	100	50	430
Toshiba	NMOS		30	30	20	0	80
Total			5,185	5,550	6,555	5,820	23,110
Percentage Change From Previous Quarter			28%	7%	18%	(11%)	
Cumulative Total			57,293	62,843	69,398	75,218	
Average Selling Price			$3.30	$3.35	$3.30	$3.05	$3.25
Revenue ($M)			17.1	18.6	21.6	17.8	75.1
Market Share							
North America			81.5%	81.6%	84.2%	82.2%	82.5%
Japan			15.0	14.6	12.0	13.1	13.6
Europe			3.5	3.8	3.8	4.6	3.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Fast MOS SRAM--Data

Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		1,700	1,800	1,850	1,950	7,300
AMI	NMOS		0	0	0	0	0
Cypress	CMOS	1Kx4	30	40	40	45	155
Fujitsu	NMOS		220	200	175	150	745
Intel	NMOS		2,050	1,680	1,550	1,350	6,630
Intersil	NMOS		0	0	0	0	0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		0	0	0	0	0
	CMOS	4Kx1	455	155	110	190	910
National	NMOS		340	290	250	200	1,080
NEC	NMOS		610	640	180	270	1,700
Synertek	NMOS		0	0	0	0	0
TCMC	NMOS	4Kx1	300	380	440	420	1,540
Texas Instruments	NMOS		0	0	0	0	0
Toshiba	NMOS		0	0	0	0	0
Total			5,705	5,185	4,595	4,575	20,060
Percentage Change From Previous Quarter			(2%)	(9%)	(11%)	0	
Cumulative Total			80,923	86,108	90,703	95,278	
Average Selling Price			$3.00	$3.00	$2.80	$2.75	$2.90
Revenue ($M)			17.1	15.6	12.9	12.6	58.1
Market Share							
North America			80.2%	76.5%	82.7%	81.6%	80.1%
Japan			14.5	16.2	7.7	9.2	12.2
Europe			5.3	7.3	9.6	9.2	7.7
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Fast MOS SRAM--Data

Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		1,500	1,100	1,000	1,000	4,600
AMI	NMOS		0	0	0	0	0
Cypress	CMOS	1Kx4	55	60	65	70	250
Fujitsu	NMOS		100	75	60	35	270
Inmos	CMOS	4Kx1	0	0	0	0	0
	CMOS	1Kx4	0	0	0	0	0
Intel	NMOS		1,120	1,240	930	940	4,230
Intersil	NMOS		0	0	0	0	0
Matra-Harris	CMOS	4Kx1		1	1	1	3
	CMOS	1Kx4		1	1	1	3
Motorola	NMOS		0	0	0	0	0
	CMOS	4Kx1	160	240	190	155	745
National	NMOS		150	100	65	40	355
NEC	NMOS	4Kx1	150	30	130	100	410
	NMOS	1Kx4	390	60	350	400	1,200
Synertek	NMOS		0	0	0	0	0
TCMC	NMOS	4Kx1	450	480	450	450	1,830
Texas Instruments	NMOS		0	0	0	0	0
Toshiba	NMOS		0	0	0	0	0
Total			4,075	3,387	3,242	3,192	13,896
Percentage Change From Previous Quarter			(11%)	(17%)	(4%)	(2%)	
Cumulative Total			99,353	102,740	105,982	109,174	
Average Selling Price			$2.75	$2.85	$2.85	$2.90	$2.83
Revenue ($M)			11.2	9.7	9.2	9.3	39.4
Market Share							
North America			73.3%	80.9%	69.4%	69.1%	73.3%
Japan			15.7	4.9	16.7	16.8	13.5
Europe			11.0	14.2	13.9	14.2	13.2
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Fast MOS SRAM---Data

Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		1,000	900	810	800	3,510
Cypress	CMOS	4Kx1			5	10	15
	CMOS	1Kx4	70	74	76	80	300
Inmos	CMOS	4Kx1	S	3	6	10	19
	CMOS	1Kx4	S	1	4	8	13
Intel	NMOS		920	930	884	795	3,529
Matra-Harris	CMOS	4Kx1	1	0	2	0	3
	CMOS	1Kx4					
Motorola	NMOS	4Kx1	125	95	67	40	327
	NMOS	1Kx4	700	500	300	200	1,700
National	NMOS		25	15	8	4	51
NEC	NMOS	4Kx1	20	20	10	50	100
	NMOS	1Kx4	240	90	100	170	600
Performance	CMOS	4Kx1					
	CMOS	1Kx4					
Saratoga	BiCMOS	4Kx1			S	3	3
	BiCMOS	1Kx4			S	8	8
TCMC	NMOS	4Kx1	500	525	551	579	2,155
UMC	CMOS	4Kx1	29	64	65	63	221
	CMOS	1Kx4	107	90	49	169	415
Vitelic	CMOS	1Kx4					
Total			3,737	3,307	2,936	2,989	12,969
Percentage Change From Previous Quarter			17%	(11%)	(11%)	2%	
Cumulative Total			112,911	116,218	119,154	122,143	
Average Selling Price			$2.90	$2.90	$2.90	$2.90	$2.90
Revenue ($M)			10.8	9.6	8.5	8.7	37.6
Market Share							
North America			76.0%	76.0%	73.2%	64.9%	72.8%
Japan			7.0	3.3	3.7	7.4	5.4
Europe			13.4	16.0	19.2	20.0	16.9
ROW			3.6	4.7	3.9	7.8	4.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
April 1990

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Table 2

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	4Kx4					0
Cypress	CMOS	2Kx8					0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1				S	0
	NMOS	4Kx4					0
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1					0
	CMOS	4Kx4					0
IDT	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Inmos	NMOS	16Kx1				S	0
	NMOS	4Kx4					0
	CMOS	4Kx4					0
Intel	NMOS	16Kx1	S	S	S	1	1
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Mitsubishi	NMOS	16Kx1					0
	NMOS	4Kx4					0
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	2Kx8					0
NEC	NMOS	16Kx1					0
Sharp	CMOS	16Kx1					0

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS 16Kx1					0
	NMOS 4Kx4					0
TCMC	NMOS 16Kx1					0
	NMOS 4Kx4					0
Toshiba	NMOS 2Kx8					0
	NMOS 4Kx4	-	-	-	-	0
Total		0	0	0	1	1
Percentage Change From Previous Quarter						
Cumulative Total		0	0	0	1	
Average Selling Price		$50.00	$50.00	$50.00	$40.00	$40.00
Revenue ($M)		0	0	0	0.4	0.4
Market Share						
North America		0	0	0	100.0%	100.0%
Japan		0	0	0	0	0
Europe		0	0	0	0	0
Total		0	0	0	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	4Kx4					0
Cypress	CMOS	2Kx8					0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1	S	5	10	100	115
	NMOS	4Kx4			S	25	25
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1				S	0
	CMOS	4Kx4					0
IDT	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Inmos	NMOS	16Kx1	S	10	50	100	160
	NMOS	4Kx4			S	25	25
	CMOS	4Kx4					0
Intel	NMOS	16Kx1	3	5	8	10	26
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Mitsubishi	NMOS	16Kx1					0
	NMOS	4Kx4					0
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	2Kx8					0
NEC	NMOS	16Kx1	S	10	45	70	125
Sharp	CMOS	16Kx1					0

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS 16Kx1					0
	NMOS 4Kx4					0
TCMC	NMOS 16Kx1					0
	NMOS 4Kx4					0
Toshiba	NMOS 2Kx8					0
	NMOS 4Kx4	-	-	-	-	0
Total		3	30	113	330	476
Percentage Change From Previous Quarter		200%	900%	277%	192%	
Cumulative Total		4	34	147	477	
Average Selling Price		$20.00	$18.00	$15.00	$12.00	$13.14
Revenue ($M)		0.1	0.5	1.7	4.0	6.3
Market Share						
North America		100.0%	16.7%	7.1%	3.0%	5.5%
Japan		0	50.0	48.7	59.1	55.7
Europe		0	33.3	44.2	37.9	38.9
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	4Kx4					0
Cypress	CMOS	2Kx8					0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1	125	200	270	290	885
	NMOS	4Kx4	40	65	100	120	325
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1	50	120	180	250	600
	CMOS	4Kx4					0
IDT	CMOS	16Kx1		S	5	15	20
	CMOS	4Kx4				S	0
	CMOS	2Kx8					0
Inmos	NMOS	16Kx1	150	220	300	380	1,050
	NMOS	4Kx4	75	150	225	280	730
	CMOS	4Kx4					0
Intel	NMOS	16Kx1	3	0	0	0	3
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Mitsubishi	NMOS	16Kx1	6	5	5	50	60
	NMOS	4Kx4					0
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	2Kx8					0
NEC	NMOS	16Kx1	100	100	120	120	440
Sharp	CMOS	16Kx1					0

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1					0
	NMOS	4Kx4					0
TCMC	NMOS	16Kx1	5	5	10	5	25
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8					0
	NMOS	4Kx4					0
Total			548	865	1,215	1,510	4,138
Percentage Change From Previous Quarter			66%	58%	40%	24%	
Cumulative Total			1,025	1,890	3,105	4,615	
Average Selling Price			$9.50	$8.00	$7.50	$7.25	$7.78
Revenue ($M)			5.2	6.9	9.1	10.9	32.2
Market Share							
North America			0.5%	0	0.4%	1.0%	0.6%
Japan			57.5	56.6%	55.6	55.0	55.8
Europe			42.0	43.4	44.0	44.0	43.6
Total			100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1		S	S	10	10
	CMOS	4Kx4					0
	NMOS	4Kx4					0
Cypress	CMOS	2Kx8					0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1	350	400	600	800	2,150
	NMOS	4Kx4	150	200	350	600	1,300
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1	350	500	600	800	2,250
	CMOS	4Kx4	S	S	10	25	35
IDT	CMOS	16Kx1	25	40	60	75	200
	CMOS	4Kx4	5	15	30	40	90
	CMOS	2Kx8					0
Inmos	NMOS	16Kx1	400	450	600	750	2,200
	NMOS	4Kx4	300	350	550	700	1,900
	CMOS	4Kx4					0
Intel	NMOS	16Kx1	0	0	0	0	0
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8	0	10	25	50	85
Mitsubishi	NMOS	16Kx1	90	70	60	80	300
	NMOS	4Kx4	S	S	S	20	20
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1		S	S	S	0
	CMOS	4Kx4					0
	NMOS	2Kx8			S	5	5
NEC	NMOS	16Kx1	120	100	100	200	520
Sharp	CMOS	16Kx1				S	0

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Fast MOS SRAM--Data

Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1	S	10	20	50	80
	NMOS	4Kx4		S	S	10	10
TCMC	NMOS	16Kx1	5	5	5	5	20
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8	S	10	50	100	160
	NMOS	4Kx4					0
Total			1,795	2,160	3,060	4,320	11,335
Percentage Change From Previous Quarter			19%	20%	42%	41%	
Cumulative Total			6,410	8,570	11,630	15,950	
Average Selling Price			$7.25	$7.50	$7.75	$8.15	$7.78
Revenue ($M)			13.0	16.2	23.7	35.2	88.1
Market Share							
North America			1.7%	2.5%	2.9%	3.0%	2.7%
Japan			59.1	59.3	57.8	60.8	59.4
Europe			39.3	38.2	39.2	36.2	37.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1	25	75	150	250	500
	CMOS	4Kx4	S	5	5	5	15
	NMOS	4Kx4				S	0
Cypress	CMOS	2Kx8			S	S	0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1	1,050	1,250	1,400	1,500	5,200
	NMOS	4Kx4	800	1,000	1,350	1,400	4,550
	CMOS	16Kx1	S	S	25	50	75
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1	1,000	1,200	1,300	1,500	5,000
	CMOS	4Kx4	50	75	150	250	525
IDT	CMOS	16Kx1	80	85	95	105	365
	CMOS	4Kx4	50	65	75	85	275
	CMOS	2Kx8			S	S	0
Inmos	NMOS	16Kx1	850	900	950	850	3,550
	NMOS	4Kx4	900	1,400	1,800	1,500	5,600
	CMOS	4Kx4	S	S	10	25	35
Intel	NMOS	16Kx1	0	0	0	0	0
	CMOS	16Kx1	S	S	S	S	0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1	10	15	15	21	61
	CMOS	4Kx4	0	0	0	0	0
	CMOS	2Kx8	65	90	85	100	340
Mitsubishi	NMOS	16Kx1	110	130	170	220	630
	NMOS	4Kx4	40	125	150	200	515
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1	1	0	5	13	19
	CMOS	4Kx4	0	0	0	0	0
	NMOS	2Kx8	4	13	31	97	145
NEC	NMOS	16Kx1	230	180	220	200	830
Sharp	CMOS	16Kx1	S	25	50	75	150

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1	100	200	250	300	850
	NMOS	4Kx4	15	25	40	50	130
TCMC	NMOS	16Kx1	5	5	0	0	10
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8	250	300	400	600	1,550
	NMOS	4Kx4				S	0
Total			5,635	7,163	8,726	9,396	30,920
Percentage Change From Previous Quarter			30%	27%	22%	8%	
Cumulative Total			21,585	28,748	37,474	46,870	
Average Selling Price			$8.00	$7.80	$7.30	$6.65	$7.35
Revenue ($M)			45.1	55.9	63.7	62.5	227.1
Market Share							
North America			2.8%	3.4%	4.1%	5.9%	4.3%
Japan			62.6	59.8	59.8	63.8	61.5
Europe			34.5	36.8	36.1	30.3	34.2
Total			100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1	250	275	250	250	1,025
	CMOS	4Kx4	5	20	25	30	80
	NMOS	4Kx4	1	5	25	35	66
Cypress	CMOS	2Kx8	10	25	50	100	185
	CMOS	4Kx4	S	10	25	50	85
	CMOS	16Kx1		S	5	25	30
Fujitsu	NMOS	16Kx1	1,350	1,300	1,000	800	4,450
	NMOS	4Kx4	1,500	1,585	1,700	1,850	6,635
	CMOS	16Kx1	200	300	500	580	1,580
	CMOS	4Kx4	10	50	125	200	385
Hitachi	CMOS	16Kx1	1,200	1,200	1,200	1,200	4,800
	CMOS	4Kx4	400	650	800	1,000	2,850
IDT	CMOS	16Kx1	110	130	165	195	600
	CMOS	4Kx4	100	125	160	180	565
	CMOS	2Kx8	5	10	25	40	80
Inmos	NMOS	16Kx1	800	650	500	300	2,250
	NMOS	4Kx4	1,300	1,140	1,030	1,210	4,680
	CMOS	4Kx4	34	42	109	175	360
Intel	NMOS	16Kx1					0
	CMOS	16Kx1	1	5	10	10	26
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1	51	43	42	11	147
	CMOS	4Kx4	0	8	3	9	20
	CMOS	2Kx8	123	138	222	267	750
Mitsubishi	NMOS	16Kx1	205	235	275	300	1,015
	NMOS	4Kx4	195	240	250	300	985
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1	87	66	49	30	232
	CMOS	4Kx4	1	10	95	149	255
	NMOS	2Kx8	69	70	156	99	394
NEC	NMOS	16Kx1	210	180	40	110	540
Sharp	CMOS	16Kx1	100	100	75	75	350

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Fast MOS SRAM--Data

Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1	300	380	300	180	1,160
	NMOS	4Kx4	60	75	80	85	300
TCMC	NMOS	16Kx1	0	0	0	0	0
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8	600	600	675	750	2,625
	NMOS	4Kx4	S	100	250	300	650
Total			9,277	9,767	10,216	10,895	40,155
Percentage Change From Previous Quarter			(1%)	5%	5%	7%	
Cumulative Total			56,147	65,914	76,130	87,025	
Average Selling Price			$6.25	$5.25	$4.75	$4.25	$5.08
Revenue ($M)			58.0	51.3	48.5	46.3	204.1
Market Share							
North America			6.9%	7.7%	10.2%	10.9%	9.0%
Japan			64.4	67.0	67.4	68.5	66.9
Europe			28.8	25.4	22.4	20.5	24.1
Total			100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1	285	290	300	320	1,195
	CMOS	4Kx4	40	50	65	77	232
	NMOS	4Kx4	45	55	60	70	230
Cypress	CMOS	2Kx8	350	400	450	500	1,700
	CMOS	4Kx4	275	300	350	400	1,325
	CMOS	16Kx1	120	150	225	250	745
Fujitsu	NMOS	16Kx1	400	390	370	350	1,510
	NMOS	4Kx4	1,000	950	780	670	3,400
	CMOS	16Kx1	350	430	485	550	1,815
	CMOS	4Kx4	150	210	295	500	1,155
Hitachi	CMOS	16Kx1	1,400	1,500	1,600	1,600	6,100
	CMOS	4Kx4	1,200	1,100	1,500	1,800	5,600
IDT	CMOS	16Kx1	170	173	181	182	706
	CMOS	4Kx4	110	118	123	136	487
	CMOS	2Kx8	130	148	163	175	616
Inmos	NMOS	16Kx1	332	401	410	425	1,568
	NMOS	4Kx4	824	578	482	339	2,223
	CMOS	4Kx4	293	290	225	292	1,100
	CMOS	16Kx1				3	3
	CMOS	2Kx8					0
Intel	CMOS	16Kx1	25	60	30	30	145
	CMOS	4Kx4	1	10	10	30	51
Matra-Harris	CMOS	16Kx1	34	59	21	33	147
	CMOS	4Kx4	16	23	4	15	58
	CMOS	2Kx8	280	380	388	202	1,250
Mitsubishi	NMOS	16Kx1	200	200	350	380	1,130
	NMOS	4Kx4	300	300	365	375	1,340
MOSel	CMOS	16Kx1			1	6	7
	CMOS	4Kx4			1	6	7
	CMOS	2Kx8	5	10	20	30	65
Motorola	NMOS	16Kx1	80	76	86	81	323
	CMOS	4Kx4	240	265	430	195	1,130
	NMOS	2Kx8	255	250	427	196	1,128

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NEC	NMOS	16Kx1	80	120	60	70	330
	CMOS	16Kx1	22	25	30	35	112
	CMOS	4Kx4	3	5	6	8	22
SMOS/Seiko	CMOS	16Kx1	30	35	40	45	150
	CMOS	4Kx4	15	20	25	30	90
Sharp	CMOS	16Kx1	100	120	160	175	555
STC (ITT)	NMOS	16Kx1	150	120	120	100	490
	NMOS	4Kx4	75	65	75	100	315
TCMC	NMOS	16Kx1			5	20	25
	NMOS	4Kx4			5	25	30
Toshiba	NMOS	2Kx8	725	775	750	800	3,050
	NMOS	4Kx4	400	475	350	350	1,575
VLSI	CMOS	4Kx4					0
	CMOS	2Kx8					0
Total			10,510	10,926	11,823	11,976	45,235
Percentage Change From Previous Quarter			(4%)	4%	8%	1%	
Cumulative Total			97,535	108,461	120,284	132,260	
Average Selling Price			$4.00	$3.75	$3.50	$3.40	$3.65
Revenue ($M)			42.0	41.0	41.4	40.7	165.1
Market Share							
North America			20.3%	21.6%	24.7%	22.4%	22.3%
Japan			60.7	60.9	60.6	64.6	61.8
Europe			19.1	17.5	14.7	13.0	15.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1	340	350	357	364	1,411
	NMOS	4Kx4	80	95	119	137	430
Cypress	CMOS	16Kx1	270	290	310	315	1,185
	CMOS	4Kx4	450	475	500	515	1,940
	CMOS	2Kx8	550	600	650	700	2,500
Fujitsu	NMOS	16Kx1	300	250	200	150	900
	NMOS	4Kx4	425	415	375	325	1,540
	CMOS	16Kx1	600	625	650	670	2,545
	CMOS	4Kx4	625	740	780	790	2,935
Hitachi	CMOS	16Kx1	1,500	1,300	1,040	780	4,620
	CMOS	4Kx4	1,700	1,500	1,470	1,323	5,993
IDT	CMOS	16Kx1	180	185	210	215	790
	CMOS	4Kx4	140	150	175	180	645
	CMOS	2Kx8	185	192	215	220	812
Inmos	NMOS	16Kx1	299	182	145	39	665
	NMOS	4Kx4	286	178	86	116	666
	CMOS	4Kx4	340	267	470	369	1,446
	CMOS	16Kx1	5	112	224	192	533
	CMOS	2Kx8	S	S	11	17	28
Intel	CMOS	16Kx1	30	30	30	30	120
	CMOS	4Kx4	30	30	30	30	120
Matra-Harris	CMOS	16Kx1	80	141	128	180	529
	CMOS	4Kx4	96	141	135	152	524
	CMOS	2Kx8	412	406	301	235	1,354
Mitsubishi	CMOS	16Kx1	120	180	150	110	560
	CMOS	4Kx4	450	500	550	630	2,130
Mosel	CMOS	16Kx1	10	15	17	18	60
	CMOS	4Kx4	5	10	18	22	55
	CMOS	2Kx8	45	90	144	202	481
Motorola	NMOS	16Kx1	10	9	3	3	25
	CMOS	4Kx4	305	360	325	340	1,330
	NMOS	2Kx8	331	437	300	100	1,168
NEC	NMOS	16Kx1	40	30	40	50	160
	CMOS	16Kx1	40	45	47	53	185
	CMOS	4Kx4	10	12	15	17	54
Saratoga	BiCMOS	16Kx1					
	BiCMOS	4Kx4		S	8	15	23
	BiCMOS	2Kx8		S	5	10	15

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seiko	CMOS	16Kx1	45	50	55	60	210
	CMOS	4Kx4	60	80	90	110	340
Sharp	CMOS	16Kx1	177	184	194	219	774
STC (ITT)	NMOS	16Kx1	80	65	59	50	253
	NMOS	4Kx4	110	145	196	235	686
TCMC	CMOS	16Kx1	20	25	29	32	105
	CMOS	4Kx4	20	40	50	55	165
Toshiba	NMOS	4Kx4	350	350	385	404	1,489
	NMOS	2Kx8	825	865	995	1,094	3,779
UMC	CMOS	16Kx1	3	7	9	3	22
	CMOS	4Kx4	2	10	22	17	51
	CMOS	2Kx8	5	10	25	30	70
Vitelic	CMOS	16Kx1					
	CMOS	4Kx4					
	CMOS	2Kx8	25	40	50	75	190
VLSI	CMOS	4Kx4	S	S	2	5	7
	CMOS	2Kx8	S	S	4	12	16
Total			12,011	12,213	12,397	12,014	48,635
Percentage Change From Previous Quarter			0	2%	2%	(3%)	
Cumulative Total			144,271	156,484	168,881	180,895	
Average Selling Price			$3.40	$3.40	$3.42	$3.43	$3.41
Revenue ($M)			40.8	41.5	42.4	41.2	166.0
Market Share							
North America			24.9%	27.5%	28.0%	29.2%	27.4%
Japan			60.5	58.3	56.8	56.5	58.0
Europe			14.6	13.9	14.8	13.9	14.3
ROW			0.1	0.2	0.5	0.4	0.3
Total			100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

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Table 3

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	64Kx1					0
	CMOS	8Kx8					0
Cypress	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx8					0
Fairchild	CMOS	64Kx1	S	S	S	S	0
Fujitsu	NMOS	64Kx1	S	10	20	35	65
	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx9					0
	CMOS	8Kx8					0
Hitachi	CMOS	64Kx1		S	S	20	25
	BiCMOS	64Kx1					0
	BiCMOS	16Kx4					0
IDT	CMOS	16Kx1					0
	CMOS	64Kx1					0
	CMOS	8Kx8					0
Inmos	CMOS	64Kx1		S	S	5	5
	CMOS	16Kx4					0
Lattice Semi.	CMOS	16Kx4					0
	CMOS	64Kx1					0
	CMOS	8Kx8					0
Mitsubishi	CMOS	8Kx8					0
MOSel	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx8					0
Motorola	CMOS	8Kx8					0
	CMOS	64Kx1					0
	CMOS	16Kx4					0
NEC	CMOS	64Kx1		S	10	20	30
	CMOS	16Kx4					0
Oki	CMOS	16Kx4					0
Performance	CMOS	16Kx4					0

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seiko/SMOS	CMOS	16Kx4					0
	CMOS	8Kx8					0
	CMOS	64Kx1					0
Sharp	CMOS	8Kx8					0
Toshiba	CMOS	64Kx1					0
	CMOS	16Kx4					0
	NMOS	8Kx9					0
Visic	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx9					0
VTI	CMOS	16Kx4					0
	CMOS	64Kx1	—	—	—	—	0
Total			0	10	35	80	125
Percentage Change From Previous Quarter				N/A	250%	129%	
Cumulative Total				10	45	125	
Average Selling Price			$125.00	$100.00	$75.00	$60.00	$67.40
Revenue ($M)			0	1.0	2.6	4.8	8.4
Market Share							
North America			0	0	0	0	0
Japan			0	100.0%	100.0%	93.8%	96.0%
Europe			0	0	0	6.3	4.0
Total			0	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	64Kx1				S	0
	CMOS	8Kx8	S	S	S	1	1
Cypress	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx8					0
Fairchild	CMOS	64Kx1	1	16	20	23	60
Fujitsu	NMOS	64Kx1	50	75	110	120	355
	CMOS	64Kx1	S	S	5	20	25
	CMOS	16Kx4					0
	CMOS	8Kx9		S	0	5	5
	CMOS	8Kx8				10	10
Hitachi	CMOS	64Kx1	40	75	135	250	500
	BiCMOS	64Kx1		S	5	15	20
	BiCMOS	16Kx4					0
IDT	CMOS	16Kx4	S	5	20	50	75
	CMOS	64Kx1			S	5	5
	CMOS	8Kx8				S	0
Inmos	CMOS	64Kx1	25	55	95	125	300
	CMOS	16Kx4				S	0
Lattice Semi.	CMOS	16Kx4	S	5	10	20	35
	CMOS	64Kx1				S	0
	CMOS	8Kx8					0
Mitsubishi	CMOS	8Kx8					0
MOSel	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx8					0
Motorola	CMOS	8Kx8			S	S	0
	CMOS	64Kx1			S	S	0
	CMOS	16Kx4				S	0
NEC	CMOS	64Kx1	30	140	300	250	720
	CMOS	16Kx4				S	0
Oki	CMOS	16Kx4					0
Performance	CMOS	16Kx4					0

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seiko/SMOS	CMOS	16Kx4					0
	CMOS	8Kx8			S	20	20
	CMOS	64Kx1					0
Sharp	CMOS	8Kx8					0
Toshiba	CMOS	64Kx1		S	S	5	5
	CMOS	16Kx4				S	0
	NMOS	8Kx9			S	S	0
Visic	CMOS	64Kx1			S	5	5
	CMOS	16Kx4				S	0
	CMOS	8Kx9					0
VTI	CMOS	16Kx4		S	5	15	20
	CMOS	64Kx1	---	---	S	S	0
Total			146	371	705	939	2,161
Percentage Change From Previous Quarter			83%	154%	90%	33%	
Cumulative Total			271	642	1,347	2,286	
Average Selling Price			$55.00	$38.00	$30.00	$20.00	$28.72
Revenue ($M)			8.0	14.1	21.2	18.8	62.1
Market Share							
North America			0.7%	7.0%	7.8%	12.7%	9.3%
Japan			82.2	78.2	78.7	74.0	76.8
Europe			17.1	14.8	13.5	13.3	13.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	64Kx1	S	2	12	20	34
	CMOS	8Kx8	4	5	25	40	74
Cypress	CMOS	64Kx1	0	S	2	4	6
	CMOS	16Kx4	0	S	3	5	8
	CMOS	8Kx8	0	S	2	4	6
Fujitsu	NMOS	64Kx1	110	80	60	40	290
	CMOS	64Kx1	50	100	200	250	600
	CMOS	16Kx4	0	0	0	10	10
	CMOS	8Kx9	10	30	50	100	190
	CMOS	8Kx8	50	100	150	200	500
Hitachi	CMOS	64Kx1	300	350	400	420	1,470
	BiCMOS	64Kx1	40	75	100	120	335
	BiCMOS	16Kx4	S	15	25	40	80
IDT	CMOS	16Kx4	65	70	95	120	350
	CMOS	64Kx1	10	14	17	20	61
	CMOS	8Kx8	0	0	15	55	70
Inmos	CMOS	64Kx1	62	117	102	129	410
	CMOS	16Kx4	1	6	7	25	39
	CMOS	8Kx8					0
Lattice Semi.	CMOS	16Kx4	33	41	46	80	200
	CMOS	64Kx1	0	7	38	25	70
	CMOS	8Kx8	S	1	2	5	8
Mitsubishi	CMOS	64Kx1				S	0
	CMOS	16Kx4				S	0
	CMOS	8Kx8	5	25	40	80	150
Mosel	CMOS	64Kx1	0	0	0	S	0
	CMOS	16Kx4	0	0	0	S	0
	CMOS	8Kx8	0	0	5	25	30
Motorola	CMOS	8Kx8	1	1	2	16	20
	CMOS	64Kx1	1	2	12	30	45
	CMOS	16Kx4		1	7	25	33
National	CMOS	64Kx1	7	10	8	6	31
NEC	CMOS	64Kx1	210	110	210	180	710
	CMOS	16Kx4	50	60	50	65	225
Oki	CMOS	16Kx4	S	30	60	80	170
Performance	CMOS	16Kx4	0	S	5	10	15

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seiko/SMOS	CMOS	16Kx4	S	25	40	75	140
	CMOS	8Kx8	20	50	80	100	250
	CMOS	64Kx1	0	S	5	10	15
Sharp	CMOS	8Kx8	S	10	15	25	50
Toshiba	CMOS	64Kx1	100	120	150	200	570
	CMOS	16Kx4	0	0	0	0	0
	NMOS	8Kx9	S	5	10	25	40
Visic	CMOS	64Kx1	5	5	10	15	35
	CMOS	16Kx4	S	S	5	10	15
	CMOS	8Kx9	S	S	S	5	5
VLSI	CMOS	16Kx4	35	50	80	120	285
	CMOS	8Kx8	0	0	0	0	0
Total			1,169	1,517	2,145	2,814	7,645
Percentage Change From Previous Quarter			24%	30%	41%	31%	
Cumulative Total			3,455	4,972	7,117	9,931	
Average Selling Price			$19.00	$17.00	$13.50	$10.50	$13.93
Revenue ($M)			22.2	25.8	29.0	29.5	106.5
Market Share							
North America			13.8%	13.8%	18.2%	22.7%	18.3%
Japan			80.8	78.1	76.7	71.8	75.8
Europe			5.4	8.1	5.1	5.5	5.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	C	64Kx1	40	88	141	190	459
	C	8Kx8	65	107	150	210	532
Cypress	C	64Kx1	7	12	40	45	104
	C	16Kx4	10	35	50	100	195
	C	8Kx8	7	11	30	40	88
Fujitsu	N	64Kx1	30	20	10	0	60
	C	64Kx1	325	400	540	702	1,967
	C	16Kx4	40	100	200	350	690
	C	8Kx8	250	275	316	364	1,205
	C	8Kx9	125	150	180	207	662
Hitachi	C	64Kx1	400	360	342	325	1,427
	C	16Kx4					
	BiC	64Kx1	150	300	429	558	1,437
	BiC	16Kx4	75	120	210	338	743
IDT	C	64Kx1	48	62	74	89	273
	C	16Kx4	190	200	227	238	855
	C	8Kx8	50	60	75	90	275
	BiC	64Kx1					
Inmos	C	64Kx1	121	268	356	264	1,009
	C	16Kx4	61	62	88	99	310
	C	8Kx8	S	S	2	15	17
Lattice Semi.	C	64Kx1	25	18	17	16	76
	C	16Kx4	85	80	76	72	313
	C	8Kx8	8	8	8	7	31
Micron	C	16Kx4					
Mitsubishi	C	64Kx1	S	17	50	30	97
	C	16Kx4	S	20	60	80	160
	C	8Kx8	68	164	184	251	667
Mosel	C	64Kx1					
	C	16Kx4					
	C	8Kx8	35	75	98	127	334
Motorola	C	64Kx1	60	50	35	56	201
	C	16Kx4	30	35	45	55	165
	C	8Kx8	20	30	40	40	130

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
National	C	64Kx1					
	C	16Kx4					
NEC	C	64Kx1	230	280	550	740	1,800
	C	16Kx4	90	50	240	240	620
Oki	C	16Kx4	5	8	6	10	29
Performance	C	64Kx1					
	C	16Kx4	20	35	61	107	223
	C	8Kx8					
Saratoga	BiC	16Kx4	S	S	5	10	15
	BiC	8Kx8		S	4	8	12
Seiko	C	64Kx1	25	58	100	140	323
	C	16Kx4	125	230	215	83	653
	C	8Kx8	130	200	200	53	583
Sharp	C	8Kx8	31	46	68	212	357
Texas Instruments	C	64Kx1					
	C	16Kx4					
	C	8Kx8					
	C	8Kx9					
Toshiba	C	64Kx1	300	400	520	650	1,870
	C	16Kx4		S	4	12	16
	C	8Kx8					
	C/N	8Kx9	40	80	112	157	389
Vitelic	C	8Kx8					
VLSI	C	16Kx4	40	10	8	6	64
	C	8Kx8					
Total			3,361	4,524	6,165	7,385	21,436

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Percent Change From Previous Quarter		19%	35%	36%	20%	
Cumulative Total		13,292	17,816	23,981	31,367	
Average Selling Price		$9.60	$8.45	$8.35	$8.10	$8.48
Revenue ($M)		32.3	38.2	51.5	59.8	181.8
Market Share						
North America		22.0%	20.2%	19.2%	20.4%	20.3%
Japan		72.6	72.5	73.6	74.5	73.5
Europe		5.4	7.3	7.2	5.1	6.2
Total		100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

Source: Dataquest
April 1990

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Fast MOS SRAM--Data

Table 4

Estimated Worldwide Fast 256K MOS SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	32Kx8					0
Cypress	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
EDI	CMOS	32Kx8					0
Fujitsu	CMOS	256Kx1			S	5	5
	CMOS	64Kx4			S	S	0
	CMOS	64Kx4*				S	0
Hitachi	CMOS	256Kx1					0
	CMOS	64Kx4					0
	BiCMOS	256Kx1					0
	BiCMOS	64Kx4					0
IDT	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
Inmos	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
Mitsubishi	CMOS	256Kx1			S	S	0
	CMOS	64Kx4			S	S	0
Mosel	CMOS	32Kx8			S	3	3
Motorola	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
National	BiCMOS	256Kx1					0
NEC	CMOS	256Kx1					0
	CMOS	64Kx4					0
Performance	CMOS	256Kx1					0
	CMOS	64Kx4					0

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Table 4 (Continued)

Estimated Worldwide Fast 256K MOS SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Sony	CMOS	32Kx8					0
Toshiba	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
VLSI	CMOS	64Kx4					0
	CMOS	32Kx8	-	-	-	-	0
Total			0	0	0	8	8
Percentage Change From Previous Quarter							
Cumulative Total					0	8	
Average Selling Price			N/A	N/A	$85.00	$80.00	$80.00
Revenue ($M)			0	0	0	0.6	0.6
Market Share							
North America			0	0	0	37.5%	37.5%
Japan			0	0	0	62.5	62.5
Europe			0	0	0	0	0
Total			0	0	0	100.0%	100.0%

*Separate I/O

(Continued)

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Table 4 (Continued)

Estimated Worldwide Fast 256K MOS SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	32Kx8	3	3	5	7	18
Cypress	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
EDI	CMOS	32Kx8					0
Fujitsu	CMOS	256Kx1	10	15	25	40	90
	CMOS	64Kx4	2	4	8	20	34
	CMOS	32Kx8					0
	BiCMOS	256Kx1			S	1	1
	BiCMOS	64Kx4					0
Hitachi	CMOS	256Kx1				S	0
	CMOS	64Kx4		S	3	7	10
	BiCMOS	256Kx1					0
	BiCMOS	64Kx4					0
IDT	CMOS	64Kx4					0
	CMOS	32Kx8		S	2	4	6
Inmos	CMOS	256Kx1		S	1	2	3
	CMOS	64Kx4	S	1	2	4	7
	CMOS	32Kx8				S	0
Micron	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
Mitsubishi	CMOS	256Kx1	S	1	21	22	44
	CMOS	64Kx4	S	8	47	55	110
Mosel	CMOS	32Kx8	3	3	6	10	22
Motorola	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
National	BiCMOS	256Kx1			S	S	0
NEC	CMOS	256Kx1					0
	CMOS	64Kx4					0
Peformance	CMOS	256Kx1					0
	CMOS	64Kx4					0
Samsung	CMOS	256Kx1					0

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Table 4 (Continued)

Estimated Worldwide Fast 256K MOS SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Sharp	CMOS	64Kx4					0
	CMOS	32Kx8					0
Sony	CMOS	32Kx8					0
Toshiba	CMOS	64Kx4					0
	CMOS	32Kx8					0
	CMOS	32Kx9	—	—	—	—	0
Total			18	35	120	172	345
Percent Change From Previous Quarter			125%	94%	243%	43%	
Cumulative Total			26	61	181	353	
Average Selling Price			$70.00	$57.00	$46.00	$43.00	$46.87
Revenue ($M)			1.3	2.0	5.5	7.4	16.2
Market Share							
North America			33.3%	17.1%	10.8%	12.2%	13.3%
Japan			66.7	80.0	86.7	84.3	83.8
Europe			0	2.9	2.5	3.5	2.9
ROW			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

Source: Dataquest
April 1990

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Reference material--will not be republished

Fast MOS SRAM--Data

INTRODUCTION

This section contains complete historical unit shipments for fast MOS static RAMs (SRAMs) from 1977 through 1987. For each quarter, we list estimates of unit shipments by supplier for the 4K, 16K, 64K, and 256K densities; worldwide quarterly prices; and the resulting revenue. Also, at the bottom of each table, we list the unit market share of suppliers based in the United States, Japan, and Europe. The tables are organized as follows:

- Table 1—4K SRAM (1977–1987)
- Table 2—16K SRAM (1980–1987)
- Table 3—64K SRAM (1984–1987)
- Table 4—256K SRAM (1986 and 1987)

DEFINITIONS

Speeds

Slow SRAMs are defined as parts that have access times greater than 70ns. These most often come in x8 organizations. Fast SRAMs, on the other hand, have access times of 70ns or less; they are commonly organized as either x1, x4, or x8.

A more general definition is based on applications. Fast SRAMs generally go into markets where use of the fastest device available can improve the system performance. Examples of applications for fast SRAMs would be cache memory in computing systems or writable control store for high-speed bit-slice processors. Slow SRAMs are often used as I/O buffers and in other applications where the limiting factor to system performance is not the memory access time. Because of the differentiation in applications, Dataquest treats the fast and slow SRAM markets separately.

Prices

Dataquest estimates the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and speed mixes (within the fast and slow categories). This information includes devices sold into both commercial and military markets.

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Fast MOS SRAM--Data

Unit Shipments

Historical shipment data are as published in earlier service sections, with occasional restatements, additions, and deletions based on later availability of other information. Portions of the 1986 data have been updated to reflect new information.

Quarterly Revenue

Quarterly revenue is calculated by multiplying the units shipped by the average billing price during the quarter.

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Fast MOS SRAM--Data

Table 1

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1977 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS						0
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS						0
Intel	NMOS		S	S	100	300	400
Intersil	NMOS						0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS						0
	CMOS	4Kx1					0
National	NMOS						0
NEC	NMOS						0
Synertek	NMOS						0
TCMC	NMOS	4Kx1					0
Texas Instruments	NMOS						0
Toshiba	NMOS		-	-	---	---	0
Total			S	S	100	300	400
Percentage Change From Previous Quarter						200%	
Cumulative Total			S	S	100	400	
Average Selling Price			$28.00	$25.00	$22.00	$21.00	$21.25
Revenue ($M)			0	0	2.2	6.3	8.5
Market Share							
United States			0	0	100.0%	100.0%	100.0%
Japan			0	0	0	0	0
Europe			0	0	0	0	0
Total			0	0	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1978 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS						0
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS						0
Intel	NMOS		300	500	350	650	1,800
Intersil	NMOS						0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS						0
	CMOS	4Kx1					0
National	NMOS						0
NEC	NMOS				S	5	5
Synertek	NMOS						0
TCMC	NMOS	4Kx1					0
Texas Instruments	NMOS						0
Toshiba	NMOS						0
Total			300	500	350	655	1,805
Percentage Change From Previous Quarter			0	67%	(30%)	87%	
Cumulative Total			700	1,200	1,550	2,205	
Average Selling Price			$20.00	$20.00	$18.00	$15.00	$17.80
Revenue ($M)			6.0	10.0	6.3	9.8	32.1
Market Share							
United States			100.0%	100.0%	100.0%	99.2%	99.7%
Japan			0	0	0	0.8	0.3
Europe			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Fast MOS SRAM--Data

Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1979 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS						0
AMI	NMOS		S	10	5	5	25
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS			S	15	60	75
Intel	NMOS		800	1,200	650	900	3,550
Intersil	NMOS				3	20	23
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		S	10	20	50	80
	CMOS	4Kx1					0
National	NMOS			10	25	65	100
NEC	NMOS		25	70	250	250	595
Synertek	NMOS						0
TCMC	NMOS	4Kx1				S	0
Texas Instruments	NMOS					5	5
Toshiba	NMOS				S	15	15
Total			830	1,300	968	1,370	4,468
Percentage Change From Previous Quarter			27%	57%	(26%)	42%	
Cumulative Total			3,035	4,335	5,303	6,673	
Average Selling Price			$16.00	$15.00	$19.00	$15.00	$16.05
Revenue ($M)			13.3	19.5	18.4	20.6	71.7
Market Share							
United States			97.0%	94.6%	72.6%	76.3%	84.7%
Japan			3.0	5.4	27.4	23.7	15.3
Europe			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		S	S	S	5	5
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS		150	200	250	300	900
Intel	NMOS		1,125	1,100	1,200	1,200	4,625
Intersil	NMOS		35	40	65	60	200
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		70	70	70	30	240
	CMOS	4Kx1					0
National	NMOS		200	325	450	450	1,425
NEC	NMOS		200	150	140	150	640
Synertek	NMOS						0
TCMC	NMOS	4Kx1	S	S	5	10	15
Texas Instruments	NMOS		30	40	75	100	245
Toshiba	NMOS		15	20	25	40	100
Total			1,825	1,945	2,280	2,345	8,395
Percentage Change From Previous Quarter			33%	7%	17%	3%	
Cumulative Total			8,498	10,443	12,723	15,068	
Average Selling Price			$10.00	$8.00	$8.00	$5.50	$7.74
Revenue ($M)			18.3	15.6	18.2	12.9	64.9
Market Share							
United States			80.0%	81.0%	81.6%	78.7%	80.3%
Japan			20.0	19.0	18.2	20.9	19.5
Europe			0	0	0.2	0.4	0.2
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		5	25	50	75	155
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS		350	275	250	250	1,125
Intel	NMOS		1,200	1,300	1,300	1,300	5,100
Intersil	NMOS		35	45	45	20	145
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		60	70	50	40	220
	CMOS	4Kx1			10	10	20
National	NMOS		400	500	550	500	1,950
NEC	NMOS		180	300	250	150	880
Synertek	NMOS		S	10	50	80	140
TCMC	NMOS	4Kx1	5	0	S	S	5
Texas Instruments	NMOS		120	120	125	130	495
Toshiba	NMOS		50	65	75	80	270
Total			2,405	2,710	2,755	2,635	10,505
Percentage Change From Previous Quarter			3%	13%	2%	(4%)	
Cumulative Total			17,473	20,183	22,938	25,573	
Average Selling Price			$5.00	$5.00	$4.00	$4.00	$4.49
Revenue ($M)			12.0	13.6	11.0	10.5	47.1
Market Share							
United States			75.7%	76.4%	79.1%	81.8%	78.3%
Japan			24.1	23.6	20.9	18.2	21.7
Europe			0.2	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Fast MOS SRAM--Data

Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		100	230	280	320	930
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS		200	200	200	220	820
Intel	NMOS		1,200	1,250	1,300	1,300	5,050
Intersil	NMOS		5	0	0	0	5
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		40	15	0	0	55
	CMOS	4Kx1	10	10	10	80	110
National	NMOS		350	450	470	400	1,670
NEC	NMOS		150	160	215	150	675
Synertek	NMOS		80	100	130	150	460
TCMC	NMOS	4Kx1	20	20	100	150	290
Texas Instruments	NMOS		140	150	150	160	600
Toshiba	NMOS		100	120	120	100	440
Total			2,395	2,705	2,975	3,030	11,105
Percentage Change From Previous Quarter			(9%)	13%	10%	2%	
Cumulative Total			27,968	30,673	33,648	36,678	
Average Selling Price			$3.60	$3.20	$3.00	$2.80	$3.12
Revenue ($M)			8.6	8.7	8.9	8.5	34.7
Market Share							
United States			80.4%	81.5%	78.7%	79.5%	80.0%
Japan			18.8	17.7	18.0	15.5	17.4
Europe			0.8	0.7	3.4	5.0	2.6
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Fast MOS SRAM--Data

Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		525	725	800	1,000	3,050
AMI	NMOS						0
Cypress	CMOS	1Kx4					0
Fujitsu	NMOS		250	300	300	350	1,200
Intel	NMOS		1,300	1,250	1,250	1,150	4,950
Intersil	NMOS						0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS						0
	CMOS	4Kx1	60	80	150	300	590
National	NMOS		400	400	600	650	2,050
NEC	NMOS		200	250	300	300	1,050
Synertek	NMOS		170	200	250	350	970
TCMC	NMOS	4Kx1	150	170	200	200	720
Texas Instruments	NMOS		175	175	175	175	700
Toshiba	NMOS		60	40	30	20	150
Total			3,290	3,590	4,055	4,495	15,430
Percentage Change From Previous Quarter			9%	9%	13%	11%	
Cumulative Total			39,968	43,558	47,613	52,108	
Average Selling Price			$2.70	$2.75	$2.80	$3.00	$2.83
Revenue ($M)			8.9	9.9	11.4	13.5	43.6
Market Share							
United States			79.9%	78.8%	79.5%	80.6%	79.8%
Japan			15.5	16.4	15.5	14.9	15.6
Europe			4.6	4.7	4.9	4.4	4.7
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		1,200	1,400	1,550	1,650	5,800
AMI	NMOS						0
Cypress	CMOS	1Kx4	5	5	10	25	40
Fujitsu	NMOS		300	280	265	245	1,090
Intel	NMOS		1,620	1,920	2,450	2,250	8,240
Intersil	NMOS						0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS						0
	CMOS	4Kx1	355	375	780	260	1,770
National	NMOS		650	500	450	400	2,000
NEC	NMOS		450	500	500	520	1,970
Synertek	NMOS		250	200	180	150	780
TCMC	NMOS	4Kx1	180	210	250	270	910
Texas Instruments	NMOS		150	130	100	50	430
Toshiba	NMOS		30	30	20	0	80
Total			5,185	5,550	6,555	5,820	23,110
Percentage Change From Previous Quarter			28%	7%	18%	(11%)	
Cumulative Total			57,293	62,843	69,398	75,218	
Average Selling Price			$3.30	$3.35	$3.30	$3.05	$3.25
Revenue ($M)			17.1	18.6	21.6	17.8	75.1
Market Share							
United States			81.5%	81.6%	84.2%	82.2%	82.5%
Japan			15.0	14.6	12.0	13.1	13.6
Europe			3.5	3.8	3.8	4.6	3.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		1,700	1,800	1,850	1,950	7,300
AMI	NMOS		0	0	0	0	0
Cypress	CMOS	1Kx4	30	40	40	45	155
Fujitsu	NMOS		220	200	175	150	745
Intel	NMOS		2,050	1,680	1,550	1,350	6,630
Intersil	NMOS		0	0	0	0	0
Matra-Harris	CMOS	1Kx4					0
Motorola	NMOS		0	0	0	0	0
	CMOS	4Kx1	455	155	110	190	910
National	NMOS		340	290	250	200	1,080
NEC	NMOS		610	640	180	270	1,700
Synertek	NMOS		0	0	0	0	0
TCMC	NMOS	4Kx1	300	380	440	420	1,540
Texas Instruments	NMOS		0	0	0	0	0
Toshiba	NMOS		0	0	0	0	0
Total			5,705	5,185	4,595	4,575	20,060
Percentage Change From Previous Quarter			(2%)	(9%)	(11%)	0	
Cumulative Total			80,923	86,108	90,703	95,278	
Average Selling Price			$3.00	$3.00	$2.80	$2.75	$2.90
Revenue ($M)			17.1	15.6	12.9	12.6	58.1
Market Share							
United States			80.2%	76.5%	82.7%	81.6%	80.1%
Japan			14.5	16.2	7.7	9.2	12.2
Europe			5.3	7.3	9.6	9.2	7.7
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		1,500	1,100	1,000	1,000	4,600
AMI	NMOS		0	0	0	0	0
Cypress	CMOS	1Kx4	55	60	65	70	250
Fujitsu	NMOS		100	75	60	35	270
Inmos	CMOS	4Kx1	0	0	0	0	0
	CMOS	1Kx4	0	0	0	0	0
Intel	NMOS		1,120	1,240	930	940	4,230
Intersil	NMOS		0	0	0	0	0
Matra-Harris	CMOS	4Kx1		1	1	1	3
	CMOS	1Kx4		1	1	1	3
Motorola	NMOS		0	0	0	0	0
	CMOS	4Kx1	160	240	190	155	745
National	NMOS		150	100	65	40	355
NEC	NMOS	4Kx1	150	30	130	100	410
	NMOS	1Kx4	390	60	350	400	1,200
Synertek	NMOS		0	0	0	0	0
TCMC	NMOS	4Kx1	450	480	450	450	1,830
Texas Instruments	NMOS		0	0	0	0	0
Toshiba	NMOS		0	0	0	0	0
Total			4,075	3,387	3,242	3,192	13,896
Percentage Change From Previous Quarter			(11%)	(17%)	(4%)	(2%)	
Cumulative Total			99,353	102,740	105,982	109,174	
Average Selling Price			$2.75	$2.85	$2.85	$2.90	$2.83
Revenue ($M)			11.2	9.7	9.2	9.3	39.4
Market Share							
United States			73.3%	80.9%	69.4%	69.1%	73.3%
Japan			15.7	4.9	16.7	16.8	13.5
Europe			11.0	14.2	13.9	14.2	13.2
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Fast MOS SRAM—Data

Table 1 (Continued)

Estimated Worldwide Fast 4K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		1,000	900	810	648	3,358
AMI	NMOS		0	0	0	0	0
Cypress	CMOS	1Kx4	70	74	76	80	300
Fujitsu	NMOS		0	0	0	0	0
Inmos	CMOS	4Kx1	S	3	6	10	19
	CMOS	1Kx4	S	1	4	8	13
Intel	NMOS		920	930	884	795	3,529
Intersil	NMOS		0	0	0	0	0
Matra-Harris	CMOS	4Kx1	1	0	2	0	3
	CMOS	1Kx4	0	0	0	0	0
Motorola	NMOS		0	0	0	0	0
	CMOS	4Kx1	125	95	67	40	326
National	NMOS		25	15	8	4	51
NEC	NMOS	4Kx1	20	20	10	50	100
	NMOS	1Kx4	240	90	100	170	600
Synertek	NMOS		0	0	0	0	0
TCMC	NMOS	4Kx1	500	525	551	579	2,155
Texas Instruments	NMOS		0	0	0	0	0
Toshiba	NMOS		0	0	0	0	0
Total			2,901	2,653	2,516	2,384	10,454
Percentage Change From Previous Quarter			(9%)	(9%)	(5%)	(5%)	
Cumulative Total			112,075	114,728	117,244	119,628	
Average Selling Price			$2.90	$2.90	$2.90	$2.92	$2.90
Revenue ($M)			8.4	7.7	7.3	7.0	30.4
Market Share							
United States			73.8%	75.9%	73.3%	65.7%	72.4%
Japan			9.0	4.1	4.4	9.2	6.7
Europe			17.3	19.9	22.4	25.0	20.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

Source: Dataquest
May 1988

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Fast MOS SRAM--Data

Table 2

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	4Kx4					0
Cypress	CMOS	2Kx8					0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1				S	0
	NMOS	4Kx4					0
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1					0
	CMOS	4Kx4					0
IDT	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Inmos	NMOS	16Kx1				S	0
	NMOS	4Kx4					0
	CMOS	4Kx4					0
Intel	NMOS	16Kx1	S	S	S	1	1
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Mitsubishi	NMOS	16Kx1					0
	NMOS	4Kx4					0
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	2Kx8					0
NEC	NMOS	16Kx1					0
Sharp	CMOS	16Kx1					0

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1					0
	NMOS	4Kx4					0
TCMC	NMOS	16Kx1					0
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8					0
	NMOS	4Kx4	-	-	-	-	0
Total			0	0	0	1	1
Percentage Change From Previous Quarter							
Cumulative Total			0	0	0	1	
Average Selling Price			$50.00	$50.00	$50.00	$40.00	$40.00
Revenue ($M)			0	0	0	0.4	0.4
Market Share							
United States			0	0	0	100.0%	100.0%
Japan			0	0	0	0	0
Europe			0	0	0	0	0
Total			0	0	0	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	4Kx4					0
Cypress	CMOS	2Kx8					0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1	S	5	10	100	115
	NMOS	4Kx4			S	25	25
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1				S	0
	CMOS	4Kx4					0
IDT	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Inmos	NMOS	16Kx1	S	10	50	100	160
	NMOS	4Kx4			S	25	25
	CMOS	4Kx4					0
Intel	NMOS	16Kx1	3	5	8	10	26
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Mitsubishi	NMOS	16Kx1					0
	NMOS	4Kx4					0
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	2Kx8					0
NEC	NMOS	16Kx1	S	10	45	70	125
Sharp	CMOS	16Kx1					0

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1					0
	NMOS	4Kx4					0
TCMC	NMOS	16Kx1				S	0
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8					0
	NMOS	4Kx4	-	-	-	-	0
Total			3	30	113	330	476
Percentage Change From Previous Quarter			200%	900%	277%	192%	
Cumulative Total			4	34	147	477	
Average Selling Price			$20.00	$18.00	$15.00	$12.00	$13.14
Revenue ($M)			0.1	0.5	1.7	4.0	6.3
Market Share							
United States			100.0%	16.7%	7.1%	3.0%	5.5%
Japan			0	50.0	48.7	59.1	55.7
Europe			0	33.3	44.2	37.9	38.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	4Kx4					0
Cypress	CMOS	2Kx8					0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1	125	200	270	290	885
	NMOS	4Kx4	40	65	100	120	325
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1	50	120	180	250	600
	CMOS	4Kx4					0
IDT	CMOS	16Kx1		S	5	15	20
	CMOS	4Kx4				S	0
	CMOS	2Kx8					0
Inmos	NMOS	16Kx1	150	220	300	380	1,050
	NMOS	4Kx4	75	150	225	280	730
	CMOS	4Kx4					0
Intel	NMOS	16Kx1	3	0	0	0	3
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Mitsubishi	NMOS	16Kx1	5	5	5	50	60
	NMOS	4Kx4					0
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1					0
	CMOS	4Kx4					0
	NMOS	2Kx8					0
NEC	NMOS	16Kx1	100	100	120	120	440
Sharp	CMOS	16Kx1					0

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1					0
	NMOS	4Kx4					0
TCMC	NMOS	16Kx1	5	5	10	5	25
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8					0
	NMOS	4Kx4					0
Total			548	865	1,215	1,510	4,138
Percentage Change From Previous Quarter			66%	58%	40%	24%	
Cumulative Total			1,025	1,890	3,105	4,615	
Average Selling Price			$9.50	$8.00	$7.50	$7.25	$7.78
Revenue ($M)			5.2	6.9	9.1	10.9	32.2
Market Share							
United States			0.5%	0	0.4%	1.0%	0.6%
Japan			57.5	56.6%	55.6	55.0	55.8
Europe			42.0	43.4	44.0	44.0	43.6
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1		S	S	10	10
	CMOS	4Kx4					0
	NMOS	4Kx4					0
Cypress	CMOS	2Kx8					0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1	350	400	600	800	2,150
	NMOS	4Kx4	150	200	350	600	1,300
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1	350	500	600	800	2,250
	CMOS	4Kx4	S	S	10	25	35
IDT	CMOS	16Kx1	25	40	60	75	200
	CMOS	4Kx4	5	15	30	40	90
	CMOS	2Kx8					0
Inmos	NMOS	16Kx1	400	450	600	750	2,200
	NMOS	4Kx4	300	350	550	700	1,900
	CMOS	4Kx4					0
Intel	NMOS	16Kx1	0	0	0	0	0
	CMOS	16Kx1					0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8	0	10	25	50	85
Mitsubishi	NMOS	16Kx1	90	70	60	80	300
	NMOS	4Kx4	S	S	S	20	20
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1		S	S	S	0
	CMOS	4Kx4					0
	NMOS	2Kx8			S	5	5
NEC	NMOS	16Kx1	120	100	100	200	520
Sharp	CMOS	16Kx1				S	0

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1	S	10	20	50	80
	NMOS	4Kx4		S	S	10	10
TCMC	NMOS	16Kx1	5	5	5	5	20
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8	S	10	50	100	160
	NMOS	4Kx4					0
Total			1,795	2,160	3,060	4,320	11,335
Percentage Change From Previous Quarter			19%	20%	42%	41%	
Cumulative Total			6,410	8,570	11,630	15,950	
Average Selling Price			$7.25	$7.50	$7.75	$8.15	$7.78
Revenue ($M)			13.0	16.2	23.7	35.2	88.1
Market Share							
United States			1.7%	2.5%	2.9%	3.0%	2.7%
Japan			59.1	59.3	57.8	60.8	59.4
Europe			39.3	38.2	39.2	36.2	37.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1	25	75	150	250	500
	CMOS	4Kx4	S	5	5	5	15
	NMOS	4Kx4				S	0
Cypress	CMOS	2Kx8			S	S	0
	CMOS	4Kx4					0
	CMOS	16Kx1					0
Fujitsu	NMOS	16Kx1	1,050	1,250	1,400	1,500	5,200
	NMOS	4Kx4	800	1,000	1,350	1,400	4,550
	CMOS	16Kx1	S	S	25	50	75
	CMOS	4Kx4					0
Hitachi	CMOS	16Kx1	1,000	1,200	1,300	1,500	5,000
	CMOS	4Kx4	50	75	150	250	525
IDT	CMOS	16Kx1	80	85	95	105	365
	CMOS	4Kx4	50	65	75	85	275
	CMOS	2Kx8			S	S	0
Inmos	NMOS	16Kx1	850	900	950	850	3,550
	NMOS	4Kx4	900	1,400	1,800	1,500	5,600
	CMOS	4Kx4	S	S	10	25	35
Intel	NMOS	16Kx1	0	0	0	0	0
	CMOS	16Kx1	S	S	S	S	0
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1	10	15	15	21	61
	CMOS	4Kx4	0	0	0	0	0
	CMOS	2Kx8	65	90	85	100	340
Mitsubishi	NMOS	16Kx1	110	130	170	220	630
	NMOS	4Kx4	40	125	150	200	515
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1	1	0	5	13	19
	CMOS	4Kx4	0	0	0	0	0
	NMOS	2Kx8	4	13	31	97	145
NEC	NMOS	16Kx1	230	180	220	200	830
Sharp	CMOS	16Kx1	S	25	50	75	150

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1	100	200	250	300	850
	NMOS	4Kx4	15	25	40	50	130
TCMC	NMOS	16Kx1	5	5	0	0	10
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8	250	300	400	600	1,550
	NMOS	4Kx4				S	0
Total			5,635	7,163	8,726	9,396	30,920
Percentage Change From Previous Quarter			30%	27%	22%	8%	
Cumulative Total			21,585	28,748	37,474	46,870	
Average Selling Price			$8.00	$7.80	$7.30	$6.65	$7.35
Revenue ($M)			45.1	55.9	63.7	62.5	227.1
Market Share							
United States			2.8%	3.4%	4.1%	5.9%	4.3%
Japan			62.6	59.8	59.8	63.8	61.5
Europe			34.5	36.8	36.1	30.3	34.2
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1	250	275	250	250	1,025
	CMOS	4Kx4	5	20	25	30	80
	NMOS	4Kx4	1	5	25	35	66
Cypress	CMOS	2Kx8	10	25	50	100	185
	CMOS	4Kx4	S	10	25	50	85
	CMOS	16Kx1		S	5	25	30
Fujitsu	NMOS	16Kx1	1,350	1,300	1,000	800	4,450
	NMOS	4Kx4	1,500	1,585	1,700	1,850	6,635
	CMOS	16Kx1	200	300	500	580	1,580
	CMOS	4Kx4	10	50	125	200	385
Hitachi	CMOS	16Kx1	1,200	1,200	1,200	1,200	4,800
	CMOS	4Kx4	400	650	800	1,000	2,850
IDT	CMOS	16Kx1	110	130	165	195	600
	CMOS	4Kx4	100	125	160	180	565
	CMOS	2Kx8	5	10	25	40	80
Inmos	NMOS	16Kx1	800	650	500	300	2,250
	NMOS	4Kx4	1,300	1,140	1,030	1,210	4,680
	CMOS	4Kx4	34	42	109	175	360
Intel	NMOS	16Kx1					0
	CMOS	16Kx1	1	5	10	10	26
	CMOS	4Kx4					0
Matra-Harris	CMOS	16Kx1	51	43	42	11	147
	CMOS	4Kx4	0	8	3	9	20
	CMOS	2Kx8	123	138	222	267	750
Mitsubishi	NMOS	16Kx1	205	235	275	300	1,015
	NMOS	4Kx4	195	240	250	300	985
MOSel	CMOS	16Kx1					0
	CMOS	4Kx4					0
	CMOS	2Kx8					0
Motorola	NMOS	16Kx1	87	66	49	30	232
	CMOS	4Kx4	1	10	95	149	255
	NMOS	2Kx8	69	70	156	99	394
NEC	NMOS	16Kx1	210	180	40	110	540
Sharp	CMOS	16Kx1	100	100	75	75	350

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
STC (ITT)	NMOS	16Kx1	300	380	300	180	1,160
	NMOS	4Kx4	60	75	80	85	300
TCMC	NMOS	16Kx1	0	0	0	0	0
	NMOS	4Kx4					0
Toshiba	NMOS	2Kx8	600	600	675	750	2,625
	NMOS	4Kx4	S	100	250	300	650
Total			9,277	9,767	10,216	10,895	40,155
Percentage Change From Previous Quarter			(1%)	5%	5%	7%	
Cumulative Total			56,147	65,914	76,130	87,025	
Average Selling Price			$6.25	$5.25	$4.75	$4.25	$5.08
Revenue ($M)			58.0	51.3	48.5	46.3	204.1
Market Share							
United States			6.9%	7.7%	10.2%	10.9%	9.0%
Japan			64.4	67.0	67.4	68.5	66.9
Europe			28.8	25.4	22.4	20.5	24.1
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1	285	290	300	320	1,195
	CMOS	4Kx4	40	50	65	77	232
	NMOS	4Kx4	45	55	60	70	230
Cypress	CMOS	2Kx8	350	400	450	500	1,700
	CMOS	4Kx4	275	300	350	400	1,325
	CMOS	16Kx1	120	150	225	250	745
Fujitsu	NMOS	16Kx1	400	390	370	350	1,510
	NMOS	4Kx4	1,000	950	780	670	3,400
	CMOS	16Kx1	350	430	485	550	1,815
	CMOS	4Kx4	150	210	295	500	1,155
Hitachi	CMOS	16Kx1	1,400	1,500	1,600	1,600	6,100
	CMOS	4Kx4	1,200	1,100	1,500	1,800	5,600
IDT	CMOS	16Kx1	170	173	181	182	706
	CMOS	4Kx4	110	118	123	136	487
	CMOS	2Kx8	130	148	163	175	616
Inmos	NMOS	16Kx1	332	401	410	425	1,568
	NMOS	4Kx4	824	578	482	339	2,223
	CMOS	4Kx4	293	290	225	292	1,100
	CMOS	16Kx1				3	3
	CMOS	2Kx8					0
Intel	CMOS	16Kx1	25	60	30	30	145
	CMOS	4Kx4	1	10	10	30	51
Matra-Harris	CMOS	16Kx1	34	59	21	33	147
	CMOS	4Kx4	16	23	4	15	58
	CMOS	2Kx8	280	380	388	202	1,250
Mitsubishi	NMOS	16Kx1	200	200	350	380	1,130
	NMOS	4Kx4	300	300	365	375	1,340
MOSel	CMOS	16Kx1			1	6	7
	CMOS	4Kx4			1	6	7
	CMOS	2Kx8	5	10	20	30	65
Motorola	NMOS	16Kx1	80	76	86	81	323
	CMOS	4Kx4	240	265	430	195	1,130
	NMOS	2Kx8	255	250	427	196	1,128

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NEC	NMOS	16Kx1	80	120	60	70	330
	CMOS	16Kx1	22	25	30	35	112
	CMOS	4Kx4	3	5	6	8	22
SMOS/Seiko	CMOS	16Kx1	30	35	40	45	150
	CMOS	4Kx4	15	20	25	30	90
Sharp	CMOS	16Kx1	100	120	160	175	555
STC (ITT)	NMOS	16Kx1	150	120	120	100	490
	NMOS	4Kx4	75	65	75	100	315
TCMC	NMOS	16Kx1			5	20	25
	NMOS	4Kx4			5	25	30
Toshiba	NMOS	2Kx8	725	775	750	800	3,050
	NMOS	4Kx4	400	475	350	350	1,575
VLSI	CMOS	4Kx4					0
	CMOS	2Kx8					0
Total			10,510	10,926	11,823	11,976	45,235
Percentage Change From Previous Quarter			(4%)	4%	8%	1%	
Cumulative Total			97,535	108,461	120,284	132,260	
Average Selling Price			$4.00	$3.75	$3.50	$3.40	$3.65
Revenue ($M)			42.0	41.0	41.4	40.7	165.1
Market Share							
United States			20.3%	21.6%	24.7%	22.4%	22.3%
Japan			60.7	60.9	60.6	64.6	61.8
Europe			19.1	17.5	14.7	13.0	15.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	16Kx1	340	350	357	364	1,411
	CMOS	4Kx4	95	125	163	187	569
	NMOS	4Kx4	80	95	119	137	430
Cypress	CMOS	2Kx8	550	600	650	700	2,500
	CMOS	4Kx4	450	475	500	515	1,940
	CMOS	16Kx1	270	290	310	315	1,185
Fujitsu	NMOS	16Kx1	300	250	200	150	900
	NMOS	4Kx4	425	415	375	325	1,540
	CMOS	16Kx1	600	625	650	670	2,545
	CMOS	4Kx4	625	740	780	790	2,935
Hitachi	CMOS	16Kx1	1,500	1,300	1,040	780	4,620
	CMOS	4Kx4	1,700	1,500	1,470	1,323	5,993
IDT	CMOS	16Kx1	180	185	210	215	790
	CMOS	4Kx4	140	150	175	180	645
	CMOS	2Kx8	185	192	215	220	812
Inmos	NMOS	16Kx1	299	182	145	39	665
	NMOS	4Kx4	286	178	86	116	666
	CMOS	4Kx4	340	267	470	369	1,446
	CMOS	16Kx1	5	112	224	192	533
	CMOS	2Kx8	S	S	11	17	28
Intel	CMOS	16Kx1	30	30	30	30	120
	CMOS	4Kx4	30	30	30	30	120
Matra-Harris	CMOS	16Kx1	80	141	128	180	529
	CMOS	4Kx4	96	141	135	152	524
	CMOS	2Kx8	412	406	301	235	1,354
Mitsubishi	NMOS	16Kx1	400	420	449	472	1,741
	NMOS	4Kx4	385	450	549	631	2,015
MOSel	CMOS	16Kx1	10	15	17	18	60
	CMOS	4Kx4	5	10	18	22	55
	CMOS	2Kx8	45	90	144	202	481
Motorola	NMOS	16Kx1	10	9	3	3	25
	CMOS	4Kx4	305	360	325	340	1,330
	NMOS	2Kx8	331	437	454	522	1,744

(Continued)

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Table 2 (Continued)

Estimated Worldwide Fast 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NEC	NMOS	16Kx1	40	30	40	50	160
	CMOS	16Kx1	40	45	47	53	185
	CMOS	4Kx4	10	12	15	17	54
Seiko/SMOS	CMOS	16Kx1	45	50	55	60	210
	CMOS	4Kx4	60	80	90	110	340
Sharp	CMOS	16Kx1	177	184	194	219	774
STC (ITT)	NMOS	16Kx1	80	65	59	50	253
	NMOS	4Kx4	110	145	196	235	686
TCMC	NMOS	16Kx1	25	25	29	32	110
	NMOS	4Kx4	40	40	54	70	204
Toshiba	NMOS	2Kx8	825	865	995	1,094	3,779
	NMOS	4Kx4	350	350	385	404	1,489
VLSI	CMOS	4Kx4	S	S	2	5	7
	CMOS	2Kx8	S	S	4	12	16
Total			12,311	12,461	12,897	12,851	50,520
Percentage Change From Previous Quarter			3%	1%	3%	0	
Cumulative Total			144,571	156,032	169,929	182,780	
Average Selling Price			$3.40	$3.40	$3.42	$3.43	$3.41
Revenue ($M)			41.9	42.4	44.1	44.1	172.4
Market Share							
United States			24.8%	27.6%	28.9%	31.2%	28.2%
Japan			60.8	58.7	56.9	55.6	58.0
Europe			14.4	13.7	14.2	13.1	13.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

Source: Dataquest
May 1988

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Table 3

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	64Kx1					0
	CMOS	8Kx8					0
Cypress	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx8					0
Fairchild	CMOS	64Kx1	S	S	S	S	0
Fujitsu	NMOS	64Kx1	S	10	20	35	65
	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx9					0
	CMOS	8Kx8					0
Hitachi	CMOS	64Kx1		S	5	20	25
	BICMOS	64Kx1					0
	BICMOS	16Kx4					0
IDT	CMOS	16Kx1					0
	CMOS	64Kx1					0
	CMOS	8Kx8					0
Inmos	CMOS	64Kx1		S	S	5	5
	CMOS	16Kx4					0
Lattice Semi.	CMOS	16Kx4					0
	CMOS	64Kx1					0
	CMOS	8Kx8					0
Mitsubishi	CMOS	8Kx8					0
MOSel	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx8					0
Motorola	CMOS	8Kx8					0
	CMOS	64Kx1					0
	CMOS	16Kx4					0
NEC	CMOS	64Kx1		S	10	20	30
	CMOS	16Kx4					0
Oki	CMOS	16Kx4					0
Performance	CMOS	16Kx4					0

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seiko/SMOS	CMOS	16Kx4					0
	CMOS	8Kx8					0
	CMOS	64Kx1					0
Sharp	CMOS	8Kx8					0
Toshiba	CMOS	64Kx1					0
	CMOS	16Kx4					0
	NMOS	8Kx9					0
Visic	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx9					0
VTI	CMOS	16Kx4					0
	CMOS	64Kx1	-	-	-	-	0
Total			0	10	35	80	125
Percentage Change From Previous Quarter				N/A	250%	129%	
Cumulative Total				10	45	125	
Average Selling Price			$125.00	$100.00	$75.00	$60.00	$67.40
Revenue ($M)			0	1.0	2.6	4.8	8.4
Market Share							
United States			0	0	0	0	0
Japan			0	100.0%	100.0%	93.8%	96.0%
Europe			0	0	0	6.3	4.0
Total			0	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	64Kx1				S	0
	CMOS	8Kx8	S	S	S	1	1
Cypress	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx8					0
Fairchild	CMOS	64Kx1	1	16	20	23	60
Fujitsu	NMOS	64Kx1	50	75	110	120	355
	CMOS	64Kx1	S	S	5	20	25
	CMOS	16Kx4					0
	CMOS	8Kx9		S	0	5	5
	CMOS	8Kx8				10	10
Hitachi	CMOS	64Kx1	40	75	135	250	500
	BICMOS	64Kx1		S	5	15	20
	BICMOS	16Kx4					0
IDT	CMOS	16Kx4	S	5	20	50	75
	CMOS	64Kx1			S	5	5
	CMOS	8Kx8				S	0
Inmos	CMOS	64Kx1	25	55	95	125	300
	CMOS	16Kx4				S	0
Lattice Semi.	CMOS	16Kx4	S	5	10	20	35
	CMOS	64Kx1				S	0
	CMOS	8Kx8					0
Mitsubishi	CMOS	8Kx8					0
MOSel	CMOS	64Kx1					0
	CMOS	16Kx4					0
	CMOS	8Kx8					0
Motorola	CMOS	8Kx8			S	S	0
	CMOS	64Kx1			S	S	0
	CMOS	16Kx4				S	0
NEC	CMOS	64Kx1	30	140	300	250	720
	CMOS	16Kx4				S	0
Oki	CMOS	16Kx4					0
Performance	CMOS	16Kx4					0

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seiko/SMOS	CMOS	16Kx4					0
	CMOS	8Kx8			S	20	20
	CMOS	64Kx1					0
Sharp	CMOS	8Kx8					0
Toshiba	CMOS	64Kx1		S	S	5	5
	CMOS	16Kx4				S	0
	NMOS	8Kx9			S	S	0
Visic	CMOS	64Kx1			S	5	5
	CMOS	16Kx4				S	0
	CMOS	8Kx9					0
VTI	CMOS	16Kx4		S	5	15	20
	CMOS	64Kx1	---	---	S	S	0
Total			146	371	705	939	2,161
Percentage Change From Previous Quarter			83%	154%	90%	33%	
Cumulative Total			271	642	1,347	2,286	
Average Selling Price			$55.00	$38.00	$30.00	$20.00	$28.72
Revenue ($M)			8.0	14.1	21.2	18.8	62.1
Market Share							
United States			0.7%	7.0%	7.8%	12.7%	9.3%
Japan			82.2	78.2	78.7	74.0	76.8
Europe			17.1	14.8	13.5	13.3	13.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	64Kx1	S	2	12	20	34
	CMOS	8Kx8	4	5	25	40	74
Cypress	CMOS	64Kx1	0	S	2	4	6
	CMOS	16Kx4	0	S	3	5	8
	CMOS	8Kx8	0	S	2	4	6
Fujitsu	NMOS	64Kx1	110	80	60	40	290
	CMOS	64Kx1	50	100	200	250	600
	CMOS	16Kx4	0	0	0	10	10
	CMOS	8Kx9	10	30	50	100	190
	CMOS	8Kx8	50	100	150	200	500
Hitachi	CMOS	64Kx1	300	350	400	420	1,470
	BICMOS	64Kx1	40	75	100	120	335
	BICMOS	16Kx4	S	15	25	40	80
IDT	CMOS	16Kx4	65	70	95	120	350
	CMOS	64Kx1	10	14	17	20	61
	CMOS	8Kx8	0	0	15	55	70
Inmos	CMOS	64Kx1	62	117	102	129	410
	CMOS	16Kx4	1	6	7	25	39
	CMOS	8Kx8					0
Lattice Semi.	CMOS	16Kx4	33	41	46	80	200
	CMOS	64Kx1	0	7	38	25	70
	CMOS	8Kx8	S	1	2	5	8
Mitsubishi	CMOS	64Kx1				S	0
	CMOS	16Kx4				S	0
	CMOS	8Kx8	5	25	40	80	150
MOSel	CMOS	64Kx1	0	0	0	S	0
	CMOS	16Kx4	0	0	0	S	0
	CMOS	8Kx8	0	0	5	25	30
Motorola	CMOS	8Kx8	1	1	2	16	20
	CMOS	64Kx1	1	2	12	30	45
	CMOS	16Kx4		1	7	25	33
National	CMOS	64Kx1	7	10	8	6	31
NEC	CMOS	64Kx1	210	110	210	180	710
	CMOS	16Kx4	50	60	50	65	225
Oki	CMOS	16Kx4	S	30	60	80	170
Performance	CMOS	16Kx4	0	S	5	10	15

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seiko/SMOS	CMOS	16Kx4	S	25	40	75	140
	CMOS	8Kx8	20	50	80	100	250
	CMOS	64Kx1	0	S	5	10	15
Sharp	CMOS	8Kx8	S	10	15	25	50
Toshiba	CMOS	64Kx1	100	120	150	200	570
	CMOS	16Kx4	0	0	0	0	0
	NMOS	8Kx9	S	5	10	25	40
Visic	CMOS	64Kx1	5	5	10	15	35
	CMOS	16Kx4	S	S	5	10	15
	CMOS	8Kx9	S	S	S	5	5
VLSI	CMOS	16Kx4	35	50	80	120	285
	CMOS	8Kx8	0	0	0	0	0
Total			1,169	1,517	2,145	2,814	7,645
Percentage Change From Previous Quarter			24%	30%	41%	31%	
Cumulative Total			3,455	4,972	7,117	9,931	
Average Selling Price			$19.00	$17.00	$13.50	$10.50	$13.93
Revenue ($M)			22.2	25.8	29.0	29.5	106.5
Market Share							
United States			13.8%	13.8%	18.2%	22.7%	18.3%
Japan			80.8	78.1	76.7	71.8	75.8
Europe			5.4	8.1	5.1	5.5	5.9
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	64Kx1	40	88	141	190	459
	CMOS	8Kx8	65	107	150	210	532
Cypress	CMOS	64Kx1	7	12	40	50	109
	CMOS	16Kx4	10	35	50	100	195
	CMOS	8Kx8	7	11	30	40	88
Fujitsu	NMOS	64Kx1	30	20	10	0	60
	CMOS	64Kx1	325	400	540	702	1,967
	CMOS	16Kx4	40	100	200	350	690
	CMOS	8Kx9	125	150	180	207	662
	CMOS	8Kx8	250	275	316	364	1,205
Hitachi	CMOS	64Kx1	400	360	342	325	1,427
	BICMOS	64Kx1	150	300	390	507	1,347
	BICMOS	16Kx4	75	120	192	307	694
IDT	CMOS	16Kx4	190	200	227	238	855
	CMOS	64Kx1	48	62	74	89	273
	CMOS	8Kx8	50	60	75	90	275
Inmos	CMOS	64Kx1	121	268	356	264	1,009
	CMOS	16Kx4	61	62	88	99	310
	CMOS	8Kx8	S	S	2	15	17
Lattice Semi.	CMOS	16Kx4	85	80	76	72	313
	CMOS	64Kx1	25	18	17	16	76
	CMOS	8Kx8	8	8	8	7	31
Mitsubishi	CMOS	64Kx1	S	17	50	100	167
	CMOS	16Kx4	S	20	60	130	210
	CMOS	8Kx8	110	140	175	219	644
MOSel	CMOS	64Kx1	S	S	2	6	8
	CMOS	16Kx4	S	S	3	11	14
	CMOS	8Kx8	35	75	98	127	334
Motorola	CMOS	8Kx8	20	30	40	40	130
	CMOS	64Kx1	60	50	35	56	201
	CMOS	16Kx4	30	35	45	55	165
National	CMOS	64Kx1	0	0	0	0	0
NEC	CMOS	64Kx1	230	280	550	740	1,800
	CMOS	16Kx4	90	50	240	240	620
Oki	CMOS	16Kx4	5	8	6	10	29
Performance	CMOS	16Kx4	20	35	61	107	223

(Continued)

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Table 3 (Continued)

Estimated Worldwide Fast 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seiko/SMOS	CMOS	16Kx4	125	230	315	433	1,103
	CMOS	8Kx8	130	200	250	313	893
	CMOS	64Kx1	25	58	100	140	323
Sharp	CMOS	8Kx8	31	46	68	212	357
Toshiba	CMOS	64Kx1	300	400	520	650	1,870
	CMOS	16Kx4	0	S	4	12	16
	NMOS	8Kx9	40	80	112	157	389
Visic	CMOS	64Kx1	0	0	0	0	0
	CMOS	16Kx4	0	0	0	0	0
	CMOS	8Kx9	0	0	0	0	0
VLSI	CMOS	16Kx4	40	50	80	128	298
	CMOS	8Kx8	S	S	2	6	8
Total			3,403	4,540	6,319	8,132	22,395
Percentage Change From Previous Quarter			21%	33%	39%	29%	
Cumulative Total			13,334	17,874	24,193	32,326	
Average Selling Price			$9.50	$8.25	$8.05	$7.80	$8.22
Revenue ($M)			32.3	37.5	50.9	63.4	184.1
Market Share							
United States			21.7%	21.1%	19.8%	20.1%	20.5%
Japan			72.9	71.7	73.1	75.2	73.6
Europe			5.3	7.3	7.1	4.6	6.0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

Source: Dataquest
May 1988

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Table 4

Estimated Worldwide Fast 256K MOS SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	32Kx8					0
Cypress	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
EDI	CMOS	32Kx8					0
Fujitsu	CMOS	256Kx1			S	5	5
	CMOS	64Kx4			S	S	0
	CMOS	64Kx4*				S	0
Hitachi	CMOS	256Kx1					0
	CMOS	64Kx4					0
	BICMOS	256Kx1					0
	BICMOS	64Kx4					0
IDT	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
Inmos	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
Mitsubishi	CMOS	256Kx1			S	S	0
	CMOS	64Kx4			S	S	0
MOSel	CMOS	32Kx8			S	3	3
Motorola	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
National	BICMOS	256Kx1**					0
NEC	CMOS	256Kx1					0
	CMOS	64Kx4					0
Performance	CMOS	256Kx1					0
	CMOS	64Kx4					0

(Continued)

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Table 4 (Continued)

Estimated Worldwide Fast 256K MOS SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Sony	CMOS	32Kx8					0
Toshiba	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
VLSI	CMOS	64Kx4					0
	CMOS	32Kx8	-	-	-	-	0
Total			0	0	0	8	8
Percentage Change From Previous Quarter							
Cumulative Total					0	8	
Average Selling Price			N/A	N/A	$85.00	$80.00	$80.00
Revenue ($M)			0	0	0	0.6	0.6
Market Share							
United States			0	0	0	37.5%	37.5%
Japan			0	0	0	62.5	62.5
Europe			0	0	0	0	0
Total			0	0	0	100.0%	100.0%

*Separate I/O
**ECL I/O

(Continued)

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Table 4 (Continued)

Estimated Worldwide Fast 256K MOS SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	CMOS	32Kx8	3	3	5	7	18
Cypress	CMOS	256Kx1					0
	CMOS	64Kx4					0
	CMOS	32Kx8					0
EDI	CMOS	32Kx8					0
Fujitsu	CMOS	256Kx1	10	15	25	40	90
	CMOS	64Kx4	1	3	6	12	22
	CMOS	64Kx4*	1	1	3	8	13
Hitachi	CMOS	256Kx1				S	0
	CMOS	64Kx4		S	3	7	10
	BICMOS	256Kx1					0
	BICMOS	64Kx4					0
IDT	CMOS	256Kx1				S	0
	CMOS	64Kx4				S	0
	CMOS	32Kx8		S	2	4	6
Inmos	CMOS	256Kx1		S	1	2	3
	CMOS	64Kx4	S	1	2	4	7
	CMOS	32Kx8				S	0
Mitsubishi	CMOS	256Kx1	5	8	12	20	45
	CMOS	64Kx4	20	30	40	55	145
MOSel	CMOS	32Kx8	3	3	6	10	22
Motorola	CMOS	256Kx1				S	0
	CMOS	64Kx4				S	0
	CMOS	32Kx8					0
National	BICMOS	256Kx1**			S	S	0
NEC	CMOS	256Kx1					0
	CMOS	64Kx4					0
Performance	CMOS	256Kx1					0
	CMOS	64Kx4					0

(Continued)

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Table 4 (Continued)

Estimated Worldwide Fast 256K MOS SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Sony	CMOS 32Kx8					0
Toshiba	CMOS 256Kx1					0
	CMOS 64Kx4					0
	CMOS 32Kx8					0
VLSI	CMOS 64Kx4					0
	CMOS 32Kx8	—	—	—	—	0
Total		43	64	105	169	381
Percentage Change From Previous Quarter		438%	49%	64%	61%	
Cumulative Total		51	115	220	389	
Average Selling Price		$70.00	$57.00	$49.00	$43.00	$50.05
Revenue ($M)		3.0	3.6	5.1	7.3	19.1
Market Share						
United States		14.0%	9.4%	12.4%	12.4%	12.1%
Japan		86.0	89.1	84.8	84.0	85.3
Europe		0	1.6	2.9	3.6	2.6
Total		100.0%	100.0%	100.0%	100.0%	100.0%

*Separate I/O
**ECL I/O
S = Sampling

Source: Dataquest
May 1988

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Slow MOS SRAM--Data Update

INTRODUCTION

This section contains complete historical unit shipments for slow MOS static RAMs (SRAMs) for 1988. For each quarter we have included estimates on: unit shipments by supplier for the 16K, 64K, 256K, and 1Mb densities; worldwide quarterly prices; and the resulting revenue. Also, at the bottom of each table is the unit market share of suppliers based in North America, Japan, Europe, and the Rest of World (ROW) region. The tables are as follows:

- Table 1—16K SRAMs (1988)
- Table 2—64K SRAMs (1988)
- Table 3—256K SRAMs (1988)
- Table 4—1Mb SRAMs (1988)

DEFINITIONS

Speeds

Slow SRAMs are defined as parts that have an access time greater than 70ns. These most often come in x8 organizations. Fast SRAMs, on the other hand, have access times of 70ns or less, and are commonly organized as either x1, x4, or x8.

A more general definition is based on applications. Fast static RAMs generally go into markets where the use of the fastest device available can improve the system performance. Examples of applications for fast static RAMs would be in cache memory in computing systems or writable control store for high-speed bit slice processors. Slow static RAMs are often used as I/O buffers and in other applications where the factor limiting the system performance is not the memory access time. Because of the differentiation in applications, Dataquest treats the fast and slow SRAM markets separately.

Prices

Dataquest estimates the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and speed mixes (within the fast and slow categories) and include devices sold into both the commercial and military markets.

Quarterly Revenue

Quarterly revenue is calculated by multiplying the units shipped by the average billing price during the quarter.

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Slow MOS SRAM--Data Update

Table 1

Estimated 1988 Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	570	970	1,900	1,270	4,710
Fujitsu	CMOS	308	280	220	170	978
Harris	CMOS	42	44	46	49	181
Hitachi	CMOS	3,114	3,425	3,493	3,319	13,351
Hyundai	CMOS	600	1,000	2,000	3,100	6,700
IDT	CMOS	0	0	0	0	0
Matra-Harris	CMOS	127	178	232	301	839
Matsushita	CMOS	200	0	0	0	200
Mitsubishi	NMOS	25	15	30	20	90
Mosel	CMOS	20	50	100	200	370
Motorola	CMOS	400	349	480	628	1,857
NEC	NMOS	500	750	600	400	2,250
	CMOS	2,200	1,950	1,775	1,575	7,500
Oki	CMOS	931	885	796	716	3,328
RCA	CMOS	702	351	176	88	1,316
Rohm	CMOS	700	1,000	1,150	1,200	4,050
Sanyo	CMOS	4,000	4,500	5,500	6,000	20,000
Seiko	CMOS	992	1,488	1,935	2,128	6,543
SGS-Thomson	NMOS	110	104	99	94	406
	CMOS	300	330	450	600	1,680
Sharp	CMOS	1,400	2,000	4,200	3,850	11,450
Sony	CMOS	4,800	6,240	6,864	7,207	25,111
Toshiba	NMOS	5,714	6,285	6,159	5,544	23,702
	CMOS	1,000	200	0	0	1,200
UMC	CMOS	486	1,520	6,109	8,800	16,915
Total		29,241	33,914	44,314	47,259	154,728
Percentage Change From Previous Quarter		11%	16%	31%	7%	
Cumulative Total		567,362	601,276	645,590	692,849	
Average Selling Price		$2.00	$2.25	$2.50	$2.60	$2.38

(Continued)

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Table 1 (Continued)

Estimated 1988 Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Revenue ($M)		58.5	76.3	110.8	122.9	368.4
Market Share						
North America		5.9%	5.2%	6.1%	4.7%	5.5%
Japan		88.5	85.6	73.8	68.0	77.4
Europe		1.8	1.8	1.8	2.1	1.9
ROW		3.7	7.4	18.3	25.2	15.3
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
April 1990

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Slow MOS SRAM--Data Update

Table 2

Estimated 1988 Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	CMOS	2,638	2,375	2,137	1,710	8,860
Hitachi	CMOS	9,200	8,500	7,900	7,200	32,800
Hyundai	CMOS	500	1,500	2,500	3,100	7,600
Matra-Harris	CMOS	370	432	536	697	2,035
Matsushita	CMOS	450	500	500	550	2,000
Mitsubishi	CMOS	2,070	2,100	2,200	3,500	9,870
Motorola	CMOS	377	432	504	497	1,810
NEC	CMOS	8,500	6,400	5,975	5,375	26,250
	PSRAM	900	700	500	300	2,400
Oki	CMOS	429	437	610	650	2,126
RCA	CMOS	665	632	600	582	2,479
Samsung	CMOS	230	650	620	700	2,200
Seiko/SMOS	CMOS	1,678	1,761	1,849	1,831	7,119
SGS-Thomson	CMOS	165	170	175	200	710
Sharp	CMOS	4,303	4,844	4,208	4,689	18,044
Sony	CMOS	2,745	2,809	2,950	2,861	11,365
Toshiba	CMOS	6,038	6,796	6,803	6,599	26,236
	NMOS	500	200	0	0	700
Total		41,758	41,237	40,567	41,041	164,604
Percent Change From Previous Quarter		(1%)	(1%)	(2%)	1%	
Cumulative Total		352,418	393,655	434,222	475,263	
Average Selling Price		$2.50	$2.90	$3.25	$3.50	$3.03
Revenue ($M)		104.4	119.6	131.8	143.6	499.5
Market Share						
North America		2.5%	2.6%	2.7%	2.6%	2.6%
Japan		94.5	90.7	87.8	85.9	89.8
Europe		1.3	1.5	1.8	2.2	1.7
ROW		1.7	5.2	7.7	9.3	6.0
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
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Table 3

Estimated 1988 Worldwide Slow 256K SRAM Shipments
(Thousands of Units)

Company	Product Type	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu		2,790	2,650	2,520	2,570	10,530
Hitachi		3,300	3,400	3,600	4,000	14,300
	PSRAM	3,014	3,075	3,228	3,390	12,707
Matra-Harris		135	189	265	370	959
Matsushita		300	400	400	500	1,600
Mitsubishi		1,900	1,300	1,400	1,600	6,200
Motorola		160	153	258	400	971
NEC		2,650	2,750	3,000	4,000	12,400
	PSRAM	850	800	600	500	2,750
Oki		346	380	437	525	1,688
RCA		S	3	10	30	43
Samsung		S	30	50	100	180
Seiko		1,188	1,366	1,571	1,885	6,010
Sharp		600	800	1,000	1,200	3,600
Sony		825	908	998	1,148	3,879
Toshiba		1,050	1,100	1,250	1,500	4,900
	PSRAM	1,200	1,400	1,700	2,000	6,300
Total		20,308	20,704	22,287	25,718	89,017
Percent Change From Previous Quarter		16%	2%	8%	15%	
Cumulative Total		73,249	93,953	116,240	141,958	
Average Selling Price		$6.80	$7.50	$7.70	$7.85	$7.49
Revenue ($M)		138.1	155.3	171.6	201.9	666.9
Market Share						
North America		0.8%	0.8%	1.2%	1.7%	1.1%
Japan		98.5	98.2	97.4	96.5	97.6
Europe		0.7	0.9	1.2	1.4	1.1
ROW		0	0.1	0.2	0.4	0.2
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
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Table 4

Estimated 1988 Worldwide Slow 1Mb SRAM Shipments
(Thousands of Units)

Company	Product Type	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu		0	0	0	0	0
Hitachi		0	S	5	50	55
	PSRAM	350	420	480	550	1,800
Inova		S	2	3	5	10
Mitsubishi		0	0	0	0	0
Motorola		0	0	0	0	0
NEC		0	0	S	5	5
	PSRAM	0	0	0	0	0
Oki		0	0	0	0	0
Samsung		0	0	0	0	0
Seiko		0	0	0	0	0
Sharp		0	0	0	0	0
Sony		0	0	0	0	0
Toshiba		0	S	2	10	12
	PSRAM	15	30	60	120	225
Total		365	452	550	740	2,107
Percent Change From Previous Quarter		0	124%	122%	135%	
Cumulative Total		0	817	1,367	2,107	
Average Selling Price						
SRAM		0	$600.00	$400.00	$275.00	$298.17
PSRAM		$25.00	$24.00	$23.00	$22.00	$23.25
Revenue ($M)		9.1	12.0	16.4	34.0	71.5
Market Share						
North America		0	0.4%	0.5%	0.7%	0.5%
Japan		100.0%	99.6%	99.5%	99.3%	99.5%
Europe		0	0	0	0	0
ROW		0	0	0	0	0
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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

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Slow MOS SRAM—Data

INTRODUCTION

This section contains complete historical unit shipments for slow MOS static RAMs (SRAMs) from 1975 through 1987. For each quarter we have included estimates on: unit shipments by supplier for the 4K, 16K, 64K, and 256K densities; worldwide quarterly prices; and the resulting revenue. Also, at the bottom of each table is the unit market share of suppliers based in North America, Japan, Europe, and the Rest of World (ROW) region. The tables are as follows:

- Table 1—4K NMOS SRAMs (1975–1987)
- Table 2—4K CMOS SRAMs (1978–1987)
- Table 3—16K SRAMs (1980–1987)
- Table 4—64K SRAMs (1982–1987)
- Table 5—256K SRAMs (1986–1987)

DEFINITIONS

Speeds

Slow SRAMs are defined as parts that have an access time greater than 70ns. These most often come in x8 organizations. Fast SRAMs, on the other hand, have access times of 70ns or less, and are commonly organized as either x1, x4, or x8.

A more general definition is based on applications. Fast static RAMs generally go into markets where the use of the fastest device available can improve the system performance. Examples of applications for fast static RAMs would be in cache memory in computing systems or writable control store for high-speed bit slice processors. Slow static RAMs are often used as I/O buffers and in other applications where the factor limiting the system performance is not the memory access time. Because of the differentiation in applications, Dataquest treats the fast and slow SRAM markets separately.

Prices

Dataquest estimates the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and speed mixes (within the fast and slow categories) and include devices sold into both the commercial and military markets.

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Slow MOS SRAM--Data

Unit Shipments

Historical shipment data remain as they have been published in earlier service sections, with occasional restatements, additions, and deletions based on availability of later information. Some of the 1987 data have been updated to reflect new information.

Quarterly Revenue

Quarterly revenue is calculated by multiplying the units shipped by the average billing price during the quarter.

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Table 1

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1975 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD									0	0
AMI									0	0
Commodore MOS									0	0
Eurotechnique									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (EMM Prior 1980)					10		40	8	50	8
Hitachi									0	0
Intel									0	0
Intersil									0	0
Matsushita									0	0
Mitsubishi									0	0
Mostek									0	0
Motorola									0	0
National									0	0
NEC									0	0
Oki Electric									0	0
Synertek									0	0
Texas Instruments									0	0
Toshiba									0	0
Zilog	—	—	—	—	—	—	—	—	0	0
Total	0	0	0	0	10	0	40	0	50	0
Percentage Change From Previous Quarter							300%			
Cumulative Total	0	0	0	0	10	0	50	0		
Average Selling Price					$25.00		$20.00		$21.00	
Revenue ($M)	0	0	0	0	0.3	0	0.8	0	1.1	0
Market Share										
North America					100.0%		100.0%		100.0%	
Japan					0		0		0	
Europe					0		0		0	
Total					100.0%		100.0%		100.0%	

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

	1976									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD									0	0
AMI			s		15		20		35	0
Commodore MOS									0	0
Eurotechnique									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (GMM Prior 1980)	75	10	125	30	170	70	200	130	570	240
Hitachi									0	0
Intel					s	s	15	5	15	5
Intersil									0	0
Matsushita									0	0
Mitsubishi									0	0
Mostek									0	0
Motorola									0	0
National									0	0
NEC									0	0
Oki Electric									0	0
Synertek									0	0
Texas Instruments									0	0
Toshiba									0	0
Zilog	—	—	—	—	—	—	—	—	0	0
Total	75	10	125	30	185	70	235	135	620	245
Percentage Change From Previous Quarter	88%		67%	200%	48%	133%	27%	93%		
Cumulative Total	125	10	250	40	435	110	670	245		
Average Selling Price	$18.00	$20.00	$15.00	$18.00	$11.00	$12.50	$8.50	$10.00	$11.71	$12.10
Revenue ($M)	1.4	0.2	1.9	0.5	2.0	0.9	2.0	1.4	7.3	3.0
Market Share										
North America	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Japan	0	0	0	0	0	0	0	0	0	0
Europe	0	0	0	0	0	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1977 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD									0	0
AMI	30		50		80		90	10	250	10
Commodore MOS									0	0
Eurotechnique									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (EMM Prior 1980)	250	150	250	160	300	250	375	300	1,175	860
Hitachi	5		30		50		85		170	0
Intel	20	20	100	50	100	50	100	50	320	170
Intersil			10		15	5	20	10	45	15
Matsushita									0	0
Mitsubishi									0	0
Mostek				15		30		50	0	95
Motorola			10		20		20		50	0
National									0	0
NEC			30	10	150	100	175	175	355	285
Oki Electric									0	0
Synertek	15		25		65		100		205	0
Texas Instruments	10	5	15	10	35	30	55	45	115	90
Toshiba									0	0
Zilog	—	—	—	—	—	15	—	25	0	40
Total	330	175	520	245	815	480	1,020	665	2,685	1,565
Percentage Change From Previous Quarter	40%	30%	58%	40%	57%	96%	25%	39%		
Cumulative Total	1,000	420	1,520	665	2,335	1,145	3,355	1,810		
Average Selling Price	$8.00	$8.50	$8.00	$8.25	$8.00	$8.00	$8.00	$8.00	$8.00	$8.10
Revenue ($M)	2.6	1.5	4.2	2.0	6.5	3.8	8.2	5.3	21.5	12.7
Market Share										
North America	98.5%	100.0%	88.5%	95.9%	75.5%	79.2%	74.5%	73.7%	80.4%	81.8%
Japan	1.5	0	11.5	4.1	24.5	20.8	25.5	26.3	19.6	18.2
Europe	0	0	0	0	0	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1978 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD									0	0
AMI	190	10	230	20	270	30	325	25	1,015	85
Commodore MOS							15		15	0
Eurotechnique									0	0
Fairchild							20		20	0
Fujitsu	50		75		100		100		325	0
GTE (EMM Prior 1980)	500	400	650	500	550	450	550	550	2,250	1,900
Hitachi	90		130		200		300		720	0
Intel	250	250	250	300	200	250	400	350	1,100	1,150
Intersil	50	20	40	10	120	20	150	50	360	100
Matsushita									0	0
Mitsubishi									0	0
Mostek		120		250		200		230	0	800
Motorola	45	5	175	25	220	30	220	30	660	90
National			80	20	200	50	325	75	605	145
NEC	200	300	300	300	300	350	400	400	1,200	1,350
Oki Electric									0	0
Synertek	160		280		350		450		1,240	0
Texas Instruments	350	350	400	400	350	350	400	400	1,500	1,500
Toshiba					30		60		90	0
Zilog		60		120		140		150	0	470
Total	1,885	1,515	2,610	1,945	2,890	1,870	3,715	2,260	11,100	7,590
Percentage Change From Previous Quarter	85%	128%	38%	28%	11%	(4%)	29%	21%		
Cumulative Total	5,240	3,325	7,850	5,270	10,740	7,140	14,455	9,400		
Average Selling Price	$7.00	$7.00	$6.00	$6.00	$5.00	$5.00	$5.00	$4.75	$5.57	$5.58
Revenue ($M)	13.2	10.6	15.7	11.7	14.5	9.4	18.6	10.7	61.9	42.4
Market Share										
North America	82.0%	80.2%	80.7%	84.6%	78.2%	81.3%	76.9%	82.3%	79.0%	82.2%
Japan	18.0	19.8	19.3	15.4	21.8	18.7	23.1	17.7	21.0	17.8
Europe	0	0	0	0	0	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

	1979									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD	150	30	275	75	330	140	420	220	1,175	465
AMI	50		55		95		50		250	0
Commodore MOS	5		25		100		175		305	0
Fairchild	50		100		300		400		850	0
Fujitsu	80		150		250		100		580	0
GTE (EMM Prior 1980)	300	250	350	300	350	350	400	450	1,400	1,350
Hitachi	450		450		450		450		1,800	0
Intel	400	400	600	600	850	100	800	200	2,650	1,300
Intersil	200	100	230	130	250	150	200	250	880	630
Matsushita			20		50		75		145	0
Mitsubishi	100		150		250		300		800	0
Motorola	270	30	320	20	450	30	300	50	1,340	130
National	530	120	900	190	900	200	1,100	400	3,430	910
NEC	400	600	600	450	800	400	1,000	300	2,800	1,750
OKI Electric									0	0
Synertek	560		600		900		1,000		3,060	0
TCMC		450		600		900		1,000	0	2,950
Texas Instruments	500	500	500	500	550	450	350	350	1,900	1,800
Toshiba	150		210		300		350		1,010	0
Zilog		110		110		150		45	0	415
Total	4,195	2,590	5,535	2,975	7,175	2,870	7,470	3,265	24,375	11,700
Percentage Change From Previous Quarter	13%	15%	32%	15%	30%	(4%)	4%	14%		
Cumulative Total	18,650	11,990	24,185	14,965	31,360	17,835	38,830	21,100		
Average Selling Price	$4.25	$4.00	$4.25	$4.00	$4.00	$4.25	$3.50	$3.75	$3.95	$3.99
Revenue ($M)	17.8	10.4	23.5	11.9	28.7	12.2	26.1	12.2	96.2	46.7
Market Share										
North America	71.9%	59.5%	71.5%	64.7%	70.7%	54.7%	69.5%	60.2%	70.7%	59.8%
Japan	28.1	23.2	28.5	15.1	29.3	13.9	30.5	9.2	29.3	15.0
Europe	0	17.4	0	20.2	0	31.4	0	30.6	0	25.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1980 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	350	200	400	250	450	300	300	300	1,500	1,050
AMI	5		0		0		0		5	0
Commodore MOS	250		275		350		390		1,265	0
Fairchild	450		450		450		450		1,800	0
Fujitsu	50		0		20		5		75	0
GTE (EMM Prior 1980)	800	800	800	800	800	800	800	800	3,200	3,200
Hitachi	450		450		600		600		2,100	0
Intel	800	250	800	250	1,000	250	1,100	250	3,700	1,000
Intersil	500	350	250	130	90	40	80	30	920	550
Matsushita	75		75		80		80		310	0
Mitsubishi	180	60	270	125	330	125	740	620	1,520	930
Motorola	425	75	425	75	350	75	650	80	1,850	350
National	1,200	600	1,500	750	1,500	800	1,600	700	5,800	2,850
NEC	1,350	270	1,800	330	1,200	400	2,400	240	6,750	1,240
Oki Electric	5		50		150		250		450	0
Synertek	1,000		750		850		1,120		3,720	0
TCMC		750		600		500		500	0	2,350
Texas Instruments	350	350	350	350	350	350	350	350	1,400	1,400
Toshiba	225		275		300		350		1,150	0
Zilog									0	0
Total	8,460	3,705	8,920	3,660	8,870	3,640	11,265	3,870	37,515	14,875
Percentage Change From Previous Quarter	13%	13%	5%	(1%)	(1%)	(1%)	27%	6%		
Cumulative Total	47,290	24,805	56,210	28,465	65,080	32,105	76,345	35,975		
Average Selling Price	$3.25	$3.25	$2.50	$3.75	$2.50	$2.25	$2.25	$2.00	$2.59	$2.80
Revenue ($M)	27.5	12.0	22.3	13.7	22.2	8.2	25.3	7.7	97.3	41.7
Market Share										
North America	72.5%	70.9%	67.3%	71.2%	69.8%	71.8%	60.7%	64.9%	67.1%	69.6%
Japan	27.5	8.9	32.7	12.4	30.2	14.4	39.3	22.2	32.9	14.6
Europe	0	20.2	0	16.4	0	13.7	0	12.9	0	15.8
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1981 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	570	300	780	400	800	450	800	350	2,950	1,500
AMI	0		0		0		0		0	0
Commodore MOS	240		230		100		0		570	0
Fairchild	450		500		500		450		1,900	0
Fujitsu	5		0		0		0		5	0
GTE (EMM Prior 1980)	830	830	800	800	350	250	150	100	2,130	1,980
Hitachi	600		600		600		600		2,400	0
Intel	1,200	275	1,200	275	1,300	250	1,500	250	5,200	1,050
Intersil	50	30	50	40	75	60	90	50	265	180
Matsushita	85		100		100		100		385	0
Mitsubishi	920	340	1,100	250	900	150	770	85	3,690	825
Motorola	650	80	750	120	1,000	175	1,000	150	3,400	525
National	1,600	550	1,750	600	1,900	250	2,000	100	7,250	1,500
NEC	2,500	220	2,450	250	2,600	150	2,900	90	10,450	710
Oki Electric	300		300		250		200	0	1,050	0
Synertek	1,050		1,100		1,050		900	0	4,100	0
TCMC	S	400	25	225	150	120	350	50	525	795
Texas Instruments	350	350	350	350	400	300	400	300	1,500	1,300
Toshiba	350		530		950		800		2,630	0
Zilog									0	0
Total	11,750	3,375	12,615	3,310	13,025	2,155	13,010	1,525	50,400	10,365
Percentage Change From Previous Quarter	4%	(13%)	7%	(2%)	3%	(35%)	0	(29%)		
Cumulative Total	88,095	39,350	100,710	42,660	113,735	44,815	126,745	46,340		
Average Selling Price	$2.75	$2.50	$2.50	$2.25	$1.85	$1.75	$1.40	$1.25	$2.11	$2.08
Revenue ($M)	32.3	8.4	31.5	7.4	24.1	3.8	18.2	1.9	106.2	21.6
Market Share										
North America	59.5%	71.6%	59.5%	78.1%	57.4%	80.5%	56.0%	85.2%	58.1%	77.5%
Japan	40.5	16.6	40.3	15.1	41.5	13.9	41.3	11.5	40.9	14.8
Europe	0	11.9	0.2	6.8	1.2	5.6	2.7	3.3	1.0	7.7
Total	100.0%	100.1%	100.0%	100.0%	100.0%	100.1%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1982 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	800	400	1,150	450	1,200	400	1,250	250	4,400	1,500
AMI									0	0
Commodore MOS									0	0
Fairchild	400		350		300		275		1,325	0
Fujitsu									0	0
GTE (EMM Prior 1980)	150	100	150	100	150	100	100	50	550	350
Hitachi	600		600		600		500		2,300	0
Intel	1,600	250	1,400	250	1,400	200	1,300	200	5,700	900
Intersil	75	30	50	20	50	20	50	20	225	90
Matsushita	100		100		0		0		200	0
Mitsubishi	700	100	500	100	1,000	100	800	160	3,000	460
Motorola	1,100	130	1,500	50	1,600	50	1,800	10	6,000	240
National	2,200	150	3,000	120	3,000	100	3,800	250	12,000	620
NEC	3,000	200	3,400	150	3,200	100	3,500	200	13,100	650
Oki Electric	200		200		150		150		700	0
Synertek	750		750		750		700		2,950	0
TOMC	200	35	100	25	150	25	150	0	600	85
Texas Instruments	350	200	250	150	200	100	200	100	1,000	550
Toshiba	1,500		2,000		2,400		2,400		8,300	0
Zilog									0	0
Total	13,725	1,595	15,500	1,415	16,150	1,195	16,975	1,240	62,350	5,445
Percentage Change From Previous Quarter	5%	5%	13%	(11%)	4%	(16%)	5%	4%		
Cumulative Total	140,470	47,935	155,970	49,350	172,120	50,545	189,095	51,785		
Average Selling Price	$1.50	$1.25	$1.40	$1.20	$1.35	$1.15	$1.10	$1.15	$1.33	$1.19
Revenue ($M)	20.6	2.0	21.7	1.7	21.8	1.4	18.7	1.4	82.8	6.5
Market Share										
North America	54.1%	79.0%	55.5%	80.6%	53.6%	81.2%	55.8%	71.0%	54.8%	78.1%
Japan	44.4	18.8	43.9	17.7	45.5	16.7	43.3	29.0	44.3	20.4
Europe	1.5	2.2	0.6	1.8	0.9	2.1	0.9	0	1.0	1.6
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1983 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	1,300	150	1,700	110	1,300	200	1,500	150	5,800	610
AMI									0	0
Commodore MOS									0	0
Fairchild	220		180		120		40		560	0
Fujitsu									0	0
GTE (EMM Prior 1980)	50	25							50	25
Hitachi	400		300		200		100		1,000	0
Intel	1,000	180	700	150	525	120	320	130	2,545	580
Intersil									0	0
Matsushita									0	0
Mitsubishi	400	100	380	90	300	50	180	60	1,260	300
Motorola	1,200		1,500		1,900		2,200		6,800	0
National	3,500	200	3,600	150	4,000	100	4,500	150	15,600	600
NEC	3,100	150	2,800	65	2,200	110	1,900	100	10,000	425
Oki Electric	100		100		50		25		275	0
Synertek	700		200		250		300		1,450	0
TCMC	200		200		250		250		900	0
Texas Instruments	200	20	200	50	200	50	200	50	800	170
Toshiba	2,700		2,400		2,400		2,400		9,900	0
Zilog									0	0
Total	15,070	825	14,260	615	13,695	630	13,915	640	56,940	2,710
Percentage Change From Previous Quarter	(11%)	(33%)	(5%)	(25%)	(4%)	2%	2%	2%		
Cumulative Total	204,165	52,610	218,425	53,225	232,120	53,855	246,035	54,495		
Average Selling Price	$1.05	$1.10	$1.10	$1.20	$1.25	$1.30	$1.30	$1.30	$1.17	$1.22
Revenue ($M)	15.8	0.9	15.7	0.7	17.1	0.8	18.1	0.8	66.7	3.3
Market Share										
North America	54.2%	69.7%	56.7%	74.8%	60.6%	74.6%	65.1%	75.0%	59.0%	73.2%
Japan	44.5	30.3	41.9	25.2	37.6	25.4	33.1	25.0	39.4	26.8
Europe	1.3	0	1.4	0	1.8	0	1.8	0	1.6	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1984 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	1,200	130	1,000	100	750	80	600	75	3,550	385
AMI	0	0	0	0					0	0
Commodore MOS	0	0	0	0					0	0
Fairchild	3	0	0	0	0		0		3	0
Fujitsu	0	0	0	0					0	0
GTE (EMM Prior 1980)	0	0	0	0					0	0
Hitachi	50	0	25	0					75	0
Intel	160	90	220	100	290	120	200	140	370	450
Intersil	0	0	0	0					0	0
Matsushita	0	0	0	0					0	0
Mitsubishi	140	40	125	35	110	30	100	30	475	135
Motorola	3,160	0	2,460	0	1,861		1,138		8,619	0
National	2,800	150	2,000	120	1,500	95	1,000	75	7,300	440
NEC	2,680	60	2,200	35	1,500	20	1,200	10	7,580	125
Oki Electric	25	0	25	0	15		0		65	0
Synertek	350	0	400	0	400		350		1,500	0
TOMC	225	0	175	0	150		125		675	0
Texas Instruments	150	50	140	50	120	40	110	25	520	165
Toshiba	1,800	0	1,400	0	1,800	0	1,400	0	6,400	0
Zilog	0	0	0	0					0	0
Total	12,743	520	10,170	440	8,496	385	6,223	355	37,632	1,700
Percentage Change From Previous Quarter	(8%)	(19%)	(20%)	(15%)	(16%)	(13%)	(27%)	(8%)		
Cumulative Total	258,778	55,015	268,948	55,455	277,444	55,840	283,667	56,195		
Average Selling Price	$1.30	$1.30	$1.30	$1.30	$1.30	$1.30	$1.40	$1.40	$1.32	$1.32
Revenue ($M)	16.6	0.7	13.2	0.6	11.0	0.5	8.7	0.5	49.5	2.2
Market Share										
North America	61.4%	80.8%	61.2%	84.1%	57.9%	87.0%	54.6%	88.7%	59.4%	84.7%
Japan	36.8	19.2	37.1	15.9	40.3	13.0	43.4	11.3	38.8	15.3
Europe	1.8	0	1.7	0	1.8	0	2.0	0	1.8	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1985 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	550	50	500	40	525	25	500	15	2,075	130
AMI									0	0
Commodore MOS									0	0
Fairchild	0	0	0	0	0		0		0	0
Fujitsu									0	0
GTE (EMM Prior 1980)									0	0
Hitachi									0	0
Intel	230	110	140	110	180	80	170	60	720	360
Intersil									0	0
Matsushita									0	0
Mitsubishi	75	25	50	10	40	0	25	0	190	35
Motorola	1,157		1,377		712		944		4,190	0
National	750	50	500	35	400	20	250	10	1,900	115
NEC	1,440	0	250	0	320	0	240	0	2,250	0
Oki Electric									0	0
Synertek									0	0
TCMC	100		50		30		10		190	0
Texas Instruments	95		75		50		40		260	0
Toshiba	1,500	0	700	0	400	0	300	0	2,900	0
Zilog									0	0
Total	5,897	235	3,642	195	2,657	125	2,479	85	14,675	640
Percentage Change From Previous Quarter	(5%)	(34%)	(38%)	(17%)	(27%)	(36%)	(7%)	(32%)		
Cumulative Total	289,564	56,430	293,206	56,625	295,863	56,750	298,342	56,835		
Average Selling Price	$1.40	$1.40	$1.35	$1.35	$1.25	$1.25	$1.15	$1.15	$1.32	$1.32
Revenue ($M)	8.3	0.3	4.9	0.3	3.3	0.2	2.9	0.1	19.3	0.8
Market Share										
North America	47.2%	89.4%	71.2%	94.9%	70.3%	100.0%	76.8%	100.0%	62.3%	94.5%
Japan	51.1	10.6	27.5	5.1	28.6	0	22.8	0	36.4	5.5
Europe	1.7	0	1.4	0	1.1	0	0.4	0	1.3	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1986 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	580	20	440	10	392	0	295	5	1,707	43
AMI									0	0
Commodore MOS									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (EMM Prior 1980)									0	0
Hitachi									0	0
Intel	190	30	180	50	160	30	130	40	660	150
Intersil									0	0
Matsushita									0	0
Mitsubishi	15		5		0		0		20	0
Motorola	782		801		526		933		3,042	0
National	200	100	500	125	300	150	700	120	1,700	495
NEC	260		330		160		90		840	0
Oki Electric									0	0
Synertek									0	0
TCMC									0	0
Texas Instruments	15		5						20	0
Toshiba	220		145		100		65	0	530	0
Zilog									0	0
Total	2,262	150	2,406	185	1,638	188	2,213	165	8,519	688
Percentage Change From Previous Quarter	(9%)	76%	6%	23%	(32%)	2%	35%	(12%)		
Cumulative Total	300,604	56,985	303,010	57,170	304,648	57,358	306,861	57,523		
Average Selling Price	$1.19	$1.35	$1.23	$1.80	$1.29	$1.90	$1.35	$2.00	$1.26	$1.78
Revenue ($M)	2.7	0.2	3.0	0.3	2.1	0.4	3.0	0.3	10.8	1.2
Market Share										
North America	78.1%	100.0%	80.0%	100.0%	84.1%	100.0%	93.0%	100.0%	83.7%	100.0%
Japan	21.9	0	20.0	0	15.9	0	7.0	0	16.3	0
Europe	0	0	0	0	0	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1987 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	195	5	195	5	150	0	120	0	660	10
AMI									0	0
Commodore MOS									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (EMM Prior 1980)									0	0
Hitachi									0	0
Intel	110	30	80	15	60	S	40	0	290	50
Intersil									0	0
Matsushita									0	0
Mitsubishi	0		0		0		0		0	0
Motorola	700		500		300		200		1,700	0
National	1,000	350	450	125	300	75	200	40	1,950	590
NEC	80		60		30		40		210	0
Oki Electric									0	0
Synertek									0	0
TI/MC									0	0
Texas Instruments									0	0
Toshiba	60		40		30		20		150	0
Zilog									0	0
Total	2,145	385	1,325	145	870	80	620	40	4,960	650
Percentage Change From Previous Quarter	31%	105%	(38%)	(62%)	(34%)	(45%)	(29%)	(50%)		
Cumulative Total	306,793	57,743	308,118	57,888	308,988	57,968	309,608	58,008		
Average Selling Price	$1.38	$2.00	$1.40	$2.00	$1.42	$2.00	$1.45	$2.05	$1.40	$2.00
Revenue ($M)	3.0	0.8	1.9	0.3	1.2	0.2	0.9	0.1	6.9	1.3
Market Share										
North America	93.5%	100.0%	92.5%	100.0%	93.1%	100.0%	90.3%	100.0%	92.7%	100.0%
Japan	6.5	0	7.5	0	6.9	0	9.7	0	7.3	0
Europe	0	0	0	0	0	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

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Table 2

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

Company	1978 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
Fujitsu									0	0
Harris	S		10		10	10	20	10	40	20
Hitachi				S	0	10	0	50	0	60
Matra-Harris									0	0
Mitsubishi									0	0
Motorola									0	0
National			S		20		60		80	0
NEC									0	0
Oki Electric									0	0
RCA	S		20		30		50		100	0
Seiko									0	0
Solid State Scientific									0	0
Toshiba	-	-	S	-	50	S	80	20	130	20
Total	0	0	30	0	110	20	210	80	350	100
Percentage Change From Previous Quarter					267%		91%	300%		
Cumulative Total	0	0	30	0	140	20	350	100		
Average Selling Price	$100		$75.00	$85.00	$40.00	$40.00	$35.00	$35.00	$40.00	$36.00
Revenue ($M)	0	0	2.3	0	4.4	0.8	7.4	2.8	14.0	3.6
Market Share										
North America			100.0%		54.5%	50.0%	61.9%	12.5%	62.9%	20.0%
Japan			0		45.5	50.0	38.1	87.5	37.1	80.0
Europe			0		0	0	0	0	0	0
Total			100.0%		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

	1979									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu									0	0
Harris	25	15	40	30	100	100	125	125	290	270
Hitachi		50		150		300		450	0	950
Matra-Harris									0	0
Mitaubishi	5		10		35		40		90	0
Motorola					S		S		0	0
National					S	S	5	5	5	5
NEC	100		270		450		500		1,320	0
Oki Electric									0	0
RCA	50		80		125		100		355	0
Seiko									0	0
Solid State Scientific									0	0
Toshiba	175	25	450	50	500	100	500	100	1,625	275
Total	355	90	850	230	1,210	500	1,270	680	3,685	1,500
Percentage Change From Previous Quarter	69%	13%	139%	156%	42%	117%	5%	36%		
Cumulative Total	355	90	1,205	320	2,415	820	3,685	1,500		
Average Selling Price	$30.00	$30.00	$20.00	$20.00	$13.00	$12.50	$13.00	$12.50	$16.25	$18.07
Revenue ($M)	10.7	2.7	17.0	4.6	15.7	6.3	16.5	13.6	59.9	27.1
Market Share										
North America	21.1%	16.7%	14.1%	13.0%	18.6%	20.0%	18.1%	19.1%	17.6%	18.3%
Japan	78.9	83.3	85.9	87.0	81.4	80.0	81.9	80.9	82.4	81.7
Europe	0	0	0	0	0	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

Company	1980 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
Fujitsu	30	30	100	150	150	200	150	220	430	600
Harris	150	150	200	200	225	225	220	220	795	795
Hitachi	50	500	100	600	150	650	150	650	450	2,400
Matra-Harris									0	0
Mitsubishi	60		60		100		75		295	0
Motorola						8		10	0	10
National	15	15	30	30	35	35	100	35	180	115
NEC	600		425		700		1,070		2,795	0
Oki Electric			5	5	10	10	20	20	35	35
RCA	150		150		170		200		670	0
Seiko									0	0
Solid State Scientific									0	0
Toshiba	600	100	650	120	750	150	900	200	2,900	570
Total	1,655	795	1,720	1,105	2,290	1,270	2,885	1,355	8,550	4,525
Percentage Change From Previous Quarter	30%	17%	4%	39%	33%	15%	26%	7%		
Cumulative Total	5,340	2,295	7,060	3,400	9,350	4,670	12,235	6,025		
Average Selling Price	$15.00	$15.00	$14.00	$12.00	$8.00	$8.00	$4.00	$4.00	$9.21	$9.01
Revenue ($M)	24.8	11.9	24.1	13.3	18.3	10.2	11.5	5.4	78.8	40.8
Market Share										
North America	19.0%	20.8%	22.1%	20.8%	18.8%	20.5%	18.0%	19.6%	19.2%	20.3%
Japan	81.0	79.2	77.9	79.2	81.2	79.5	82.0	80.4	80.8	79.7
Europe	0	0	0	0	0	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

	1981									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu	175	225	50	150	40	100	30	70	295	545
Harris	220	220	230	230	300	300	375	375	1,125	1,125
Hitachi	250	825	350	1,000	400	1,100	450	1,200	1,450	4,125
Matra-Harris	100	50	50	50	100	60	180	60	430	220
Mitsubishi	230		310		320		350		1,210	0
Motorola		10		30		0		0	0	40
National	150	25	200	50	200	50	150	40	700	165
NEC	1,500		1,300		1,500		1,800		6,100	0
Oki Electric	35	35	45	45	50	50	50	50	180	180
RCA	220		190		150		110		670	0
Seiko									0	0
Solid State Scientific	S		10		25		50		85	
Toshiba	1,050	250	1,200	350	1,100	300	1,200	250	4,550	1,150
Total	3,930	1,640	3,935	1,905	4,185	1,960	4,745	2,045	16,795	7,550
Percentage Change From Previous Quarter	36%	21%	0	16%	6%	3%	13%	4%		
Cumulative Total	16,165	7,665	20,100	9,570	24,285	11,530	29,030	13,575		
Average Selling Price	$3.75	$3.50	$3.50	$3.35	$3.25	$3.15	$3.00	$3.00	$3.35	$3.24
Revenue ($M)	14.7	5.7	13.8	6.4	13.6	6.2	14.2	6.1	56.3	24.4
Market Share										
North America	15.0%	15.5%	16.0%	16.3%	16.1%	17.9%	14.4%	20.3%	15.4%	17.6%
Japan	82.4	81.4	82.7	81.1	81.5	79.1	81.8	76.8	82.1	79.5
Europe	2.5	3.0	1.3	2.6	2.4	3.1	3.8	2.9	2.6	2.9
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

Company	1982 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
Fujitsu	25	50	25	50	25	50	25	50	100	200
Harris	400	400	400	400	400	400	400	400	1,600	1,600
Hitachi	450	1,200	450	1,200	500	1,400	500	1,400	1,900	5,200
Matra-Harris	400	350	200	200	200	130	200	150	1,000	830
Mitsubishi	350		330		330		220		1,230	0
Motorola									0	0
National	200	100	220	175	220	250	300	175	940	700
NEC	1,900		1,500		1,500		1,100		6,000	0
Oki Electric	70	70	70	70	70	70	70	70	280	280
RCA	80		70		50		50		250	0
Seiko									0	0
Solid State Scientific	80		100		150		175		505	0
Toshiba	1,400	350	1,500	550	1,600	700	1,700	900	6,200	2,500
Total	5,355	2,520	4,865	2,645	5,045	3,000	4,740	3,145	20,005	11,310
Percentage Change From Previous Quarter	13%	23%	(9%)	5%	4%	13%	(6%)	5%		
Cumulative Total	34,385	16,095	39,250	18,740	44,295	21,740	49,035	24,885		
Average Selling Price	$2.50	$2.50	$2.35	$2.35	$2.25	$2.25	$2.10	$2.10	$2.31	$2.29
Revenue ($M)	13.4	6.3	11.4	6.2	11.4	6.8	10.0	6.6	46.1	25.9
Market Share										
North America	14.2%	19.8%	16.2%	21.7%	16.3%	21.7%	19.5%	18.3%	16.5%	20.3%
Japan	78.3	66.3	79.7	70.7	79.8	74.0	76.3	76.9	78.5	72.3
Europe	7.5	13.9	4.1	7.6	4.0	4.3	4.2	4.8	5.0	7.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

Company	1983 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
Fujitsu	0	0	0	0	0	0	0	0	0	0
Harris	340	200	240	200	250	200	250	200	1,080	800
Hitachi	400	1,300	450	1,100	450	1,000	400	800	1,700	4,200
Matra-Harris	200	150	200	150	200	150	200	150	800	600
Mitsubishi	130		140		70		50		390	0
Motorola									0	0
National	250	200	250	200	300	200	400	250	1,200	850
NEC	1,000		1,000		1,300		1,200		4,500	0
Oki Electric	50	50	50	50	50	50	50	50	200	200
RCA	50		50		50		50		200	0
Seiko									0	0
Solid State Scientific	200		200		150		150		700	0
Toshiba	1,300	600	1,200	600	1,400	600	1,500	500	5,400	2,300
Total	3,920	2,500	3,780	2,300	4,220	2,200	4,250	1,950	16,170	8,950
Percentage Change From Previous Quarter	(17%)	(21%)	(4%)	(8%)	12%	(4%)	1%	(11%)		
Cumulative Total	52,955	27,385	56,735	29,685	60,955	31,885	65,205	33,835		
Average Selling Price	$2.00	$2.00	$2.00	$2.00	$2.25	$2.25	$2.25	$2.25	$2.13	$2.12
Revenue ($M)	7.8	5.0	7.6	4.6	9.5	5.0	9.6	4.4	34.5	18.9
Market Share										
North America	21.4%	16.0%	19.6%	17.4%	17.8%	18.2%	20.0%	23.1%	19.7%	18.4%
Japan	73.5	78.0	75.1	76.1	77.5	75.0	75.3	69.2	75.4	74.9
Europe	5.1	6.0	5.3	6.5	4.7	6.8	4.7	7.7	4.9	6.7
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

	1984									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu	0	0	0	0					0	0
Harris	180	150	160	140	140	120	120	100	600	510
Hitachi	350	600	280	500	220	400	180	350	1,030	1,850
Matra-Harris	165	160	140	155	180	140	200	110	685	565
Mitsubishi	70	0	70	0	65		60		265	0
Motorola	0	0	0	0					0	0
National	280	150	210	100	190	80	150	65	830	395
NEC	1,590	0	1,160	0	800	0	720		4,270	0
Oki Electric	25	25	25	25	20	25	20	20	90	95
RCA	70	0	80	0	85		90		325	0
Seiko									0	0
Solid State Scientific	120		110		100		100		430	0
Toshiba	1,400	400	1,350	375	1,220	350	1,050	325	5,020	1,450
Total	4,250	1,485	3,585	1,295	3,020	1,115	2,690	970	13,545	4,865
Percentage Change From Previous Quarter	0	(24%)	(16%)	(13%)	(16%)	(14%)	(11%)	(13%)		
Cumulative Total	69,455	35,320	73,040	36,615	76,060	37,730	78,750	38,700		
Average Selling Price	$2.20	$2.20	$2.20	$2.20	$2.25	$2.25	$2.30	$2.30	$2.23	$2.23
Revenue ($M)	9.4	3.3	7.9	2.8	6.8	2.5	6.2	2.2	30.2	10.9
Market Share										
North America	15.3%	20.2%	15.6%	18.5%	17.1%	17.9%	17.1%	17.0%	16.1%	18.6%
Japan	80.8	69.0	80.5	69.5	77.0	69.5	75.5	71.6	78.8	69.8
Europe	3.9	10.8	3.9	12.0	6.0	12.6	7.4	11.3	5.1	11.6
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

	1985									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu									0	0
Harris	120	90	110	75	100	70	90	55	420	290
Hitachi	150	250	120	200	100	150	70	100	440	700
Matra-Harris	228	108	169	130	141	22	62	15	600	275
Mitsubishi	55		50		40		35		180	0
Motorola									0	0
National	135	50	120	45	110	35	95	30	460	160
NEC	580		490		300		310		1,680	0
Oki Electric	15	15	10	10	10	10	5	5	40	40
RCA	90		80		75		65		310	0
Seiko									0	0
Solid State Scientific	90		85		75		65		315	0
Toshiba	1,000	300	850	275	750	250	650	200	3,250	1,025
Total	2,463	813	2,084	735	1,701	537	1,447	405	7,695	2,490
Percentage Change From Previous Quarter	(8%)	(16%)	(15%)	(10%)	(18%)	(27%)	(15%)	(25%)		
Cumulative Total	81,213	39,513	83,297	40,248	84,998	40,785	86,445	41,190		
Average Selling Price	$2.25	$2.25	$2.25	$2.25	$2.15	$2.30	$2.30	$2.20	$2.20	$2.25
Revenue ($M)	5.5	1.8	4.7	1.7	3.7	1.2	3.3	0.9	17.2	5.6
Market Share										
North America	17.7%	17.2%	19.0%	16.3%	21.2%	19.6%	21.8%	21.0%	19.6%	18.1%
Japan	73.1	69.5	72.9	66.0	70.5	76.4	73.9	75.3	72.6	70.9
Europe	9.3	13.3	8.1	17.7	8.3	4.1	4.3	3.7	7.8	11.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

Company	1986 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
Fujitsu									0	0
Harris	85		80		70		60		295	0
Hitachi	60	90	50	80	50	75	50	75	210	320
Matra-Harris	164	35	113	30	89	12	65	10	431	87
Mitsubishi	55		50		40		35		180	0
Motorola									0	0
National										
NEC	160		80		110		130		480	0
Oki Electric	0	0	0	0	0	0	0	0	0	0
RCA	55		45		40		30		170	0
Seiko									0	0
Solid State Scientific	55		50		45		40		190	0
Toshiba	600	50	500	50	440	50	400	50	1,940	200
Total	1,234	175	968	160	884	137	810	135	3,896	607
Percentage Change From Previous Quarter	(15%)	(57%)	(22%)	(9%)	(9%)	(14%)	(8%)	(1%)		
Cumulative Total	87,679	41,365	88,647	41,525	89,531	41,662	90,341	41,797		
Average Selling Price	$2.40	$2.50	$2.60	$2.75	$2.80	$2.95	$2.95	$3.10	$2.65	$2.80
Revenue ($M)	3.0	0.4	2.5	0.4	2.5	0.4	2.4	0.4	10.3	1.7
Market Share										
North America	15.8%	0	18.1%	0	17.5%	0	16.0%	0	16.8%	0
Japan	70.9	80.0%	70.2	81.3%	72.4	91.2%	75.9	92.6%	72.1	85.7%
Europe	13.3	20.0	11.7	18.8	10.1	8.8	8.0	7.4	11.1	14.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

Company	1987 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
Fujitsu									0	0
Harris	50		30		20		15		115	0
Hitachi	40	70	20	55	10	40	5	30	75	195
Matra-Harris	103	9	105	12	30	6	21	9	259	36
Mitsubishi	25		15		10		5		55	0
Motorola									0	0
National									0	0
NEC	0		0		0		0		0	0
Oki Electric									0	0
RCA	20		10		5		5		40	0
Seiko									0	0
Solid State Scientific	30		20		10		5		65	0
Toshiba	400	30	300	20	200	15	100	10	1,000	75
Total	668	109	500	87	285	61	156	49	1,609	306
Percentage Change From Previous Quarter	(24%)	(20%)	(25%)	(20%)	(43%)	(30%)	(45%)	(20%)		
Cumulative Total	90,199	41,771	90,699	41,858	90,984	41,919	91,140	41,968		
Average Selling Price	$3.10	$3.30	$3.25	$3.50	$3.40	$3.65	$3.50	$3.75	$3.24	$3.50
Revenue ($M)	2.1	0.4	1.6	0.3	1.0	0.2	0.5	0.2	5.2	1.1
Market Share										
North America	15.0%	0	12.0%	0	12.3%	0	16.0%	0	13.7%	0
Japan	69.6	91.7%	67.0	86.2%	77.2	90.2%	70.5	81.6%	70.2	88.2%
Europe	15.4	8.3	21.0	13.8	10.5	9.8	13.5	18.4	16.1	11.8
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

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Slow MOS SRAM--Data

Table 3

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS					0
Fairchild	NMOS					0
Fujitsu	NMOS				S	S
	CMOS					0
Harris	CMOS					0
Hitachi	CMOS	S	10	90	320	420
IDT	CMOS					0
Matra-Harris	CMOS					0
Matsushita	NMOS					
Mitsubishi	NMOS		S	2	10	12
	CMOS					0
Motorola	CMOS					0
	NMOS					0
National	NMOS					0
NEC	NMOS					0
	CMOS					0
Oki Electric	NMOS	3	7	9	12	31
	CMOS					0
RCA	CMOS					0
Seiko	CMOS					0
Sharp	CMOS					0
Synertek	NMOS					0
TCMC	NMOS			S	5	5
	CMOS					0
Texas Instruments	NMOS	S	S	4	8	12
Toshiba	NMOS		S	10	35	45
	CMOS	4	10	20	35	69
Total		7	27	135	425	594
Percentage Change From Previous Quarter			286%	400%	215%	
Cumulative Total		7	34	169	594	
Average Selling Price	NMOS	$40.00	$30.00	$20.00	$15.00	$17.90
	CMOS	$70.00	$40.00	$28.00	$20.00	$23.03
Total		$57.14	$37.41	$26.52	$19.18	$22.12
Revenue ($M)	NMOS	0.1	0.2	0.5	1.1	1.9
	CMOS	0.3	0.8	3.1	7.1	11.3
Total		0.4	1.0	3.6	8.2	13.1
Market Share						
North America		0	0	3.0%	1.9%	2.0%
Japan		100.2%	100.0%	97.0	96.9	97.1
Europe		0	0	0	1.2	0.8
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS					0
Fairchild	NMOS					0
Fujitsu	NMOS	S	S	45	110	155
	CMOS	S	5	60	100	165
Harris	CMOS	S	5	10	15	30
Hitachi	CMOS	450	550	850	1,200	3,050
IDT	CMOS				S	S
Matra-Harris	CMOS					0
Matsushita	NMOS					
Mitsubishi	NMOS	20	100	470	450	1,040
	CMOS				S	S
Motorola	CMOS					0
	NMOS					0
National	NMOS					0
NEC	NMOS		S	15	100	115
	CMOS			S	50	50
Oki Electric	NMOS	15	20	40	60	135
	CMOS		S	10	50	60
RCA	CMOS					0
Seiko	CMOS					0
Sharp	CMOS					0
Synertek	NMOS		S	S	5	5
TCMC	NMOS	25	30	45	80	180
	CMOS					0
Texas Instruments	NMOS	12	15	20	20	67
Toshiba	NMOS	200	330	450	750	1,730
	CMOS	160	225	400	700	1,485
Total		882	1,280	2,415	3,690	8,267
Percentage Change From Previous Quarter		108%	45%	89%	53%	
Cumulative Total		1,476	2,756	5,171	8,861	
Average Selling Price	NMOS	$10.00	$ 8.00	$6.00	$5.00	$6.15
	CMOS	$15.00	$11.00	$8.50	$7.00	$9.07
Total		$13.46	$ 9.84	$7.38	$6.15	$7.86
Revenue ($M)	NMOS	2.7	4.0	6.5	7.9	21.1
	CMOS	9.2	8.6	11.3	14.8	43.9
Total		11.9	12.6	17.8	22.7	65.0
Market Share						
North America		1.4%	1.6%	1.2%	1.1%	1.2%
Japan		95.8	96.1	96.9	96.7	96.6
Europe		2.8	2.3	1.9	2.2	2.2
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		S	45	140	185
Fairchild	NMOS	S	S	S	S	S
Fujitsu	NMOS	210	265	370	450	1,295
	CMOS	120	150	225	300	795
Harris	CMOS	10	10	15	15	50
Hitachi	CMOS	1,900	2,700	3,500	4,200	12,300
IDT	CMOS	10	25	50	80	165
Matra-Harris	CMOS	S	20	100	150	270
Matsushita	NMOS					
Mitsubishi	NMOS	500	550	550	520	2,120
	CMOS	S	60	60	100	220
Motorola	CMOS			S	10	10
	NMOS					0
National	NMOS	S	S	10	50	60
NEC	NMOS	250	650	650	700	2,250
	CMOS	120	250	350	350	1,070
Oki Electric	NMOS	80	100	150	200	530
	CMOS	100	150	200	250	700
RCA	CMOS			S	10	10
Seiko	CMOS				10	10
Sharp	CMOS					0
Synertek	NMOS	5	20	150	500	675
TCMC	NMOS	40	20	20	30	110
	CMOS					0
Texas Instruments	NMOS	70	100	125	150	445
Toshiba	NMOS	1,200	1,400	1,600	1,800	6,000
	CMOS	1,000	1,400	2,200	2,400	7,000
Total		5,615	7,870	10,370	12,415	36,270
Percentage Change From Previous Quarter		52%	40%	32%	20%	
Cumulative Total		14,476	22,346	32,716	45,131	
Average Selling Price	NMOS	$4.10	$3.80	$3.50	$3.25	$3.59
	CMOS	$6.25	$5.50	$5.00	$4.50	$5.11
Total		$5.35	$4.83	$4.47	$4.04	$4.54
Revenue ($M)	NMOS	9.7	11.8	12.8	14.8	49.1
	CMOS	20.4	26.2	33.5	35.4	115.5
Total		30.0	38.0	46.3	50.2	164.6
Market Share						
North America		1.7%	2.0%	3.8%	7.7%	4.4%
Japan		97.6	97.5	95.0	90.9	94.5
Europe		0.7	0.5	1.2	1.4	1.0
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	400	775	850	700	2,725
Fairchild	NMOS	0	0	0	0	0
Fujitsu	NMOS	600	800	1,000	1,200	3,600
	CMOS	450	700	1,000	1,400	3,550
Harris	CMOS	15	20	50	150	235
Hitachi	CMOS	5,500	8,000	10,000	11,000	34,500
IDT	CMOS	100	150	200	250	700
Matra-Harris	CMOS	250	350	400	500	1,500
Matsushita	NMOS					
Mitsubishi	NMOS	600	600	950	900	3,050
	CMOS	90	420	160	350	1,020
Motorola	CMOS	20	30	50	80	180
	NMOS					0
National	NMOS	50	300	400	600	1,350
NEC	NMOS	750	800	1,000	800	3,350
	CMOS	500	750	1,900	2,300	5,450
Oki Electric	NMOS	400	550	750	900	2,600
	CMOS	500	650	800	1,100	3,050
RCA	CMOS	150	450	700	850	2,150
Seiko	CMOS	50	50	100	300	500
Sharp	CMOS					0
Synertek	NMOS	700	1,000	750	900	3,350
TCMC	NMOS	60	110	160	260	590
	CMOS			8	25	25
Texas Instruments	NMOS	250	350	400	450	1,450
Toshiba	NMOS	2,200	3,100	3,800	4,500	13,600
	CMOS	2,600	2,900	3,700	4,200	13,400
Total		16,235	22,855	29,120	33,715	101,925
Percentage Change From Previous Quarter		31%	41%	27%	16%	
Cumulative Total		61,366	84,221	113,341	147,056	
Average Selling Price	NMOS	$3.10	$2.75	$2.90	$3.10	$2.96
	CMOS	$4.25	$3.70	$3.90	$4.15	$4.00
Total		$3.82	$3.35	$3.55	$3.80	$3.63
Revenue ($M)	NMOS	18.6	23.1	29.2	34.8	105.6
	CMOS	43.5	53.5	74.3	93.4	264.7
Total		62.1	76.6	103.5	128.1	370.3
Market Share						
North America		10.4%	13.5%	11.7%	11.8%	11.9%
Japan		87.7	84.5	86.4	85.9	86.0
Europe		1.9	2.0	1.9	2.3	2.1
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	850	1,000	1,100	1,000	3,950
Fairchild	NMOS	0	0	0	0	0
Fujitsu	NMOS	1,350	1,300	1,280	1,280	5,210
	CMOS	1,500	1,600	1,750	1,600	6,450
Harris	CMOS	250	300	280	250	1,080
Hitachi	CMOS	11,500	12,000	11,500	11,000	46,000
IDT	CMOS	150	155	160	165	630
Matra-Harris	CMOS	600	640	680	680	2,600
Matsushita	NMOS					
Mitsubishi	NMOS	950	1,000	1,100	1,100	4,150
	CMOS	350	370	400	350	1,470
Motorola	CMOS	169	78	25	6	278
	NMOS	0	0	0	0	0
National	NMOS	750	850	1,000	1,100	3,700
NEC	NMOS	700	1,480	1,500	1,800	5,480
	CMOS	2,640	2,000	2,100	2,400	9,140
Oki Electric	NMOS	600	200	50	0	850
	CMOS	1,000	800	650	600	3,050
RCA	CMOS	1,100	1,200	1,300	1,350	4,950
Seiko	CMOS	500	600	700	750	2,550
Sharp	CMOS					0
Synertek	NMOS	1,100	1,300	1,200	1,200	4,800
TCMC	NMOS	260	310	290	270	1,130
	CMOS	140	190	320	360	1,010
Texas Instruments	NMOS	480	475	425	400	1,780
Toshiba	NMOS	5,000	5,700	6,100	6,200	23,000
	CMOS	4,000	5,100	5,100	5,000	19,200
Total		35,939	38,648	39,010	38,861	152,458
Percentage Change From Previous Quarter		7%	8%	1%	0	
Cumulative Total		182,995	221,643	260,653	299,514	
Average Selling Price	NMOS	$3.25	$3.35	$3.10	$2.75	$3.10
	CMOS	$4.25	$4.40	$4.00	$3.40	$4.01
Total		$3.91	$4.03	$3.68	$3.16	$3.69
Revenue ($M)	NMOS	39.1	45.6	43.5	39.5	167.7
	CMOS	101.6	110.1	99.9	83.3	394.9
Total		140.7	155.8	143.4	122.8	562.7
Market Share						
North America		13.5%	13.9%	14.1%	14.1%	13.9%
Japan		83.7	83.2	82.6	82.6	83.0
Europe		2.8	2.9	3.3	3.4	3.1
Total		100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	1,000	1,000	900	850	3,750
Fairchild	NMOS	0	0	0	0	0
Fujitsu	NMOS	1,250	1,250	1,200	1,180	4,880
	CMOS	1,550	1,500	1,500	1,450	6,000
Harris	CMOS	220	200	200	180	800
Hitachi	CMOS	10,000	10,000	9,500	9,000	38,500
IDT	CMOS	180	170	180	190	720
Matra-Harris	CMOS					0
Matsushita	NMOS					
Mitsubishi	NMOS	1,000	1,000	1,000	950	3,950
	CMOS	400	380	380	350	1,510
Motorola	CMOS	7	0	0	0	7
	NMOS	0	0	0	161	161
National	NMOS	1,100	1,000	1,000	950	4,050
NEC	NMOS	2,570	3,050	1,430	1,710	8,760
	CMOS	2,690	2,980	1,580	2,010	9,260
Oki Electric	NMOS	0	0	0	0	0
	CMOS	425	450	450	500	1,825
RCA	CMOS	1,270	1,320	1,200	1,100	4,890
Seiko	CMOS	800	880	920	850	3,450
Sharp	CMOS					0
Synertek	NMOS	1,150	1,200	1,200	1,150	4,700
TCMC	NMOS	260	210	210	190	870
	CMOS	380	410	425	435	1,650
Texas Instruments	NMOS	320	280	250	225	1,075
Toshiba	NMOS	6,500	6,500	6,000	6,000	25,000
	CMOS	5,000	4,800	4,800	4,500	19,100
Total		38,072	38,580	34,325	33,931	144,908
Percentage Change From Previous Quarter		(2%)	1%	(11%)	(1%)	
Cumulative Total		221,067	259,647	293,972	327,903	
Average Selling Price	NMOS	$2.00	$1.50	$1.25	$1.10	$1.48
	CMOS	$2.75	$2.00	$1.45	$1.25	$1.89
Total		$2.45	$1.80	$1.37	$1.19	$1.73
Revenue ($M)	NMOS	30.3	23.2	16.5	14.7	84.7
	CMOS	63.0	46.2	30.6	25.7	165.6
Total		93.3	69.4	47.1	40.4	250.3
Market Share						
North America		13.8%	13.4%	14.4%	14.2%	13.9%
Japan		84.5	85.0	83.8	84.0	84.4
Europe		1.7	1.6	1.8	1.8	1.7
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Slow MOS SRAM--Data

Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Best Speed		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	90	800	750	720	450	2,720
Fairchild	N	120	0	0	0	0	0
Fujitsu	N	120	0	0	0	0	0
	C	120	1,400	1,250	1,100	1,000	4,750
Harris	C	120	170	150	140	125	585
Hitachi	C	120	8,000	7,000	6,400	5,900	27,300
IDT	C	70	200	210	230	220	860
Matra-Harris	C						0
Matsushita	C		200	400	450		1,050
Mitsubishi	N	120	170	80	50	200	500
	C	120	320	300	200	10	830
Motorola	C	120	0	0	0	0	0
	N		115	156	140	90	501
National	N	120	0	0	0	0	0
NEC	N	100	2,050	1,740	1,730	1,700	7,220
	C	120	2,770	2,200	1,940	1,900	8,810
Oki Electric	N	120	0	0	0	0	0
	C	120	600	700	700	750	2,750
RCA	C	120	850	610	490	410	2,360
Seiko	C	120	800	780	720	675	2,975
Sharp	C	120	0	0	0	25	25
Sony	C	120	100	400	600	925	2,025
Synertek	N	120	0	0	0	0	0
TCMC	N	70	155	145	130	125	555
	C	120	425	430	435	425	1,715
Texas Instruments	N	120	200	200	180	75	665
Toshiba	N	120	6,000	6,000	6,500	7,000	25,500
	C	120	3,500	3,500	3,700	3,700	14,400
Total			28,825	27,001	26,555	25,705	108,086
Percentage Change From Previous Quarter			(15%)	(6%)	(2%)	(3%)	
Cumulative Total			356,728	383,729	410,284	435,989	
Average Selling Price	NMOS		$1.00	$1.05	$1.10	$1.15	$1.08
	CMOS		$1.15	$1.25	$1.35	$1.40	$1.32
Total			$1.10	$1.18	$1.26	$1.31	$1.21
Revenue ($M)	NMOS		9.7	9.9	10.9	11.1	41.6
	CMOS		22.0	21.9	22.5	22.5	88.9
Total			31.7	31.9	33.4	33.6	130.5
Market Share							
North America			8.1%	7.7%	7.2%	5.3%	7.1%
Japan			89.9	90.2	90.7	92.5	90.8
Europe			2.0	2.1	2.1	2.1	2.1
Total			100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	400	350	343	336	1,429
Fujitsu	CMOS	800	760	722	400	2,682
Harris	CMOS	110	88	66	40	304
Hitachi	CMOS	4,500	3,700	3,330	2,831	14,361
Hyundai	CMOS	30	100	150	400	680
IDT	CMOS	100	50	30	20	200
Matra-Harris	CMOS	0	32	66	91	189
Matsushita	CMOS	150	150	200	200	700
Mitsubishi	NMOS	30	30	20	25	105
Mosel	CMOS	2	5	7	10	24
Motorola	CMOS	331	437	454	522	1,744
NEC	NMOS	1,590	1,260	1,050	730	4,630
	CMOS	2,350	1,880	2,000	2,700	8,930
Oki	CMOS	750	825	908	980	3,463
RCA	CMOS	465	800	933	780	2,978
Rohm	CMOS	5	10	50	200	265
Sanyo	CMOS	300	750	900	1,800	3,750
Seiko	CMOS	608	614	675	709	2,605
Sharp	CMOS	85	200	550	1,200	2,035
Sony	CMOS	1,250	2,750	3,700	4,000	11,700
TCMC	NMOS	123	120	118	115	475
	CMOS	200	220	250	280	950
Toshiba	NMOS	7,000	6,790	6,111	5,194	25,095
	CMOS	3,500	3,395	3,056	2,597	12,548
UMC	CMOS	28	29	59	175	291
Total		24,706	25,345	25,747	26,335	102,132
Percentage Change From Previous Quarter		(4%)	3%	2%	2%	
Cumulative Total		460,695	486,040	511,786	538,121	
Average Selling Price		$1.30	$1.31	$1.32	$1.35	$1.32
Revenue ($M)		32.1	33.2	34.0	35.6	134.9
Market Share						
North America		5.7%	6.8%	7.1%	6.5%	6.5%
Japan		92.8	91.2	90.4	89.5	90.9
Europe		1.3	1.5	1.7	1.8	1.6
ROW		0.2	0.5	0.8	2.2	1.0
Total		100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

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Slow MOS SRAM—Data

Table 4

Estimated Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	MOS Technology/ Type		1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD							
Fujitsu						S	S
Hitachi			10	20	30	50	110
Intel	NMOS	iRAM			S	10	10
	CMOS	iRAM					
Matra-Harris	CMOS						0
Mitsubishi							
Motorola							
National							
NEC	CMOS						
	CMOS	PSRAM					
Oki Electric	CMOS						
RCA							
Seiko/SMOS							
Sony							
Toshiba			S	5	10	20	35
Total			10	25	40	80	155
Percentage Change From Previous Quarter				150%	60%	100%	
Cumulative Total				35	75	155	
Average Selling Price			$135.00	$115.00	$110.00	$90.00	$102.10
Revenue ($M)			1.4	2.9	4.4	7.2	15.8
Market Share							
North America			0	0	0	12.5%	6.5%
Japan			100.0%	100.0%	100.0%	87.5	93.5
Europe			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	MOS Technology/ Type		1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD							
Fujitsu			15	40	75	150	280
Hitachi			100	450	800	1,100	2,450
Intel	NMOS	iRAM	25	75	150	250	500
	CMOS	iRAM					
Matra-Harris	CMOS						0
Mitsubishi				S	S	S	S
Motorola							
National							
NEC	CMOS				S	S	S
	CMOS	PSRAM			S	10	10
Oki Electric	CMOS						
RCA							
Seiko/SMOS					S	10	10
Sony							0
Toshiba			50	150	250	450	900
Total			190	715	1,275	1,970	4,150
Percentage Change From Previous Quarter			138%	276%	78%	55%	
Cumulative Total			345	1,060	2,335	4,305	
Average Selling Price			$60.00	$40.00	$27.00	$22.00	$28.38
Revenue ($M)			11.4	28.6	34.4	43.3	117.8
Market Share							
North America			13.2%	10.5%	11.8%	12.7%	12.0%
Japan			86.8	89.5	88.2	87.3	88.0
Europe			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Slow MOS SRAM--Data

Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	MOS Technology/ Type		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD							0
Fujitsu			300	600	1,000	1,250	3,150
Hitachi			1,800	2,500	3,200	4,000	11,500
Intel	NMOS	iRAM	400	750	850	1,000	3,000
	CMOS	iRAM				S	S
Matra-Harris	CMOS		0	0	0	0	0
Mitsubishi			S	10	25	100	135
Motorola							0
National					S	10	10
NEC	CMOS		25	160	950	2,500	3,635
	CMOS	PSRAM	25	25	200	750	1,000
Oki Electric	CMOS						
RCA							0
Seiko/SMOS			10	25	75	250	360
Sony				S	10	50	60
Toshiba			700	1,000	1,800	3,000	6,500
Total			3,260	5,070	8,110	12,910	29,350
Percentage Change From Previous Quarter			65%	56%	60%	59%	
Cumulative Total			7,565	12,635	20,745	33,655	
Average Selling Price			$23.00	$18.00	$14.50	$11.00	$14.51
Revenue ($M)			75.0	91.3	117.6	142.0	425.8
Market Share							
North America			12.3%	14.8%	10.5%	7.8%	10.3%
Japan			87.7	85.2	89.5	92.2	89.7
Europe			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	MOS Technology/ Type		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD							0
Fujitsu			1,400	1,500	1,600	1,800	6,300
Hitachi			4,000	4,200	4,700	5,500	18,400
Intel	NMOS	iRAM	600	400	200	100	1,300
	CMOS	iRAM	100	250	400	400	1,500
Matra-Harris	CMOS		0	5	26	64	95
Mitsubishi			250	400	500	600	1,750
Motorola							0
National			50	100	100	150	400
NEC	CMOS		3,020	1,710	1,290	3,440	9,460
	CMOS	PSRAM	840	750	910	1,440	3,940
Oki Electric	CMOS		S	50	100	150	300
RCA			S	25	100	250	375
Seiko/SMOS			350	500	750	1,000	2,600
Sony			100	150	200	250	700
Toshiba			3,200	3,200	3,200	3,000	12,600
Total			13,910	13,240	14,076	18,144	59,370
Percentage Change From Previous Quarter			8%	(5%)	6%	29%	
Cumulative Total			21,475	34,715	48,791	66,935	
Average Selling Price			$7.75	$5.00	$3.15	$2.25	$4.37
Revenue ($M)			107.8	66.2	44.3	40.8	259.2
Market Share							
North America			5.4%	5.9%	5.7%	5.0%	5.4%
Japan			94.6	94.1	94.1	94.7	94.4
Europe			0	0	0.2	0.4	0.2
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Slow MOS SRAM--Data

Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	MOS Technology/ Product Type	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	CMOS	2,000	2,100	2,400	2,700	9,200
Hitachi	CMOS	5,050	7,810	8,570	9,500	30,930
Intel	NMOS iRAM	50	25	17	8	100
	CMOS iRAM	150	75	50	25	300
Matra-Harris	CMOS	171	234	399	156	960
Mitsubishi	CMOS	650	1,000	2,500	2,700	6,850
NEC	CMOS & MIX MOS	4,000	3,540	4,810	3,200	15,550
	CMOS PSRAM	1,850	1,570	1,910	1,540	6,870
Oki Electric	CMOS	200	300	300	300	1,100
RCA		200	220	250	280	950
Seiko/SMOS	CMOS	250	400	600	750	2,000
Sharp	CMOS	0	0	0	10	10
Sony	CMOS	125	200	300	265	890
Toshiba	CMOS & MIX MOS	3,000	4,500	5,500	5,500	18,500
	NMOS	700	1,000	1,200	1,500	4,400
TCMC		50	100	100	150	400
Total		18,446	23,074	28,906	28,584	99,010
Percentage Change From Previous Quarter		2%	25%	25%	(1%)	
Cumulative Total		85,381	108,455	137,361	165,945	
Average Selling Price		$2.10	$2.00	$1.90	$1.70	$1.90
Revenue ($M)		38.7	46.1	54.9	48.6	188.4
Market Share						
North America		2.2%	1.4%	1.1%	1.1%	1.4%
Japan		96.6	97.2	97.2	97.8	97.3
Europe		1.2	1.4	1.7	1.1	1.4
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	Process/Product Type	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	CMOS	2,000	2,300	2,645	2,777	9,722
Hitachi	CMOS	9,000	8,500	9,010	9,911	36,421
Hyundai	CMOS				S	0
Matra-Harris	CMOS	214	182	193	336	925
Matsushita	CMOS	10	50	100	200	360
Mitsubishi	CMOS	1,400	2,000	1,300	1,500	6,200
Motorola	CMOS	10	50	100	200	360
NEC	CMOS	6,130	7,680	8,000	8,700	30,510
	CMOS PSRAM	1,600	1,680	1,730	1,782	6,793
Oki	CMOS	300	348	400	420	1,468
RCA	CMOS	335	448	820	700	2,303
Samsung	CMOS					
Seiko	CMOS	825	1,125	1,400	1,525	4,875
Sharp	CMOS	37	81	236	1,442	1,796
Sony	CMOS	1,250	2,750	3,700	4,000	11,700
TCMC	CMOS	150	158	161	164	632
Toshiba	CMOS	5,000	5,550	6,105	6,410	23,065
	NMOS	1,500	1,815	2,033	2,236	7,584
Total		29,761	34,717	37,933	42,304	144,715
Percent Change From Previous Quarter		4%	17%	9%	12%	
Cumulative Total		195,706	230,423	268,356	310,660	
Average Selling Price		$2.00	$1.95	$1.95	$2.15	$2.02
Revenue ($M)		59.5	67.7	74.0	91.0	292.1
Market Share						
North America		1.2%	1.4%	2.4%	2.1%	1.8%
Japan		97.6	97.6	96.6	96.7	97.1
Europe		1.2	1.0	0.9	1.2	1.1
ROW		0	0	0	0	0
Total		100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

Source: Dataquest
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Table 5

Estimated Worldwide Slow 256K SRAM Shipments
(Thousands of Units)

Company	Product Type	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu				5	50	55
Hitachi		S	S	5	35	40
	PSRAM				S	0
Matra-Harris						0
Mitsubishi					S	0
NEC				S	40	40
	PSRAM				0	0
Oki Electric						
Seiko/Epson					S	0
Sony						
Toshiba		S	S	5	15	20
	PSRAM	-	-	-	0	0
Total		0	0	15	140	155
Percentage Change From Previous Quarter					833%	
Cumulative Total			0	15	155	
Average Selling Price		$75.00	$70.00	$55.00	$45.00	$45.97
Revenue ($M)		0	0	0.8	6.3	7.1
Market Share						
North America		0	0	0	0	0
Japan		0	0	100.0%	100.0%	100.0%
Europe		0	0	0	0	0
Total		0	0	100.0%	100.0%	100.0%

(Continued)

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Table 5 (Continued)

Estimated Worldwide Slow 256K SRAM Shipments
(Thousands of Units)

Company	Product Type	1986 1st Qtr.	1986 2nd Qtr.	1986 3rd Qtr.	1986 4th Qtr.	1986 Year
Fujitsu		85	120	200	350	755
Hitachi		50	200	400	650	1,300
	PSRAM		S	S	600	600
Matra-Harris					-	0
Mitsubishi		0	3	110	140	253
NEC		370	410	470	500	1,750
	PSRAM		S	S	400	400
Oki Electric			S	20	50	70
Seiko/Epson		10	50	90	140	290
Sony				10	20	30
Toshiba		50	150	200	350	750
	PSRAM					0
Total		565	933	1,500	3,200	6,198
Percentage Change From Previous Quarter		304%	65%	61%	113%	
Cumulative Total		720	1,653	3,153	6,353	
Average Selling Price		$40.00	$25.00	$18.00	$12.00	$17.96
Revenue ($M)		22.6	23.3	27.0	38.4	111.3
Market Share						
North America		0	0	0	0	0
Japan		100.0%	100.0%	100.0%	100.0%	100.0%
Europe		0	0	0	0	0
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 5 (Continued)

Estimated Worldwide Slow 256K SRAM Shipments
(Thousands of Units)

Company	Product Type	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu		525	971	1,632	1,958	5,086
Hitachi		1,050	1,400	2,198	2,748	7,396
	PSRAM	800	1,600	2,512	3,014	7,926
Matra-Harris		0	19	35	90	144
Matsushita		5	20	75	100	200
Mitsubishi		290	700	965	1,900	3,855
Motorola						
NEC		1,560	1,800	3,150	3,000	9,510
	PSRAM	600	840	1,050	900	3,390
Oki		80	156	242	314	792
RCA						0
Samsung						0
Seiko		250	470	738	1,033	2,491
Sharp			S	50	100	150
Sony		80	200	400	750	1,430
Toshiba		400	752	1,181	1,417	3,749
	PSRAM	50	94	148	177	469
Total		5,690	9,022	14,375	17,501	46,588
Percent Change From Previous Quarter		78%	59%	59%	22%	
Cumulative Total		12,043	21,065	35,440	52,941	
Average Selling Price		$7.50	$6.75	$6.25	$6.50	$6.59
Revenue ($M)		42.7	60.9	89.8	113.8	307.2
Market Share						
North America		0	0	0	0	0
Japan		100.0%	99.8%	99.8%	99.5%	99.7%
Europe		0	0.2	0.2	0.5	0.3
ROW		0		0	0	0
Total		100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

Source: Dataquest
April 1990

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Slow MOS SRAM--Data

INTRODUCTION

This section contains complete historical unit shipments for slow MOS static RAMs (SRAMs) from 1975 through 1987. For each quarter we have included estimates on: unit shipments by supplier for the 4K, 16K, 64K, and 256K densities; worldwide quarterly prices; and the resulting revenue. Also, at the bottom of each table is the unit market share of suppliers based in the United States, Japan, and Europe. The tables are as follows:

- Table 1—4K NMOS SRAMs (1975–1987)
- Table 2—4K CMOS SRAMs (1978–1987)
- Table 3—16K SRAMs (1980–1987)
- Table 4—64K SRAMs (1982–1987)
- Table 5—256K SRAMs (1986–1987)

DEFINITIONS

Speeds

Slow SRAMs are defined as parts that have an access time greater than 70ns. These most often come in x8 organizations. Fast SRAMs, on the other hand, have access times of 70ns or less, and are commonly organized as either x1, x4, or x8.

A more general definition is based on applications. Fast static RAMs generally go into markets where the use of the fastest device available can improve the system performance. Examples of applications for fast static RAMs would be in cache memory in computing systems, or writable control store for high-speed bit slice processors. Slow static RAMs are often used as I/O buffers and in other applications where the factor limiting the system performance is not the memory access time. Because of the differentiation in applications, Dataquest treats the fast and slow SRAM markets separately.

Prices

Dataquest estimates the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and speed mixes (within the fast and slow categories), and include devices sold into both the commercial and military markets.

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Slow MOS SRAM--Data

Unit Shipments

Historical shipment data remain as they have been published in earlier service sections, with occasional restatements, additions, and deletions based on availability of later information. Some of the 1986 data have been updated to reflect new information.

Quarterly Revenue

Quarterly revenue is calculated by multiplying the units shipped by the average billing price during the quarter.

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Slow MOS SRAM--Data

Table 1

Estimated Worldwide Slow NMOS 4K SRAM Shipments (Thousands of Units)

	1975									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD									0	0
AMI									0	0
Commodore MOS									0	0
Eurotechnique									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (EMM Prior 1980)					10		40	S	50	S
Hitachi									0	0
Intel									0	0
Intersil									0	0
Matsushita									0	0
Mitsubishi									0	0
Mostek									0	0
Motorola									0	0
National									0	0
NEC									0	0
Oki Electric									0	0
Synertek									0	0
Texas Instruments									0	0
Toshiba									0	0
Zilog	—	—	—	—	—	—	—	—	0	0
Total	0	0	0	0	10	0	40	0	50	0
Percentage Change From Previous Quarter							300%			
Cumulative Total	0	0	0	0	10	0	50	0		
Average Selling Price					$25.00		$20.00		$21.00	
Revenue ($M)	0.0	0.0	0.0	0.0	0.3	0.0	0.8	0.0	1.1	0.0
Market Share										
U.S.					100.0%		100.0%		100.0%	
Japan					0.0%		0.0%		0.0%	
Europe					0.0%		0.0%		0.0%	
Total					100.0%		100.0%		100.0%	

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments (Thousands of Units)

	1976									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD									0	0
AMI			S		15		20		35	0
Commodore MOS									0	0
Eurotechnique									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (EMM Prior 1980)	75	10	125	30	170	70	200	130	570	240
Hitachi									0	0
Intel					S	S	15	5	15	5
Intersil									0	0
Matsushita									0	0
Mitsubishi									0	0
Mostek									0	0
Motorola									0	0
National									0	0
NEC									0	0
Oki Electric									0	0
Synertek									0	0
Texas Instruments									0	0
Toshiba									0	0
Zilog	—	—	—	—	—	—	—	—	0	0
Total	75	10	125	30	185	70	235	135	620	245
Percentage Change From Previous Quarter	88%		67%	200%	48%	133%	27%	93%		
Cumulative Total	125	10	250	40	435	110	670	245		
Average Selling Price	$18.00	$20.00	$15.00	$18.00	$11.00	$12.50	$8.50	$10.00	$11.71	$12.10
Revenue ($M)	1.4	0.2	1.9	0.5	2.0	0.9	2.0	1.4	7.3	3.0
Market Share										
U.S.	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Japan	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Europe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

	1977									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD									0	0
AMI	30		50		80		90	10	250	10
Commodore MOS									0	0
Eurotechnique									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (EMM Prior 1980)	250	150	250	160	300	250	375	300	1,175	860
Hitachi	5		30		50		85		170	0
Intel	20	20	100	50	100	50	100	50	320	170
Interail			10		15	5	20	10	45	15
Matsushita									0	0
Mitsubishi									0	0
Mostek				15		30		50	0	95
Motorola			10		20		20		50	0
National									0	0
NEC			30	10	150	100	175	175	355	285
Oki Electric									0	0
Synertek	15		25		65		100		205	0
Texas Instruments	10	5	15	10	35	30	55	45	115	90
Toshiba									0	0
Zilog	—	—	—	—	—	15	—	25	0	40
Total	330	175	520	245	815	480	1,020	665	2,685	1,565
Percentage Change From Previous Quarter	40%	30%	58%	40%	57%	96%	25%	39%		
Cumulative Total	1,000	420	1,520	665	2,335	1,145	3,355	1,810		
Average Selling Price	$8.00	$8.50	$8.00	$8.25	$8.00	$8.00	$8.00	$8.00	$8.00	$8.10
Revenue ($M)	2.6	1.5	4.2	2.0	6.5	3.8	8.2	5.3	21.5	12.7
Market Share										
U.S.	98.5%	100.0%	88.5%	95.9%	75.5%	79.2%	74.5%	73.7%	80.4%	81.8%
Japan	1.5%	0.0%	11.5%	4.1%	24.5%	20.8%	25.5%	26.3%	19.6%	18.2%
Europe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments (Thousands of Units)

	1978									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD									0	0
AMI	190	10	230	20	270	30	325	25	1,015	85
Commodore MOS							15		15	0
Eurotechnique									0	0
Fairchild							20		20	0
Fujitsu	50		75		100		100		325	0
GTE (ENM Prior 1980)	500	400	650	500	550	450	550	550	2,250	1,900
Hitachi	90		130		200		300		720	0
Intel	250	250	250	300	200	250	400	350	1,100	1,150
Intersil	50	20	40	10	120	20	150	50	360	100
Matsushita									0	0
Mitsubishi									0	0
Mostek		120		250		200		230	0	800
Motorola	45	5	175	25	220	30	220	30	660	90
National			80	20	200	50	325	75	605	145
NEC	200	300	300	300	300	350	400	400	1,200	1,350
Oki Electric									0	0
Synertek	160		280		350		450		1,240	0
Texas Instruments	350	350	400	400	350	350	400	400	1,500	1,500
Toshiba					30		60		90	0
Zilog		60		120		140		150	0	470
Total	1,885	1,515	2,610	1,945	2,890	1,870	3,715	2,260	11,100	7,590
Percentage Change From Previous Quarter	85%	128%	38%	28%	11%	(4%)	29%	21%		
Cumulative Total	5,240	3,325	7,850	5,270	10,740	7,140	14,455	9,400		
Average Selling Price	$7.00	$7.00	$6.00	$6.00	$5.00	$5.00	$5.00	$4.75	$5.57	$5.58
Revenue ($M)	13.2	10.6	15.7	11.7	14.5	9.4	18.6	10.7	61.9	42.4
Market Share										
U.S.	82.0%	80.2%	80.7%	84.6%	78.2%	81.3%	76.9%	82.3%	79.0%	82.2%
Japan	18.0%	19.8%	19.3%	15.4%	21.8%	18.7%	23.1%	17.7%	21.0%	17.8%
Europe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Slow MOS SRAM--Data

Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

	1979									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD	150	30	275	75	330	140	420	220	1,175	465
AMI	50		55		95		50		250	0
Commodore MOS	5		25		100		175		305	0
Fairchild	50		100		300		400		850	0
Fujitsu	80		150		250		100		580	0
GTE (EMM Prior 1980)	300	250	350	300	350	350	400	450	1,400	1,350
Hitachi	450		450		450		450		1,800	0
Intel	400	400	600	600	850	100	800	200	2,650	1,300
Intersil	200	100	230	130	250	150	200	250	880	630
Matsushita			20		50		75		145	0
Mitsubishi	100		150		250		300		800	0
Motorola	270	30	320	20	450	30	300	50	1,340	130
National	530	120	900	190	900	200	1,100	400	3,430	910
NEC	400	600	600	450	800	400	1,000	300	2,800	1,750
Oki Electric									0	0
Synertek	560		600		900		1,000		3,060	0
TCMC		450		600		900		1,000	0	2,950
Texas Instruments	500	500	500	500	550	450	350	350	1,900	1,800
Toshiba	150		210		300		350		1,010	0
Zilog		110		110		150		45	0	415
Total	4,195	2,590	5,535	2,975	7,175	2,870	7,470	3,265	24,375	11,700
Percentage Change From Previous Quarter	13%	15%	32%	15%	30%	(4%)	4%	14%		
Cumulative Total	18,650	11,990	24,185	14,965	31,360	17,835	38,830	21,100		
Average Selling Price	$4.25	$4.00	$4.25	$4.00	$4.00	$4.25	$3.50	$3.75	$3.95	$3.99
Revenue ($M)	17.8	10.4	23.5	11.9	28.7	12.2	26.1	12.2	96.2	46.7
Market Share										
U.S.	71.9%	59.5%	71.5%	64.7%	70.7%	54.7%	69.5%	60.2%	70.7%	59.8%
Japan	28.1%	23.2%	28.5%	15.1%	29.3%	13.9%	30.5%	9.2%	29.3%	15.0%
Europe	0.0%	17.4%	0.0%	20.2%	0.0%	31.4%	0.0%	30.6%	0.0%	25.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments (Thousands of Units)

	1980									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD	350	200	400	250	450	300	300	300	1,500	1,050
AMI	5		0		0		0		5	0
Commodore MOS	250		275		350		390		1,265	0
Fairchild	450		450		450		450		1,800	0
Fujitsu	50		0		20		5		75	0
GTE (EMM Prior 1980)	800	800	800	800	800	800	800	800	3,200	3,200
Hitachi	450		450		600		600		2,100	0
Intel	800	250	800	250	1,000	250	1,100	250	3,700	1,000
Intersil	500	350	250	130	90	40	80	30	920	550
Matsushita	75		75		80		80		310	0
Mitsubishi	180	60	270	125	330	125	740	620	1,520	930
Motorola	425	75	425	75	350	75	650	80	1,850	350
National	1,200	600	1,500	750	1,500	800	1,600	700	5,800	2,850
NEC	1,350	270	1,800	330	1,200	400	2,400	240	6,750	1,240
Oki Electric	S		50		150		250		450	0
Synertek	1,000		750		850		1,120		3,720	0
TCMC		750		600		500		500	0	2,350
Texas Instruments	350	350	350	350	350	350	350	350	1,400	1,400
Toshiba	225		275		300		350		1,150	0
Zilog									0	0
Total	8,460	3,705	8,920	3,660	8,870	3,640	11,265	3,870	37,515	14,875
Percentage Change From Previous Quarter	13%	13%	5%	(1%)	(1%)	(1%)	27%	6%		
Cumulative Total	47,290	24,805	56,210	28,465	65,080	32,105	76,345	35,975		
Average Selling Price	$3.25	$3.25	$2.50	$3.75	$2.50	$2.25	$2.25	$2.00	$2.59	$2.80
Revenue ($M)	27.5	12.0	22.3	13.7	22.2	8.2	25.3	7.7	97.3	41.7
Market Share										
U.S.	72.5%	70.9%	67.3%	71.2%	69.8%	71.8%	60.7%	64.9%	67.1%	69.6%
Japan	27.5%	8.9%	32.7%	12.4%	30.2%	14.4%	39.3%	22.2%	32.9%	14.6%
Europe	0.0%	20.2%	0.0%	16.4%	0.0%	13.7%	0.0%	12.9%	0.0%	15.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

	1981									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD	570	300	780	400	800	450	800	350	2,950	1,500
AMI	0		0		0		0		0	0
Commodore MOS	240		230		100		0		570	0
Fairchild	450		500		500		450		1,900	0
Fujitsu	5		0		0		0		5	0
GTE (EMM Prior 1980)	830	830	800	800	350	250	150	100	2,130	1,980
Hitachi	600		600		600		600		2,400	0
Intel	1,200	275	1,200	275	1,300	250	1,500	250	5,200	1,050
Intersil	50	30	50	40	75	60	90	50	265	180
Matsushita	85		100		100		100		385	0
Mitsubishi	920	340	1,100	250	900	150	770	85	3,690	825
Motorola	650	80	750	120	1,000	175	1,000	150	3,400	525
National	1,600	550	1,750	600	1,900	250	2,000	100	7,250	1,500
NEC	2,500	220	2,450	250	2,600	150	2,900	90	10,450	710
Oki Electric	300		300		250		200	0	1,050	0
Synertek	1,050		1,100		1,050		900	0	4,100	0
TCMC	S	400	25	225	150	120	350	50	525	795
Texas Instruments	350	350	350	350	400	300	400	300	1,500	1,300
Toshiba	350		530		950		800		2,630	0
Zilog									0	0
Total	11,750	3,375	12,615	3,310	13,025	2,155	13,010	1,525	50,400	10,365
Percentage Change From Previous Quarter	4%	(13%)	7%	(2%)	3%	(35%)	0%	(29%)		
Cumulative Total	88,095	39,350	100,710	42,660	113,735	44,815	126,745	46,340		
Average Selling Price	$2.75	$2.50	$2.50	$2.25	$1.85	$1.75	$1.40	$1.25	$2.11	$2.08
Revenue ($M)	32.3	8.4	31.5	7.4	24.1	3.8	18.2	1.9	106.2	21.6
Market Share										
U.S.	59.5%	71.6%	59.5%	78.1%	57.4%	80.5%	56.0%	85.2%	58.1%	77.5%
Japan	40.5%	16.6%	40.3%	15.1%	41.5%	13.9%	41.3%	11.5%	40.9%	14.8%
Europe	0.0%	11.9%	0.2%	6.8%	1.2%	5.6%	2.7%	3.3%	1.0%	7.7%
Total	100.0%	100.1%	100.0%	100.0%	100.0%	100.1%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1982 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	800	400	1,150	450	1,200	400	1,250	250	4,400	1,500
AMI									0	0
Commodore MOS									0	0
Fairchild	400		350		300		275		1,325	0
Fujitsu									0	0
GTE (EMM Prior 1980)	150	100	150	100	150	100	100	50	550	350
Hitachi	600		600		600		500		2,300	0
Intel	1,600	250	1,400	250	1,400	200	1,300	200	5,700	900
Intersil	75	30	50	20	50	20	50	20	225	90
Matsushita	100		100		0		0		200	0
Mitsubishi	700	100	500	100	1,000	100	800	160	3,000	460
Motorola	1,100	130	1,500	50	1,600	50	1,800	10	6,000	240
National	2,200	150	3,000	120	3,000	100	3,800	250	12,000	620
NEC	3,000	200	3,400	150	3,200	100	3,500	200	13,100	650
Oki Electric	200		200		150		150		700	0
Synertek	750		750		750		700		2,950	0
TCMC	200	35	100	25	150	25	150	0	600	85
Texas Instruments	350	200	250	150	200	100	200	100	1,000	550
Toshiba	1,500		2,000		2,400		2,400		8,300	0
Zilog									0	0
Total	13,725	1,595	15,500	1,415	16,150	1,195	16,975	1,240	62,350	5,445
Percentage Change From Previous Quarter	5%	5%	13%	(11%)	4%	(16%)	5%	4%		
Cumulative Total	140,470	47,935	155,970	49,350	172,120	50,545	189,095	51,785		
Average Selling Price	$1.50	$1.25	$1.40	$1.20	$1.35	$1.15	$1.10	$1.15	$1.33	$1.19
Revenue ($M)	20.6	2.0	21.7	1.7	21.8	1.4	18.7	1.4	82.8	6.5
Market Share										
U.S.	54.1%	79.0%	55.5%	80.6%	53.6%	81.2%	55.8%	71.0%	54.8%	78.1%
Japan	44.4%	18.8%	43.9%	17.7%	45.5%	16.7%	43.3%	29.0%	44.3%	20.4%
Europe	1.5%	2.2%	0.6%	1.8%	0.9%	2.1%	0.9%	0.0%	1.0%	1.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

	1983									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD	1,300	150	1,700	110	1,300	200	1,500	150	5,800	610
AMI									0	0
Commodore MOS									0	0
Fairchild	220		180		120		40		560	0
Fujitsu									0	0
GTE (EMM Prior 1980)	50	25							50	25
Hitachi	400		300		200		100		1,000	0
Intel	1,000	180	700	150	525	120	320	130	2,545	580
Intersil									0	0
Matsushita									0	0
Mitsubishi	400	100	380	90	300	50	180	60	1,260	300
Motorola	1,200		1,500		1,900		2,200		6,800	0
National	3,500	200	3,600	150	4,000	100	4,500	150	15,600	600
NEC	3,100	150	2,800	65	2,200	110	1,900	100	10,000	425
Oki Electric	100		100		50		25		275	0
Synertek	700		200		250		300		1,450	0
TCMC	200		200		250		250		900	0
Texas Instruments	200	20	200	50	200	50	200	50	800	170
Toshiba	2,700		2,400		2,400		2,400		9,900	0
Zilog									0	0
Total	15,070	825	14,260	615	13,695	630	13,915	640	56,940	2,710
Percentage Change From Previous Quarter	(11%)	(33%)	(5%)	(25%)	(4%)	2%	2%	2%		
Cumulative Total	204,165	52,610	218,425	53,225	232,120	53,855	246,035	54,495		
Average Selling Price	$1.05	$1.10	$1.10	$1.20	$1.25	$1.30	$1.30	$1.30	$1.17	$1.22
Revenue ($M)	15.8	0.9	15.7	0.7	17.1	0.8	18.1	0.8	66.7	3.3
Market Share										
U.S.	54.2%	69.7%	56.7%	74.8%	60.6%	74.6%	65.1%	75.0%	59.0%	73.2%
Japan	44.5%	30.3%	41.9%	25.2%	37.6%	25.4%	33.1%	25.0%	39.4%	26.8%
Europe	1.3%	0.0%	1.4%	0.0%	1.8%	0.0%	1.8%	0.0%	1.6%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

	1984									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD	1,200	130	1,000	100	750	80	600	75	3,550	385
AMI	0	0	0	0					0	0
Commodore MOS	0	0	0	0					0	0
Fairchild	3	0	0	0	0		0		3	0
Fujitsu	0	0	0	0					0	0
GTE (EMM Prior 1980)	0	0	0	0					0	0
Hitachi	50	0	25	0					75	0
Intel	160	90	220	100	290	120	200	140	870	450
Intersil	0	0	0	0					0	0
Matsushita	0	0	0	0					0	0
Mitsubishi	140	40	125	35	110	30	100	30	475	135
Motorola	3,160	0	2,460	0	1,861		1,138		8,619	0
National	2,800	150	2,000	120	1,500	95	1,000	75	7,300	440
NEC	2,680	60	2,200	35	1,500	20	1,200	10	7,580	125
Oki Electric	25	0	25	0	15		0		65	0
Synertek	350	0	400	0	400		350		1,500	0
TCMC	225	0	175	0	150		125		675	0
Texas Instruments	150	50	140	50	120	40	110	25	520	165
Toshiba	1,800	0	1,400	0	1,800	0	1,400	0	6,400	0
Zilog	0	0	0	0					0	0
Total	12,743	520	10,170	440	8,496	385	6,223	355	37,632	1,700
Percentage Change From Previous Quarter	(8%)	(19%)	(20%)	(15%)	(16%)	(13%)	(27%)	(8%)		
Cumulative Total	258,778	55,015	268,948	55,455	277,444	55,840	283,667	56,195		
Average Selling Price	$1.30	$1.30	$1.30	$1.30	$1.30	$1.30	$1.40	$1.40	$1.32	$1.32
Revenue ($M)	16.6	0.7	13.2	0.6	11.0	0.5	8.7	0.5	49.5	2.2
Market Share										
U.S.	61.4%	80.8%	61.2%	84.1%	57.9%	87.0%	54.6%	88.7%	59.4%	84.7%
Japan	36.8%	19.2%	37.1%	15.9%	40.3%	13.0%	43.4%	11.3%	38.8%	15.3%
Europe	1.8%	0.0%	1.7%	0.0%	1.8%	0.0%	2.0%	0.0%	1.8%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

Company	1985 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	550	50	500	40	525	25	500	15	2,075	130
AMI									0	0
Commodore MOS									0	0
Fairchild	0	0	0	0	0		0		0	0
Fujitsu									0	0
GTE (EMM Prior 1980)									0	0
Hitachi									0	0
Intel	230	110	140	110	180	80	170	60	720	360
Intersil									0	0
Matsushita									0	0
Mitsubishi	75	25	50	10	40	0	25	0	190	35
Motorola	1,157		1,377		712		944		4,190	0
National	750	50	500	35	400	20	250	10	1,900	115
NEC	1,440	0	250	0	320	0	240	0	2,250	0
Oki Electric									0	0
Synertek									0	0
TCMC	100		50		30		10		190	0
Texas Instruments	95		75		50		40		260	0
Toshiba	1,500	0	700	0	400	0	300	0	2,900	0
Zilog									0	0
Total	5,897	235	3,642	195	2,657	125	2,479	85	14,675	640
Percentage Change From Previous Quarter	(5%)	(34%)	(38%)	(17%)	(27%)	(36%)	(7%)	(32%)		
Cumulative Total	289,564	56,430	293,206	56,625	295,863	56,750	298,342	56,835		
Average Selling Price	$1.40	$1.40	$1.35	$1.35	$1.25	$1.25	$1.15	$1.15	$1.32	$1.32
Revenue ($M)	8.3	0.3	4.9	0.3	3.3	0.2	2.9	0.1	19.3	0.8
Market Share										
U.S.	47.2%	89.4%	71.2%	94.9%	70.3%	100.0%	76.8%	100.0%	62.3%	94.5%
Japan	51.1%	10.6%	27.5%	5.1%	28.6%	0.0%	22.8%	0.0%	36.4%	5.5%
Europe	1.7%	0.0%	1.4%	0.0%	1.1%	0.0%	0.4%	0.0%	1.3%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments (Thousands of Units)

Company	1986 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
AMD	580	20	440	10	392	8	295	5	1,707	43
AMI									0	0
Commodore MOS									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (EMM Prior 1980)									0	0
Hitachi									0	0
Intel	190	30	180	50	160	30	130	40	660	150
Intersil									0	0
Matsushita									0	0
Mitsubishi	15		5		0		0		20	0
Motorola	782		801		526		933		3,042	0
National	200	100	500	125	300	150	700	120	1,700	495
NEC	260		330		160		90		840	0
Oki Electric									0	0
Synertek									0	0
TCMC									0	0
Texas Instruments	15		5						20	0
Toshiba	220		145		100		65	0	530	0
Zilog									0	0
Total	2,262	150	2,406	185	1,638	188	2,213	165	8,519	688
Percentage Change From Previous Quarter	(9%)	76%	6%	23%	(32%)	2%	35%	(12%)		
Cumulative Total	300,604	56,985	303,010	57,170	304,648	57,358	306,861	57,523		
Average Selling Price	$1.19	$1.35	$1.23	$1.80	$1.29	$1.90	$1.35	$2.00	$1.26	$1.78
Revenue ($M)	2.7	0.2	3.0	0.3	2.1	0.4	3.0	0.3	10.8	1.2
Market Share										
U.S.	78.1%	100.0%	80.0%	100.0%	84.1%	100.0%	93.0%	100.0%	83.7%	100.0%
Japan	21.9%	0.0%	20.0%	0.0%	15.9%	0.0%	7.0%	0.0%	16.3%	0.0%
Europe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

Estimated Worldwide Slow NMOS 4K SRAM Shipments
(Thousands of Units)

	1987									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD	195	S	195	S	150	0	120	0	660	10
AMI									0	0
Commodore MOS									0	0
Fairchild									0	0
Fujitsu									0	0
GTE (EMM Prior 1980)									0	0
Hitachi									0	0
Intel	110	30	80	15	60	5	40	0	290	50
Intersil									0	0
Matsushita									0	0
Mitsubishi	0		0		0		0		0	0
Motorola	700		500		300		200		1,700	0
National	1,000	350	450	125	300	75	200	40	1,950	590
NEC	80		60		30		40		210	0
Oki Electric									0	0
Synertek									0	0
TCMC									0	0
Texas Instruments									0	0
Toshiba	60		40		30		20		150	0
Zilog									0	0
Total	2,145	385	1,325	145	870	80	620	40	4,960	650
Percentage Change From Previous Quarter	31%	105%	(38%)	(62%)	(34%)	(45%)	(29%)	(50%)		
Cumulative Total	306,793	57,743	308,118	57,888	308,988	57,968	309,608	58,008		
Average Selling Price	$1.38	$2.00	$1.40	$2.00	$1.42	$2.00	$1.45	$2.05	$1.40	$2.00
Revenue ($M)	3.0	0.8	1.9	0.3	1.2	0.2	0.9	0.1	6.9	1.3
Market Share										
U.S.	93.5%	100.0%	92.5%	100.0%	93.1%	100.0%	90.3%	100.0%	92.7%	100.0%
Japan	6.5%	0.0%	7.5%	0.0%	6.9%	0.0%	9.7%	0.0%	7.3%	0.0%
Europe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

Source: Dataquest
May 1988

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Table 2

Estimated Worldwide Slow CMOS 4K SRAM Shipments (Thousands of Units)

Company	1978 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
Fujitsu									0	0
Harris	S		10		10	10	20	10	40	20
Hitachi				S	0	10	0	50	0	60
Matra-Harris									0	0
Mitsubishi									0	0
Motorola									0	0
National			S		20		60		80	0
NEC									0	0
Oki Electric									0	0
RCA	S		20		30		50		100	0
Seiko									0	0
Solid State Scientific									0	0
Toshiba	-	-	S	-	50	S	80	20	130	20
Total	0	0	30	0	110	20	210	80	350	100
Percentage Change From Previous Quarter					267%		91%	300%		
Cumulative Total	0	0	30	0	140	20	350	100		
Average Selling Price	$100		$75.00	$85.00	$40.00	$40.00	$35.00	$35.00	$40.00	$36.00
Revenue ($M)	0.0	0.0	2.3	0.0	4.4	0.8	7.4	2.8	14.0	3.6
Market Share										
U.S.			100.0%		54.5%	50.0%	61.9%	12.5%	62.9%	20.0%
Japan			0.0%		45.5%	50.0%	38.1%	87.5%	37.1%	80.0%
Europe			0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total			100.0%		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments (Thousands of Units)

Company	1979 1st Quarter 1Kx4	1st Quarter 4Kx1	2nd Quarter 1Kx4	2nd Quarter 4Kx1	3rd Quarter 1Kx4	3rd Quarter 4Kx1	4th Quarter 1Kx4	4th Quarter 4Kx1	Year 1Kx4	Year 4Kx1
Fujitsu									0	0
Harris	25	15	40	30	100	100	125	125	290	270
Hitachi		50		150		300		450	0	950
Matra-Harris									0	0
Mitsubishi	5		10		35		40		90	0
Motorola					S		S		0	0
National					S	S	5	5	5	5
NEC	100		270		450		500		1,320	0
Oki Electric									0	0
RCA	50		80		125		100		355	0
Seiko									0	0
Solid State Scientific									0	0
Toshiba	175	25	450	50	500	100	500	100	1,625	275
Total	355	90	850	230	1,210	500	1,270	680	3,685	1,500
Percentage Change From Previous Quarter	69%	13%	139%	156%	42%	117%	5%	36%		
Cumulative Total	355	90	1,205	320	2,415	820	3,685	1,500		
Average Selling Price	$30.00	$30.00	$20.00	$20.00	$13.00	$12.50	$13.00	$12.50	$16.25	$18.07
Revenue ($M)	10.7	2.7	17.0	4.6	15.7	6.3	16.5	13.6	59.9	27.1
Market Share										
U.S.	21.1%	16.7%	14.1%	13.0%	18.6%	20.0%	18.1%	19.1%	17.6%	18.3%
Japan	78.9%	83.3%	85.9%	87.0%	81.4%	80.0%	81.9%	80.9%	82.4%	81.7%
Europe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments (Thousands of Units)

	1990									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu	30	30	100	150	150	200	150	220	430	600
Harris	150	150	200	200	225	225	220	220	795	795
Hitachi	50	500	100	600	150	650	150	650	450	2,400
Matra-Harris									0	0
Mitsubishi	60		60		100		75		295	0
Motorola						S		10	0	10
National	15	15	30	30	35	35	100	35	180	115
NEC	600		425		700		1,070		2,795	0
Oki Electric			5	5	10	10	20	20	35	35
RCA	150		150		170		200		670	0
Seiko									0	0
Solid State Scientific									0	0
Toshiba	600	100	650	120	750	150	900	200	2,900	570
Total	1,655	795	1,720	1,105	2,290	1,270	2,885	1,355	8,550	4,525
Percentage Change From Previous Quarter	30%	17%	4%	39%	33%	15%	26%	7%		
Cumulative Total	5,340	2,295	7,060	3,400	9,350	4,670	12,235	6,025		
Average Selling Price	$15.00	$15.00	$14.00	$12.00	$8.00	$8.00	$4.00	$4.00	$9.21	$9.01
Revenue ($M)	24.8	11.9	24.1	13.3	18.3	10.2	11.5	5.4	78.8	40.8
Market Share										
U.S.	19.0%	20.8%	22.1%	20.8%	18.8%	20.5%	18.0%	19.6%	19.2%	20.3%
Japan	81.0%	79.2%	77.9%	79.2%	81.2%	79.5%	82.0%	80.4%	80.8%	79.7%
Europe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments (Thousands of Units)

	1981									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu	175	225	50	150	40	100	30	70	295	545
Harris	220	220	230	230	300	300	375	375	1,125	1,125
Hitachi	250	825	350	1,000	400	1,100	450	1,200	1,450	4,125
Matra-Harris	100	50	50	50	100	60	180	60	430	220
Mitsubishi	230		310		320		350		1,210	0
Motorola		10		30		0		0	0	40
National	150	25	200	50	200	50	150	40	700	165
NEC	1,500		1,300		1,500		1,800		6,100	0
Oki Electric	35	35	45	45	50	50	50	50	180	180
RCA	220		190		150		110		670	0
Seiko									0	0
Solid State Scientific	5		10		25		50		85	
Toshiba	1,050	250	1,200	350	1,100	300	1,200	250	4,550	1,150
Total	3,930	1,640	3,935	1,905	4,185	1,960	4,745	2,045	16,795	7,550
Percentage Change From Previous Quarter	36%	21%	0	16%	6%	3%	13%	4%		
Cumulative Total	16,165	7,665	20,100	9,570	24,285	11,530	29,030	13,575		
Average Selling Price	$3.75	$3.50	$3.50	$3.35	$3.25	$3.15	$3.00	$3.00	$3.35	$3.24
Revenue ($M)	14.7	5.7	13.8	6.4	13.6	6.2	14.2	6.1	56.3	24.4
Market Share										
U.S.	15.0%	15.5%	16.0%	16.3%	16.1%	17.9%	14.4%	20.3%	15.4%	17.6%
Japan	82.4%	81.4%	82.7%	81.1%	81.5%	79.1%	81.8%	76.8%	82.1%	79.5%
Europe	2.5%	3.0%	1.3%	2.6%	2.4%	3.1%	3.8%	2.9%	2.6%	2.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

	1982									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu	25	50	25	50	25	50	25	50	100	200
Harris	400	400	400	400	400	400	400	400	1,600	1,600
Hitachi	450	1,200	450	1,200	500	1,400	500	1,400	1,900	5,200
Matra-Harris	400	350	200	200	200	130	200	150	1,000	830
Mitsubishi	350		330		330		220		1,230	0
Motorola									0	0
National	200	100	220	175	220	250	300	175	940	700
NEC	1,900		1,500		1,500		1,100		6,000	0
Oki Electric	70	70	70	70	70	70	70	70	280	280
RCA	80		70		50		50		250	0
Seiko									0	0
Solid State Scientific	80		100		150		175		505	0
Toshiba	1,400	350	1,500	550	1,600	700	1,700	900	6,200	2,500
Total	5,355	2,520	4,865	2,645	5,045	3,000	4,740	3,145	20,005	11,310
Percentage Change From Previous Quarter	13%	23%	(9%)	5%	4%	13%	(6%)	5%		
Cumulative Total	34,385	16,095	39,250	18,740	44,295	21,740	49,035	24,885		
Average Selling Price	$2.50	$2.50	$2.35	$2.35	$2.25	$2.25	$2.10	$2.10	$2.31	$2.29
Revenue ($M)	13.4	6.3	11.4	6.2	11.4	6.8	10.0	6.6	46.1	25.9
Market Share										
U.S.	14.2%	19.8%	16.2%	21.7%	16.3%	21.7%	19.5%	18.3%	16.5%	20.3%
Japan	78.3%	66.3%	79.7%	70.7%	79.8%	74.0%	76.3%	76.9%	78.5%	72.3%
Europe	7.5%	13.9%	4.1%	7.6%	4.0%	4.3%	4.2%	4.8%	5.0%	7.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

	1983									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu	0	0	0	0	0	0	0	0	0	0
Harris	340	200	240	200	250	200	250	200	1,080	800
Hitachi	400	1,300	450	1,100	450	1,000	400	800	1,700	4,200
Matra-Harris	200	150	200	150	200	150	200	150	800	600
Mitsubishi	130		140		70		50		390	0
Motorola									0	0
National	250	200	250	200	300	200	400	250	1,200	850
NEC	1,000		1,000		1,300		1,200		4,500	0
Oki Electric	50	50	50	50	50	50	50	50	200	200
RCA	50		50		50		50		200	0
Seiko									0	0
Solid State Scientific	200		200		150		150		700	0
Toshiba	1,300	600	1,200	600	1,400	600	1,500	500	5,400	2,300
Total	3,920	2,500	3,780	2,300	4,220	2,200	4,250	1,950	16,170	8,950
Percentage Change From Previous Quarter	(17%)	(21%)	(4%)	(8%)	12%	(4%)	1%	(11%)		
Cumulative Total	52,955	27,385	56,735	29,685	60,955	31,885	65,205	33,835		
Average Selling Price	$2.00	$2.00	$2.00	$2.00	$2.25	$2.25	$2.25	$2.25	$2.13	$2.12
Revenue ($M)	7.8	5.0	7.6	4.6	9.5	5.0	9.6	4.4	34.5	18.9
Market Share										
U.S.	21.4%	16.0%	19.6%	17.4%	17.8%	18.2%	20.0%	23.1%	19.7%	18.4%
Japan	73.5%	78.0%	75.1%	76.1%	77.5%	75.0%	75.3%	69.2%	75.4%	74.9%
Europe	5.1%	6.0%	5.3%	6.5%	4.7%	6.8%	4.7%	7.7%	4.9%	6.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments (Thousands of Units)

	1984									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu	0	0	0	0					0	0
Harris	180	150	160	140	140	120	120	100	600	510
Hitachi	350	600	280	500	220	400	180	350	1,030	1,850
Matra-Harris	165	160	140	155	180	140	200	110	685	565
Mitsubishi	70	0	70	0	65		60		265	0
Motorola	0	0	0	0					0	0
National	280	150	210	100	190	80	150	65	830	395
NEC	1,590	0	1,160	0	800	0	720		4,270	0
Oki Electric	25	25	25	25	20	25	20	20	90	95
RCA	70	0	80	0	85		90		325	0
Seiko									0	0
Solid State Scientific	120		110		100		100		430	0
Toshiba	1,400	400	1,350	375	1,220	350	1,050	325	5,020	1,450
Total	4,250	1,485	3,585	1,295	3,020	1,115	2,690	970	13,545	4,865
Percentage Change From Previous Quarter	0	(24%)	(16%)	(13%)	(16%)	(14%)	(11%)	(13%)		
Cumulative Total	69,455	35,320	73,040	36,615	76,060	37,730	78,750	38,700		
Average Selling Price	$2.20	$2.20	$2.20	$2.20	$2.25	$2.25	$2.30	$2.30	$2.23	$2.23
Revenue ($M)	9.4	3.3	7.9	2.8	6.8	2.5	6.2	2.2	30.2	10.9
Market Share										
U.S.	15.3%	20.2%	15.6%	18.5%	17.1%	17.9%	17.1%	17.0%	16.1%	18.6%
Japan	80.8%	69.0%	80.5%	69.5%	77.0%	69.5%	75.5%	71.6%	78.8%	69.8%
Europe	3.9%	10.8%	3.9%	12.0%	6.0%	12.6%	7.4%	11.3%	5.1%	11.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments (Thousands of Units)

	1985									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu									0	0
Harris	120	90	110	75	100	70	90	55	420	290
Hitachi	150	250	120	200	100	150	70	100	440	700
Matra-Harris	228	108	169	130	141	22	62	15	600	275
Mitsubishi	55		50		40		35		180	0
Motorola									0	0
National	135	50	120	45	110	35	95	30	460	160
NEC	580		490		300		310		1,680	0
Oki Electric	15	15	10	10	10	10	5	5	40	40
RCA	90		80		75		65		310	0
Seiko									0	0
Solid State Scientific	90		85		75		65		315	0
Toshiba	1,000	300	850	275	750	250	650	200	3,250	1,025
Total	2,463	813	2,084	735	1,701	537	1,447	405	7,695	2,490
Percentage Change From Previous Quarter	(8%)	(16%)	(15%)	(10%)	(18%)	(27%)	(15%)	(25%)		
Cumulative Total	81,213	39,513	83,297	40,248	84,998	40,785	86,445	41,190		
Average Selling Price	$2.25	$2.25	$2.25	$2.25	$2.15	$2.30	$2.30	$2.20	$2.20	$2.25
Revenue ($M)	5.5	1.8	4.7	1.7	3.7	1.2	3.3	0.9	17.2	5.6
Market Share										
U.S.	17.7%	17.2%	19.0%	16.3%	21.2%	19.6%	21.8%	21.0%	19.6%	18.1%
Japan	73.1%	69.5%	72.9%	66.0%	70.5%	76.4%	73.9%	75.3%	72.6%	70.9%
Europe	9.3%	13.3%	8.1%	17.7%	8.3%	4.1%	4.3%	3.7%	7.8%	11.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments (Thousands of Units)

	1986									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu									0	0
Harris	85		80		70		60		295	0
Hitachi	60	90	50	80	50	75	50	75	210	320
Matra-Harris	164	35	113	30	89	12	65	10	431	87
Mitsubishi	55		50		40		35		180	0
Motorola									0	0
National										
NEC	160		80		110		130		480	0
Oki Electric	0	0	0	0	0	0	0	0	0	0
RCA	55		45		40		30		170	0
Seiko									0	0
Solid State Scientific	55		50		45		40		190	0
Toshiba	600	50	500	50	440	50	400	50	1,940	200
Total	1,234	175	968	160	884	137	810	135	3,896	607
Percentage Change From Previous Quarter	(15%)	(57%)	(22%)	(9%)	(9%)	(14%)	(8%)	(1%)		
Cumulative Total	87,679	41,365	88,647	41,525	89,531	41,662	90,341	41,797		
Average Selling Price	$2.40	$2.50	$2.60	$2.75	$2.80	$2.95	$2.95	$3.10	$2.65	$2.80
Revenue ($M)	3.0	0.4	2.5	0.4	2.5	0.4	2.4	0.4	10.3	1.7
Market Share										
U.S.	15.8%	0.0%	18.1%	0.0%	17.5%	0.0%	16.0%	0.0%	16.8%	0.0%
Japan	70.9%	80.0%	70.2%	81.3%	72.4%	91.2%	75.9%	92.6%	72.1%	85.7%
Europe	13.3%	20.0%	11.7%	18.8%	10.1%	8.8%	8.0%	7.4%	11.1%	14.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Estimated Worldwide Slow CMOS 4K SRAM Shipments
(Thousands of Units)

	1987									
	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Year	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Fujitsu									0	0
Harris	50		30		20		15		115	0
Hitachi	40	70	20	55	10	40	5	30	75	195
Matra-Harris	103	9	105	12	30	6	21	9	259	36
Mitsubishi	25		15		10		5		55	0
Motorola									0	0
National									0	0
NEC	0		0		0		0		0	0
Oki Electric									0	0
RCA	20		10		5		5		40	0
Seiko									0	0
Solid State Scientific	30		20		10		5		65	0
Toshiba	400	30	300	20	200	15	100	10	1,000	75
Total	668	109	500	87	285	61	156	49	1,609	306
Percentage Change From Previous Quarter	(24%)	(20%)	(25%)	(20%)	(43%)	(30%)	(45%)	(20%)		
Cumulative Total	90,199	41,771	90,699	41,858	90,984	41,919	91,140	41,968		
Average Selling Price	$3.10	$3.30	$3.25	$3.50	$3.40	$3.65	$3.50	$3.75	$3.24	$3.50
Revenue ($M)	2.1	0.4	1.6	0.3	1.0	0.2	0.5	0.2	5.2	1.1
Market Share										
U.S.	15.0%	0.0%	12.0%	0.0%	12.3%	0.0%	16.0%	0.0%	13.7%	0.0%
Japan	69.6%	91.7%	67.0%	86.2%	77.2%	90.2%	70.5%	81.6%	70.2%	88.2%
Europe	15.4%	8.3%	21.0%	13.8%	10.5%	9.8%	13.5%	18.4%	16.1%	11.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

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Table 3

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS					0
Fairchild	NMOS					0
Fujitsu	NMOS				S	S
	CMOS					0
Harris	CMOS					0
Hitachi	CMOS	S	10	90	320	420
IDT	CMOS					0
Matra-Harris	CMOS					0
Matsushita	NMOS					
Mitsubishi	NMOS		S	2	10	12
	CMOS					0
Motorola	CMOS					0
	NMOS					0
National	NMOS					0
NEC	NMOS					0
	CMOS					0
Oki Electric	NMOS	3	7	9	12	31
	CMOS					0
RCA	CMOS					0
Seiko	CMOS					0
Sharp	CMOS					0
Synertek	NMOS					0
TCMC	NMOS			S	5	5
	CMOS					0
Texas Instruments	NMOS	S	S	4	8	12
Toshiba	NMOS		S	10	35	45
	CMOS	4	10	20	35	69
Total		7	27	135	425	594
Percentage Change From Previous Quarter			286%	400%	215%	
Cumulative Total		7	34	169	594	
Average Selling Price	NMOS	$40.00	$30.00	$20.00	$15.00	$17.90
	CMOS	$70.00	$40.00	$28.00	$20.00	$23.03
Total		$57.14	$37.41	$26.52	$19.18	$22.12
Revenue ($M)	NMOS	0.1	0.2	0.5	1.1	1.9
	CMOS	0.3	0.8	3.1	7.1	11.3
Total		0.4	1.0	3.6	8.2	13.1
Market Share						
U.S.		0.0%	0.0%	3.0%	1.9%	2.0%
Japan		100.2%	100.0%	97.0%	96.9%	97.1%
Europe		0.0%	0.0%	0.0%	1.2%	0.8%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments (Thousands of Units)

Company	MOS Process	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS					0
Fairchild	NMOS					0
Fujitsu	NMOS	S	S	45	110	155
	CMOS	S	S	60	100	165
Harris	CMOS	S	5	10	15	30
Hitachi	CMOS	450	550	850	1,200	3,050
IDT	CMOS				S	S
Matra-Harris	CMOS					0
Matsushita	NMOS					
Mitsubishi	NMOS	20	100	470	450	1,040
	CMOS				S	S
Motorola	CMOS					0
	NMOS					0
National	NMOS					0
NEC	NMOS			15	100	115
	CMOS			S	50	50
Oki Electric	NMOS	15	20	40	60	135
	CMOS		S	10	50	60
RCA	CMOS					0
Seiko	CMOS					0
Sharp	CMOS					0
Synertek	NMOS		S	S	5	5
TCMC	NMOS	25	30	45	80	180
	CMOS					0
Texas Instruments	NMOS	12	15	20	20	67
Toshiba	NMOS	200	330	450	750	1,730
	CMOS	160	225	400	700	1,485
Total		882	1,280	2,415	3,690	8,267
Percentage Change From Previous Quarter		108%	45%	89%	53%	
Cumulative Total		1,476	2,756	5,171	8,861	
Average Selling Price	NMOS	$10.00	$ 8.00	$6.00	$5.00	$6.15
	CMOS	$15.00	$11.00	$8.50	$7.00	$9.07
Total		$13.46	$ 9.84	$7.38	$6.15	$7.86
Revenue ($M)	NMOS	2.7	4.0	6.5	7.9	21.1
	CMOS	9.2	8.6	11.3	14.8	43.9
Total		11.9	12.6	17.8	22.7	65.0
Market Share						
U.S.		1.4%	1.6%	1.2%	1.1%	1.2%
Japan		95.8%	96.1%	96.9%	96.7%	96.6%
Europe		2.8%	2.3%	1.9%	2.2%	2.2%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments (Thousands of Units)

Company	MOS Process	1992 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS		S	45	140	185
Fairchild	NMOS	S	S	S	S	S
Fujitsu	NMOS	210	265	370	450	1,295
	CMOS	120	150	225	300	795
Harris	CMOS	10	10	15	15	50
Hitachi	CMOS	1,900	2,700	3,500	4,200	12,300
IDT	CMOS	10	25	50	80	165
Matra-Harris	CMOS	S	20	100	150	270
Matsushita	NMOS					
Mitsubishi	NMOS	500	550	550	520	2,120
	CMOS	S	60	60	100	220
Motorola	CMOS			S	10	10
	NMOS					0
National	NMOS	S	S	10	50	60
NEC	NMOS	250	650	650	700	2,250
	CMOS	120	250	350	350	1,070
Oki Electric	NMOS	80	100	150	200	530
	CMOS	100	150	200	250	700
RCA	CMOS			S	10	10
Seiko	CMOS				10	10
Sharp	CMOS					0
Synertek	NMOS	5	20	150	500	675
TCMC	NMOS	40	20	20	30	110
	CMOS					0
Texas Instruments	NMOS	70	100	125	150	445
Toshiba	NMOS	1,200	1,400	1,600	1,800	6,000
	CMOS	1,000	1,400	2,200	2,400	7,000
Total		5,615	7,870	10,370	12,415	36,270
Percentage Change From Previous Quarter		52%	40%	32%	20%	
Cumulative Total		14,476	22,346	32,716	45,131	
Average Selling Price	NMOS	$4.10	$3.80	$3.50	$3.25	$3.59
	CMOS	$6.25	$5.50	$5.00	$4.50	$5.11
Total		$5.35	$4.83	$4.47	$4.04	$4.54
Revenue ($M)	NMOS	9.7	11.8	12.8	14.8	49.1
	CMOS	20.4	26.2	33.5	35.4	115.5
Total		30.0	38.0	46.3	50.2	164.6
Market Share						
U.S.		1.7%	2.0%	3.8%	7.7%	4.4%
Japan		97.6%	97.5%	95.0%	90.9%	94.5%
Europe		0.7%	0.5%	1.2%	1.4%	1.0%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments (Thousands of Units)

Company	MOS Process	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	400	775	850	700	2,725
Fairchild	NMOS	0	0	0	0	0
Fujitsu	NMOS	600	800	1,000	1,200	3,600
	CMOS	450	700	1,000	1,400	3,550
Harris	CMOS	15	20	50	150	235
Hitachi	CMOS	5,500	8,000	10,000	11,000	34,500
IDT	CMOS	100	150	200	250	700
Matra-Harris	CMOS	250	350	400	500	1,500
Matsushita	NMOS					
Mitsubishi	NMOS	600	600	950	900	3,050
	CMOS	90	420	160	350	1,020
Motorola	CMOS	20	30	50	80	180
	NMOS					0
National	NMOS	50	300	400	600	1,350
NEC	NMOS	750	800	1,000	800	3,350
	CMOS	500	750	1,900	2,300	5,450
Oki Electric	NMOS	400	550	750	900	2,600
	CMOS	500	650	800	1,100	3,050
RCA	CMOS	150	450	700	850	2,150
Seiko	CMOS	50	50	100	300	500
Sharp	CMOS					0
Synertek	NMOS	700	1,000	750	900	3,350
TCMC	NMOS	60	110	160	260	590
	CMOS			8	25	25
Texas Instruments	NMOS	250	350	400	450	1,450
Toshiba	NMOS	2,200	3,100	3,800	4,500	13,600
	CMOS	2,600	2,900	3,700	4,200	13,400
Total		16,235	22,855	29,120	33,715	101,925
Percentage Change From Previous Quarter		31%	41%	27%	16%	
Cumulative Total		61,366	84,221	113,341	147,056	
Average Selling Price	NMOS	$3.10	$2.75	$2.90	$3.10	$2.96
	CMOS	$4.25	$3.70	$3.90	$4.15	$4.00
Total		$3.82	$3.35	$3.55	$3.80	$3.63
Revenue ($M)	NMOS	18.6	23.1	29.2	34.8	105.6
	CMOS	43.5	53.5	74.3	93.4	264.7
Total		62.1	76.6	103.5	128.1	370.3
Market Share						
U.S.		10.4%	13.5%	11.7%	11.8%	11.9%
Japan		87.7%	84.5%	86.4%	85.9%	86.0%
Europe		1.9%	2.0%	1.9%	2.3%	2.1%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	850	1,000	1,100	1,000	3,950
Fairchild	NMOS	0	0	0	0	0
Fujitsu	NMOS	1,350	1,300	1,280	1,280	5,210
	CMOS	1,500	1,600	1,750	1,600	6,450
Harris	CMOS	250	300	280	250	1,080
Hitachi	CMOS	11,500	12,000	11,500	11,000	46,000
IDT	CMOS	150	155	160	165	630
Matra-Harris	CMOS	600	640	680	680	2,600
Matsushita	NMOS					
Mitsubishi	NMOS	950	1,000	1,100	1,100	4,150
	CMOS	350	370	400	350	1,470
Motorola	CMOS	169	78	25	6	278
	NMOS	0	0	0	0	0
National	NMOS	750	850	1,000	1,100	3,700
NEC	NMOS	700	1,480	1,500	1,800	5,480
	CMOS	2,640	2,000	2,100	2,400	9,140
Oki Electric	NMOS	600	200	50	0	850
	CMOS	1,000	800	650	600	3,050
RCA	CMOS	1,100	1,200	1,300	1,350	4,950
Seiko	CMOS	500	600	700	750	2,550
Sharp	CMOS					0
Synertek	NMOS	1,100	1,300	1,200	1,200	4,800
TCMC	NMOS	260	310	290	270	1,130
	CMOS	140	190	320	360	1,010
Texas Instruments	NMOS	480	475	425	400	1,780
Toshiba	NMOS	5,000	5,700	6,100	6,200	23,000
	CMOS	4,000	5,100	5,100	5,000	19,200
Total		35,939	38,648	39,010	38,861	152,458
Percentage Change From Previous Quarter		7%	8%	1%	0%	
Cumulative Total		182,995	221,643	260,653	299,514	
Average Selling Price	NMOS	$3.25	$3.35	$3.10	$2.75	$3.10
	CMOS	$4.25	$4.40	$4.00	$3.40	$4.01
Total		$3.91	$4.03	$3.68	$3.16	$3.69
Revenue ($M)	NMOS	39.1	45.6	43.5	39.5	167.7
	CMOS	101.6	110.1	99.9	83.3	394.9
Total		140.7	155.8	143.4	122.8	562.7
Market Share						
U.S.		13.5%	13.9%	14.1%	14.1%	13.9%
Japan		83.7%	83.2%	82.6%	82.6%	83.0%
Europe		12.8%	2.9%	3.3%	3.4%	3.1%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	1,000	1,000	900	850	3,750
Fairchild	NMOS	0	0	0	0	0
Fujitsu	NMOS	1,250	1,250	1,200	1,180	4,880
	CMOS	1,550	1,500	1,500	1,450	6,000
Harris	CMOS	220	200	200	180	800
Hitachi	CMOS	10,000	10,000	9,500	9,000	38,500
IDT	CMOS	180	170	180	190	720
Matra-Harris	CMOS					0
Matsushita	NMOS					
Mitsubishi	NMOS	1,000	1,000	1,000	950	3,950
	CMOS	400	380	380	350	1,510
Motorola	CMOS	7	0	0	0	7
	NMOS	0	0	0	161	161
National	NMOS	1,100	1,000	1,000	950	4,050
NEC	NMOS	2,570	3,050	1,430	1,710	8,760
	CMOS	2,690	2,980	1,580	2,010	9,260
Oki Electric	NMOS	0	0	0	0	0
	CMOS	425	450	450	500	1,825
RCA	CMOS	1,270	1,320	1,200	1,100	4,890
Seiko	CMOS	800	880	920	850	3,450
Sharp	CMOS					0
Synertek	NMOS	1,150	1,200	1,200	1,150	4,700
TCMC	NMOS	260	210	210	190	870
	CMOS	380	410	425	435	1,650
Texas Instruments	NMOS	320	280	250	225	1,075
Toshiba	NMOS	6,500	6,500	6,000	6,000	25,000
	CMOS	5,000	4,800	4,800	4,500	19,100
Total		38,072	38,580	34,325	33,931	144,908
Percentage Change From Previous Quarter		(2%)	1%	(11%)	(1%)	
Cumulative Total		221,067	259,647	293,972	327,903	
Average Selling Price	NMOS	$2.00	$1.50	$1.25	$1.10	$1.48
	CMOS	$2.75	$2.00	$1.45	$1.25	$1.89
Total		$2.45	$1.80	$1.37	$1.19	$1.73
Revenue ($M)	NMOS	30.3	23.2	16.5	14.7	84.7
	CMOS	63.0	46.2	30.6	25.7	165.6
Total		93.3	69.4	47.1	40.4	250.3
Market Share						
U.S.		13.8%	13.4%	14.4%	14.2%	13.9%
Japan		84.5%	85.0%	83.8%	84.0%	84.4%
Europe		1.7%	1.6%	1.8%	1.8%	1.7%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments (Thousands of Units)

Company	MOS Process/ Best Speed		1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	90	800	750	720	450	2,720
Fairchild	N	120	0	0	0	0	0
Fujitsu	N	120	0	0	0	0	0
	C	120	1,400	1,250	1,100	1,000	4,750
Harris	C	120	170	150	140	125	585
Hitachi	C	120	8,000	7,000	6,400	5,900	27,300
IDT	C	70	200	210	230	220	860
Matra-Harris	C						0
Matsushita	C		200	400	450		1,050
Mitsubishi	N	120	170	80	50	200	500
	C	120	320	300	200	10	830
Motorola	C	120	0	0	0	0	0
	N		115	156	140	90	501
National	N	120	0	0	0	0	0
NEC	N	100	2,050	1,740	1,730	1,700	7,220
	C	120	2,770	2,200	1,940	1,900	8,810
Oki Electric	N	120	0	0	0	0	0
	C	120	600	700	700	750	2,750
RCA	C	120	850	610	490	410	2,360
Seiko	C	120	800	780	720	675	2,975
Sharp	C	120	0	0	0	25	25
Sony	C	120	100	400	600	925	2,025
Synertek	N	120	0	0	0	0	0
TCMC	N	70	155	145	130	125	555
	C	120	425	430	435	425	1,715
Texas Instruments	N	120	200	200	180	75	665
Toshiba	N	120	6,000	6,000	6,500	7,000	25,500
	C	120	3,500	3,500	3,700	3,700	14,400
Total			28,825	27,001	26,555	25,705	108,086
Percentage Change From Previous Quarter			(15%)	(6%)	(2%)	(3%)	
Cumulative Total			356,728	383,729	410,284	435,989	
Average Selling Price	NMOS		$1.00	$1.05	$1.10	$1.15	$1.08
	CMOS		$1.15	$1.25	$1.35	$1.40	$1.32
Total			$1.10	$1.18	$1.26	$1.31	$1.21
Revenue ($M)	NMOS		9.7	9.9	10.9	11.1	41.6
	CMOS		22.0	21.9	22.5	22.5	88.9
Total			31.7	31.9	33.4	33.6	130.5
Market Share							
U.S.			8.1%	7.7%	7.2%	5.3%	7.1%
Japan			89.9%	90.2%	90.7%	92.5%	90.8%
Europe			2.0%	2.1%	2.1%	2.1%	2.1%
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Slow MOS SRAM--Data

Table 3 (Continued)

Estimated Worldwide Slow 16K SRAM Shipments
(Thousands of Units)

Company	MOS Process/ Best Speed		1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	90	400	350	343	336	1,429
Fairchild	N	120	0	0	0	0	0
Fujitsu	N	120	0	0	0	0	0
	C	120	800	760	722	650	2,932
Harris	C	120	110	88	66	40	304
Hitachi	C	120	4,500	3,700	3,330	2,831	14,361
IDT	C	70	100	50	30	20	200
Matra-Harris	C		0	32	66	91	189
Matsushita	C		0	0	0	0	0
Mitsubishi	N	120	30	0	0	0	30
	C	120	0	0	0	0	0
Motorola	C	120	0	0	0	0	0
	N		0	0	0	0	0
National	N	120	0	0	0	0	0
NEC	N	100	1,590	1,260	1,050	730	4,630
	C	120	2,350	1,880	2,000	2,700	8,930
Oki Electric	N	120	0	0	0	0	0
	C	120	750	825	908	980	3,463
RCA	C	120	465	800	933	780	2,978
Seiko	C	120	608	614	675	709	2,605
Sharp	C	120	85	200	550	3,200	4,035
Sony	C	120	1,250	2,750	3,700	4,000	11,700
Synertek	N	120	0	0	0	0	0
TCMC	N	70	123	120	118	115	475
	C	120	404	384	364	346	1,498
Texas Instruments	N	120	0	0	0	0	0
Toshiba	N	120	7,000	6,790	6,111	5,194	25,095
	C	120	3,500	3,395	3,056	2,597	12,548
Total			24,064	23,997	24,021	25,319	97,401
Percentage Change From Previous Quarter			(6%)	0	0	5%	
Cumulative Total			380,792	404,789	428,810	454,129	
Average Selling Price	NMOS		$1.15	$1.15	$1.15	$1.16	$1.15
	CMOS		$1.40	$1.40	$1.41	$1.42	$1.41
Total			$1.31	$1.31	$1.32	$1.35	$1.32
Revenue ($M)	NMOS		10.5	9.8	8.8	7.4	36.5
	CMOS		20.9	21.7	23.0	26.9	92.5
Total			31.4	31.5	31.8	34.3	129.0
Market Share							
U.S.			4.5%	5.4%	5.7%	4.6%	5.0%
Japan			93.3%	92.4%	92.0%	93.2%	92.7%
Europe			2.2%	2.2%	2.3%	2.2%	2.2%
Total			100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

Source: Dataquest
May 1988

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Table 4

Estimated Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	MOS Technology/ Type	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD						
Fujitsu					S	S
Hitachi		10	20	30	50	110
Intel	NMOS iRAM			S	10	10
	CMOS iRAM					
Matra-Harris	CMOS					0
Mitsubishi						
Motorola						
National						
NEC	CMOS					
	CMOS PSRAM					
Oki Electric	CMOS					
RCA						
Seiko/SMOS						
Sony						
Toshiba		S	5	10	20	35
Total		10	25	40	80	155
Percentage Change From Previous Quarter			150%	60%	100%	
Cumulative Total			35	75	155	
Average Selling Price		$135.00	$115.00	$110.00	$90.00	$102.10
Revenue ($M)		1.4	2.9	4.4	7.2	15.8
Market Share						
U.S.		0.0%	0.0%	0.0%	12.5%	6.5%
Japan		100.0%	100.0%	100.0%	87.5%	93.5%
Europe		0.0%	0.0%	0.0%	0.0%	0.0%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	MOS Technology/ Type		1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD							
Fujitsu			15	40	75	150	280
Hitachi			100	450	800	1,100	2,450
Intel	NMOS	iRAM	25	75	150	250	500
	CMOS	iRAM					
Matra-Harris	CMOS						0
Mitsubishi				S	S	S	S
Motorola							
National							
NEC	CMOS				S	S	S
	CMOS	PSRAM			S	10	10
Oki Electric	CMOS						
RCA							
Seiko/SMOS					S	10	10
Sony							0
Toshiba			50	150	250	450	900
Total			190	715	1,275	1,970	4,150
Percentage Change From Previous Quarter			138%	276%	78%	55%	
Cumulative Total			345	1,060	2,335	4,305	
Average Selling Price			$60.00	$40.00	$27.00	$22.00	$28.38
Revenue ($M)			11.4	28.6	34.4	43.3	117.8
Market Share							
U.S.			13.2%	10.5%	11.8%	12.7%	12.0%
Japan			86.8%	89.5%	88.2%	87.3%	88.0%
Europe			0.0%	0.0%	0.0%	0.0%	0.0%
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments
(Thousands of Units)

Company	MOS Technology/ Type		1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD							0
Fujitsu			300	600	1,000	1,250	3,150
Hitachi			1,800	2,500	3,200	4,000	11,500
Intel	NMOS	iRAM	400	750	850	1,000	3,000
	CMOS	iRAM				S	S
Matra-Harris	CMOS		0	0	0	0	0
Mitsubishi			S	10	25	100	135
Motorola							0
National					S	10	10
NEC	CMOS		25	160	950	2,500	3,635
	CMOS	PSRAM	25	25	200	750	1,000
Oki Electric	CMOS						
RCA							0
Seiko/SMOS			10	25	75	250	360
Sony				S	10	50	60
Toshiba			700	1,000	1,800	3,000	6,500
Total			3,260	5,070	8,110	12,910	29,350
Percentage Change From Previous Quarter			65%	56%	60%	59%	
Cumulative Total			7,565	12,635	20,745	33,655	
Average Selling Price			$23.00	$18.00	$14.50	$11.00	$14.51
Revenue ($M)			75.0	91.3	117.6	142.0	425.8
Market Share							
U.S.			12.3%	14.8%	10.5%	7.8%	10.3%
Japan			87.7%	85.2%	89.5%	92.2%	89.7%
Europe			0.0%	0.0%	0.0%	0.0%	0.0%
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments (Thousands of Units)

Company	MOS Technology/ Type		1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD							0
Fujitsu			1,400	1,500	1,600	1,800	6,300
Hitachi			4,000	4,200	4,700	5,500	18,400
Intel	NMOS	iRAM	600	400	200	100	1,300
	CMOS	iRAM	100	250	400	400	1,500
Matra-Harris	CMOS		0	5	26	64	95
Mitsubishi			250	400	500	600	1,750
Motorola							0
National			50	100	100	150	400
NEC	CMOS		3,020	1,710	1,290	3,440	9,460
	CMOS	PSRAM	840	750	910	1,440	3,940
Oki Electric	CMOS		S	50	100	150	300
RCA			S	25	100	250	375
Seiko/SMOS			350	500	750	1,000	2,600
Sony			100	150	200	250	700
Toshiba			3,200	3,200	3,200	3,000	12,600
Total			13,910	13,240	14,076	18,144	59,370
Percentage Change From Previous Quarter			8%	(5%)	6%	29%	
Cumulative Total			21,475	34,715	48,791	66,935	
Average Selling Price			$7.75	$5.00	$3.15	$2.25	$4.37
Revenue ($M)			107.8	66.2	44.3	40.8	259.2
Market Share							
U.S.			5.4%	5.9%	5.7%	5.0%	5.4%
Japan			94.6%	94.1%	94.1%	94.7%	94.4%
Europe			0.0%	0.0%	0.2%	0.4%	0.2%
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments (Thousands of Units)

Company	MOS Technology/ Product Type	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	CMOS	2,000	2,100	2,400	2,700	9,200
Hitachi	CMOS	5,050	7,810	8,570	9,500	30,930
Intel	NMOS iRAM	50	25	17	8	100
	CMOS iRAM	150	75	50	25	300
Matra-Harris	CMOS	171	234	399	156	960
Mitsubishi	CMOS	650	1,000	2,500	2,700	6,850
NEC	CMOS & MIX MOS	4,000	3,540	4,810	3,200	15,550
	CMOS PSRAM	1,850	1,570	1,910	1,540	6,870
Oki Electric	CMOS	200	300	300	300	1,100
RCA		200	220	250	280	950
Seiko/SMOS	CMOS	250	400	600	750	2,000
Sharp	CMOS	0	0	0	10	10
Sony	CMOS	125	200	300	265	890
Toshiba	CMOS & MIX MOS	3,000	4,500	5,500	5,500	18,500
	NMOS	700	1,000	1,200	1,500	4,400
TCMC		50	100	100	150	400
Total		18,446	23,074	28,906	28,584	99,010
Percentage Change From Previous Quarter		2%	25%	25%	(1%)	
Cumulative Total		85,301	108,455	137,361	165,945	
Average Selling Price		$2.10	$2.00	$1.90	$1.70	$1.90
Revenue ($M)		38.7	46.1	54.9	48.6	188.4
Market Share						
U.S.		2.2%	1.4%	1.1%	1.1%	1.4%
Japan		96.6%	97.2%	97.2%	97.8%	97.3%
Europe		1.2%	1.4%	1.7%	1.1%	1.4%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Slow MOS SRAM--Data

Table 4 (Continued)

Estimated Worldwide Slow 64K SRAM Shipments (Thousands of Units)

Company	MOS Technology Product Type	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	CMOS	2,000	2,300	2,645	2,777	9,722
Hitachi	CMOS	9,000	8,500	9,010	9,911	36,421
Intel	NMOS iRAM	0	0	0	0	0
	CMOS iRAM	0	0	0	0	0
Matra-Harris	CMOS	214	182	193	336	925
Mitsubishi	CMOS	1,400	1,680	1,848	2,033	6,961
NEC	CMOS & MIX MOS	6,130	7,680	8,000	8,700	30,510
	CMOS PSRAM	1,600	1,680	1,730	1,782	6,793
Oki Electric	CMOS	300	348	400	420	1,468
RCA		335	448	820	700	2,303
Seiko/SMOS	CMOS	825	1,125	1,400	1,525	4,875
Sharp	CMOS	37	81	236	1,442	1,796
Sony	CMOS	400	900	2,000	2,700	6,000
Toshiba	CMOS & MIX MOS	5,000	5,550	6,105	6,410	23,065
	NMOS	1,500	1,815	2,033	2,236	7,584
TCMC		150	158	161	164	632
Total		28,891	32,447	36,581	41,137	139,055
Percentage Change From Previous Quarter		1%	12%	13%	12%	
Cumulative Total		194,836	227,283	263,864	305,000	
Average Selling Price		$2.00	$1.95	$1.95	$2.10	$2.00
Revenue ($M)		57.8	63.3	71.3	86.4	278.8
Market Share						
U.S.		1.2%	1.4%	2.2%	1.7%	1.7%
Japan		97.6%	97.6%	96.8%	97.1%	97.2%
Europe		1.3%	1.0%	1.0%	1.2%	1.1%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

Source: Dataquest

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Table 5

Estimated Worldwide Slow 256K SRAM Shipments (Thousands of Units)

Company	Product Type	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu				5	50	55
Hitachi		S	S	5	35	40
	PSRAM				S	0
Matra-Harris						0
Mitsubishi					S	0
NEC				S	40	40
	PSRAM				0	0
Oki Electric						
Seiko/Epson					S	0
Sony						
Toshiba		S	S	5	15	20
	PSRAM	-	-	-	0	0
Total		0	0	15	140	155
Percentage Change From Previous Quarter					833%	
Cumulative Total			0	15	155	
Average Selling Price		$75.00	$70.00	$55.00	$45.00	$45.97
Revenue ($M)		0.0	0.0	0.8	6.3	7.1
Market Share						
U.S.		0.0%	0.0%	0.0%	0.0%	0.0%
Japan		0.0%	0.0%	100.0%	100.0%	100.0%
Europe		0.0%	0.0%	0.0%	0.0%	0.0%
Total		0.0%	0.0%	100.0%	100.0%	100.0%

(Continued)

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Table 5 (Continued)

Estimated Worldwide Slow 256K SRAM Shipments
(Thousands of Units)

Company	Product Type	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu		85	120	200	350	755
Hitachi		50	200	400	650	1,300
	PSRAM		S	S	600	600
Matra-Harris						0
Mitsubishi		0	3	110	140	253
NEC		370	410	470	500	1,750
	PSRAM		S	S	400	400
Oki Electric			S	20	50	70
Seiko/Epson		10	50	90	140	290
Sony				10	20	30
Toshiba		50	150	200	350	750
	PSRAM					0
Total		565	933	1,500	3,200	6,198
Percentage Change From Previous Quarter		304%	65%	61%	113%	
Cumulative Total		720	1,653	3,153	6,353	
Average Selling Price		$40.00	$25.00	$18.00	$12.00	$17.96
Revenue ($M)		22.6	23.3	27.0	38.4	111.3
Market Share						
U.S.		0.0%	0.0%	0.0%	0.0%	0.0%
Japan		100.0%	100.0%	100.0%	100.0%	100.0%
Europe		0.0%	0.0%	0.0%	0.0%	0.0%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 5 (Continued)

Estimated Worldwide Slow 256K SRAM Shipments
(Thousands of Units)

Company	Product Type	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu		525	971	1,632	1,958	5,086
Hitachi		1,050	1,400	2,198	2,748	7,396
	PSRAM	800	1,600	2,512	3,014	7,926
Matra-Harris		0	19	35	90	144
Mitsubishi		290	545	965	1,158	2,958
NEC		1,560	1,800	3,150	3,000	9,510
	PSRAM	600	840	1,050	900	3,390
Oki Electric		80	156	242	314	792
Seiko/Epson		250	470	738	1,033	2,491
Sony		80	200	400	750	1,430
Toshiba		400	752	1,181	1,417	3,749
	PSRAM	50	94	148	177	469
Total		5,685	8,847	14,250	16,559	45,341
Percentage Change From Previous Quarter		78%	56%	61%	16%	
Cumulative Total		12,038	20,885	35,135	51,694	
Average Selling Price		$7.50	$6.75	$6.25	$6.50	$6.60
Revenue ($M)		42.6	59.7	89.1	107.6	299.1
Market Share						
U.S.		0.0%	0.0%	0.0%	0.0%	0.0%
Japan		100.0%	99.8%	99.8%	99.5%	99.7%
Europe		0.0%	0.2%	0.2%	0.5%	0.3%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling

Source: Dataquest
May 1988

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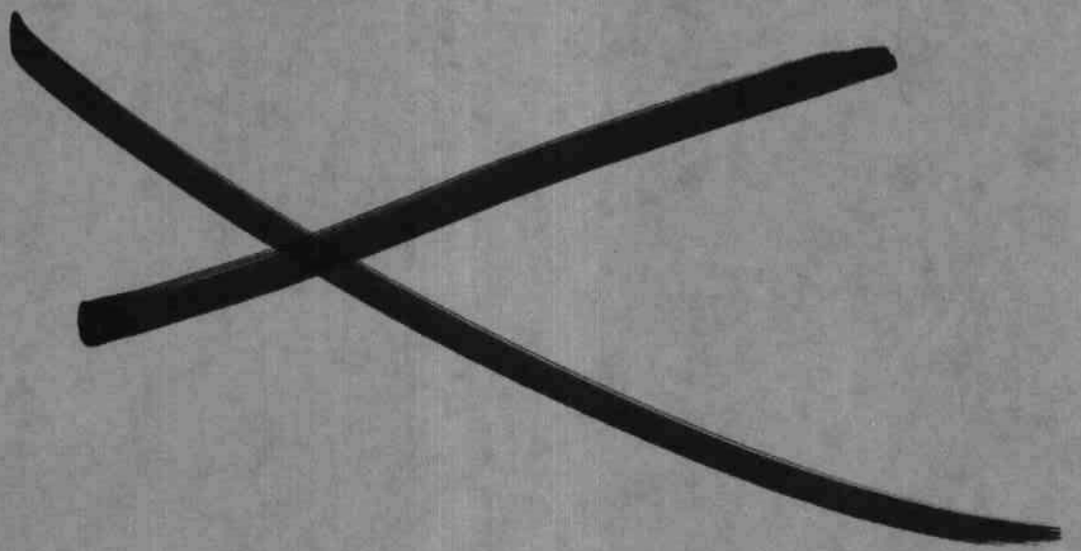

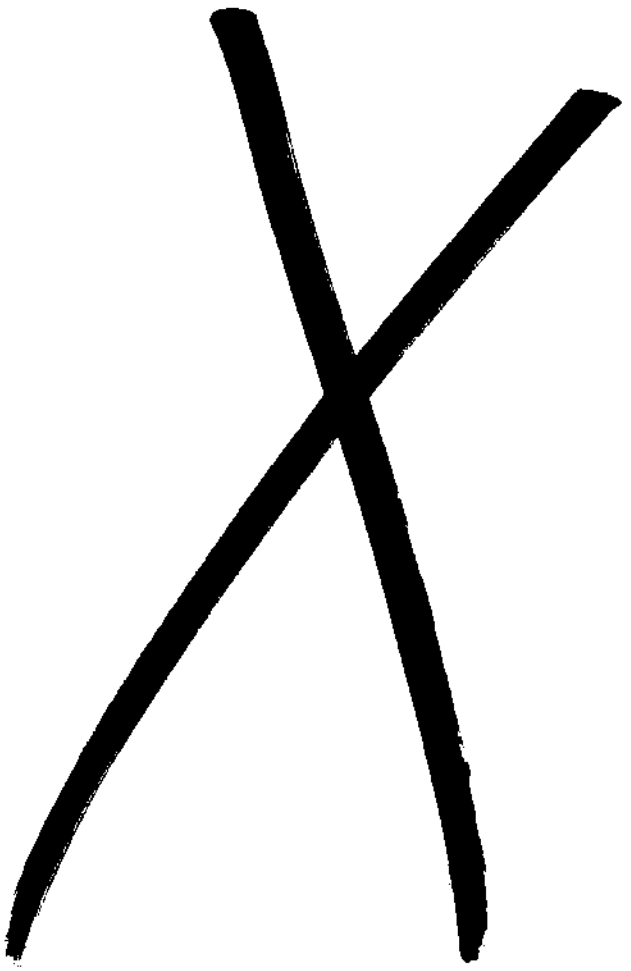

MOS ROM—Forecast

MOS ROMs—TOTAL WORLDWIDE FORECAST

Dataquest's MOS ROM forecast consists of revenue, unit shipments, and prices for MOS ROM product lines. Table 1 is the top-level market estimate for the tables in the forecast.

Included in our tables are all mask ROMs, whether used for software storage, character generators, or keyboard encoders. Revenue listed is total revenue generated from the sale of ROM products, regardless of the technology employed (NMOS or CMOS), including mask charges that are amortized over the entire production run. Tables contained in this forecast are shown as follows:

- Table 1—Worldwide Market Forecast—Total MOS ROMs
- Table 2—Worldwide NMOS ROM Market Forecast
- Table 3—Worldwide CMOS ROM Market Forecast

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Table 1

Worldwide Market Forecast—Total MOS ROMs

Millions of Dollars

	1988	1989	1990	1991	1992	1993	1994	1995
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	2	0	0	0	0	0	0	0
32K	10	1	0	0	0	0	0	0
64K	36	19	9	1	0	0	0	0
128K	17	9	4	1	0	0	0	0
256K	66	52	37	26	14	3	1	0
512K	99	84	68	42	25	15	5	2
1Mb	362	446	285	176	118	77	38	21
2Mb	160	173	176	210	118	76	41	23
4Mb	176	361	390	470	289	170	96	56
8Mb	1	36	119	238	394	490	355	226
16Mb	0	9	80	247	446	574	706	455
32Mb	0	0	0	9	84	266	518	696
64Mb	0	0	0	0	0	10	128	384
Total	929	1,190	1,166	1,419	1,487	1,681	1,888	1,863
Percent Change from Previous Year	41	28	(2)	22	5	13	12	(1)

Millions of Units

	1988	1989	1990	1991	1992	1993	1994	1995
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0.6	0	0	0	0	0	0	0
32K	6.7	0.4	0	0	0	0	0	0
64K	22.0	11.4	5.0	0.3	0	0	0	0
128K	10.4	5.3	2.1	0.8	0.1	0	0	0
256K	33.9	29.0	20.6	14.0	7.5	1.8	0.5	0
512K	30.6	34.9	29.0	19.2	12.0	7.0	2.4	0.9
1Mb	88.3	127.5	95.0	65.0	47.0	32.0	16.0	9.0
2Mb	27.6	37.6	45.0	60.0	37.0	25.0	14.0	8.0
4Mb	17.6	51.6	78.0	112.0	78.0	50.0	30.0	18.0
8Mb	0.1	3.0	14.0	34.0	64.0	89.0	71.0	48.0
16Mb	0	0.3	3.8	18.0	45.0	70.0	98.0	70.0
32Mb	0	0	0	0.2	3.1	14.0	37.0	58.0
64Mb	0	0	0	0	0	0.2	4.0	16.0
Total	237.8	301.1	292.5	323.5	293.7	289.0	272.9	227.9

(Continued)

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Table 1 (Continued)

Worldwide Market Forecast—Total MOS ROMs

	Average Selling Price ($)							
	1988	1989	1990	1991	1992	1993	1994	1995
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	2.50	0	0	0	0	0	0	0
32K	1.55	1.60	0	0	0	0	0	0
64K	1.62	1.65	1.70	1.75	0	0	0	0
128K	1.65	1.70	1.75	1.80	1.80	0	0	0
256K	1.94	1.80	1.80	1.85	1.85	1.85	1.90	0
512K	3.23	2.40	2.33	2.20	2.12	2.15	2.18	2.20
1Mb	4.10	3.50	3.00	2.70	2.50	2.40	2.35	2.35
2Mb	5.80	4.60	3.90	3.50	3.20	3.05	2.95	2.90
4Mb	10.00	7.00	5.00	4.20	3.70	3.40	3.20	3.10
8Mb	18.00	12.00	8.50	7.00	6.15	5.50	5.00	4.70
16Mb	0	32.00	21.00	13.70	9.90	8.20	7.20	6.50
32Mb	0	0	0	44.00	27.00	19.00	14.00	12.00
64Mb	0	0	0	0	0	51.00	32.00	24.00
Overall ASP	3.91	3.95	3.99	4.39	5.06	5.82	6.92	8.17

Source: Dataquest (November 1990)

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Table 2

Worldwide NMOS ROM Market Forecast

	Millions of Dollars							
	1988	1989	1990	1991	1992	1993	1994	1995
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	0	0	0	0	0	0	0
32K	9	1	0	0	0	0	0	0
64K	12	6	4	0	0	0	0	0
128K	8	4	2	0	0	0	0	0
256K	10	5	2	1	0	0	0	0
512K	8	14	9	4	1	0	0	0
1Mb	33	40	42	32	20	10	2	0
2Mb	0	1	3	4	4	5	6	6
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
16Mb	0	0	0	0	0	0	0	0
32Mb	0	0	0	0	0	0	0	0
Total	80	72	62	42	26	15	8	6
Percent Change from Previous Year	26	(10)	(13)	(33)	(38)	(42)	0	0

	Millions of Units							
	1988	1989	1990	1991	1992	1993	1994	1995
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0.1	0	0	0	0	0	0	0
32K	5.9	0.4	0	0	0	0	0	0
64K	7.4	3.6	2.5	0	0	0	0	0
128K	4.6	2.6	1.0	0.2	0	0	0	0
256K	4.9	2.7	1.3	0.5	0.2	0	0	0
512K	2.6	6.0	4.0	2.0	0.5	0	0	0
1Mb	8.0	11.5	14.0	12.0	8.0	4.0	1.0	0
2Mb	NA	0.3	0.7	1.0	1.4	1.8	2.0	1.9
4Mb	NA	NA	NA	NA	NA	NA	NA	NA
8Mb	NA	NA	NA	NA	NA	NA	NA	NA
16Mb	NA	NA	NA	NA	NA	NA	NA	NA
32Mb	NA	NA	NA	NA	NA	NA	NA	NA
64Mb	NA	NA	NA	NA	NA	NA	NA	NA
Total	33.5	27.1	23.5	15.7	10.1	5.8	3.0	1.9

(Continued)

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Table 2 (Continued)

Worldwide NMOS ROM Market Forecast

	Average Selling Price ($)							
	1988	1989	1990	1991	1992	1993	1994	1995
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	2.50	0	0	0	0	0	0	0
32K	1.55	1.60	0	0	0	0	0	0
64K	1.62	1.65	1.70	1.75	0	0	0	0
128K	1.65	1.70	1.75	1.80	1.80	0	0	0
256K	1.94	1.80	1.80	1.85	1.85	0	0	0
512K	3.23	2.40	2.33	2.20	2.12	0	0	0
1Mb	4.10	3.50	3.00	2.70	2.50	2.40	2.35	0
2Mb	0	4.60	3.90	3.50	3.20	3.05	2.95	2.90
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
16Mb	0	0	0	0	0	0	0	0
32Mb	0	0	0	0	0	0	0	0
64Mb	0	0	0	0	0	0	0	0
Overall ASP	2.38	2.65	2.65	2.65	2.57	2.60	2.75	2.90

NA = Not available
Source: Dataquest (November 1990)

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Table 3

Worldwide CMOS ROM Market Forecast

Millions of Dollars

	1988	1989	1990	1991	1992	1993	1994	1995
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	1	0	0	0	0	0	0	0
32K	1	0	0	0	0	0	0	0
64K	24	13	4	1	0	0	0	0
128K	10	5	2	1	0	0	0	0
256K	56	48	35	25	14	3	1	0
512K	90	69	58	38	24	15	5	2
1Mb	329	406	243	143	98	67	35	21
2Mb	160	172	173	207	114	71	35	18
4Mb	176	361	390	470	289	170	96	56
8Mb	1	36	119	238	394	490	355	226
16Mb	0	9	80	247	446	574	706	455
32Mb	0	0	0	9	84	266	518	696
64Mb	0	0	0	0	0	10	128	384
Total	849	1,118	1,104	1,378	1,461	1,666	1,879	1,857
Percent Change from Previous Year	50	32	(1)	25	6	14	13	(1)

Millions of Units

	1988	1989	1990	1991	1992	1993	1994	1995
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0.5	0	0	0	0	0	0	0
32K	0.8	0	0	0	0	0	0	0
64K	14.6	7.8	2.5	0.3	0	0	0	0
128K	5.8	2.7	1.1	0.6	0.1	0	0	0
256K	29.0	26.4	19.3	13.5	7.3	1.8	0.5	0
512K	28.0	28.9	25.0	17.2	11.5	7.0	2.4	0.9
1Mb	80.3	116.0	81.0	53.0	39.0	28.0	15.0	9.0
2Mb	27.6	37.3	44.3	59.0	35.6	23.2	12.0	6.1
4Mb	17.6	51.6	78.0	112.0	78.0	50.0	30.0	18.0
8Mb	0.1	3.0	14.0	34.0	64.0	89.0	71.0	48.0
16Mb	0	0.3	3.8	18.0	45.0	70.0	98.0	70.0
32Mb	NA	NA	0	0.2	3.1	14.0	37.0	58.0
64Mb	NA	NA	NA	NA	0	0.2	4.0	16.0
Total	204.3	274.0	269.0	307.8	283.6	283.2	269.9	226.0

(Continued)

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Table 3 (Continued)

Worldwide CMOS ROM Market Forecast

	Average Selling Price ($)							
	1988	1989	1990	1991	1992	1993	1994	1995
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	2.50	0	0	0	0	0	0	0
32K	1.55	0	0	0	0	0	0	0
64K	1.62	1.65	1.70	1.75	0	0	0	0
128K	1.65	1.70	1.75	1.80	1.80	0	0	0
256K	1.94	1.80	1.80	1.85	1.85	1.85	1.90	0
512K	3.23	2.40	2.33	2.20	2.12	2.15	2.18	2.20
1Mb	4.10	3.50	3.00	2.70	2.50	2.40	2.35	2.35
2Mb	5.80	4.60	3.90	3.50	3.20	3.05	2.95	2.90
4Mb	10.00	7.00	5.00	4.20	3.70	3.40	3.20	3.10
8Mb	18.00	12.00	8.50	7.00	6.15	5.50	5.00	4.70
16Mb	0	32.00	21.00	13.70	9.90	8.20	7.20	6.50
32Mb	0	0	0	44.00	27.00	19.00	14.00	12.00
64Mb	0	0	0	0	0	51.00	32.00	24.00
Overall ASP	4.16	4.08	4.10	4.48	5.15	5.88	6.96	8.22

NA = Not available
Source: Dataquest (November 1990)

MARKET SUMMARY

Highlights of the 1989 MOS ROM forecast are as follows:

- MOS ROM revenue totaled $1,190 billion in 1989, having grown by 28 percent over the $929 million revenue earned in 1988. Shipments grew 27 percent to 301.1 million units. Figure 1 is an illustrated evaluation of Dataquest's 1989 forecast of MOS ROM revenue and unit growth and how it compares with the 1990 forecast.
- Propelled by development and ramping up in production of the 4Mb (4-Mbit) through 16Mb devices, ROM bit growth increased by 92 percent from 1988 to 1989. As illustrated by Figure 2, we expect strong bit growth to continue through 1995.
- Japanese manufacturers continued to dominate the market, controlling 92 percent of the worldwide ROM production.
- As shown in Figure 3, CMOS ROMs clearly dominate the worldwide ROM market. High-capacity CMOS devices at 1Mb and above represented 56 percent of total units produced in 1988, 78 percent of production in 1989, and potentially 81 percent of production by year-end 1990.

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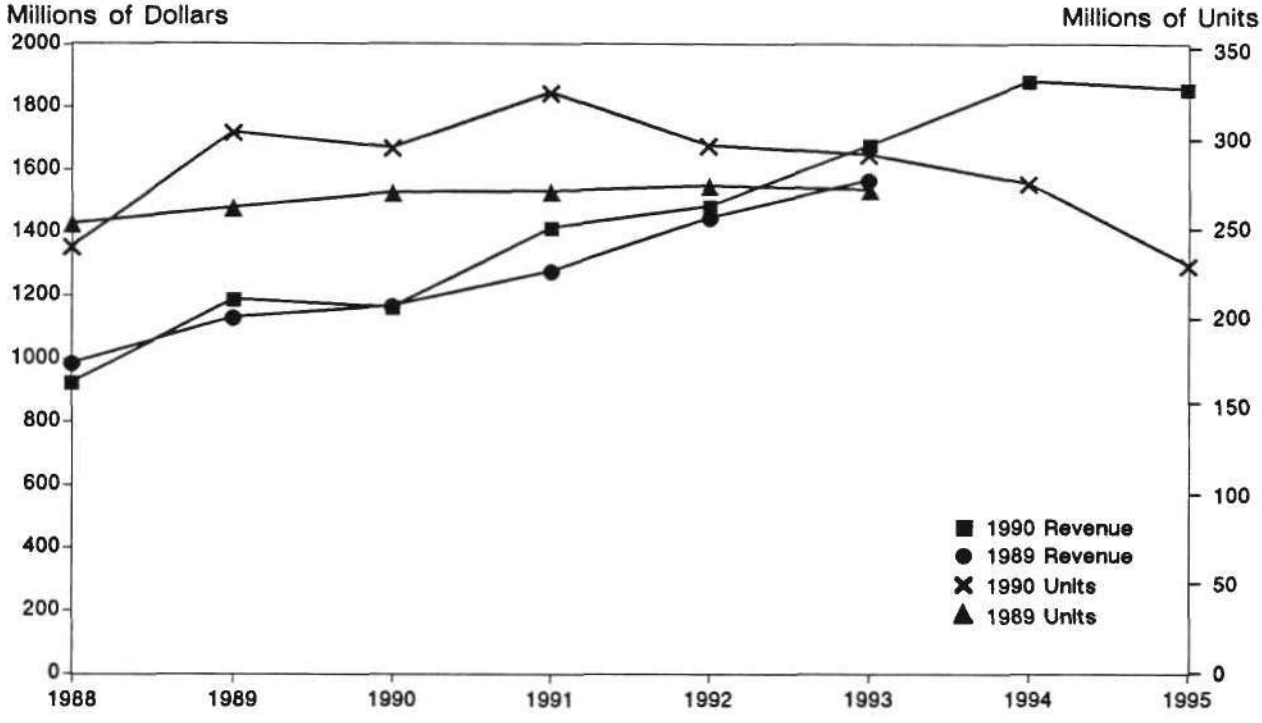
Figure 1

MOS ROM Forecast Evaluation



Source: Dataquest (November 1990)

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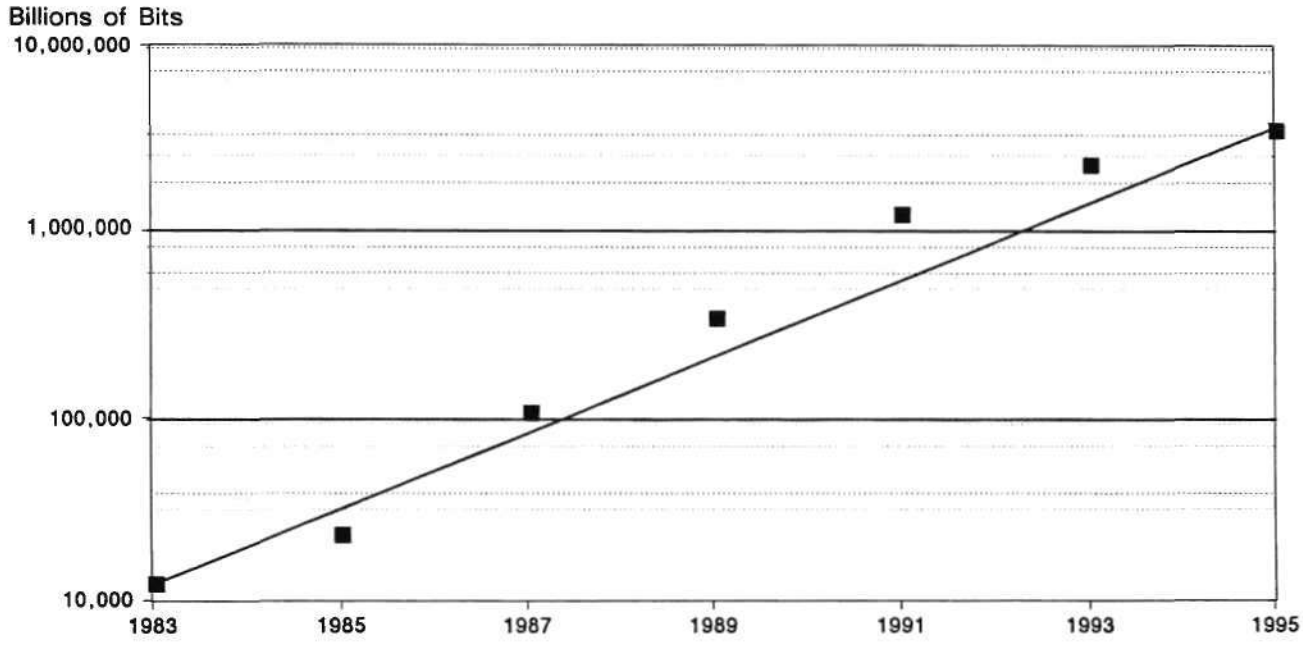
Figure 2

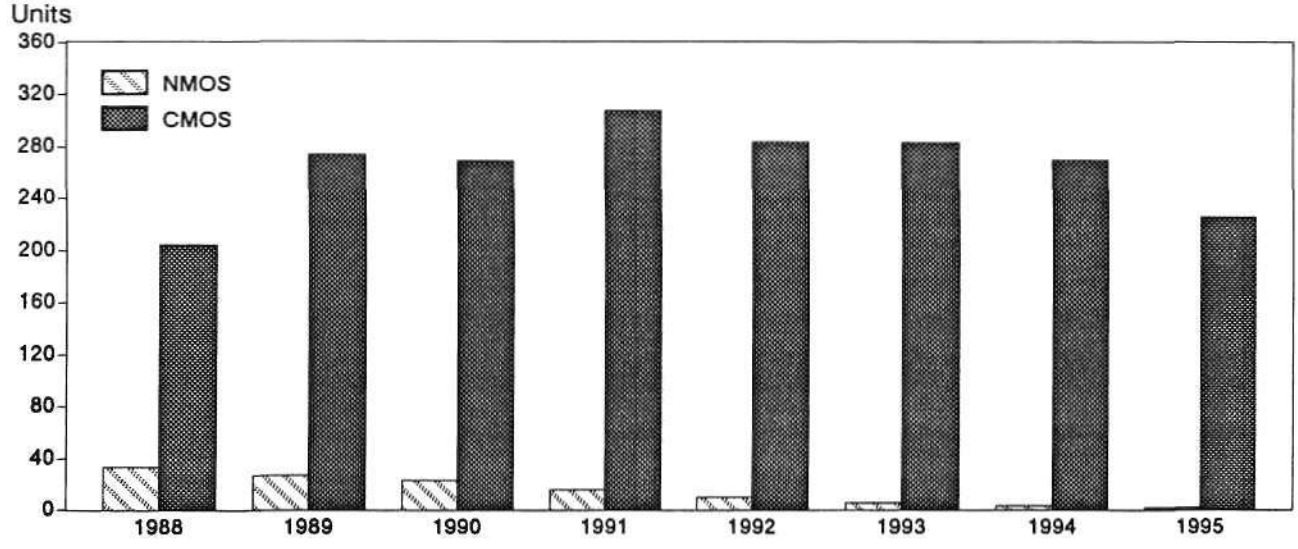
MOS ROM Bit Growth



Source: Dataquest (November 1990)

Figure 3

NMOS/CMOS ROM Growth



Source: Dataquest (November 1990)

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MARKET DEVELOPMENTS

The following MOS ROM market developments occurred in 1990:

- The next-generation 32Mb ROM was introduced to the market by NEC in June 1990. NEC will begin sampling its 0.6um 200ns product in the first quarter of 1991. The vertically stacked cell design is expected to offer 50 percent improvement in cell size over the 16Mb ROM.
- Samsung and Sony entered the ROM market in the second quarter of 1990. Other new entrants to the high-capacity 4Mb ROM arena include Gould/AMI, Hualon, IMP, Silicon Integrated Systems, UMC, and Winbond. MOSEL is expected to enter the market in 1991.

LONG-TERM FORECAST

High-speed office automated systems and a growing demand for portable data storage systems continue to drive the need for sub-150ns high-density ROMs. Table 4 presents Dataquest's speed demand forecast for high-density ROMs. Although the very high speed sub-150ns 1Mb ROM is expected to represent only 1 percent of total 1Mb production in 1990, it does signal a continued shift away from the traditional 200ns market.

During the last decade, the video game market has been the greatest impetus for growth in the ROM market. As noted in the September 16, 1990, *San Francisco Examiner* article entitled "The Game People Play," there is increased evidence that the video game market has peaked and now is declining. Figures 4 and 5, respectively, illustrate Nintendo's hardware sales and estimates on the video game penetration in the US market. It has been estimated that Nintendo consumed approximately 50 percent of the 1Mb and 4Mb ROMs produced in Japan during 1988.

Although industry indicators point to a decline of the games market after having reached its peak in 1989, a shift to high-speed automated and portable equipment will continue to drive high-capacity ROM growth through 1995. While ROM users are ramping up demand for 4Mb products, suppliers already have begun increasing production of the 8Mb and 16Mb designs. The 8Mb and 16Mb devices are currently being incorporated in font storage and musical data storage applications. A 16Mb device can double the resolution of character storage of a 4Mb ROM. NEC has reported that although storage capacity of a 16Mb ROM is required for an electric piano, multiples of 16Mb ROMs are necessary for storage capacity in synthesizers.

A continued glut of game cartridges, increased competition from Taiwan, and an economic downturn have dampened the profit margins of all ROM suppliers in 1990. However, continued strong demand from US office system manufacturers for high-density and high-speed ROMs is expected to push revenue to $1.4 billion by the end of 1991. Future ROM bit growth will be driven by the following application areas:

- Nintendo's shift from home video games in the Nintendo Entertainment System (NES) to the NES Network for interactive entertainment and on-line informational products.
- Microsoft's development of ROM executable MS-DOS for hand-held data collection terminals, embedded controllers for automation applications, and portable laptop and notebook computers. The MS-DOS operating system is burned into ROM for "instant on" operating system capability.

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Table 4

High-Speed MOS ROM Forecast
(Millions of Units)

	1990	1991	1992	1993	1994	1995
1Mb	95.0	65.0	47.0	32.0	16.0	9.0
2Mb	45.0	60.0	37.0	25.0	14.0	8.0
4Mb	78.0	112.0	78.0	50.0	30.0	5.0
8Mb	14.0	34.0	64.0	89.0	71.0	48.0
16Mb	3.8	18.0	45.0	70.0	98.0	70.0
32Mb	0	0.2	3.1	14.0	37.0	61.0
64Mb	0	0	0	0.2	4.0	22.0
Total	235.8	289.2	274.1	280.2	270.0	233.0
1Mbx8	93.1	63.7	46.1	31.4	15.7	8.8
80ns	0.5	0.3	0.2	0.2	0.1	0
100ns	0.7	0.8	0.8	0.8	0.6	0.6
150ns	47.5	32.7	24.3	17.9	9.5	5.5
200ns	44.4	29.9	20.7	12.5	5.5	2.6
Total	93.1	63.7	46.1	31.4	15.7	8.8
1Mbx16	1.9	1.3	0.9	0.6	0.3	0.2
80ns	0	0	0	0	0	0
100ns	0	0.1	0.1	0.1	0.1	0.1
150ns	1.9	1.2	0.9	0.6	0.3	0.1
200ns	0	0	0	0	0	0
Total	1.9	1.3	0.9	0.6	0.3	0.2
2Mbx8	44.1	57.0	34.4	22.8	12.5	6.9
80ns	0	0.1	0.1	0.1	0.1	0.1
100ns	0.4	1.1	0.7	0.5	0.2	0.1
150ns	43.2	55.2	33.3	22.0	12.0	6.6
200ns	0.4	0.6	0.3	0.2	0.1	0.1
Total	44.1	57.0	34.4	22.8	12.5	6.9
2Mbx16	0.9	3.0	2.6	2.3	1.5	1.1
80ns	0	0	0	0	0	0
100ns	0	0	0	0	0	0
150ns	0.9	2.9	2.5	2.2	1.5	1.1
200ns	0	0	0	0	0	0
Total	0.9	3.0	2.6	2.3	1.5	1.1

(Continued)

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Table 4 (Continued)

High-Speed MOS ROM Forecast
(Millions of Units)

	1990	1991	1992	1993	1994	1995
4Mbx8	46.8	67.2	46.8	30.0	18.0	9.0
80ns	0	0.7	0.9	1.2	1.8	2.3
100ns	2.3	5.4	4.7	4.5	3.8	2.7
150ns	37.4	53.1	36.5	21.6	11.0	3.4
200ns	7.0	8.1	4.7	2.7	1.4	0.6
Total	46.8	67.2	46.8	30.0	18.0	9.0
4Mbx16	31.2	44.8	31.2	20.0	12.0	7.2
80ns	0	0	0.3	0.2	0.1	0.1
100ns	0.3	0.4	0.3	0.2	0.1	0.1
150ns	26.2	39.0	27.1	17.6	10.7	5.4
200ns	4.7	5.4	3.4	2.0	1.1	0.5
Total	31.2	44.8	31.2	20.0	12.0	6.0
8Mbx8	9.1	22.1	41.6	57.9	46.2	31.2
80ns	0	0	0	0.3	0.5	0.6
100ns	0	0.1	0.2	0.6	0.7	0.8
150ns	3.6	9.9	18.7	27.2	23.1	17.2
200ns	5.5	12.0	22.7	29.8	21.9	12.6
Total	9.1	22.1	41.6	57.9	46.2	31.2
8Mbx16	4.9	11.9	22.4	31.2	24.9	16.8
80ns	0	0	0	0	0.1	0.1
100ns	0	0.1	0.1	0.2	0.2	0.2
150ns	2.7	6.5	13.3	20.2	17.1	12.4
200ns	2.2	5.3	9.0	10.7	7.5	4.2
Total	4.9	11.9	22.4	31.2	24.9	16.8
16Mbx8	3.4	14.4	31.5	42.0	49.0	35.0
80ns	0	0	0	0.2	0.5	0.7
100ns	0	0.1	0.6	1.7	2.9	3.5
150ns	1.9	8.5	19.8	27.5	33.3	23.8
200ns	1.5	5.8	11.0	12.6	12.3	7.0
Total	3.4	14.4	31.5	42.0	49.0	35.0

(Continued)

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Table 4 (Continued)

High-Speed MOS ROM Forecast
(Millions of Units)

	1990	1991	1992	1993	1994	1995
16Mbx16	0.4	3.6	13.5	28.0	49.0	35.0
80ns	0	0	0	0.1	0.3	0.4
100ns	0	0	0.1	0.3	0.5	0.7
150ns	0.2	2.0	8.1	18.2	31.9	22.8
200ns	0.2	1.6	5.3	9.4	16.3	11.2
Total	0.4	3.6	13.5	28.0	49.0	35.0
32Mbx8	0	0.2	3.1	14.0	37.0	61.0
80ns	0	0	0	0	0	0.6
100ns	0	0	0	0.3	1.1	2.3
150ns	0	0.2	3.0	13.4	35.2	56.7
200ns	0	0	0.1	0.3	0.7	1.2
Total	0	0.2	3.1	14.0	37.0	61.0
64Mbx8	0	0	0	0.2	4.0	22.0
80ns	0	0	0	0	0	0.2
100ns	0	0	0	0	0	0.4
150ns	0	0	0	0.2	3.6	19.8
200ns	0	0	0	0	0.4	1.5
Total	0	0	0	0.2	4.0	22.0

Source: Dataquest (November 1990)

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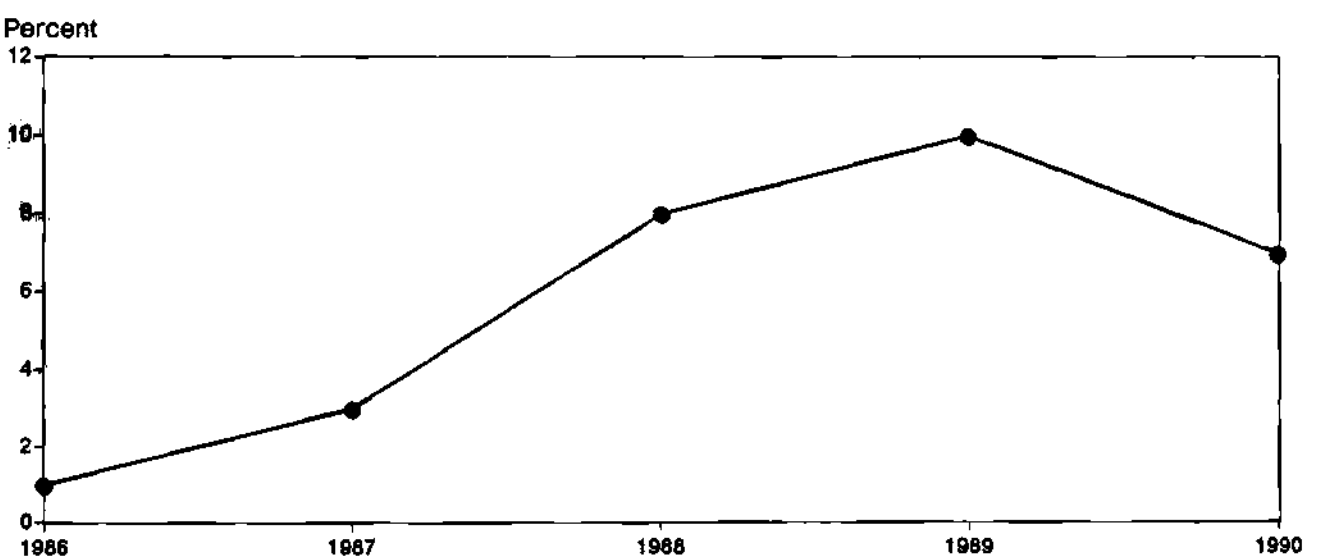
Figure 4

Hardware Sales

Source: Nintendo of America, Inc.

Figure 5

Video Games—US Household Penetration



Source: Nintendo of America, Inc.

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CONTACT REPORT

Route: ☐ File only ☐ Full group

Other: _____

☐ File Code: _____ , _____ , _____

☐ Copies to: _____ , _____ , _____

Group: _____ Staff Member: _____ (Full last name) Date: _____

Name _____ Title _____

Company _____

Address _____

City & State _____ Zip _____ Phone ( ) _____

–Indicate 1 choice per box–

Initiator:
- ☐ Contact
- ☐ DQ

Medium:
- ☐ Phone
- ☐ Visit
- ☐ Ltr/Tlx

Type
- ☐ 01 Inquiry
- ☐ 02 Research
- ☐ 03 Marketing
- ☐ 04 Client Care
- ☐ 05 Conference
- ☐ 06 Internal
- ☐ 07 Consulting

Client Contact
- ☐ 01 Industry
- ☐ 02 FSP
- ☐ 03 Prudential-Bache
- ☐ 04 Other DQ Service
- ☐ 05 CIO Adviser
- ☐ 12 SES
- ☐ 13 Corporate Technology

Non-Client Contact
- ☐ 06 Prospect (Copy Mktg.)
- ☐ 07 Press (Copy PR Dept.)
- ☐ 08 Consultant
- ☐ 09 Industry Source
- ☐ 10 Recruiting (Copy Pers)
- ☐ 11 Other (Specify) _____

Time Spent: Minutes ☐ 5 ☐ 10 ☐ 15 ☐ 30 ☐ 45 ____ Hours

DISCUSSION: _____

ACTION: _____

MOS ROM—Forecast

MOS ROMS—TOTAL WORLDWIDE FORECAST

Dataquest's MOS ROM forecast consists of revenue, unit shipments, and prices for MOS ROM product lines. Table 1 is the top-level market estimate for the tables in the forecast.

Included in our tables are all Mask ROMs, whether used for software storage, character generators, or keyboard encoders. Revenue listed is total revenue generated from the sale of ROM products, regardless of the technology employed (NMOS or CMOS), including mask charges that are amortized over the entire production run. Tables contained in this forecast are shown as follows:

- Table 1—Worldwide Market Forecast—Total MOS ROMs
- Table 2—Worldwide NMOS ROM Market Forecast
- Table 3—Worldwide CMOS ROM Market Forecast

The Market—1988

Dataquest estimates that worldwide MOS ROM revenue totaled $989 million in 1988, growing by 49 percent over the $663 million market in 1987. Unit shipments increased more than 29 percent to 250.3 million units. A major shift by users from the mature 512K and below densities to the 1Mb-and-above densities occurred from 1987 through 1988. Notable changes in the ROM market in 1988 included the following:

- Increased demand for the 1Mb and 4Mb ROMs from the consumer and electronic data process markets (EDP) in both Japan and the United States created severe shortages and high prices for end users during 1988.
- CMOS ROMs continued to gain unit share over NMOS. CMOS units represented more than 87 percent of the total ROMs produced worldwide in 1988.

MOS ROM--Forecast

Table 1

Worldwide Market Forecast—Total MOS ROMs

	1986	1987	1988	1989	1990	1991	1992	1993
	Value (Millions of Dollars)							
4K	0	0	0	0	0	0	0	0
8K	$ 3	0	0	0	0	0	0	0
16K	8	$ 4	$ 2	$ 1	0	0	0	0
32K	18	19	18	11	$ 7	$ 3	$ 1	0
64K	42	38	36	30	22	11	2	0
128K	48	32	16	7	2	1	0	0
256K	154	94	67	46	28	17	9	$ 5
512K	52	114	101	106	67	42	23	14
1Mb	95	284	347	220	109	73	50	38
2Mb	9	56	215	307	361	205	109	69
4Mb	3	22	186	392	432	495	308	200
8Mb	0	0	1	11	116	259	429	486
16Mb	0	0	0	1	24	167	435	483
32Mb	0	0	0	0	1	9	84	266
64Mb	0	0	0	0	0	0	1	10
Total	$432	$663	$989	$1,132	$1,169	$1,281	$1,451	$1,572
Percent Change from Previous Year	8%	54%	49%	15%	3%	10%	13%	8%
	Units (Millions)							
4K	0	0	0	0	0	0	0	0
8K	1.0	0	0	0	0	0	0	0
16K	3.0	1.7	0.8	0.2	0	0	0	0
32K	11.8	12.7	11.3	7.0	4.5	2.0	0.5	0
64K	28.0	24.7	22.4	18.0	13.0	6.0	1.0	0
128K	27.0	18.0	9.6	4.0	1.0	0.3	0.1	0
256K	68.0	46.5	34.5	25.0	15.2	9.0	4.8	2.8
512K	9.0	27.7	31.3	39.0	28.0	19.0	11.0	6.5
1Mb	12.0	54.7	84.6	58.0	34.0	26.0	20.0	16.0
2Mb	0.4	6.4	37.1	58.0	84.0	54.0	32.0	22.0
4Mb	0.1	1.4	18.6	49.0	72.0	97.0	70.0	50.0
8Mb	0	0	0.1	1.0	14.0	37.0	74.0	90.0
16Mb	0	0	0	0.1	2.0	18.0	55.0	68.0
32Mb	0	0	0	0	0	0.2	3.1	14.0
64Mb	0	0	0	0	0	0	0	0.2
Total	160.3	193.8	250.3	259.3	267.7	268.5	271.5	269.5

(Continued)

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MOS ROM--Forecast

Table 1 (Continued)

Worldwide Market Forecast—Total MOS ROMs

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	$ 3.25	0	0	0	0	0	0	0
16K	$ 2.50	$ 2.50	$ 2.50	$ 2.50	0	0	0	0
32K	$ 1.50	$ 1.50	$ 1.55	$ 1.60	$ 1.60	$ 1.65	$ 1.65	0
64K	$ 1.50	$ 1.55	$ 1.62	$ 1.65	$ 1.70	$ 1.75	$ 1.75	0
128K	$ 1.79	$ 1.75	$ 1.65	$ 1.70	$ 1.75	$ 1.80	$ 1.80	0
256K	$ 2.26	$ 2.03	$ 1.94	$ 1.85	$ 1.85	$ 1.85	$ 1.85	$ 1.85
512K	$ 5.83	$ 4.10	$ 3.23	$ 2.72	$ 2.38	$ 2.21	$ 2.12	$ 2.15
1Mb	$ 7.88	$ 5.19	$ 4.10	$ 3.80	$ 3.20	$ 2.80	$ 2.52	$ 2.40
2Mb	$23.00	$ 8.75	$ 5.80	$ 5.30	$ 4.30	$ 3.80	$ 3.40	$ 3.15
4Mb	$32.00	$16.00	$10.00	$ 8.00	$ 6.00	$ 5.10	$ 4.40	$ 4.00
8Mb	0	$34.00	$18.00	$11.00	$ 8.30	$ 7.00	$ 5.80	$ 5.40
16Mb	0	$70.00	$38.00	$23.00	$12.00	$ 9.30	$ 7.90	$ 7.10
32Mb	0	0	0	0	$80.00	$44.00	$27.00	$19.00
64Mb	0	0	0	0	0	0	$98.00	$51.00
Overall ASP	$ 2.69	$ 3.42	$ 3.95	$ 4.37	$ 4.37	$ 4.77	$ 5.34	$ 5.83

Source: Dataquest
October 1989

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MOS ROM--Forecast

Table 2

Worldwide NMOS ROM Market Forecast

	Value (Millions of Dollars)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 6	$ 3	$ 1	0	0	0	0	0
32K	15	15	16	$11	$ 7	$3	$1	0
64K	31	18	15	5	2	0	0	0
128K	34	10	7	2	0	0	0	0
256K	100	19	15	7	4	2	0	0
512K	23	0	0	0	0	0	0	0
1Mb	39	0	0	0	0	0	0	0
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
16Mb	0	0	0	0	0	0	0	0
32Mb	0	0	0	0	0	0	0	0
64Mb	0	0	0	0	0	0	0	0
Total	$248	$65	$53	$26	$13	$5	$1	0
Percent Change from Previous Year		(74%)	(19%)	(51%)	(51%)	(59%)	(84%)	(100%)
	Units (Millions)							
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	2.5	1.2	0.3	0	0	0	0	0
32K	10.0	10.0	10.0	7.0	4.5	2.0	0.5	0
64K	20.4	11.6	9.4	3.3	1.0	0	0	0
128K	19.0	5.6	4.0	1.0	0	0	0	0
256K	44.2	9.5	7.7	4.0	2.0	1.0	0	0
512K	4.0	0	0	0	0	0	0	0
1Mb	5.0	0	0	0	0	0	0	0
2Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
64Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	105.1	37.9	31.4	15.3	7.5	3.0	0.5	0

(Continued)

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MOS ROM--Forecast

Table 2 (Continued)

Worldwide NMOS ROM Market Forecast

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$2.50	$2.50	$2.50	$2.50	0	0	0	0
32K	$1.50	$1.50	$1.55	$1.60	$1.60	$1.65	$1.65	0
64K	$1.50	$1.55	$1.62	$1.65	$1.70	0	0	0
128K	$1.79	$1.75	$1.65	$1.70	0	0	0	0
256K	$2.26	$2.03	$1.94	$1.85	$1.85	$1.85	0	0
512K	$5.83	0	0	0	0	0	0	0
1Mb	$7.88	0	0	0	0	0	0	0
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
16Mb	0	0	0	0	0	0	0	0
32Mb	0	0	0	0	0	0	0	0
64Mb	0	0	0	0	0	0	0	0
Overall ASP	$2.36	$1.72	$1.69	$1.68	$1.68	$1.72	$1.65	0

Source: Dataquest
October 1989

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MOS ROM--Forecast

Table 3

Worldwide CMOS ROM Market Forecast

	1986	1987	1988	1989	1990	1991	1992	1993
	Value (Millions of Dollars							
4K	0	0	0	0	0	0	0	0
8K	$ 3	0	0	0	0	0	0	0
16K	1	$ 1	$ 1	$ 1	0	0	0	0
32K	3	4	2	0	0	0	0	0
64K	11	20	21	24	$ 20	$ 11	$ 2	0
128K	14	22	9	5	2	1	0	0
256K	54	75	52	39	24	15	9	$ 5
512K	29	114	101	106	67	42	23	14
1Mb	55	284	347	220	109	73	50	38
2Mb	9	56	215	307	361	205	109	69
4Mb	3	22	186	392	432	495	308	200
8Mb	0	0	1	11	116	259	429	486
16Mb	0	0	0	1	24	167	435	483
32Mb	0	0	0	0	1	9	84	266
64Mb	0	0	0	0	0	0	2	10
Total	$183	$598	$936	$1,107	$1,156	$1,276	$1,451	$1,572
Percent Change from Previous Year		226%	56%	18%	4%	10%	14%	8%
	Units (Millions)							
4K	0	0	0	0	0	0	0	0
8K	1.0	0	0	0	0	0	0	0
16K	0.5	0.5	0.5	0.2	0	0	0	0
32K	1.8	2.7	1.3	0	0	0	0	0
64K	7.6	13.1	13.0	14.7	12.0	6.0	1.0	0
128K	8.0	12.4	5.6	3.0	1.0	0.3	0.1	0
256K	23.8	37.0	26.8	21.0	13.2	8.0	4.8	2.8
512K	5.0	27.7	31.3	39.0	28.0	19.0	11.0	6.5
1Mb	7.0	54.7	84.6	58.0	34.0	26.0	20.0	16.0
2Mb	0.4	6.4	37.1	58.0	84.0	54.0	32.0	22.0
4Mb	0.1	1.4	18.6	49.0	72.0	97.0	70.0	50.0
8Mb	N/A	0	0.1	1.0	14.0	37.0	74.0	90.0
16Mb	N/A	N/A	0	0.1	2.0	18.0	55.0	68.0
32Mb	N/A	N/A	N/A	N/A	0	0.2	3.1	14.0
64Mb	N/A	N/A	N/A	N/A	N/A	N/A	0	0.2
Total	55.2	155.9	218.9	244.0	260.2	265.5	271.0	269.5

(Continued)

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MOS ROM--Forecast

Table 3 (Continued)

Worldwide CMOS ROM Market Forecast

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	$ 3.25	0	0	0	0	0	0	0
16K	$ 2.50	$ 2.50	$ 2.50	$ 2.50	0	0	0	0
32K	$ 1.50	$ 1.50	$ 1.55	$ 1.60	$ 1.60	$ 1.65	$ 1.65	0
64K	$ 1.50	$ 1.55	$ 1.62	$ 1.65	$ 1.70	$ 1.75	$ 1.75	0
128K	$ 1.79	$ 1.75	$ 1.65	$ 1.70	$ 1.75	$ 1.80	$ 1.80	0
256K	$ 2.26	$ 2.03	$ 1.94	$ 1.85	$ 1.85	$ 1.85	$ 1.85	$ 1.85
512K	$ 5.83	$ 4.10	$ 3.23	$ 2.72	$ 2.38	$ 2.21	$ 2.12	$ 2.15
1Mb	$ 7.88	$ 5.19	$ 4.10	$ 3.80	$ 3.20	$ 2.80	$ 2.52	$ 2.40
2Mb	$23.00	$ 8.75	$ 5.80	$ 5.30	$ 4.30	$ 3.80	$ 3.40	$ 3.15
4Mb	$32.00	$16.00	$10.00	$ 8.00	$ 6.00	$ 5.10	$ 4.40	$ 4.00
8Mb	0	$34.00	$18.00	$11.00	$ 8.30	$ 7.00	$ 5.80	$ 5.40
16Mb	0	$70.00	$38.00	$23.00	$12.00	$ 9.30	$ 7.90	$ 7.10
32Mb	0	0	0	0	$80.00	$44.00	$27.00	$19.00
64Mb	0	0	0	0	0	0	$98.00	$51.00
Overall ASP	$ 3.32	$ 3.84	$ 4.28	$ 4.54	$ 4.44	$ 4.81	$ 5.35	$ 5.83

Source: Dataquest
October 1989

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MOS ROM—Forecast

Comparison with Earlier Forecast

The present MOS ROM forecast contains several significant changes from the earlier Dataquest ROM forecast, published in June 1988. The changes and reasons for these differences are as follows:

- Adjustments have been made to the 1986 and 1987 actual unit data based on updated data base information. As a result, the actual 1988 revenue far surpassed our previously forecast $496 million.

- CMOS share of ROM is expected to continue absorbing the larger share of the ROM market, with NMOS declining and finally becoming obsolete by 1993. Virtually every manufacturer is producing CMOS ROM in all densities, with CMOS being the sole process technology used in next-generation product development.

Market Outlook

Dataquest saw continued market growth for more dense, very high speed ROMs (typically 150ns and below) for use in new laser printers, electronic video game computers, high-speed electronic typewriters, and ROM-supported cache systems.

CMOS/NMOS

As indicated in the 1988 forecast, CMOS has grown significantly over NMOS. As demand continues for larger memory capacity, higher speed, and low power, we anticipate that CMOS will command the larger portion of total ROM unit share. CMOS is becoming the dominant technology in all of the MOS memory areas and as such, will follow the same path to growth in the mask ROM area. Dataquest expects a complete displacement of NMOS ROMs during the next few years, as illustrated in Figure 1.

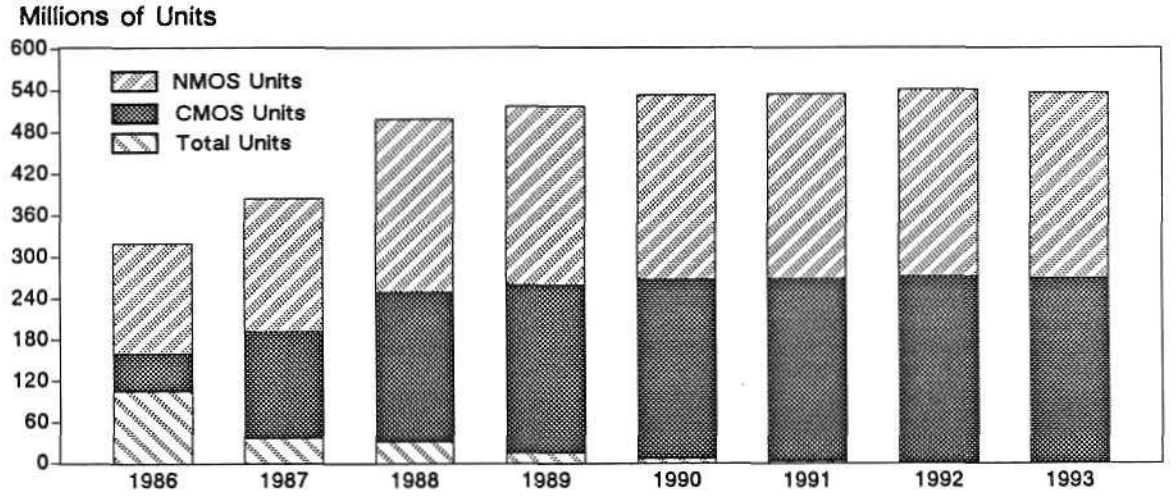
Short-Term Forecast

Strong market growth is projected for ROMs through the end of 1989, driven primarily by increased user demand for high-density, high-speed products. Although the 256K-and-below densities continued the expected decline in their life cycles, shipments of the 512K-and-above grew tremendously in 1988. The high-density products contributed significantly to the 49 percent growth in revenue in 1988, with an expected continued growth in revenue of 15 percent in 1989 over 1988. As ROM usage increased in the EDP sector for office automation systems in both Japan and the United States, suppliers shifted production to the 1Mb and 4Mb designs.

MOS ROM--Forecast

Figure 1

CMOS/NMOS ROM Growth
(Total Units)



0004881-1

Source: Dataquest
October 1989

Although the 512K density continued to grow, driven primarily by U.S. users, increased demand for 1Mb and 4Mb designs from Nintendo in Japan and office automation users in the United States, and lack of capacity drove 1Mb and 4Mb prices to astronomical heights during the third and fourth quarters of 1988 and during the first half of 1989. U.S. office system usage was the greatest contributor to 1Mb product growth in 1988. As U.S. users shifted from 512K to the 1Mb and 4Mb devices, their demand for high speed followed. Office automation system design upgrades for 1990 products are expected to boost shipments of very high speed 1Mb, 2Mb, and 4Mb designs to more than 190 million units.

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MOS ROM--Forecast

Long-Term Forecast

The new high-speed office systems and portable data storage applications will continue to drive the very high density ROM product growth through 1993. The very large 8Mb and 16Mb ROMs that are currently in low volume and sampling stages are expected to be major contributors to growth in 1992 and 1993. The high-speed, sub-150ns, high-density ROMs will open new markets, driven by new applications during the 1990s. Although there is a flurry of discussion and activity by current and potential U.S. suppliers regarding support of 1Mb and above devices to satisfy U.S. user demand for high-density, high-speed ROMs, ROM market dominance is not expected to shift away from the Japanese suppliers. The very high speed 100ns 1Mb and 4Mb ROM market could become a very profitable niche for the quick-to-market U.S. based supplier during the next four years. However, the Japanese suppliers have been producing the 1Mb device since 1984 and the 4Mb device since 1985. If these devices follow the typical life cycle and learning curve trends for products, the 1Mb device has already peaked (in 1988), and the 4Mb product will peak by 1991. Although shortages and demand in 1988 and 1989 have raised these product prices substantially, an expected slowdown in 1990 could dampen the profit margins of a newly ramping ROM producer. Currently, six U.S., two Taiwanese, two Korean, and one European semiconductor manufacturers are interested in pursuing high-density ROM production. By being positioned onshore, a U.S.-based supplier can offer its customers shorter turnaround time and more cost-effective products. Although ROMs will be competing with new high-density EPROM and FLASH devices, the potential for ROM growth in the United States, from U.S. office system manufacturer, could be significant.

MOS ROM--Forecast

MOS ROMS—TOTAL WORLDWIDE FORECAST

Dataquest's MOS ROM forecast consists of revenue, unit shipments, and prices for MOS ROM product lines. Table 1 is the top-level market estimate for the tables in the forecast.

Included in our tables are all Mask ROMs, whether used for software storage, character generators, or keyboard encoders. Revenue listed is total revenue generated from the sale of ROM products, regardless of the technology employed (NMOS or CMOS), including mask charges that are amortized over the entire production run. Tables contained in this forecast are shown as follows:

- Table 1—Worldwide Market Forecast—Total MOS ROMs
- Table 2—Worldwide NMOS ROM Market Forecast
- Table 3—Worldwide CMOS ROM Market Forecast

The Market—1988

Dataquest estimates that worldwide MOS ROM revenue totaled $989 million in 1988, growing by 49 percent over the $663 million market in 1987. Unit shipments increased more than 29 percent to 250.3 million units. A major shift by users from the mature 512K and below densities to the 1Mb-and-above densities occurred from 1987 through 1988. Notable changes in the ROM market in 1988 included the following:

- Increased demand for the 1Mb and 4Mb ROMs from the consumer and electronic data process markets (EDP) in both Japan and the United States created severe shortages and high prices for end users during 1988.
- CMOS ROMs continued to gain unit share over NMOS. CMOS units represented more than 87 percent of the total ROMs produced worldwide in 1988.

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MOS ROM--Forecast

Table 1

Worldwide Market Forecast—Total MOS ROMs

	Value (Millions of Dollars)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	$ 3	0	0	0	0	0	0	0
16K	8	$ 4	$ 2	$ 1	0	0	0	0
32K	18	19	18	11	$ 7	$ 3	$ 1	0
64K	42	38	36	30	22	11	2	0
128K	48	32	16	7	2	1	0	0
256K	154	94	67	46	28	17	9	$ 5
512K	52	114	101	106	67	42	23	14
1Mb	95	284	347	220	109	73	50	38
2Mb	9	56	215	307	361	205	109	69
4Mb	3	22	186	392	432	495	308	200
8Mb	0	0	1	11	116	259	429	486
16Mb	0	0	0	1	24	167	435	483
32Mb	0	0	0	0	1	9	84	266
64Mb	0	0	0	0	0	0	1	10
Total	$432	$663	$989	$1,132	$1,169	$1,281	$1,451	$1,572
Percent Change from Previous Year	8%	54%	49%	15%	3%	10%	13%	8%
	Units (Millions)							
4K	0	0	0	0	0	0	0	0
8K	1.0	0	0	0	0	0	0	0
16K	3.0	1.7	0.8	0.2	0	0	0	0
32K	11.8	12.7	11.3	7.0	4.5	2.0	0.5	0
64K	28.0	24.7	22.4	18.0	13.0	6.0	1.0	0
128K	27.0	18.0	9.6	4.0	1.0	0.3	0.1	0
256K	68.0	46.5	34.5	25.0	15.2	9.0	4.8	2.8
512K	9.0	27.7	31.3	39.0	28.0	19.0	11.0	6.5
1Mb	12.0	54.7	84.6	58.0	34.0	26.0	20.0	16.0
2Mb	0.4	6.4	37.1	58.0	84.0	54.0	32.0	22.0
4Mb	0.1	1.4	18.6	49.0	72.0	97.0	70.0	50.0
8Mb	0	0	0.1	1.0	14.0	37.0	74.0	90.0
16Mb	0	0	0	0.1	2.0	18.0	55.0	68.0
32Mb	0	0	0	0	0	0.2	3.1	14.0
64Mb	0	0	0	0	0	0	0	0.2
Total	160.3	193.8	250.3	259.3	267.7	268.5	271.5	269.5

(Continued)

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MOS ROM--Forecast

Table 1 (Continued)

Worldwide Market Forecast—Total MOS ROMs

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	$ 3.25	0	0	0	0	0	0	0
16K	$ 2.50	$ 2.50	$ 2.50	$ 2.50	0	0	0	0
32K	$ 1.50	$ 1.50	$ 1.55	$ 1.60	$ 1.60	$ 1.65	$ 1.65	0
64K	$ 1.50	$ 1.55	$ 1.62	$ 1.65	$ 1.70	$ 1.75	$ 1.75	0
128K	$ 1.79	$ 1.75	$ 1.65	$ 1.70	$ 1.75	$ 1.80	$ 1.80	0
256K	$ 2.26	$ 2.03	$ 1.94	$ 1.85	$ 1.85	$ 1.85	$ 1.85	$ 1.85
512K	$ 5.83	$ 4.10	$ 3.23	$ 2.72	$ 2.38	$ 2.21	$ 2.12	$ 2.15
1Mb	$ 7.88	$ 5.19	$ 4.10	$ 3.80	$ 3.20	$ 2.80	$ 2.52	$ 2.40
2Mb	$23.00	$ 8.75	$ 5.80	$ 5.30	$ 4.30	$ 3.80	$ 3.40	$ 3.15
4Mb	$32.00	$16.00	$10.00	$ 8.00	$ 6.00	$ 5.10	$ 4.40	$ 4.00
8Mb	0	$34.00	$18.00	$11.00	$ 8.30	$ 7.00	$ 5.80	$ 5.40
16Mb	0	$70.00	$38.00	$23.00	$12.00	$ 9.30	$ 7.90	$ 7.10
32Mb	0	0	0	0	$80.00	$44.00	$27.00	$19.00
64Mb	0	0	0	0	0	0	$98.00	$51.00
Overall ASP	$ 2.69	$ 3.42	$ 3.95	$ 4.37	$ 4.37	$ 4.77	$ 5.34	$ 5.83

Source: Dataquest
October 1989

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MOS ROM--Forecast

Table 2

Worldwide NMOS ROM Market Forecast

	Value (Millions of Dollars)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 6	$ 3	$ 1	0	0	0	0	0
32K	15	15	16	$11	$ 7	$3	$1	0
64K	31	18	15	5	2	0	0	0
128K	34	10	7	2	0	0	0	0
256K	100	19	15	7	4	2	0	0
512K	23	0	0	0	0	0	0	0
1Mb	39	0	0	0	0	0	0	0
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
16Mb	0	0	0	0	0	0	0	0
32Mb	0	0	0	0	0	0	0	0
64Mb	0	0	0	0	0	0	0	0
Total	$248	$65	$53	$26	$13	$5	$1	0
Percent Change from Previous Year		(74%)	(19%)	(51%)	(51%)	(59%)	(84%)	(100%)
	Units (Millions)							
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	2.5	1.2	0.3	0	0	0	0	0
32K	10.0	10.0	10.0	7.0	4.5	2.0	0.5	0
64K	20.4	11.6	9.4	3.3	1.0	0	0	0
128K	19.0	5.6	4.0	1.0	0	0	0	0
256K	44.2	9.5	7.7	4.0	2.0	1.0	0	0
512K	4.0	0	0	0	0	0	0	0
1Mb	5.0	0	0	0	0	0	0	0
2Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
64Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	105.1	37.9	31.4	15.3	7.5	3.0	0.5	0

(Continued)

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Table 2 (Continued)

Worldwide NMOS ROM Market Forecast

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$2.50	$2.50	$2.50	$2.50	0	0	0	0
32K	$1.50	$1.50	$1.55	$1.60	$1.60	$1.65	$1.65	0
64K	$1.50	$1.55	$1.62	$1.65	$1.70	0	0	0
128K	$1.79	$1.75	$1.65	$1.70	0	0	0	0
256K	$2.26	$2.03	$1.94	$1.85	$1.85	$1.85	0	0
512K	$5.83	0	0	0	0	0	0	0
1Mb	$7.88	0	0	0	0	0	0	0
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
16Mb	0	0	0	0	0	0	0	0
32Mb	0	0	0	0	0	0	0	0
64Mb	0	0	0	0	0	0	0	0
Overall ASP	$2.36	$1.72	$1.69	$1.68	$1.68	$1.72	$1.65	0

Source: Dataquest
October 1989

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MOS ROM--Forecast

Table 3

Worldwide CMOS ROM Market Forecast

	Value (Millions of Dollars)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	$ 3	0	0	0	0	0	0	0
16K	1	$ 1	$ 1	$ 1	0	0	0	0
32K	3	4	2	0	0	0	0	0
64K	11	20	21	24	$ 20	$ 11	$ 2	0
128K	14	22	9	5	2	1	0	0
256K	54	75	52	39	24	15	9	$ 5
512K	29	114	101	106	67	42	23	14
1Mb	55	284	347	220	109	73	50	38
2Mb	9	56	215	307	361	205	109	69
4Mb	3	22	186	392	432	495	308	200
8Mb	0	0	1	11	116	259	429	486
16Mb	0	0	0	1	24	167	435	483
32Mb	0	0	0	0	1	9	84	266
64Mb	0	0	0	0	0	0	2	10
Total	$183	$598	$936	$1,107	$1,156	$1,276	$1,451	$1,572
Percent Change from Previous Year		226%	56%	18%	4%	10%	14%	8%
	Units (Millions)							
4K	0	0	0	0	0	0	0	0
8K	1.0	0	0	0	0	0	0	0
16K	0.5	0.5	0.5	0.2	0	0	0	0
32K	1.8	2.7	1.3	0	0	0	0	0
64K	7.6	13.1	13.0	14.7	12.0	6.0	1.0	0
128K	8.0	12.4	5.6	3.0	1.0	0.3	0.1	0
256K	23.8	37.0	26.8	21.0	13.2	8.0	4.8	2.8
512K	5.0	27.7	31.3	39.0	28.0	19.0	11.0	6.5
1Mb	7.0	54.7	84.6	58.0	34.0	26.0	20.0	16.0
2Mb	0.4	6.4	37.1	58.0	84.0	54.0	32.0	22.0
4Mb	0.1	1.4	18.6	49.0	72.0	97.0	70.0	50.0
8Mb	N/A	0	0.1	1.0	14.0	37.0	74.0	90.0
16Mb	N/A	N/A	0	0.1	2.0	18.0	55.0	68.0
32Mb	N/A	N/A	N/A	N/A	0	0.2	3.1	14.0
64Mb	N/A	N/A	N/A	N/A	N/A	N/A	0	0.2
Total	55.2	155.9	218.9	244.0	260.2	265.5	271.0	269.5

(Continued)

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MOS ROM--Forecast

Table 3 (Continued)

Worldwide CMOS ROM Market Forecast

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	$ 3.25	0	0	0	0	0	0	0
16K	$ 2.50	$ 2.50	$ 2.50	$ 2.50	0	0	0	0
32K	$ 1.50	$ 1.50	$ 1.55	$ 1.60	$ 1.60	$ 1.65	$ 1.65	0
64K	$ 1.50	$ 1.55	$ 1.62	$ 1.65	$ 1.70	$ 1.75	$ 1.75	0
128K	$ 1.79	$ 1.75	$ 1.65	$ 1.70	$ 1.75	$ 1.80	$ 1.80	0
256K	$ 2.26	$ 2.03	$ 1.94	$ 1.85	$ 1.85	$ 1.85	$ 1.85	$ 1.85
512K	$ 5.83	$ 4.10	$ 3.23	$ 2.72	$ 2.38	$ 2.21	$ 2.12	$ 2.15
1Mb	$ 7.88	$ 5.19	$ 4.10	$ 3.80	$ 3.20	$ 2.80	$ 2.52	$ 2.40
2Mb	$23.00	$ 8.75	$ 5.80	$ 5.30	$ 4.30	$ 3.80	$ 3.40	$ 3.15
4Mb	$32.00	$16.00	$10.00	$ 8.00	$ 6.00	$ 5.10	$ 4.40	$ 4.00
8Mb	0	$34.00	$18.00	$11.00	$ 8.30	$ 7.00	$ 5.80	$ 5.40
16Mb	0	$70.00	$38.00	$23.00	$12.00	$ 9.30	$ 7.90	$ 7.10
32Mb	0	0	0	0	$80.00	$44.00	$27.00	$19.00
64Mb	0	0	0	0	0	0	$98.00	$51.00
Overall ASP	$ 3.32	$ 3.84	$ 4.28	$ 4.54	$ 4.44	$ 4.81	$ 5.35	$ 5.83

Source: Dataquest
October 1989

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MOS ROM--Forecast

Comparison with Earlier Forecast

The present MOS ROM forecast contains several significant changes from the earlier Dataquest ROM forecast, published in June 1988. The changes and reasons for these differences are as follows:

- Adjustments have been made to the 1986 and 1987 actual unit data based on updated data base information. As a result, the actual 1988 revenue far surpassed our previously forecast $496 million.

- CMOS share of ROM is expected to continue absorbing the larger share of the ROM market, with NMOS declining and finally becoming obsolete by 1993. Virtually every manufacturer is producing CMOS ROM in all densities, with CMOS being the sole process technology used in next-generation product development.

Market Outlook

Dataquest saw continued market growth for more dense, very high speed ROMs (typically 150ns and below) for use in new laser printers, electronic video game computers, high-speed electronic typewriters, and ROM-supported cache systems.

CMOS/NMOS

As indicated in the 1988 forecast, CMOS has grown significantly over NMOS. As demand continues for larger memory capacity, higher speed, and low power, we anticipate that CMOS will command the larger portion of total ROM unit share. CMOS is becoming the dominant technology in all of the MOS memory areas and as such, will follow the same path to growth in the mask ROM area. Dataquest expects a complete displacement of NMOS ROMs during the next few years, as illustrated in Figure 1.

Short-Term Forecast

Strong market growth is projected for ROMs through the end of 1989, driven primarily by increased user demand for high-density, high-speed products. Although the 256K-and-below densities continued the expected decline in their life cycles, shipments of the 512K-and-above grew tremendously in 1988. The high-density products contributed significantly to the 49 percent growth in revenue in 1988, with an expected continued growth in revenue of 15 percent in 1989 over 1988. As ROM usage increased in the EDP sector for office automation systems in both Japan and the United States, suppliers shifted production to the 1Mb and 4Mb designs.

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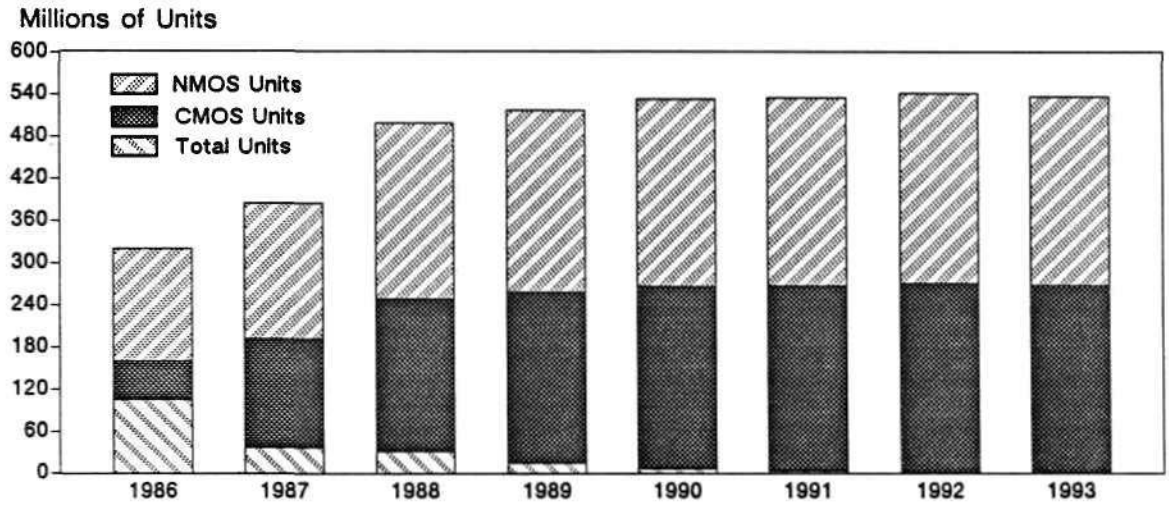
MOS ROM--Forecast

Figure 1

CMOS/NMOS ROM Growth
(Total Units)



0004882-1

Source: Dataquest
October 1989

Although the 512K density continued to grow, driven primarily by U.S. users, increased demand for 1Mb and 4Mb designs from Nintendo in Japan and office automation users in the United States, and lack of capacity drove 1Mb and 4Mb prices to astronomical heights during the third and fourth quarters of 1988 and during the first half of 1989. U.S. office system usage was the greatest contributor to 1Mb product growth in 1988. As U.S. users shifted from 512K to the 1Mb and 4Mb devices, their demand for high speed followed. Office automation system design upgrades for 1990 products are expected to boost shipments of very high speed 1Mb, 2Mb, and 4Mb designs to more than 190 million units.

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MOS ROM--Forecast

Long-Term Forecast

The new high-speed office systems and portable data storage applications will continue to drive the very high density ROM product growth through 1993. The very large 8Mb and 16Mb ROMs that are currently in low volume and sampling stages are expected to be major contributors to growth in 1992 and 1993. The high-speed, sub-150ns, high-density ROMs will open new markets, driven by new applications during the 1990s. Although there is a flurry of discussion and activity by current and potential U.S. suppliers regarding support of 1Mb and above devices to satisfy U.S. user demand for high-density, high-speed ROMs, ROM market dominance is not expected to shift away from the Japanese suppliers. The very high speed 100ns 1Mb and 4Mb ROM market could become a very profitable niche for the quick-to-market U.S. based supplier during the next four years. However, the Japanese suppliers have been producing the 1Mb device since 1984 and the 4Mb device since 1985. If these devices follow the typical life cycle and learning curve trends for products, the 1Mb device has already peaked (in 1988), and the 4Mb product will peak by 1991. Although shortages and demand in 1988 and 1989 have raised these product prices substantially, an expected slowdown in 1990 could dampen the profit margins of a newly ramping ROM producer. Currently, six U.S., two Taiwanese, two Korean, and one European semiconductor manufacturers are interested in pursuing high-density ROM production. By being positioned onshore, a U.S.-based supplier can offer its customers shorter turnaround time and more cost-effective products. Although ROMs will be competing with new high-density EPROM and FLASH devices, the potential for ROM growth in the United States, from U.S. office system manufacturer, could be significant.

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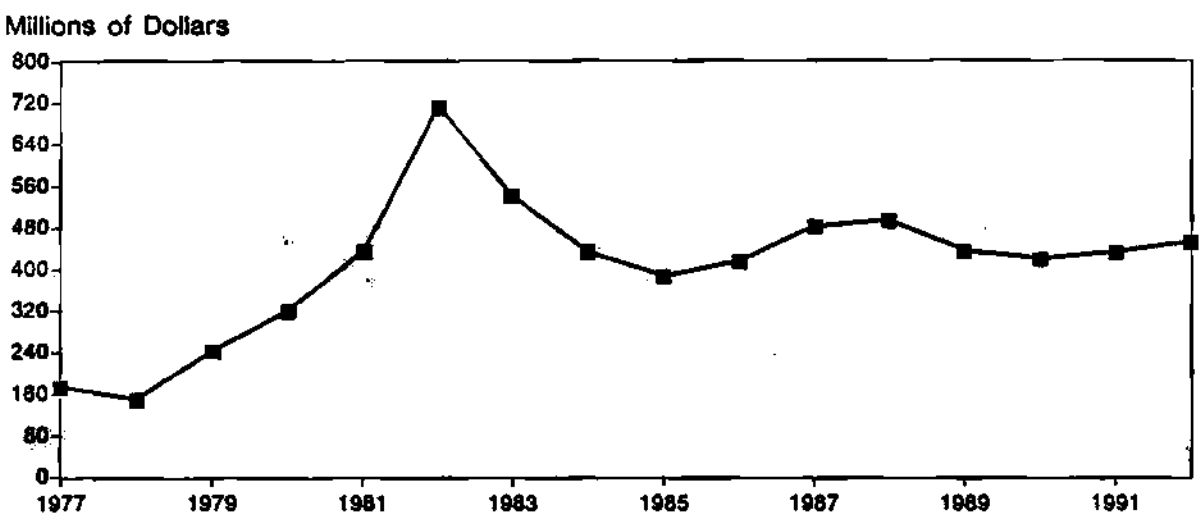
MOS ROM--Forecast

OVERVIEW

Ever since Electronic Arrays designed the industry's first MOS ROMs (read-only memories) in the 1968 and 1969 time frame, the ROM market has run the gamut of growth and decline. The ROM market maintained a fairly steady rate of growth from 1970 through 1979. Boosted by consumers' insatiable appetites for home video game cartridges, the market for mask ROMs exceeded $400 million in 1981, up 35 percent from 1980, as shown in Figure 1. The 64K ROM was the densest device in high-volume production in 1981. An estimated 3.2 million units were shipped in just the first half of 1981. Atari alone was estimated to have purchased more than 1 trillion bits of ROM. Along with Activision, Bally, Fidelity, Magnavox, Mattel, and others, Atari, during its heyday, made MOS ROMs one of the few bright and profitable markets for MOS memory producers. Worldwide ROM revenue increased at a compound annual growth rate (CAGR) of 146 percent from 1970 to 1982, dropping to a negative 5 percent from 1983 to 1986.

Figure 1

ROM Revenue Growth



Source: Dataquest June 1988

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MOS ROM--Forecast

As ROM growth continued in 1982, more suppliers converged on the market. We have estimated that the consumer sector made up 74 percent of the total ROM business in 1982. Video game cartridges accounted for 50 percent of this market, and the EDP sector made up the remaining share for small electronic systems, personal computers, and graphics terminals.

The ROM market declined precipitously from late 1982 through 1985, due to three main factors:

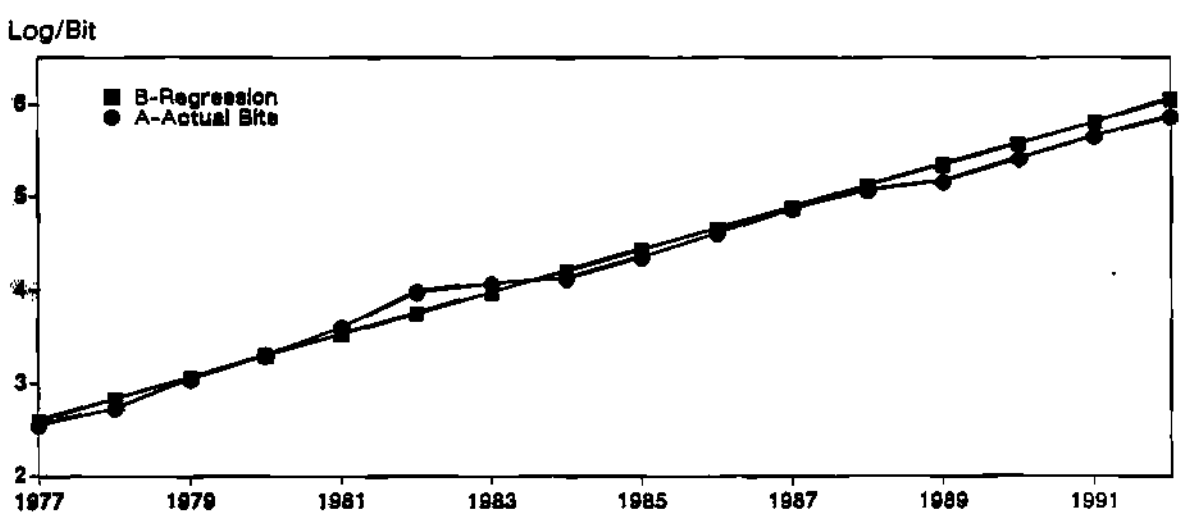
- Increased vendor competition in the MOS ROM market
- The virtual disappearance of the immense but short-lived demand for video games
- A user trend away from ROMs to other software storage solutions

Although the 1984 total MOS memory market grew nearly 60 percent in revenue over 1983, the market for mask ROMs declined more than 20 percent.

The outstanding growth of the ROM market from 1979 to 1982 is illustrated in the significant ROM bit growth shown in Figure 2. The slowdown in bit growth between 1982 and 1984 can be attributed to the slowdown in the computer and video games markets and to EPROM growth. ROMs were being displaced by increasingly price competitive EPROMs in certain low-volume and quick-turnaround applications. In 1983, there were 42 mask ROM vendors worldwide, with the top 16 ROM vendors accounting for about 82 percent of the total ROM business.

Figure 2

MOS ROM Bit Growth



Source: Dataquest June 1988

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MOS ROM--Forecast

By 1985, the ROM market had declined 28 percent. Although the video games market had died in the United States, it was and continues to be a strong business in Japan. By 1985, Japanese manufacturers had gained 50 percent of the overall ROM market. While mask ROMs were the lowest price-per-bit nonvolatile memory product, competition continued unabated from fast-turn EPROMs, easy-to-inventory EPROMs, and low-cost DRAMs used in conjunction with flexible disks.

MOS ROMs—TOTAL WORLDWIDE FORECAST

Dataquest's MOS ROM forecast consists of revenue, unit shipments, and prices for MOS ROM product lines. Table 1 is the top-level market estimate for the tables in the forecast.

Included in our tables are all mask ROMs, whether used for software storage, character generators, or keyboard encoders. Revenue listed is total revenue generated from the sale of ROM products, regardless of the technology employed (NMOS or CMOS), including mask charges that are amortized over the entire production run. Tables contained in this forecast are shown as follows:

- Table 1—Worldwide Market Forecast—Total MOS ROMs
- Table 2—Worldwide NMOS ROM Market Forecast
- Table 3—Worldwide CMOS ROM Market Forecast

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MOS ROM--Forecast

Table 1

Worldwide Market Forecast—Total MOS ROMs

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
4K	0	0	0	0	0	0	0	0
8K	$ 5	$ 3	0	0	0	0	0	0
16K	12	4	$ 2	0	0	0	0	0
32K	19	9	6	0	0	0	0	0
64K	66	42	25	$ 14	$ 8	$ 4	$ 2	0
128K	75	50	37	25	13	9	4	$ 2
256K	116	154	114	80	48	31	16	10
512K	37	52	68	82	99	72	55	29
1 Mbit	58	95	196	221	156	97	55	28
2 Mbit	0	9	29	54	71	105	120	95
4 Mbit	0	0	8	16	28	46	93	143
8 Mbit	0	0	0	3	8	24	44	69
16 Mbit	0	0	0	1	7	33	48	77
Total	$388	$418	$485	$496	$437	$421	$435	$454
Percent Change from Previous Year	(11%)	8%	16%	2%	(12%)	(3%)	3%	4%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
4K	0	0	0	0	0	0	0	0
8K	1.5	1.0	0	0	0	0	0	0
16K	6.2	1.5	0.9	0	0	0	0	0
32K	12.2	6.0	3.8	0	0	0	0	0
64K	41.0	28.0	16.3	9.0	4.5	2.0	1.0	0
128K	33.5	28.0	21.0	14.5	8.0	5.4	2.1	0.9
256K	34.5	68.0	56.4	42.4	28.3	18.4	9.1	5.9
512K	4.0	9.0	16.5	25.6	36.4	31.4	25.0	14.0
1 Mbit	4.1	12.0	37.7	60.5	48.0	35.0	23.0	12.6
2 Mbit	0	0.4	3.3	9.4	17.5	31.0	43.0	38.2
4 Mbit	0	0	0.5	2.3	5.4	12.8	29.0	52.0
8 Mbit	0	0	0	0.2	0.9	4.0	10.0	19.5
16 Mbit	0	0	0	0	0.4	3.4	8.0	17.0
Total	137.0	153.9	156.4	163.9	149.4	143.4	150.2	160.1

(Continued)

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MOS ROM—Forecast

Table 1 (Continued)

Worldwide Market Forecast—Total MOS ROMs

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
4K	0	0	0	0	0	0	0	0
8K	$ 3.25	$ 3.25	0	0	0	0	0	0
16K	$ 1.93	$ 2.50	$ 2.50	0	0	0	0	0
32K	$ 1.52	$ 1.50	$ 1.50	0	0	0	0	0
64K	$ 1.61	$ 1.50	$ 1.55	$ 1.60	$ 1.70	$1.84	$1.85	0
128K	$ 2.25	$ 1.79	$ 1.75	$ 1.69	$ 1.65	$1.69	$1.72	$1.78
256K	$ 3.37	$ 2.26	$ 2.03	$ 1.88	$ 1.69	$1.71	$1.75	$1.76
512K	$ 9.20	$ 5.83	$ 4.15	$ 3.19	$ 2.72	$2.30	$2.19	$2.09
1 Mbit	$14.22	$ 7.88	$ 5.19	$ 3.65	$ 3.25	$2.76	$2.39	$2.25
2 Mbit	0	$23.00	$ 8.75	$ 5.78	$ 4.03	$3.40	$2.80	$2.48
4 Mbit	0	0	$14.00	$ 7.10	$ 5.11	$3.60	$3.20	$2.75
8 Mbit	0	0	$34.00	$17.40	$ 9.00	$5.90	$4.35	$3.55
16 Mbit	0	0	$70.00	$35.00	$18.00	$9.80	$5.94	$4.55
Overall ASP	$ 2.83	$ 2.72	$ 3.10	$ 3.02	$ 2.92	$2.94	$2.90	$2.84

Source: Dataquest
June 1988

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MOS ROM--Forecast

Table 2

Worldwide NMOS ROM Market Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 5	$ 1	$ 2	0	0	0	0	0
32K	12	5	4	0	0	0	0	0
64K	54	30	15	$ 9	$ 5	$ 2	$ 1	0
128K	59	33	18	12	6	3	0	0
256K	77	95	59	38	19	14	7	$ 3
512K	27	20	19	30	24	16	13	8
1 Mbit	21	35	69	75	38	24	17	11
2 Mbit	0	0	0	0	0	0	0	0
4 Mbit	0	0	0	0	0	0	0	0
8 Mbit	0	0	0	0	0	0	0	0
16 Mbit	0	0	0	0	0	0	0	0
Total	$255	$220	$187	$164	$92	$58	$38	$23
Percent Change from Previous Year	(21%)	(14%)	(15%)	(12%)	(44%)	(37%)	(34%)	(40%)

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16K	4.0	1.0	0.8	N/A	N/A	N/A	N/A	N/A
32K	9.0	4.0	3.0	N/A	N/A	N/A	N/A	N/A
64K	36.0	20.4	10.3	6.0	3.0	1.0	0.5	0
128K	28.0	20.0	11.0	7.0	3.5	1.5	0.1	0.1
256K	24.0	44.2	30.0	20.4	11.3	8.0	4.0	1.9
512K	3.2	4.0	5.0	9.6	9.0	7.1	6.0	4.0
1 Mbit	1.6	5.0	15.7	20.9	12.0	9.0	7.4	5.0
2 Mbit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4 Mbit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8 Mbit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16 Mbit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	105.8	98.6	75.8	63.9	38.8	26.6	18.0	11.0

(Continued)

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MOS ROM--Forecast

Table 2 (Continued)

Worldwide NMOS ROM Market

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16K	$ 1.20	$1.25	$2.50	N/A	N/A	N/A	N/A	N/A
32K	$ 1.35	$1.35	$1.35	N/A	N/A	N/A	N/A	N/A
64K	$ 1.50	$1.45	$1.50	$1.55	$1.63	$1.78	$1.85	0
128K	$ 2.10	$1.65	$1.60	$1.65	$1.65	$1.67	$1.70	$1.75
256K	$ 3.20	$2.15	$1.98	$1.85	$1.67	$1.70	$1.75	$1.75
512K	$ 8.50	$5.10	$3.80	$3.12	$2.65	$2.24	$2.10	$2.05
1 Mbit	$13.00	$7.00	$4.40	$3.60	$3.18	$2.67	$2.35	$2.25
2 Mbit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4 Mbit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8 Mbit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16 Mbit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Overall ASP	$ 2.41	$2.23	$2.46	$2.56	$2.36	$2.17	$2.12	$2.09

N/A = Not Available

Source: Dataquest
June 1988

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MOS ROM—Forecast

Table 3

Worldwide CMOS ROM Market Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
4K	0	0	0	0	0	0	0	0
8K	$ 5	$ 3	0	0	0	0	0	0
16K	7	1	0	0	0	0	0	0
32K	6	4	$ 1	0	0	0	0	0
64K	12	14	10	$ 5	$ 3	$ 2	$ 1	0
128K	17	18	18	13	8	7	4	$ 2
256K	39	59	57	42	29	18	9	7
512K	10	33	50	52	76	56	42	21
1 Mbit	38	59	125	147	117	72	37	17
2 Mbit	0	8	29	54	71	105	120	95
4 Mbit	0	0	7	16	28	46	93	143
8 Mbit	0	0	0	3	8	24	44	69
16 Mbit	0	0	0	0	7	33	48	77
Total	$133	$199	$298	$333	$346	$364	$397	$432
Percent Change from Previous Year	17%	49%	50%	12%	4%	5%	9%	9%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	1.5	1.0	N/A	N/A	N/A	N/A	N/A	N/A
16K	2.2	0.5	0.1	N/A	N/A	N/A	N/A	N/A
32K	3.2	2.0	0.8	N/A	N/A	N/A	N/A	N/A
64K	5.0	7.6	6.0	3.00	1.5	1.0	0.5	N/A
128K	5.5	8.0	10.0	7.50	4.5	3.9	2.0	0.9
256K	10.5	23.8	26.4	22.00	17.0	10.4	5.1	4.0
512K	0.8	5.0	11.5	16.00	27.4	24.3	19.0	10.0
1 Mbit	2.5	7.0	22.0	39.60	36.0	26.0	15.6	7.6
2 Mbit	N/A	0.4	3.3	9.40	17.5	31.0	43.0	38.2
4 Mbit	N/A	0	0.5	2.30	5.4	12.8	29.0	52.0
8 Mbit	N/A	N/A	0	0.20	0.9	4.0	10.0	19.5
16 Mbit	N/A	N/A	0	0.01	0.4	3.4	8.0	17.0
Total	31.2	55.3	80.6	100.00	110.6	116.8	132.2	149.2

(Continued)

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Table 3 (Continued)

Worldwide CMOS ROM Market Forecast

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	$ 3.25	$ 3.25	N/A	N/A	N/A	N/A	N/A	N/A
16K	$ 3.25	$ 2.50	$ 2.50	0	N/A	N/A	N/A	N/A
32K	$ 2.00	$ 1.80	$ 1.65	0	N/A	N/A	N/A	N/A
64K	$ 2.40	$ 1.85	$ 1.70	$ 1.72	$ 1.75	$1.84	$1.85	0
128K	$ 3.00	$ 2.24	$ 1.80	$ 1.75	$ 1.75	$1.78	$1.85	$1.85
256K	$ 3.75	$ 2.47	$ 2.17	$ 1.90	$ 1.70	$1.73	$1.80	$1.80
512K	$12.00	$ 6.60	$ 4.35	$ 3.22	$ 2.76	$2.32	$2.20	$2.12
1 Mbit	$15.00	$ 8.40	$ 5.68	$ 3.70	$ 3.26	$2.77	$2.40	$2.28
2 Mbit	N/A	$23.00	$ 8.75	$ 5.78	$ 4.03	$3.40	$2.80	$2.48
4 Mbit	N/A	0	$14.00	$ 7.10	$ 5.11	$3.60	$3.20	$2.75
8 Mbit	N/A	N/A	$34.00	$17.40	$ 9.00	$5.90	$4.35	$3.55
16 Mbit	N/A	N/A	$70.00	$35.00	$18.00	$9.80	$5.94	$4.55
Overall ASP	$ 4.28	$ 3.59	$ 3.70	$ 3.33	$ 3.13	$3.11	$3.01	$2.89

N/A = Not Available

Source: Dataquest
June 1988

The Market—1987

Dataquest estimates that worldwide MOS ROM revenue totaled $485 million in 1987, growing by 16 percent over the $418 million market in 1986. Unit shipments increased only 2 percent, to 156.4 million units. The ROM market is in a state of transition. Users are currently shifting emphasis from the mature, low-density devices to the larger, 512K-and-above ROMs. Notable changes in the ROM market in 1987 included the following:

- Japanese vendors began sampling and shipping the new 4-Mbit, 8-Mbit, and 16-Mbit mask ROMS. Demand increased from the video game market and growing office automation systems market in the United States and Japan.
- CMOS ROMS continued to gain unit share over NMOS. CMOS units grew 46 percent in 1987 over 1986, while NMOS declined 23 percent. The CMOS unit share of the ROM market represented 52 percent in 1987, in comparison with the 48 percent share of NMOS units.

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MOS ROM--Forecast

Comparison with Earlier Forecast

The present MOS ROM forecast contains several significant changes from the earlier Dataquest ROM forecast, published in June 1987. The changes and reasons for these differences are as follows:

- ROM market revenue fell short of our forecast of $542 million in 1987. Although ROM units increased to 156.4 million, they did not achieve the anticipated 158.5 million units.
- CMOS share of ROM is expected to surpass NMOS at a faster rate than previously expected. CMOS is forecast to garner 61 percent of total ROM revenue in 1988 and reach 93 percent of revenue by 1992. Virtually every manufacturer is producing CMOS ROM in all densities, with CMOS being the sole process technology used in next-generation product development.

Market Outlook

The market for denser, high-speed ROMs has considerable growth potential for existing and new market applications. The new 1-Mbit ROMs have expanded the memory capacity for present ROM applications. The larger 2-Mbit through 16-Mbit densities go beyond the realm of talking toys and game cartridges and into the following application areas:

- Kanji character generators for word processing
- Kanji font ROMs for printers
- Waveform storage for electronic musical instruments
- Speech-synthesis products
- Hand-held translators
- High-speed 32-bit MPU-based systems
- High-speed electronic typewriters
- PC and laptop computers
- ROM memory cards
- Pocket calculators
- Dictionary data storage in computer-assisted translation systems

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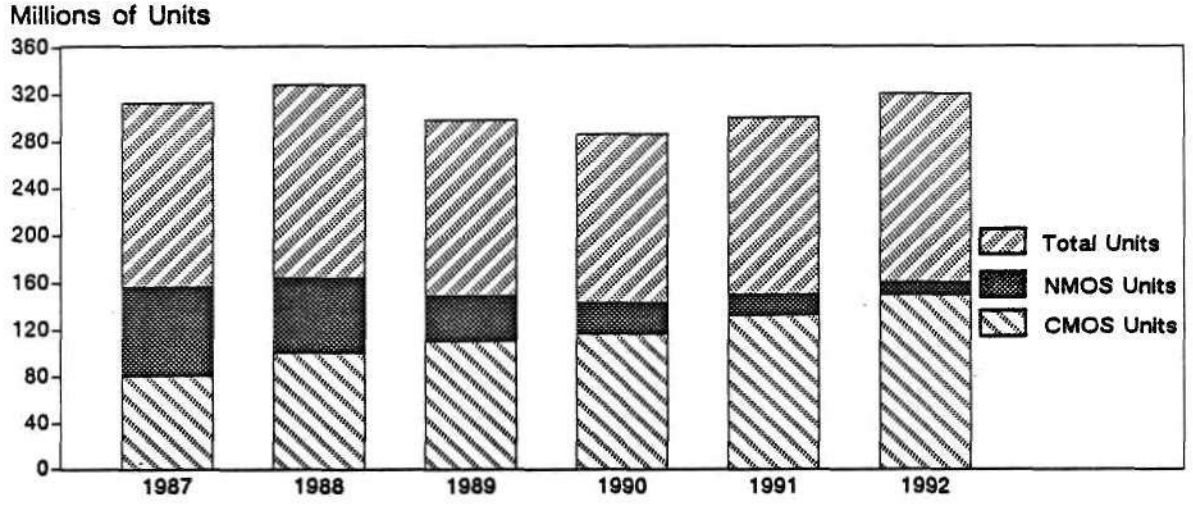
CMOS/NMOS ROMs

Historically, CMOS ROMs have made up only a small percent of ROM market revenue. This share has grown substantially over the last four years. As the need grew for larger memory capacity, speed, and low power, so too did the demand for CMOS. As shown in Figure 3, we anticipate that CMOS ROMs will continue to consume a larger portion of total ROM unit share. CMOS is becoming the dominant technology in all of the MOS memory areas and, as such, will follow the same path to growth in the mask ROM area.

Figure 3

CMOS/NMOS ROM Growth
(Total Units)



Source: Dataquest
June 1988

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Competition to ROMs: UV/OTP EPROMs

MOS ROMs traditionally have had to compete with EPROMs in many applications. Numerous borderline applications have been lost to EPROMs because of the improved price competitiveness of EPROMs. Many users continued to opt for EPROMs for the following reasons:

- EPROMs reduce component inventory problems.
  - ROMs are programmed during the manufacturing process, usually by customizing the design of one or more layers of the ROM IC. These customized or masked ROMs are generally chosen when a company requires a relatively large quantity of identical devices.
  - ROMs are nonvolatile and well-suited to applications in which data is to be stored permanently and accessed repetitively. EPROMs, on the other hand, can be stored and programmed on an as-needed basis for a variety of software programs.
- EPROMs typically have a shorter production turnaround time.
  - Production volumes of ROMs can take from a minimum of 5 weeks to a maximum of 14 weeks from customer submission of tapes to delivery of volume production, although delivery of prototypes can be done in a shorter period of time.
  - With EPROMs, users can get their designs into volume production much more readily and without the initial mask charges that can average as high as $5,000.
- Once considered a threat to ROMs, OTP EPROMs are now carving out their own piece of the nonvolatile market.
  - OTPs are windowless-plastic-packaged EPROMs that have a cost savings of approximately 20 to 40 percent over the conventional EPROM package.
  - OTP products have had such significant technical problems and low-acceptance levels to overcome that they are now relegated to end markets where low-cost EPROM capability is of utmost importance.
  - ROM densities have now gone beyond the realm of the OTP and have captured and secured market applications that are beyond OTP penetration.

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MOS ROM--Forecast

Short-Term Forecast

The market outlook for ROMs in general is favorable. Although ROMs will not match the year-to-year growth that will permeate other MOS memory products, the new megabit densities will boost a previously declining market. We anticipate that the mature 256K-and-below densities will continue to follow the decline phase of product life cycles. Although these lower-density products will be supported by a few suppliers, as shown in Table 4, user emphasis will continue to shift to the higher, 512K-and-above CMOS products.

Table 4

MOS ROM Suppliers

Company	Process Technology	Densities 16K	32K	64K	128K	256K	512K	1 Mbit	2 Mbit	4 Mbit	8 Mbit	16 Mbit
El Cap	NMOS	X	X	X		X						
ERSO	CMOS/NMOS	X	X	X	X							
Fujitsu	CMOS				X	X	X	X	X	X		
Goldstar	CMOS						X	X				
Gould	CMOS					X	X					
Hitachi	CMOS			X	X	X	X	X	X	X	X	X
Hua Ko	CMOS			X		X						
Macronix	CMOS/NMOS	X	X	X	X	X	X	X				
Matsushita	CMOS			X	X	X	X	X	X	X	X	X
Microchip	CMOS/NMOS		X	X	X	X						
Mitsubishi	CMOS			X	X	X		X		X		
NCR	CMOS/NMOS	X	X	X	X	X	X					
NEC	CMOS						X	X	X	X		
Oki	CMOS		X	X		X		X				
Ricoh	CMOS/NMOS				X	X		X				
Seiko	CMOS							X				
Sharp	CMOS/NMOS		X	X	X	X	X	X	X	X		
Toshiba	CMOS/NMOS			X	X	X		X	X	X	X	X
UMC	NMOS	X	X	X	X	X						
VLSI Tech.	CMOS		X	X	X	X	X	X				

Source: Dataquest
June 1988

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MOS ROM--Forecast

Although 512K density shipments increased in 1987, a large percent of this growth can be attributed to long lead times, high prices, and lack of capacity in the 512K EPROM area. As the office automation equipment market and video business grew in Japan and the United States, demand for 1-Mbit ROMs increased. The 1-Mbit models are now available in 28-pin, 32-pin, and 40-pin packages. U.S. users such as Digital Equipment Corporation and Hewlett-Packard booked large orders for the 32-pin and 40-pin packaged 1-Mbit devices for low-end PC and laptop computers. Nintendo virtually used the majority of 1-Mbit 28-pin and 40-pin devices for video applications. Use of 1-Mbit ROMs by U.S. users is expected to boost shipments to 60.5 million in 1988. Dataquest's Office Systems Group has identified five hardware areas used to create and manage documents in the office that are in a state of transition in the U.S. These areas are:

- High-end electronic typewriters
- Dedicated word processors
- Personal computers
- Technical workstations
- Multiuser business computer systems

Office system upgrades occurring in both the United States and Japan in 1988 are expected to boost usage of the new 2-Mbit and 4-Mbit densities in the 1989 time frame. Smith-Corona is already incorporating the 2-Mbit ROMs in its high-end electronic typewriters. Laptop PCs and ROM cards for printer font selection will incorporate the 4-Mbit ROMs by 1989. Storage of Japanese character fonts has required the use of three 1-Mbit ROMs. The 4-Mbit products now offer the necessary font storage capability on a single ROM chip. The reduction in number of components will reduce board/card real estate, thus reducing production costs.

Long-Term Forecast

Innovative office systems and portable data storage applications are expected to grow in orders of magnitude in the next five years. Mask ROM developments in 1987 make such expectations a reality. Matsushita introduced its 1.0-micron CMOS 8-Mbit and 16-Mbit ROMs with access speeds of 200ns. The devices are available in 24-pin and 64-pin quad plastic flat packages (QPFPs) and 40-pin dual in-line packages (DIPs). The 64-pin QPFPs allow high-density mounting in IC cards and hand-held products. Other entrants to this market are Hitachi, Mitsubishi, and Toshiba. Not only will the Japanese suppliers continue to control and dominate the ROM market, they will control it from both shores. We anticipate that these large ROM manufacturers will bring ROM manufacturing back into the United States during 1989. By positioning themselves on-shore, they can then offer their customers shorter turnaround time and more

cost-effective products, all of which will boost user consumption in the 1991 and 1992 time frame. The main source of growth will continue to come from the high-performance, high-density, high-speed CMOS ROMs for smart card applications. Although ROMs will be competing with EPROMs/EEPROMs in this market, the potential for ROMs in this area, especially in the United States, could be significant.

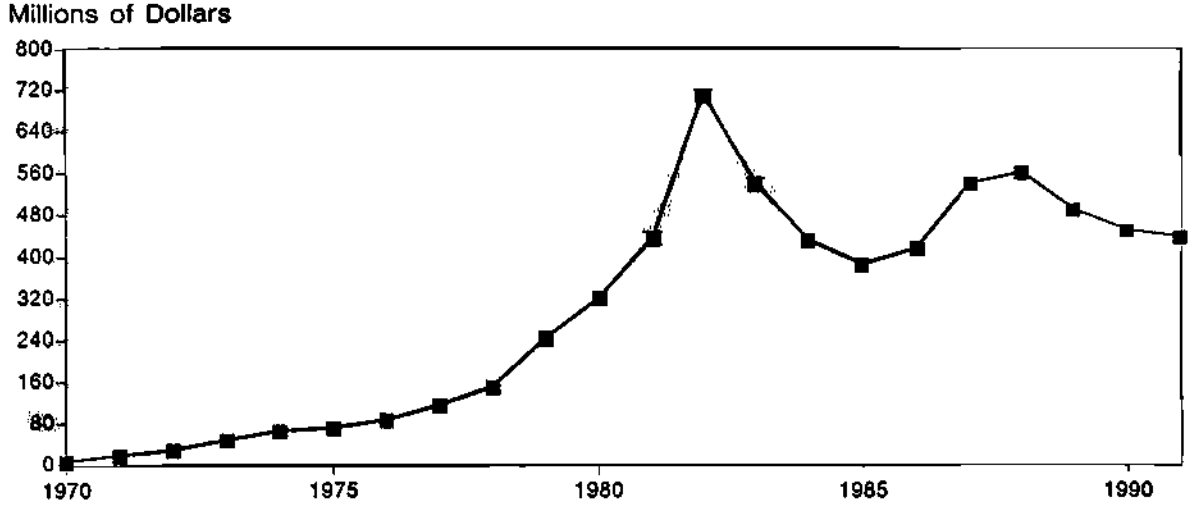
MOS ROM--Forecast

FORECAST OVERVIEW

Ever since Electronic Arrays designed the industry's first MOS ROMs (read-only memories) in the 1968 and 1969 time frame, the ROM market has run the gamut of growth and decline. The ROM market maintained a fairly steady rate of growth from 1970 through 1979. Boosted by consumers' insatiable appetites for home video game cartridges, the market for mask ROMs exceeded $400 million in 1981, up 35 percent from 1980, as shown in Figure 1. The 64K ROM was the densest device in high-volume production in 1981. An estimated 3.2 million units were shipped in just the first half of 1981. Atari alone was estimated to have purchased more than 1 trillion bits of ROM. Along with Activision, Bally, Fidelity, Magnavox, Mattel, and others, Atari, during its heyday, made MOS ROMs one of the few bright and profitable markets for MOS memory producers. Worldwide ROM revenue increased at a compound annual growth rate (CAGR) of 146 percent from 1970 to 1982, dropping to a negative 5 percent from 1983 to 1986.

Figure 1

ROM REVENUE GROWTH



Source: Dataquest June 1987

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MOS ROM--Forecast

As ROM growth continued in 1982, more suppliers converged on the market. We have estimated that the consumer sector made up 74 percent of the total ROM business in 1982. Video game cartridges accounted for 50 percent of this market, and the EDP sector made up the remaining share for small electronic systems, personal computers, and graphics terminals.

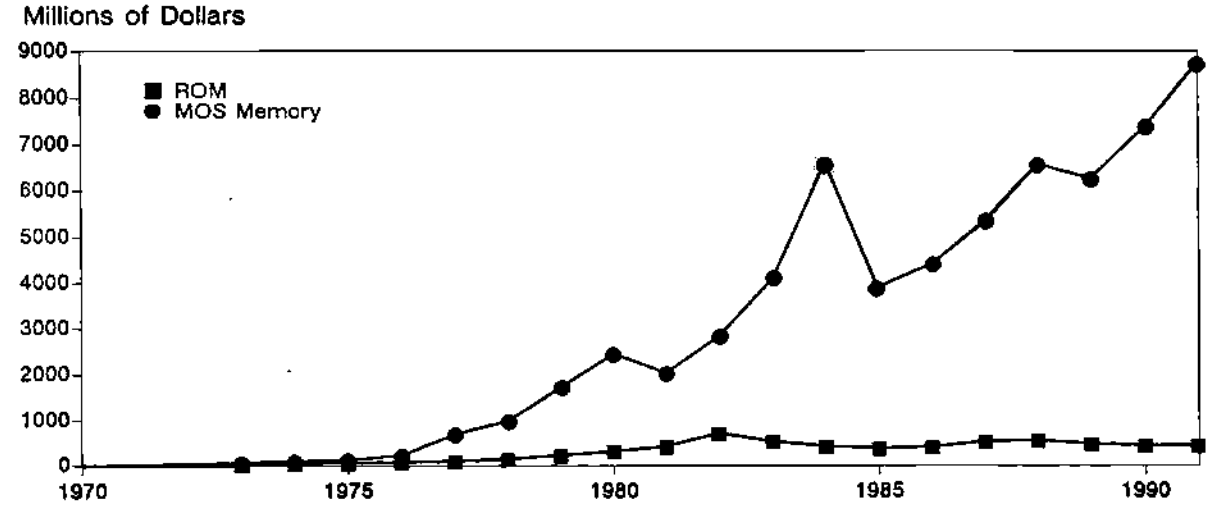
The ROM market declined precipitously from late 1982 through 1985, due to three main factors:

- Increased vendor competition in the MOS ROM market
- The virtual disappearance of the immense but short-lived demand for video games
- A user trend away from ROMs to other software storage solutions

Although the 1984 total MOS memory market grew nearly 60 percent in revenue over 1983, the market for mask ROMs declined more than 20 percent, as shown in Figure 2.

Figure 2

ROM SHARE OF MOS MEMORY



Source: Dataquest June 1987

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MOS ROM--Forecast

The outstanding growth of the ROM market from 1979 to 1982 is illustrated in the significant ROM bit growth shown in Figure 3. The slowdown in bit growth between 1982 and 1984 can be attributed to the slowdown in the computer and video games markets and to EPROM growth. ROMs were being displaced by increasingly price competitive EPROMs in certain low-volume and quick-turnaround applications. In 1983, there were 42 mask ROM vendors worldwide, with the top 16 ROM vendors accounting for about 82 percent of the total ROM business.

By 1985, the ROM market had declined 28 percent. Although the video games market had died in the United States, it was and continues to be a strong business in Japan. By 1985, Japanese manufacturers had gained 50 percent of the overall ROM market. While mask ROMs were the lowest price-per-bit nonvolatile memory product, competition continued unabated from fast-turn EPROMs, easy-to-inventory EPROMs, and low-cost DRAMs used in conjunction with flexible disks.

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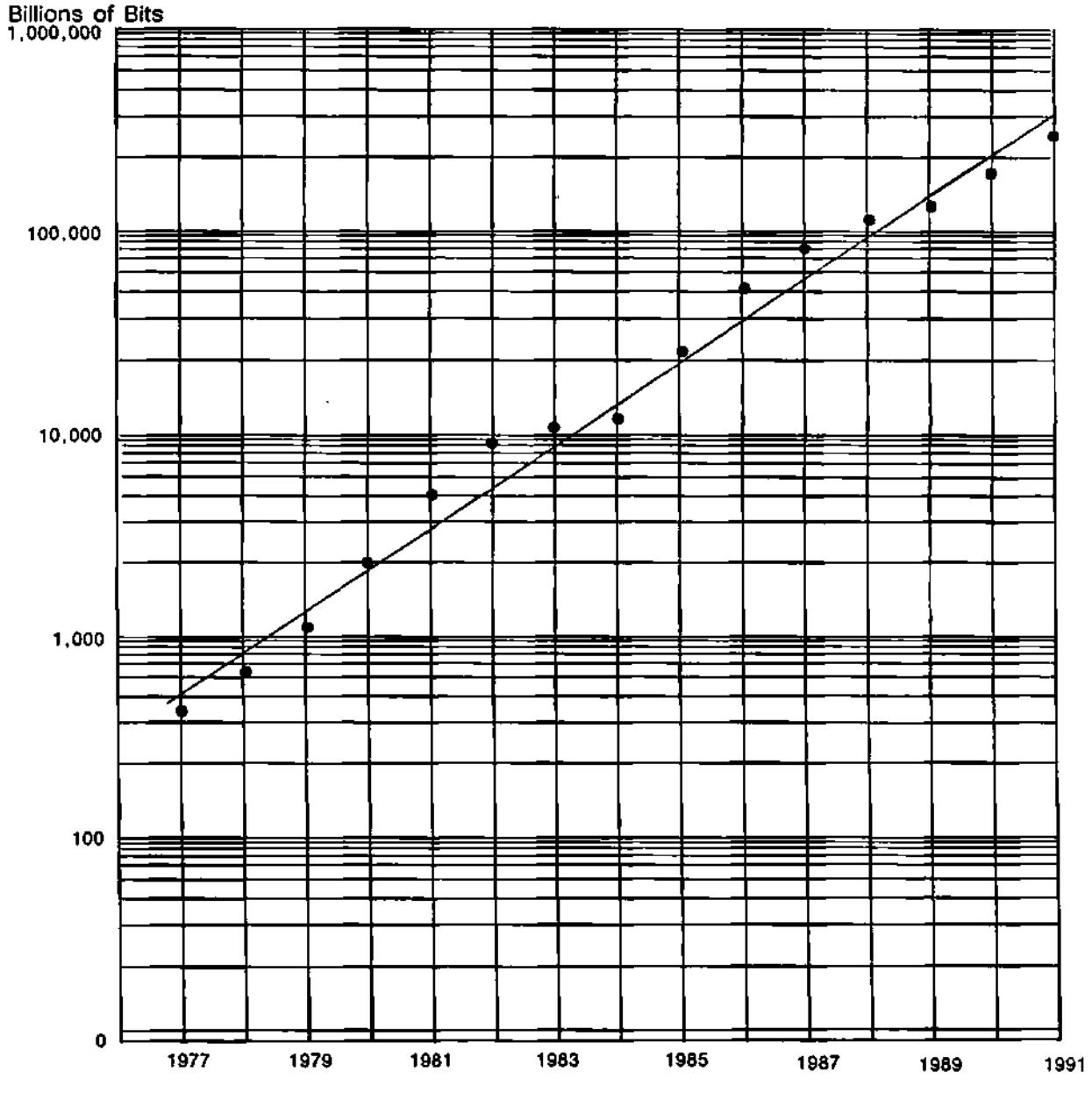
MOS ROM--Forecast

Figure 3

MOS ROM BIT GROWTH



Source: Dataquest
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MOS ROM--Forecast

MOS ROMs--TOTAL WORLDWIDE FORECAST

Dataquest's MOS ROM forecast consists of revenue, unit shipments, and prices for MOS ROM product lines. Table 1 is the top-level market estimate for the tables in the forecast.

Included in our tables are all mask ROMs, whether used for software storage, character generators, or keyboard encoders. Revenue listed is total revenue generated from the sale of ROM products, regardless of the technology employed (NMOS or CMOS), including mask charges that are amortized over the entire production run. Tables contained in this forecast are shown as follows:

- Table 1--Worldwide Market Forecast--Total MOS ROMs
- Table 2--Worldwide NMOS ROM Market Forecast
- Table 3--Worldwide CMOS ROM Market Forecast

The tables are interrelated as follows:

Table 1 = Table 2 + Table 3

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MOS ROM--Forecast

Table 1

WORLDWIDE MARKET FORECAST--TOTAL MOS ROMs

	Value (Millions of Dollars)							
	1984	1985	1986	1987	1988	1989	1990	1991
4K	0	0	0	0	0	0	0	0
8K	$ 10	$ 5	$ 3	0	0	0	0	0
16K	23	12	4	$ 3	0	0	0	0
32K	36	19	9	6	0	0	0	0
64K	112	66	42	27	$ 16	$ 8	$ 4	$ 2
128K	79	75	50	40	27	17	12	9
256K	133	116	154	119	83	48	31	16
512K	10	37	53	72	82	99	73	55
1 Mbit	31	58	95	206	217	149	95	62
2 Mbit	0	0	9	42	79	96	126	166
4 Mbit	0	0	0	28	60	75	113	132
Total	$434	$388	$418	$542	$564	$492	$453	$441
Percent Change from Previous Year	(20%)	(11%)	8%	30%	4%	(13%)	(8%)	(3%)

	Units (Millions)							
	1984	1985	1986	1987	1988	1989	1990	1991
4K	0	0	0	0	0	0	0	0
8K	4.5	1.5	1.0	0	0	0	0	0
16K	11.0	6.2	1.5	1.0	0	0	0	0
32K	18.5	12.2	6.0	4.0	0	0	0	0
64K	55.5	41.0	28.0	18.0	10.0	5.0	2.0	1.0
128K	21.5	33.5	28.0	22.5	16.0	10.0	7.0	5.0
256K	20.0	34.5	68.0	56.0	42.0	28.0	18.0	9.0
512K	0.4	4.0	9.0	16.0	25.0	36.0	31.0	25.0
1 Mbit	0.9	4.1	12.0	37.0	55.0	44.0	32.0	22.0
2 Mbit	0	0	0.4	3.5	9.5	18.0	32.0	50.0
4 Mbit	0	0	0	0.5	2.0	5.0	12.5	28.0
Total	132.3	137.0	153.9	158.5	159.5	146.0	134.5	140.0

(Continued)

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MOS ROM--Forecast

Table 1 (Continued)

WORLDWIDE MARKET FORECAST--TOTAL MOS ROMs

	Average Selling Price (Dollars/Unit)							
	1984	1985	1986	1987	1988	1989	1990	1991
4K	0	0	0	0	0	0	0	0
8K	$ 2.25	$ 3.25	$ 3.25	0	0	0	0	0
16K	$ 2.11	$ 1.93	$ 2.50	$ 2.50	0	0	0	0
32K	$ 1.97	$ 1.52	$ 1.50	$ 1.49	0	0	0	0
64K	$ 2.02	$ 1.61	$ 1.50	$ 1.50	$ 1.59	$ 1.69	$1.84	$1.85
128K	$ 3.66	$ 2.25	$ 1.79	$ 1.77	$ 1.71	$ 1.65	$1.69	$1.73
256K	$ 6.65	$ 3.37	$ 2.26	$ 2.13	$ 1.98	$ 1.70	$1.72	$1.77
512K	$27.86	$ 9.20	$ 5.83	$ 4.51	$ 3.29	$ 2.76	$2.35	$2.20
1 Mbit	$34.44	$14.22	$ 7.88	$ 5.57	$ 3.94	$ 3.39	$2.96	$2.82
2 Mbit	0	0	$23.00	$11.97	$ 8.27	$ 5.34	$3.94	$3.31
4 Mbit	0	0	0	$55.00	$30.00	$15.00	$9.00	$4.72
Overall ASP	$ 3.28	$ 2.83	$ 2.72	$ 3.42	$ 3.54	$ 3.37	$3.37	$3.15

Source: Dataquest
June 1987

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MOS ROM--Forecast

Table 2

WORLDWIDE NMOS ROM FORECAST

	Value (Millions of Dollars)							
	1984	1985	1986	1987	1988	1989	1990	1991
4K	0	0	0	0	0	0	0	0
8K	$ 4	0	0	0	0	0	0	0
16K	11	$ 5	0	0	0	0	0	0
32K	26	12	$ 5	$ 4	0	0	0	0
64K	90	54	35	22	$ 13	$ 7	$ 3	$ 2
128K	63	59	36	31	21	13	10	7
256K	104	77	101	83	53	27	18	10
512K	8	27	26	35	36	24	17	14
1 Mbit	15	21	35	68	80	42	26	18
2 Mbit	0	0	4	23	21	17	16	17
4 Mbit	0	0	0	17	30	30	23	14
Total	$321	$255	$243	$283	$256	$160	$112	$81
Percent Change from Previous Year	(27%)	(21%)	(5%)	16%	(9%)	(38%)	(30%)	(28%)

	Units (Millions)							
	1984	1985	1986	1987	1988	1989	1990	1991
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	2.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16K	8.0	4.0	0	0	N/A	N/A	N/A	N/A
32K	15.0	9.0	4.0	3.0	N/A	N/A	N/A	N/A
64K	50.0	36.0	24.4	15.5	8.3	4.2	1.7	1.0
128K	18.0	28.0	22.0	18.0	13.0	8.3	6.0	4.0
256K	16.0	24.0	46.9	39.8	28.1	15.7	10.4	5.7
512K	0.3	3.2	5.0	9.9	11.5	9.0	7.1	6.0
1 Mbit	0.5	1.6	5.0	15.0	20.9	11.9	8.6	6.8
2 Mbit	N/A	N/A	0.2	1.7	2.9	4.0	4.5	5.5
4 Mbit	N/A	N/A	0	0.3	1.0	2.0	2.5	3.0
Total	110.3	105.8	107.5	103.2	85.7	55.0	40.9	32.0

(Continued)

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MOS ROM--Forecast

Table 2 (Continued)

WORLDWIDE HMOS ROM FORECAST

	Average Selling Price (Dollars/Unit)							
	1984	1985	1986	1987	1988	1989	1990	1991
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	$ 1.65	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16K	$ 1.40	$ 1.20	0	0	N/A	N/A	N/A	N/A
32K	$ 1.75	$ 1.35	$ 1.35	$ 1.35	N/A	N/A	N/A	N/A
64K	$ 1.80	$ 1.50	$ 1.45	$ 1.45	$ 1.55	$ 1.65	$1.80	$1.85
128K	$ 3.50	$ 2.10	$ 1.65	$ 1.70	$ 1.65	$ 1.60	$1.65	$1.70
256K	$ 6.50	$ 3.20	$ 2.15	$ 2.10	$ 1.90	$ 1.70	$1.70	$1.75
512K	$25.00	$ 8.50	$ 5.10	$ 3.50	$ 3.15	$ 2.65	$2.35	$2.35
1 Mbit	$30.00	$13.00	$ 7.00	$ 4.50	$ 3.85	$ 3.50	$3.00	$2.65
2 Mbit	N/A	N/A	$22.00	$13.50	$ 7.50	$ 4.40	$3.55	$3.00
4 Mbit	N/A	N/A	0	$55.00	$30.00	$15.00	$9.00	$4.50
Overall ASP	$ 2.91	$ 2.41	$ 2.26	$ 2.74	$ 2.99	$ 2.90	$2.73	$2.52

N/A = Not Available

Source: Dataquest
June 1987

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MOS ROM--Forecast

Table 3

WORLDWIDE CMOS ROM FORECAST

	Value (Millions of Dollars)							
	1984	1985	1986	1987	1988	1989	1990	1991
4K	0	0	0	0	0	0	0	0
8K	$ 6	$ 5	$ 3	0	0	0	0	0
16K	12	7	4	$ 3	0	0	0	0
32K	10	6	4	2	0	0	0	0
64K	22	12	7	5	$ 3	$ 2	$ 1	0
128K	16	17	14	9	6	3	2	$ 2
256K	29	39	53	36	30	21	13	6
512K	2	10	27	37	46	76	56	41
1 Mbit	16	38	60	139	136	108	69	44
2 Mbit	0	0	5	19	57	79	110	149
4 Mbit	0	0	0	11	30	45	90	119
Total	$113	$133	$175	$260	$308	$333	$341	$361
Percent Change from Previous Year	10%	18%	31%	48%	19%	8%	2%	6%

	Units (Millions)							
	1984	1985	1986	1987	1988	1989	1990	1991
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	2.0	1.5	1.0	N/A	N/A	N/A	N/A	N/A
16K	3.0	2.2	1.5	1.0	0	N/A	N/A	N/A
32K	3.5	3.2	2.0	1.0	0	N/A	N/A	N/A
64K	5.5	5.0	3.6	2.5	1.7	0.9	0.3	N/A
128K	3.5	5.5	6.0	4.5	3.0	1.7	1.0	1.0
256K	4.0	10.5	21.1	16.2	13.9	12.3	7.6	3.3
512K	0.1	0.8	4.0	6.1	13.5	27.0	23.9	19.0
1 Mbit	0.4	2.5	7.0	22.0	34.1	32.1	23.4	15.2
2 Mbit	N/A	N/A	0.2	1.8	6.7	14.0	27.5	44.5
4 Mbit	N/A	N/A	0	0.2	1.0	3.0	10.0	25.0
Total	22.0	31.2	46.4	55.3	73.9	91.0	93.6	108.0

(Continued)

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MOS ROM--Forecast

Table 3 (Continued)

WORLDWIDE CMOS ROM FORECAST

	Average Selling Price (Dollars/Unit)							
	1984	1985	1986	1987	1988	1989	1990	1991
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	$ 3.00	$ 3.25	$ 3.25	N/A	N/A	N/A	N/A	N/A
16K	$ 4.00	$ 3.25	$ 2.50	$ 2.50	0	N/A	N/A	N/A
32K	$ 2.90	$ 2.00	$ 1.80	$ 1.90	0	N/A	N/A	N/A
64K	$ 4.00	$ 2.40	$ 1.85	$ 1.80	$ 1.80	$ 1.90	$2.05	N/A
128K	$ 4.50	$ 3.00	$ 2.30	$ 2.05	$ 1.95	$ 1.90	$1.90	$1.85
256K	$ 7.25	$ 3.75	$ 2.50	$ 2.20	$ 2.15	$ 1.70	$1.75	$1.80
512K	$45.00	$12.00	$ 6.75	$ 6.15	$ 3.40	$ 2.80	$2.35	$2.15
1 Mbit	$40.00	$15.00	$ 8.50	$ 6.30	$ 4.00	$ 3.35	$2.95	$2.90
2 Mbit	N/A	N/A	$24.00	$10.50	$ 8.60	$ 5.60	$4.00	$3.35
4 Mbit	N/A	N/A	0	$55.00	$30.00	$15.00	$9.00	$4.75
Overall ASP	$ 5.15	$ 4.28	$ 3.77	$ 4.69	$ 4.17	$ 3.65	$3.64	$3.34

N/A = Not Available

Source: Dataquest
June 1987

The Market--1986

Dataquest estimates that worldwide MOS ROM revenue totaled $418 million in 1986, growing by 8 percent over the $388 million market in 1985. After suffering through a three-year bout of depressed prices and sales, shipments increased to 154 million units, up 12 percent from 137 million units in 1985. Notable changes in the ROM market in 1986 included the following:

- Two U.S. vendors (Signetics and Texas Instruments) left the ROM market.
- Japanese vendors introduced their 2-Mbit and 4-Mbit mask ROMs for Kanji character generators (CGs), PC software, and other office automation applications.
- CMOS ROMs are growing and gaining a larger share of the total ROM market as vendors move into densities of 1 Mbit and above. CMOS ROM revenue increased 31 percent, while NMOS ROM revenue declined 5 percent.

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MOS ROM--Forecast

Comparison with Earlier Forecasts

The present MOS ROM forecast contains several significant changes from the earlier Dataquest ROM forecast:

- We believe that the ROM market will increase from about $418 million in 1986 to $542 million in 1987.
- We expect CMOS to exceed NMOS, reaching 55 percent of total ROM revenue in 1988 and 82 percent of revenue by 1991. Virtually every manufacturer is producing CMOS ROMs in all densities, with CMOS being the sole process technology used in next-generation product development.
- More high-density 2-Mbit and 4-Mbit ROM products were shipped in 1986, with 8-Mbit and 16-Mbit production expected on the 1987 horizon.
- Generally, manufacturers of the 2-Mbit and 4-Mbit ROMs are favoring use of the 40-pin DIP package.
- Mask ROM consumption increased substantially in Japan during 1986, spurred on by demand in the computer/video games and word processing application areas.

Market Outlook

The market for high-density ROMs at 512K and above could have considerable growth potential because of high demand in the areas of Kanji CG word processing dictionaries, waveform storage for electronic musical instruments, Kanji ROM for printers, speech synthesis products, hand-held translators, and high-speed 32-bit microprocessor-based systems.

CMOS/NMOS ROMs

Historically, CMOS ROMs have made up only 5 or 6 percent of ROM market revenue. Given the growing need for CMOS ROMs and the fact that the range of CMOS suppliers and products has widened, we expect CMOS process products to increase significantly through the end of the decade. CMOS typically has had a price premium over NMOS ROMs. At the higher densities, however, there is often a problem with power consumption in NMOS.

MOS ROM--Forecast

Competition to ROMs: UV/OTP EPROMs

MOS ROMs have traditionally had to compete with EPROMs in many applications over the last five years. Many of the borderline applications have been lost to EPROMs because of the improved price competitiveness of EPROMs. Many users continue to opt for EPROMs for the following reasons:

- EPROMs reduce component inventory problems.
  - ROMs are programmed during the manufacturing process, usually by customizing the design of one or more layers of the ROM IC. These customized or masked ROMs are generally chosen when a company requires a relatively large quantity of identical devices.
  - ROMs are nonvolatile and well suited to applications where data is to be stored permanently and accessed repetitively. EPROMs, on the other hand, can be stored and programmed on an "as needed" basis for a variety of software programs.
- EPROMs typically have a shorter production turnaround time.
  - Production volumes of ROMs can take from a minimum of 5 to a maximum of 14 weeks from customer submission of tapes to delivery of volume production, although delivery of prototypes can be done in a shorter period of time.
  - With EPROMs, users can get their designs into volume production much more readily and without the initial $3,000 to more than $5,000 mask charge.
  - Specific Japanese ROM manufacturers improved ROM production in 1986 by shortening the period of writing in customer-designated programs; Matsushita, Oki, Sharp, and Toshiba have reduced ROM production from design to delivery from 5 weeks to 10 days.
- One other possible threat to ROMs comes from the one-time programmable (OTP) EPROMs.
  - OPTs are windowless-plastic-packaged EPROMs that have a cost savings of approximately $1.00 to $1.50 over the conventional EPROM package.
  - If these products, which have had some significant technical problems to overcome, are found more acceptable by users, they could become an extremely attractive competitor to MOS ROMs as well as MOS EPROMs.

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MOS ROM--Forecast

The Short-Term Forecast

The market outlook for ROMs in general has significantly improved, after a three-year decline. We expect strong growth through 1988, followed by a period of decline from 1989 through 1991. While the lower and mature 256K-and-below densities fall into the decline phase of the product life cycle, CMOS ROMs (especially at densities of 512K to 4 Mbits) are expected to reach volume production.

Initially introduced by NEC Electronics in 1983, 1-Mbit ROMs had ramped up to shipments of 12 million units by 1986. We expect volume production and increased competition to boost unit shipments to 37 million in 1987.

The Long-Term Forecast

During the last two years, we have seen MOS ROM suppliers developing innovative products and new applications for the next MOS memory market recovery, as follows:

- Matsushita has developed a 4-Mbit NMOS ROM and, more recently, announced development of 8-Mbit and 16-Mbit CMOS ROMs that achieve 200ns access times, equal to the 4-Mbit products. The 8- and 16-Mbit devices are fabricated with Matsushita's 1-micron shallow-trench technology. The 8-Mbit stores 14,000 characters for Kanji word processor dictionaries, while the 16-Mbit can store 28,000 characters.

- Fujitsu, Mitsubishi, NEC, Oki, and Ricoh have developed CMOS versions of the 4-Mbit ROMs at 1.0 to 1.4 microns, with speeds ranging from 150ns to 250ns.

- Fujitsu, Hitachi, NEC, Ricoh, and Toshiba have developed CMOS 2-Mbit ROMs at 1.2 to 1.5 microns, with speeds ranging from 150ns to 200ns.

We expect that the main source of growth will be an expansion in demand for high-performance, high-density CMOS ROM products, with specific application trends. While the lower-end 32K to 256K mask ROMs will be marketed for the software of low-end office automation, computers, and video game applications, the generation of products at 1 Mbit and above will serve the high-speed products such as 32-bit microprocessors and the high-end office-automation segments that demand memories with large storage capacity.

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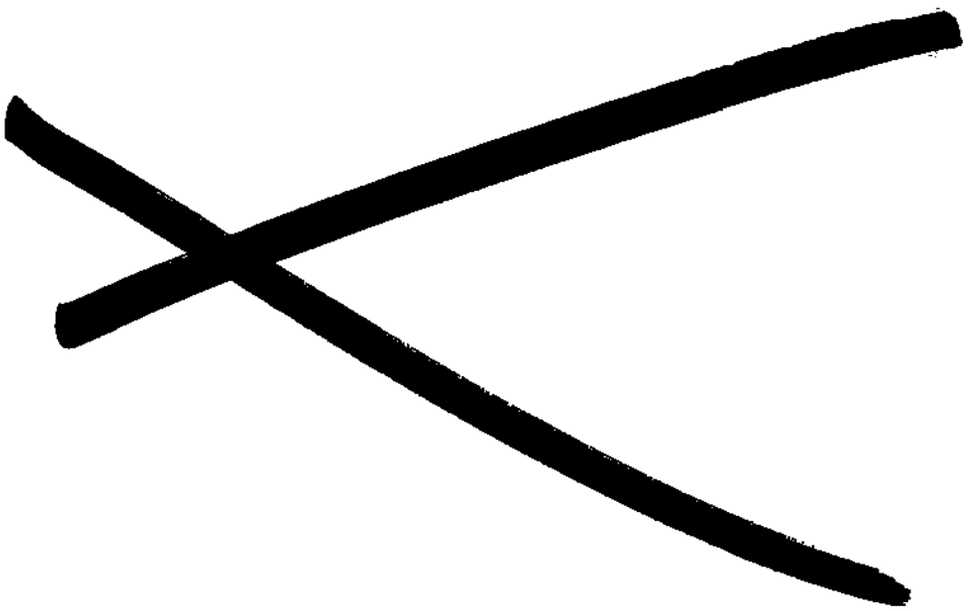

MOS ROM--Product Life Cycles

OVERVIEW

The objectives of this section are to discuss the changes taking place in MOS ROM life cycles and to determine what new directions and strategies are being implemented by ROM manufacturers and users worldwide. Product life cycle analysis offers the following advantages to manufacturers:

- The ability to identify specific market segments over the product life cycle
- The ability to recognize technical opportunities for product innovation
- The ability to determine whether the timing of their entry and departure maximizes their revenue and profits
- The ability to evaluate the strength of their product portfolios

Product life cycle analysis also offers the following advantages to users:

- The ability to make new design decisions
- The ability to develop a commodity plan for purchasing and design engineering that maximizes the availability of vital components and minimizes the cost
- The ability to control and/or alter the product life cycle, given a thorough understanding of its behavior

MOS ROM PRODUCT LIFE CYCLES

Figure 1 illustrates the stage of each group of ROM devices in a standard product life cycle and the typical interval of each stage. The figure shows each product's position in its life cycle phase during 1987. Due to the low-cost technology process used to manufacture ROMs, compared with the high cost of technology used to manufacture other memory devices, the per unit cost is much lower for ROMs. Although ROMs are custom products requiring a unique mask for each code, the initial masking charge is often waived by the manufacturer or amortized into the unit cost for large-volume production. Because the production cost of ROMs purchased in small volumes is much higher due to masking and testing charges, large-volume applications typically have driven ROM bit growth. The large-volume applications that require large amounts of fixed memory include disk drives, graphics display terminals, telecommunication equipment, small and large business computers, and ZIP code monitors.

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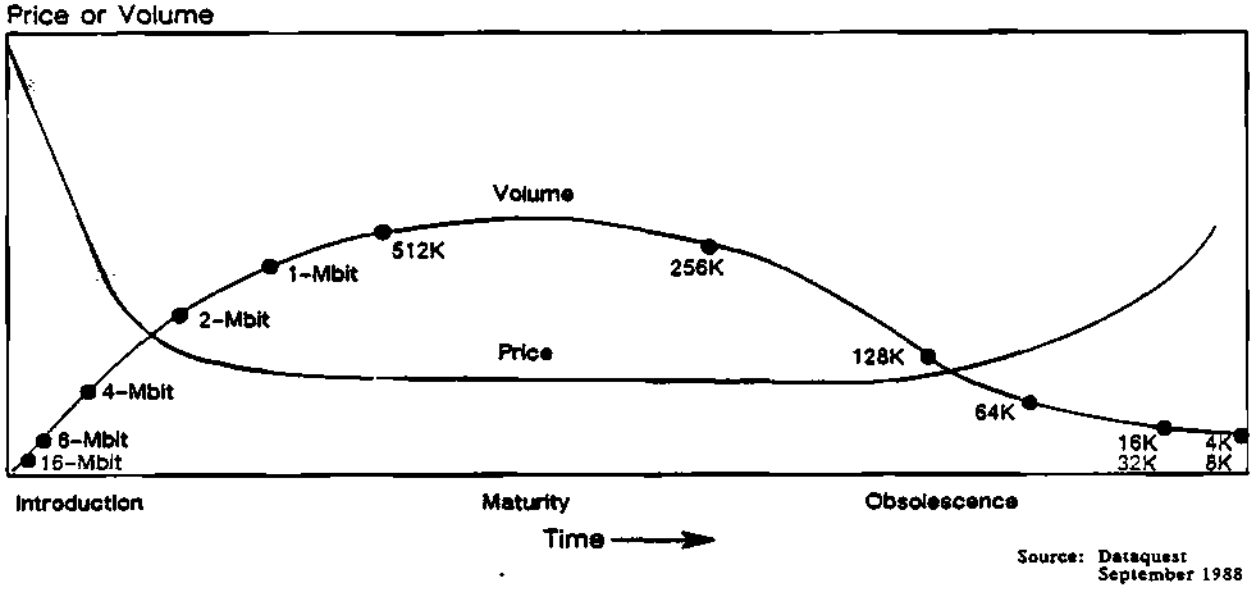
MOS ROM—Product Life Cycles

Figure 1

Typical IC Product Life Cycles
1987



Source: Dataquest
September 1988

Product Life Cycles by Density

The actual life cycle curves for ROMs and how they vary by density are shown in Figures 2a and 2b. Unlike EPROMs that peak and decline slowly through the mature phase, MOS ROMs peak and decline rapidly through that phase.

Traditionally, the lower-density ROMs have peaked during the sixth year of production, with the major exception of 64K devices. Introduced in 1978, the 64K ROM was the densest device in very-high-volume production in 1981; it peaked at 98 million units in 1983, during its fifth year of production. Its early demise can be attributed to a drastic slowdown in the computer and video games market, and the trend away from ROMs to the more price-competitive EPROMs, which are available in low volumes and can be implemented for quick-turnaround applications.

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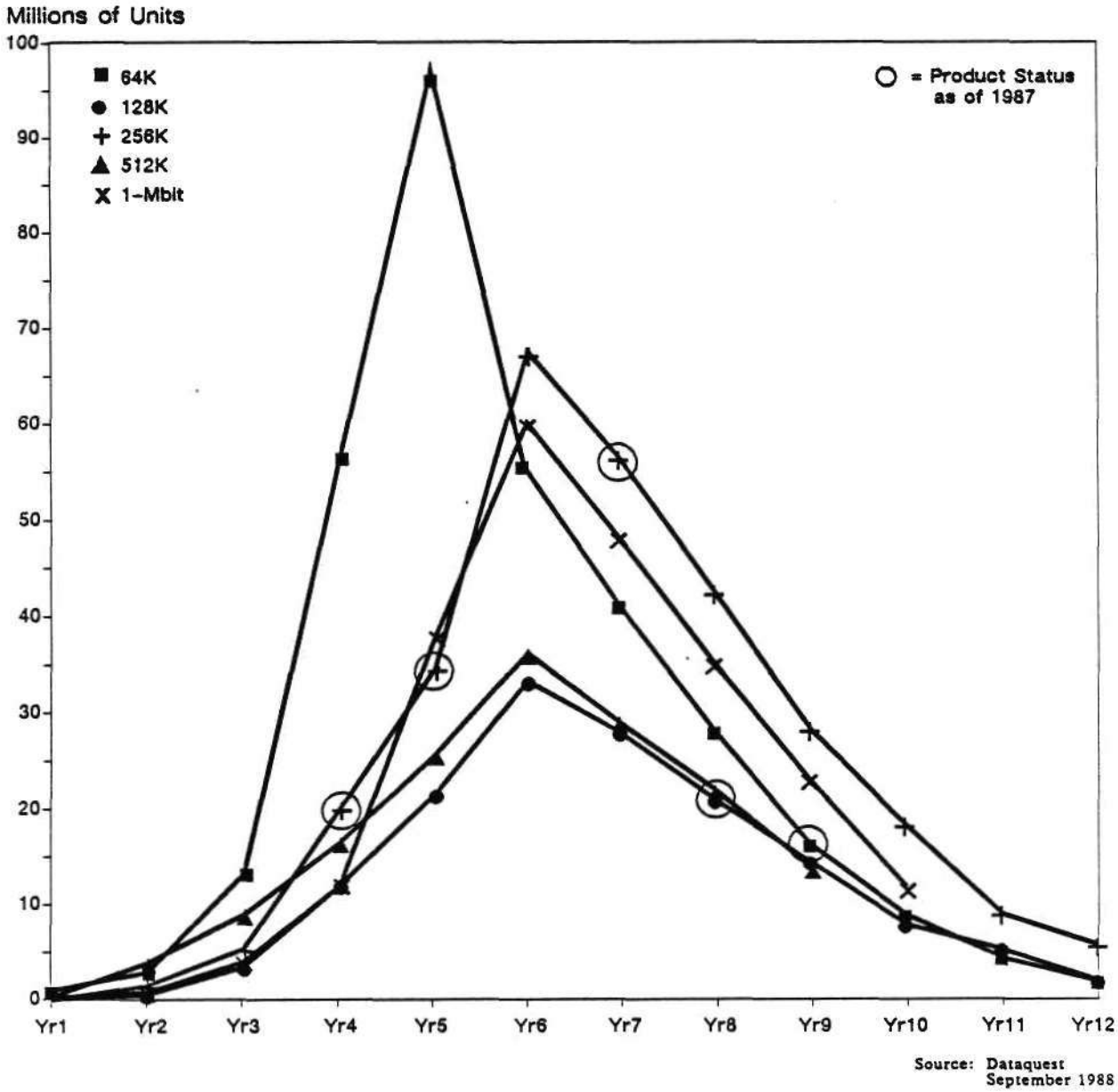
MOS ROM—Product Life Cycles

Figure 2a

MOS ROM Product Life Cycle



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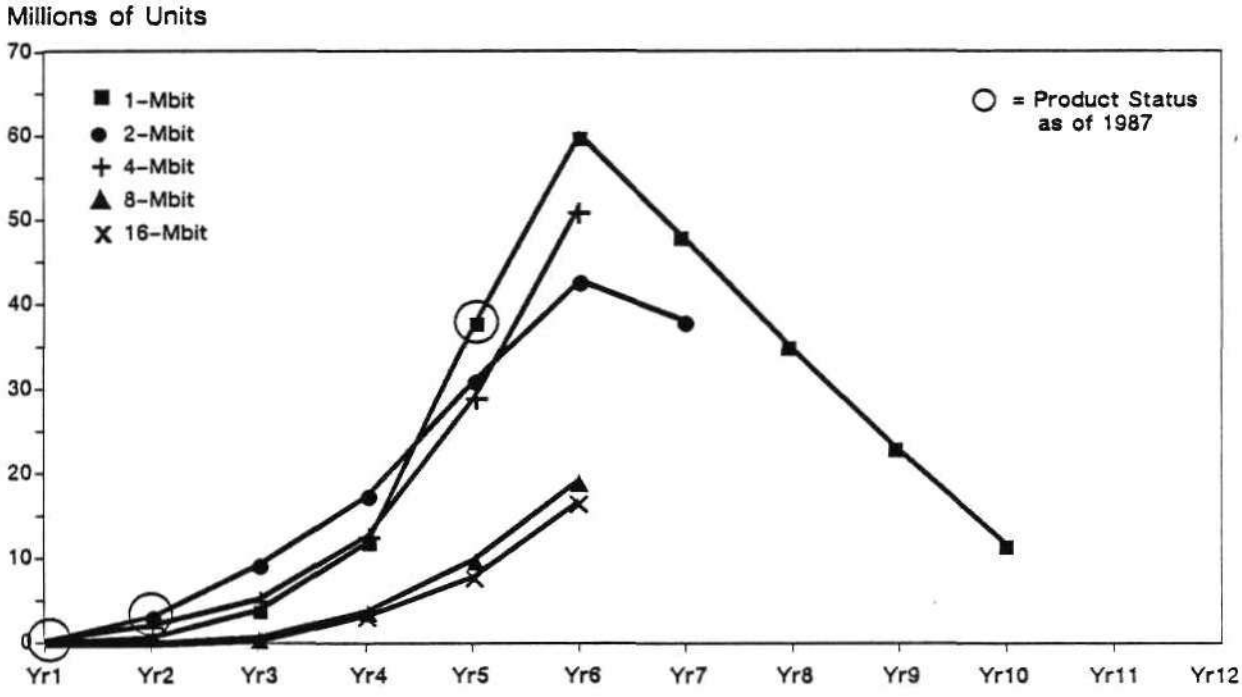
MOS ROM--Product Life Cycles

Figure 2b

MOS ROM Product Life Cycle



Source: Dataquest
September 1988

Product Life Cycles through Time

Figures 3a and 3b illustrate the anticipated behavior of each density through time. As with EPROMs, the historical two-year interval between new density introductions changed with the 256K ROM. The 256K was introduced in 1981, only one year after the 128K was introduced. Although the 512K was not introduced until 1983, its introduction was preceded by the 1-Mbit ROM in early 1983. These introductions were closely followed by the 2-Mbit ROM in 1985, the 4-Mbit in 1986, and the 8- and 16-Mbit in 1987. U.S. and Japanese user demand for the 1-Mbit products for video games and office automation applications has far outstripped supply in the last six months. As such, users are beginning to jump to the 2- and 4-Mbit designs to fill new system product specifications.

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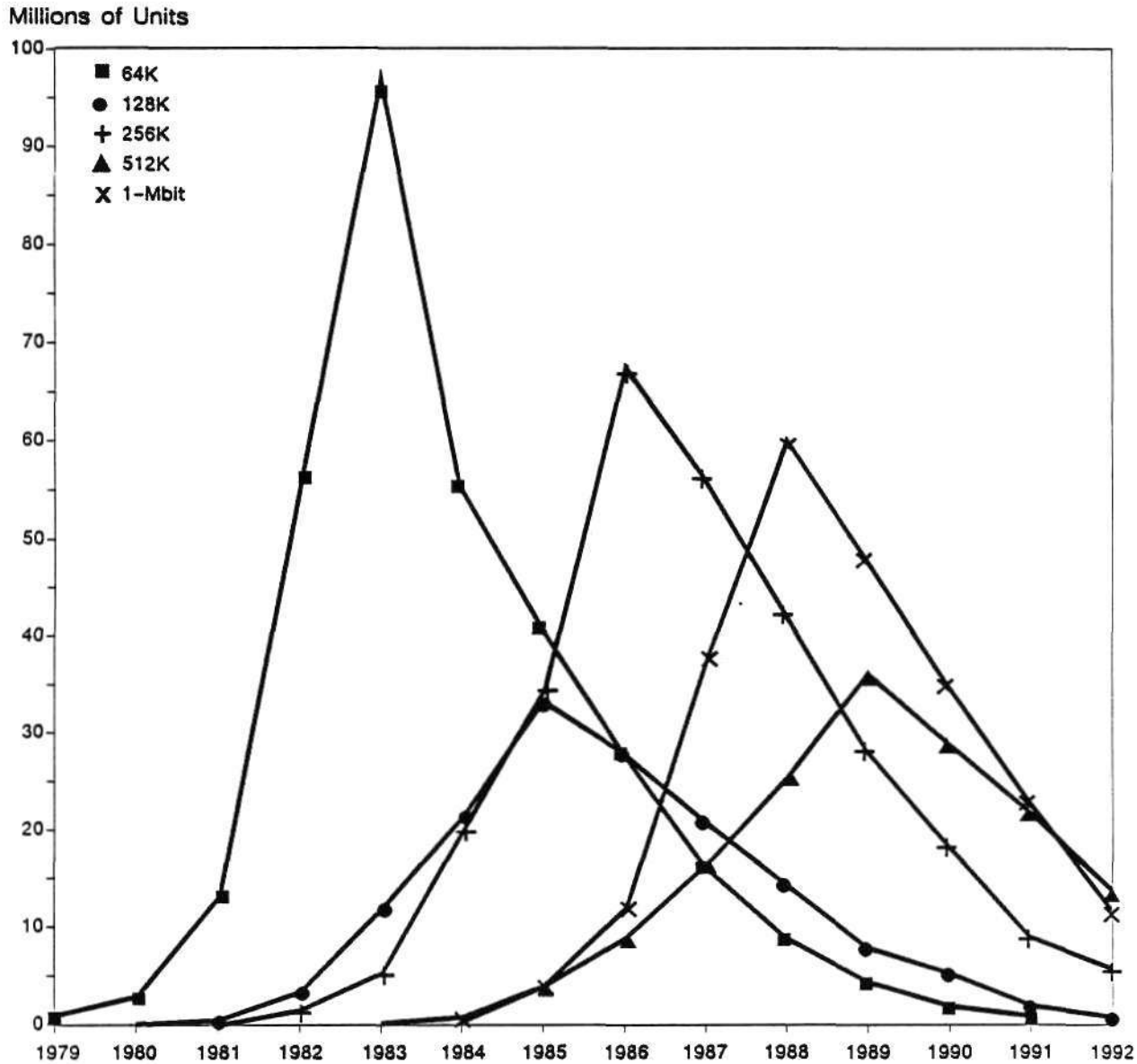
MOS ROM—Product Life Cycles

Figure 3a

MOS ROM Product Life Cycle through Time



Source: Dataquest
September 1988

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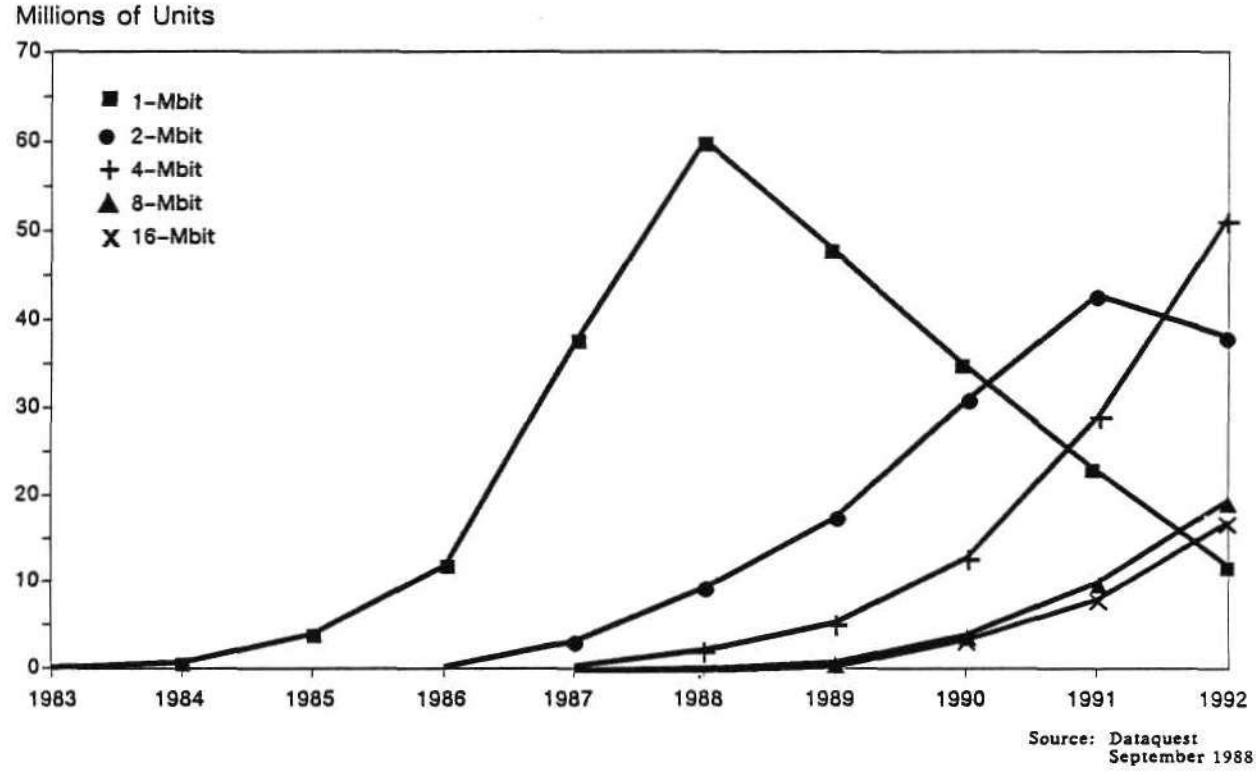
MOS ROM--Product Life Cycles

Figure 3b

MOS ROM Product Life Cycle through Time



Source: Dataquest
September 1988

BIT-GROWTH ANALYSIS

The actual and projected bit growth of the entire ROM product line from 1977 through 1992 is illustrated in Figure 4. Although ROM bits grew significantly between 1977 and 1982, market and application slowdowns from 1982 through 1984 contributed to a major decline in ROM bit growth. The ROM market continued to decline through 1985, but slowly stabilized during 1986 and 1987. Although a projected economic downturn could result in yet another decline in bit growth through late 1989 and 1990, demand for the 4-Mbit and above densities for new applications is expected to promote bit growth in the 1992 and beyond time frame.

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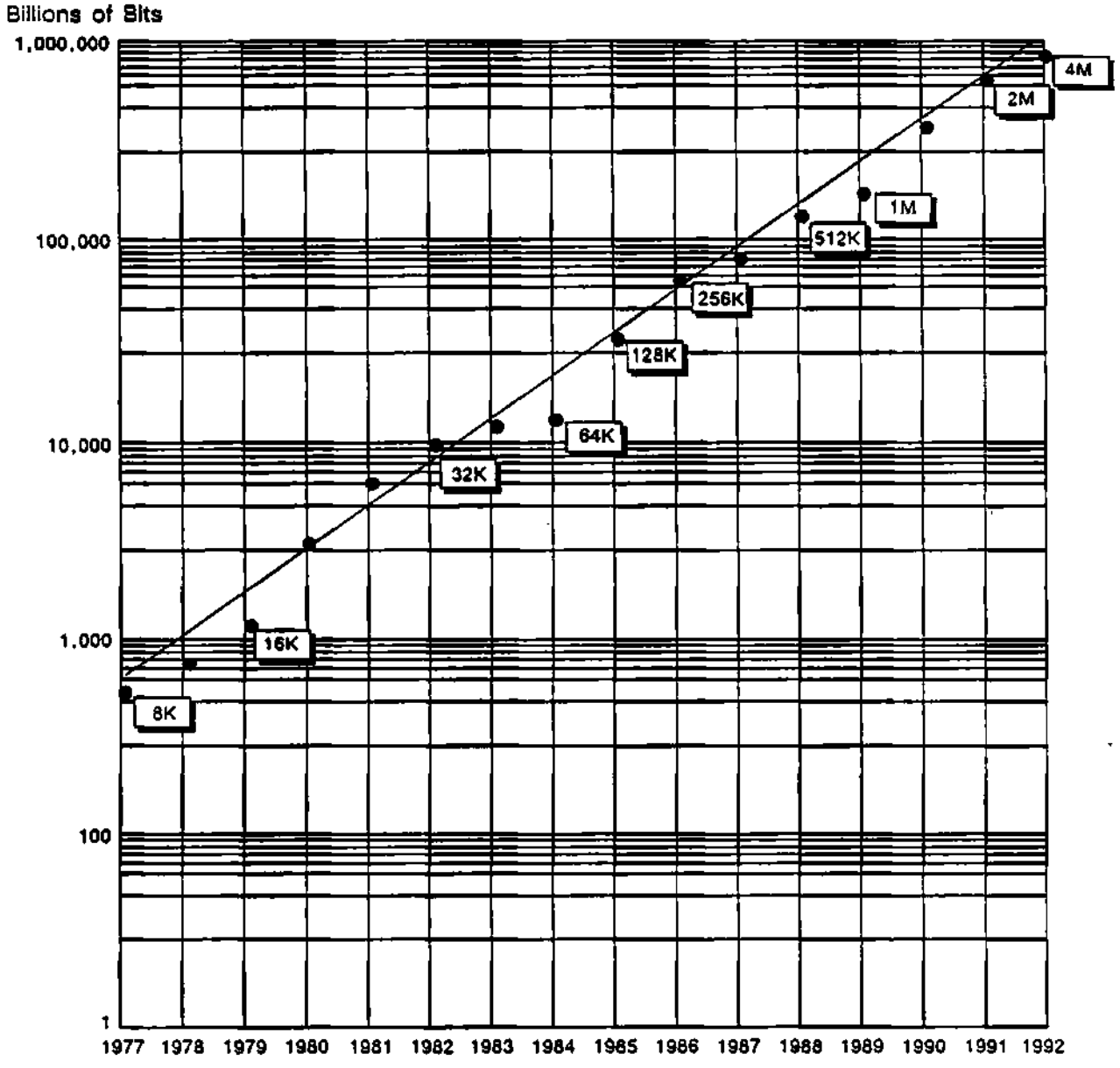
MOS ROM—Product Life Cycles

Figure 4

MOS ROM Bit Growth



Source: Dataquest
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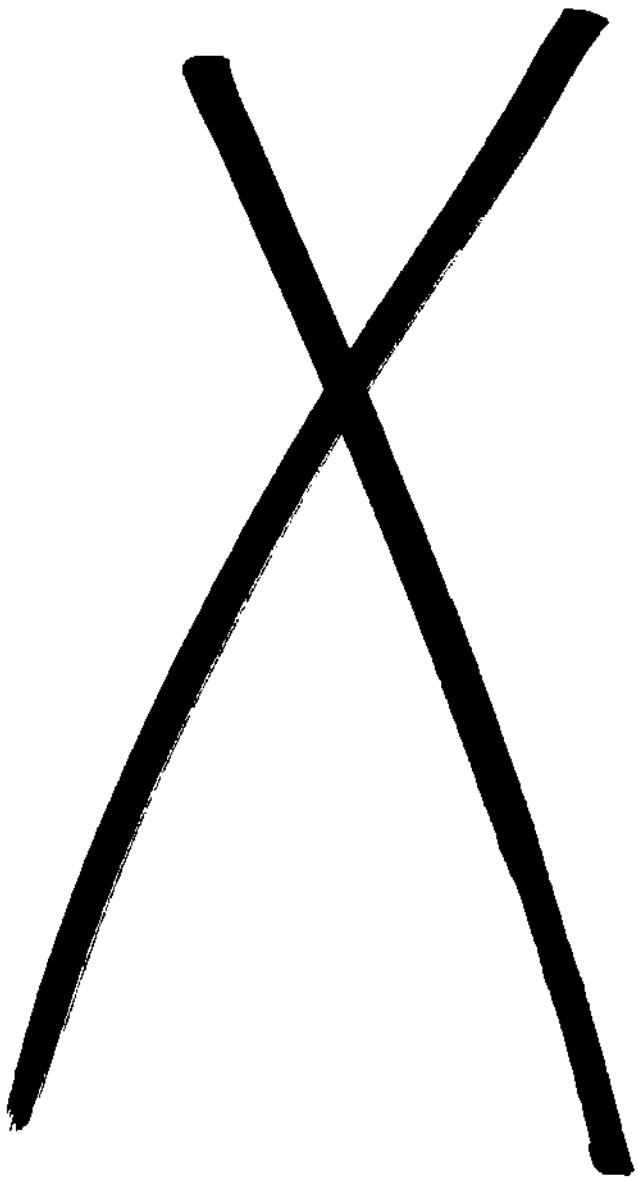

MOS ROM--Data

YEARLY COMPANY MOS ROM SHIPMENT DATA

This section contains unit shipment data on MOS ROMs for 1987 and 1988. At the bottom of each table, we show unit shipment and market share data for companies based in the United States, Japan, Europe, and Asia Pacific. The tables are organized as follows:

- Table 1—16K MOS ROM Shipment Data, 1987 and 1988
- Table 2—32K MOS ROM Shipment Data, 1987 and 1988
- Table 3—64K MOS ROM Shipment Data, 1987 and 1988
- Table 4—128K MOS ROM Shipment Data, 1987 and 1988
- Table 5—256K MOS ROM Shipment Data, 1987 and 1988
- Table 6—512K MOS ROM Shipment Data, 1987 and 1988
- Table 7—1-Mbit MOS ROM Shipment Data, 1987 and 1988
- Table 8—2-Mbit MOS ROM Shipment Data, 1987 and 1988
- Table 9—4-Mbit MOS ROM Shipment Data, 1987 and 1988
- Table 10—8-Mbit MOS ROM Shipment Data, 1987 and 1988
- Table 11—16-Mbit MOS ROM Shipment Data, 1987 and 1988

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MOS ROM--Data

Table 1

16K MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
El Cap	NMOS	0.1	0.0
Gould	NMOS	0.5	0.1
Hua Ko	NMOS	0.1	0
NCR	NMOS	0.5	0.2
RCA	CMOS	0.5	0.5
Total		1.7	0.8
Market Share			
United States		88%	99%
Japan		0	0
Europe		0	0
Asia Pacific		12	1
Total		100%	100%

Source: Dataquest
April 1989

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MOS ROM--Data

Table 2

32K MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
El Cap	NMOS	0.3	0.6
Erso	NMOS	2.4	2.0
Gould	NMOS	0.5	0.1
Harris	CMOS	0.5	0.4
Microchip Tech. Inc.	NMOS	0.7	0.5
NCR	NMOS	1.0	2.0
Oki	CMOS	1.2	0
RCA	CMOS	1.0	0.5
Sharp	NMOS/CMOS	0	2.8
UMC	NMOS	5.1	2.4
Total		12.7	11.3
Market Share			
United States		29%	31%
Japan		9	25
Europe		0	0
Asia Pacific		61	44
Total		100%	100%

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

Source: Dataquest
April 1989

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Table 3

64K MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
Austria Mikros Systems	NMOS	0	0.6
El Cap	NMOS	0	0
Gould	NMOS/CMOS	2.8	2.5
Harris	CMOS	1.0	1.5
Hitachi	CMOS	0	0
Hua Ko	CMOS	0.3	0.1
Macronix	CMOS	0	0.3
Matsushita	CMOS	0	0
Microchip Tech. Inc.	NMOS/CMOS	2.6	2.0
Mitsubishi	CMOS	0.1	0
NCR	NMOS	2.0	4.0
NEC	NMOS/CMOS	3.5	1.2
Oki	NMOS	1.6	0
RCA	CMOS	1.7	1.7
Sharp	NMOS/CMOS	8.0	8.0
Toshiba	NMOS/CMOS	0	0
UMC	NMOS	0	0
VLSI Tech. Inc.	CMOS	1.0	0
Total		24.7	22.0
Market Share			
United States		45%	55%
Japan		53	42
Europe		0	3
Asia Pacific		1	1
Total		100%	100%

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

Source: Dataquest
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MOS ROM--Data

Table 4

128K MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
Austria Mikros Systems	CMOS	0	0.3
Fujitsu	CMOS	1.5	0
Gould	NMOS	1.9	1.5
Harris	CMOS	2.0	0.5
Macronix	NMOS	0	0
Matsushita	CMOS	0	0
Microchip Tech. Inc.	NMOS	1.5	0.5
Mitsubishi	CMOS	0	0
NCR	NMOS	1.0	2.0
NEC	CMOS	0.7	0.4
RCA	CMOS	2.5	1.8
Ricoh	NMOS/CMOS	2.5	1.0
Sharp	NMOS/CMOS	1.0	0
Toshiba	NMOS/CMOS	2.0	0
VLSI Tech. Inc.	CMOS	1.4	0
Total		18.0	8.0
Market Share			
United States		57%	79%
Japan		43	17
Europe		0	4
Asia Pacific		0	0
Total		100%	100%

Source: Dataquest
April 1989

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Table 5

256K MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	Speed	1987	1988
Austria Mikros Systems	CMOS		0	1.0
El Cap	NMOS		0	0
Fujitsu	CMOS		5.0	0.1
Gould	NMOS/CMOS	150ns	1.0	1.0
Harris	CMOS		2.5	1.4
Hitachi	CMOS		0	0
Hua Ko	CMOS		1.0	0.5
Macronix	NMOS	200ns	0	0.2
Matsushita	CMOS		4.0	0
Microchip Tech. Inc.	NMOS/CMOS		0.5	0.5
Mitsubishi	CMOS		0	0
NCR	NMOS		0.5	1.0
NEC	CMOS		6.0	1.3
Oki	NMOS		4.0	0
RCA	CMOS		4.0	4.0
Ricoh	NMOS/CMOS		5.0	7.0
Sharp	NMOS/CMOS		5.0	10.2
Toshiba	NMOS/CMOS		5.0	3.0
VLSI Tech. Inc.	CMOS		3.0	2.0
Total			46.5	33.3

Market Share		
United States	25%	30%
Japan	73	65
Europe	0	3
Asia Pacific	2	2
Total	100%	100%

Source: Dataquest
April 1989

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MOS ROM--Data

Table 6

512K MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
Fujitsu	CMOS	4.3	0.4
Gould	CMOS	0.5	4.5
Harris	CMOS	1.5	8.1
Macronix	NMOS	0	0
Matsushita	CMOS	3.0	2.3
Sharp	CMOS	15.0	13.9
Sony	CMOS	2.0	0
VLSI Tech. Inc.	CMOS	1.4	0.4
Total		27.7	29.6
Market Share			
United States		12%	44%
Japan		88	56
Europe		0	0
Asia Pacific		0	0
Total		100%	100%

Source: Dataquest
April 1989

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Table 7

1-Mbit MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
Fujitsu	CMOS	4.4	6.0
Gold Star	CMOS	0.5	0.3
Harris	CMOS	2.0	3.0
Hitachi	CMOS	5.7	4.0
Macronix	CMOS	0	0.3
Matsushita	CMOS	2.2	8.0
Mitsubishi	CMOS	0.1	0
NEC	CMOS	1.0	2.0
Oki	CMOS	3.0	1.3
Ricoh	CMOS	6.5	13.3
Seiko	CMOS	3.0	1.5
Sharp	CMOS	7.8	17.0
Sony	CMOS	2.0	0
Toshiba	CMOS	4.0	8.0
VLSI Tech. Inc.	CMOS	1.5	0.5
Total		43.7	65.2
Market Share			
United States		8%	6%
Japan		91	94
Europe		0	0
Asia Pacific		1	0
Total		100%	100%

Source: Dataquest
April 1989

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MOS ROM--Data

Table 8

2-Mbit MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
Fujitsu	CMOS	S	5.0
Hitachi	CMOS	S	6.0
Macronix	CMOS	0	0.1
Matsushita	CMOS	0.4	0
NEC	CMOS	2.4	2.8
Sharp	CMOS	0	15.5
Toshiba	CMOS	0.1	0.8
Total		2.9	30.2
Market Share			
United States		0	0
Japan		100%	100%
Europe		0	0
Asia Pacific		0	0
Total		100%	100%

S = Sampling

Source: Dataquest
April 1989

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Table 9

4-Mbit MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
Fujitsu	CMOS	S	2.0
Hitachi	CMOS	0	5.0
Macronix	CMOS	0	0.1
Matsushita	CMOS	0.4	3.0
Mitsubishi	CMOS	0.4	0
NEC	CMOS	0	S
Sharp	CMOS	S	2.6
Toshiba	CMOS	0	0
Total		0.8	12.7
Market Share			
United States		0	1%
Japan		100%	99
Europe		0	0
Asia Pacific		0	0
Total		100%	100%

Source: Dataquest
April 1989

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MOS ROM--Data

Table 10

8-Mbit MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
Hitachi	CMOS	N/A	S
Matsushita	CMOS	S	0
Sharp	CMOS	N/A	0.1
Toshiba	CMOS	S	0
Total		0	0.1
Market Share			
United States		0	0
Japan		0	100%
Europe		0	0
Asia Pacific		0	0
Total		0	100%

N/A = Not Available
S = Sampling

Source: Dataquest
April 1989

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Table 11

16-Mbit MOS ROM Shipment Data
1987 and 1988
(Thousands of Units)

Company	MOS Process	1987	1988
Hitachi	CMOS	N/A	S
Matsushita	CMOS	S	0
Sharp	CMOS	N/A	S
Toshiba	CMOS	N/A	S
Total		0	0
Market Share			
United States		0	0
Japan		0	100%
Europe		0	0
Asia Pacific		0	0
Total		0	100%

N/A = Not Available
S = Sampling

Source: Dataquest
April 1989

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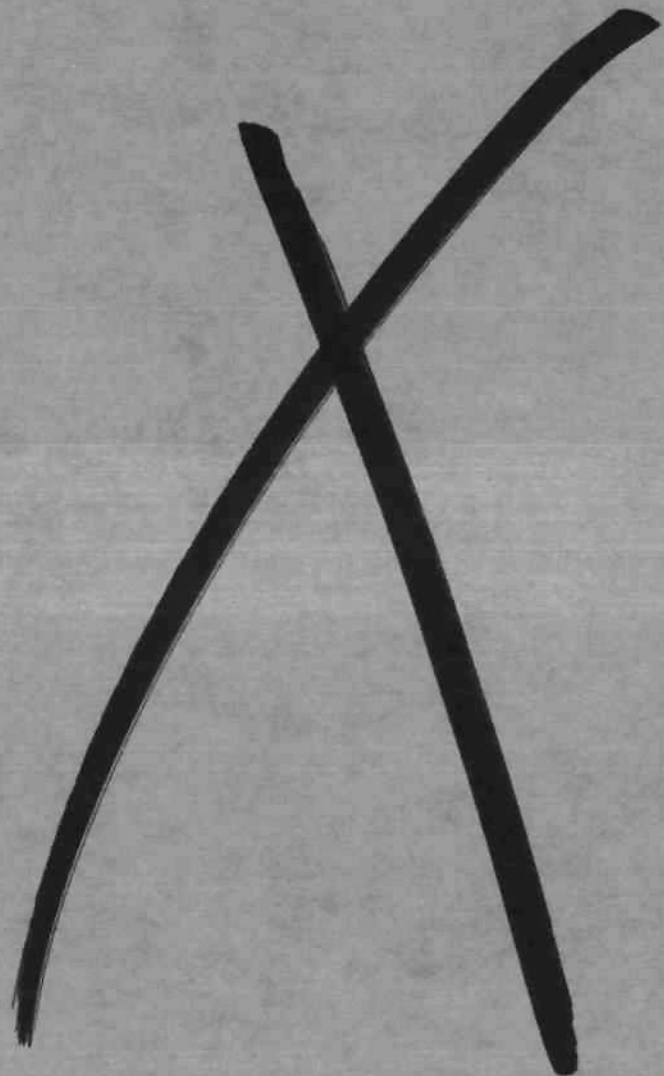

MOS EPROM--Price Learning Curves

OVERVIEW OF PRICE LEARNING CURVES

Applying learning curves to MOS EPROM product prices can be a strategic tool for long-range business planning and analysis. Unlike cost experience curves, price curves are heavily influenced by extraneous market forces such as competition, substitute technology, general economic conditions, and/or supply and demand dynamics. The experience curve concept was developed by the Boston Consulting Group in the late 1960s. The concept is based on historical studies showing that costs decrease between 20 and 30 percent each time the accumulated experience for a product or commodity doubles. This same concept can be applied to the MOS EPROM price learning curve.

The objective of this section is to illustrate the application of learning curves to overall MOS EPROM and specific MOS EPROM device density prices. The curves are plotted on a logarithmic scale in order to show the relationship of the percent change in price relative to the percent change in cumulative volume as a straight line. This more easily allows the user to calculate the rate of price change within the growth in cumulative volume.

MOS EPROM PRICE LEARNING CURVES

Figure 1 encompasses the accumulated bits shipped for total MOS EPROMs from 1976 through 1987, illustrating how prices gravitate around the declining slope of an experience curve over time. Figures 2 through 5 illustrate price learning curve developments for the 16K, 64K, 256K, and 1-Mbit MOS EPROM densities through 1987.

While MOS EPROM prices traditionally followed an 80 percent decline, as shown in Figure 2, certain notable changes occurred over time. During the industry boom periods of 1978 and 1979 and again in 1983 and 1984, product shortages and vendor controls drove prices up above the 80 percent curve norm. During the early 1980s and again in 1985 and 1986, the industry balloon burst. Capacity utilization rates declined; prices dropped, sometimes below cost; and the industry fell into a deep recession.

A price stabilization period in 1986, as a result of the trade agreement between the United States and Japan, is reflected at the end of the curve. Foreign market values (FMVs) were stipulated in the agreement to act as minimum prices for EPROMs fabricated in Japan and sold in the United States. (These FMVs are based on a cost model and are determined by the U.S. Department of Commerce on a quarterly basis.) The trade agreement also called for a narrowing of the price differentials between U.S. prices and those in Asia and Europe. In the first half of 1987, MITI imposed EPROM production cuts just as demand was beginning to pick up. Shortages and increased demand in 1987 have raised EPROM prices substantially.

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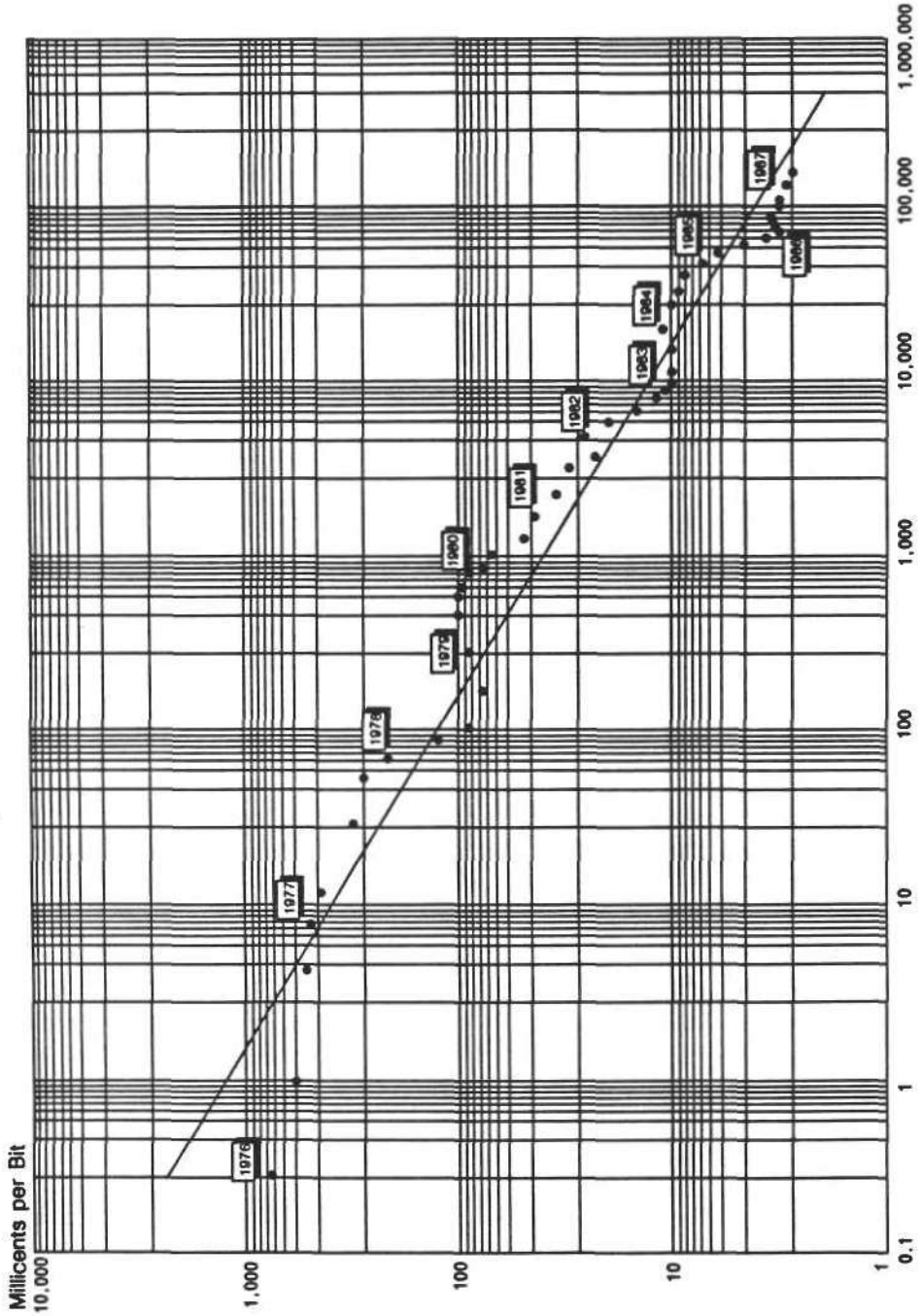
MOS EPROM--Price Learning Curves

Figure 1

MOS EPROM Price Learning Curve*



* The EPROM price learning curve is based on actual quarterly data from 1976 through 1987.

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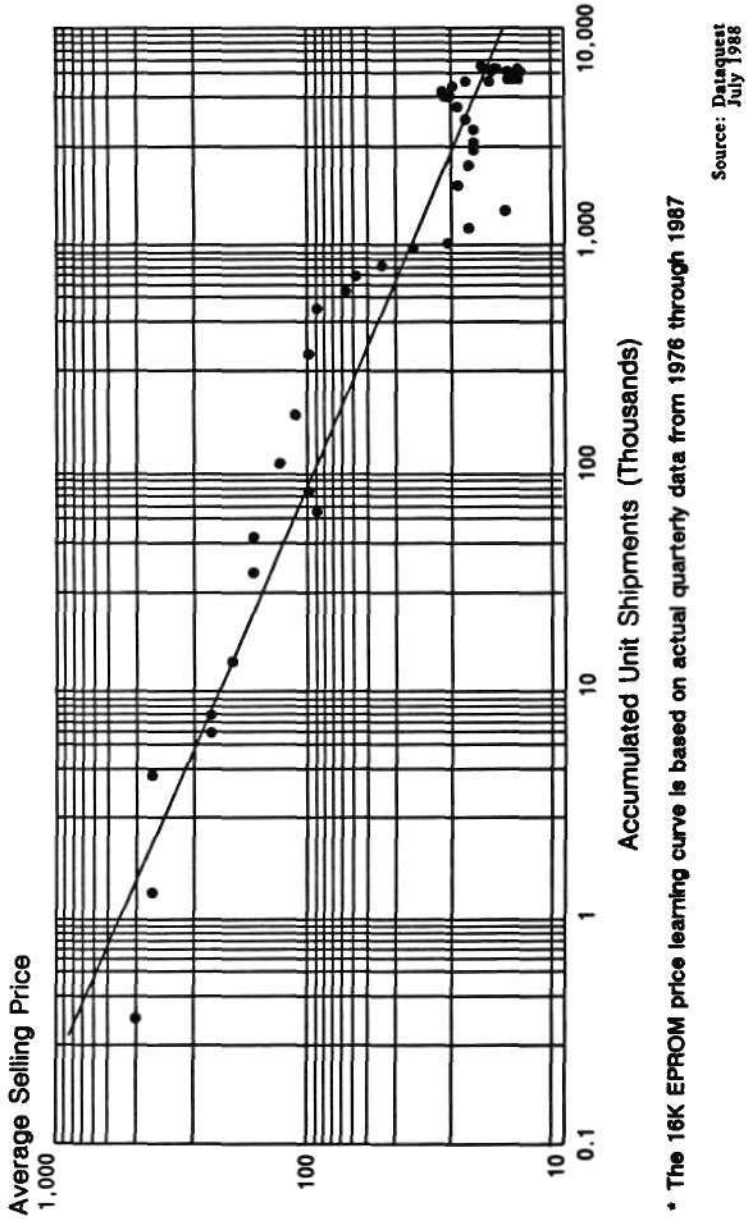
MOS EPROM--Price Learning Curves

Figure 2

16K MOS EPROM Price Learning Curve*



* The 16K EPROM price learning curve is based on actual quarterly data from 1976 through 1987

Source: Dataquest July 1988

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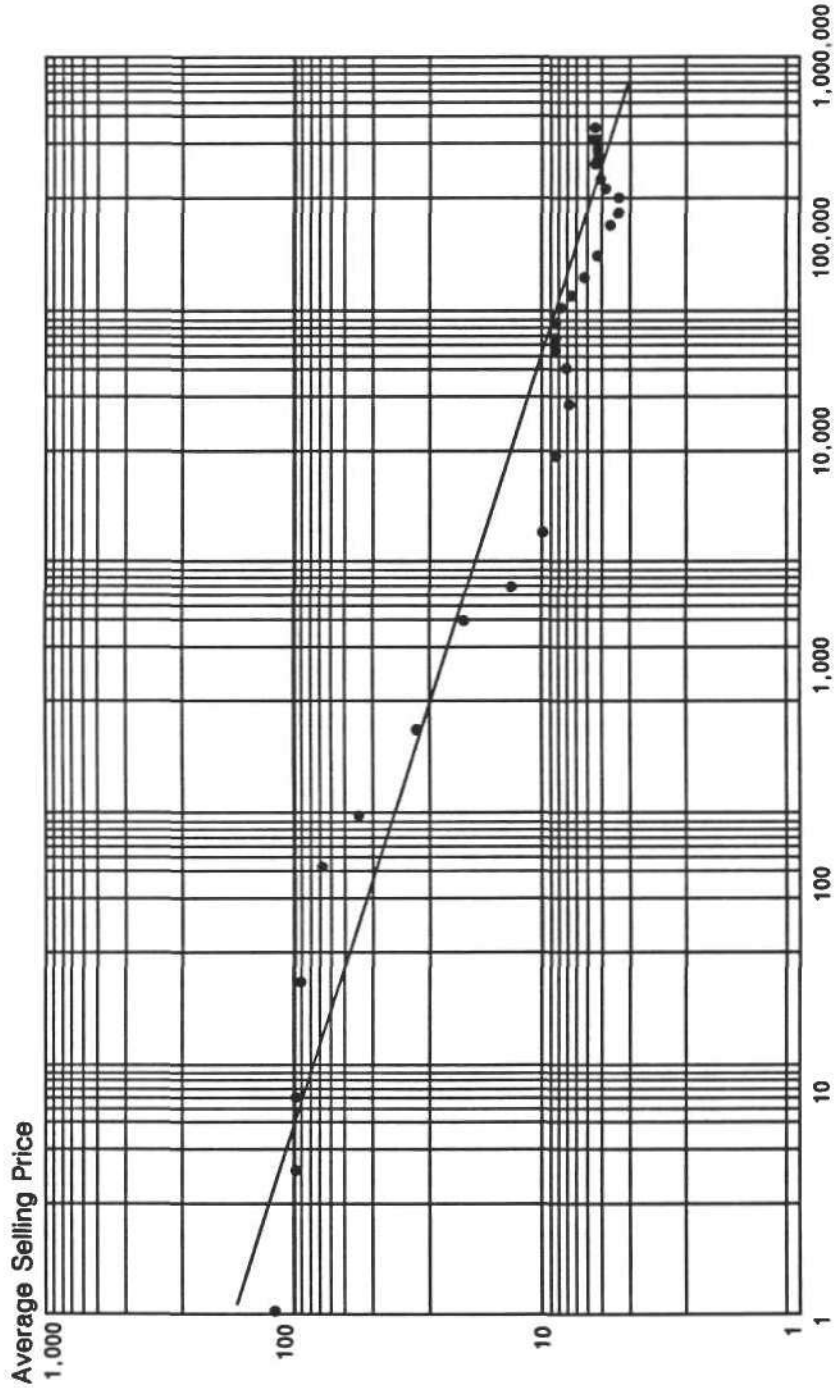
MOS EPROM--Price Learning Curves

Figure 3

64K MOS EPROM Price Learning Curve*



* The 64K EPROM price learning curve is based on actual quarterly data from 1980 through 1987.

Source: Dataquest July 1988

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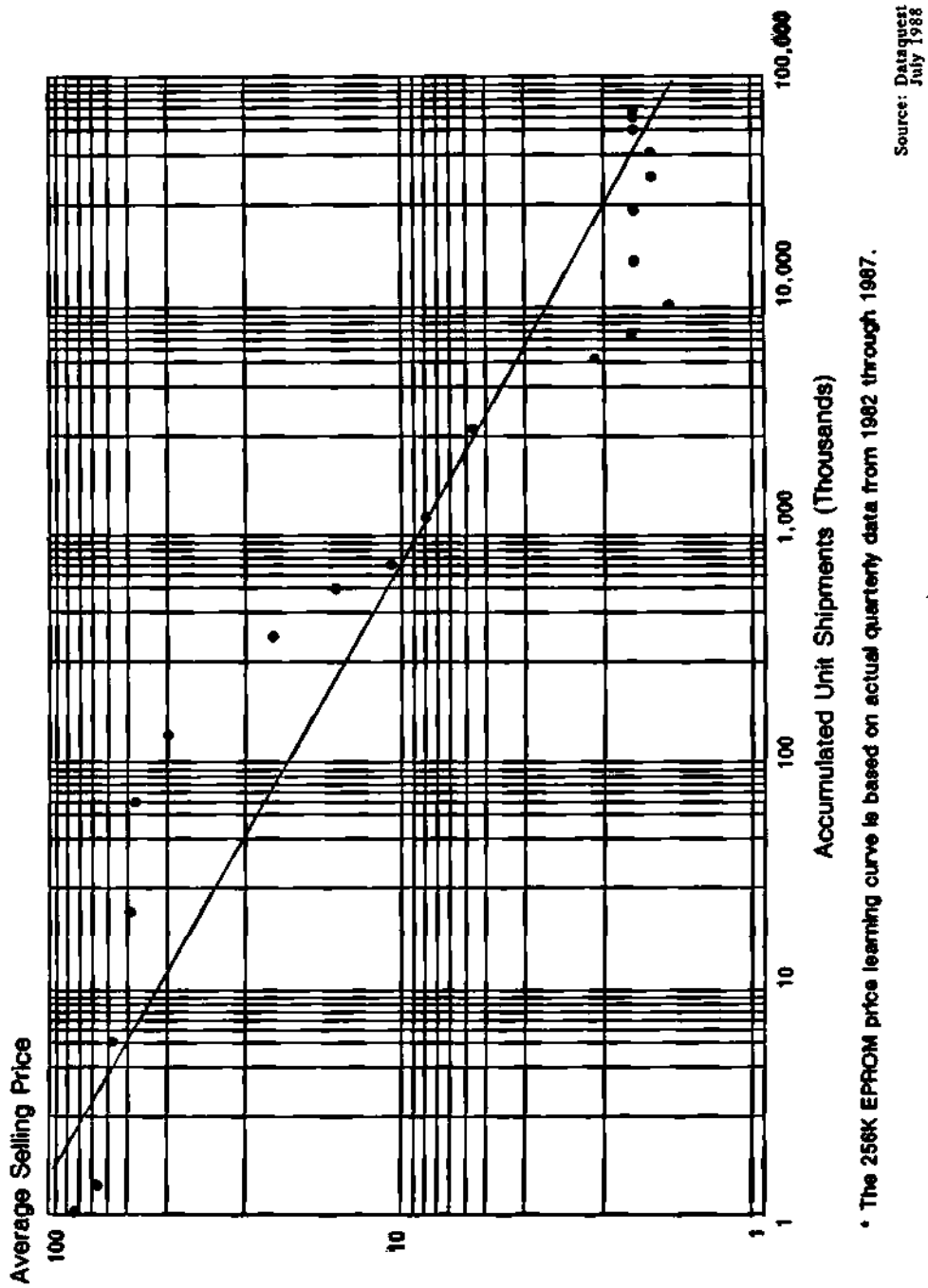
MOS EPROM--Price Learning Curves

Figure 4
256K MOS EPROM Price Learning Curve*



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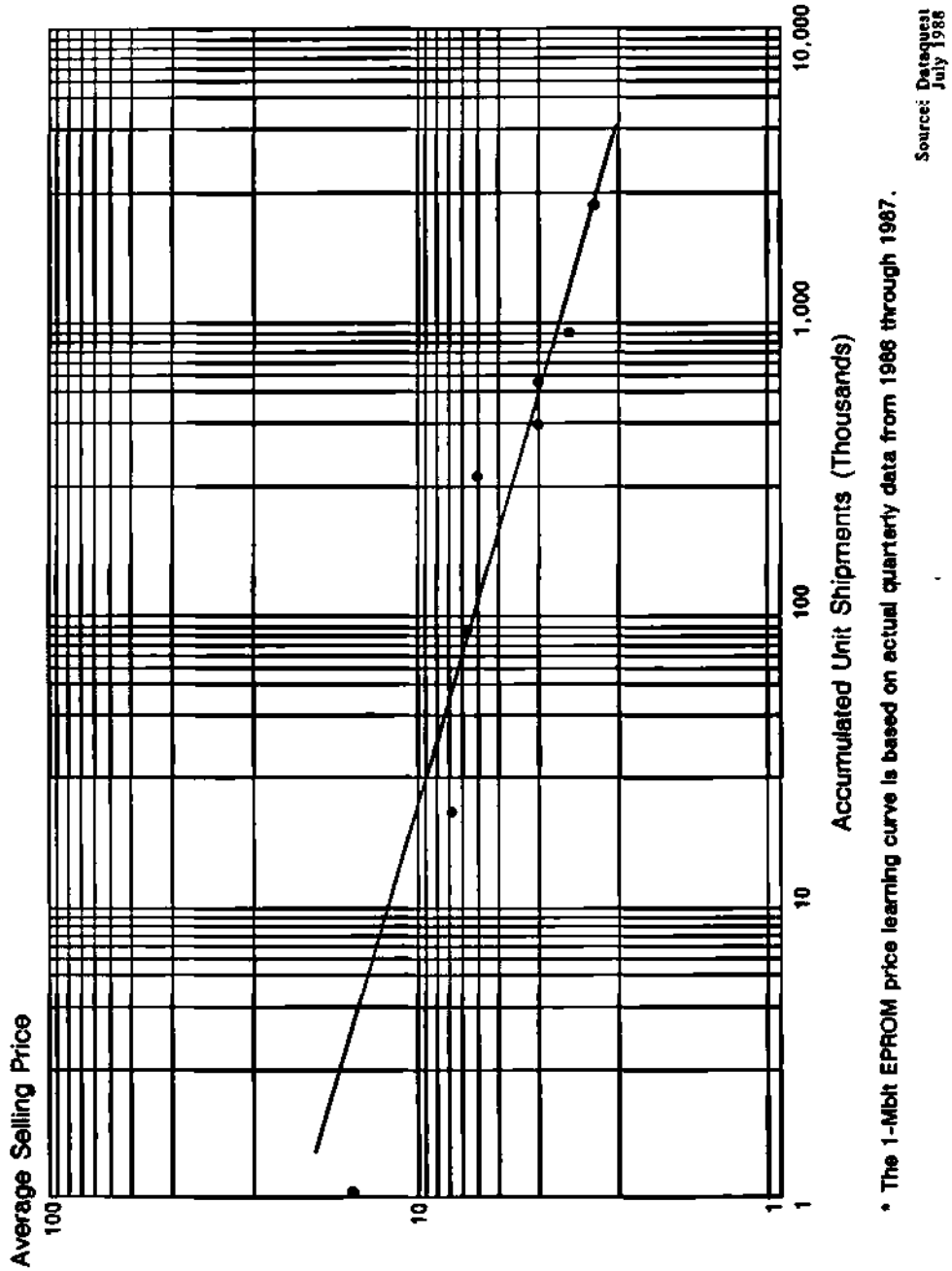
MOS EPROM--Price Learning Curves

Figure 5

1-Mbit MOS EPROM Price Learning Curve*



* The 1-Mbit EPROM price learning curve is based on actual quarterly data from 1986 through 1987.

Source: Dataquest July 1988

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MOS EPROM--Price Learning Curves

DATAQUEST ANALYSIS

Trade agreement FMVs and MITI-imposed production cuts continue to play a major role in the EPROM price learning curves. Although the learning curve for the 1-Mbit EPROM is steep, the curve began at a lower level than that of previous generations. Introduced during a semiconductor downturn, 1-Mbit EPROM development and acceptance has been slow. These factors, in conjunction with continued political intervention, have resulted in slowly declining prices.

As nonvolatile memory product development moves into the 2-Mbit, 4-Mbit, and 8-Mbit densities at submicron levels, manufacturers will no longer be able to afford the high cost of R&D investment with minimal profit margins. The manufacturer's concerns for profits and cautious buildup in capacity may very well change the structure of the EPROM product area and the learning curve slope over the next five years.

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MOS EPROM--Forecast

Dataquest's MOS EPROM data consist of revenue, unit shipments, and prices for MOS EPROM product lines. Table 1 lists the top-level market data for all of the tables. The data include all EPROM revenue, regardless of the technology employed (NMOS or CMOS) or package type (plastic or ceramic). The tables included in these data are as follows:

- Table 1--MOS EPROMs--Total Worldwide Market
- Table 2--Worldwide NMOS EPROM Market--Total (UV and OTP)
- Table 3--Worldwide CMOS EPROM Market—Total (UV and OTP)
- Table 4—Worldwide MOS UV EPROM Market—Total (NMOS and CMOS)
- Table 5--Worldwide NMOS UV EPROM Market
- Table 6--Worldwide CMOS UV EPROM Market
- Table 7--Worldwide MOS OTP EPROM Market—Total (NMOS and CMOS)
- Table 8—Worldwide NMOS OTP EPROM Market
- Table 9—Worldwide CMOS OTP EPROM Market

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MOS EPROM--Forecast

Table 1

MOS EPROMs—Total Worldwide Market

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 35	$ 27	$ 33	$ 31	$ 28	$ 28	$ 26	$ 26
32K	48	46	50	45	40	36	34	31
64K	266	227	254	247	220	216	172	122
128K	163	201	254	239	194	121	103	89
256K	320	548	634	592	512	439	418	393
512K	68	254	449	496	395	317	255	216
1Mb	12	46	176	521	741	757	651	554
2Mb	0	0	0	11	25	119	445	648
4Mb	0	0	18	77	182	536	802	1,096
8Mb	0	0	0	0	0	0	5	136
Total	$913	$1,350	$1,868	$2,258	$2,338	$2,569	$2,911	$3,312
% Change from Previous Year	4%	48%	38%	21%	4%	10%	13%	14%

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	14.7	9.7	8.6	7.8	7.0	6.8	6.4	6.2
32K	21.6	16.2	13.9	11.6	10.0	8.8	8.0	7.3
64K	99.6	75.7	65.3	61.0	54.0	52.0	40.0	28.0
128K	57.3	57.6	61.9	58.0	47.0	28.8	23.6	20.1
256K	70.0	118.4	130.8	130.0	122.0	102.0	95.0	86.0
512K	5.7	30.9	60.9	78.0	77.5	69.0	54.0	45.0
1Mb	0.2	1.7	9.0	37.2	68.0	88.0	87.8	85.0
2Mb	0	0	0	0.3	1.4	10.0	50.0	82.0
4Mb	0	0	0.2	1.7	7.0	36.0	81.0	126.0
8Mb	0	0	0	0	0	0	0.1	4.0
Total	269.1	310.1	350.7	385.6	393.9	401.4	445.9	489.6
% Change from Previous Year	10%	15%	13%	10%	2%	2%	11%	10%

(Continued)

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MOS EPROM--Forecast

Table 1 (Continued)

MOS EPROMs—Total Worldwide Market

	Average Selling Price ($)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 2.40	$ 2.80	$ 3.88	$ 4.00	$ 4.00	$ 4.07	$ 4.10	$ 4.20
32K	$ 2.24	$ 2.83	$ 3.57	$ 3.88	$ 4.04	$ 4.10	$ 4.20	$ 4.25
64K	$ 2.67	$ 3.00	$ 3.89	$ 4.05	$ 4.08	$ 4.15	$ 4.30	$ 4.35
128K	$ 2.85	$ 3.50	$ 4.10	$ 4.12	$ 4.12	$ 4.20	$ 4.35	$ 4.45
256K	$ 4.57	$ 4.63	$ 4.85	$ 4.55	$ 4.20	$ 4.30	$ 4.40	$ 4.57
512K	$11.96	$ 8.23	$ 7.36	$ 6.36	$ 5.10	$ 4.60	$ 4.72	$ 4.80
1Mb	$56.87	$27.54	$19.51	$14.00	$10.90	$ 8.60	$ 7.42	$ 6.52
2Mb	0	0	0	$35.00	$18.00	$11.90	$ 8.90	$ 7.90
4Mb	0	0	$80.00	$45.00	$26.00	$14.90	$ 9.90	$ 8.70
8Mb	0	0	0	0	0	$90.00	$50.00	$34.00
Overall ASP	$ 3.39	$ 4.35	$ 5.33	$ 5.85	$ 5.94	$ 6.40	$ 6.53	$ 6.76
% Change from Previous Year	(5%)	28%	22%	10%	1%	8%	2%	4%

Source: Dataquest
August 1989

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MOS EPROM--Forecast

Table 2

Worldwide NMOS EPROM Market—Total (UV and OTP)

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 35	$ 19	$ 18	$ 12	$ 11	$ 9	$ 8	$ 7
32K	44	36	42	34	26	23	21	18
64K	206	143	145	90	57	45	36	23
128K	152	157	174	144	107	58	43	33
256K	237	312	262	163	116	80	81	52
512K	63	179	279	236	138	87	50	29
1Mb	3	8	28	94	56	25	15	11
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
Total	$740	$854	$949	$773	$510	$327	$253	$173
% Change from Previous Year	(6%)	15%	11%	(18%)	(34%)	(36%)	(23%)	(31%)

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	14.7	7.3	5.6	3.5	2.9	2.4	1.9	1.7
32K	18.9	13.1	11.9	9.3	7.0	5.8	5.0	4.3
64K	82.5	48.5	38.3	24.0	15.0	11.5	8.5	5.4
128K	55.4	46.3	44.1	36.1	26.8	14.1	10.1	7.6
256K	53.8	71.6	58.0	38.0	28.0	19.0	18.8	11.5
512K	5.4	22.2	39.2	37.5	27.5	19.4	11.0	6.0
1Mb	0.1	0.3	1.3	5.2	5.0	2.8	2.0	1.7
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
Total	230.9	209.3	198.3	153.6	112.2	75.0	57.3	38.2
% Change From Previous Year	3%	(9%)	(5%)	(23%)	(27%)	(33%)	(24%)	(33%)

(Continued)

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MOS EPROM--Forecast

Table 2 (Continued)

Worldwide NMOS EPROM Market—Total (UV and OTP)

	Average Selling Price ($)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 2.40	$ 2.62	$ 3.22	$ 3.55	$ 3.60	$3.80	$4.05	$4.20
32K	$ 2.32	$ 2.77	$ 3.53	$ 3.65	$ 3.75	$3.90	$4.15	$4.25
64K	$ 2.49	$ 2.95	$ 3.80	$ 3.75	$ 3.80	$3.95	$4.20	$4.30
128K	$ 2.75	$ 3.38	$ 3.95	$ 4.00	$ 4.00	$4.10	$4.25	$4.40
256K	$ 4.40	$ 4.36	$ 4.52	$ 4.30	$ 4.14	$4.20	$4.30	$4.48
512K	$11.73	$ 8.06	$ 7.12	$ 6.28	$ 5.00	$4.50	$4.54	$4.75
1Mb	$48.50	$24.32	$22.06	$18.00	$11.20	$8.80	$7.40	$6.55
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
Overall ASP	$ 3.21	$ 4.08	$ 4.78	$ 5.03	$ 4.55	$4.36	$4.41	$4.53
% Change from Previous Year	(7%)	27%	17%	5%	(10%)	(4%)	1%	3%

Source: Dataquest
August 1989

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MOS EPROM--Forecast

Table 3

Worldwide CMOS EPROM Market—Total (UV and OTP)

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	$ 8	$ 16	$ 19	$ 17	$ 18	$ 19	$ 19
32K	$ 7	10	8	9	13	13	13	13
64K	65	84	109	152	168	172	135	98
128K	7	45	80	96	84	62	59	56
256K	80	236	372	415	400	359	337	340
512K	4	75	170	258	265	231	204	189
1Mb	9	38	148	448	674	733	639	543
2Mb	0	0	0	11	25	119	445	648
4Mb	0	0	18	77	182	536	802	1,096
8Mb	0	0	0	0	0	0	5	136
Total	$173	$496	$920	$1,485	$1,827	$2,243	$2,658	$3,138
% Change from Previous Year	60%	187%	85%	61%	23%	23%	19%	18%

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	2.4	3.1	4.3	4.1	4.4	4.5	4.5
32K	2.7	3.1	2.0	2.3	3.0	3.0	3.0	3.0
64K	17.1	27.2	27.0	37.0	39.0	40.5	31.5	22.6
128K	1.9	11.2	17.8	21.9	20.2	14.7	13.5	12.5
256K	16.2	46.9	72.8	92.0	94.0	83.0	76.2	74.5
512K	0.3	8.7	21.7	40.5	50.0	49.6	43.0	39.0
1Mb	0.1	1.4	7.8	32.0	63.0	85.2	85.8	83.3
2Mb	0	0	0	0.3	1.4	10.0	50.0	82.0
4Mb	0	0	0.2	1.7	7.0	36.0	81.0	126.0
8Mb	0	0	0	0	0	0	0.1	4.0
Total	38.3	100.8	152.4	232.0	281.7	326.4	388.6	451.4
% Change from Previous Year	82%	163%	51%	52%	21%	16%	19%	16%

(Continued)

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MOS EPROM--Forecast

Table 3 (Continued)

Worldwide CMOS EPROM Market—Total (UV and OTP)

	Average Selling Price ($)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	$ 3.36	$ 5.08	$ 4.50	$ 4.20	$ 4.10	$ 4.20	$ 4.20
32K	$ 2.71	$ 3.08	$ 3.81	$ 3.90	$ 4.30	$ 4.20	$ 4.20	$ 4.25
64K	$ 3.80	$ 3.08	$ 4.02	$ 4.10	$ 4.30	$ 4.25	$ 4.30	$ 4.35
128K	$ 3.89	$ 4.00	$ 4.47	$ 4.40	$ 4.15	$ 4.25	$ 4.38	$ 4.45
256K	$ 4.93	$ 5.04	$ 5.11	$ 4.51	$ 4.25	$ 4.32	$ 4.42	$ 4.57
512K	$13.95	$ 8.69	$ 7.80	$ 6.38	$ 5.30	$ 4.65	$ 4.75	$ 4.85
1Mb	$62.62	$28.27	$19.09	$14.00	$10.70	$ 8.60	$ 7.45	$ 6.52
2Mb	0	0	0	$35.00	$18.00	$11.90	$ 8.90	$ 7.90
4Mb	0	0	$80.00	$45.00	$26.00	$14.90	$ 9.90	$ 8.70
8Mb	0	0	0	0	0	$90.00	$50.00	$34.00
Overall ASP	$ 4.52	$ 4.92	$ 6.03	$ 6.40	$ 6.49	$ 6.87	$ 6.84	$ 6.95
% Change from Previous Year		9%	23%	6%	1%	6%	0	2%

Source: Dataquest
August 1989

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MOS EPROM--Forecast

Table 4

Worldwide MOS UV EPROM Market—Total (NMOS and CMOS)

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 35	$ 27	$ 33	$ 32	$ 28	$ 27	$ 27	$ 26
32K	46	46	50	43	39	35	33	31
64K	256	174	232	228	213	215	173	125
128K	150	182	234	229	186	119	103	91
256K	272	478	574	536	494	425	412	387
512K	68	246	414	409	333	265	204	181
1Mb	12	46	171	507	632	605	485	458
2Mb	0	0	0	11	24	86	389	546
4Mb	0	0	18	77	163	486	721	896
8Mb	0	0	0	0	0	0	5	136
Total	$840	$1,199	$1,726	$2,070	$2,111	$2,264	$2,552	$2,877
% Change from Previous Year	(5%)	43%	44%	20%	2%	7%	13%	13%

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	14.7	9.7	8.6	7.8	7.0	6.8	6.4	6.2
32K	20.7	16.2	13.9	11.6	10.0	8.8	8.0	7.3
64K	93.9	56.3	58.8	56.1	51.0	50.4	39.5	28.0
128K	52.2	50.3	55.8	53.9	44.6	27.8	23.4	20.1
256K	57.5	100.8	115.3	117.0	112.7	95.1	89.3	81.5
512K	5.7	29.0	55.0	63.0	61.8	55.0	41.9	34.5
1Mb	0.2	1.7	8.7	34.2	57.0	68.0	63.8	61.5
2Mb	0	0	0	0.3	1.3	7.0	42.0	65.0
4Mb	0	0	0.2	1.7	6.2	32.0	70.0	106.0
8Mb	0	0	0	0	0	0	0.1	4.0
Total	244.8	264.1	316.3	345.6	351.6	350.9	384.4	414.1
% Change from Previous Year	0	8%	20%	9%	2%	0	10%	8%

(Continued)

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MOS EPROM--Forecast

Table 4 (Continued)

Worldwide MOS UV EPROM Market—Total (NMOS and CMOS)

	Average Selling Price ($)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 2.40	$ 2.80	$ 3.88	$ 4.07	$ 3.95	$ 3.99	$ 4.16	$ 4.20
32K	$ 2.24	$ 2.83	$ 3.57	$ 3.70	$ 3.92	$ 4.00	$ 4.17	$ 4.25
64K	$ 2.73	$ 3.08	$ 3.95	$ 4.06	$ 4.18	$ 4.26	$ 4.37	$ 4.46
128K	$ 2.88	$ 3.62	$ 4.20	$ 4.24	$ 4.17	$ 4.28	$ 4.40	$ 4.53
256K	$ 4.73	$ 4.74	$ 4.98	$ 4.58	$ 4.38	$ 4.47	$ 4.62	$ 4.75
512K	$11.94	$ 8.49	$ 7.52	$ 6.49	$ 5.39	$ 4.82	$ 4.87	$ 5.25
1Mb	$58.57	$27.53	$19.63	$14.82	$11.09	$ 8.90	$ 7.60	$ 7.45
2Mb	0	0	0	$35.00	$18.45	$12.25	$ 9.26	$ 8.40
4Mb	0	0	0	$45.00	$26.25	$15.20	$10.30	$ 8.45
8Mb	0	0	0	0	0	$90.00	$50.00	$34.00
Overall ASP	$ 3.43	$ 4.54	$ 5.46	$ 5.99	$ 6.01	$ 6.45	$ 6.64	$ 6.95
% Change from Previous Year	(5%)	32%	20%	10%	0	7%	3%	5%

Source: Dataquest
August 1989

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MOS EPROM--Forecast

Table 5

Worldwide NMOS UV EPROM Market

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 35	$ 19	$ 18	$ 12	$ 10	$ 9	$ 8	$ 7
32K	39	36	42	34	26	23	21	18
64K	193	122	135	85	54	44	36	23
128K	143	137	161	139	104	57	43	34
256K	202	252	239	149	106	74	62	48
512K	63	172	249	175	106	66	35	16
1Mb	3	8	28	94	56	25	15	12
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
Total	$679	$745	$872	$688	$462	$297	$220	$158
% Change from Previous Year	(13%)	10%	17%	(21%)	(33%)	(36%)	(26%)	(28%)

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	14.7	7.3	5.6	3.5	2.9	2.4	1.9	1.7
32K	18.1	13.1	11.9	9.3	7.0	5.8	5.0	4.3
64K	77.6	40.6	35.1	22.1	14.0	11.1	8.5	5.4
128K	50.3	39.5	39.7	33.8	25.6	13.7	10.1	7.6
256K	43.4	56.9	51.7	33.9	25.0	16.9	14.0	10.5
512K	5.4	20.4	34.3	27.5	20.5	14.4	7.4	3.0
1Mb	0.1	0.3	1.3	5.2	5.0	2.8	2.0	1.7
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
Total	209.5	178.1	179.5	135.3	100.0	67.1	48.9	34.2
% Change from Previous Year	(7%)	(15%)	1%	(25%)	(26%)	(33%)	(27%)	(30%)

(Continued)

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MOS EPROM--Forecast

Table 5 (Continued)

Worldwide NMOS UV EPROM Market

	Average Selling Price ($)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	$ 2.40	$ 2.62	$ 3.22	$ 3.55	$ 3.60	$3.80	$4.05	$4.20
32K	$ 2.17	$ 2.77	$ 3.53	$ 3.65	$ 3.75	$3.90	$4.15	$4.25
64K	$ 2.49	$ 3.00	$ 3.85	$ 3.85	$ 3.85	$3.95	$4.20	$4.30
128K	$ 2.84	$ 3.48	$ 4.06	$ 4.12	$ 4.05	$4.15	$4.30	$4.45
256K	$ 4.65	$ 4.42	$ 4.62	$ 4.40	$ 4.25	$4.35	$4.45	$4.55
512K	$11.82	$ 8.40	$ 7.26	$ 6.35	$ 5.15	$4.60	$4.75	$5.20
1Mb	$48.50	$24.32	$22.06	$18.00	$11.20	$8.80	$7.45	$7.30
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
8Mb	0	0	0	0	0	0	0	0
Overall ASP	$ 3.24	$ 4.18	$ 4.86	$ 5.09	$ 4.62	$4.42	$4.50	$4.63
% Change from Previous Year	(7%)	(29%)	16%	5%	(9%)	(4%)	2%	3%

Source: Dataquest
August 1989

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Table 6

Worldwide CMOS UV EPROM Market

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	$ 8	$ 16	$ 19	$ 17	$ 18	$ 19	$ 19
32K	$ 7	10	8	9	13	13	13	13
64K	63	52	97	143	159	171	137	102
128K	7	45	73	89	82	62	60	57
256K	70	226	335	386	388	352	350	339
512K	4	75	164	234	228	199	169	165
1Mb	9	38	143	413	576	580	470	446
2Mb	0	0	0	11	24	86	389	546
4Mb	0	0	18	77	163	486	721	896
8Mb	0	0	0	0	0	0	5	136
Total	$161	$454	$855	$1,382	$1,649	$1,967	$2,332	$2,719
% Change from Previous Year	54%	181%	88%	62%	19%	19%	19%	17%

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	2.4	3.1	4.3	4.1	4.4	4.5	4.5
32K	2.7	3.1	2.0	2.3	3.0	3.0	3.0	3.0
64K	16.3	15.8	23.7	34.0	37.0	39.3	31.0	22.6
128K	1.9	10.8	16.1	20.1	19.0	14.1	13.3	12.5
256K	14.1	43.9	63.6	83.1	87.7	78.2	75.3	71.0
512K	0.3	8.6	20.7	35.5	41.3	40.6	34.5	31.5
1Mb	0.1	1.4	7.5	29.0	52.0	65.2	61.8	59.8
2Mb	0	0	0	0.3	1.3	7.0	42.0	65.0
4Mb	0	0	0.2	1.7	6.2	32.0	70.0	106.0
8Mb	0	0	0	0	0	0	0.1	4.0
Total	35.3	86.0	136.8	210.3	251.6	283.8	335.5	379.9
% Change from Previous Year	76%	143%	59%	54%	20%	13%	18%	13%

(Continued)

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Table 6 (Continued)

Worldwide CMOS UV EPROM Market

	Average Selling Price ($)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	$ 3.36	$ 5.08	$ 4.50	$ 4.20	$ 4.10	$ 4.20	$ 4.20
32K	$ 2.71	$ 3.08	$ 3.81	$ 3.90	$ 4.30	$ 4.20	$ 4.20	$ 4.25
64K	$ 3.87	$ 3.30	$ 4.10	$ 4.20	$ 4.30	$ 4.35	$ 4.42	$ 4.50
128K	$ 3.94	$ 4.15	$ 4.55	$ 4.45	$ 4.32	$ 4.40	$ 4.48	$ 4.58
256K	$ 4.98	$ 5.15	$ 5.27	$ 4.65	$ 4.42	$ 4.50	$ 4.65	$ 4.78
512K	$14.08	$ 8.69	$ 7.95	$ 6.60	$ 5.51	$ 4.90	$ 4.90	$ 5.25
1Mb	$62.62	$28.27	$19.21	$14.25	$11.08	$ 8.90	$ 7.60	$ 7.45
2Mb	0	0	0	$35.00	$18.45	$12.25	$ 9.26	$ 8.40
4Mb	0	0	$80.00	$45.00	$26.25	$15.20	$10.30	$ 8.45
8Mb	0	0	0	0	0	$90.00	$50.00	$34.00
Overall ASP	$ 4.57	$ 5.28	$ 6.25	$ 6.57	$ 6.56	$ 6.93	$ 6.95	$ 7.16
% Change from Previous Year	(12%)	16%	18%	5%	0	6%	0	3%

Source: Dataquest
August 1989

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MOS EPROM--Forecast

Table 7

Worldwide MOS OTP EPROM Market—Total (NMOS and CMOS)

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	0	0	0	0	0	0	0
32K	$ 1	0	0	0	0	0	0	0
64K	12	$ 51	$ 21	$ 16	$ 10	$ 5	$ 2	0
128K	12	21	20	14	8	3	1	0
256K	46	65	61	47	32	24	21	$ 17
512K	0	14	35	78	65	54	47	44
1Mb	0	0	5	34	94	141	144	123
2Mb	0	0	0	0	1	29	58	111
4Mb	0	0	0	0	17	48	87	140
Total	$72	$151	$142	$188	$227	$305	$359	$435
% Change from Previous Year	259%	111%	(6%)	32%	20%	35%	18%	21%

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	0	0	0	0	0	0	0
32K	0.9	0	0	0	0	0	0	0
64K	5.7	19.3	6.5	4.9	3.0	1.6	0.5	0
128K	5.2	7.2	6.2	4.1	2.4	1.0	0.2	0
256K	12.5	17.6	15.5	13.0	9.3	6.9	5.7	4.5
512K	0	1.8	6.0	15.0	15.7	14.0	12.1	10.5
1Mb	0	0	0.3	3.0	11.0	20.0	24.0	23.5
2Mb	0	0	0	0	0.1	3.0	8.0	17.0
4Mb	0	0	0	0	0.8	4.0	11.0	20.0
Total	24.2	46.0	34.5	40.0	42.3	50.5	61.5	75.5
% Change from Previous Year	192%	90%	(25%)	16%	6%	19%	22%	23%

(Continued)

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Table 7 (Continued)

Worldwide MOS OTP EPROM Market—Total (NMOS and CMOS)

	Average Selling Price ($)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	0	0	0	0	0	0	0
32K	$ 1.75	0	0	0	0	0	0	0
64K	$ 2.01	$2.64	$ 3.17	$ 3.22	$ 3.23	$ 3.39	$3.49	0
128K	$ 2.27	$2.92	$ 3.31	$ 3.38	$ 3.32	$ 3.40	$3.52	0
256K	$ 3.73	$3.67	$ 3.96	$ 3.64	$ 3.43	$ 3.51	$3.64	$3.78
512K	$10.19	$7.56	$ 5.89	$ 5.17	$ 4.13	$ 3.83	$3.89	$4.18
1Mb	0	0	$15.30	$11.22	$ 8.56	$ 7.05	$6.00	$5.25
2Mb	0	0	0	0	$14.50	$ 9.70	$7.25	$6.55
4Mb	0	0	0	0	$20.80	$12.10	$7.88	$6.99
Overall ASP	$ 2.95	$3.27	$ 4.13	$ 4.71	$ 5.36	$ 6.04	$5.84	$5.77

Source: Dataquest
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MOS EPROM--Forecast

Table 8

Worldwide NMOS OTP EPROM Market

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	0	0	0	0	0	0	0
32K	$ 1	0	0	0	0	0	0	0
64K	10	$ 19	$10	$ 6	$ 3	$ 1	0	0
128K	12	20	14	8	4	1	0	0
256K	38	52	23	14	10	7	$ 5	$ 4
512K	0	13	28	52	28	19	14	12
1Mb	0	0	0	0	0	0	0	0
2Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	$61	$105	$76	$80	$45	$29	$19	$16
% Change from Previous Year	266%	72%	(28)	5	(44)	(36)	(32)	(19)

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32K	0.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A
64K	4.9	7.9	3.2	1.9	1.0	0.4	0	0
128K	5.2	6.8	4.5	2.3	1.2	0.4	0	0
256K	10.4	14.7	6.3	4.1	3.0	2.1	1.5	1.0
512K	0	1.8	4.9	10.0	7.0	5.0	3.6	3.0
1Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	21.4	31.2	18.8	18.3	12.2	7.9	5.1	4.0

(Continued)

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Table 8 (Continued)

Worldwide NMOS OTP EPROM Market

	Average Selling Price ($)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32K	$ 1.75	N/A	N/A	N/A	N/A	N/A	N/A	N/A
64K	$ 1.96	$2.42	$3.08	$3.10	$2.90	$3.22	0	0
128K	$ 2.27	$2.90	$3.20	$3.25	$3.20	$3.28	0	0
256K	$ 3.63	$3.58	$3.68	$3.50	$3.40	$3.40	$3.60	$3.70
512K	$10.00	$7.55	$5.80	$5.20	$4.00	$3.80	$3.90	$4.00
1Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4Mb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Overall ASP	$ 2.85	$3.36	$4.02	$4.36	$3.68	$3.64	$3.81	$3.93

N/A = Not Available

Source: Dataquest
August 1989

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Table 9

Worldwide CMOS OTP EPROM Market

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	0	0	0	0	0	0	0	0
8K	0	0	0	0	0	0	0	0
16K	0	0	0	0	0	0	0	0
32K	0	0	0	0	0	0	0	0
64K	$ 2	$32	$11	$ 10	$ 7	$ 4	$ 2	0
128K	0	1	6	6	4	2	1	0
256K	9	12	38	33	22	17	15	$ 13
512K	0	0	7	26	37	35	33	32
1Mb	0	0	5	34	94	141	144	123
2Mb	0	0	0	0	1	29	58	111
4Mb	0	0	0	0	17	48	87	140
Total	$11	$46	$67	$109	$182	$276	$339	$420
% Change from Previous Year	228%	330%	46%	63%	67%	52%	23%	24%

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
64K	0.8	11.4	3.3	3.0	2.0	1.2	0.5	0
128K	0	0.4	1.7	1.8	1.2	0.6	0.2	0
256K	2.1	3.0	9.2	8.9	6.3	4.8	4.2	3.5
512K	0	0.1	1.1	5.0	8.7	9.0	8.5	7.5
1Mb	0	0	0.3	3.0	11.0	20.0	24.0	23.5
2Mb	N/A	N/A	N/A	0	0.1	3.0	8.0	17.0
4Mb	N/A	N/A	N/A	0	0.8	4.0	11.0	20.0
Total	2.9	14.8	15.6	21.7	30.1	42.6	56.4	71.5

(Continued)

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Table 9 (Continued)

Worldwide CMOS OTP EPROM Market

	Average Selling Price ($)							
	1986	1987	1988	1989	1990	1991	1992	1993
4K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
64K	$ 2.35	$2.80	$ 3.25	$ 3.30	$ 3.40	$ 3.44	$3.49	0
128K	$ 2.89	$3.20	$ 3.60	$ 3.55	$ 3.43	$ 3.48	$3.52	0
256K	$ 4.22	$4.10	$ 4.15	$ 3.71	$ 3.45	$ 3.56	$3.65	$ 3.80
512K	$11.30	$7.90	$ 6.30	$ 5.12	$ 4.24	$ 3.85	$3.88	$ 4.25
1Mb	N/A	N/A	$15.30	$11.22	$ 8.56	$ 7.05	$6.00	$ 5.25
2Mb	N/A	N/A	N/A	N/A	$14.50	$ 9.70	$7.25	$ 6.55
4Mb	N/A	N/A	N/A	0	$20.80	$12.10	$7.88	$ 6.99
Overall ASP	$ 3.71	$3.09	$ 4.27	$ 5.00	$ 6.04	$ 6.49	$6.02	$ 5.87

N/A = Not Available

Source: Dataquest
August 1989

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MOS EPROM--Forecast

THE MARKET—1988

Worldwide MOS EPROM revenue totaled $1.87 billion in 1988, growing 38 percent in revenue over a 1987 total of $1.35 billion, with strong growth expected to continue through 1989. Intel maintained its lead with more than 18.0 percent unit share of the worldwide market, followed by SGS–Thomson with 12.6 percent unit share. In 1988, worldwide reported units increased to 350.7 million, 13.0 percent over the 310.1 million units shipped in 1987. Although CMOS technology continued to garner share from NMOS during 1988, the most significant changes in 1988 were product shortages and higher average selling prices (ASPs) in key EPROM densities.

COMPARISON WITH EARLIER FORECASTS

The current Dataquest EPROM forecast contains several significant differences from our July 1988 forecast. The changes and reasons for these differences are as follows:

- Actual revenue, unit shipments, and ASPs for 1987 have been adjusted to reflect final numbers that were completed by the middle of 1988.
- Actual bit shipments increased 44 percent as a result of continued strong growth in the 256K and 512K densities.
- The NMOS share of EPROMs continued to decline, representing 56.5 percent of all EPROM units shipped in 1988 (down from 67.5 percent in 1987) and 85.8 percent share of units in 1986.
- U.S. manufacturers' share of the EPROM market increased for a second consecutive year, reaching 51.3 percent, while Japanese manufacturers' share dropped to 39.6 percent and European manufacturers' share grew to 13.2 percent.
- Shipments of high–speed 16K through 1Mb CMOS devices continued to increase in 1988. As a result, Dataquest increased its unit forecasts and extended the life cycle forecasts of the 16K, 64K, and 256K EPROMs.

MARKET OUTLOOK

Although worldwide EPROM production and shipments grew 13 percent in 1988, strong demand and continued high ASPs were the greatest contributors to strong revenue growth in 1988. Although U.S. and European EPROM suppliers continued to benefit from MITI–imposed production reductions, EPROM users were forced to endure product shortages, long lead times, and very high prices in the 64K through 512K densities during the first three quarters of 1988. ASPs increased 22 percent overall in 1988,

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averaging out at $5.33. This price is in comparison with $4.35 in 1987. The fourth quarter of 1988 saw EPROM prices softening from the 1Mb 128Kx8 configurations, down through the 64K densities as a result of increased capacity from the U.S. and European manufacturers. As MITI continued to impose production cutback guidelines for memory suppliers in Japan, Fujitsu and Mitsubishi followed in the path of Hitachi, NEC, Oki and Toshiba, drastically slowing down and/or stopping quarter-to-quarter production of their 64K, 128K, and 256K EPROMs. These suppliers give very little indication that they will return to the low-density EPROM arena. Dataquest expects these manufacturers to redirect their focus into the extremely high-speed, high-density market during the next six quarters for a large ramp-up in production that could promote very strong nonvolatile memory growth from 1991 through 1993.

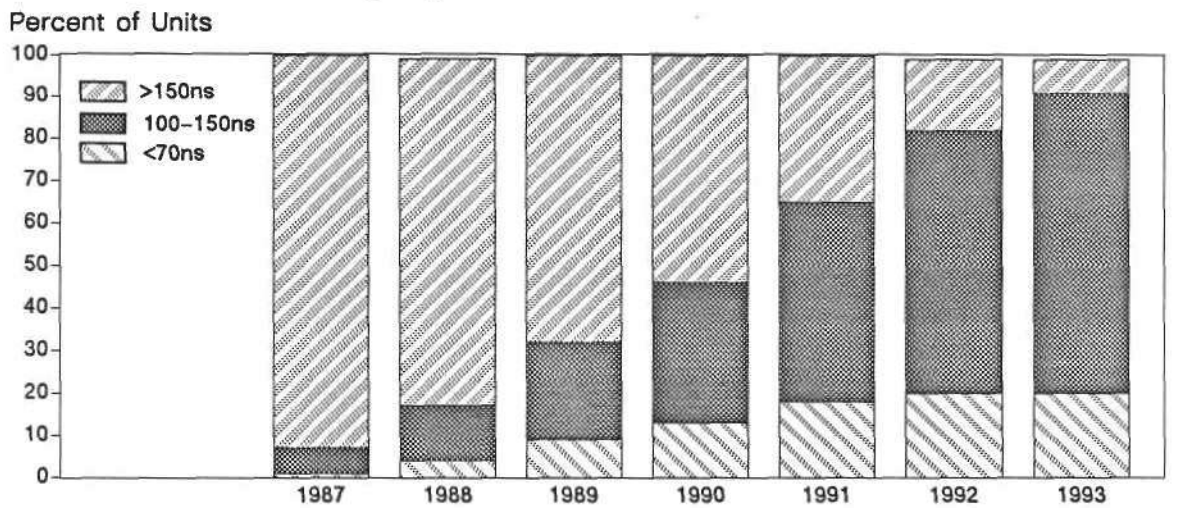
High-Speed EPROMs

Figure 1 illustrates Dataquest's estimate of the 1989 to 1993 high-speed EPROM market as a percentage of total units. The very high speed (less than 70ns) products, which now have speeds averaging 20 to 55ns, continue to be driven by the low-speed 8K, 16K, and 64K devices. These low-density, high-speed products are designed for very specific bipolar PROM replacement applications. The 55 to 100ns or high-speed arena saw many developments in the 256K through 4Mb EPROMs to accommodate high-speed developments in the 16-bit/32-bit MPUs. A few of these include 1988 ISSCC announcements of new products such as Intel's 90ns 4Mb CMOS EPROM, Hitachi's 55ns 64Kx16 device, and SGS-Thomson's 70ns 64Kx16 device. We continue to believe that the 100 to 150ns range will be the most prevalent EPROM speed range by 1992, with ramp-up in volume production beginning in the latter part of 1990. Although 64K and 256K densities sustained the largest growth for demands of high speed and very high speed in 1988, production grew in densities of 512K and more in the first quarter of 1989, and continued growth is expected through the end of the year.

MOS EPROM--Forecast

Figure 1

High-Speed EPROM Market Forecast



0004718-1

Source: Dataquest August 1989

CMOS/NMOS EPROMs

CMOS technology represented a 51 percent share of total EPROM production in 1988, surpassing Dataquest's previous projection of a 45 percent share. As such, we expect the CMOS share to continue growing, surpassing NMOS with a more than 52 percent share of units by the end of 1989 and an expected 71 percent share of the total market by the end of 1990. The 64K and 256K devices maintained the strongest density share of the entire EPROM product lineup in 1988, with respective shares of 41 and 55 percent.

MOS UV/OTP EPROMs

Table 4 shows EPROMs packaged in UV erasable packages, while Table 7 deals strictly with production of one-time programmable (OTP) EPROMs in plastic packages without windows.

Dataquest consistently has made the packaging distinction between EPROMs in UV erasable packages and those in nonerasable plastic packages, or OTPs, for the primary reason of separately tracking an anticipated shift to less expensive packages. Our forecast for 1988 through 1993 shows that UV EPROMs will continue to have a larger share of the EPROM market. The OTP EPROM product has continued to maintain a marginal and declining share of the EPROM market. Product introduction and product

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demand continue to come from densities of 256K and more. Although OTP represented a 14.8 percent share of the EPROM market in 1987, its 1988 share dropped to 10.0 percent, with an expected 10.0 percent share of the total market by the end of 1989. We expect that AMD, Mitsubishi, Sharp, Texas Instruments, and Toshiba will continue to be the major OTP suppliers, with a predominant shift to CMOS occurring during the 1990 through 1993 time frame.

Flash Memory

Flash memory technology is a new, nonvolatile memory product area that will be covered in a separate section of Dataquest's semiconductor memories notebook. Further information on flash memory technology can be found in Dataquest's SIS newsletter, "The Bare Facts About Flash," published in June 1989.

Short-Term Forecast

Dataquest believes that the EPROM pricing softness that occurred during the first two quarters of 1989 will continue through the end of the year. The price declines currently are affecting the 64K through 1Mb densities, with the most aggressive pricing occurring at the 256K level, where prices have been quoted at less than $2. Although 1Mb EPROM unit shipments reached 9 million in 1988 as Japanese vendors captured more than 79.4 percent of market share, up from 75.0 percent in 1987, 1Mb unit shipments fell far below our expected forecast for the second consecutive year. Although user interest in the 1Mb product is high and shipments of both x8 and x16 configurations have been strong through the first two quarters of 1989, it is questionable that 1Mb EPROMs will reach market expectations of 37 million units by the end of 1989.

LONG-TERM FORECAST

Dataquest believes that the slow bit growth that has occurred since 1987 will continue through the first half of 1990. A slow but positive upturn is expected to begin during the second half of 1990, with a rapid ramp-up in production in 1991 that will continue through 1993, as demand for 1Mb through 4Mb densities increases. Bit growth is expected to have a compound annual growth rate (CAGR) of 57.7 percent from 1988 through 1993. The automotive and electronic data processing segments continue to be the strongest drivers for bit growth in the 1991 through 1993 time frame.

Although product sampling and shipment of the 2Mb and 4Mb EPROMs has been minimal during the first half of 1989, increased shipments are expected from all participants during the second half of 1990. Although strong user demand and supplier support are expected for 2Mb EPROMs in both the x8 and x16 configurations, we believe that the 4Mb will be the next area of major growth for the EPROM sector. Table 10 lists all of the known 2Mb and 4Mb participants and their products by organization.

MOS EPROM--Forecast

Table 10

1989 2Mb/4Mb CMOS EPROM Suppliers

Company	Fastest Speed	2Mb x8	2Mb x16	4Mb x8	4Mb x16
AMD	100ns		X		
	120ns				X
Fujitsu	150ns			X	X
Intel	150ns	X	X		X
Mitsubishi	100ns	X	X		
	120ns				X
NEC	150ns	X		X	
Toshiba	150ns			X	
WaferScale	100ns				X

Source: Dataquest
August 1989

Although EPROM revenue is expected to exceed $2.3 billion in 1990, its expected growth in units and dollars during 1989 will be marginal; 24 suppliers will be scurrying for a share of that 1990 commodity market. With densities now ranging from 16K through 4Mb and increased user demands for a variety of speeds, varying organizations, and packages, Dataquest anticipates that successful market share gains will be made only by the broad-based and/or very focused high-speed suppliers during the expected 1990 slowdown.

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MOS EPROM--Data

QUARTERLY COMPANY MOS EPROM SHIPMENT DATA

This section contains historical unit shipment data on MOS EPROMs from 1976 through 1987. In addition to unit shipments for 8K, 16K, 32K, 64K, 128K, 256K, 512K, and 1-Mbit EPROMs, we have added our estimates of the worldwide billing prices for each product during the four quarters of the year. At the bottom of each table, we show market share data (units, not revenue) for companies based in the United States, Japan, Europe, and Asia Pacific. The tables are organized as follows:

- Table 1—8K MOS EPROM Shipment Data, 1976–1985
- Table 2—16K MOS EPROM Shipment Data, 1976–1987
- Table 3—32K MOS EPROM Shipment Data, 1978–1987
- Table 4—64K MOS EPROM Shipment Data, 1980–1987
- Table 5—128K MOS EPROM Shipment Data, 1982–1987
- Table 6—256K MOS EPROM Shipment Data, 1983–1987
- Table 7—512K MOS EPROM Shipment Data, 1984–1987
- Table 8—1-Mbit MOS EPROM Shipment Data, 1986–1987

Definitions

Prices

Prices are Dataquest estimates of the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and the entire speed mix, and they represent sales to both military and commercial accounts.

Quarterly Revenue

Quarterly revenue is calculated as units shipped times the prevailing price during that period.

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MOS EPROM--Data

Table 1

8K MOS EPROM Shipment Data, 1976–1985

Company	1976 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD					
Electronic Arrays	N/A	N/A	N/A	S	S
Fairchild	N/A	N/A	N/A	N/A	N/A
Fujitsu	N/A	N/A	N/A	S	S
Intel	S	25	75	125	225
Mitsubishi	N/A	N/A	N/A	N/A	N/A
Motorola	N/A	N/A	N/A	N/A	N/A
National Semi.	N/A	N/A	N/A	N/A	N/A
Oki Electric	N/A	N/A	N/A	N/A	N/A
Texas Instruments	N/A	N/A	S	5	5
Toshiba	N/A	S	20	50	70
Total	S	25	95	180	300
Percentage Change from Previous Quarter	0	0	280%	89%	
Cumulative Total	0	25	120	300	
Average Selling Price	$80.00	$50.00	$35.00	$30.00	$33.25
Revenue ($M)	0	1.3	3.3	5.4	10.0

	1976 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	0	100.0%	78.9%	72.2%	76.7%
Japan	0	0	21.1	27.8	23.3
Europe	0	0	0	0	0
Total	0	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sampling

(Continued)

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Table 1 (Continued)

8K MOS EPROM Shipment Data, 1976–1985

Company	1977 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD					
Electronic Arrays	10	15	50	75	150
Fairchild	0	0	0	5	5
Fujitsu	10	15	25	40	90
Intel	200	325	475	600	1,600
Mitsubishi	N/A	N/A	N/A	N/A	N/A
Motorola	S	15	20	35	70
National Semi.	S	25	40	85	150
Oki Electric	N/A	N/A	N/A	N/A	N/A
Texas Instruments	15	25	40	70	150
Toshiba	100	100	200	300	700
Total	335	520	850	1,210	2,915
Percentage Change from Previous Quarter	86%	55%	63%	42%	
Cumulative Total	635	1,155	2,005	3,215	
Average Selling Price	$30.00	$25.00	$21.00	$18.00	$21.50
Revenue ($M)	10.1	13.0	17.9	21.8	62.7

	1977 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	67.2%	77.9%	73.5%	71.9%	72.9%
Japan	32.8	22.1	26.5	28.1	27.1
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sampling

(Continued)

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Table 1 (Continued)

8K MOS EPROM Shipment Data, 1976–1985

Company	1978 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	15	50	80	340	485
Electronic Arrays	30	50	60	60	200
Fairchild	40	60	60	120	280
Fujitsu	50	90	70	70	280
Intel	700	900	800	1,000	3,400
Mitsubishi	50	125	175	250	600
Motorola	100	250	250	420	1,020
National Semi.	275	260	310	405	1,250
Oki Electric	N/A	N/A	N/A	N/A	N/A
Texas Instruments	350	550	400	800	2,100
Toshiba	N/A	N/A	10	30	40
Total	1,610	2,335	2,215	3,495	9,655
Percentage Change from Previous Quarter	33%	45%	(5%)	58%	
Cumulative Total	4,825	7,160	9,375	12,870	
Average Selling Price	$15.00	$9.00	$5.00	$4.50	$7.45
Revenue ($M)	24.2	21.0	11.1	15.7	72.0

	1978 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	93.8%	90.8%	88.5%	90.0%	90.5%
Japan	6.2	9.2	11.5	10.0	9.5
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available

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Table 1 (Continued)

8K MOS EPROM Shipment Data, 1976–1985

Company	1979 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	600	700	700	500	2,500
Electronic Arrays	75	100	125	35	335
Fairchild	160	200	350	600	1,310
Fujitsu	70	50	50	50	220
Intel	1,100	1,400	1,400	1,100	5,000
Mitsubishi	190	240	240	270	940
Motorola	700	750	1,000	1,000	3,450
National Semi.	600	800	800	900	3,100
Oki Electric	N/A	N/A	N/A	N/A	N/A
Texas Instruments	800	800	800	800	3,200
Toshiba	50	100	100	50	300
Total	4,345	5,140	5,565	5,305	20,355
Percentage Change from Previous Quarter	24%	18%	8%	(5%)	
Cumulative Total	17,215	22,355	27,920	33,225	
Average Selling Price	$6.00	$8.00	$7.00	$5.50	$6.65
Revenue ($M)	26.1	41.1	39.0	29.2	135.3

	1979 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	92.9%	92.4%	93.0%	93.0%	92.8%
Japan	7.1	7.6	7.0	7.0	7.2
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available

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Table 1 (Continued)

8K MOS EPROM Shipment Data, 1976–1985

Company	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	600	700	650	350	2,300
Electronic Arrays	0	0	0	0	0
Fairchild	750	1,000	850	600	3,200
Fujitsu	50	50	50	50	200
Intel	700	500	500	250	1,950
Mitsubishi	160	60	90	80	390
Motorola	500	500	350	250	1,600
National Semi.	1,000	1,000	700	600	3,300
Oki Electric	N/A	N/A	N/A	S	N/A
Texas Instruments	800	600	600	580	2,580
Toshiba	35	0	0	0	35
Total	4,595	4,410	3,790	2,760	15,555
Percentage Change from Previous Quarter	(13%)	(4%)	(14%)	(27%)	
Cumulative Total	37,820	42,230	46,020	48,780	
Average Selling Price	$5.00	$4.50	$4.50	$3.00	$4.38
Revenue ($M)	23.0	19.8	17.1	8.3	68.2

	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	94.7%	97.5%	96.3%	95.3%	96.0%
Japan	5.3	2.5	3.7	4.7	4.0
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sampling

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Table 1 (Continued)

8K MOS EPROM Shipment Data, 1976–1985

Company	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	500	200	200	190	1,090
Electronic Arrays	0	0	0	0	0
Fairchild	300	240	150	50	740
Fujitsu	50	20	10	0	80
Intel	200	150	100	50	500
Mitsubishi	110	40	30	25	205
Motorola	150	175	150	220	695
National Semi.	400	350	200	100	1,050
Oki Electric	50	50	70	50	220
Texas Instruments	550	400	300	200	1,450
Toshiba	0	0	0	0	0
Total	2,310	1,625	1,210	885	6,030
Percentage Change from Previous Quarter	(16%)	(30%)	(26%)	(27%)	
Cumulative Total	51,090	52,715	53,925	54,810	
Average Selling Price	$3.50	$3.00	$2.50	$2.00	$2.94
Revenue ($M)	8.1	4.9	3.0	1.8	17.8

	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	90.9%	93.2%	90.9%	91.5%	91.6%
Japan	9.1	6.8	9.1	8.5	8.4
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 1 (Continued)

8K MOS EPROM Shipment Data, 1976–1985

Company	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	180	100	100	50	430
Electronic Arrays	0	0	0	0	0
Fairchild	30	5	0	0	35
Fujitsu	0	0	0	0	0
Intel	15	5	0	0	20
Mitsubishi	20	15	30	0	65
Motorola	200	160	250	150	760
National Semi.	70	50	50	50	220
Oki Electric	30	25	15	25	95
Texas Instruments	100	70	35	25	230
Toshiba	0	0	0	0	0
Total	645	430	480	300	1,855
Percentage Change from Previous Quarter	(27%)	(33%)	12%	(38%)	
Cumulative Total	55,455	55,885	56,365	56,665	
Average Selling Price	$3.50	$3.50	$3.25	$3.25	$3.39
Revenue ($M)	2.3	1.5	1.6	1.0	6.3

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	92.2%	90.7%	90.6%	91.7%	91.4%
Japan	7.8	9.3	9.4	8.3	8.6
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

8K MOS EPROM Shipment Data, 1976-1985

Company	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	100	100	50	50	300
Electronic Arrays	0	0	0	0	0
Fairchild	0	0	0	0	0
Fujitsu	0	0	0	0	0
Intel	0	0	0	0	0
Mitsubishi	0	0	0	0	0
Motorola	120	100	70	0	290
National Semi.	50	50	25	25	150
Oki Electric	0	0	0	0	0
Texas Instruments	0	0	0	0	0
Toshiba	0	0	0	0	0
Total	270	250	145	75	740
Percentage Change from Previous Quarter	(10%)	(7%)	(42%)	(48%)	
Cumulative Total	56,935	57,185	57,330	57,405	
Average Selling Price	$3.50	$4.00	$4.00	$4.25	$3.84
Revenue ($M)	0.9	1.0	0.6	0.3	2.8

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	100.0%	100.0%	100.0%	100.0%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

8K MOS EPROM Shipment Data, 1976–1985

Company	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	80	130	30	20	260
Electronic Arrays	0	0	0	0	0
Fairchild	0	0	0	0	0
Fujitsu	0	0	0	0	0
Intel	0	0	0	0	0
Mitsubishi	0	0	0	0	0
Motorola	0	0	0	0	0
National Semi.	25	0	0	0	25
Oki Electric	0	0	0	0	0
Texas Instruments	0	0	0	0	0
Toshiba	0	0	0	0	0
Total	105	130	30	20	285
Percentage Change from Previous Quarter	40%	24%	(77%)	(33%)	
Cumulative Total	57,510	57,640	57,670	57,690	
Average Selling Price	$4.00	$4.00	$4.00	$5.00	$4.07
Revenue ($M)	0.4	0.5	0.1	0.1	1.2

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	100.0%	100.0%	100.0%	100.0%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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MOS EPROM--Data

Table 1 (Continued)

8K MOS EPROM Shipment Data, 1976–1985

Company	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	15	10	5	5	35
Electronic Arrays	0	0	0	0	0
Fairchild	0	0	0	0	0
Fujitsu	0	0	0	0	0
Intel	0	0	0	0	0
Mitsubishi	0	0	0	0	0
Motorola	0	0	0	0	0
National Semi.	0	0	0	0	0
Oki Electric	0	0	0	0	0
Texas Instruments	0	0	0	0	0
Toshiba	0	0	0	0	0
Total	15	10	5	5	35
Percentage Change from Previous Quarter	(25%)	(33%)	(50%)	0	
Cumulative Total	57,705	57,715	57,720	57,725	
Average Selling Price	$5.50	$6.00	$7.00	$8.00	$6.21
Revenue ($M)	0.1	0.1	0	0	0.2

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	100.0%	100.0%	100.0%	100.0%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1976 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	N/A	N/A	N/A	N/A
Eurotechnique	C	N/A	N/A	N/A	N/A	N/A
Fairchild	N	N/A	N/A	N/A	N/A	N/A
Fujitsu	N	N/A	N/A	N/A	N/A	N/A
Hitachi	N	N/A	N/A	N/A	N/A	N/A
Intel	N	N/A	N/A	S	10	10
Matsushita	N	N/A	N/A	N/A	N/A	N/A
Mitsubishi	N	N/A	N/A	N/A	N/A	N/A
Mostek	N	N/A	N/A	N/A	N/A	N/A
Motorola	N	N/A	N/A	N/A	N/A	N/A
National Semi.	N	N/A	N/A	N/A	N/A	N/A
	C	N/A	N/A	N/A	N/A	N/A
NEC	N	N/A	N/A	N/A	N/A	N/A
Oki Electric	N	N/A	N/A	N/A	N/A	N/A
SGS-Ates	N	N/A	N/A	N/A	N/A	N/A
Synertek	N	N/A	N/A	N/A	N/A	N/A
Texas Instruments	N	N/A	N/A	N/A	5	5
Toshiba	N	N/A	N/A	N/A	N/A	N/A
	N	0	0	0	15	15
	C	0	0	0	0	0
Total		0	0	0	15	15
Percentage Change from Previous Quarter						
Cumulative Total		0	0	0	15	
ASPs: NMOS		$50.00	$50.00	$50.00	$50.00	$50.00
CMOS		0	0	0	0	0
Overall		$50.00	$50.00	$50.00	$50.00	$50.00
Revenue ($M)		0	0	0	0.8	0.8

	1976 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	0	0	0	100.0%	100.0%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	0	0	0	100.0%	100.0%

S = Sampling
N/A = Not Available

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1977 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	N/A	N/A	N/A	N/A
Eurotechnique	C	N/A	N/A	N/A	N/A	N/A
Fairchild	N	N/A	N/A	N/A	N/A	N/A
Fujitsu	N	N/A	N/A	N/A	N/A	N/A
Hitachi	N	N/A	N/A	N/A	N/A	N/A
Intel	N	40	75	100	125	340
Matsushita	N	N/A	N/A	N/A	N/A	N/A
Mitsubishi	N	N/A	N/A	N/A	N/A	N/A
Mostek	N	N/A	N/A	N/A	N/A	N/A
Motorola	N	N/A	N/A	N/A	N/A	N/A
National Semi.	N	N/A	N/A	N/A	N/A	N/A
	C	N/A	N/A	N/A	N/A	N/A
NEC	N	N/A	N/A	N/A	N/A	N/A
Oki Electric	N	N/A	N/A	N/A	N/A	N/A
SGS-Ates	N	N/A	N/A	N/A	N/A	N/A
Synertek	N	N/A	N/A	N/A	N/A	N/A
Texas Instruments	N	20	25	30	55	130
Toshiba	N	N/A	N/A	N/A	N/A	N/A
	N	60	100	130	180	470
	C	0	0	0	0	0
Total		60	100	130	180	470
Percentage Change from Previous Quarter		0	67%	30%	38%	
Cumulative Total		75	175	305	485	
ASPs: NMOS		$45.00	$45.00	$30.00	$30.00	$35.11
CMOS		0	0	0	0	0
Overall		$45.00	$45.00	$30.00	$30.00	$35.11
Revenue ($M)		2.7	4.5	3.9	5.4	16.5

	1977 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	100.0%	100.0%	100.0%	100.0%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1978 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	N/A	N/A	N/A	0
Eurotechnique	C	N/A	N/A	N/A	N/A	0
Fairchild	N	N/A	N/A	N/A	N/A	0
Fujitsu	N	N/A	N/A	N/A	5	5
Hitachi	N	N/A	N/A	5	30	35
Intel	N	250	400	250	450	1,350
Matsushita	N	N/A	N/A	N/A	N/A	0
Mitsubishi	N	N/A	N/A	N/A	N/A	0
Mostek	N	S	S	S	25	25
Motorola	N	N/A	S	10	90	100
National Semi.	N	N/A	N/A	S	S	0
	C	N/A	N/A	N/A	N/A	0
NEC	N	N/A	N/A	N/A	N/A	0
Oki Electric	N	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Synertek	N	N/A	N/A	N/A	N/A	0
Texas Instruments	N	100	250	200	300	850
Toshiba	N	N/A	N/A	S	5	5
	N	350	650	465	905	2,370
	C	0	0	0	0	0
Total		350	650	465	905	2,370
Percentage Change from Previous Quarter		94%	86%	(28%)	95%	
Cumulative Total		835	1,485	1,950	2,855	
ASPs: NMOS		$28.00	$25.00	$25.00	$15.00	$21.62
CMOS		0	0	0	0	0
Overall		$28.00	$25.00	$25.00	$15.00	$21.62
Revenue ($M)		9.8	16.3	11.6	13.6	51.3

	1978 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	100.0%	98.9%	95.6%	98.1%
Japan	0	0	1.1	4.4	1.9
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1979 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	S	5	10	15
Eurotechnique	C	N/A	N/A	N/A	N/A	0
Fairchild	N	N/A	N/A	N/A	N/A	0
Fujitsu	N	70	200	300	300	870
Hitachi	N	125	200	350	500	1,175
Intel	N	550	750	800	900	3,000
Matsushita	N	N/A	N/A	N/A	N/A	0
Mitsubishi	N	10	20	50	90	170
Mostek	N	90	150	250	350	840
Motorola	N	160	150	160	200	670
National Semi.	N	5	50	80	120	255
	C	N/A	N/A	N/A	N/A	0
NEC	N	N/A	N/A	N/A	5	5
Oki Electric	N	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Synertek	N	N/A	N/A	N/A	S	0
Texas Instruments	N	400	900	1,100	1,800	4,200
Toshiba	N	25	50	90	200	365
	N	1,435	2,470	3,185	4,475	11,565
	C	0	0	0	0	0
Total		1,435	2,470	3,185	4,475	11,565
Percentage Change from Previous Quarter		59%	72%	29%	41%	
Cumulative Total		4,290	6,760	9,945	14,420	
ASPs: NMOS		$17.00	$22.00	$19.00	$17.00	$18.62
CMOS		0	0	0	0	0
Overall		$17.00	$22.00	$19.00	$17.00	$18.62
Revenue ($M)		24.4	54.3	60.5	76.1	215.3

	1979 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	84.0%	81.0%	75.2%	75.5%	77.6%
Japan	16.0	19.0	24.8	24.5	22.4
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	25	50	100	175	350
Eurotechnique	C	N/A	N/A	N/A	N/A	0
Fairchild	N	30	300	300	250	880
Fujitsu	N	350	750	700	650	2,450
Hitachi	N	700	850	1,025	1,325	3,900
Intel	N	950	1,000	1,700	1,850	5,500
Matsushita	N	S	50	50	80	180
Mitsubishi	N	210	260	270	410	1,150
Mostek	N	275	250	350	450	1,325
Motorola	N	250	350	500	500	1,600
National Semi.	N	250	250	300	425	1,225
	C	N/A	N/A	N/A	N/A	0
NEC	N	10	25	50	125	210
Oki Electric	N	S	0	0	0	0
SGS-Ates	N	1,800	0	0	5	1,805
Synertek	N	200	25	10	0	235
Texas Instruments	N	2,000	2,000	2,000	2,100	8,100
Toshiba	N	300	330	350	400	1,380
	N	7,350	6,490	7,705	8,745	30,290
	C	0	0	0	0	0
Total		7,350	6,490	7,705	8,745	30,290
Percentage Change from Previous Quarter		64%	(12%)	19%	13%	
Cumulative Total		21,770	28,260	35,965	44,710	
ASPs: NMOS		$15.00	$11.00	$8.00	$6.00	$9.76
CMOS		0	0	0	0	0
Overall		$15.00	$11.00	$8.00	$6.00	$9.76
Revenue ($M)		110.3	71.4	61.6	52.5	295.8

	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	54.1%	65.1%	68.3%	65.8%	63.4%
Japan	21.4	34.9	31.7	34.2	30.6
Europe	24.5	0	0	0.1	6.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available
Note: Columns may not add to totals shown because of rounding.

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	250	350	485	750	1,835
Eurotechnique	C	N/A	N/A	S	15	15
Fairchild	N	100	20	20	0	140
Fujitsu	N	750	1,000	700	500	2,950
Hitachi	N	1,700	1,700	1,200	700	5,300
Intel	N	2,600	3,000	3,000	3,000	11,600
Matsushita	N	120	150	200	250	720
Mitsubishi	N	580	740	670	520	2,510
Mostek	N	700	600	700	800	2,800
Motorola	N	400	420	500	400	1,720
National Semi.	N	500	550	700	1,100	2,850
	C	N/A	N/A	N/A	N/A	N/A
NEC	N	175	250	600	900	1,925
Oki Electric	N	25	40	80	100	245
SGS-Ates	N	15	25	50	75	165
Synertek	N	0	0	0	0	0
Texas Instruments	N	2,200	2,500	2,200	2,200	9,100
Toshiba	N	90	100	200	350	740
	N	10,205	11,445	11,305	11,645	44,600
	C	0	0	0	15	15
Total		10,205	11,445	11,305	11,660	44,615
Percentage Change from Previous Quarter		17%	12%	(1%)	3%	
Cumulative Total		54,915	66,360	77,665	89,325	
ASPs: NMOS		$4.50	$3.50	$3.00	$2.50	$3.34
CMOS		0	0	0	0	0
Overall		$4.50	$3.50	$3.00	$2.50	$3.34
Revenue ($M)		45.9	40.1	33.9	29.1	149.0

	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	66.1%	65.0%	67.3%	70.8%	67.3%
Japan	33.7	34.8	32.3	28.5	32.3
Europe	0.1	0.2	0.4	0.8	0.4
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available
Note: Columns may not add to totals shown because of rounding.

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	1,000	1,150	1,150	900	4,200
Eurotechnique	C	100	400	500	600	1,600
Fairchild	N	0	0	0	0	0
Fujitsu	N	400	350	250	100	1,100
Hitachi	N	450	250	200	200	1,100
Intel	N	3,000	2,500	1,800	1,200	8,500
Matsushita	N	250	250	150	100	750
Mitsubishi	N	450	350	300	160	1,260
Mostek	N	500	200	250	250	1,200
Motorola	N	250	160	100	60	570
National Semi.	N	1,200	1,250	1,300	2,200	5,950
	C	50	150	200	200	600
NEC	N	900	1,000	1,200	1,200	4,300
Oki Electric	N	250	400	400	400	1,450
SGS-Ates	N	100	180	350	520	1,150
Synertek	N	0	0	0	0	0
Texas Instruments	N	2,000	2,000	1,800	1,800	7,600
Toshiba	N	500	400	300	300	1,500
	N	11,250	10,440	9,550	9,390	40,630
	C	150	550	700	800	2,200
Total		11,400	10,990	10,250	10,190	42,830
Percentage Change from Previous Quarter		(2%)	(4%)	(7%)	(1%)	
Cumulative Total		100,725	111,715	121,965	132,155	
ASPs: NMOS		$3.25	$3.10	$3.00	$3.00	$3.09
CMOS		0	0	0	0	0
Overall		$3.25	$3.10	$3.00	$3.00	$3.09
Revenue ($M)		36.6	32.4	28.7	28.2	125.7

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	70.2%	67.4%	64.4%	64.9%	66.8%
Japan	28.1	27.3	27.3	24.1	26.8
Europe	1.8	5.3	8.3	11.0	6.4
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	700	700	1,000	1,200	3,600
Eurotechnique	C	200	200	200	200	800
Fairchild	N	0	0	0	0	0
Fujitsu	N	50	50	0	0	100
Hitachi	N	100	100	50	0	250
Intel	N	1,000	1,000	800	700	3,500
Matsushita	N	100	100	100	100	400
Mitsubishi	N	180	120	160	130	590
Mostek	N	200	150	150	50	550
Motorola	N	50	80	30	0	160
National Semi.	N	2,150	2,500	2,500	2,800	9,950
	C	350	500	500	700	2,050
NEC	N	2,000	2,500	2,700	1,500	8,700
Oki Electric	N	400	400	350	350	1,500
SGS-Ates	N	500	800	800	900	3,000
Synertek	N	0	0	0	0	0
Texas Instruments	N	2,000	2,500	3,000	3,000	10,500
Toshiba	N	200	100	100	100	500
	N	9,630	11,100	11,740	10,830	43,300
	C	550	700	700	900	2,850
Total		10,180	11,800	12,440	11,730	46,150
Percentage Change from Previous Quarter		0%	16%	5%	(6%)	
Cumulative Total		142,335	154,135	166,575	178,305	
ASPs: NMOS		$3.00	$3.15	$3.25	$3.35	$3.19
CMOS		0	0	0	0	0
Overall		$3.00	$3.15	$3.25	$3.35	$3.19
Revenue ($M)		28.9	35.0	38.2	36.3	138.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	63.4%	63.0%	64.1%	72.0%	65.7%
Japan	29.8	28.6	27.8	18.6	26.1
Europe	6.9	8.5	8.0	9.4	8.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	1,000	1,100	1,200	1,300	4,600
Fairchild	N	0	0	0	0	0
Fujitsu	N	0	0	0	0	0
Hitachi	N	0	0	0	0	0
Intel	N	300	150	100	50	600
Matsushita	N	50	50	25	0	125
Mitsubishi	N	130	130	130	100	490
Mostek	N	0	0	0	0	0
Motorola	N	0	0	0	0	0
National Semi.	N	2,800	2,700	2,400	2,000	9,900
	C	700	700	550	400	2,350
NEC	N	1,350	1,200	950	700	4,200
Oki Electric	N	250	250	200	200	900
SGS	N	1,050	600	300	800	2,750
Synertek	N	0	0	0	0	0
Texas Instruments	N	3,500	3,000	2,000	1,800	10,300
Thomson-Eurotechnique	C	200	250	250	250	950
Toshiba	N	0	0	0	0	0
	N	10,430	9,180	7,305	6,950	33,865
	C	900	950	800	650	3,300
Total		11,330	10,130	8,105	7,600	37,165
Percentage Change from Previous Quarter		(3%)	(11%)	(20%)	(6%)	
Cumulative Total		189,635	199,765	207,870	215,470	
ASPs: NMOS		$3.35	$3.35	$3.00	$2.85	$3.17
CMOS		$5.50	$5.50	$5.25	$4.50	$5.24
Overall		$3.52	$3.55	$3.22	$2.99	$3.36
Revenue ($M)		39.9	36.0	26.1	22.7	124.7

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	73.3%	75.5%	77.1%	73.0%	74.7%
Japan	15.7	16.1	16.1	13.2	15.4
Europe	11.0	8.4	6.8	13.8	10.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	1,550	1,850	1,350	1,050	5,800
Fairchild	N	0	0	0	0	0
Fujitsu	N	0	0	0	0	0
Hitachi	N	0	0	0	0	0
Intel	N	0	0	0	0	0
Matsushita	N	0	0	0	0	0
Mitsubishi	N	50	50	0	0	100
Mostek	N	0	0	0	0	0
Motorola	N	0	0	0	0	0
National Semi.	N	1,800	1,600	1,500	1,200	6,100
	C	400	350	400	500	1,650
NEC	N	400	250	800	270	1,720
Oki Electric	N	150	150	100	100	500
SGS	N	750	800	1,100	1,200	3,850
Synertek	N	0	0	0	0	0
Texas Instruments	N	1,500	1,500	1,600	1,600	6,200
Thomson-Eurotechnique	C	350	450	400	500	1,700
Toshiba	N	0	0	0	0	0
	N	6,200	6,200	6,450	5,420	24,270
	C	750	800	800	1,000	3,350
Total		6,950	7,000	7,250	6,420	27,620
Percentage Change from Previous Quarter		(9%)	1%	4%	(11%)	
Cumulative Total		222,420	229,420	236,670	243,090	
ASPs: NMOS		$2.60	$2.40	$2.25	$2.25	$2.38
CMOS		$4.00	$3.50	$3.25	$3.25	$3.48
Overall		$2.75	$2.53	$2.36	$2.41	$2.51
Revenue ($M)		19.1	17.7	17.1	15.4	69.4

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	75.5%	75.7%	66.9%	67.8%	71.5%
Japan	8.6	6.4	12.4	5.8	8.4
Europe	15.8	17.9	20.7	26.5	20.1
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	1,000	600	450	375	2,425
Intel	N	250	250	250	250	1,000
National Semi.	N	1,500	1,200	950	800	4,450
NEC	N	180	220	80	40	520
SGS	N	356	189	600	400	1,545
Texas Instruments	N	750	750	400	200	2,100
Thomson	N	1,000	600	600	425	2,625
	N	5,036	3,809	3,330	2,490	14,665
	C	0	0	0	0	0
Total		5,036	3,809	3,330	2,490	14,665
Percentage Change from Previous Quarter		(22%)	(24%)	(13%)	(25%)	
Cumulative Total		248,126	251,935	255,265	257,755	
ASPs: NMOS		$2.35	$2.40	$2.40	$2.50	$2.40
CMOS		0	0	0	0	0
Overall		$2.35	$2.40	$2.40	$2.50	$2.40
Revenue ($M)		11.8	9.1	8.0	6.2	35.2

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	69.5%	73.5%	61.6%	65.3%	68.0%
Japan	3.6	5.8	2.4	1.6	3.5
Europe	26.9	20.7	36.0	33.1	28.4
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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MOS EPROM--Data

Table 2 (Continued)

16K MOS EPROM Shipment Data, 1976–1987

Company	MOS Process	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	500	300	300	290	1,390
Cypress	C	150	200	200	350	900
Intel	N	200	200	200	200	800
National Semi.	C	158	227	204	195	784
NEC	N	40	40	50	30	160
SGS-Thomson	N	1,185	1,125	1,240	720	4,270
	C	15	70	30	75	190
Texas Instruments	N	200	200	150	150	700
	C	50	50	110	125	335
WaferScale	C	10	25	75	75	185
	N	2,125	1,865	1,940	1,390	7,320
	C	383	572	619	820	2,394
Total		2,508	2,437	2,559	2,210	9,714
* Percentage Change from Previous Quarter		1%	(3%)	5%	(14%)	
Cumulative Total		260,263	262,700	265,259	267,469	
ASPs: NMOS		$2.55	$2.60	$2.65	$2.70	$2.62
CMOS		$4.60	$2.90	$3.10	$3.30	$3.36
Overall		$2.86	$2.67	$2.76	$2.92	$2.80
Revenue ($M)		7.2	6.5	7.1	6.5	27.2

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	50.6%	49.3%	48.4%	62.7%	52.4%
Japan	1.6	1.6	2.0	1.3	1.6
Europe	47.8	49.0	49.6	36.0	45.9
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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MOS EPROM--Data

Table 3

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1978 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	N/A	N/A	N/A	0
Eurotechnique	C	N/A	N/A	N/A	N/A	0
Fujitsu	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
Hitachi	N	N/A	N/A	N/A	N/A	0
Intel	N	N/A	N/A	N/A	S	0
Mitsubishi	N	N/A	N/A	N/A	N/A	0
Motorola	N	N/A	N/A	N/A	N/A	0
National Semi.	C	N/A	N/A	N/A	N/A	0
NEC	N	N/A	N/A	N/A	N/A	0
Ricoh	C	N/A	N/A	N/A	N/A	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Texas Instruments	N	N/A	N/A	N/A	5	5
Toshiba	N	N/A	N/A	N/A	N/A	0
	N	0	0	0	5	5
	C	0	0	0	0	0
Total		0	0	0	5	5
Percentage Change from Previous Quarter		0	0	0	0	
Cumulative Total		0	0	0	5	
ASPs: NMOS		0	0	0	0	$80.00
CMOS		0	0	0	0	0
Overall		0	0	0	0	$80.00
Revenue ($M)		0	0	0	0	0

	1978 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	0	0	0	0	0
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	0	0	0	0	0

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Table 3 (Continued)

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1979 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	N/A	N/A	N/A	0
Eurotechnique	C	N/A	N/A	N/A	N/A	0
Fujitsu	N	N/A	N/A	N/A	S	0
	C	N/A	N/A	N/A	N/A	0
Hitachi	N	N/A	N/A	N/A	S	0
Intel	N	5	30	50	100	185
Mitsubishi	N	N/A	N/A	N/A	S	0
Motorola	N	N/A	N/A	N/A	S	0
National Semi.	C	N/A	N/A	N/A	N/A	0
NEC	N	N/A	N/A	N/A	N/A	0
Ricoh	C	N/A	N/A	N/A	N/A	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Texas Instruments	N	10	35	60	90	195
Toshiba	N	N/A	N/A	N/A	N/A	0
	N	15	65	110	190	380
	C	0	0	0	0	0
Total		15	65	110	190	380
Percentage Change from Previous Quarter		0	333%	69%	73%	
Cumulative Total		20	85	195	385	
ASPs: NMOS		$80.00	$80.00	$75.00	$75.00	$76.05
CMOS		0	0	0	0	0
Overall		$80.00	$80.00	$75.00	$75.00	$76.05
Revenue ($M)		1.2	5.2	8.3	14.3	28.9

	1979 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	100.0%	100.0%	100.0%	100.0%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	N/A	S	2	2
Eurotechnique	C	N/A	N/A	N/A	N/A	0
Fujitsu	N	S	S	15	100	115
	C	N/A	N/A	N/A	N/A	0
Hitachi	N	S	120	220	280	620
Intel	N	165	250	325	450	1,190
Mitsubishi	N	S	6	40	90	136
Motorola	N	5	30	60	50	145
National Semi.	C	S	10	15	15	40
NEC	N	N/A	N/A	5	15	20
Ricoh	C	N/A	N/A	N/A	N/A	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Texas Instruments	N	150	300	350	450	1,250
Toshiba	N	N/A	S	5	10	15
	N	320	706	1,020	1,447	3,493
	C	0	10	15	15	40
Total		320	716	1,035	1,462	3,533
Percentage Change from Previous Quarter		68%	124%	45%	41%	
Cumulative Total		705	1,421	2,456	3,918	
ASPs: NMOS		$55.00	$40.00	$30.00	$10.00	$26.03
CMOS		0	0	0	0	0
Overall		$55.00	$40.00	$30.00	$10.00	$26.03
Revenue ($M)		17.6	28.2	30.6	14.5	90.9

	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	82.4%	72.5%	66.1%	74.4%
Japan	0	17.6	27.5	33.9	25.6
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	10	100	120	310	540
Eurotechnique	C	N/A	N/A	S	5	5
Fujitsu	N	150	170	600	1,000	1,920
	C	N/A	N/A	N/A	N/A	0
Hitachi	N	500	600	900	1,050	3,050
Intel	N	600	700	1,050	1,600	3,950
Mitsubishi	N	190	270	270	660	1,390
Motorola	N	50	120	250	350	770
National Semi.	C	10	20	30	30	90
NEC	N	30	50	325	700	1,105
Ricoh	C	N/A	N/A	N/A	N/A	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Texas Instruments	N	560	700	900	1,000	3,160
Toshiba	N	10	25	100	180	315
	N	2,100	2,735	4,515	6,850	16,200
	C	10	20	30	35	95
Total		2,110	2,755	4,545	6,885	16,295
Percentage Change from Previous Quarter		44%	31%	65%	51%	
Cumulative Total		6,028	8,783	13,328	20,213	
ASPs: NMOS		$9.00	$8.00	$7.00	$5.80	$6.92
CMOS		0	0	0	0	0
Overall		$9.00	$8.00	$7.00	$5.80	$6.92
Revenue ($M)		18.9	21.9	31.6	39.7	112.1

	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	58.3%	59.5%	51.7%	47.8%	52.2%
Japan	41.7	40.5	48.3	52.1	47.7
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available
Note: Columns may not add to totals shown because of rounding.

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Table 3 (Continued)

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	600	1,050	650	850	3,150
Eurotechnique	C	30	100	150	200	480
Fujitsu	N	600	700	1,000	1,200	3,500
	C	N/A	N/A	N/A	S	0
Hitachi	N	1,500	2,500	2,500	2,500	9,000
Intel	N	2,000	2,500	2,500	2,500	9,500
Mitsubishi	N	1,450	1,500	1,800	1,500	6,250
Motorola	N	325	100	100	0	525
National Semi.	C	75	100	220	250	645
NEC	N	1,300	1,600	2,200	2,300	7,400
Ricoh	C	N/A	N/A	N/A	N/A	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	S	10	25	50	85
Texas Instruments	N	500	600	700	900	2,700
Toshiba	N	300	400	600	600	1,900
	N	8,575	10,960	12,075	12,400	44,010
	C	105	200	370	450	1,125
Total		8,680	11,160	12,445	12,850	45,135
Percentage Change from Previous Quarter		26%	29%	12%	3%	
Cumulative Total		28,893	40,053	52,498	65,348	
ASPs: NMOS		$6.00	$5.50	$5.00	$4.75	$5.25
CMOS		0	0	0	0	0
Overall		$6.00	$5.50	$5.00	$4.75	$5.25
Revenue ($M)		51.5	60.3	60.4	58.9	231.0

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	40.3%	39.0%	33.5%	35.0%	36.6%
Japan	59.3	60.0	65.1	63.0	62.1
Europe	0.3	1.0	1.4	1.9	1.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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Table 3 (Continued)

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.	1983 Year
AMD	N	800	1,000	1,200	1,500	4,500
Eurotechnique	C	200	300	400	400	1,300
Fujitsu	N	1,200	1,500	1,500	1,500	5,700
	C	10	25	50	50	135
Hitachi	N	3,000	3,500	3,500	3,000	13,000
Intel	N	2,500	2,500	2,200	1,800	9,000
Mitsubishi	N	1,600	1,700	1,500	1,300	6,100
Motorola	N	0	0	0	0	0
National Semi.	C	350	450	600	800	2,200
NEC	N	2,400	2,500	1,700	1,700	8,300
Ricoh	C	N/A	N/A	N/A	S	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	S	25	25
SGS-Ates	N	50	100	100	100	350
Texas Instruments	N	1,000	2,000	3,000	3,500	9,500
Toshiba	N	600	400	500	500	2,000
	N	13,150	15,200	15,200	14,900	58,450
	C	560	775	1,050	1,275	3,660
Total		13,710	15,975	16,250	16,175	62,110
Percentage Change from Previous Quarter		7%	17%	2%	0%	
Cumulative Total		79,058	95,033	111,283	127,458	
ASPs: NMOS		$4.50	$4.00	$3.75	$3.75	$3.98
CMOS		0	0	0	0	0
Overall		$4.50	$4.00	$3.75	$3.75	$3.98
Revenue ($M)		59.2	60.8	57.0	55.9	232.9

	1983 1st Qtr.	1983 2nd Qtr.	1983 3rd Qtr.	1983 4th Qtr.	1983 Year
Market Share					
U.S.	33.9%	37.2%	43.1%	47.1%	40.6%
Japan	64.3	60.3	53.8	49.8	56.7
Europe	1.8	2.5	3.1	3.1	2.7
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	1,600	1,800	2,200	2,200	7,800
Fujitsu	N	1,600	1,800	1,500	1,200	6,100
	C	150	250	250	250	900
Hitachi	N	2,500	2,000	1,500	1,200	7,200
Intel	N	1,800	1,800	2,000	2,000	7,600
Mitsubishi	N	1,100	900	650	400	3,050
Motorola	N	0	0	0	0	0
National Semi.	C	900	1,000	1,100	850	3,850
NEC	N	1,400	1,550	1,000	750	4,700
Ricoh	C	S	S	50	100	150
Rockwell	N	N/A	N/A	S	S	0
	C	50	25	0	0	75
SGS	N	200	350	600	1,000	2,150
Texas Instruments	N	3,800	4,000	3,200	2,200	13,200
Thomson-Eurotecnnique	C	350	300	300	250	1,200
Toshiba	N	300	150	50	25	525
	N	14,300	14,350	12,700	10,975	52,325
	C	1,450	1,575	1,700	1,450	6,175
Total		15,750	15,925	14,400	12,425	58,500
Percentage Change from Previous Quarter		(3%)	1%	(10%)	(14%)	
Cumulative Total		143,208	159,133	173,533	185,958	
ASPs: NMOS		$3.60	$3.50	$3.25	$3.10	$3.38
CMOS		$7.50	$7.50	$7.25	$7.00	$7.31
Overall		$3.96	$3.90	$3.72	$3.56	$3.80
Revenue ($M)		62.4	62.0	53.6	44.2	222.2

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	51.7%	54.2%	59.0%	58.4%	55.6%
Japan	44.8	41.8	34.7	31.6	38.7
Europe	3.5	4.1	6.3	10.1	5.7
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	2,200	2,450	1,750	1,300	7,700
Fujitsu	N	800	600	300	250	1,950
	C	250	250	250	150	900
Hitachi	N	900	700	400	400	2,400
Intel	N	1,800	1,500	1,500	1,500	6,300
Mitsubishi	N	650	1,000	450	300	2,400
Motorola	N	0	0	0	0	0
National Semi.	C	700	600	500	500	2,300
NEC	N	730	500	800	530	2,560
Ricoh	C	150	200	200	150	700
Rockwell	N	50	50	0	0	100
	C	0	0	0	0	0
SGS	N	800	700	850	1,000	3,350
Texas Instruments	N	1,800	1,600	1,500	1,200	6,100
Thomson-Eurotechnique	C	350	400	400	400	1,550
Toshiba	N	0	0	0	0	0
	N	9,730	9,100	7,550	6,480	32,860
	C	1,450	1,450	1,350	1,200	5,450
Total		11,180	10,550	8,900	7,680	38,310
Percentage Change from Previous Quarter		(10%)	(6%)	(16%)	(14%)	
Cumulative Total		197,138	207,688	216,588	224,268	
ASPs: NMOS		$2.80	$2.25	$2.20	$2.20	$2.39
CMOS		$5.50	$4.50	$3.50	$2.80	$4.14
Overall		$3.15	$2.56	$2.40	$2.29	$2.64
Revenue ($M)		35.2	27.0	21.3	17.6	101.2

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	58.6%	58.8%	59.0%	58.6%	58.7%
Japan	31.1	30.8	27.0	23.2	28.5
Europe	10.3	10.4	14.0	18.2	12.8
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	950	850	675	450	2,925
Fujitsu	N	150	50	0	0	200
	C	50	0	0	0	50
Hitachi	N	500	200	100	50	850
Intel	N	1,300	1,300	1,000	1,550	5,150
	OTP	250	250	250	100	950
Mitsubishi	N	0	0	282	7	289
National Semi.	C	400	300	300	300	1,300
NEC	N	330	270	150	100	850
Ricoh	C	50	50	0	0	100
SGS	N	463	350	1,200	1,200	3,213
Texas Instruments	N	1,000	1,000	1,100	1,500	4,600
Thomson-Eurotechnique	C	300	300	300	300	1,200
	N	4,943	4,270	4,757	4,957	18,927
	C	800	650	600	600	2,650
Total		5,743	4,920	5,357	5,557	21,577
Percentage Change from Previous Quarter		(25%)	(14%)	9%	4%	
Cumulative Total		230,011	234,931	240,288	245,845	
ASPs: NMOS		$2.10	$2.15	$2.20	$2.25	$2.18
CMOS		$2.50	$2.75	$2.80	$2.85	$2.71
Overall		$2.16	$2.23	$2.27	$2.31	$2.24
Revenue ($M)		12.4	11.0	12.1	12.9	48.4

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	67.9%	75.2%	62.1%	70.2%	68.7%
Japan	18.8	11.6	9.9	2.8	10.8
Europe	13.3	13.2	28.0	27.0	20.5
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 3 (Continued)

32K MOS EPROM Shipment Data, 1978–1987

Company	MOS Process	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	400	450	475	510	1,835
Fujitsu	N	0	0	0	0	0
	C	0	0	0	0	0
Hitachi	N	0	0	0	0	0
Intel	N	1,050	1,300	1,100	1,100	4,550
	OTP	0	0	0	0	0
Mitsubishi	N	0	0	0	0	0
National Semi.	C	750	750	744	628	2,872
NEC	N	100	20	20	10	150
Ricoh	C	0	0	0	0	0
SGS-Thomson	N	685	550	470	560	2,265
	C	75	65	50	45	235
Texas Instruments	N	1,500	1,000	1,000	800	4,300
	N	3,735	3,320	3,065	2,980	13,100
	C	825	915	794	673	3,107
Total		4,560	4,135	3,859	3,653	16,207
Percentage Change from Previous Quarter		(18%)	(9%)	(7%)	(5%)	
Cumulative Total		250,405	254,540	258,399	262,052	
ASPs: NMOS		$2.50	$2.75	$2.90	$3.00	$2.77
CMOS		$2.90	$3.00	$3.20	$3.25	$3.08
Overall		$2.57	$2.80	$2.96	$3.05	$2.83
Revenue ($M)		11.7	11.6	11.4	11.1	45.9

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	81.1%	84.6%	86.0%	83.2%	83.6%
Japan	2.2	0.5	0.5	0.3	0.9
Europe	16.7	14.9	13.5	16.6	15.4
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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Table 4

64K MOS EPROM Shipment Data, 1980–1987

Company	MOS Process	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	N/A	N/A	N/A	0
Fujitsu	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
Hitachi	N	N/A	N/A	N/A	S	0
	C	N/A	N/A	N/A	N/A	0
Intel	N	N/A	N/A	N/A	S	0
	N	N/A	N/A	N/A	N/A	0
Mitsubishi	N	N/A	N/A	N/A	N/A	0
Mostek	N	N/A	N/A	N/A	S	0
Motorola	N	S	S	5	5	10
NEC	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
Oki Electric	N	N/A	N/A	N/A	N/A	0
Ricoh	C	N/A	N/A	N/A	N/A	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
SEEQ	N	N/A	N/A	N/A	N/A	0
Seiko-Epson	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Sharp	C	N/A	N/A	N/A	N/A	0
Signetics	C	N/A	N/A	N/A	N/A	0
Texas Instruments	N	N/A	S	10	20	30
Toshiba	N	N/A	N/A	N/A	N/A	0
VLSI Technology	C	N/A	N/A	N/A	N/A	0
WaferScale	N	N/A	N/A	N/A	N/A	0
	N	0	0	15	25	40
	C	0	0	0	0	0
Total		0	0	15	25	40
Percentage Change from Previous Quarter		0	0	0	67%	
Cumulative Total		0	0	15	40	
ASPs: NMOS		0	0	0	0	0
CMOS		0	0	0	0	0
Overall		$200.00	$100.00	$80.00	$70.00	$73.75
Revenue ($M)		0	0	1.2	1.8	3.0

	1980 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	0	0	100.0%	100.0%	100.0%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	0	0	100.0%	100.0%	100.0%

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Table 4 (Continued)

64K MOS EPROM Shipment Data, 1980–1987

Company	MOS Process	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	N/A	N/A	N/A	0
Fujitsu	N	S	1	15	100	116
	C	N/A	N/A	N/A	N/A	0
Hitachi	N	S	2	5	25	32
	C	N/A	N/A	N/A	N/A	0
Intel	N	10	70	200	500	780
	N	N/A	N/A	N/A	N/A	0
Mitsubishi	N	N/A	N/A	N/A	S	0
Mostek	N	S	2	5	3	10
Motorola	N	15	40	30	50	135
NEC	N	N/A	N/A	N/A	S	0
	C	N/A	N/A	N/A	N/A	0
Oki Electric	N	N/A	N/A	N/A	N/A	0
Ricoh	C	N/A	N/A	N/A	N/A	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
SEEQ	N	N/A	N/A	N/A	N/A	0
Seiko-Epson	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Sharp	C	N/A	N/A	N/A	N/A	0
Signetics	C	N/A	N/A	N/A	N/A	0
Texas Instruments	N	30	65	100	100	295
Toshiba	N	N/A	N/A	N/A	N/A	0
VLSI Technology	C	N/A	N/A	N/A	N/A	0
WaferScale	N	N/A	N/A	N/A	N/A	0
	N	55	180	355	778	1,368
	C	0	0	0	0	0
Total		55	180	355	778	1,368
Percentage Change from Previous Quarter		120%	227%	97%	119%	
Cumulative Total		95	275	630	1,408	
ASPs: NMOS		0	0	0	0	0
CMOS		0	0	0	0	0
Overall		$70.00	$60.00	$38.00	$24.00	$34.22
Revenue ($M)		3.9	10.8	13.5	18.7	46.8

	1981 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	98.3%	94.4%	83.9%	89.2%
Japan	0	1.7	5.6	16.1	10.8
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 4 (Continued)

64K MOS EPROM Shipment Data, 1980–1987

Company	MOS Process	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	S	10	250	500	760
Fujitsu	N	400	1,000	1,500	2,000	4,900
	C	10	25	50	100	185
Hitachi	N	100	250	600	800	1,750
	C	N/A	N/A	N/A	N/A	0
Intel	N	800	1,700	2,500	2,500	7,500
	N	N/A	N/A	N/A	N/A	0
Mitsubishi	N	S	15	500	1,400	1,915
Mostek	N	0	0	0	0	0
Motorola	N	60	100	100	100	360
NEC	N	S	10	60	200	270
	C	N/A	N/A	N/A	N/A	0
Oki Electric	N	N/A	N/A	N/A	S	0
Ricoh	C	N/A	N/A	N/A	N/A	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
SEEQ	N	N/A	S	5	15	20
Seiko-Epson	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Sharp	C	N/A	N/A	N/A	N/A	0
Signetics	C	N/A	N/A	N/A	N/A	0
Texas Instruments	N	100	100	100	100	400
Toshiba	N	N/A	S	20	50	70
VLSI Technology	C	N/A	N/A	N/A	N/A	0
WaferScale	N	N/A	N/A	N/A	N/A	0
	N	1,460	3,185	5,635	7,665	17,945
	C	10	25	50	100	185
Total		1,470	3,210	5,685	7,765	18,130
Percentage Change from Previous Quarter		89%	118%	77%	37%	
Cumulative Total		2,878	6,088	11,773	19,538	
ASPs: NMOS		0	0	0	0	0
CMOS		0	0	0	0	0
Overall		$15.00	$11.50	$8.50	$6.50	$8.70
Revenue ($M)		22.1	36.9	48.3	50.5	157.8

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	65.3%	59.5%	52.0%	41.4%	49.9%
Japan	34.7	40.5	48.0	58.6	50.1
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

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Table 4 (Continued)

64K MOS EPROM Shipment Data, 1980–1987

Company	MOS Process	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	600	900	1,300	1,800	4,600
Fujitsu	N	2,200	2,400	2,500	3,000	10,100
	C	250	300	350	400	1,300
Hitachi	N	1,500	2,300	3,500	5,500	12,800
	C	N/A	S	50	50	100
Intel	N	3,000	3,500	4,000	3,500	14,000
	N	N/A	N/A	N/A	N/A	0
Mitsubishi	N	1,700	2,000	3,200	3,800	10,700
Mostek	N	0	0	0	0	0
Motorola	N	150	200	450	700	1,500
NEC	N	350	500	500	600	1,950
	C	N/A	N/A	N/A	N/A	0
Oki Electric	N	25	50	100	200	375
Ricoh	C	N/A	N/A	N/A	N/A	0
Rockwell	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
SEEQ	N	25	100	310	600	1,035
Seiko-Epson	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	S	0
Sharp	C	N/A	N/A	N/A	N/A	0
Signetics	C	N/A	N/A	S	S	0
Texas Instruments	N	400	800	1,500	2,000	4,700
Toshiba	N	200	400	400	600	1,600
VLSI Technology	C	N/A	N/A	N/A	N/A	0
WaferScale	N	N/A	N/A	N/A	N/A	0
	N	10,150	13,150	17,760	22,300	63,360
	C	250	300	400	450	1,400
Total		10,400	13,450	18,160	22,750	64,760
Percentage Change from Previous Quarter		34%	29%	35%	25%	
Cumulative Total		29,938	43,388	61,548	84,298	
ASPs: NMOS		0	0	0	0	0
CMOS		0	0	0	0	0
Overall		$5.50	$4.75	$5.00	$5.50	$5.20
Revenue ($M)		57.2	63.9	90.8	125.1	337.0

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	40.1%	40.9%	41.6%	37.8%	39.9%
Japan	59.9	59.1	58.4	62.2	60.1
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
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Table 4 (Continued)

64K MOS EPROM Shipment Data, 1980–1987

Company	MOS Process	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	1,200	1,300	1,600	1,700	5,800
Fujitsu	N	2,500	2,800	3,000	3,000	11,300
	C	500	600	700	900	2,700
Hitachi	N	4,000	5,000	6,000	6,000	21,000
	C	100	250	300	350	1,000
Intel	N	2,000	2,000	2,000	2,000	8,000
	N	N/A	N/A	N/A	S	0
Mitsubishi	N	5,000	5,700	5,700	5,000	21,400
Mostek	N	0	0	0	0	0
Motorola	N	900	900	600	500	2,900
NEC	N	800	1,400	900	1,200	4,300
	C	N/A	N/A	N/A	S	0
Oki Electric	N	400	600	500	400	1,900
Ricoh	C	N/A	0	25	100	125
Rockwell	N	S	10	0	0	10
	C	10	50	0	0	60
SEEQ	N	800	1,000	1,050	1,100	3,950
Seiko-Epson	C	N/A	N/A	N/A	N/A	0
SGS	N	50	150	350	600	1,150
Sharp	C	N/A	N/A	N/A	N/A	0
Signetics	C	S	10	10	10	30
Texas Instruments	N	2,400	2,600	2,800	2,400	10,200
Toshiba	N	400	1,200	800	500	2,900
VLSI Technology	C	N/A	N/A	N/A	N/A	0
WaferScale	N	N/A	N/A	N/A	N/A	0
	N	20,450	24,660	25,300	24,400	94,810
	C	610	910	1,035	1,360	3,915
Total		21,060	25,570	26,335	25,760	98,725
Percentage Change from Previous Quarter		(7%)	21%	3%	(2%)	
Cumulative Total		105,358	130,928	157,263	183,023	
ASPs: NMOS		$5.25	$5.25	$4.75	$4.25	$4.86
CMOS		$15.00	$15.00	$13.50	$10.00	$12.87
Overall		$5.53	$5.60	$5.09	$4.55	$5.18
Revenue ($M)		116.5	143.1	134.1	117.3	511.1

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	34.7%	30.8%	30.6%	29.9%	31.3%
Japan	65.1	68.6	68.1	67.7	67.5
Europe	0.2	0.6	1.3	2.3	1.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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Table 4 (Continued)

64K MOS EPROM Shipment Data, 1980–1987

Company	MOS Process	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	2,100	1,550	1,825	1,150	6,625
Fujitsu	N	3,500	3,500	3,800	3,500	14,300
	C	800	950	1,000	1,200	3,950
Hitachi	N	5,500	5,200	5,000	4,500	20,200
	C	400	400	450	500	1,750
Intel	N	2,600	3,000	3,000	2,900	11,500
	N	25	75	150	250	500
Mitsubishi	N	4,850	2,600	4,300	4,200	15,950
Mostek	N	0	0	0	0	0
Motorola	N	400	300	300	400	1,400
NEC	N	1,250	1,450	1,650	1,800	6,150
	C	40	200	350	300	890
Oki Electric	N	350	300	200	150	1,000
Ricoh	C	200	250	250	150	850
Rockwell	N	0	0	0	0	0
	C	0	0	0	0	0
SEEQ	N	625	500	350	275	1,750
Seiko-Epson	C	N/A	N/A	N/A	S	0
SGS	N	880	850	1,000	1,350	4,080
Sharp	C	N/A	N/A	N/A	S	0
Signetics	C	0	0	0	0	0
Texas Instruments	N	2,200	2,000	2,000	2,000	8,200
Toshiba	N	800	600	500	350	2,250
VLSI Technology	C	N/A	S	20	40	60
WaferScale	N	N/A	N/A	S	10	10
	N	25,080	21,925	24,075	22,825	93,905
	C	1,440	1,800	2,070	2,200	7,510
Total		26,520	23,725	26,145	25,025	101,415
Percentage Change from Previous Quarter		3%	(11%)	10%	(4%)	
Cumulative Total		209,543	233,268	259,413	284,438	
ASPs: NMOS		$3.60	$2.80	$2.35	$2.10	$2.73
CMOS		$6.00	$4.55	$3.75	$3.25	$4.23
Overall		$3.63	$2.93	$2.46	$2.20	$2.84
Revenue ($M)		98.9	69.6	64.3	55.1	287.9

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	30.0%	31.3%	29.2%	28.1%	29.6%
Japan	66.7	65.1	66.9	66.5	66.4
Europe	3.3	3.6	3.8	5.4	4.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 4 (Continued)

64K MOS EPROM Shipment Data, 1980–1987

Company	MOS Process	1986 1st Qtr.	1986 2nd Qtr.	1986 3rd Qtr.	1986 4th Qtr.	Year
AMD	N	850	800	900	1,385	3,935
Fujitsu	N	1,500	1,500	2,000	4,000	9,000
	C	1,000	1,000	2,000	4,000	8,000
General Instruments	C	S	0	31	170	201
	OTP	N/A	N/A	S	10	10
Gold Star	C	S	S	0	5	5
Hitachi	N	5,400	5,000	4,500	4,000	18,900
	C	700	700	700	700	2,800
Hyundai	C	S	S	0	5	5
Intel	N	3,400	3,300	2,400	3,200	12,300
	C	250	500	425	400	1,575
	N OTP	400	400	300	200	1,300
	C OTP	0	30	130	100	260
Mitsubishi	N	3,226	3,339	3,459	2,810	12,834
	OTP	775	43	564	511	1,893
Motorola	N	147	346	177	114	784
	OTP	66	87	54	22	229
National Semi.	C	25	75	150	200	450
NEC	N	1,850	1,000	300	150	3,300
	C	800	1,000	490	300	2,590
	OTP	240	140	100	50	530
Ricoh	C	0	0	25	50	75
SEEQ	N	525	615	315	150	1,605
Seiko-Epson	C	0	75	100	150	325
SGS	N	552	608	2,500	2,500	6,160
Sharp	C	0	5	10	15	30
	OTP	S	S	0	0	0
Signetics	C	0	5	5	10	20
Texas Instruments	N	1,400	1,400	1,800	1,600	6,200
Toshiba	N	500	600	600	900	2,600
	OTP	100	400	500	500	1,500
VLSI Technology	C	40	40	40	50	170
WaferScale	C	0	10	10	10	30
Others	C	0	0	5	5	10
	N	20,691	19,438	20,369	22,042	82,540
	C	3,055	3,580	4,221	6,230	17,086
Total		23,746	23,018	24,590	28,272	99,626
Percentage Change from Previous Quarter		(5%)	(3%)	7%	15%	
Cumulative Total		308,184	331,202	355,792	384,064	
ASPs: NMOS		$2.15	$2.35	$2.60	$2.75	$2.47
CMOS		$3.50	$3.75	$3.85	$4.10	$3.86
Overall		$2.32	$2.57	$2.81	$3.05	$2.71
Revenue ($M)		55.2	59.1	69.2	86.2	269.7

	1986 1st Qtr.	1986 2nd Qtr.	1986 3rd Qtr.	1986 4th Qtr.	Year
Market Share					
U.S.	29.9%	33.1%	27.4%	27.0%	29.2%
Japan	67.8	64.3	62.4	64.1	64.6
Europe	2.3	2.6	10.2	8.8	6.2
ROW	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 4 (Continued)

64K MOS EPROM Shipment Data, 1980–1987

Company	MOS Process	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	1,300	1,500	1,170	1,600	5,570
Cypress	C	50	75	100	100	325
Fujitsu	N	400	1,000	1,000	1,000	3,400
	C	1,800	2,000	2,200	2,200	8,200
Gold Star	C	5	5	5	5	20
Hitachi	N	2,500	1,500	1,000	0	5,000
	C	700	700	400	0	1,800
	C OTP	0	50	100	0	150
Hyundai	C	5	5	10	20	40
Intel	N	1,400	1,400	1,100	1,700	5,600
	C	400	400	500	400	1,700
	N OTP	350	300	150	250	1,050
	C OTP	200	250	200	200	850
Microchip Tech., Inc.	C	100	299	202	632	1,233
	OTP	10	20	50	100	180
Mitsubishi	N	1,450	1,150	1,250	1,600	5,450
	OTP	450	250	200	300	1,200
Motorola	N	125	100	86	60	371
	OTP	17	10	13	6	46
National Semi.	C	606	1,198	1,580	2,341	5,725
	C OTP	N/A	N/A	N/A	S	0
NEC	N	400	60	70	0	530
	C	1,000	370	390	200	1,960
	OTP	0	0	0	0	0
Oki Electric	N	50	50	50	50	200
	N OTP	450	450	400	350	1,650
Ricoh	C	50	50	100	100	300
SEEQ	N	200	200	200	200	800
Seiko-Epson	C	100	100	100	100	400
SGS-Thomson	N	870	1,645	2,080	2,100	6,695
	C	80	110	40	100	330
	C OTP	5	45	70	100	220
Sharp	C	0	80	150	250	480
	OTP	0	0	0	0	0
Signetics	C	200	450	800	1,100	2,550
Texas Instruments	N	1,100	1,200	1,350	1,400	5,050
Toshiba	N	700	500	500	200	1,900
	N OTP	1,000	1,000	1,000	1,000	4,000
VLSI Technology	C	75	100	100	100	375
WaferScale	C	30	50	50	50	180
	N	12,762	12,315	11,619	11,816	48,512
	C	5,416	6,407	7,247	8,098	27,168
Total		18,178	18,722	18,866	19,914	75,680

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Table 4 (Continued)

64K MOS EPROM Shipment Data, 1980–1987

	1987				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Percentage Change from Previous Quarter	(36%)	(3%)	1%	6%	
Cumulative Total	402,242	420,964	439,830	459,744	
ASPs: NMOS	$2.80	$2.90	$3.00	$3.10	$2.95
CMOS	$3.00	$3.10	$3.00	$3.20	$3.08
Overall	$2.86	$2.97	$3.00	$3.14	$3.00
Revenue ($M)	52.0	55.6	56.6	62.5	226.7

	1987				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	32.8%	37.9%	36.3%	45.9%	38.4%
Japan	60.8	49.7	47.2	36.9	48.4
Europe	6.4	12.0	15.8	17.0	12.9
ROW	0.1	0.3	0.6	0.1	0.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available
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Table 5

128K MOS EPROM Shipment Data, 1982–1987

Company	MOS Process	1982 1st Qtr.	1982 2nd Qtr.	1982 3rd Qtr.	1982 4th Qtr.	Year
AMD	N	N/A	N/A	N/A	S	0
Fujitsu	N	N/A	N/A	N/A	S	0
	C	N/A	N/A	N/A	N/A	0
Hitachi	N	N/A	N/A	N/A	S	0
Intel	N	3	15	50	150	218
Mitsubishi	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
NEC	N	N/A	N/A	N/A	N/A	0
SEEQ	N	N/A	N/A	N/A	S	0
Texas Instruments	N	N/A	S	5	5	10
	C	N/A	N/A	N/A	N/A	0
Toshiba	N	N/A	N/A	N/A	N/A	N/A
	N	3	15	55	155	228
	C	0	0	0	0	0
Total		3	15	55	155	228
Percentage Change from Previous Quarter		0	400%	267%	182%	
Cumulative Total		3	18	73	228	
Average Selling Price		$75.00	$60.00	$50.00	$40.00	$44.19
Revenue ($M)		0.2	0.9	2.8	6.2	10.1

	1982 1st Qtr.	1982 2nd Qtr.	1982 3rd Qtr.	1982 4th Qtr.	Year
Market Share					
U.S.	100.0%	100.0%	100.0%	100.0%	100.0%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
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Table 5 (Continued)

128K MOS EPROM Shipment Data, 1982–1987

Company	MOS Process	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	50	175	300	500	1,025
Fujitsu	N	10	50	150	350	560
	C	S	10	25	35	70
Hitachi	N	10	50	150	350	560
Intel	N	450	800	1,200	1,500	3,950
Mitsubishi	N	S	10	10	10	30
	C	N/A	N/A	N/A	N/A	0
NEC	N	S	10	20	100	130
SEEQ	N	N/A	S	50	100	150
Texas Instruments	N	0	0	0	0	0
	C	N/A	N/A	N/A	N/A	0
Toshiba	N	S	10	20	50	80
	N	520	1,105	1,900	2,960	6,485
	C	0	10	25	35	70
Total		520	1,115	1,925	2,995	6,555
Percentage Change from Previous Quarter		235%	114%	73%	56%	
Cumulative Total		748	1,863	3,788	6,783	
Average Selling Price		$30.00	$22.00	$17.00	$16.00	$18.44
Revenue ($M)		15.6	24.5	32.7	47.9	120.8

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	96.2%	87.4%	80.5%	70.1%	78.2%
Japan	3.8	12.6	19.5	29.9	21.8
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
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Table 5 (Continued)

128K MOS EPROM Shipment Data, 1982–1987

Company	MOS Process	1984 1st Qtr.	1984 2nd Qtr.	1984 3rd Qtr.	1984 4th Qtr.	1984 Year
AMD	N	500	800	850	900	3,050
Fujitsu	N	550	750	800	700	2,800
	C	50	75	100	100	325
Hitachi	N	650	1,800	2,000	2,800	7,250
Intel	N	1,500	1,600	1,700	2,200	7,000
Mitsubishi	N	60	400	1,500	2,200	4,160
	C	N/A	N/A	N/A	S	0
NEC	N	20	160	600	1,000	1,780
SEEQ	N	150	400	525	575	1,650
Texas Instruments	N	10	25	25	25	85
	C	N/A	N/A	N/A	N/A	0
Toshiba	N	100	300	500	900	1,800
	N	3,540	6,235	8,500	11,300	29,575
	C	50	75	100	100	325
Total		3,590	6,310	8,600	11,400	29,900
Percentage Change from Previous Quarter		20%	76%	36%	33%	
Cumulative Total		10,373	16,683	25,283	36,683	
ASPs: NMOS		$15.25	$14.00	$12.25	$10.00	$12.12
CMOS		$28.00	$25.00	$20.00	$18.00	$21.77
Overall		$15.43	$14.13	$12.34	$10.07	$12.22
Revenue ($M)		55.4	89.2	106.1	114.8	365.5

	1984 1st Qtr.	1984 2nd Qtr.	1984 3rd Qtr.	1984 4th Qtr.	1984 Year
Market Share					
U.S.	60.2%	44.8%	36.0%	32.5%	39.4%
Japan	39.8	55.2	64.0	67.5	60.6
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 5 (Continued)

128K MOS EPROM Shipment Data, 1982–1987

Company	MOS Process	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	1,150	950	850	900	3,850
Fujitsu	N	1,000	1,500	1,750	2,000	6,250
	C	100	100	100	100	400
Hitachi	N	3,000	3,200	3,500	3,100	12,800
Intel	N	2,000	1,800	2,000	2,200	8,000
Mitsubishi	N	1,800	2,000	2,700	3,000	9,500
	C	5	10	10	100	125
NEC	N	1,500	2,000	1,750	3,200	8,450
SEEQ	N	375	300	250	225	1,150
Texas Instruments	N	50	25	0	0	75
	C	N/A	N/A	S	25	25
Toshiba	N	1,000	1,200	1,500	1,500	5,200
	N	11,875	12,975	14,300	16,125	55,275
	C	105	110	110	225	550
Total		11,980	13,085	14,410	16,350	55,825
Percentage Change from Previous Quarter		5%	9%	10%	13%	
Cumulative Total		48,663	61,748	76,158	92,508	
ASPs: NMOS		$6.50	$4.10	$3.10	$2.60	$3.92
CMOS		$15.00	$9.00	$5.00	$3.75	$7.20
Overall		$6.57	$4.14	$3.11	$2.62	$3.95
Revenue ($M)		78.8	54.2	44.9	42.8	220.6

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	29.8%	23.5%	21.5%	20.5%	23.5%
Japan	70.2	76.5	78.5	79.5	76.5
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 5 (Continued)

128K MOS EPROM Shipment Data, 1982–1987

Company	MOS Process	1986 1st Qtr.	1986 2nd Qtr.	1986 3rd Qtr.	1986 4th Qtr.	Year
AMD	N	1,300	1,100	1,050	1,715	5,165
Fujitsu	N	800	800	800	800	3,200
	C	100	100	100	100	400
General Instrument	C	N/A	S	20	150	170
	OTP	N/A	N/A	S	10	10
Hitachi	N	3,200	3,000	2,500	2,500	11,200
Intel	N	2,200	2,600	2,800	2,900	10,500
	OTP	200	500	650	400	1,750
Mitsubishi	N	2,300	1,850	1,800	1,700	7,650
	C	75	70	90	120	355
	N OTP	650	650	550	300	2,150
	C OTP	0	0	0	0	0
NEC	N	3,110	3,000	1,520	1,000	8,630
SEEQ	N	325	325	300	225	1,175
Seiko-Epson	N	0	10	15	25	50
Texas Instruments	N	N/A	N/A	N/A	N/A	0
	C	100	175	225	400	900
Toshiba	N	700	700	700	600	2,700
	OTP	50	200	400	600	1,250
VLSI Technology	C	5	10	10	10	35
WaferScale	C	S	0	5	5	10
Others	C	N/A	S	5	10	15
	N	14,835	14,735	13,085	12,780	55,435
	C	280	355	455	805	1,895
Total		15,115	15,090	13,540	13,585	57,330
Percentage Change from Previous Quarter		(8%)	0	(10%)	0	
Cumulative Total		107,623	122,713	136,253	149,838	
ASPs: NMOS		$2.55	$2.65	$2.75	$2.75	$ 2.67
CMOS		$3.70	$3.90	$4.00	$4.00	$ 3.94
Overall		$2.57	$2.68	$2.79	$2.82	$ 2.71
Revenue ($M)		38.9	40.4	37.8	38.4	155.5

	1986 1st Qtr.	1986 2nd Qtr.	1986 3rd Qtr.	1986 4th Qtr.	Year
Market Share					
U.S.	27.3%	31.2%	37.4%	42.9%	34.4%
Japan	72.7	68.8	62.6	57.0	65.6
Europe	0.0	0.0	0.0	0.1	0.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Applicable

(Continued)

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Table 5 (Continued)

128K MOS EPROM Shipment Data, 1982–1987

Company	MOS Process	1987 1st Qtr.	1987 2nd Qtr.	1987 3rd Qtr.	1987 4th Qtr.	1987 Year
AMD	N	1,300	1,925	1,725	1,900	6,850
Fujitsu	N	1,000	1,200	1,100	1,100	4,400
	C	600	800	900	900	3,200
Hitachi	N	2,000	2,000	1,800	0	5,800
Intel	N	2,200	2,250	1,000	2,250	7,700
	N OTP	800	600	420	140	1,960
	C	0	100	250	300	650
	C OTP	0	0	20	20	40
Microchip Tech., Inc.	C	141	227	420	741	1,529
	C OTP	20	45	80	228	373
Mitsubishi	N	1,150	1,300	1,400	950	4,800
	C	40	100	130	60	330
	N OTP	120	250	300	100	770
	C OTP	0	0	0	0	0
National Semi.	C	222	191	223	390	1,026
NEC	N	900	590	430	330	2,250
Oki Electric	N	100	150	100	100	450
	N OTP	0	0	0	0	0
SEEQ	N	150	150	100	100	500
Seiko-Epson	N	0	10	15	25	50
SGS-Thomson	N	180	525	1,160	1,700	3,565
Texas Instruments	N	0	25	25	70	120
	C	800	950	1,100	1,200	4,050
Toshiba	N	500	500	1,000	1,000	3,000
	N OTP	900	1,000	1,000	1,200	4,100
VLSI Technology	C	5	10	10	10	35
WaferScale	C	S	0	5	5	10
	N	11,300	12,475	11,575	10,965	46,315
	C	1,828	2,423	3,138	3,854	11,243
Total		13,128	14,898	14,713	14,819	57,558
Percentage Change from Previous Quarter		(3%)	13%	(1%)	1%	
Cumulative Total		162,966	177,864	192,577	207,396	
ASPs: NMOS		$3.00	$3.35	$3.45	$3.75	$ 3.38
CMOS		$3.90	$3.80	$3.90	$4.25	$ 4.00
Overall		$3.13	$3.42	$3.54	$3.88	$ 3.50
Revenue ($M)		41.0	51.0	52.2	57.5	201.7

	1987 1st Qtr.	1987 2nd Qtr.	1987 3rd Qtr.	1987 4th Qtr.	1987 Year
Market Share					
U.S.	42.9%	43.4%	36.6%	49.6%	43.2%
Japan	55.7	53.0	55.6	38.9	50.6
Europe	1.4	3.5	7.9	11.5	6.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Applicable
Note: Columns may not add to totals shown because of rounding.

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Table 6

256K MOS EPROM Shipment Data, 1983–1987

Company	MOS Process	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	N/A	S	10	25	35
Atmel	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
Fujitsu	N	N/A	N/A	N/A	N/A	0
	C	S	S	5	20	25
General Instrument	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
Hitachi	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
Intel	N	5	10	35	90	140
	C	N/A	N/A	N/A	N/A	0
Mitsubishi	N	N/A	N/A	N/A	S	0
National Semi.	C	N/A	N/A	N/A	N/A	0
NEC	N	N/A	N/A	N/A	S	0
	C	N/A	N/A	N/A	N/A	0
SEEQ	C	N/A	N/A	N/A	N/A	0
Seiko-Epson	C	N/A	N/A	N/A	N/A	0
SGS-Ates	N	N/A	N/A	N/A	N/A	0
Texas Instruments	C	N/A	N/A	N/A	N/A	0
Toshiba	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
VLSI Technology	C	N/A	N/A	N/A	N/A	0
WaferScale	C	N/A	N/A	N/A	N/A	0
	N	5	10	45	115	175
	C	0	0	5	20	25
Total		5	10	50	135	200
Percentage Change from Previous Quarter		0	100%	400%	170%	
Cumulative Total		5	15	65	200	
ASPs: NMOS		$150	$125	$100	$95	$100
CMOS		0	0	$145	$115	$121
Overall		$150	$125	$105	$98	$102
Revenue ($M)		0.8	1.3	5.2	13.2	20.5

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	100.0%	90.0%	85.2%	87.5%
Japan	0	0	10.0	14.8	12.5
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

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Table 6 (Continued)

256K MOS EPROM Shipment Data, 1983–1987

Company	MOS Process	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	100	130	100	250	580
Atmel	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
Fujitsu	N	N/A	N/A	N/A	10	10
	C	30	40	50	75	195
General Instrument	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
Hitachi	N	N/A	N/A	S	S	0
	C	N/A	N/A	S	S	0
Intel	N	150	250	375	475	1,250
	C	N/A	N/A	N/A	N/A	0
Mitsubishi	N	S	S	S	5	5
National Semi.	C	N/A	N/A	N/A	N/A	0
NEC	N	S	S	S	5	5
	C	N/A	N/A	N/A	N/A	0
SEEQ	C	N/A	S	S	5	5
Seiko-Epson	C	N/A	N/A	N/A	N/A	0
SGS	N	N/A	N/A	N/A	N/A	0
Texas Instruments	C	N/A	N/A	N/A	N/A	0
Toshiba	N	10	30	50	100	190
	C	N/A	N/A	S	S	0
VLSI Technology	C	N/A	N/A	N/A	N/A	0
WaferScale	C	N/A				0
	N	260	410	525	845	2,040
	C	30	40	50	80	200
Total		290	450	575	925	2,240
Percentage Change from Previous Quarter		115%	55%	28%	61%	
Cumulative Total		490	940	1,515	2,440	
ASPs: NMOS		$75.00	$45.00	$35.00	$28.00	$39.21
CMOS		$100.00	$80.00	$60.00	$45.00	$64.00
Overall		$77.59	$48.11	$37.17	$29.47	$41.42
Revenue ($M)		22.5	21.7	21.4	27.3	92.8

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	86.2%	84.4%	82.6%	78.9%	81.9%
Japan	13.8	15.6	17.4	21.1	18.1
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
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Table 6 (Continued)

256K MOS EPROM Shipment Data, 1983–1987

Company	MOS Process	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	450	800	950	950	3,150
Atmel	N	N/A	N/A	N/A	S	0
	C	N/A	N/A	N/A	S	0
Fujitsu	N	25	200	400	650	1,275
	C	150	250	400	600	1,400
General Instrument	N	N/A	N/A	S	25	25
	C	N/A	N/A	S	10	10
Hitachi	N	50	200	500	800	1,550
	C	S	25	150	300	475
Intel	N	1,000	1,800	2,400	2,700	7,900
	C	N/A	S	50	100	150
Mitsubishi	N	5	25	70	600	700
National Semi.	C	S	S	S	10	10
NEC	N	30	230	550	750	1,560
	C	S	50	150	200	400
SEEQ	C	15	110	180	250	555
Seiko-Epson	C	N/A	N/A	N/A	S	0
SGS	N	N/A	N/A	S	10	10
Texas Instruments	C	N/A	N/A	S	50	50
Toshiba	N	150	350	550	700	1,750
	C	150	200	300	425	1,075
VLSI Technology	C	N/A	S	25	50	75
WaferScale	C	N/A	N/A	S	S	0
	N	1,710	3,605	5,420	7,185	17,920
	C	315	635	1,255	1,995	4,200
Total		2,025	4,240	6,675	9,180	22,120
Percentage Change from Previous Quarter		350%	109%	57%	38%	
Cumulative Total		4,465	8,705	15,380	24,560	
ASPs: NMOS		$20.00	$12.00	$5.30	$4.25	$7.63
CMOS		$30.00	$13.50	$7.00	$6.00	$9.23
Overall		$21.56	$12.22	$5.62	$4.63	$7.93
Revenue ($M)		43.7	51.8	37.5	42.5	175.5

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	72.3%	63.9%	54.0%	45.2%	53.9%
Japan	27.7	36.1	46.0	54.7	46.0
Europe	0	0	0	0.1	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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Table 6 (Continued)

256K MOS EPROM Shipment Data, 1983–1987

Company	MOS Process	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	700	1,000	1,050	1,000	3,750
Atmel	N	0	0	0	0	0
	C	0	0	0	0	0
Fujitsu	N	500	500	500	600	2,100
	C	200	250	250	400	1,100
General Instrument	N	908	600	545	500	2,553
	C	112	317	493	500	1,422
	C OTP	35	85	10	200	330
Hitachi	N	950	1,100	1,350	1,500	4,900
	C	350	500	650	800	2,300
	C OTP	0	0	0	0	0
Intel	N	3,300	4,000	4,200	4,000	15,500
	C	150	175	450	550	1,325
	N OTP	200	250	280	300	1,030
Mitsubishi	N	1,637	2,096	1,776	935	6,444
	C	0	0	19	157	176
	N OTP	1,249	1,480	1,435	3,435	7,599
	C OTP	0	0	0	0	0
National Semi.	C	25	100	250	300	675
NEC	N	1,230	1,250	990	500	3,970
	C	1,620	1,220	1,140	800	4,780
Oki Electric	N	N/A	S	0	30	30
Ricoh	C	0	0	5	5	10
SEEQ	C	70	70	40	40	220
Seiko-Epson	C	0	5	10	10	25
SGS	N	6	136	10	10	162
Signetics	C	S	S	5	15	20
Texas Instrument	C	125	200	225	800	1,350
Toshiba	N	600	800	800	800	3,000
	C	300	400	400	400	1,500
	N OTP	300	500	800	1,200	2,800
	C OTP	100	200	200	200	700
VLSI Technology	C	50	50	50	50	200
WaferScale	C	S	5	5	5	15
Others	N	0	0	0	0	0
	C	5	5	5	5	20
	N	11,580	13,712	13,736	14,810	53,838
	C	3,142	3,582	4,207	5,237	16,168
Total		14,722	17,294	17,943	20,047	70,006

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Table 6 (Continued)

256K MOS EPROM Shipment Data, 1983–1987

	1986				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Percentage Change from Previous Quarter	60%	17%	4%	12%	
Cumulative Total	39,282	56,576	74,519	94,566	
ASPs: NMOS	$4.14	$4.50	$4.50	$4.20	$4.34
CMOS	$5.00	$5.50	$5.50	$5.25	$5.32
Overall	$4.32	$4.71	$4.73	$4.47	$4.57
Revenue ($M)	63.7	81.4	85.0	89.7	319.7

	1986				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	38.6%	39.6%	42.4%	41.2%	40.6%
Japan	61.4	59.6	57.5	58.7	59.2
Europe	0.0	0.8	0.1	0.0	0.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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N/A = Not Available
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Table 6 (Continued)

256K MOS EPROM Shipment Data, 1983–1987

Company	MOS Process	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	1,585	1,850	1,600	1,860	6,895
	C	0	10	100	215	325
Fujitsu	N	900	800	950	900	3,550
	C	700	1,700	2,050	2,500	6,950
Hitachi	N	2,500	2,500	1,600	0	6,600
	C	2,200	2,000	2,000	0	6,200
	C OTP	0	0	0	0	0
Intel	N	4,500	5,400	4,300	4,600	18,800
	C	450	500	370	260	1,580
	N OTP	800	1,200	1,000	950	3,950
	C OTP	100	50	250	170	570
Microchip Tech., Inc.	N	600	700	700	800	2,800
	C	900	1,000	1,000	300	3,200
	OTP	200	200	400	100	900
Mitsubishi	N	1,300	1,800	2,200	1,750	7,050
	C	400	500	750	800	2,450
	N OTP	950	450	800	400	2,600
	C OTP	0	0	20	60	80
National Semi.	C	654	1,257	1,606	3,510	7,027
NEC	N	690	540	360	400	1,990
	C	1,090	870	1,600	1,250	4,810
Oki Electric	N	100	100	100	50	350
	N OTP	800	800	800	800	3,200
Ricoh	C	5	5	10	20	40
SEEQ	C	75	75	75	75	300
Seiko-Epson	C	20	20	20	10	70
SGS-Thomson	N	840	1,160	1,170	1,600	4,770
Signetics	C	200	250	400	500	1,350
Texas Instrument	C	1,300	1,400	1,500	1,700	5,900
Toshiba	N	800	800	1,000	1,500	4,100
	C	500	800	1,200	1,000	3,500
	N OTP	1,400	1,500	1,000	1,000	4,900
	C OTP	200	400	400	400	1,400
VLSI Technology	C	25	30	30	50	135
WaferScale	C	15	20	20	30	85
	N	17,765	19,600	17,580	16,610	71,555
	C	9,034	11,087	13,801	12,950	46,872
Total		26,799	30,687	31,381	29,560	118,427

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Table 6 (Continued)

256K MOS EPROM Shipment Data, 1983–1987

	1987				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Percentage Change from Previous Quarter	34%	15%	2%	(6%)	
Cumulative Total	121,365	152,052	183,433	212,993	
ASPs: NMOS	$4.25	$4.35	$4.40	$4.45	$4.36
CMOS	$4.90	$5.00	$5.10	$5.10	$5.04
Overall	$4.47	$4.59	$4.71	$4.73	$4.63
Revenue ($M)	119.8	140.7	147.7	140.0	548.2

	1987				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	41.8%	44.6%	41.3%	49.5%	44.3%
Japan	54.3	50.8	53.7	43.4	50.5
Europe	3.9	4.6	5.0	7.1	5.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 7

512K MOS EPROM Shipment Data, 1984–1987

Company	MOS Process	1984 1st Qtr.	1984 2nd Qtr.	1984 3rd Qtr.	1984 4th Qtr.	Year
AMD	N	S	2	2	4	8
Fujitsu	N	N/A	N/A	N/A	N/A	0
General Instrument	C	N/A	N/A	N/A	N/A	0
Hitachi	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
Intel	N	N/A	S	2	6	8
Mitsubishi	N	N/A	N/A	N/A	N/A	0
Toshiba	N	N/A	N/A	N/A	N/A	0
	C	N/A	N/A	N/A	N/A	0
VLSI Technology	C	N/A	N/A	N/A	N/A	0
WaferScale	C	N/A	N/A	N/A	N/A	0
	N	0	2	4	10	16
	C	0	0	0	0	0
Total		0	2	4	10	16
Percentage Change from Previous Quarter		0	0	100%	150%	
Cumulative Total		0	2	6	16	
ASPs: NMOS		$250.00	$150.00	$120.30	$95.00	$108.13
CMOS		0	0	0	0	0
Overall		$250.00	$150.00	$120.00	$95.00	$108.13
Revenue ($M)		0	0.3	0.5	1.0	1.7

	1984 1st Qtr.	1984 2nd Qtr.	1984 3rd Qtr.	1984 4th Qtr.	Year
Market Share					
U.S.	0	100.0%	100.0%	100.0%	100.0%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	0	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

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Table 7 (Continued)

512K MOS EPROM Shipment Data, 1984–1987

Company	MOS Process	1985 1st Qtr.	1985 2nd Qtr.	1985 3rd Qtr.	1985 4th Qtr.	1985 Year
AMD	N	12	30	35	75	152
Fujitsu	N	N/A	N/A	S	10	10
General Instrument	C	N/A	N/A	N/A	N/A	0
Hitachi	N	N/A	N/A	S	15	15
	C	N/A	N/A	N/A	N/A	0
Intel	N	15	50	65	135	265
Mitsubishi	N	N/A	N/A	N/A	N/A	0
Toshiba	N	N/A	N/A	N/A	S	0
	C	N/A	N/A	N/A	N/A	0
VLSI Technology	C	N/A	N/A	N/A	N/A	0
WaferScale	C	N/A	N/A	N/A	N/A	0
	N	27	80	100	225	432
	C	0	0	0	10	10
Total		27	80	100	235	442
Percentage Change from Previous Quarter		170%	196%	25%	135%	
Cumulative Total		43	123	223	458	
ASPs: NMOS		$80.00	$50.00	$30.00	$22.00	$32.66
CMOS		0	0	$45.00	$25.00	$25.00
Overall		$80.00	$50.00	$30.00	$22.13	$32.49
Revenue ($M)		2.2	4.0	3.0	5.2	14.4

	1985 1st Qtr.	1985 2nd Qtr.	1985 3rd Qtr.	1985 4th Qtr.	1985 Year
Market Share					
U.S.	100.0%	100.0%	100.0%	89.4%	94.3%
Japan	0	0	0	10.6	5.7
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

(Continued)

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Table 7 (Continued)

512K MOS EPROM Shipment Data, 1984–1987

Company	MOS Process	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	175	280	540	400	1,395
Fujitsu	C	25	25	25	25	100
General Instrument	C	S	10	25	100	135
	OTP	N/A	N/A	S	5	5
Hitachi	N	N/A	S	60	300	360
	C	N/A	N/A	N/A	N/A	0
Intel	N	250	400	730	900	2,280
Mitsubishi	N	N/A	S	58	365	423
National Semi.	C	N/A	S	0	0	0
Oki Electric	N	N/A	N/A	S	S	0
Texas Instruments	C	N/A	N/A	S	50	50
Toshiba	N	50	150	300	400	900
	OTP	N/A	N/A	S	30	30
VLSI Technology	C	S	0	3	5	8
WaferScale	C	N/A	N/A	N/A	N/A	0
Others	C	S	S	S	S	15
	N	475	830	1,688	2,395	5,388
	C	25	40	58	190	313
Total		500	870	1,746	2,585	5,701
Percentage Change from Previous Quarter		113%	74%	101%	48%	
Cumulative Total		958	1,828	3,574	6,159	
ASPs: NMOS		$14.00	$12.00	$12.00	$11.00	$11.73
CMOS		$16.50	$15.50	$15.00	$13.00	$13.97
Overall		$14.13	$12.16	$12.10	$11.15	$11.85
Revenue ($M)		7.1	10.6	21.1	28.8	67.6

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	85.0%	79.9%	74.6%	56.7%	68.2%
Japan	15.0	20.1	25.4	43.3	31.8
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
N/A = Not Available

(Continued)

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Table 7 (Continued)

512K MOS EPROM Shipment Data, 1984–1987

Company	MOS Process	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	N	740	785	525	605	2,655
	C	S	5	25	285	315
Fujitsu	C	500	1,500	1,800	2,100	5,900
Hitachi	N	750	800	850	950	3,350
	C	S	0	0	0	0
Intel	N	800	1,200	1,800	2,700	6,500
Microchip Tech., Inc.	C	100	150	100	120	470
	OTP	10	10	20	20	60
Mitsubishi	N	750	800	1,200	1,450	4,200
National Semi.	C	0	0	0	0	0
NEC	C	N/A	S	0	1,050	1,050
Oki Electric	N	0	180	200	400	780
	N OTP	0	170	200	650	1,020
SGS-Thomson	N	N/A	1	50	350	401
Texas Instruments	C	100	150	200	400	850
Toshiba	N	550	500	700	800	2,550
	N OTP	200	180	200	170	750
VLSI Technology	C	5	5	5	8	23
WaferScale	C	0	0	0	0	0
	N	3,790	4,616	5,725	8,075	22,206
	C	715	1,820	2,150	3,983	8,668
Total		4,505	6,436	7,875	12,058	30,874
Percentage Change from Previous Quarter		74%	43%	22%	53%	
Cumulative Total		10,664	17,100	24,975	37,033	
ASPs: NMOS		$10.00	$ 9.00	$7.78	$6.80	$8.06
CMOS		$11.00	$10.00	$9.00	$7.50	$8.69
Overall		$10.16	$ 9.28	$8.11	$7.03	$8.23
Revenue ($M)		45.8	59.7	63.9	84.8	254.2

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	39.0%	35.8%	34.0%	34.3%	35.2%
Japan	61.0	64.2	65.4	62.8	63.5
Europe	0	0	0.6	2.9	1.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 8

1-Mbit MOS EPROM Shipment Data, 1986-1987

Company	MOS Process	Technology Features	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	C	x16	1	1	4	6	12
Atmel	C	N/A	0	0	0	0	0
Fujitsu	C	x8, x16	N/A	S	S	1	1
General Instrument	C	x16	N/A	N/A	N/A	N/A	0
Hitachi	C	x8, x16	S	10	30	75	115
Intel	N	x8, x16	S	5	25	30	60
Motorola	C	N/A	S	S	S	0	0
National Semi.	C	x8, x16	N/A	N/A	N/A	S	0
NEC	C	x16	N/A	S	0	1	1
Oki Electric	C	x16	N/A	N/A	N/A	S	0
Texas Instruments	C	N/A	N/A	N/A	S	S	0
Toshiba	C	x8	N/A	S	5	15	20
Other	C	N/A	N/A	N/A	S	0	0
	N		0	5	25	30	60
	C		1	11	39	98	149
Total			1	16	64	128	209
Percentage Change from Previous Quarter			0	3,100%	300%	100%	
Cumulative Total			1	17	81	209	
ASPs: NMOS			$110.00	$80.00	$50.00	$42.00	$48.50
CMOS			$150.00	$70.00	$66.00	$60.00	$62.62
Overall			$150.00	$73.13	$59.75	$55.78	$58.56
Revenue ($M)			0.1	1.2	3.8	7.1	12.2

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100.0%	37.5%	45.3%	28.1%	34.3%
Japan	0	62.5	54.7	71.9	65.7
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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Table 8 (Continued)

1-Mbit MOS EPROM Shipment Data, 1986-1987

Company	MOS Process	Technology Features	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	C	x16	5	5	5	15	30
Fujitsu	C	x8, x16	N/A	S	5	10	15
Hitachi	C	x8, x16	100	70	150	250	570
Intel	N	x8, x16	50	30	80	150	310
Microchip Tech., Inc.	C		N/A	N/A	N/A	N/A	0
Mitsubishi	C	x8, x16	0	5	5	80	90
National Semi.	C	x8, x16	0	0	0	0	0
NEC	C	x8	N/A	0	50	300	350
	C	x16	N/A	0	50	100	150
Oki Electric	C	x8, x16	N/A	N/A	N/A	S	0
SGS-thomson	C		N/A	N/A	N/A	N/A	0
Texas Instruments	C		0	0	0	0	0
Toshba	C	x8, x16	20	40	40	50	150
	N		50	30	80	150	310
	C		125	120	305	805	1,355
Total			175	150	385	955	1,655
Percentage Change from Previous Quarter			37%	(14%)	157%	148%	
Cumulative Total			384	534	919	1,874	
ASPs: NMOS			$26.00	$24.00	$24.00	$24.00	$24.32
CMOS			$40.00	$32.00	$28.00	$26.00	$28.27
Overall			$36.00	$30.40	$27.17	$25.69	$27.54
Revenue ($M)			6.3	4.6	10.5	24.5	45.9

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	31.4%	23.3%	22.1%	17.3%	20.4%
Japan	68.6	76.7	77.9	82.7	79.6
Europe	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

S = Sampling
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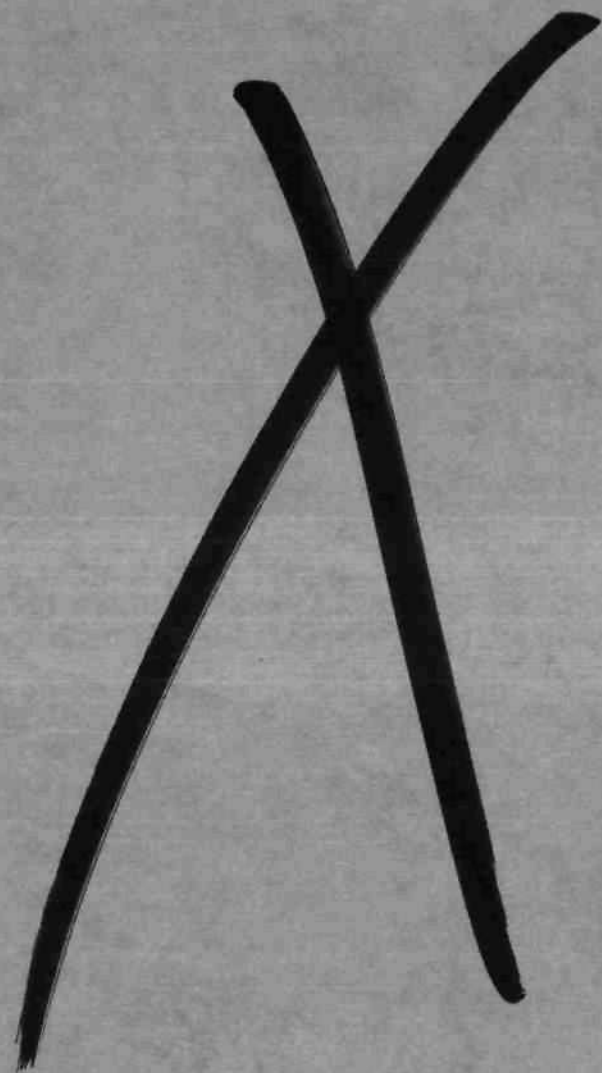

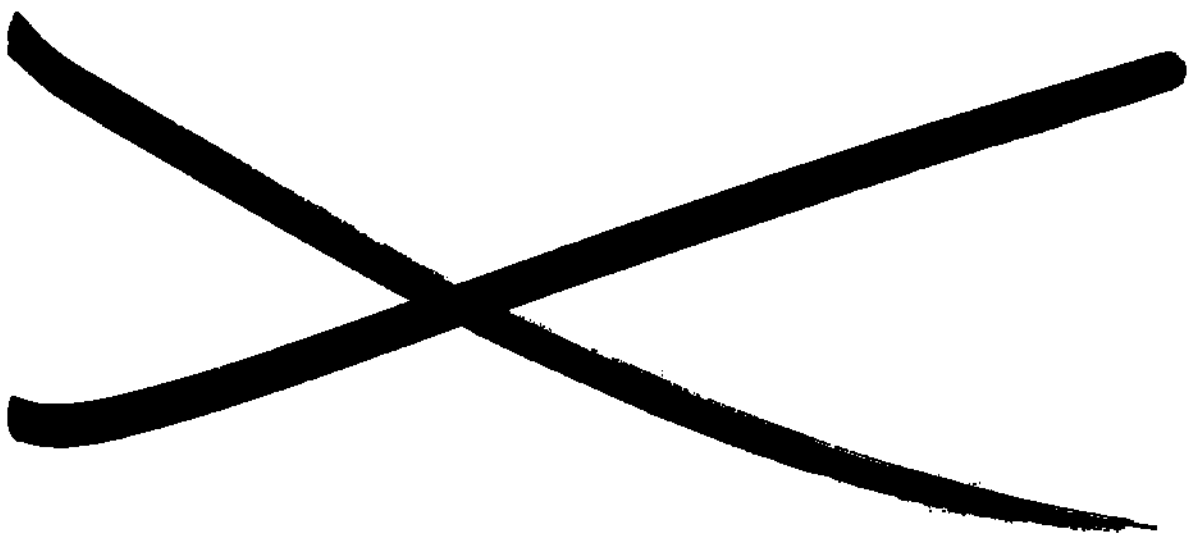

MOS EEPROM—Forecast

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MOS EEPROM—Forecast

MOS EEPROM TOTAL WORLDWIDE FORECAST

Dataquest's MOS EEPROM forecast consists of revenue, unit shipments, and prices for MOS EEPROM product lines. The tables in this section combine NVRAMs and EEPROMs. Products include only monolithic EEPROMs and NVRAMs, and they are not assemblages made up of traditional CMOS static RAMs with battery backup in the same package.

We have included products that are fabricated using both the nitrox technology (MNOS or SNOS) and the floating-gate technology. These products are sold under a variety of generic product names: EAROM, EEPROM, or EEROM. The sole requirements for inclusion are nonvolatility, electrical programmability, and erase.

The purpose of this forecast is to indicate trends, approximate market needs, and key sensitivities to products that can benefit both manufacturers and users. The overall average selling price (ASP) is an industry average over a mix of speeds and package styles. ASPs may vary significantly from company to company and by application. Tables contained in this forecast are as follows:

- Table 1—Worldwide MOS EEPROM Forecast
- Table 2—Worldwide NMOS EEPROM Forecast
- Table 3—Worldwide CMOS EEPROM Market

Table 1

Worldwide MOS EEPROM Forecast

	Millions of Dollars							
	1988	1989	1990	1991	1992	1993	1994	1995
Less than 1K	16	16	14	13	13	13	13	12
1K	57	54	51	47	41	36	32	27
2K	17	36	37	40	39	39	39	38
4K	33	66	86	89	100	118	131	145
8K	0	0	0	0	0	0	0	0
16K	36	31	26	27	28	32	40	37
32K	1	0	0	0	0	0	0	0
64K	64	64	61	75	88	115	136	144
256K	50	44	43	61	100	150	145	141
1Mb	0	7	18	36	60	84	106	124
4Mb	0	0	0	0	3	13	16	29
Total	274	318	337	389	473	602	657	697
Percent Change from Previous Year	48	16	6	16	22	27	9	6

(Continued)

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Table 1 (Continued)

Worldwide MOS EEPROM Forecast

	Millions of Units							
	1988	1989	1990	1991	1992	1993	1994	1995
Less than 1K	21.3	24.2	23.7	21.5	20.3	19.8	18.8	16.6
1K	51.9	54.0	50.7	45.0	37.6	32.5	27.5	22.5
2K	6.0	14.2	16.9	18.3	17.5	17.1	16.6	16.0
4K	7.3	16.6	22.0	23.6	27.0	32.0	35.0	36.2
8K	0	0	0	0	0	0	0	0
16K	7.1	7.0	6.6	7.0	7.7	9.0	11.7	11.4
32K	0.1	0	0	0	0	0	0	0
64K	6.4	8.3	9.9	13.1	16.6	23.0	28.6	32.0
256K	0.4	0.8	1.2	2.6	5.3	9.4	13.2	16.2
1Mb	0	0	0.1	0.3	0.7	1.4	2.4	4.0
4Mb	0	0	0	0	0	0.1	0.2	0.6
Low Density	86.5	109.0	113.3	108.4	102.4	101.4	97.9	91.3
Total	100.5	125.2	131.1	131.3	132.7	144.3	154.0	155.5
Percent Change from Previous Year	54	25	5	0	1	9	7	1
	Average Selling Price ($)							
	1988	1989	1990	1991	1992	1993	1994	1995
Less than 1K	0.75	0.65	0.60	0.62	0.65	0.68	0.68	0.70
1K	1.10	1.00	1.00	1.05	1.10	1.12	1.15	1.20
2K	2.90	2.50	2.20	2.20	2.25	2.30	2.35	2.40
4K	4.50	4.00	3.90	3.75	3.70	3.70	3.75	4.00
8K	0	0	0	0	0	0	0	0
16K	5.10	4.35	4.00	3.90	3.70	3.55	3.40	3.25
32K	16.00	0	0	0	0	0	0	0
64K	10.00	7.75	6.20	5.70	5.30	5.00	4.75	4.50
256K	113.00	55.00	35.00	24.00	19.00	16.00	11.00	8.70
1Mb	0	380.00	180.00	125.00	81.00	60.00	44.00	31.00
4Mb	0	0	0	440.00	210.00	130.00	80.00	49.00
Total	2.73	2.54	2.57	2.96	3.57	4.17	4.27	4.48
Percent Change from Previous Year	(3)	(7)	1	15	20	17	2	5

Source: Dataquest (November 1990)

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Table 2

Worldwide NMOS EEPROM Forecast

	Millions of Dollars							
	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Less than 1K	2	2	2	2	1	1	1	1
1K	2	1	1	1	1	1	1	1
2K	3	4	4	4	5	6	6	7
4K	16	21	23	23	24	26	28	29
8K	0	0	0	0	0	0	0	0
16K	29	22	18	17	16	15	14	13
32K	0	0	0	0	0	0	0	0
64K	34	40	37	40	43	45	46	45
256K	15	12	8	6	5	3	2	2
1Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	100	103	92	92	94	96	97	97
Percent Change from Previous Year	9	3	(10)	0	1	3	1	0
	Millions of Units							
	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Less than 1K	2.0	2.9	2.7	2.5	2.3	2.0	1.8	1.6
1K	1.5	0.9	0.7	0.6	0.6	0.5	0.5	0.5
2K	1.1	1.7	1.9	1.9	2.0	2.4	2.6	3.0
4K	3.6	5.3	5.9	6.1	6.4	7.0	7.4	7.2
8K	0	0	0	0	0	0	0	0
16K	6.1	5.1	4.5	4.4	4.2	4.1	4.1	4.0
32K	0	0	0	0	0	0	0	0
64K	4.7	5.2	5.9	7.0	8.1	9.0	9.6	10.0
256K	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.2
1Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	19.1	21.3	21.8	22.8	23.8	25.2	26.2	26.5
Percent Change from Previous Year	19	12	2	4	5	6	4	1

(Continued)

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Table 2 (Continued)

Worldwide NMOS EEPROM Forecast

	Average Selling Price ($)							
	1988	1989	1990	1991	1992	1993	1994	1995
Less than 1K	0.75	0.65	0.60	0.62	0.65	0.68	0.68	0.70
1K	1.10	1.00	1.00	1.05	1.10	1.12	1.15	1.20
2K	2.90	2.50	2.20	2.20	2.25	2.30	2.35	2.40
4K	4.50	4.00	3.90	3.75	3.70	3.70	3.75	4.00
8K	0	0	0	0	0	0	0	0
16K	4.75	4.35	4.00	3.90	3.70	3.55	3.40	3.25
32K	0	0	0	0	0	0	0	0
64K	7.20	7.75	6.20	5.70	5.30	5.00	4.75	4.50
256K	80.00	55.00	35.00	24.00	19.00	16.00	11.00	8.70
1Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	5.22	4.81	4.24	4.06	3.93	3.81	3.72	3.68
Percent Change from Previous Year	(9)	(8)	(12)	(4)	(3)	(3)	(3)	(1)

Source: Dataquest (November 1990)

Table 3

Worldwide CMOS EEPROM Forecast

	Millions of Dollars							
	1988	1989	1990	1991	1992	1993	1994	1995
Less than 1K	14	14	13	12	12	12	12	11
1K	55	53	50	47	41	36	31	26
2K	15	31	33	36	35	34	33	31
4K	17	45	63	66	76	93	104	116
8K	0	0	0	0	0	0	0	0
16K	8	9	8	10	13	17	26	24
32K	1	0	0	0	0	0	0	0
64K	30	24	25	35	45	70	90	99
256K	34	32	35	55	95	147	143	139
1Mb	0	7	18	36	60	84	106	124
4Mb	0	0	0	0	3	13	16	29
Total	174	215	245	297	380	506	560	600
Percent Change from Previous Year	86	24	14	21	28	33	11	7

(Continued)

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Table 3 (Continued)

Worldwide CMOS EEPROM Forecast

	Millions of Units							
	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Less than 1K	19.3	21.2	21.0	19.0	18.0	17.8	17.0	15.0
1K	50.4	53.1	50.0	44.4	37.0	32.0	27.0	22.0
2K	4.9	12.5	15.0	16.4	15.5	14.7	14.0	13.0
4K	3.7	11.3	16.1	17.5	20.6	25.0	27.6	29.0
8K	0	0	0	0	0	0	0	0
16K	1.1	2.0	2.1	2.6	3.5	4.9	7.6	7.4
32K	0.1	0	0	0	0	0	0	0
64K	1.7	3.1	4.0	6.1	8.5	14.0	19.0	22.0
256K	0.3	0.6	1.0	2.3	5.0	9.2	13.0	16.0
1Mb	0	0	0.1	0.3	0.7	1.4	2.4	4.0
4Mb	0	0	0	0	0	0.1	0.2	0.6
Total	81.4	103.8	109.3	108.6	108.9	119.1	127.8	129.0
Percent Change from Previous Year	65	28	5	(1)	0	9	7	1
	Average Selling Price ($)							
	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Less than 1K	0.75	0.65	0.60	0.62	0.65	0.68	0.68	0.70
1K	1.10	1.00	1.00	1.05	1.10	1.12	1.15	1.20
2K	2.95	2.50	2.20	2.20	2.25	2.30	2.35	2.40
4K	4.50	4.00	3.90	3.75	3.70	3.70	3.75	4.00
8K	0	0	0	0	0	0	0	0
16K	7.12	4.35	4.00	3.90	3.70	3.55	3.40	3.25
32K	16.00	0	0	0	0	0	0	0
64K	18.00	7.75	6.20	5.70	5.30	5.00	4.75	4.50
256K	133.00	55.00	35.00	24.00	19.00	16.00	11.00	8.70
1Mb	0	380.00	180.00	125.00	81.00	60.00	44.00	31.00
4Mb	0	0	0	440.00	210.00	130.00	80.00	49.00
Total	2.14	2.07	2.24	2.73	3.49	4.25	4.38	4.65
Percent Change from Previous Year	13	(3)	8	22	28	22	3	6

Source: Dataquest (November 1990)

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MARKET SUMMARY 1989

Highlights of the MOS EEPROM market in 1989 are as follows:

- MOS EEPROM revenue grew a moderate 16 percent in 1989 to $318 million, up from $274 million in 1988.
- Worldwide ASPs continued to decline to an overall $2.50 or 7 percent below the 1988 overall ASP of $2.73.
- Unit shipments grew 25 percent to 125.2 million in 1989 compared with 100.5 million units shipped in 1988.

Traditionally viewed as a price-sensitive, high-revenue generating market for a handful of suppliers, the EEPROM market became a veritable nightmare for suppliers during the second half of 1989 and the first half of 1990. Issues that affected major losses in profit margins during that time frame included the following:

- Downgrading or cancellation of military defense contracts
- Manufacturing problems of newer-generation 256K EEPROMs
- Factory underutilization
- High costs attributed to factory upgrades from 4-inch to 6-inch fab lines
- Increased competition from new entrants to the high-density product market
- Price erosion of full-featured high-density devices

As a result, the majority of EEPROM suppliers resorted to layoffs and/or reorganization of their manufacturing structures to streamline manufacturing operations. Prohibitively high manufacturing costs of this very complex technology forced many of the EEPROM suppliers to license the manufacturing of the products to offshore companies in order to allow conversion of their manufacturing operations to research and design facilities.

MARKET OUTLOOK

Although moderate growth trends in revenue are expected to continue through the end of 1990 (see Figure 1), increased demand for high-speed, high-density products in the 1991 through 1993 time frame is expected to promote revenue growth for the majority of the stronger EEPROM suppliers.

After a peak growth period in 1990, the low-density products will decline as a percentage of the total market (see Figure 2), as the high-density products increase in demand. A rally in bit growth (see Figure 3) will begin during the 1992 through 1994 time frame, driven by increased demand for high-density products in aircraft, scientific instruments, and telecommunications products.

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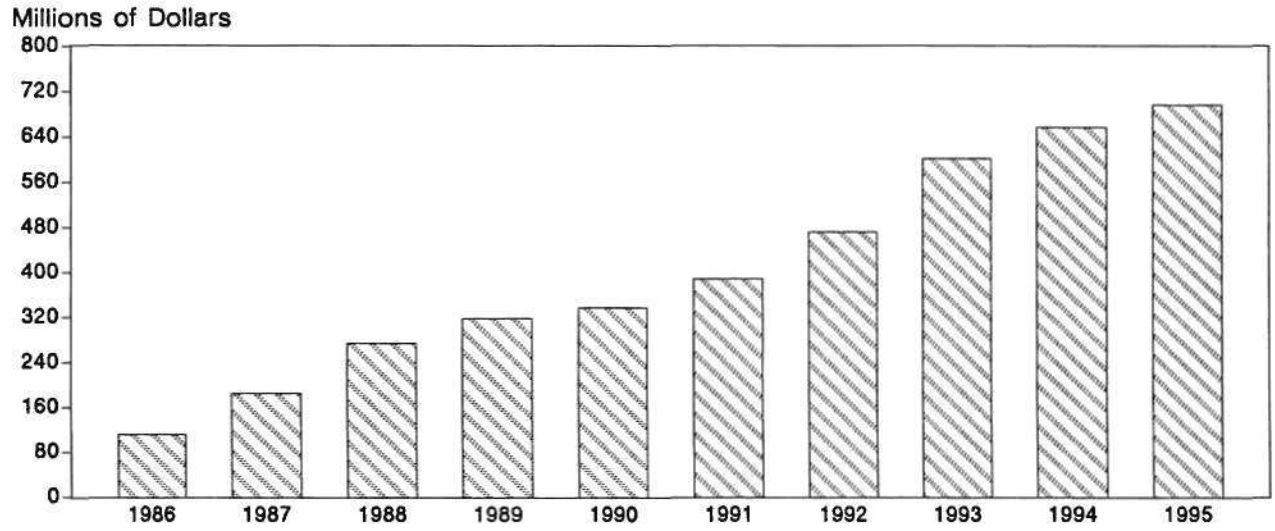
Figure 1

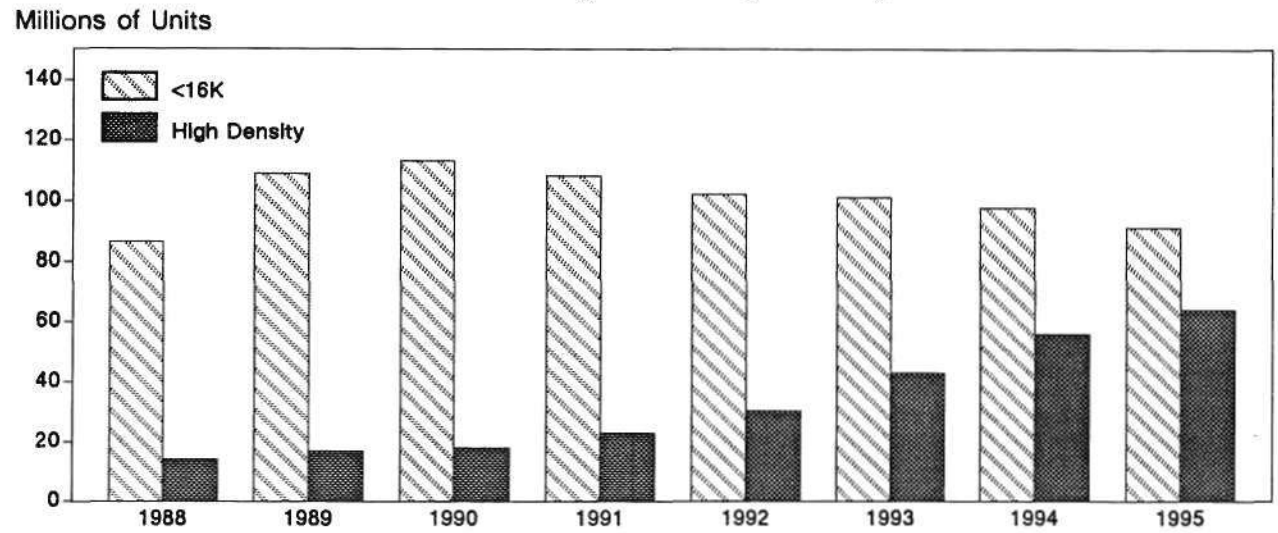
MOS EEPROM Revenue



Source: Dataquest (November 1990)

Figure 2

MOS EEPROM Shipments
Low Density versus High Density



Source: Dataquest (November 1990)

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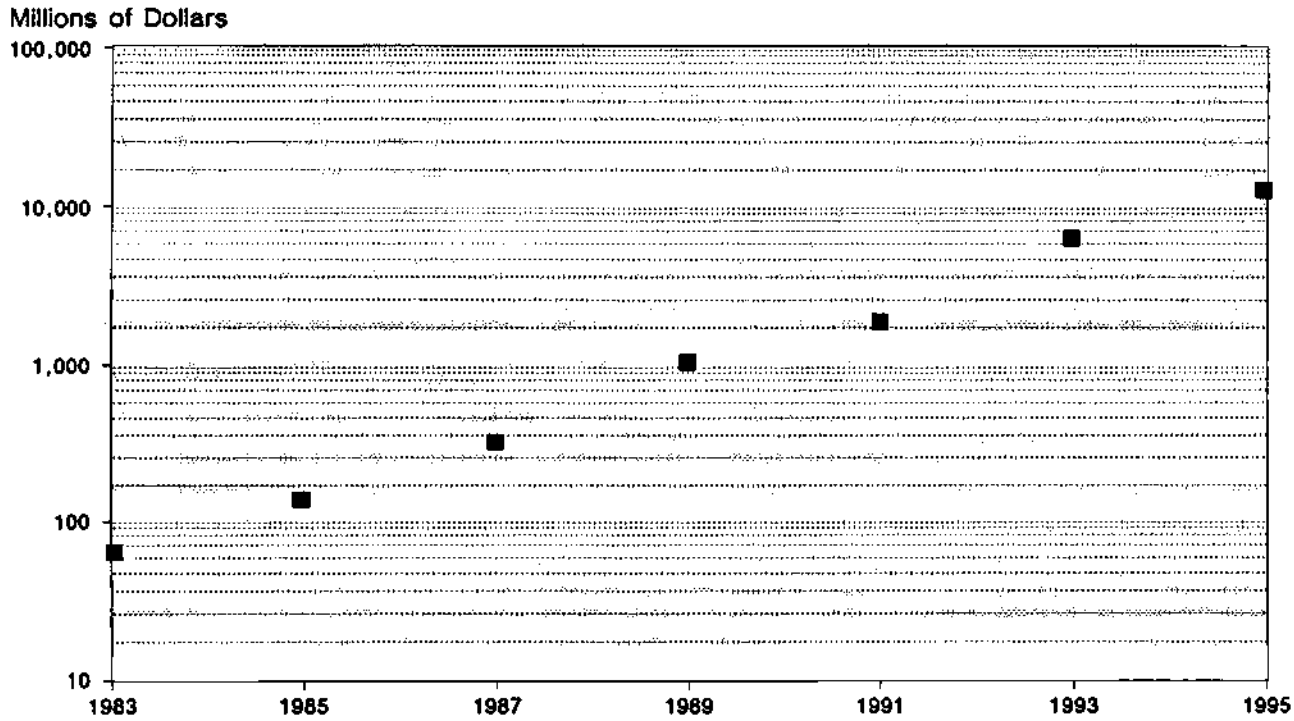
Figure 3

MOS EEPROM Bit Growth



Source: Dataquest (November 1990)

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MOS EEPROM--Forecast

MOS EEPROM TOTAL WORLDWIDE FORECAST

Dataquest's MOS EEPROM forecast consists of revenue, unit shipments, and prices for MOS EEPROM product lines. The tables in this section combine NVRAMs and EEPROMs. Products include only monolithic EEPROMs and NVRAMs, and they are not assemblages made up of traditional CMOS static RAMs with battery backup in the same package.

We have included products that are fabricated using both the nitrox technology (MNOS or SNOS) and the floating-gate technology. These products are sold under a variety of generic product names: EAROM, EEPROM, or EEROM. The sole requirements for inclusion are nonvolatility, electrical programmability, and erase.

The purpose of this forecast is to indicate trends, approximate market needs, and key sensitivities to products that can benefit both manufacturers and users. The overall average selling price (ASP) is an industry average over a mix of speeds and package styles. ASPs may vary significantly from company to company and by application. Tables contained in this forecast are as follows:

- Table 1—Worldwide MOS EEPROM Forecast
- Table 2—Worldwide NMOS EEPROM Forecast
- Table 3—Worldwide CMOS EEPROM Market

Table 1

Worldwide MOS EEPROM Forecast

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	29	20	17	17	16	16	17	17
1K	17	42	40	41	35	36	36	37
2K	2	12	17	23	24	24	25	25
4K	2	16	22	31	31	32	33	32
8K	1	0	0	0	0	0	0	0
16K	25	30	36	46	56	73	85	127
32K	0	0	1	1	1	1	1	1
64K	27	38	54	68	71	84	91	125
256K	9	26	50	70	62	85	157	195
1Mb	0	0	0	4	20	44	66	106
4Mb	0	0	0	0	0	0	0	12
Total	112	185	237	301	315	395	511	676
Percent Change from Previous Year	(7%)	65%	28%	27%	4%	26%	29%	32%

(Continued)

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MOS EEPROM--Forecast

Table 1 (Continued)

Worldwide MOS EEPROM Forecast

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	23.0	24.1	26.2	26.1	26.0	25.7	25.4	25.0
1K	6.7	25.4	36.1	37.0	35.1	34.2	33.0	32.8
2K	0.5	3.6	5.9	7.9	8.3	8.5	8.8	8.7
4K	0.5	3.6	5.4	7.7	7.8	8.0	8.2	8.0
8K	0.1	0	0	0	0	0	0	0
16K	4.5	5.7	7.1	9.3	11.8	15.8	19.0	30.0
32K	0	0	0.1	0.1	0.1	0.1	0.1	0.2
64K	2.1	2.9	6.0	7.8	9.7	13.4	16.8	25.0
256K	0	0.1	0.4	1.0	1.5	2.8	6.5	10.8
1Mb	0	0	0	0	0.1	0.3	0.7	1.6
4Mb	0	0	0	0	0	0	0	0.1
Total	37.4	65.5	87.1	96.9	100.4	108.9	118.5	142.2
Percent Change from Previous Year	(10%)	75%	33%	11%	4%	8%	9%	20%

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	$ 1.26	$ 0.85	$ 0.65	$ 0.65	$ 0.60	$ 0.62	$ 0.65	$ 0.68
1K	$ 2.50	$ 1.65	$ 1.10	$ 1.10	$ 1.00	$ 1.05	$ 1.10	$ 1.12
2K	$ 3.50	$ 3.40	$ 2.90	$ 2.90	$ 2.85	$ 2.85	$ 2.85	$ 2.85
4K	$ 4.67	$ 4.50	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00
8K	$ 5.00	0	0	0	0	0	0	0
16K	$ 5.71	$ 5.27	$ 5.10	$ 4.99	$ 4.72	$ 4.60	$ 4.48	$ 4.22
32K	$ 6.44	$ 16.00	$ 16.00	$ 13.00	$ 11.90	$ 11.20	$ 8.10	$ 5.98
64K	$ 13.00	$ 13.00	$ 9.10	$ 8.70	$ 7.30	$ 6.22	$ 5.44	$ 5.00
256K	$400.00	$184.00	$113.00	$ 68.00	$ 40.00	$ 30.00	$ 24.00	$ 18.00
1Mb	0	0	0	$440.00	$200.00	$150.00	$ 89.00	$ 65.00
4Mb	0	0	0	0	$500.00	$300.00	$190.00	$120.00
Total	$ 3.00	$ 2.82	$ 2.72	$ 3.11	$ 3.13	$ 3.62	$ 4.31	$ 4.75
Percent Change from Previous Year	4%	(6%)	(4%)	14%	1%	16%	19%	10%

Source: Dataquest
September 1989

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MOS EEPROM--Forecast

Table 2

Worldwide NMOS EEPROM Forecast

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	27	14	12	10	9	8	8	8
1K	17	34	16	16	12	11	9	8
2K	2	8	9	10	9	8	8	6
4K	2	11	13	15	14	13	11	10
8K	0	0	0	0	0	0	0	0
16K	25	28	29	35	38	46	49	66
32K	0	0	0	0	0	0	0	0
64K	25	27	30	44	42	46	46	56
256K	6	12	20	22	14	14	17	20
1Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	103	133	129	153	139	146	148	174
Percent Change from Previous Year	(13%)	29%	(3%)	19%	(9%)	5%	1%	18%

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	21.2	16.0	16.3	15.6	14.8	12.9	12.2	11.1
1K	6.6	16.8	13.9	14.4	12.0	10.4	8.4	7.2
2K	0.5	2.4	2.9	3.6	3.3	3.0	2.6	2.2
4K	0.5	2.5	3.0	3.9	3.5	3.2	2.9	2.4
8K	0	0	0	0	0	0	0	0
16K	4.4	5.6	6.1	7.0	8.0	10.0	11.0	15.6
32K	0	0	0	0	0	0	0	0
64K	2.0	2.7	4.4	5.1	5.8	7.4	8.4	11.2
256K	0	0.1	0.2	0.3	0.3	0.5	0.7	1.1
1Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	35.2	46.0	46.6	49.8	47.8	47.3	46.2	50.8
Percent Change from Previous Year	(13%)	31%	1%	7%	(4%)	(1%)	(2%)	10%

(Continued)

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Table 2 (Continued)

Worldwide NMOS EEPROM Forecast

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	$ 1.26	$ 0.90	$ 0.75	$ 0.65	$ 0.60	$ 0.62	$ 0.65	$ 0.68
1K	$ 2.50	$ 2.00	$ 1.15	$ 1.10	$ 1.00	$ 1.05	$ 1.10	$ 1.12
2K	$ 3.50	$ 3.40	$ 3.20	$ 2.90	$ 2.85	$ 2.85	$ 2.85	$ 2.85
4K	$ 4.67	$ 4.50	$ 4.25	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00
8K	0	0	0	0	0	0	0	0
16K	$ 5.70	$ 4.98	$ 4.75	$ 4.99	$ 4.72	$ 4.60	$ 4.48	$ 4.22
32K	$ 6.44	0	0	0	0	0	0	0
64K	$ 12.40	$ 10.00	$ 7.00	$ 8.70	$ 7.30	$ 6.22	$ 5.44	$ 5.00
256K	$370.00	$162.00	$108.00	$68.00	$40.00	$30.00	$24.00	$18.00
1Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	$ 2.94	$ 2.90	$ 2.77	$ 3.07	$ 2.90	$ 3.08	$ 3.20	$ 3.42
Percent Change from Previous Year	0	(1%)	(4%)	11%	(6%)	6%	4%	7%

Source: Dataquest
September 1989

Table 3

Worldwide CMOS EEPROM Forecast

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	2	7	7	7	7	8	9	9
1K	0	17	28	25	23	25	27	29
2K	0	4	10	13	14	16	18	19
4K	0	5	11	15	17	19	21	22
8K	1	0	0	0	0	0	0	0
16K	0	0	5	12	18	27	36	61
32K	0	0	1	1	1	1	1	1
64K	2	5	16	24	28	38	46	69
256K	3	13	29	48	48	73	144	176
1Mb	0	0	0	4	20	44	62	104
4Mb	0	0	0	0	0	0	0	12
Total	9	52	107	148	176	249	363	502
Percent Change from Previous Year	207%	501%	108%	38%	19%	42%	45%	38%

(Continued)

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Table 3 (Continued)

Worldwide CMOS EEPROM Forecast

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	1.8	8.1	9.9	10.5	11.2	12.8	13.2	13.9
1K	0.1	8.6	22.2	22.6	23.1	23.8	24.6	25.6
2K	0	1.2	3.0	4.3	5.0	5.5	6.2	6.5
4K	0	1.1	2.4	3.9	4.3	4.8	5.3	5.6
8K	0.1	0	0	0	0	0	0	0
16K	0	0.1	1.1	2.3	3.8	5.9	8.0	14.4
32K	0	0	0.1	0.1	0.1	0.1	0.1	0.2
64K	0.1	0.3	1.6	2.7	3.9	6.0	8.4	13.8
256K	0	0.1	0.3	0.7	1.2	2.4	5.9	9.7
1Mb	0	0	0	0	0.1	0.3	0.7	1.6
4Mb	0	0	0	0	0	0	0	0.1
Total	2.1	19.4	40.5	47.1	52.6	61.6	72.3	91.3
Percent Change from Previous Year	90%	832%	108%	16%	12%	17%	17%	26%

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	$ 1.34	$ 0.90	$ 0.75	$ 0.65	$ 0.60	$ 0.62	$ 0.65	$ 0.68
1K	$ 2.70	$ 2.00	$ 1.25	$ 1.10	$ 1.00	$ 1.05	$ 1.10	$ 1.12
2K	0	$ 3.40	$ 3.30	$ 2.90	$ 2.85	$ 2.85	$ 2.85	$ 2.85
4K	0	$ 4.50	$ 4.40	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00
8K	$ 10.00	0	0	0	0	0	0	0
16K	0	$ 5.13	$ 5.10	$ 4.99	$ 4.72	$ 4.60	$ 4.48	$ 4.22
32K	0	$ 16.00	$ 16.00	$ 13.00	$ 11.90	$ 11.20	$ 8.10	$ 5.98
64K	$ 24.00	$ 18.00	$ 10.00	$ 8.70	$ 7.30	$ 6.22	$ 5.44	$ 5.00
256K	$400.00	$184.00	$113.00	$ 68.00	$ 40.00	$ 30.50	$ 24.60	$ 18.15
1Mb	0	0	0	$440.00	$200.00	$150.00	$ 89.00	$ 65.00
4Mb	0	0	0	0	$500.00	$300.00	$190.00	$120.00
Total	$ 4.12	$ 2.66	$ 2.65	$ 3.14	$ 3.35	$ 4.05	$ 5.02	$ 5.50
Percent Change from Previous Year	62%	(36%)	0	18%	7%	21%	24%	9%

Source: Dataquest
September 1989

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MOS EEPROM--Forecast

COMPARISON WITH EARLIER FORECASTS

Several changes have been incorporated in this forecast since the last publication in June 1988. Notable changes in the MOS EEPROM market in 1988 and projected market occurrences are as follows:

- EEPROM product revenue grew 28 percent in 1988 to $237 million, up from $185 million in 1987. Strong unit growth continued with a total of 87.1 million units shipped in 1988, up from 65.5 million units in 1987.

- Overall ASPs continued to decline to $2.72, down from $2.82 in 1987. Overall ASPs have been lowered through 1993. The lower-priced, low-density EEPROM and NVRAM products should continue to capture the larger share of the EEPROM market, keeping the industry average price to a more manageable level. Although the prices of the high-speed and high-density devices are beginning to decline, they are not expected to drop as rapidly as other commodity memory product prices.

- CMOS shipments grew to 40.5 million units, representing a 46.5 percent share of EEPROM technology in 1988. As more CMOS suppliers enter the market and demand for CMOS increases from telecommunication, consumer, automotive, and industrial sectors, CMOS could command 64 percent of the technology share by 1993.

MARKET OUTLOOK

We expect the strong revenue and unit growth in MOS EEPROM experienced in 1987 and 1988 to continue through 1989. Some of the key assumptions that we used in our new forecast are as follows:

- EEPROM units are expected to grow 11 percent in 1988.

- Low-density EEPROM and NVRAM devices captured 84 percent of EEPROM unit shipments in 1989. High-density 16K and above devices are expected to represent an increasing portion of EEPROM shipments, growing to 47.6 percent of unit share by 1993.

- Shipments of the full-featured 16K, 64K, and 256K densities grew more than 56 percent from 1987 to 1988. This shift in growth to the higher densities is a result of increased demand for EEPROMs in the computer, consumer, and industrial segments. Although military continues to be the driving force for 16K and above densities, a moderate shift to high-speed, higher-density EEPROM devices in other applications is occurring.

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MOS EEPROM--Forecast

- New high-speed 16K and 64K full-featured EEPROM products, as well as new entrants such as Asahei Kasei Microsystems, Mitsubishi, and Simtek, will contribute to the long-term growth of the EEPROM market through the 1993 time frame.

- Flash memory technology is a new nonvolatile memory product area that will be covered in a separate section of Dataquest's Semiconductor Memories notebook. Further information on Flash can be found in Dataquest's SIS newsletter entitled The Bare Facts About Flash, published in June 1989.

Short-Term Forecast

The low-density products will decline as a percent of the total to 53.3 percent by 1993, down from the 84.0 percent share in 1988. Healthy bit growth at a year-to-year rate of 59.7 percent, 74.6 percent, and 80.0 percent is expected in 1991, 1992, and 1993, respectively, from a base of 1.43 billion bits in 1990. Strong bit growth in the high-density devices will be driven primarily by increased pervasiveness in current applications and newly developing applications.

Long-Term Forecast

Dataquest expects overall strong growth in all MOS memory product groups through 1993. EEPROM is expected to follow that same pattern with a compound annual growth rate (CAGR) of 23.3 percent from 1988 through 1993. The supplier base, especially in high-performance CMOS products, will continue to increase, with more entrants coming from the European and Japanese regions.

The market for denser, higher-speed EEPROMs has considerable growth potential for existing and new market applications. The new high-speed 256K devices have expanded the memory capability for present EEPROM applications. These larger densities offer greater potential in the following areas:

- Electronic petroleum marketing systems
- Point-of-sale control systems
- Card-activated transaction systems
- Solid-state time delay and temperature control devices
- Optical scanning systems
- Robotic systems configurations

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MOS EEPROM--Forecast

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MOS EEPROM--Forecast

MOS EEPROM TOTAL WORLDWIDE FORECAST

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We have included products that are fabricated using both the nitrox technology (MNOS or SNOS) and the floating-gate technology. These products are sold under a variety of generic product names: EAROM, EEPROM, or EEROM. The sole requirements for inclusion are nonvolatility, electrical programmability, and erase.

The purpose of this forecast is to indicate trends, approximate market needs, and key sensitivities to products that can benefit both manufacturers and users. The overall average selling price (ASP) is an industry average over a mix of speeds and package styles. ASPs may vary significantly from company to company and by application. Tables contained in this forecast are as follows:

- Table 1—Worldwide MOS EEPROM Forecast
- Table 2—Worldwide NMOS EEPROM Forecast
- Table 3—Worldwide CMOS EEPROM Market

Table 1

Worldwide MOS EEPROM Forecast

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	29	20	17	17	16	16	17	17
1K	17	42	40	41	35	36	36	37
2K	2	12	17	23	24	24	25	25
4K	2	16	22	31	31	32	33	32
8K	1	0	0	0	0	0	0	0
16K	25	30	36	46	56	73	85	127
32K	0	0	1	1	1	1	1	1
64K	27	38	54	68	71	84	91	125
256K	9	26	50	70	62	85	157	195
1Mb	0	0	0	4	20	44	66	106
4Mb	0	0	0	0	0	0	0	12
Total	112	185	237	301	315	395	511	676
Percent Change from Previous Year	(7%)	65%	28%	27%	4%	26%	29%	32%

(Continued)

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MOS EEPROM--Forecast

Table 1 (Continued)

Worldwide MOS EEPROM Forecast

Millions of Units

	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	23.0	24.1	26.2	26.1	26.0	25.7	25.4	25.0
1K	6.7	25.4	36.1	37.0	35.1	34.2	33.0	32.8
2K	0.5	3.6	5.9	7.9	8.3	8.5	8.8	8.7
4K	0.5	3.6	5.4	7.7	7.8	8.0	8.2	8.0
8K	0.1	0	0	0	0	0	0	0
16K	4.5	5.7	7.1	9.3	11.8	15.8	19.0	30.0
32K	0	0	0.1	0.1	0.1	0.1	0.1	0.2
64K	2.1	2.9	6.0	7.8	9.7	13.4	16.8	25.0
256K	0	0.1	0.4	1.0	1.5	2.8	6.5	10.8
1Mb	0	0	0	0	0.1	0.3	0.7	1.6
4Mb	0	0	0	0	0	0	0	0.1
Total	37.4	65.5	87.1	96.9	100.4	108.9	118.5	142.2
Percent Change from Previous Year	(10%)	75%	33%	11%	4%	8%	9%	20%

Average Selling Price (Dollars/Unit)

	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	$ 1.26	$ 0.85	$ 0.65	$ 0.65	$ 0.60	$ 0.62	$ 0.65	$ 0.68
1K	$ 2.50	$ 1.65	$ 1.10	$ 1.10	$ 1.00	$ 1.05	$ 1.10	$ 1.12
2K	$ 3.50	$ 3.40	$ 2.90	$ 2.90	$ 2.85	$ 2.85	$ 2.85	$ 2.85
4K	$ 4.67	$ 4.50	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00
8K	$ 5.00	0	0	0	0	0	0	0
16K	$ 5.71	$ 5.27	$ 5.10	$ 4.99	$ 4.72	$ 4.60	$ 4.48	$ 4.22
32K	$ 6.44	$ 16.00	$ 16.00	$ 13.00	$ 11.90	$ 11.20	$ 8.10	$ 5.98
64K	$ 13.00	$ 13.00	$ 9.10	$ 8.70	$ 7.30	$ 6.22	$ 5.44	$ 5.00
256K	$400.00	$184.00	$113.00	$ 68.00	$ 40.00	$ 30.00	$ 24.00	$ 18.00
1Mb	0	0	0	$440.00	$200.00	$150.00	$ 89.00	$ 65.00
4Mb	0	0	0	0	$500.00	$300.00	$190.00	$120.00
Total	$ 3.00	$ 2.82	$ 2.72	$ 3.11	$ 3.13	$ 3.62	$ 4.31	$ 4.75
Percent Change from Previous Year	4%	(6%)	(4%)	14%	1%	16%	19%	10%

Source: Dataquest
September 1989

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MOS EEPROM—Forecast

Table 2

Worldwide NMOS EEPROM Forecast

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	27	14	12	10	9	8	8	8
1K	17	34	16	16	12	11	9	8
2K	2	8	9	10	9	8	8	6
4K	2	11	13	15	14	13	11	10
8K	0	0	0	0	0	0	0	0
16K	25	28	29	35	38	46	49	66
32K	0	0	0	0	0	0	0	0
64K	25	27	30	44	42	46	46	56
256K	6	12	20	22	14	14	17	20
1Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	103	133	129	153	139	146	148	174
Percent Change from Previous Year	(13%)	29%	(3%)	19%	(9%)	5%	1%	18%

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	21.2	16.0	16.3	15.6	14.8	12.9	12.2	11.1
1K	6.6	16.8	13.9	14.4	12.0	10.4	8.4	7.2
2K	0.5	2.4	2.9	3.6	3.3	3.0	2.6	2.2
4K	0.5	2.5	3.0	3.9	3.5	3.2	2.9	2.4
8K	0	0	0	0	0	0	0	0
16K	4.4	5.6	6.1	7.0	8.0	10.0	11.0	15.6
32K	0	0	0	0	0	0	0	0
64K	2.0	2.7	4.4	5.1	5.8	7.4	8.4	11.2
256K	0	0.1	0.2	0.3	0.3	0.5	0.7	1.1
1Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	35.2	46.0	46.6	49.8	47.8	47.3	46.2	50.8
Percent Change from Previous Year	(13%)	31%	1%	7%	(4%)	(1%)	(2%)	10%

(Continued)

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Table 2 (Continued)

Worldwide NMOS EEPROM Forecast

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	$ 1.26	$ 0.90	$ 0.75	$ 0.65	$ 0.60	$ 0.62	$ 0.65	$ 0.68
1K	$ 2.50	$ 2.00	$ 1.15	$ 1.10	$ 1.00	$ 1.05	$ 1.10	$ 1.12
2K	$ 3.50	$ 3.40	$ 3.20	$ 2.90	$ 2.85	$ 2.85	$ 2.85	$ 2.85
4K	$ 4.67	$ 4.50	$ 4.25	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00
8K	0	0	0	0	0	0	0	0
16K	$ 5.70	$ 4.98	$ 4.75	$ 4.99	$ 4.72	$ 4.60	$ 4.48	$ 4.22
32K	$ 6.44	0	0	0	0	0	0	0
64K	$ 12.40	$ 10.00	$ 7.00	$ 8.70	$ 7.30	$ 6.22	$ 5.44	$ 5.00
256K	$370.00	$162.00	$108.00	$68.00	$40.00	$30.00	$24.00	$18.00
1Mb	0	0	0	0	0	0	0	0
4Mb	0	0	0	0	0	0	0	0
Total	$ 2.94	$ 2.90	$ 2.77	$ 3.07	$ 2.90	$ 3.08	$ 3.20	$ 3.42
Percent Change from Previous Year	0	(1%)	(4%)	11%	(6%)	6%	4%	7%

Source: Dataquest
September 1989

Table 3

Worldwide CMOS EEPROM Forecast

	Millions of Dollars							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	2	7	7	7	7	8	9	9
1K	0	17	28	25	23	25	27	29
2K	0	4	10	13	14	16	18	19
4K	0	5	11	15	17	19	21	22
8K	1	0	0	0	0	0	0	0
16K	0	0	5	12	18	27	36	61
32K	0	0	1	1	1	1	1	1
64K	2	5	16	24	28	38	46	69
256K	3	13	29	48	48	73	144	176
1Mb	0	0	0	4	20	44	62	104
4Mb	0	0	0	0	0	0	0	12
Total	9	52	107	148	176	249	363	502
Percent Change from Previous Year	207%	501%	108%	38%	19%	42%	45%	38%

(Continued)

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MOS EEPROM--Forecast

Table 3 (Continued)

Worldwide CMOS EEPROM Forecast

	Millions of Units							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	1.8	8.1	9.9	10.5	11.2	12.8	13.2	13.9
1K	0.1	8.6	22.2	22.6	23.1	23.8	24.6	25.6
2K	0	1.2	3.0	4.3	5.0	5.5	6.2	6.5
4K	0	1.1	2.4	3.9	4.3	4.8	5.3	5.6
8K	0.1	0	0	0	0	0	0	0
16K	0	0.1	1.1	2.3	3.8	5.9	8.0	14.4
32K	0	0	0.1	0.1	0.1	0.1	0.1	0.2
64K	0.1	0.3	1.6	2.7	3.9	6.0	8.4	13.8
256K	0	0.1	0.3	0.7	1.2	2.4	5.9	9.7
1Mb	0	0	0	0	0.1	0.3	0.7	1.6
4Mb	0	0	0	0	0	0	0	0.1
Total	2.1	19.4	40.5	47.1	52.6	61.6	72.3	91.3
Percent Change from Previous Year	90%	832%	108%	16%	12%	17%	17%	26%

	Average Selling Price (Dollars/Unit)							
	1986	1987	1988	1989	1990	1991	1992	1993
Less than 1K	$ 1.34	$ 0.90	$ 0.75	$ 0.65	$ 0.60	$ 0.62	$ 0.65	$ 0.68
1K	$ 2.70	$ 2.00	$ 1.25	$ 1.10	$ 1.00	$ 1.05	$ 1.10	$ 1.12
2K	0	$ 3.40	$ 3.30	$ 2.90	$ 2.85	$ 2.85	$ 2.85	$ 2.85
4K	0	$ 4.50	$ 4.40	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00
8K	$ 10.00	0	0	0	0	0	0	0
16K	0	$ 5.13	$ 5.10	$ 4.99	$ 4.72	$ 4.60	$ 4.48	$ 4.22
32K	0	$ 16.00	$ 16.00	$ 13.00	$ 11.90	$ 11.20	$ 8.10	$ 5.98
64K	$ 24.00	$ 18.00	$ 10.00	$ 8.70	$ 7.30	$ 6.22	$ 5.44	$ 5.00
256K	$400.00	$184.00	$113.00	$ 68.00	$ 40.00	$ 30.50	$ 24.60	$ 18.15
1Mb	0	0	0	$440.00	$200.00	$150.00	$ 89.00	$ 69.00
4Mb	0	0	0	0	$500.00	$300.00	$190.00	$120.00
Total	$ 4.12	$ 2.66	$ 2.65	$ 3.14	$ 3.35	$ 4.05	$ 5.02	$ 5.50
Percent Change from Previous Year	62%	(36%)	0	18%	7%	21%	24%	9%

Source: Dataquest
September 1989

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MOS EEPROM--Forecast

COMPARISON WITH EARLIER FORECASTS

Several changes have been incorporated in this forecast since the last publication in June 1988. Notable changes in the MOS EEPROM market in 1988 and projected market occurrences are as follows:

- EEPROM product revenue grew 28 percent in 1988 to $237 million, up from $185 million in 1987. Strong unit growth continued with a total of 87.1 million units shipped in 1988, up from 65.5 million units in 1987.

- Overall ASPs continued to decline to $2.72, down from $2.82 in 1987. Overall ASPs have been lowered through 1993. The lower-priced, low-density EEPROM and NVRAM products should continue to capture the larger share of the EEPROM market, keeping the industry average price to a more manageable level. Although the prices of the high-speed and high-density devices are beginning to decline, they are not expected to drop as rapidly as other commodity memory product prices.

- CMOS shipments grew to 40.5 million units, representing a 46.5 percent share of EEPROM technology in 1988. As more CMOS suppliers enter the market and demand for CMOS increases from telecommunication, consumer, automotive, and industrial sectors, CMOS could command 64 percent of the technology share by 1993.

MARKET OUTLOOK

We expect the strong revenue and unit growth in MOS EEPROM experienced in 1987 and 1988 to continue through 1989. Some of the key assumptions that we used in our new forecast are as follows:

- EEPROM units are expected to grow 11 percent in 1988.

- Low-density EEPROM and NVRAM devices captured 84 percent of EEPROM unit shipments in 1989. High-density 16K and above devices are expected to represent an increasing portion of EEPROM shipments, growing to 47.6 percent of unit share by 1993.

- Shipments of the full-featured 16K, 64K, and 256K densities grew more than 56 percent from 1987 to 1988. This shift in growth to the higher densities is a result of increased demand for EEPROMs in the computer, consumer, and industrial segments. Although military continues to be the driving force for 16K and above densities, a moderate shift to high-speed, higher-density EEPROM devices in other applications is occurring.

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- New high-speed 16K and 64K full-featured EEPROM products, as well as new entrants such as Asahei Kasei Microsystems, Mitsubishi, and Simtek, will contribute to the long-term growth of the EEPROM market through the 1993 time frame.

- Flash memory technology is a new nonvolatile memory product area that will be covered in a separate section of Dataquest's Semiconductor Memories notebook. Further information on Flash can be found in Dataquest's SIS newsletter entitled The Bare Facts About Flash, published in June 1989.

Short-Term Forecast

The low-density products will decline as a percent of the total to 53.3 percent by 1993, down from the 84.0 percent share in 1988. Healthy bit growth at a year-to-year rate of 59.7 percent, 74.6 percent, and 80.0 percent is expected in 1991, 1992, and 1993, respectively, from a base of 1.43 billion bits in 1990. Strong bit growth in the high-density devices will be driven primarily by increased pervasiveness in current applications and newly developing applications.

Long-Term Forecast

Dataquest expects overall strong growth in all MOS memory product groups through 1993. EEPROM is expected to follow that same pattern with a compound annual growth rate (CAGR) of 23.3 percent from 1988 through 1993. The supplier base, especially in high-performance CMOS products, will continue to increase, with more entrants coming from the European and Japanese regions.

The market for denser, higher-speed EEPROMs has considerable growth potential for existing and new market applications. The new high-speed 256K devices have expanded the memory capability for present EEPROM applications. These larger densities offer greater potential in the following areas:

- Electronic petroleum marketing systems
- Point-of-sale control systems
- Card-activated transaction systems
- Solid-state time delay and temperature control devices
- Optical scanning systems
- Robotic systems configurations

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5/87

MOS EEPROM--Forecast

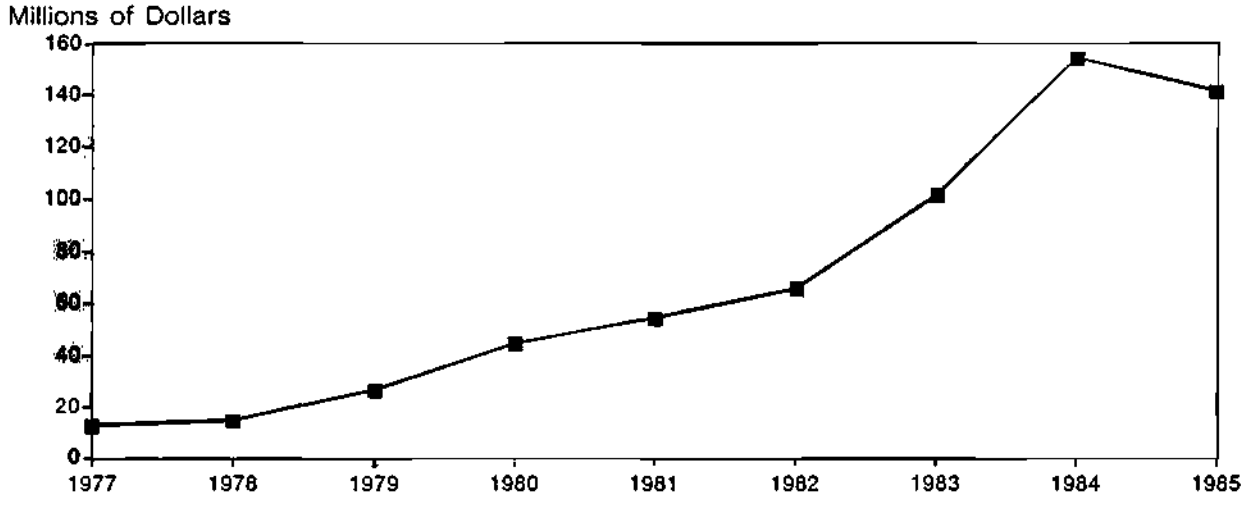
OVERVIEW OF THE MOS EEPROM MARKET

The market for MOS EEPROMs has been developing since 1972, when NCR first patented and developed the nonvolatile memory cell. The MOS EEPROM market reached $13 million in revenue by 1977; by 1984, it had achieved $155 million in revenue. (The year-to-year growth rate is shown in Figure 1.) Worldwide MOS EEPROM revenue grew at a compound annual growth rate (CAGR) of 64.2 percent from 1977 through 1984 and a 61.3 percent CAGR from 1977 through 1985. Although the EEPROM market has gone through a variety of phases, suppliers, densities, and process technologies, it is still considered to be in an immature product stage, its growth hindered by a number of key technical, conceptual, institutional, and manufacturing issues.

The 1970 to 1980 time frame can best be described as the MOS EEPROM niche-market period--marked by few market participants and limited applications. The market had reached only $45 million in revenue in 1980, and the highest-density device available was 8 Kbits. As shown in Figure 2, the early EEPROM segment averaged a marginal share of the total memory market.

Figure 1

Estimated Worldwide MOS EEPROM Revenue
1977-1985



Source: Dataquest
June 1988

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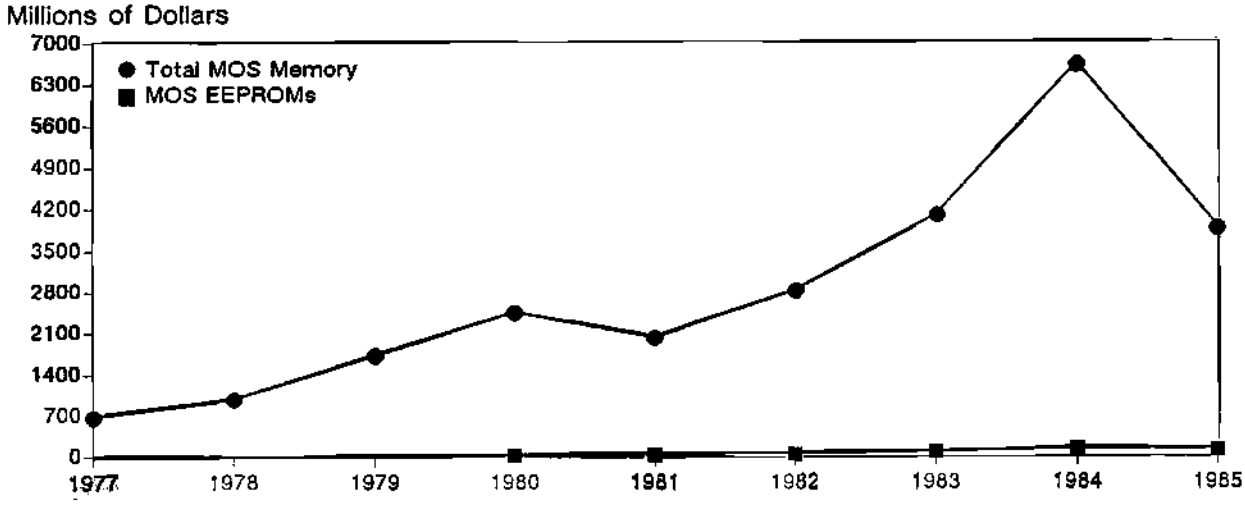
MOS EEPROM--Forecast

Figure 2

Estimated EEPROM Share of MOS Memory Revenue
1977–1985



Source: Dataquest June 1988

From 1973 through 1980, the first EEPROM devices, pioneered by NCR and known as EAROMs (electrically alterable ROMs), were built exclusively around a P–channel MNOS (metal–nitride oxide silicon) process, which used trapped charges at the nitride interface for bit storage. This process was limited by low speed (1,000 nanoseconds) and low density. Between 1972 and 1977, much of the market was captive and controlled by NCR. NCR licensed its technology to General Instrument Corporation in 1977 and to Nitron in 1979. By 1980, most of the U.S. merchant market was controlled by General Instrument and Nitron, with 75 percent of NCR's output used for internal consumption. The only other major competition was coming from Mitsubishi, Toshiba, and NEC. While Mitsubishi purchased the technology rights from NCR, Toshiba and NEC used a floating–gate process. The tunneling processes found in most floating–gate EEPROM devices are controlled by the Fowler–Nordheim theory introduced in the 1920s.

The major areas of application at this time were tuners in consumer electronics (TV and radio), in point–of–sale (POS) equipment to store prices or tax tables, in postage meters to store postal rates, or in other lookup tables.

The 1980 and 1981 time frame marks the beginning of the EEPROM transitional period. The EEPROM market experienced a shift to new technologies, new areas of application, and new participants. General Instrument began to phase out its P–channel MNOS devices and switched to N–channel MNOS technology. The N–channel technology provided increased speed and better transistor gains for improving packaging densities, thereby reducing system cost and insuring the ability to achieve a +5 voltage operation. This technology was later followed by N–channel silicon nitrox (SNOS).

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MOS EEPROM—Forecast

In 1980, Intel introduced its 2816 device, the first EEPROM using floating-gate tunnel oxide (FLOTOX, an Intel trademark). FLOTOX is an extension of Intel's EPROM technology. Xicor, founded in 1978, introduced the first nonvolatile shadow RAM (NOVRAM) in 1980, followed closely by its 16K EEPROM. Xicor also introduced the first full-featured 16K EEPROM that had 5-volt programming as well as the on-chip functions required for in-system programming. Other entrants at this time included AMD, Hughes, Motorola, National, Seeq, and Siemens. While the number of suppliers had more than doubled by 1983, much of the major technological innovation came from only three companies—Intel, Seeq, and Xicor. During this period of development, average EEPROM speeds plummeted. From the early product speeds of 1,000 nanoseconds (ns), access times dropped to 450ns by 1980, down to 300ns by 1982, and to 200ns by 1984. The influx of new market participants and more products drove EEPROM revenue to $103 million by 1983. Although floating-gate device consumption grew, nitrox-type technologies continued to garner half of the 1983 revenue.

Product False Starts

In the product arena, many of the early devices offered did not embody technology that adequately reflected the market needs. In other cases, some of the devices offered were too difficult for the manufacturer to produce economically. General Instrument, Hitachi, Hughes, Intel, Motorola, NCR, and Seeq have all, at one time or another, made tentative entries at the 16K level that were later downplayed or withdrawn.

As the market developed, more functions were required of devices, forcing manufacturers to backtrack and to incorporate these functions in their devices. This trend resulted from features that:

- Were attractive to users
- Were feasible from a manufacturer's viewpoint
- Were demanded by the basic product functioning to avoid unacceptable error conditions and ensure predictable product operation

Competing Markets

Although both the NVRAM and EEPROM markets experienced strong growth in the 1983 and 1984 time frame, the recessionary markets of 1985 and 1986, along with the emergence of the more competitive EPROM and CMOS SRAMs, hindered EEPROM penetration into more established semiconductor markets. Led by Intel, manufacturers made immense improvements in EPROM price/performance. Average prices per bit dropped 80 percent from 1980 to 1983. End users with system applications that required read times commensurate with MPU speeds often opted for CMOS SRAMs with battery backup. By 1983, full CMOS 64K SRAMs were available at prices under $20.00, offering full read-write capability faster than most EEPROMs can read only. While the price recessions of the early 1980s pushed EPROM and SRAM prices down the learning curve,

EEPROMs, still establishing the basic circuits and manufacturing techniques during those years, generated inadequate volumes to drive the process technology that would allow prices to drop faster than they actually did. Because there was very little if any standardization in EEPROM devices, each vendor was very much like a sole source to its customers. As a result, device prices were not as tightly coupled to one another for EEPROMs as prices were in the commodity-type products. In 1983, prices for 16K EEPROMs ranged from $10.00 to nearly $30.00 (depending on vendor and device type).

Product Standards and Second Sources

During the EEPROM formative years, the lack of product standardization and viable second sources was probably the greatest inhibitor to market growth. Foremost among the "feature-related" issues as to what constituted the ideal EEPROM were:

- Complete 5-volt operation, including erase/write cycles
- On-board clocks
- Latched data and addresses

By the end of 1983, a consensus was ultimately reached on these three issues, with Xicor's X2816A part type emerging as the de facto standard in the EEPROM market. At the end of 1984, Exel, Seeq, Tristar, and Xicor were all shipping functionally compatible 16K products.

With the emergence of second-sourcing and device standards in 1984, the 1985 market saw more participation from larger, more established producers such as AMD and Hitachi. Production volumes of 64K densities became available from Hitachi, Seeq, and Xicor, with 256K sampling becoming available at the end of 1985. This gave the EEPROM market some added credibility and improved price/performance.

MOS EEPROM TOTAL WORLDWIDE FORECAST

Dataquest's MOS EEPROM forecast consists of revenue, unit shipments, and prices for MOS EEPROM product lines. The tables in this section combine NVRAMs and EEPROMs. NVRAMs are discussed separately in the text, but are combined with EEPROMs in the tables. Products include only monolithic EEPROMs and NVRAMs, and they are not assemblages made up of traditional CMOS Static RAMs with battery backup in the same package.

We have included products that are fabricated using both the nitrox technology (MNOS or SNOS) and the floating-gate technology. These products are sold under a variety of generic product names: EAROM, EEPROM, or EEROM. The sole requirements for inclusion are nonvolatility, electrical programmability, and erase.

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MOS EEPROM--Forecast

The purpose of this forecast is to indicate trends, approximate market needs, and key sensitivities to products that can benefit both manufacturers and users. The overall average selling price (ASP) is an industry average over a mix of speeds and package styles. ASPs may vary significantly from company to company and by application. Tables contained in this forecast are as follows:

- Table 1--Worldwide MOS EEPROM Forecast
- Table 2—Worldwide NMOS EEPROM Forecast
- Table 3--Worldwide CMOS EEPROM Forecast

Table 1

Worldwide MOS EEPROM Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 43	$ 29	$ 33	$ 34	$ 35	$ 36	$ 36	$ 38
1K	20	17	58	63	66	67	68	70
2K	2	2	8	4	3	3	3	3
4K	8	2	10	4	4	3	4	4
8K	1	1	1	0	0	0	0	0
16K	26	25	29	40	35	29	23	19
32K	2	0	0	0	0	0	0	0
64K	19	27	38	86	111	85	61	43
128K	0	0	0	0	0	0	0	0
256K	0	9	26	78	125	150	256	300
512K	0	0	0	0	9	28	47	104
1Mb	0	0	0	2	48	73	106	125
Total	$121	$112	$203	$312	$436	$474	$605	$707
Percent Change from Previous Year	(22%)	(8%)	82%	54%	40%	9%	28%	17%

(Continued)

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MOS EEPROM--Forecast

Table 1 (Continued)

Worldwide MOS EEPROM Forecast

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	27.0	23.0	29.1	30.1	32.1	33.4	34.2	36.5
1K	7.8	6.7	24.2	26.4	27.3	27.9	28.2	29.0
2K	0.6	0.5	2.3	1.1	1.0	0.8	1.0	1.0
4K	1.8	0.5	2.2	1.0	1.0	0.9	1.0	1.0
8K	0.1	0.1	0.1	0	0	0	0	0
16K	3.4	4.5	5.6	7.9	7.3	6.2	5.2	4.2
32K	0.1	0	0	0	0	0.1	0.1	0.1
64K	0.8	2.1	2.9	7.2	12.8	13.1	12.2	10.6
128K	0	0	0	0	0	0	0	0
256K	0	0	0.1	0.8	2.5	5.5	16.0	33.0
512K	0	0	0	0	0.5	2.4	6.0	18.2
1Mb	0	0	0	0	0.5	1.5	3.6	6.6
Total	41.7	37.4	66.6	74.6	85.0	91.7	107.4	140.1

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 1.60	$ 1.26	$ 1.15	$ 1.12	$ 1.10	$ 1.08	$ 1.06	$ 1.04
1K	$ 2.57	$ 2.50	$ 2.40	$ 2.40	$ 2.40	$ 2.40	$ 2.40	$ 2.40
2K	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50
4K	$ 4.71	$ 4.67	$ 4.40	$ 4.20	$ 4.00	$ 3.80	$ 4.00	$ 4.15
8K	$ 5.60	$ 5.00	$ 5.00	$ 5.00	0	0	0	0
16K	$ 7.50	$ 5.71	$ 5.20	$ 5.02	$ 4.75	$ 4.65	$ 4.50	$ 4.20
32K	$13.00	$ 6.44	$ 16.00	$ 16.00	$11.20	$ 8.10	$ 5.98	$ 4.75
64K	$22.50	$ 13.00	$ 13.00	$ 11.94	$ 8.70	$ 6.50	$ 4.97	$ 4.10
128K	0	0	0	0	0	0	0	0
256K	0	$400.00	$184.00	$ 98.00	$50.00	$27.30	$16.00	$ 9.09
512K	0	0	0	33.00	17.80	11.60	7.85	5.70
1Mb	0	0	0	$200.00	$95.00	$48.80	$29.50	$19.00
Overall ASP	$ 2.91	$ 2.98	$ 3.04	$ 4.18	$ 5.14	$ 5.17	$ 5.64	$ 5.04

*Columns may not add to totals shown because of rounding.

Source: Dataquest
June 1988

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MOS EEPROM--Forecast

Table 2

Worldwide NMOS EEPROM Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 42	$ 27	$ 27	$ 23	$ 22	$ 23	$ 23	$ 24
1K	20	17	32	36	36	36	34	33
2K	2	2	8	4	3	2	3	3
4K	8	2	8	4	4	3	4	4
8K	0	0	0	0	0	0	0	0
16K	26	25	27	32	24	16	11	5
32K	2	0	0	0	0	0	0	0
64K	19	25	30	66	65	34	27	20
128K	0	0	0	0	0	0	0	0
256K	0	6	12	32	53	61	104	127
512K	0	0	0	0	0	0	0	0
1Mb	0	0	0	2	24	36	50	59
Total	$119	$103	$144	$198	$230	$211	$257	$276
Percent Change from Previous Year	(18%)	(13%)	39%	37%	16%	(8%)	22%	7%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	26.0	21.2	24.1	20.1	20.3	21.4	22.0	23.5
1K	7.8	6.6	14.0	15.3	14.9	14.9	14.2	13.8
2K	0.6	0.5	2.3	1.0	0.9	0.7	0.9	0.9
4K	1.8	0.5	1.8	0.9	0.9	0.8	0.9	0.9
8K	0	0	0	0	0	0	0	0
16K	3.4	4.4	5.5	6.8	5.3	3.7	2.6	1.2
32K	0.1	0	0	0	0	0	0	0
64K	0.8	2.0	2.6	6.1	8.8	6.6	6.1	5.0
128K	N/A	0	0	0	0	0	0	0
256K	N/A	0	0.1	0.4	1.3	2.8	8.0	16.0
512K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1Mb	N/A	0	0	0	0.3	0.8	1.8	3.3
Total	40.6	35.4	50.3	50.7	52.6	51.6	56.5	64.6

(Continued)

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MOS EEPROM--Forecast

Table 2 (Continued)

Worldwide NMOS EEPROM Forecast

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 1.60	$ 1.26	$ 1.14	$ 1.12	$ 1.10	$ 1.08	$ 1.06	$ 1.04
1K	$ 2.54	$ 2.50	$ 2.30	$ 2.32	$ 2.40	$ 2.40	$ 2.40	$ 2.40
2K	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50
4K	$ 4.71	$ 4.67	$ 4.40	$ 4.20	$ 4.00	$ 3.80	$ 4.00	$ 4.15
8K	0	0	0	0	0	0	0	0
16K	$ 7.60	$ 5.70	$ 4.98	$ 4.75	$ 4.50	$ 4.40	$ 4.30	$ 4.20
32K	$14.91	$ 6.44	0	0	0	0	0	0
64K	$23.00	$ 12.40	$ 11.40	$ 10.80	$ 7.40	$ 5.20	$ 4.40	$ 4.00
128K	N/A	0	0	0	0	0	0	0
256K	N/A	$370.00	$164.00	$ 80.00	$42.00	$22.00	$13.00	$ 7.94
512K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1Mb	N/A	0	0	$200.00	$94.00	$47.68	$28.00	$17.88
Overall ASP	$ 2.93	$ 2.93	$ 2.87	$ 3.89	$ 4.37	$ 4.09	$ 4.54	$ 4.27

*Columns may not add to totals shown because of rounding.
N/A = Not Available

Source: Dataquest
June 1988

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Table 3

Worldwide CMOS EEPROM Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$2	$2	$ 6	$ 12	$ 13	$ 13	$ 13	$ 14
1K	0	0	26	28	30	31	34	36
2K	0	0	0	0	0	0	0	0
4K	0	0	2	0	0	0	0	0
8K	1	1	1	0	0	0	0	0
16K	0	0	2	7	11	13	12	14
32K	0	0	0	0	0	0	0	0
64K	0	2	8	20	46	51	34	23
128K	0	0	0	0	0	0	0	0
256K	0	3	14	46	73	89	152	173
512K	0	0	0	0	9	28	47	104
1Mb	0	0	0	0	25	37	56	66
Total	$2	$8	$58	$114	$207	$263	$349	$431
Percent Change from Previous Year	(76%)	249%	623%	96%	81%	27%	32%	24%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	1.0	1.8	5.0	10.0	11.8	12.0	12.2	13.0
1K	0	0.1	10.2	11.1	12.4	13.0	14.0	15.2
2K	N/A	N/A	0.1	0.1	0.1	0.1	0.1	0.1
4K	0	0	0.4	0.1	0.1	0.1	0.1	0.1
8K	0.1	0.1	0.1	0	0	0	0	0
16K	0	0	0.1	1.1	2.0	2.5	2.6	3.0
32K	0	0	0	0	0	0.1	0.1	0.1
64K	0	0.1	0.3	1.1	4.0	6.6	6.1	5.6
128K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
256K	0	0	0.1	0.4	1.3	2.8	8.0	17.0
512K	N/A	N/A	N/A	0	0.5	2.4	6.0	18.2
1Mb	N/A	N/A	N/A	0	0.3	0.8	1.8	3.3
Total	1.1	2.0	16.3	23.9	32.4	40.2	50.9	75.5

(Continued)

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Table 3 (Continued)

Worldwide CMOS EEPROM Forecast

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 1.60	$ 1.34	$ 1.20	$ 1.16	$ 1.10	$ 1.10	$ 1.08	$ 1.06
1K	$ 2.57	$ 2.70	$ 2.50	$ 2.50	$ 2.40	$ 2.40	$ 2.40	$ 2.40
2K	N/A	N/A	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50
4K	0	0	$ 4.50	$ 4.20	$ 4.10	$ 3.90	$ 4.10	$ 4.20
8K	$12.00	$ 10.00	$ 5.00	0	0	0	0	0
16K	$ 7.60	$ 6.00	$ 13.17	$ 6.60	$ 5.60	$ 5.20	$ 4.70	$ 4.50
32K	N/A	0	$ 16.00	$ 16.00	$11.20	$ 8.10	$ 5.98	$ 4.75
64K	N/A	$ 25.00	$ 28.00	$ 18.50	$11.50	$ 7.80	$ 5.55	$ 4.10
128K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
256K	N/A	$400.00	$205.00	$114.00	$58.00	$32.50	$19.00	$10.20
512K	N/A	N/A	N/A	$ 33.00	$17.80	$11.60	$ 7.85	$ 5.70
1Mb	N/A	N/A	N/A	0	$98.00	$49.00	$31.00	$20.15
Overall ASP	$ 2.12	$ 3.94	$ 3.59	$ 4.78	$ 6.38	$ 6.56	$ 6.85	$ 5.71

*Columns may not add to totals shown because of rounding.
N/A = Not Available

Source: Dataquest
June 1988

Comparison with Earlier Forecasts

Several changes have been incorporated in this forecast since the last publication in April 1987. Notable changes in the MOS EEPROM market in 1987 and projected market occurrences are as follows:

- EEPROM product revenue grew 82 percent in 1987, after an 8 percent decline in 1986 and a 22 percent decline in 1985. The percent of revenue and unit growth for EEPROMs outstripped that of both EPROMs and ROMs from 1986 to 1987.

- Overall ASPs declined to $3.04, from our previous estimate of $4.17. Overall ASPs have been lowered through 1992. The lower-priced, low-density EEPROM and NVRAM products will continue to garner the lion's share of the EEPROM market, keeping the industry average price at a more manageable level. Prices of the high-speed and high-density devices are not expected to drop as rapidly as those of other commodity memory products.

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- CMOS shipments grew to 16.3 million units, representing a 24 percent share of EEPROM technology in 1987. Although NMOS is expected to remain the dominant technology through 1989, CMOS share will shift to 47 percent of units by 1991. As more CMOS suppliers enter the market and demand for CMOS increases from the consumer, automotive, and industrial sectors, CMOS could command 54 percent of the technology share by 1992.

MARKET OUTLOOK

We anticipate that the strong revenue and unit growth in MOS EEPROM experienced in 1987 will continue, but at a more moderate pace, through 1988 and 1989. Some of the key assumptions that we used in our new forecast are as follows:

- EEPROM units are expected to grow 12 percent, 14 percent, and 8 percent in 1988, 1989, and 1990, respectively, from a base of 78 percent in 1987. We expect the EEPROM market to flatten slightly in the latter part of 1989, with a further slowdown continuing through 1990.

- Low-density EEPROM and NVRAM devices will capture 79 percent of EEPROM unit shipments in 1988. High-density 16K and above devices are expected to represent an increasing portion of EEPROM shipments, growing to 52 percent of unit share by 1992.

- Shipments of the full-featured 16K, 64K, and 256K densities grew 24 percent, 38 percent, and 517 percent, respectively, from 1986 to 1987. This shift in growth to the higher densities is a result of new EEPROM emphasis from the computer, consumer, and industrial sectors. Although military applications continue to be the driving force for 16K and above densities, a moderate shift to high-speed, higher-density EEPROM devices in other applications is occurring.

- The market for advanced 256K and 1-Mbit densities is expected to grow at moderate rates, reaching approximately 4 percent of total units shipped in 1989. NEC, Sharp, and Toshiba are among the new entrants that will be positioning themselves in this high-density market in 1988.

- New high-speed 16K and 64K full-featured EEPROM and Flash EEPROM products will contribute to the long-term growth of the EEPROM market from 1990 through 1992.

Short-Term Forecast

Seeq and Xicor, major suppliers in high-density EEPROMs, and Mitsubishi and National, major suppliers in low-density EEPROMs, stand to be the prime beneficiaries of the trends noted. They will face increased competition from Hitachi, NEC, and Sharp in high-density EEPROMs, and from Catalyst, Microchip, and SGS-Thomson in

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low-density EEPROMs. This competition will erode their market share and quite possibly their profit margins. Beyond 1989, we believe that Seeq and Xicor will continue to hold the major portion of the high-density 256K and above products.

The market for the older 16K EEPROMs is expected to grow through 1988 and decline slightly in 1989, followed by a normal life-cycle decline. The 64K EEPROM will grow at a moderate rate, reaching its peak of more than 3 million units by 1990. There are certain critical variables in our forecast for these two devices that could skew our forecast in either direction. Several high-speed 16K and 64K devices, along with a new 32K bipolar PROM replacement EEPROM, were introduced and shipped in 1987. User emphasis on high speed could boost shipments of these new products beyond our conservative forecast. The strength of new EEPROM applications in IC cards and automotive engine controllers could go far in determining the growth of these products.

We have factored growth of Flash memory products into the the 256K and above densities. Flash EEPROMs were first introduced to the market by Toshiba in 1985. The Flash memory is an emerging technology now being supported by Intel, National, Seeq, and Toshiba. AMD, Hitachi, Microchip Technologies, and Texas Instruments are all potential entries in this area.

Improvements in performance parameters will continue to open up new markets. For the 1988 period, we expect the principal market driving forces to be the attractiveness of the basic EEPROM capability--electrically programmable memory—and the continued establishment of a sound supply of base standards and mastery of manufacturing.

Long-Term Forecast

Dataquest has continued its bullish forecast on EEPROMs. Although the supplier base and products offered in the high-performance CMOS area have been marginal, the market potential remains impressive and the application boundaries are limitless. As expected, the Japanese did jump into the EEPROM market on a larger scale in 1987. Their efforts are being concentrated not only in the low-density and commodity 16K and 64K areas, but they are now venturing into the 256K and above densities.

Hitachi introduced its new 8Kx8 64K CMOS EEPROM. The new product combines both CMOS and MNOS cell process technologies with 200ns access speeds available. Toshiba started sampling of its 32Kx8 NMOS 256K EEPROM with access speeds of 200 and 300ns.

We anticipate more technology and manufacturing agreements in EEPROM in 1988 and 1989. Licensing and technology exchanges, similar to that between National and Seeq in Flash memory, reflect a growing awareness that companies of all sizes and revenue structure can no longer afford the high cost of new product development. Leverage—pooling corporate resources in design, manufacturing, sales, and distribution through partnership—will be essential for corporate survival during the next round of economic recession and industry shakeouts.

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MOS EEPROM--Forecast

U.S. EEPROM manufacturers have the expertise but cannot continue developing next-generation devices on their own capital. The larger firms--whether from Europe, Japan, or the United States--offer many advantages to the smaller firms, including broad product capabilities. As the field of competition opens, both Seeq and Xicor cannot possibly sell into and/or control the full-featured 5-volt EEPROM market enough to recoup their R&D investments.

We continue to believe that the European and Japanese markets and applications for EEPROMs, especially at the 16K and 64K densities, will provide the impetus to drive the EEPROM market forward. In Japan, for example, the Arimura Giken Company has introduced IC cards for less than $14. The card uses a 16K EEPROM from Hitachi and a 4K EEPROM device from a U.S. manufacturer. The market in Japan for IC card readers and related equipment, in 1995 is projected by the EIAJ to reach ¥3.5 trillion. The IC card market in Japan had reached ¥1.4 billion in 1985. It was expected to reach ¥127 billion by 1990, and ¥277 billion by 1995. Of that 277 billion yen, 56 percent would be memory cards and 44 percent would be cards incorporating CPUs.

Mitsubishi introduced reprogrammable IC cards incorporating 64K or 128K (two chip type) EEPROMs on its reader-writer PC cards for desktop and laptop PCs.

The automotive sector will continue to look to and use more of the EEPROM products, both low- and high-density, full-featured, and Flash products.

European telecommunication users that have concentrated their efforts using the low 1K devices are expected to increase usage of the larger 64K densities and move into the 512K Flash area in 1989 and 1990.

We anticipate that military applications will continue to capture a 25 to 30 percent share of the 16K and above EEPROMs, with increased emphasis on CMOS technology. The military is currently the largest user of the 256K density. Commercial applications requiring the 256K capability could force our forecast unit growth and price declines beyond our expectations over the next two years, if manufacturing yields and large volume, cost-effective pricing is available.

Users, other than those in the military sector, have been reluctant to commit to volumes of high-priced and limited second-source availability in the 64K and 256K densities. Although Seeq and Xicor have captured the larger share of the high-density EEPROM market and their product quality and technology expertise are superb, their products because of their process complexity, have not been the most cost-effective nonvolatile solutions available to the user. During the past few years, the manufacturers that have offered nonvolatile products at reasonable prices (2 to 3 millicents per bit) have been able to drive their products and the market direction. If the EEPROM market is to develop to the extent that it is forecast to grow, its growth will have to come from the 256K and above densities. Although the interest is keen for the 256K device, its market continues to be predominantly military. Therefore, we believe that if our forecast is to have any credibility and if any viable commercial market is to develop, the 256K ASP will have to fall below the $40 to $50 range in late 1988 and/or early 1989. EEPROM user potential is tremendous, but the commercial customers will continue to opt for the lower-priced EPROM or battery-backed SRAM, preferring to take a "hit" on reliability in exchange for price.

MOS EEPROM--Forecast

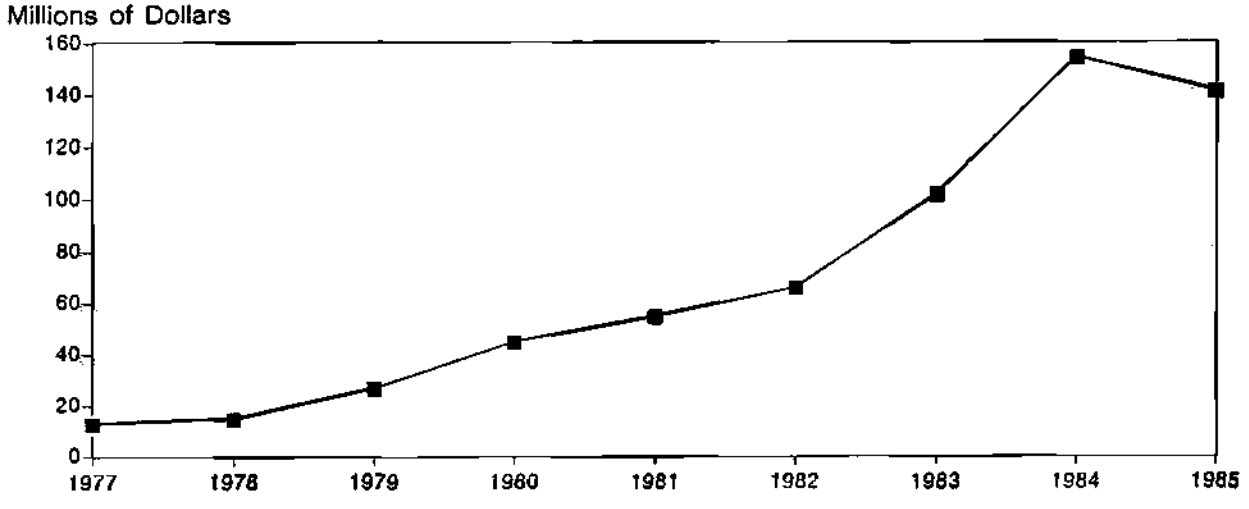
OVERVIEW OF THE MOS EEPROM MARKET

The market for MOS EEPROMs has been developing since 1972, when NCR first patented and developed the nonvolatile memory cell. The MOS EEPROM market reached $13 million in revenue by 1977; by 1984, it had achieved $155 million in revenue. (The year-to-year growth rate is shown in Figure 1.) Worldwide MOS EEPROM revenue grew at a compound annual growth rate (CAGR) of 64.2 percent from 1977 through 1984 and a 61.3 percent CAGR from 1977 through 1985. Although the EEPROM market has gone through a variety of phases, suppliers, densities, and process technologies, it is still considered to be in an immature product stage, its growth hindered by a number of key technical, conceptual, institutional, and manufacturing issues.

The 1970 to 1980 time frame can best be described as the MOS EEPROM niche-market period—marked by few market participants and limited applications. The market had reached only $45 million in revenue in 1980, and the highest-density device available was 8 Kbits. As shown in Figure 2, the early EEPROM segment averaged a marginal share of the total memory market.

Figure 1

Estimated Worldwide MOS EEPROM Revenue
1977-1985



Source: Dataquest
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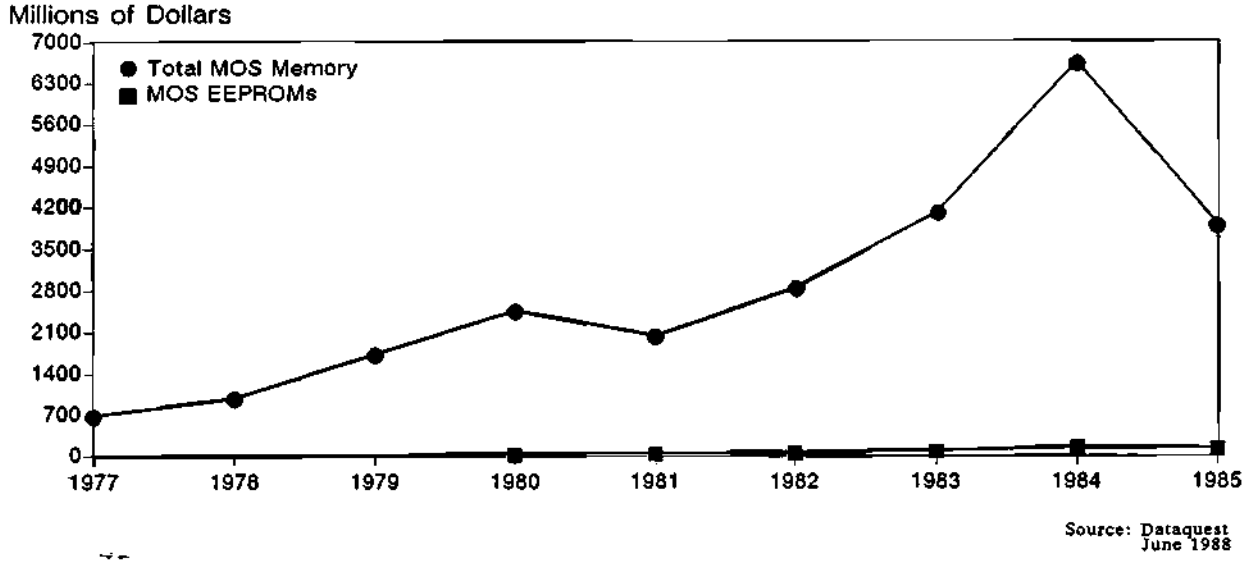
MOS EEPROM--Forecast

Figure 2

Estimated EEPROM Share of MOS Memory Revenue
1977–1985



From 1973 through 1980, the first EEPROM devices, pioneered by NCR and known as EAROMs (electrically alterable ROMs), were built exclusively around a P-channel MNOS (metal-nitride oxide silicon) process, which used trapped charges at the nitride interface for bit storage. This process was limited by low speed (1,000 nanoseconds) and low density. Between 1972 and 1977, much of the market was captive and controlled by NCR. NCR licensed its technology to General Instrument Corporation in 1977 and to Nitron in 1979. By 1980, most of the U.S. merchant market was controlled by General Instrument and Nitron, with 75 percent of NCR's output used for internal consumption. The only other major competition was coming from Mitsubishi, Toshiba, and NEC. While Mitsubishi purchased the technology rights from NCR, Toshiba and NEC used a floating-gate process. The tunneling processes found in most floating-gate EEPROM devices are controlled by the Fowler-Nordheim theory introduced in the 1920s.

The major areas of application at this time were tuners in consumer electronics (TV and radio), in point-of-sale (POS) equipment to store prices or tax tables, in postage meters to store postal rates, or in other lookup tables.

The 1980 and 1981 time frame marks the beginning of the EEPROM transitional period. The EEPROM market experienced a shift to new technologies, new areas of application, and new participants. General Instrument began to phase out its P-channel MNOS devices and switched to N-channel MNOS technology. The N-channel technology provided increased speed and better transistor gains for improving packaging densities, thereby reducing system cost and insuring the ability to achieve a +5 voltage operation. This technology was later followed by N-channel silicon nitrox (SNOS).

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In 1980, Intel introduced its 2816 device, the first EEPROM using floating-gate tunnel oxide (FLOTOX, an Intel trademark). FLOTOX is an extension of Intel's EPROM technology. Xicor, founded in 1978, introduced the first nonvolatile shadow RAM (NOVRAM) in 1980, followed closely by its 16K EEPROM. Xicor also introduced the first full-featured 16K EEPROM that had 5-volt programming as well as the on-chip functions required for in-system programming. Other entrants at this time included AMD, Hughes, Motorola, National, Seeq, and Siemens. While the number of suppliers had more than doubled by 1983, much of the major technological innovation came from only three companies—Intel, Seeq, and Xicor. During this period of development, average EEPROM speeds plummeted. From the early product speeds of 1,000 nanoseconds (ns), access times dropped to 450ns by 1980, down to 300ns by 1982, and to 200ns by 1984. The influx of new market participants and more products drove EEPROM revenue to $103 million by 1983. Although floating-gate device consumption grew, nitrox-type technologies continued to garner half of the 1983 revenue.

Product False Starts

In the product arena, many of the early devices offered did not embody technology that adequately reflected the market needs. In other cases, some of the devices offered were too difficult for the manufacturer to produce economically. General Instrument, Hitachi, Hughes, Intel, Motorola, NCR, and Seeq have all, at one time or another, made tentative entries at the 16K level that were later downplayed or withdrawn.

As the market developed, more functions were required of devices, forcing manufacturers to backtrack and to incorporate these functions in their devices. This trend resulted from features that:

- Were attractive to users
- Were feasible from a manufacturer's viewpoint
- Were demanded by the basic product functioning to avoid unacceptable error conditions and ensure predictable product operation

Competing Markets

Although both the NVRAM and EEPROM markets experienced strong growth in the 1983 and 1984 time frame, the recessionary markets of 1985 and 1986, along with the emergence of the more competitive EPROM and CMOS SRAMs, hindered EEPROM penetration into more established semiconductor markets. Led by Intel, manufacturers made immense improvements in EPROM price/performance. Average prices per bit dropped 80 percent from 1980 to 1983. End users with system applications that required read times commensurate with MPU speeds often opted for CMOS SRAMs with battery backup. By 1983, full CMOS 64K SRAMs were available at prices under $20.00, offering full read-write capability faster than most EEPROMs can read only. While the price recessions of the early 1980s pushed EPROM and SRAM prices down the learning curve,

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EEPROMs, still establishing the basic circuits and manufacturing techniques during those years, generated inadequate volumes to drive the process technology that would allow prices to drop faster than they actually did. Because there was very little if any standardization in EEPROM devices, each vendor was very much like a sole source to its customers. As a result, device prices were not as tightly coupled to one another for EEPROMs as prices were in the commodity-type products. In 1983, prices for 16K EEPROMs ranged from $10.00 to nearly $30.00 (depending on vendor and device type).

Product Standards and Second Sources

During the EEPROM formative years, the lack of product standardization and viable second sources was probably the greatest inhibitor to market growth. Foremost among the "feature-related" issues as to what constituted the ideal EEPROM were:

- Complete 5-volt operation, including erase/write cycles
- On-board clocks
- Latched data and addresses

By the end of 1983, a consensus was ultimately reached on these three issues, with Xicor's X2816A part type emerging as the de facto standard in the EEPROM market. At the end of 1984, Exel, Seeq, Tristar, and Xicor were all shipping functionally compatible 16K products.

With the emergence of second-sourcing and device standards in 1984, the 1985 market saw more participation from larger, more established producers such as AMD and Hitachi. Production volumes of 64K densities became available from Hitachi, Seeq, and Xicor, with 256K sampling becoming available at the end of 1985. This gave the EEPROM market some added credibility and improved price/performance.

MOS EEPROM TOTAL WORLDWIDE FORECAST

Dataquest's MOS EEPROM forecast consists of revenue, unit shipments, and prices for MOS EEPROM product lines. The tables in this section combine NVRAMs and EEPROMs. NVRAMs are discussed separately in the text, but are combined with EEPROMs in the tables. Products include only monolithic EEPROMs and NVRAMs, and they are not assemblages made up of traditional CMOS Static RAMs with battery backup in the same package.

We have included products that are fabricated using both the nitrox technology (MNOS or SNOS) and the floating-gate technology. These products are sold under a variety of generic product names: EAROM, EEPROM, or EEROM. The sole requirements for inclusion are nonvolatility, electrical programmability, and erase.

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MOS EEPROM--Forecast

The purpose of this forecast is to indicate trends, approximate market needs, and key sensitivities to products that can benefit both manufacturers and users. The overall average selling price (ASP) is an industry average over a mix of speeds and package styles. ASPs may vary significantly from company to company and by application. Tables contained in this forecast are as follows:

- Table 1—Worldwide MOS EEPROM Forecast
- Table 2—Worldwide NMOS EEPROM Forecast
- Table 3—Worldwide CMOS EEPROM Forecast

Table 1

Worldwide MOS EEPROM Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 43	$ 29	$ 33	$ 34	$ 35	$ 36	$ 36	$ 38
1K	20	17	58	63	66	67	68	70
2K	2	2	8	4	3	3	3	3
4K	8	2	10	4	4	3	4	4
8K	1	1	1	0	0	0	0	0
16K	26	25	29	40	35	29	23	19
32K	2	0	0	0	0	0	0	0
64K	19	27	38	86	111	85	61	43
128K	0	0	0	0	0	0	0	0
256K	0	9	26	78	125	150	256	300
512K	0	0	0	0	9	28	47	104
1Mb	0	0	0	2	48	73	106	125
Total	$121	$112	$203	$312	$436	$474	$605	$707
Percent Change from Previous Year	(22%)	(8%)	82%	54%	40%	9%	28%	17%

(Continued)

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MOS EEPROM--Forecast

Table 1 (Continued)

Worldwide MOS EEPROM Forecast

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	27.0	23.0	29.1	30.1	32.1	33.4	34.2	36.5
1K	7.8	6.7	24.2	26.4	27.3	27.9	28.2	29.0
2K	0.6	0.5	2.3	1.1	1.0	0.8	1.0	1.0
4K	1.8	0.5	2.2	1.0	1.0	0.9	1.0	1.0
8K	0.1	0.1	0.1	0	0	0	0	0
16K	3.4	4.5	5.6	7.9	7.3	6.2	5.2	4.2
32K	0.1	0	0	0	0	0.1	0.1	0.1
64K	0.8	2.1	2.9	7.2	12.8	13.1	12.2	10.6
128K	0	0	0	0	0	0	0	0
256K	0	0	0.1	0.8	2.5	5.5	16.0	33.0
512K	0	0	0	0	0.5	2.4	6.0	18.2
1Mb	0	0	0	0	0.5	1.5	3.6	6.6
Total	41.7	37.4	66.6	74.6	85.0	91.7	107.4	140.1

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 1.60	$ 1.26	$ 1.15	$ 1.12	$ 1.10	$ 1.08	$ 1.06	$ 1.04
1K	$ 2.57	$ 2.50	$ 2.40	$ 2.40	$ 2.40	$ 2.40	$ 2.40	$ 2.40
2K	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50
4K	$ 4.71	$ 4.67	$ 4.40	$ 4.20	$ 4.00	$ 3.80	$ 4.00	$ 4.15
8K	$ 5.60	$ 5.00	$ 5.00	$ 5.00	0	0	0	0
16K	$ 7.50	$ 5.71	$ 5.20	$ 5.02	$ 4.75	$ 4.65	$ 4.50	$ 4.20
32K	$13.00	$ 6.44	$ 16.00	$ 16.00	$11.20	$ 8.10	$ 5.98	$ 4.75
64K	$22.50	$ 13.00	$ 13.00	$ 11.94	$ 8.70	$ 6.50	$ 4.97	$ 4.10
128K	0	0	0	0	0	0	0	0
256K	0	$400.00	$184.00	$ 98.00	$50.00	$27.30	$16.00	$ 9.09
512K	0	0	0	33.00	17.80	11.60	7.85	5.70
1Mb	0	0	0	$200.00	$95.00	$48.80	$29.50	$19.00
Overall ASP	$ 2.91	$ 2.98	$ 3.04	$ 4.18	$ 5.14	$ 5.17	$ 5.64	$ 5.04

*Columns may not add to totals shown because of rounding.

Source: Dataquest
June 1988

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MOS EEPROM--Forecast

Table 2

Worldwide NMOS EEPROM Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 42	$ 27	$ 27	$ 23	$ 22	$ 23	$ 23	$ 24
1K	20	17	32	36	36	36	34	33
2K	2	2	8	4	3	2	3	3
4K	8	2	8	4	4	3	4	4
8K	0	0	0	0	0	0	0	0
16K	26	25	27	32	24	16	11	5
32K	2	0	0	0	0	0	0	0
64K	19	25	30	66	65	34	27	20
128K	0	0	0	0	0	0	0	0
256K	0	6	12	32	53	61	104	127
512K	0	0	0	0	0	0	0	0
1Mb	0	0	0	2	24	36	50	59
Total	$119	$103	$144	$198	$230	$211	$257	$276
Percent Change from Previous Year	(18%)	(13%)	39%	37%	16%	(8%)	22%	7%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	26.0	21.2	24.1	20.1	20.3	21.4	22.0	23.5
1K	7.8	6.6	14.0	15.3	14.9	14.9	14.2	13.8
2K	0.6	0.5	2.3	1.0	0.9	0.7	0.9	0.9
4K	1.8	0.5	1.8	0.9	0.9	0.8	0.9	0.9
8K	0	0	0	0	0	0	0	0
16K	3.4	4.4	5.5	6.8	5.3	3.7	2.6	1.2
32K	0.1	0	0	0	0	0	0	0
64K	0.8	2.0	2.6	6.1	8.8	6.6	6.1	5.0
128K	N/A	0	0	0	0	0	0	0
256K	N/A	0	0.1	0.4	1.3	2.8	8.0	16.0
512K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1Mb	N/A	0	0	0	0.3	0.8	1.8	3.3
Total	40.6	35.4	50.3	50.7	52.6	51.6	56.5	64.6

(Continued)

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Table 2 (Continued)

Worldwide NMOS EEPROM Forecast

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 1.60	$ 1.26	$ 1.14	$ 1.12	$ 1.10	$ 1.08	$ 1.06	$ 1.04
1K	$ 2.54	$ 2.50	$ 2.30	$ 2.32	$ 2.40	$ 2.40	$ 2.40	$ 2.40
2K	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50
4K	$ 4.71	$ 4.67	$ 4.40	$ 4.20	$ 4.00	$ 3.80	$ 4.00	$ 4.15
8K	0	0	0	0	0	0	0	0
16K	$ 7.60	$ 5.70	$ 4.98	$ 4.75	$ 4.50	$ 4.40	$ 4.30	$ 4.20
32K	$14.91	$ 6.44	0	0	0	0	0	0
64K	$23.00	$ 12.40	$ 11.40	$ 10.80	$ 7.40	$ 5.20	$ 4.40	$ 4.00
128K	N/A	0	0	0	0	0	0	0
256K	N/A	$370.00	$164.00	$ 80.00	$42.00	$22.00	$13.00	$ 7.94
512K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1Mb	N/A	0	0	$200.00	$94.00	$47.68	$28.00	$17.88
Overall ASP	$ 2.93	$ 2.93	$ 2.87	$ 3.89	$ 4.37	$ 4.09	$ 4.54	$ 4.27

*Columns may not add to totals shown because of rounding.
N/A = Not Available

Source: Dataquest
June 1988

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MOS EEPROM--Forecast

Table 3

Worldwide CMOS EEPROM Forecast

	Value (Millions of Dollars)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$2	$2	$ 6	$ 12	$ 13	$ 13	$ 13	$ 14
1K	0	0	26	28	30	31	34	36
2K	0	0	0	0	0	0	0	0
4K	0	0	2	0	0	0	0	0
8K	1	1	1	0	0	0	0	0
16K	0	0	2	7	11	13	12	14
32K	0	0	0	0	0	0	0	0
64K	0	2	8	20	46	51	34	23
128K	0	0	0	0	0	0	0	0
256K	0	3	14	46	73	89	152	173
512K	0	0	0	0	9	28	47	104
1Mb	0	0	0	0	25	37	56	66
Total	$2	$8	$58	$114	$207	$263	$349	$431
Percent Change from Previous Year	(76%)	249%	623%	96%	81%	27%	32%	24%

	Units (Millions)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	1.0	1.8	5.0	10.0	11.8	12.0	12.2	13.0
1K	0	0.1	10.2	11.1	12.4	13.0	14.0	15.2
2K	N/A	N/A	0.1	0.1	0.1	0.1	0.1	0.1
4K	0	0	0.4	0.1	0.1	0.1	0.1	0.1
8K	0.1	0.1	0.1	0	0	0	0	0
16K	0	0	0.1	1.1	2.0	2.5	2.6	3.0
32K	0	0	0	0	0	0.1	0.1	0.1
64K	0	0.1	0.3	1.1	4.0	6.6	6.1	5.6
128K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
256K	0	0	0.1	0.4	1.3	2.8	8.0	17.0
512K	N/A	N/A	N/A	0	0.5	2.4	6.0	18.2
1Mb	N/A	N/A	N/A	0	0.3	0.8	1.8	3.3
Total	1.1	2.0	16.3	23.9	32.4	40.2	50.9	75.5

(Continued)

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Table 3 (Continued)

Worldwide CMOS EEPROM Forecast

	Average Selling Price (Dollars/Unit)							
	1985	1986	1987	1988	1989	1990	1991	1992
Less than 1K	$ 1.60	$ 1.34	$ 1.20	$ 1.16	$ 1.10	$ 1.10	$ 1.08	$ 1.06
1K	$ 2.57	$ 2.70	$ 2.50	$ 2.50	$ 2.40	$ 2.40	$ 2.40	$ 2.40
2K	N/A	N/A	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50
4K	0	0	$ 4.50	$ 4.20	$ 4.10	$ 3.90	$ 4.10	$ 4.20
8K	$12.00	$ 10.00	$ 5.00	0	0	0	0	0
16K	$ 7.60	$ 6.00	$ 13.17	$ 6.60	$ 5.60	$ 5.20	$ 4.70	$ 4.50
32K	N/A	0	$ 16.00	$ 16.00	$11.20	$ 8.10	$ 5.98	$ 4.75
64K	N/A	$ 25.00	$ 28.00	$ 18.50	$11.50	$ 7.80	$ 5.55	$ 4.10
128K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
256K	N/A	$400.00	$205.00	$114.00	$58.00	$32.50	$19.00	$10.20
512K	N/A	N/A	N/A	$ 33.00	$17.80	$11.60	$ 7.85	$ 5.70
1Mb	N/A	N/A	N/A	0	$98.00	$49.00	$31.00	$20.15
Overall ASP	$ 2.12	$ 3.94	$ 3.59	$ 4.78	$ 6.38	$ 6.56	$ 6.85	$ 5.71

*Columns may not add to totals shown because of rounding.
N/A = Not Available

Source: Dataquest
June 1988

Comparison with Earlier Forecasts

Several changes have been incorporated in this forecast since the last publication in April 1987. Notable changes in the MOS EEPROM market in 1987 and projected market occurrences are as follows:

- EEPROM product revenue grew 82 percent in 1987, after an 8 percent decline in 1986 and a 22 percent decline in 1985. The percent of revenue and unit growth for EEPROMs outstripped that of both EPROMs and ROMs from 1986 to 1987.

- Overall ASPs declined to $3.04, from our previous estimate of $4.17. Overall ASPs have been lowered through 1992. The lower-priced, low-density EEPROM and NVRAM products will continue to garner the lion's share of the EEPROM market, keeping the industry average price at a more manageable level. Prices of the high-speed and high-density devices are not expected to drop as rapidly as those of other commodity memory products.

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- CMOS shipments grew to 16.3 million units, representing a 24 percent share of EEPROM technology in 1987. Although NMOS is expected to remain the dominant technology through 1989, CMOS share will shift to 47 percent of units by 1991. As more CMOS suppliers enter the market and demand for CMOS increases from the consumer, automotive, and industrial sectors, CMOS could command 54 percent of the technology share by 1992.

MARKET OUTLOOK

We anticipate that the strong revenue and unit growth in MOS EEPROM experienced in 1987 will continue, but at a more moderate pace, through 1988 and 1989. Some of the key assumptions that we used in our new forecast are as follows:

- EEPROM units are expected to grow 12 percent, 14 percent, and 8 percent in 1988, 1989, and 1990, respectively, from a base of 78 percent in 1987. We expect the EEPROM market to flatten slightly in the latter part of 1989, with a further slowdown continuing through 1990.

- Low-density EEPROM and NVRAM devices will capture 79 percent of EEPROM unit shipments in 1988. High-density 16K and above devices are expected to represent an increasing portion of EEPROM shipments, growing to 52 percent of unit share by 1992.

- Shipments of the full-featured 16K, 64K, and 256K densities grew 24 percent, 38 percent, and 517 percent, respectively, from 1986 to 1987. This shift in growth to the higher densities is a result of new EEPROM emphasis from the computer, consumer, and industrial sectors. Although military applications continue to be the driving force for 16K and above densities, a moderate shift to high-speed, higher-density EEPROM devices in other applications is occurring.

- The market for advanced 256K and 1-Mbit densities is expected to grow at moderate rates, reaching approximately 4 percent of total units shipped in 1989. NEC, Sharp, and Toshiba are among the new entrants that will be positioning themselves in this high-density market in 1988.

- New high-speed 16K and 64K full-featured EEPROM and Flash EEPROM products will contribute to the long-term growth of the EEPROM market from 1990 through 1992.

Short-Term Forecast

Seeq and Xicor, major suppliers in high-density EEPROMs, and Mitsubishi and National, major suppliers in low-density EEPROMs, stand to be the prime beneficiaries of the trends noted. They will face increased competition from Hitachi, NEC, and Sharp in high-density EEPROMs, and from Catalyst, Microchip, and SGS-Thomson in

low-density EEPROMs. This competition will erode their market share and quite possibly their profit margins. Beyond 1989, we believe that Seeq and Xicor will continue to hold the major portion of the high-density 256K and above products.

The market for the older 16K EEPROMs is expected to grow through 1988 and decline slightly in 1989, followed by a normal life-cycle decline. The 64K EEPROM will grow at a moderate rate, reaching its peak of more than 3 million units by 1990. There are certain critical variables in our forecast for these two devices that could skew our forecast in either direction. Several high-speed 16K and 64K devices, along with a new 32K bipolar PROM replacement EEPROM, were introduced and shipped in 1987. User emphasis on high speed could boost shipments of these new products beyond our conservative forecast. The strength of new EEPROM applications in IC cards and automotive engine controllers could go far in determining the growth of these products.

We have factored growth of Flash memory products into the the 256K and above densities. Flash EEPROMs were first introduced to the market by Toshiba in 1985. The Flash memory is an emerging technology now being supported by Intel, National, Seeq, and Toshiba. AMD, Hitachi, Microchip Technologies, and Texas Instruments are all potential entries in this area.

Improvements in performance parameters will continue to open up new markets. For the 1988 period, we expect the principal market driving forces to be the attractiveness of the basic EEPROM capability—electrically programmable memory—and the continued establishment of a sound supply of base standards and mastery of manufacturing.

Long-Term Forecast

Dataquest has continued its bullish forecast on EEPROMs. Although the supplier base and products offered in the high-performance CMOS area have been marginal, the market potential remains impressive and the application boundaries are limitless. As expected, the Japanese did jump into the EEPROM market on a larger scale in 1987. Their efforts are being concentrated not only in the low-density and commodity 16K and 64K areas, but they are now venturing into the 256K and above densities.

Hitachi introduced its new 8Kx8 64K CMOS EEPROM. The new product combines both CMOS and MNOS cell process technologies with 200ns access speeds available. Toshiba started sampling of its 32Kx8 NMOS 256K EEPROM with access speeds of 200 and 300ns.

We anticipate more technology and manufacturing agreements in EEPROM in 1988 and 1989. Licensing and technology exchanges, similar to that between National and Seeq in Flash memory, reflect a growing awareness that companies of all sizes and revenue structure can no longer afford the high cost of new product development. Leverage—pooling corporate resources in design, manufacturing, sales, and distribution through partnership—will be essential for corporate survival during the next round of economic recession and industry shakeouts.

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U.S. EEPROM manufacturers have the expertise but cannot continue developing next-generation devices on their own capital. The larger firms—whether from Europe, Japan, or the United States—offer many advantages to the smaller firms, including broad product capabilities. As the field of competition opens, both Seeq and Xicor cannot possibly sell into and/or control the full-featured 5-volt EEPROM market enough to recoup their R&D investments.

We continue to believe that the European and Japanese markets and applications for EEPROMs, especially at the 16K and 64K densities, will provide the impetus to drive the EEPROM market forward. In Japan, for example, the Arimura Giken Company has introduced IC cards for less than $14. The card uses a 16K EEPROM from Hitachi and a 4K EEPROM device from a U.S. manufacturer. The market in Japan for IC card readers and related equipment, in 1995 is projected by the EIAJ to reach ¥3.5 trillion. The IC card market in Japan had reached ¥1.4 billion in 1985. It was expected to reach ¥127 billion by 1990, and ¥277 billion by 1995. Of that 277 billion yen, 56 percent would be memory cards and 44 percent would be cards incorporating CPUs.

Mitsubishi introduced reprogrammable IC cards incorporating 64K or 128K (two chip type) EEPROMs on its reader-writer PC cards for desktop and laptop PCs.

The automotive sector will continue to look to and use more of the EEPROM products, both low- and high-density, full-featured, and Flash products.

European telecommunication users that have concentrated their efforts using the low 1K devices are expected to increase usage of the larger 64K densities and move into the 512K Flash area in 1989 and 1990.

We anticipate that military applications will continue to capture a 25 to 30 percent share of the 16K and above EEPROMs, with increased emphasis on CMOS technology. The military is currently the largest user of the 256K density. Commercial applications requiring the 256K capability could force our forecast unit growth and price declines beyond our expectations over the next two years, if manufacturing yields and large volume, cost-effective pricing is available.

Users, other than those in the military sector, have been reluctant to commit to volumes of high-priced and limited second-source availability in the 64K and 256K densities. Although Seeq and Xicor have captured the larger share of the high-density EEPROM market and their product quality and technology expertise are superb, their products because of their process complexity, have not been the most cost-effective nonvolatile solutions available to the user. During the past few years, the manufacturers that have offered nonvolatile products at reasonable prices (2 to 3 millicents per bit) have been able to drive their products and the market direction. If the EEPROM market is to develop to the extent that it is forecast to grow, its growth will have to come from the 256K and above densities. Although the interest is keen for the 256K device, its market continues to be predominantly military. Therefore, we believe that if our forecast is to have any credibility and if any viable commercial market is to develop, the 256K ASP will have to fall below the $40 to $50 range in late 1988 and/or early 1989. EEPROM user potential is tremendous, but the commercial customers will continue to opt for the lower-priced EPROM or battery-backed SRAM, preferring to take a "hit" on reliability in exchange for price.

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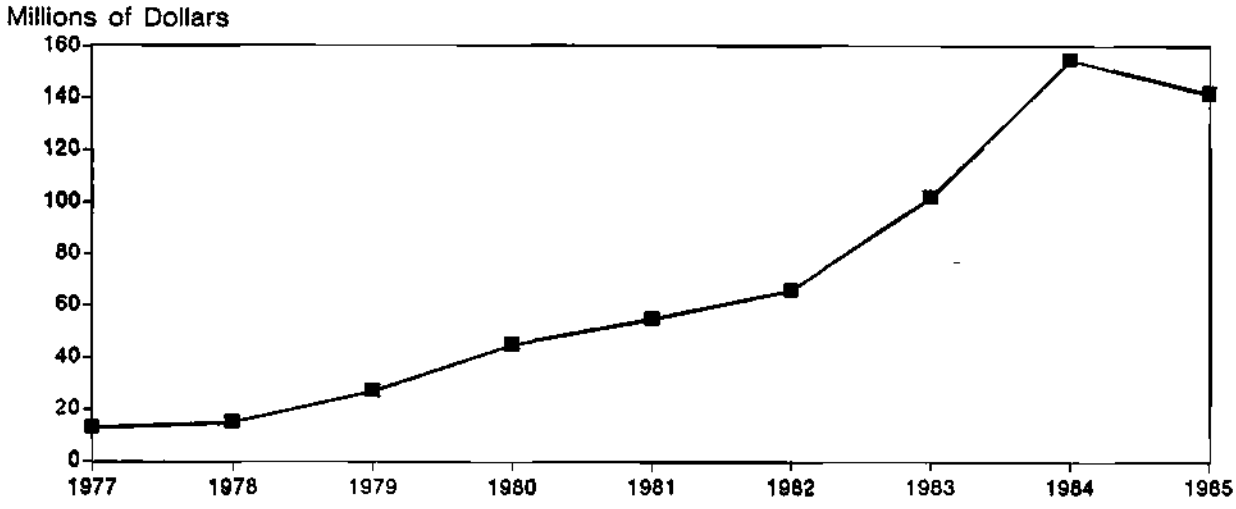
OVERVIEW OF THE MOS EEPROM MARKET

The market for MOS EEPROMs has been developing since 1972, when NCR first patented and developed the nonvolatile memory cell. The MOS EEPROM market reached $13 million in revenue by 1977; by 1984, it had achieved $155 million in revenue. (The year-to-year growth rate is shown in Figure 1.) Worldwide MOS EEPROM revenue grew at a compound annual growth rate (CAGR) of 64.2 percent from 1977 through 1984 and a 61.3 percent CAGR from 1977 through 1985. Although the EEPROM market has gone through a variety of phases, suppliers, densities, and process technologies, it is still considered to be in an immature product stage, its growth hindered by a number of key technical, conceptual, institutional, and manufacturing issues.

The 1970 to 1980 time frame can best be described as the MOS EEPROM niche-market period--marked by few market participants and limited applications. The market had reached only $45 million in revenue in 1980, and the highest-density device available was 8 Kbits. As shown in Figure 2, the early EEPROM segment averaged a marginal share of the total memory market.

Figure 1

ESTIMATED WORLDWIDE MOS EEPROM REVENUE
1977-1985



Source: Dataquest
April 1987

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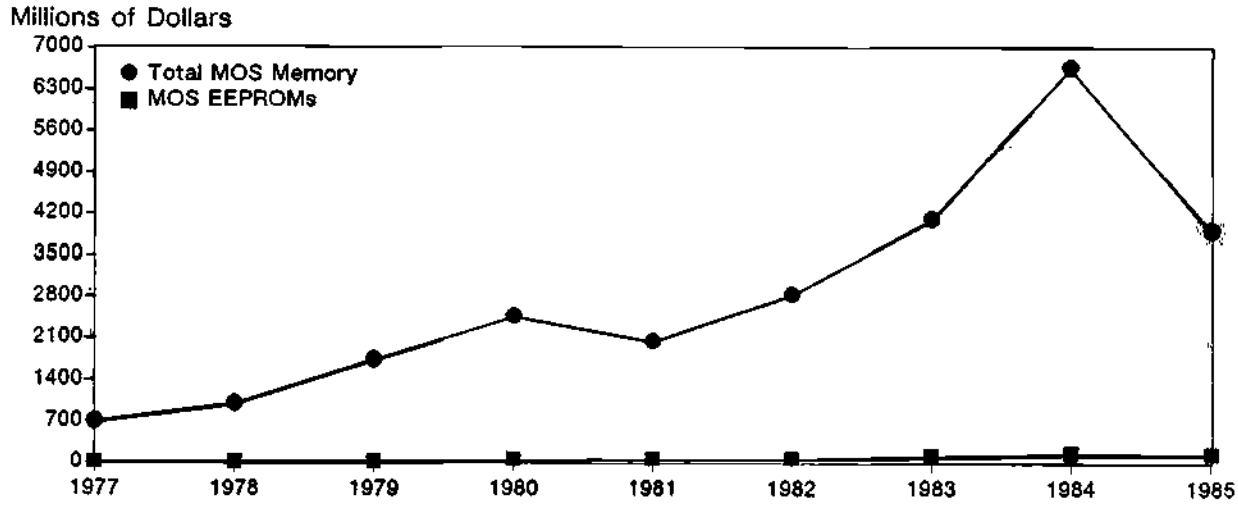
MOS EEPROM---Forecast

Figure 2

ESTIMATED EEPROM SHARE OF MOS MEMORY REVENUE
1977-1985



Source: Dataquest
April 1987

From 1973 through 1980, the first EEPROM devices, pioneered by NCR and known as EAROMs (electrically alterable ROMs), were built exclusively around a P-channel MNOS (metal-nitride oxide silicon) process, which used trapped charges at the nitride interface for bit storage. This process was limited by low speed (1,000 nanoseconds) and low density. Between 1972 and 1977, much of the market was captive and controlled by NCR. NCR licensed its technology to General Instrument Corporation in 1977 and to Nitron in 1979. By 1980, most of the U.S. merchant market was controlled by General Instrument and Nitron, with 75 percent of NCR's output used for internal consumption. The only other major competition was coming from Mitsubishi, Toshiba, and NEC. While Mitsubishi purchased the technology rights from NCR, Toshiba and NEC used a floating-gate process. The tunneling processes found in most floating-gate EEPROM devices are controlled by the Fowler-Nordheim theory introduced in the 1920s.

The major areas of application at this time were tuners in consumer electronics (TV and radio), in point-of-sale (POS) equipment to store prices or tax tables, in postage meters to store postal rates, or in other lookup tables.

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The 1980 and 1981 time frame marks the beginning of the EEPROM transitional period. The EEPROM market experienced a shift to new technologies, new areas of application, and new participants. General Instrument began to phase out its P-channel MNOS devices and switched to N-channel MNOS technology. The N-channel technology provided increased speed and better transistor gains for improving packaging densities, thereby reducing system cost and insuring the ability to achieve a +5 voltage operation. This technology was later followed by N-channel silicon nitrox (SNOS).

In 1980, Intel introduced its 2816 device, the first EEPROM using floating-gate tunnel oxide (FLOTOX, an Intel trademark). FLOTOX is an extension of Intel's EPROM technology. Xicor, founded in 1978, introduced the first nonvolatile shadow RAM (NOVRAM) in 1980, followed closely by its 16K EEPROM. Xicor also introduced the first full-featured 16K EEPROM that had 5-volt programming as well as the on-chip functions required for in-system programming. Other entrants at this time included AMD, Hughes, Motorola, National, Seeq, and Siemens. While the number of suppliers had more than doubled by 1983, much of the major technological innovation came from only three companies--Intel, Seeq, and Xicor. During this period of development, average EEPROM speeds plummeted. From the early product speeds of 1,000 nanoseconds (ns), access times dropped to 450ns by 1980, down to 300ns by 1982, and to 200ns by 1984. The influx of new market participants and more products drove EEPROM revenue to $103 million by 1983. Although floating-gate device consumption grew, nitrox-type technologies continued to garner half of the 1983 revenue.

Product False Starts

In the product arena, many of the early devices offered did not embody technology that adequately reflected the market needs. In other cases, some of the devices offered were too difficult for the manufacturer to produce economically. General Instrument, Hitachi, Hughes, Intel, Motorola, NCR, and Seeq have all, at one time or another, made tentative entries at the 16K level that were later downplayed or withdrawn.

As the market developed, more functions were required of devices, forcing manufacturers to backtrack and to incorporate these functions in their devices. This trend resulted from features that:

- Were attractive to users
- Were feasible from a manufacturer's viewpoint
- Were demanded by the basic product functioning to avoid unacceptable error conditions and ensure predictable product operation

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Competing Markets

Although both the NVRAM and EEPROM markets experienced strong growth in the 1983 and 1984 time frame, the recessionary markets of 1985 and 1986, along with the emergence of the more competitive EPROM and CMOS SRAMs, hindered EEPROM penetration into more established semiconductor markets. Led by Intel, manufacturers made immense improvements in EPROM price/performance. Average prices per bit dropped 80 percent from 1980 to 1983. End users with system applications that required read times commensurate with MPU speeds often opted for CMOS SRAMs with battery backup. By 1983, full CMOS 64K SRAMs were available at prices under $20.00, offering full read-write capability faster than most EEPROMs can read only. While the price recessions of the early 1980s pushed EPROM and SRAM prices down the learning curve, EEPROMs, still establishing the basic circuits and manufacturing techniques during those years, generated inadequate volumes to drive the process technology that would allow prices to drop faster than they actually did. Because there was very little if any standardization in EEPROM devices, each vendor was very much like a sole source to its customers. As a result, device prices were not as tightly coupled to one another for EEPROMs as prices were in the commodity-type products. In 1983, prices for 16K EEPROMs ranged from $10.00 to nearly $30.00 (depending on vendor and device type).

Product Standards and Second Sources

During the EEPROM formative years, the lack of product standardization and viable second sources was probably the greatest inhibitor to market growth. Foremost among the "feature-related" issues as to what constituted the ideal EEPROM were:

- Complete 5-volt operation, including erase/write cycles
- On-board clocks
- Latched data and addresses

By the end of 1983, a consensus was ultimately reached on these three issues, with Xicor's X2816A part type emerging as the de facto standard in the EEPROM market. At the end of 1984, Exel, Seeq, Tristar, and Xicor were all shipping functionally compatible 16K products.

With the emergence of second-sourcing and device standards in 1984, the 1985 market saw more participation from larger, more established producers such as AMD and Hitachi. Production volumes of 64K densities became available from Hitachi, Seeq, and Xicor, with 256K sampling becoming available at the end of 1985. This gave the EEPROM market some added credibility and improved price/performance.

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MOS EEPROM TOTAL WORLDWIDE FORECAST

Dataquest's MOS EEPROM forecast consists of revenue, unit shipments, and prices for MOS EEPROM product lines. The tables in this section combine NVRAMs and EEPROMs. NVRAMs are discussed separately in the text but are combined with EEPROMs in the tables. Products include only monolithic EEPROMs and NVRAMs, and they are not assemblages made up of traditional CMOS Static RAMs with battery backup in the same package.

We have included products that are fabricated using both the nitrox technology (MNOS or SNOS) and the floating-gate technology. These products are sold under a variety of generic product names: EAROM, EEPROM, or EEROM. The sole requirements for inclusion are nonvolatility, electrical programmability, and erasability. Tables contained in this forecast are as follows:

- Table 1--Worldwide Total MOS EEPROM Market
- Table 2--Worldwide NMOS EEPROM Market
- Table 3--Worldwide CMOS EEPROM Market

Table 1

TOTAL MOS EEPROM FORECAST

	Value (Millions of Dollars)							
	1984	1985	1986	1987	1988	1989	1990	1991
Less than 1K	$ 56	$ 43	$ 36	$ 37	$ 35	$ 37	$ 40	$ 42
1K	16	22	25	26	28	29	30	30
2K	3	2	2	2	2	2	0	0
4K	11	8	4	3	2	2	1	1
8K	9	6	3	1	1	1	0	1
16K	51	38	40	45	50	41	36	32
32K	2	3	7	7	5	4	3	2
64K	7	20	20	33	82	66	55	46
128K	0	0	0	0	0	0	0	0
256K	0	0	4	77	139	165	292	278
1Mb	0	0	0	0	2	82	148	207
Total	$155	$142	$139	$231	$345	$429	$606	$639
Percent Change from Previous Year	51%	(8%)	(2%)	65%	50%	24%	41%	5%

(Continued)

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MOS EEPROM--Forecast

Table 1 (Continued)

TOTAL MOS EEPROM FORECAST

	Units (Millions)							
	1984	1985	1986	1987	1988	1989	1990	1991
Less than 1K	28.0	27.0	28.3	30.5	29.5	32.1	34.2	35.5
1K	6.3	8.5	8.9	9.5	10.0	10.6	10.9	11.0
2K	0.7	0.6	0.5	0.5	0.5	0.5	0	0
4K	2.3	1.8	0.8	0.7	0.6	0.6	0.1	0.1
8K	1.2	1.0	0.7	0.1	0.1	0.1	0.1	0.1
16K	4.4	5.1	7.0	8.5	10.0	9.0	8.0	7.0
32K	0.1	0.2	1.1	1.1	1.0	1.0	1.0	0.8
64K	0.1	0.9	1.6	4.0	13.5	13.7	12.1	10.5
128K	0	0	0	0	0	0	0	0
256K	0	0	0	0.5	2.1	4.7	16.5	33.9
1Mb	0	0	0	0	0	1.0	3.1	6.1
Total	43.1	45.1	48.8	55.3	67.3	73.3	85.9	104.9

	Average Selling Price (Dollars/Unit)							
	1984	1985	1986	1987	1988	1989	1990	1991
Less than 1K	$ 2.00	$ 1.60	$ 1.26	$ 1.22	$ 1.19	$ 1.16	$ 1.18	$ 1.17
1K	$ 2.56	$ 2.57	$ 2.75	$ 2.75	$ 2.75	$ 2.75	$ 2.75	2.75
2K	$ 3.75	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	0	0
4K	$ 4.78	$ 4.71	$ 4.67	$ 4.02	$ 3.75	$ 3.75	$ 5.00	5.00
8K	$ 7.50	$ 5.60	$ 5.00	$ 8.00	$ 8.00	$ 8.00	$ 8.00	8.00
16K	$11.50	$ 7.50	$ 5.71	$ 5.35	$ 5.00	$ 4.50	$ 4.50	4.50
32K	$21.82	$13.00	$ 6.44	$ 6.08	$ 5.00	$ 4.00	$ 3.35	3.10
64K	$50.00	$22.50	$ 12.65	$ 8.36	$ 6.04	$ 4.83	$ 4.58	4.42
128K	0	0	0	0	0	0	0	0
256K	0	0	$400.00	$153.45	$ 66.99	$35.23	$17.71	$ 8.21
1Mb	0	0	0	0	$200.00	$82.00	$48.52	$34.25
Overall ASP	$ 3.58	$ 3.15	$ 2.86	$ 4.17	$ 5.13	$ 5.85	$ 7.05	$ 6.09

Source: Dataquest
April 1987

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MOS EEPROM--Forecast

Table 2

NMOS EEPROM FORECAST

	Value (Millions of Dollars)							
	1984	1985	1986	1987	1988	1989	1990	1991
Less than 1K	$ 56	$ 42	$ 31	$ 28	$ 21	$ 16	$ 9	$ 7
1K	14	18	17	21	13	12	8	7
2K	3	2	2	2	2	2	0	0
4K	8	6	2	2	2	2	0	0
8K	5	3	2	0	0	0	0	0
16K	51	38	40	45	50	41	36	32
32K	2	1	0	0	0	0	0	0
64K	7	20	19	15	36	30	23	18
128K	0	0	0	0	0	0	0	0
256K	0	0	4	44	83	54	127	147
1Mb	0	0	0	0	2	30	64	72
Total	$145	$130	$117	$158	$208	$185	$268	$282
Percent Change from Previous Year	46%	(10%)	(10%)	35%	32%	(11%)	45%	5%

	Units (Millions)							
	1984	1985	1986	1987	1988	1989	1990	1991
Less than 1K	28.0	26.0	24.9	23.5	18.5	14.1	8.6	6.8
1K	5.5	6.5	6.3	7.8	4.9	4.2	3.1	2.5
2K	0.7	0.6	0.5	0.5	0.5	0.5	0	0
4K	2.0	1.5	0.5	0.5	0.5	0.5	0	0
8K	1.0	0.8	0.5	0	0	0	0	0
16K	4.4	5.1	7.0	8.5	10.0	9.0	8.0	7.0
32K	0.1	0.1	0.1	0.1	0	0	0	0
64K	0.1	0.9	1.5	2.3	7.9	7.1	5.7	4.5
128K	N/A	N/A	0	0	0	0	0	0
256K	N/A	N/A	0	0.4	1.5	2.7	10.6	24.5
1Mb	N/A	N/A	0	0	0	0.6	2.0	3.8
Total	41.8	41.5	41.4	43.5	43.8	38.8	37.9	49.1

(Continued)

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MOS EEPROM--Forecast

Table 2 (Continued)

NMOS EEPROM FORECAST

	Average Selling Price (Dollars/Unit)							
	1984	1985	1986	1987	1988	1989	1990	1991
Less than 1K	$ 2.00	$ 1.60	$ 1.25	$ 1.20	$ 1.15	$ 1.10	$ 1.10	$ 1.05
1K	$ 2.50	$ 2.75	$ 2.75	$ 2.75	$ 2.75	$ 2.75	$ 2.75	$ 2.75
2K	$ 3.75	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50	0	0
4K	$ 4.00	$ 4.25	$ 3.75	$ 3.50	$ 3.50	$ 3.50	0	0
8K	$ 5.00	$ 4.00	$ 3.50	0	0	0	0	0
16K	$11.50	$ 7.50	$ 5.71	$ 5.35	$ 5.00	$ 4.50	$ 4.50	$ 4.50
32K	$20.00	$ 8.00	$ 4.35	$ 4.35	0	$ 0.00	0	0
64K	$50.00	$22.50	$ 12.40	$ 6.60	$ 4.50	$ 4.20	$ 4.05	$ 3.90
128K	N/A	N/A	$ 0	0	0	0	0	0
256K	N/A	N/A	$400.00	$126.00	$ 55.00	$20.00	$12.00	$ 6.00
1Mb	N/A	N/A	0	0	$200.00	$50.00	$32.00	$19.00
Overall ASP	$ 3.46	$ 3.14	$ 2.84	$ 3.64	$ 4.75	$ 4.77	$ 7.07	$ 5.75

N/A = Not Available

Source: Dataquest
April 1987

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MOS EEPROM--Forecast

Table 3

CMOS EEPROM FORECAST

	Value (Millions of Dollars)							
	1984	1985	1986	1987	1988	1989	1990	1991
Less than 1K	0	$ 2	$ 4	$ 9	$ 14	$ 22	$ 31	$ 35
1K	$ 2	4	7	5	14	17	22	23
2K	0	0	0	0	0	0	0	0
4K	3	2	2	1	1	1	1	1
8K	4	2	2	1	1	1	0	1
16K	0	0	0	0	0	0	0	0
32K	0	2	7	6	5	4	3	2
64K	0	0	1	18	46	36	32	29
128K	0	0	0	0	0	0	0	0
256K	0	0	0	33	57	111	165	131
1Mb	0	0	0	0	0	52	84	135
Total	$10	$12	$22	$73	$137	$244	$337	$357
Percent Change from Previous Year	211%	18%	92%	227%	89%	78%	39%	6%

	Units (Millions)							
	1984	1985	1986	1987	1988	1989	1990	1991
Less than 1K	N/A	1.0	3.4	7.0	11.0	18.0	25.7	28.8
1K	0.8	2.0	2.6	1.7	5.1	6.4	7.9	8.5
2K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4K	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.1
8K	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
16K	N/A	0	0	0	0	0	0	0
32K	0	0.1	1.0	1.0	1.0	1.0	1.0	0.8
64K	N/A	0	0	1.7	5.6	6.6	6.4	6.0
128K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
256K	N/A	0	0	0.2	0.6	2.0	5.9	9.4
1Mb	N/A	N/A	N/A	N/A	0	0.4	1.1	2.3
Total	1.3	3.6	7.4	11.8	23.5	34.5	48.0	55.9

N/A = Not Available

(Continued)

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MOS EEPROM--Forecast

Table 3 (Continued)

CMOS EEPROM FORECAST

	Average Selling Price (Dollars/Unit)							
	1984	1985	1986	1987	1988	1989	1990	1991
Less than 1K	N/A	$ 1.50	$ 1.30	$ 1.30	$ 1.25	$ 1.20	$ 1.20	$ 1.20
1K	$ 3.00	$ 2.00	$ 2.75	$ 2.75	$ 2.75	$ 2.75	$ 2.75	$ 2.75
2K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4K	$10.00	$ 7.50	$ 6.50	$ 5.75	$ 5.00	$ 5.00	$ 5.00	$ 5.00
8K	$20.00	$12.00	$10.00	$ 8.00	$ 8.00	$ 8.00	$ 8.00	$ 8.00
16K	'A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32K	$40.00	$18.00	$ 6.65	$ 6.25	$ 5.00	$ 4.00	$ 3.35	$ 3.10
64K	N/A	N/A	$22.20	$ 10.80	$ 8.20	$ 5.50	$ 5.05	$ 4.80
128K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
256K	N/A	N/A	0	$217.50	$98.00	$ 56.00	$28.00	$14.00
1Mb	N/A	N/A	N/A	N/A	0	$130.00	$80.00	$60.00
Overall ASP	$ 7.48	$ 3.26	$ 2.99	$ 6.14	$ 5.83	$ 7.06	$ 7.04	$ 6.38

N/A = Not Available

Source: Dataquest
April 1987

The Market--1986

Dataquest estimates that worldwide EEPROM revenue totaled $142 million in 1985, declining 2 percent to $139 million in 1986. MOS EEPROM suppliers, like other MOS memory suppliers, suffered from a two-year recessionary cycle. Suppliers focused their efforts on new application survival strategies, incorporating EEPROM technology into the following products:

- High-speed CMOS EEPROMs
- Flash EEPROMs
- EE ASICs
- EE logic
- EE on MPUs or MCUs

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MOS EEPROM--Forecast

Notable changes in the MOS EEPROM market in 1986 were as follows:

- Overall average selling prices (ASPs) declined 9 percent.
- Seeq and Xicor began volume production of 256K EEPROMs.
- Activity increased in high-speed 64K CMOS EEPROMs.
- Japanese and Korean suppliers increased their presence in the commodity EEPROM market.

Comparison to Earlier Forecasts

Compared to our earlier forecasts, several changes have been incorporated into this version of the forecast. We have substantially reduced the EEPROM market size in all densities from previous forecasts. The following should be noted about this forecast:

- We have reduced the total unit shipments from 1987 through 1991.
- The overall ASP has increased as a result of newer high-priced, high-density, high-speed devices. EEPROM market products are not expected to experience the precipitous price declines normal to other commodity MOS memory products because EEPROM technology is hard to master, costly, and low yielding.
- EEPROMs will remain predominantly NMOS through 1989, losing ground to CMOS in 1990. Such a change is indicated by more CMOS suppliers entering the market and by increased demand for CMOS from military, consumer, and automotive applications.
- The military market has continued to be the strongest driving force for consumption of densities at 16K and above. Military end use commanded the largest portion of 256K EEPROM consumption, with ASPs averaging $600 at midyear 1986 and dropping below $400 by year-end 1986.
- EEPROM revenue is expected to increase dramatically in 1987 to $231 million, increasing to $639 million by 1991.
- The low-density EEPROM and NVRAM products will continue to garner the lion's share of the EEPROM market.
- More high-speed CMOS EEPROMs were introduced in the 16K and 64K densities.

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MOS EEPROM--Forecast

MARKET OUTLOOK

We expect strong year-to-year revenue growth through 1988 in the EEPROM market. Buoyed by its strong presence and success in the NVRAM market, along with its extensive technology exchange agreements and R&D arrangements with Intel, Xicor ranked as the number one EEPROM supplier in 1986. AMD, General Instrument, Intel, NCR, and Seeq are expected to grab a sizable portion of the 1987 market. A number of new entrants will also be positioning themselves in the high-density 256K market.

Products

High-Speed EEPROMs

Several established EEPROM manufacturers and start-up companies are breaking away from offering exclusively MNOS or NMOS technology. General Instrument entered the area of CMOS EEPROMs at 70ns and below, introducing a 35ns 16K device and a 70ns 256K device. Exel/Exar is currently producing its 46C16 high-speed 16K device. Other potential 1987 competitors in this area include Atmel in the 4K, 16K, and 64K areas; Hitachi in the 64K area; Intel in the 64K and 256K areas; and Lattice, with a 64K product.

NMOS/CMOS EEPROMs

As of late, most of the market growth appears to be in floating-gate and will undoubtedly continue to be in NMOS. While most manufacturers believe that CMOS is an eventuality, feature content, endurance, reliability, and read times are the more fundamental issues that need to be dealt with to ensure further market development.

While the range of CMOS suppliers and products continues to grow, we do not expect CMOS to take a significant share of EEPROM revenue from NMOS until 1989. For the long term, we expect that CMOS will become increasingly competitive with NMOS in all densities. The strength of new EEPROM application markets in IC cards and automotive engine controllers, which appear to be the two strongest forces in the market today, could go far in determining whether NMOS or CMOS is dominant at the 256K level.

Flash EEPROMs

Flash EEPROMs were first introduced to the market by Toshiba in 1985. Rather than use the conventional tunnel effect to electrically write in and erase data, flash technology employs the hot electron method to electrically write in and erase data. By using this method, the number of transistors in a memory cell is reduced from three to one, thereby reducing cell area and production costs. The flash EEPROM requires 12.5 volts to write in or erase

data, compared to the 5 volts of the full-featured EEPROM. Its ease of use, lower cost, and reduced erase time (less than 100 milliseconds) make it a viable alternative to EPROMs and ROMs.

Exel introduced its 512K flash EEPROM in 1986. Seeq entered the flash market in 1986 with a 16Kx8 device, using its standard EPROM process. Other potential flash EEPROM suppliers include Intel and Texas Instruments.

Short-Term Outlook

Intel, Seeq, and Xicor are expected to be the leading suppliers of the traditional full-featured EEPROM products in 1987. All three suppliers have both NMOS and CMOS capability and are concentrating on developing a full range of high-speed, high-density products.

Improvements in performance parameters will continue to open up new markets. For the 1987 period, however, we expect the principal market driving forces to be the attractiveness of the basic EEPROM capability--electrically programmable memory--and the continued establishment of a sound supply of base standards, second-source arrangements, mastery of manufacturing, and price.

License and exchange agreements that could promote market development include the following:

- Siemens and Dai Nippon--IC card developments
- General Instrument and Hyundai--Hyundai to produce General Instrument's products
- Oki Semiconductor and Catalyst Semiconductor--Joint development of EPROMs, EEPROMs, and ASICs using CMOS technology

We believe that the incremental market that opened up in 1986 and early 1987 by high speed, extended durability, or dramatically faster write times will play an increasingly important role in the 1988 market.

Long-Term Outlook

Although the supplier base and products offered in the high-performance CMOS area have been marginal, the market potential is impressive. The Japanese are expected to participate in the EEPROM market on a larger scale in 1987; however, their efforts are being concentrated in the commodity 16K and 64K areas. We believe that Hitachi, NEC, and Toshiba--with their considerable high-volume manufacturing expertise--will provide the impetus to drive the EEPROM market forward.

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MOS EEPROM--Forecast

Applications

Although Xicor continues to make considerable effort to serve the military segment, AMD, Intel, and Seeq are parlaying their technology to position themselves in the military arena also. We expect military applications to drive CMOS consumption of EEPROMs, especially with increased use of CMOS EEPROMs expected in the military SDI program.

Automotive applications such as fuel injection, where there is a need for recalibration and reprogrammability, are expected to boost EEPROM growth. We expect National Semiconductor and Seeq to achieve a strong presence in this market in 1987 and 1988.

Japanese suppliers are applying their skills to the consumer segment of the EEPROM market. In all probability, Japanese suppliers see the IC card as the most promising application of the future. The IC card market (CPU cards and memory cards with built-in EEPROMs) is currently in its test phase. It is expected to reach the high-volume production stage in 1990, with a projected Japanese market share of $24.7 billion by 1995. The IC cards using 16-Kbit EEPROMs are being developed by Fujitsu, Hitachi, Mitsubishi, NEC, and Oki. Banks and credit companies have already begun experimenting with IC cards, and there is also a plan for insurance card and medical record data card conversion to IC cards. The driving forces for the IC card market are its easy use and its low price.

Competition is also very strong in the memory card area. In the United States, memory cards using EEPROMs, EPROMs, and ROMs with chip-on-board (COB) packaging technology are being produced by General Instrument Microelectronics for printer-font and terminal-security applications.

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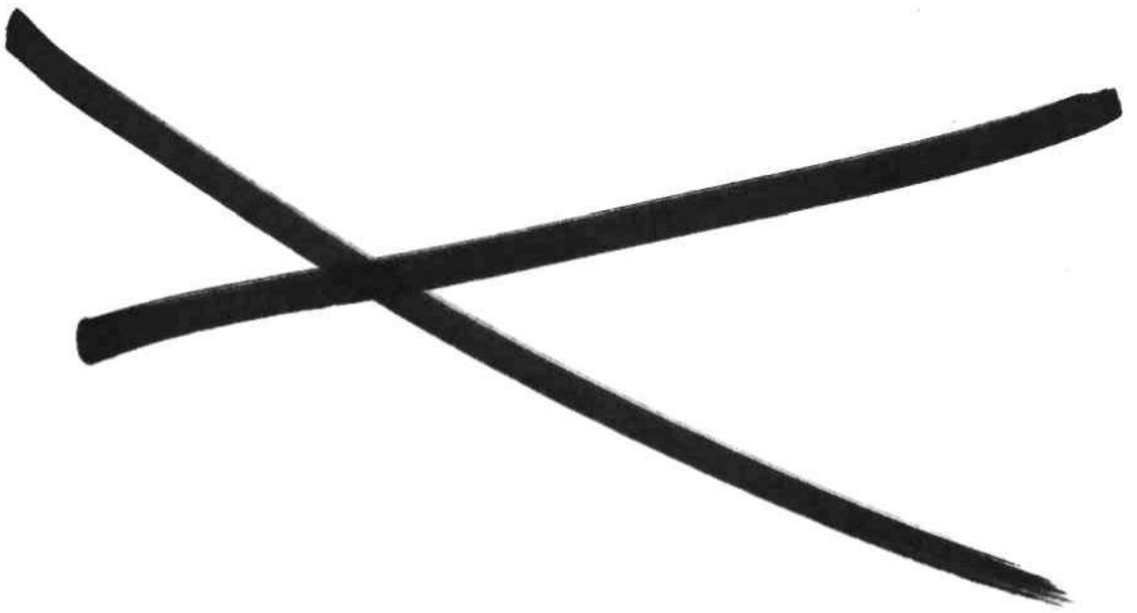

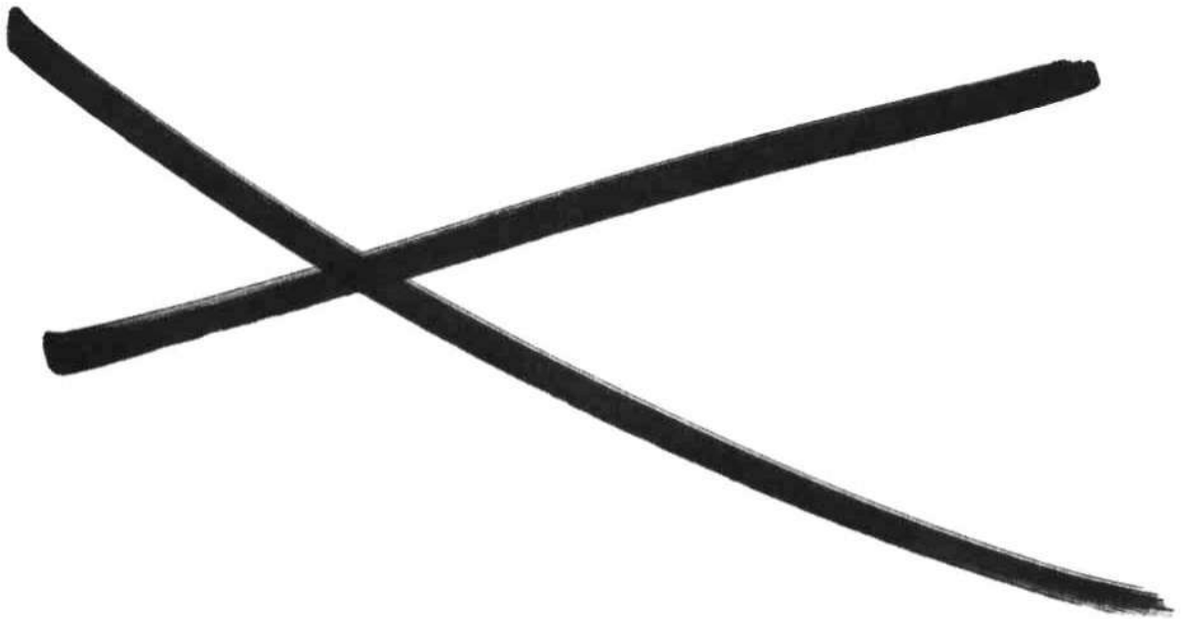

MOS EEPROM--Market Shares

MARKET SHARE DATA

An important part of Dataquest's forecast is the gathering and analysis of shipment data from each EEPROM manufacturer. The data and analysis provide insights into the EEPROM market and reinforce estimates of regional production and consumption and of company revenue. The information in this section should be interpreted as follows:

- Overall market shares are based on all "dollarized" unit shipments. Each product category, such as NVRAM and low-density EEPROMs, and each specific density's units are multiplied by an estimated average selling price (ASP) for that year. All dollar values are then added to arrive at each company's MOS EEPROM market share for the specific year.

- Products fabricated using both the nitrox technology (MNOS or SNOS), and the floating-gate technology have been included. The NVRAM and low-density categories are a composite of multiple organizations ranging from 256 bit through 8K bit. Although ASPs vary widely in these two categories, we have assigned one ASP to each category.

- The totals for all companies reflect worldwide production. Although these numbers are in dollars, they do not reflect a company's actual revenue, as ASPs can vary by region, technology, density, or package type.

We believe that the estimates presented here are the most accurate and meaningful generally available on this product area. The EEPROM data presented in the tables were derived from surveys and interviews with knowledgeable manufacturers and users.

The tables cover market data gathered since 1982. The tables cover market share in terms of dollarized units and percentages for all MOS EEPROM densities through 1987, as follows:

- Table 1--EEPROM Market Shares (Percentages)
- Table 2--EEPROM Market Shares (Dollarized Unit Shares in Thousands)
- Table 3--EEPROM Regional Market Shares (Percentages)
- Table 4--EEPROM Regional Shares(Dollarized Unit Shares in Thousands)
- Table 5--EEPROM Top 10 Shares (Percentages)
- Table 6--NVRAM Market Shares (Percentages)
- Table 7--Low-Density EEPROM Market Shares (Percentages)
- Table 8--16K EEPROM Market Shares (Percentages)
- Table 9--64K EEPROM Market Shares (Percentages)
- Table 10--256K EEPROM Market Shares (Percentages)

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MOS EEPROM--Market Shares

Table 1

EEPROM Market Shares
(Percentages)

Company	1982	1983	1984	1985	1986	1987
AMD	0	0	20%	1%	3%	4%
Atmel	0	0	0	0	0	0
Catalyst	0	0	0	0	0	0
Exel	0	0	2	2	0	0
Fujitsu	0	0	0	0	0	0
Hitachi	16%	4%	0	4	6	2
Hughes	0	0	0	1	1	0
Hyundai	0	0	0	0	0	0
ICT	0	0	0	0	0	0
Inmos	0	0	0	0	0	0
Intel	52	17	14	4	3	1
Lattice	0	0	0	0	0	0
Matsushita	0	7	4	3	1	0
Microchip	4	32	3	20	11	5
Mitsubishi	0	4	2	0	0	11
Motorola	4	1	1	1	1	1
National	0	3	8	14	11	7
NCR	5	4	6	1	2	0
NEC	0	0	0	0	0	0
Oki	0	0	0	0	0	1
Philips	0	0	0	0	0	0
Rockwell	0	0	0	0	0	0
Samsung	0	0	0	0	0	0
Seeq	3	6	12	16	19	20
SGS-Thomson	0	2	1	1	2	1
Sierra	0	0	0	0	0	0
Sony	0	0	0	0	0	0
Xicor	16	21	26	32	41	44
Total	100%	100%	100%	100%	100%	100%

Source: Dataquest
July 1988

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MOS EEPROM--Market Shares

Table 2

EEPROM Market Shares
(Dollarized Unit Shares in Thousands)

Company	1982	1983	1984	1985	1986	1987
AMD			$ 26,062	$ 1,111	$ 3,382	$ 6,478
Atmel						
Catalyst					62	298
Exel			2,404	2,166	114	140
Fujitsu				20	482	342
Hitachi	$ 2,542	$ 3,202		3,450	6,000	3,380
Hughes			93	520	1,024	553
Hyundai				6		208
ICT				17	40	375
Inmos						
Intel	8,320	13,627	18,243	4,037	2,760	1,987
Lattice					160	
Matsushita		5,960	5,120	2,775	758	
Microchip	651	26,087	3,373	19,969	11,567	7,935
Mitsubishi		2,980	2,560	333		17,250
Motorola	624	648	1,549	675	1,256	1,294
National		2,488	10,624	14,049	12,019	10,620
NCR	832	3,095	7,874	995	1,817	553
NEC			120			
Oki						884
Philips						5
Rockwell			120			
Samsung				76	63	382
Seeq	462	5,263	14,697	15,600	20,351	30,887
SGS-Thomson	35	1,480	888	982	1,916	1,443
Sierra					30	53
Sony						19
Xicor	2,539	17,496	33,619	30,772	43,882	65,585
Total	$16,005	$82,326	$127,346	$97,553	$107,683	$150,671

Source: Dataquest
July 1988

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MOS EEPROM--Market Shares

Table 3

EEPROM Regional Market Shares
(Percentages)

Regional Shares	1982	1983	1984	1985	1986	1987
United States	91.7%	79.4%	87.2%	92.3%	93.5%	61.6%
Japan	7.6	19.4	12.3	7.1	3.1	35.8
Europe	0.7	1.2	0.5	0.6	3.4	2.4
Korea	0	0	0	0	0	0.1
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
July 1988

Table 4

EEPROM Regional Shares
(Dollarized Unit Shares in Thousands)

Regional Shares	1982	1983	1984	1985	1986	1987
United States	$13,428	$68,704	$118,658	$89,911	$ 98,350	$126,618
Japan	2,542	12,142	7,800	6,578	7,354	22,015
Europe	35	1,480	888	982	1,916	1,448
Korea	0	0	0	82	63	590
Total	$16,005	$82,326	$127,346	$97,553	$107,683	$150,671

Source: Dataquest
July 1988

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MOS EEPROM--Market Shares

Table 5

EEPROM Top 10 Shares
(Percentages)

Top 5 and 10 Shares	1982	1983	1984	1985	1986	1987
Top 5	93.0%	83.1%	81.1%	86.5%	87.1%	87.8%
United States	77.1%	75.9%	81.1%	86.5%	81.6%	76.3%
Japan	15.9%	7.2%	0	0	5.6%	11.4%
Europe	0	0	0	0	0	0
Korea	0	0	0	0	0	0
Next 5	7.0%	13.1%	16.8%	10.8%	10.3%	9.7%
United States	6.8%	3.8%	10.7%	4.4%	8.6%	6.5%
Japan	0	7.5%	6.0%	6.4%	0	2.2%
Europe	0.2%	1.8%	0	0	1.8%	1.0%
Korea	0	0	0	0	0	0
Top 10	100.0%	96.2%	97.8%	97.3%	97.5%	97.5%
United States	83.9%	79.7%	91.8%	90.9%	90.1%	82.8%
Japan	15.9%	14.7%	6.0%	6.4%	5.6%	13.7%
Europe	0.2%	1.8%	0	0	1.8%	1.0%

Source: Dataquest
July 1988

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MOS EEPROM--Market Shares

Table 6

NVRAM Market Shares
(Percentages)

Company	1982	1983	1984	1985	1986	1987
AMD	0	0	0	0	0	0
Atmel	0	0	0	0	0	0
Catalyst	0	0	0	0	0	1%
Exel	0	0	0	0	0	0
Fujitsu	0	0	0	0	1%	1
Hitachi	0	0	0	0	0	0
Hughes	0	0	0	3%	6	3
Hyundai	0	0	0	0	0	0
ICT	0	0	0	0	0	0
Inmos	0	0	0	0	0	0
Intel	0	0	1%	1	0	0
Lattice	0	0	0	0	0	0
Matsushita	0	0	0	0	0	0
Microchip	21%	11%	19	10	0	0
Mitsubishi	0	0	0	0	0	0
Motorola	0	0	0	0	0	0
National	0	0	0	0	0	0
NCR	12	19	18	3	6	1
NEC	0	0	0	0	0	0
Oki	0	0	0	0	0	0
Philips	0	0	0	0	0	0
Rockwell	0	0	0	0	0	0
Samsung	0	0	0	0	0	0
Seeq	0	0	0	0	0	0
SGS-Thomson	1	10	5	7	6	2
Sierra	0	0	0	0	0	0
Sony	0	0	0	0	0	0
Xicor	66	60	57	77	81	93
Total	100%	100%	100%	100%	100%	100%

Source: Dataquest
July 1988

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MOS EEPROM--Market Shares

Table 7

Low-Density EEPROM Market Shares
(Percentages)

Company	1983	1984	1985	1986	1987
AMD	0	52%	0	0	0
Atmel	0	0	0	0	0
Catalyst	0	0	0	0	0
Exel	0	0	0	0	0
Fujitsu	0	0	0	0	0
Hitachi	0	0	0	0	0
Hughes	0	0	0	0	0
Hyundai	0	0	0	0	0
ICT	0	0	0	0	1%
Inmos	0	0	0	0	0
Intel	0	0	0	0	0
Lattice	0	0	0	0	0
Matsushita	15%	10	7%	3%	0
Microchip	62	0	49	39	14
Mitsubishi	8	5	1	0	43
Motorola	0	0	1	4	3
National	6	21	37	42	26
NCR	0	8	1	3	1
NEC	0	0	0	0	0
Oki	0	0	0	0	1
Philips	0	0	0	0	0
Rockwell	0	0	0	0	0
Samsung	0	0	0	0	0
Seeq	0	0	0	0	0
SGS-Thomson	0	0	0	4	3
Sierra	0	0	0	0	0
Sony	0	0	0	0	0
Xicor	8	4	3	4	8
Total	100%	100%	100%	100%	100%

Source: Dataquest
July 1988

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MOS EEPROM--Market Shares

Table 8

16K EEPROM Market Shares
(Percentages)

Company	1982	1983	1984	1985	1986	1987
AMD	0	0	0	0	2%	2%
Atmel	0	0	0	0	0	0
Catalyst	0	0	0	0	0	0
Exel	0	0	5%	8%	0	0
Fujitsu	0	0	0	0	0	0
Hitachi	20%	11%	0	0	0	0
Hughes	0	0	0	0	0	0
Hyundai	0	0	0	0	0	0
ICT	0	0	0	0	0	0
Inmos	0	0	0	0	0	0
Intel	65	48	36	15	9	3
Lattice	0	0	0	0	0	0
Matsushita	0	0	0	0	0	0
Microchip	0	0	0	0	0	2
Mitsubishi	0	0	0	0	0	0
Motorola	5	2	1	1	0	0
National	0	0	0	0	0	0
NCR	4	1	0	0	0	0
NEC	0	0	0	0	0	0
Oki	0	0	0	0	0	2
Philips	0	0	0	0	0	0
Rockwell	0	0	0	0	0	0
Samsung	0	0	0	0	0	0
Seeq	4	18	20	34	39	35
SGS-Thomson	0	0	0	0	0	0
Sierra	0	0	0	0	0	0
Sony	0	0	0	0	0	0
Xicor	4	20	37	40	49	56
Total	100%	100%	100%	100%	100%	100%

Source: Dataquest
July 1988

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MOS EEPROM--Market Shares

Table 9

64K EEPROM Market Shares
(Percentages)

Company	1983	1984	1985	1986	1987
AMD	0	1%	5%	9%	16%
Atmel	0	0	0	0	0
Catalyst	0	0	0	0	0
Exel	0	0	0	0	0
Fujitsu	0	0	0	1	0
Hitachi	0	0	18	18	9
Hughes	0	0	0	0	0
Hyundai	0	0	0	0	1
ICT	0	0	0	0	0
Inmos	0	0	0	0	0
Intel	0	0	0	1	3
Lattice	0	0	0	0	0
Matsushita	0	0	0	0	0
Microchip	0	0	0	1	5
Mitsubishi	0	0	0	0	0
Motorola	0	0	0	0	0
National	0	0	0	0	0
NCR	0	0	0	0	0
NEC	0	0	0	0	0
Oki	0	0	0	0	0
Philips	0	0	0	0	0
Rockwell	0	0	0	0	0
Samsung	0	0	0	0	1
Seeq	100%	60	34	24	25
SGS-Thomson	0	0	0	0	0
Sierra	0	0	0	0	0
Sony	0	0	0	0	0
Xicor	0	38	43	45	41
Total	100%	100%	100%	100%	100%

Source: Dataquest
July 1988

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MOS EEPROM--Market Shares

Table 10

256K EEPROM Market Shares
(Percentages)

Company	1986	1987
AMD	0	0
Atmel	0	0
Catalyst	0	0
Exel	0	0
Fujitsu	0	0
Hitachi	0	0
Hughes	0	0
Hyundai	0	0
ICT	0	0
Inmos	0	0
Intel	0	0
Lattice	0	0
Matsushita	0	0
Microchip	0	0
Mitsubishi	0	0
Motorola	0	0
National	0	0
NCR	0	0
NEC	0	0
Oki	0	0
Philips	0	0
Rockwell	0	0
Samsung	0	0
Seeq	44%	44%
SGS-Thomson	0	0
Sierra	0	0
Sony	0	0
Xicor	56	56
Total	100%	100%

Source: Dataquest
July 1988

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MOS EEPROM--Market Shares

MARKET SHARE OVERVIEW

Although the market for MOS EEPROMs has been developing since 1972, until that time, much of the market was captive and controlled by NCR. NCR licensed its technology to General Instrument Corporation in 1977 and to Nitron in 1979. The 1980 through 1981 timeframe marks the beginning of the EEPROM transitional period, when the market experienced a shift to new technologies and new participants. In 1980, Intel introduced its 2816 device, the first EEPROM using floating-gate tunnel oxide (FLOTOX, an Intel trademark). Xicor, founded in 1978, introduced the first nonvolatile shadow RAM (NOVRAM) in 1980, followed closely by its 16K EEPROM. By 1983, as shown on Table 5, the number of suppliers had increased to eleven and the average revenue per vendor had more than doubled from 1982. Although floating-gate device consumption has grown, nitrox-type technologies continue to garner half of all EEPROM revenue.

Highlights of the overall EEPROM market include the following:

- Regionally, U.S. suppliers consistently dominated the EEPROM market in all product categories and densities, from 1982 through 1987. Intel initially dominated the EEPROM market at the 16K level. Microchip Technology, Inc., formerly General Instrument Microelectronics, took the lead in 1983 by virtue of its strength in the low-density device area. As Xicor moved out of its start-up phase in 1980, it captured the lead in the NVRAM, 16K, and 64K product areas. Xicor has maintained the lead with 32, 41, and 44 percent of the total EEPROM market in 1985, 1986, and 1987, respectively.

- EEPROM market shares are heavily concentrated in the top five vendors. Although the number of vendors increased from 8 in 1982 to 22 by 1987, the companies at the top have maintained their dominance overall, and their shares have consistently averaged more than 80 percent of the market.

The market share tables in this section illustrate the minimal changes in the regional shares of the EEPROM market through the years, in comparison to other commodity MOS memory product areas such as DRAMs, EPROMs, and ROMs. The EEPROM participants' success from 1982 through 1986 was because revenue came at the low-density area and was primarily a consequence of their early entry into the market and their momentum in a fairly focused niche-product area.

Although U.S. suppliers have maintained a firm grasp on the NVRAM and 16K devices, regional share began shifting in the low-density and 64K product areas in 1987. While U.S. low-density unit shares were strong in 1983 and 1984, unreported factory shipments from the Japanese sector in 1985 and 1986 skewed the total available market data. While the European user base was showing strong consumption of the 1K density for telecommunication applications, the supplier base went unreported. This anomaly is illustrated in Table 7.

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MOS EEPROM--Market Shares

Although the Japanese suppliers have not been significant participants in the EEPROM market so far, we expect this situation to change during the next two years as demand increases from the IC card, facsimile, telecommunications, peripherals, and factory automation markets in Japan. Increased demand pushed 64K EEPROM prices down to $11 to $19/unit in Japan in midyear 1987, reflecting a 50 percent decrease in price from midyear 1986.

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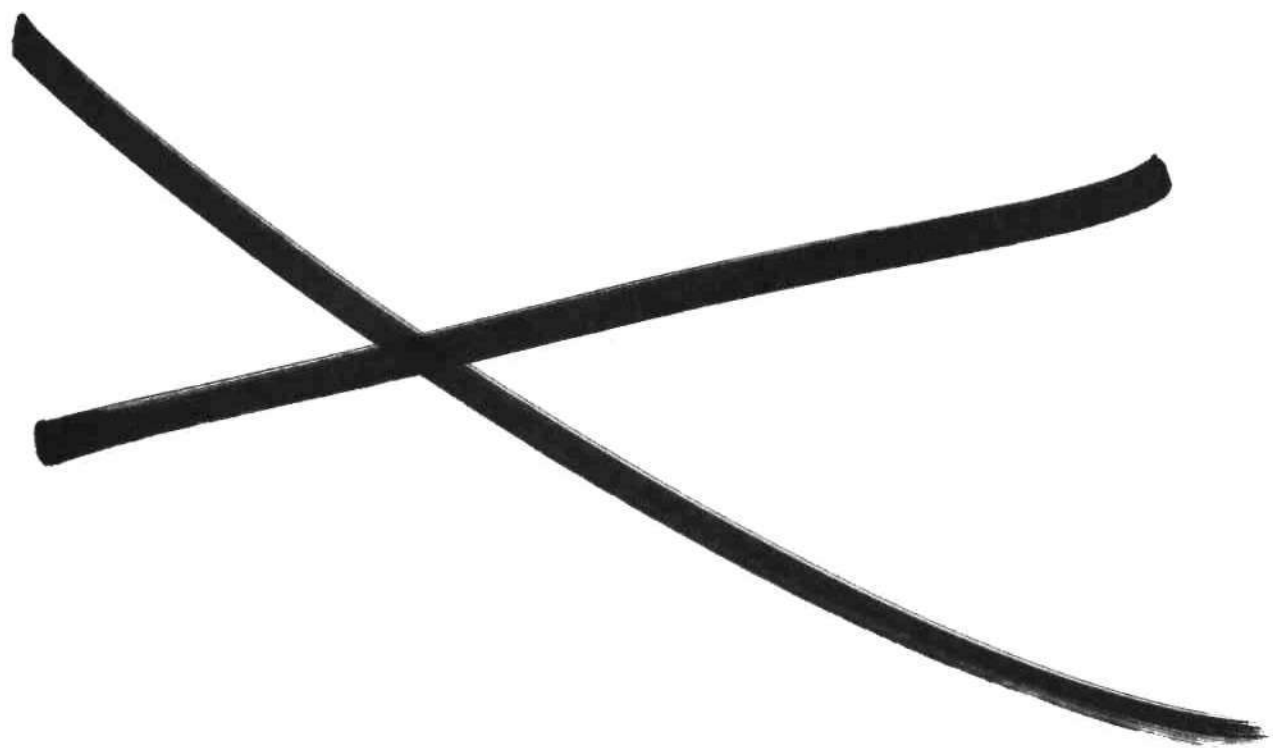

MOS EEPROM—Data Update

INTRODUCTION

This section contains unit shipment data on MOS EEPROMs and NVRAMs from 1988 and 1989. In addition to unit shipments for NVRAMs and low-density (<16K), 16K, 32K, 64K, 256K, and 1-Mbit EEPROMs, we have added our estimates of the worldwide billing prices for each product during the four quarters of the year. At the bottom of the table, we show market share data (units, not revenue) for companies based in the United States, Japan, Europe, and Asia/Pacific. The tables are organized as follows:

- Table 1—NVRAM Shipment Data, 1988-1989
- Table 2—Low-Density MOS EEPROM Shipment Data, 1988-1989
- Table 3—16K MOS EEPROM Shipment Data, 1988-1989
- Table 4—32K MOS EEPROM Shipment Data, 1988
- Table 5—64K MOS EEPROM Shipment Data, 1988-1989
- Table 6—256K MOS EEPROM Shipment Data, 1988-1989
- Table 7—1-Mbit MOS EEPROM Shipment Data, 1989

DEFINITIONS

Prices

Prices are Dataquest estimates of the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and the entire speed mix, and they represent sales to both military and commercial accounts. Because prices vary from company to company and according to volume and contract orders, our prices should not be used to calculate the company revenue.

Unit Shipments

The unit shipment data have been gathered from the manufacturers and represent actual product movements to all market channels. Actual user consumption may be greater than or less than the estimated unit shipments as a result of distributor stocking and manufacturers' inventories for internal use.

Quarterly Revenue

Quarterly revenue is calculated as units shipped times the prevailing price during that period.

Sample

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 or column calculations in the table.

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QUARTERLY COMPANY MOS EEPROM SHIPMENT DATA

Table 1

NVRAM Shipment Data
(Thousands of Units)

Company	MOS Process	Organization	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	CMOS	256 bits, 1K	15	15	20	20	70
Fujitsu	NMOS	1K	25	25	25	25	100
Hughes	CMOS	256 bits	0	0	0	0	0
NCR	SNOS	256 bits, 1K	0	1	0	0	1
Seiko-Epson	CMOS	16K	NA	NA	NA	S	0
SGS-Thomson	CMOS	1K	15	5	5	5	30
Xicor	NMOS	256 bits, 4K	1,000	1,040	1,118	1,099	4,257
Total			1,055	1,086	1,168	1,149	4,458
Percentage Change from Previous Quarter			(11%)	3%	8%	(2%)	
Cumulative Total			21,921	23,007	24,175	25,324	
Average Selling Price			$4.50	$4.50	$4.50	$4.50	$4.50
Revenue ($M)			4.7	4.9	5.3	5.2	20.1
Market Share							
United States			96.2%	97.2%	97.4%	97.4%	97.1%
Japan			2.4	2.3	2.1	2.2	2.2
Europe			1.4	0.5	0.4	0.4	0.7
Asia/Pacific			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	MOS Process	Organization	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	CMOS	256 bits, 1K	100	100	200	300	700
Fujitsu	NMOS	1K	35	30	45	45	155
Hughes	CMOS	256 bits	0	0	0	0	0
NCR	SNOS	256 bits, 1K	0	0	0	0	0
Seiko-Epson	CMOS	16K	0	0	5	10	15
SGS-Thomson	CMOS	1K	0	0	0	0	0
Xicor	NMOS	256 bits, 4K	1,700	1,430	1,200	1,100	5,430
Total			1,835	1,560	1,450	1,455	6,300
Percentage Change from Previous Quarter			60%	(15%)	(7%)	0	
Cumulative Total			1,835	3,395	4,845	6,300	
Average Selling Price			$4.30	$4.30	$4.30	$4.30	$4.30
Revenue ($M)			7.9	6.7	6.2	6.3	27.1
Market Share							
United States			98.1%	98.1%	96.6%	96.2%	97.3%
Japan			1.9	1.9	3.4	3.8	2.7
Europe			0	0	0	0	0
Asia/Pacific			0	0	0	0	0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

NA = Not available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
May 1990

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Table 2

Low-Density MOS EEPROM Shipment Data (Thousands of Units)

Company	Technology	Features Organization	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	CMOS	1K, 2K, 4K	14	14	12	14	54
Hughes	CMOS	256 bits	0	0	0	0	0
Hyundai	CMOS	1K	200	200	200	200	800
ICT	CMOS	1K	502	949	1,265	1,530	4,246
Matsushita	MNOS		0	0	0	0	0
Microchip Tech.	MNOS/SNOS	256-512 bits, 1K-4K	1,930	2,200	1,900	2,200	8,230
Mitsubishi	MNOS	256 bits, 1K	5,500	4,300	4,400	5,400	19,600
Motorola	CMOS	256 bits, 1K	0	0	0	0	0
National	CMOS	256, 512 bits, 1K-4K	7,000	7,400	7,400	7,400	29,200
NCR	SNOS	256 bits, 1K	0	1	0	0	1
NEC	CMOS	512 bits	NA	S	10	40	50
Oki	CMOS	1K	910	1,240	1,250	1,310	4,710
Philips	CMOS	2K	10	22	25	30	87
SEEQ	NMOS	4K	29	23	26	29	107
SGS-Thomson	CMOS	256 bits, 1K	800	800	1,000	1,750	4,350
Siemens	CMOS	1K, 2K	1,000	1,400	700	500	3,600
Sierra Semiconductor	CMOS	256 bits, 1K, 2K,4K	30	30	40	50	150
Sony	CMOS	1K, 2K	20	44	45	34	143
Xicor	NMOS/CMOS	2K, 4K	1,622	1,590	1,650	1,845	6,707
Total			19,567	20,213	19,923	22,332	82,035
Percentage Change from Previous Quarter			18.5%	3.3%	(1.4%)	12.1%	
Cumulative Total			207,594	227,807	247,730	270,062	
Average Selling Price			$0.78	$0.77	$0.75	$0.72	$0.75
Revenue ($M)			15.3	15.6	14.9	16.1	61.8
Market Share							
United States			56.9%	60.4%	61.7%	58.5%	59.4%
Japan			32.9	27.6	28.6	30.4	29.9
Europe			9.3	11.0	8.7	10.2	9.8
Asia/Pacific			1.0	1.0	1.0	0.9	1.0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Technology	Features Organization	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	CMOS	1K, 2K, 4K	110	232	351	421	1,114
Hughes	CMOS	256 bits	0	0	0	0	0
Hyundai	CMOS	1K	400	300	200	150	1,050
ICT	CMOS	1K	1,270	1,290	2,280	2,470	7,310
	CMOS	2K				S	0
	CMOS	4K				S	0
Matsushita	MNOS		0	0	0	0	0
Microchip Tech.	N/S/CMOS	256-512 bits, 1K-4K	2,012	2,001	2,157	2,230	8,400
Mitsubishi	MNOS	256 bits, 1K	5,200	4,300	4,000	4,000	17,500
Motorola	CMOS	256 bits, 1K	0	0	0	0	0
National	CMOS	256, 512 bits, 1K-4	7,100	7,300	7,500	7,600	29,500
NCR	SNOS	256 bits, 1K	0	0	0	0	0
NEC	CMOS	512 bits	50	50	100	100	300
Oki	CMOS	1K	2,240	3,450	4,000	3,100	12,790
Philips	CMOS	2K	10	22	25	30	87
Rohm	CMOS	1K, 2K	1,500	1,500	1,500	1,500	6,000
SEEQ	NMOS	4K	29	23	26	29	107
SGS-Thomson	CMOS	256 bits, 1K	800	800	1,000	1,750	4,350
Siemens	CMOS	1K, 2K	1,000	1,400	700	500	3,600
Sierra Semiconductor	CMOS	256 bits, 1K, 2K, 4K	40	50	55	55	200
Sony	CMOS	1K, 2K	20	44	45	34	143
Xicor	NMOS/CMOS	2K, 4K	1,800	1,740	1,600	1,600	6,740
Total			23,581	24,502	25,539	25,569	99,191
Percentage Change from Previous Quarter			5.6%	3.9%	4.2%	0.1%	
Cumulative Total			293,643	318,145	343,684	369,253	
Average Selling Price			$0.68	$0.65	$0.64	$0.64	$0.65
Revenue ($M)			16.0	15.9	16.3	16.4	64.7
Market Share							
United States			52.4%	51.6%	54.7%	56.3%	53.8%
Japan			38.2	38.1	37.8	34.2	37.0
Europe			7.7	9.1	6.8	8.9	8.1
Asia/Pacific			1.7	1.2	0.8	0.6	1.1
Total			100.0%	100.0%	100.0%	100.0%	100.0%

NA = Not available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest May 1990

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Table 3

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	MOS Process	Maximum AccT	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Atmel	CMOS	35ns	40	58	76	86	260
Catalyst	CMOS		5	5	5	5	20
	CMOS	Fast	2	4	5	5	16
Exel	NMOS	250ns	35	35	35	45	150
Microchip Tech.	CMOS	150ns	25	48	55	70	198
Oki	NMOS		0	0	0	0	0
	CMOS		66	86	115	121	388
Samsung	NMOS		10	15	22	24	71
SEEQ	NMOS		545	568	562	550	2,225
	CMOS	45ns	2	17	30	50	99
Xicor	NMOS		850	900	940	933	3,623
	CMOS		0	11	22	44	77
Total NMOS			1,440	1,518	1,559	1,552	6,069
Total CMOS			140	229	308	381	1,058
Total			1,580	1,747	1,867	1,933	7,127
Percentage Change from Previous Quarter			4%	11%	7%	4%	
Cumulative Total			21,681	23,428	25,295	27,228	
Average Selling Price							
NMOS			$5.00	$4.80	$4.70	$4.50	$4.75
CMOS			$9.00	$8.00	$7.00	$6.00	$7.12
Overall			$5.35	$5.22	$5.08	$4.80	$5.10
Revenue ($M)			8.5	9.1	9.5	9.3	36.3
Market Share							
United States			93.0%	92.2%	90.8%	90.2%	91.5%
Japan			6.4	6.9	8.0	8.6	7.5
Europe			0	0	0	0	0
Asia/Pacific			0.6	0.9	1.2	1.2	1.0
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	MOS Process	Maximum AccT	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Atmel	CMOS	35ns	94	115	132	106	447
Catalyst	CMOS		12	18	22	20	72
	CMOS	fast	10	15	18	20	63
Exel	NMOS	250ns	0	0	0	0	0
Microchip Tech.	CMOS	150ns	78	49	85	129	341
Oki	NMOS		0	0	0	0	0
	CMOS		95	60	70	70	295
Samsung	NMOS		14	26	18	15	73
SEEQ	NMOS		500	455	490	430	1,875
	CMOS	45ns	75	110	84	65	334
Xicor	NMOS		800	822	765	755	3,142
	CMOS		55	62	50	60	227
	NMOS		1,314	1,303	1,273	1,200	5,090
	CMOS		419	429	461	470	1,779
Total			1,733	1,732	1,734	1,670	6,869
Percentage Change from Previous Quarter			(10%)	0	0	(4%)	
Cumulative Total			28,961	30,693	32,427	34,097	
Average Selling Price							
NMOS			$4.40	$4.20	$4.00	$3.80	$4.11
CMOS			$5.50	$5.30	$5.00	$4.80	$5.14
Overall			$4.67	$4.47	$4.27	$4.08	$4.37
Revenue ($M)			8.1	7.7	7.4	6.8	30.0
Market Share							
United States			93.7%	95.0%	94.9%	94.9%	94.6%
Japan			5.5	3.5	4.0	4.2	4.3
Europe			0	0	0	0	0
Asia/Pacific			0.8	1.5	1.0	0.9	1.1
Total			100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest May 1990

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Table 4

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Technology/ Features		1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
SEEQ	CMOS	35ns	8	17	21	28	74
Total			8	17	21	28	74
Percentage Change from Previous Quarter				113%	24%	33%	
Cumulative Total			8	25	46	74	
Average Selling Price			$16	$16	$16	$16	
Revenue ($M)			0.1	0.3	0.3	0.4	1.2
Market Share							
United States			100%	100%	100%	100%	100%
Japan			0	0	0	0	0
Europe			0	0	0	0	0
Total			100%	100%	100%	100%	100%

Source: Dataquest May 1990

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Table 5

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	MOS Process	Maximum AccT	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	200ns	160	200	280	172	812
Atmel	CMOS		155	135	125	125	540
Catalyst	CMOS		10	15	18	22	65
Exel	NMOS		35	35	40	40	150
Fujitsu	CMOS		15	22	34	40	111
Hitachi	NMOS		160	180	200	300	840
	CMOS		40	60	70	100	270
Hyundai	CMOS		8	12	22	22	64
ICT	CMOS		NA	NA	NA	NA	0
Microchip Tech.	CMOS		25	25	30	50	130
Mitsubishi	CMOS		0	0	0	0	0
NEC	CMOS		S	5	7	10	22
Oki	CMOS		0	0	0	S	0
Samsung	NMOS		10	22	22	22	76
SEEQ	NMOS		190	195	191	180	756
	CMOS	Fast	20	25	30	30	105
	CMOS		67	77	78	80	302
Toshiba	CMOS	Fast	NA	NA	NA	NA	0
Xicor	NMOS		400	400	550	600	1,950
	NMOS	Fast	28	30	26	27	111
	CMOS		10	12	14	15	51
Total NMOS			983	1,062	1,309	1,341	4,695
Total CMOS			350	388	428	494	1,660
Total			1,333	1,450	1,737	1,835	6,355
Percentage Change from Previous Quarter			39%	9%	20%	6%	
Cumulative Total			7,329	8,779	10,516	12,351	
Average Selling Price							
NMOS			$8	$8	$7	$7	$7
CMOS			$20	$18	$16	$14	$17
Overall			$11	$11	$9	$9	$10
Revenue ($M)			14.9	15.5	16.0	16.3	62.7
Market Share							
United States			79.9%	76.8%	77.3%	70.9%	75.9%
Japan			18.8	20.8	20.2	26.7	21.9
Europe			0	0	0	0	0
Asia/Pacific			1.4	2.3	2.5	2.4	2.2
Total			100.0%	100.0%	100.0%	100.0%	100.0%

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	MOS Process	Maximum AccT	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	200ns	271	353	715	164	1,503
Atmel	CMOS		150	155	235	304	844
Catalyst	CMOS		32	30	33	28	123
Exel	NMOS		0	0	0	0	0
Fujitsu	CMOS		40	40	40	40	160
Hitachi	NMOS		300	300	200	200	1,000
	CMOS		100	100	150	200	550
Hyundai	CMOS		25	30	20	20	95
Microchip Tech.	CMOS		34	39	40	62	175
Mitsubishi	CMOS		5	12	22	40	79
NEC	CMOS		100	100	100	100	400
Oki	CMOS		0	0	0	50	50
Samsung	NMOS		15	22	20	20	77
SEEQ	NMOS		148	135	130	125	538
	CMOS	Fast	35	44	48	50	177
	CMOS		94	90	80	75	339
Toshiba	CMOS	Fast	0	0	0	0	0
Xicor	NMOS		600	480	465	400	1,945
	NMOS	Fast	32	37	35	30	1,34
	CMOS		24	32	28	25	109
	NMOS		1,366	1,327	1,565	939	5,197
	CMOS		639	672	789	929	3,029
Total			2,005	1,999	2,354	1,868	8,226
Percentage Change from Previous Quarter			9%	0	18%	(18%)	
Cumulative Total			14,356	16,355	18,709	20,577	
Average Selling Price							
NMOS			$6	$5	$5	$5	$5
CMOS			$18	$16	$12	$10	$14
Overall			$10	$9	$7	$7	$8
Revenue ($M)			19.7	17.4	17.4	14.6	69.1
Market Share							
United States			70.8%	69.8%	76.8%	67.6%	71.6%
Japan			27.2	27.6	21.5	30.2	26.3
Europe			0	0	0	0	0
Asia/Pacific			2.0	2.6	1.7	2.1	2.1
Total			100.0%	100.0%	100.0%	100.0%	100.0%

NA = Not available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
May 1990

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Table 6

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Technology/ Features		1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Atmel	CMOS	70ns	9	15	18	20	62
Hitachi	CMOS		NA	NA	NA	NA	0
NEC	CMOS		0	0	0	0	0
SEEQ	CMOS		33	32	32	25	122
Xicor	NMOS		40	40	49	55	184
	CMOS		3	10	20	40	73
Total			85	97	119	140	441
Percentage Change from Previous Quarter			67%	14%	23%	18%	
Cumulative Total			250	347	466	606	
Average Selling Price			$130	$120	$110	$100	$113
Revenue ($M)			11.1	11.6	13.1	14.0	49.8
Market Share							
United States			100%	100%	100%	100%	100%
Japan			0	0	0	0	0
Europe			0	0	0	0	0
Total			100%	100%	100%	100%	100%

(Continued)

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Table 6 (Continued)

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Technology/ Features		1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Atmel	CMOS	70ns	30	30	46	53	159
Hitachi	MNOS		NA	S	0	10	10
Microchip Tech.	CMOS		0	0	0	0	0
Mitsubishi	CMOS		0	0	0	4	4
NEC	CMOS		5	7	15	22	49
Simtek	SNOS		NA	NA	NA	S	0
SEEQ	CMOS		50	45	35	28	158
Xicor	NMOS		58	60	50	50	218
	CMOS		55	50	50	50	205
Total			198	192	196	217	803
Percentage Change from Previous Quarter			41%	(3%)	2%	11%	
Cumulative Total			804	996	1,192	1,409	
Average Selling Price			$90	$70	$50	$30	$59
Revenue ($M)			17.8	13.4	9.8	6.5	47.5
Market Share							
United States			97%	96%	92%	83%	92%
Japan			3	4	8	17	8
Europe			0	0	0	0	0
Total			100%	100%	100%	100%	100%

S = Sample
NA = Not available

Source: Dataquest
May 1990

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Table 7

1-Mbit MOS EEPROM Shipment Data
(Thousands of Units)

Company	Technology	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Xicor	CMOS	S	5	7	7	19
Total		0	5	7	7	19
Percentage Change from Previous Quarter		0	0	40%	0	
Cumulative Total			5	12	19	
Average Selling Price		NA				
Revenue ($M)						
Market Share						
United States		0	100%	100%	100%	100%
Japan		0	0	0	0	0
Europe		0	0	0	0	0
Asia/Pacific		0	0	0	0	0
Total		0	100%	100%	100%	100%

S = Sample
NA = Not available

Source: Dataquest May 1990

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MOS EEPROM--Data Update

QUARTERLY COMPANY MOS EEPROM SHIPMENT DATA

This section contains unit shipment data on MOS EEPROMs and NVRAMs for 1988. In addition to unit shipments for NVRAMs and low-density (<16K), 16K, 32K, 64K, and 256K EEPROMs, we have added our estimates of the worldwide billing prices for each product during the four quarters of the year. At the bottom of the table, we show market share data (units, not revenue) for companies based in the United States, Japan, Europe, and Asia Pacific. The tables are organized as follows:

- Table 1—NVRAM Shipment Data, 1988
- Table 2—Low-Density MOS EEPROM Shipment Data, 1988
- Table 3—16K MOS EEPROM Shipment Data, 1988
- Table 4—32K MOS EEPROM Shipment Data, 1988
- Table 5—64K MOS EEPROM Shipment Data, 1988
- Table 6—256K MOS EEPROM Shipment Data, 1988

Definitions

Prices

Prices are Dataquest estimates of the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and the entire speed mix, and they represent sales to both military and commercial accounts. Because prices vary from company to company, and according to volume and contract orders, our prices should not be used to calculate the company revenue.

Unit Shipments

The unit shipment data have been gathered from the manufacturers and represent actual product movements to all market channels. Actual user consumption may be greater than or less than the estimated unit shipments as a result of distributor stocking and manufacturers' inventories for internal use.

Quarterly Revenue

Quarterly revenue is calculated as units shipped times the prevailing price during that period.

Sample

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 or column calculations in the table.

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MOS EEPROM--Data Update

Table 1

NVRAM Shipment Data
(Thousands of Units)

Company	MOS Process	Organization	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	CMOS	256 bits, 1K	15	15	20	20	70
Fujitsu	NMOS	1K	25	25	25	25	100
Hughes	CMOS	256 bits	0	0	0	0	0
NCR	SNOS	256 bits, 1K	0	1	0	0	1
Seiko Epson	CMOS	16K	N/A	N/A	N/A	S	0
SGS-Thomson	CMOS	1K	15	5	5	5	30
Xicor	NMOS	256 bits, 4K	1,000	1,040	1,118	1,099	4,257
Total			1,055	1,086	1,168	1,149	4,458
Percentage Change from Previous Quarter			(11%)	3%	8%	(2%)	
Cumulative Total			21,921	23,007	24,175	25,324	
Average Selling Price			$4.50	$4.50	$4.50	$4.50	$4.50
Revenue ($M)			4.7	4.9	5.3	5.2	20.1

	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	96.2%	97.2%	97.4%	97.4%	97.1%
Japan	2.4	2.3	2.1	2.2	2.2
Europe	1.4	0.5	0.4	0.4	0.7
Asia/Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
July 1989

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Table 2

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Technology	Features Organization	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	CMOS	1K,2K,4K	14	14	12	14	54
Hughes	CMOS	256 bits	0	0	0	0	0
Hyundai	CMOS	1K	6	8	8	8	30
ICT	CMOS	1K	502	949	1,265	1,530	4,246
Matsushita	MNOS		0	0	0	0	0
Microchip Tech,Inc.	MNOS/SNOS	256-512 bits, 1K-4K	1,930	2,200	1,900	2,200	8,230
Mitsubishi	MNOS	256 bits,1K	5,500	4,300	4,400	5,400	19,600
Motorola	CMOS	256 bits,1K	0	0	0	0	0
National	CMOS	256,512 bits, 1K-4K	3,900	4,200	4,500	4,300	16,900
NCR	SNOS	256 bits,1K	0	1	0	0	1
NEC	CMOS	512 bits	N/A	S	10	40	50
Oki	CMOS	1K	910	1,240	1,250	1,310	4,710
Philips	CMOS	2K	10	22	25	30	87
SEEQ	NMOS	4K	29	23	26	29	107
SGS-Thomson	CMOS	256 bits,1K	800	800	1,000	1,750	4,350
Siemens	CMOS	1K,2K	1,000	1,400	700	500	3,600
Sierra Semi	CMOS	256 bits,1K, 2K,4K	30	60	70	90	250
Sony	CMOS	1K,2K	20	44	45	34	143
Xicor	NMOS/CMOS	2K,4K	1,622	1,590	1,650	1,845	6,707
Total			16,273	16,851	16,861	19,080	69,065
Percentage Change from Previous Quarter			19.4%	3.6%	0.1%	13.2%	
Cumulative Total			196,819	213,670	230,531	249,611	
Average Selling Price			$0.78	$0.77	$0.75	$0.72	$0.75
Revenue ($M)			12.7	13.0	12.6	13.7	52.1

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

	1988				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	49.3%	53.6%	55.9%	52.5%	52.8%
Japan	39.5	33.1	33.8	35.6	35.5
Europe	11.1	13.2	10.2	11.9	11.6
Asia/Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
July 1989

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MOS EEPROM—Data Update

Table 3

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	MOS Process	Maximum AccT	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Atmel	CMOS	35ns	40	58	76	86	260
Catalyst	CMOS		5	5	5	5	20
	CMOS	Fast	2	4	5	5	16
Exel	NMOS	250ns	35	35	35	45	150
Microchip Tech, Inc.	CMOS	150ns	25	48	55	70	198
Oki	NMOS		0	0	0	0	0
	CMOS		66	86	115	121	388
Samsung	NMOS		10	15	22	24	71
SEEQ	NMOS		545	568	562	550	2,225
	CMOS	45ns	2	17	30	50	99
Xicor	NMOS		850	900	940	933	3,623
	CMOS		0	11	22	44	77
Total NMOS			1,440	1,518	1,559	1,552	6,069
Total CMOS			140	229	308	381	1,058
Total			1,580	1,747	1,867	1,933	7,127
Percentage Change from Previous Quarter			4%	11%	7%	4%	
Cumulative Total			21,681	23,428	25,295	27,228	
ASPs: NMOS			$5.00	$4.80	$4.70	$4.50	$4.75
CMOS			$9.00	$8.00	$7.00	$6.00	$7.12
Overall			$5.35	$5.22	$5.08	$4.80	$5.10
Revenue ($M)			8.5	9.1	9.5	9.3	36.3

	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	93.0%	92.2%	90.8%	90.2%	91.5%
Japan	6.4	6.9	8.0	8.6	7.5
Europe	0	0	0	0	0
Asia/Pacific	0.6	0.9	1.2	1.2	1.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
July 1989

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Table 4

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Technology/ Features	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
SEEQ	CMOS 35ns	8	17	21	28	74
Total		8	17	21	28	74
Percentage Change from Previous Quarter			113%	24%	33%	
Cumulative Total		8	25	46	74	
ASP		$16	$16	$16	$16	
Revenue ($M)		0.1	0.3	0.3	0.4	1.2

	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
U.S.	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	100%	100%	100%	100%	100%

Source: Dataquest
July 1989

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Table 5

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	MOS Process	Maximum AccT	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	200ns	160	200	280	290	930
Atmel	CMOS		155	135	170	160	620
Catalyst	CMOS		10	15	18	22	65
Exel	NMOS		35	35	40	40	150
Fujitsu	CMOS		15	22	34	40	111
Hitachi	NMOS		88	94	100	100	382
	CMOS		22	40	32	44	138
Hyundai	CMOS		8	12	22	22	64
ICT	CMOS		N/A	N/A	N/A	N/A	0
Microchip Tech, Inc.	CMOS		25	25	30	50	130
Mitsubishi	CMOS		0	0	0	0	0
NEC	CMOS		5	5	7	10	22
Oki	CMOS		0	0	0	5	0
Samsung	NMOS		10	22	22	22	76
SEEQ	NMOS		190	195	191	180	756
	CMOS	Fast	20	25	30	30	105
	CMOS		67	77	78	80	302
Toshiba	CMOS	Fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS		400	400	550	600	1,950
	NMOS	Fast	28	30	26	27	111
	CMOS		10	12	14	15	51
Total NMOS			911	976	1,209	1,259	4,355
Total CMOS			332	368	435	473	1,608
Total			1,243	1,344	1,644	1,732	5,963
Percentage Change From Previous Quarter			30%	8%	22%	5%	
Cumulative Total			7,239	8,583	10,227	11,959	
ASPs: NMOS			$ 8	$ 8	$ 7	$ 7	$ 7
CMOS			$20	$18	$16	$14	$17
Overall			$11	$11	$ 9	$ 9	$10
Revenue ($M)			13.9	14.4	15.4	15.4	59.2

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

	1988				
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	85.7%	82.9%	84.4%	83.9%	84.2%
Japan	12.9	14.6	13.0	13.5	13.5
Europe	0	0	0	0	0
Asian Pacific	1.4	2.5	2.7	2.5	2.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
July 1989

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Table 6

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Technology/ Features	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Atmel	CMOS 70ns	9	15	18	20	62
Hitachi	CMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	0	0	0	0	0
SEEQ	CMOS	33	32	32	25	122
Xicor	NMOS	40	40	49	55	184
	CMOS	3	10	20	40	73
Total		85	97	119	140	441
Percentage Change from Previous Quarter		67%	14%	23%	18%	
Cumulative Total		250	347	466	606	
ASPs:		$130	$120	$110	$100	$113
Revenue ($M)		11.1	11.6	13.1	14.0	49.8

	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available

Source: Dataquest
July 1989

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MOS EEPROM--Data

QUARTERLY COMPANY MOS EEPROM SHIPMENT DATA

This section contains unit shipment data on MOS EEPROMs and NVRAMs from 1982 through 1987. In addition to unit shipments for NVRAMs and low-density (<16K), 16K, 32K, 64K, and 256K EEPROMs, we have added our estimates of the worldwide billing prices for each product during the four quarters of the year. At the bottom of the table, we show market share data (units, not revenue) for companies based in the United States, Japan, Europe, and Asia/Pacific. The tables are organized as follows:

- Table 1—NVRAM Shipment Data, 1982–1987
- Table 2—Low-Density MOS EEPROM Shipment Data, 1983–1987
- Table 3—16K MOS EEPROM Shipment Data, 1982–1987
- Table 4—32K MOS EEPROM Shipment Data, 1983–1987
- Table 5—64K MOS EEPROM Shipment Data, 1983–1987
- Table 6—256K MOS EEPROM Shipment Data, 1986–1987

Definitions

Prices

Prices are Dataquest estimates of the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and the entire speed mix, and they represent sales to both military and commercial accounts. Because prices vary from company to company, and according to volume and contract orders, our prices should not be used to calculate the company revenue.

Unit Shipments

The unit shipment data have been gathered from the manufacturers and represent actual product movements to all market channels. Actual user consumption may be greater than or less than the estimated unit shipments as a result of distributor stocking and manufacturers' inventories for internal use.

Quarterly Revenue

Quarterly revenue is calculated as units shipped times the prevailing price during that period.

Sample

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 or column calculations in the table.

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MOS EEPROM--Data

Table 1

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	10	25	50	100	185
NCR	4K SNOS	10	10	25	60	105
SGS-Ates	1K NMOS	N/A	N/A	S	10	10
Xicor	256-4K Bits NMOS	70	100	170	250	590
Total		90	135	245	420	890
Percentage Change from Previous Quarter			50%	81%	71%	
Cumulative Total		90	225	470	890	
Average Selling Price		$4.30	$4.00	$3.53	$3.20	$3.52
Revenue ($M)		0.4	0.5	0.9	1.3	3.1

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	98%	99%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	80	100	100	150	430
Hughes	64x4 CMOS	N/A	N/A	N/A	S	0
Intel	1K, 4K NMOS	N/A	N/A	S	5	5
NCR	256-4K Bits	100	150	200	300	750
Rockwell	256 Bits CMOS	N/A	N/A	N/A	S	0
SGS-Ates	1K NMOS	80	140	100	80	400
Xicor	256-4K Bits NMOS	330	590	600	830	2,350
Total		590	980	1,000	1,365	3,935
Percentage Change from Previous Quarter		40%	66%	2%	37%	
Cumulative Total		1,480	2,460	3,460	4,825	
Average Selling Price		$3.60	$3.56	$3.50	$3.98	$3.70
Revenue ($M)		2.1	3.5	3.5	5.4	14.5

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	86%	86%	90%	94%	90%
Japan	0	0	0	0	0
Europe	14	14	10	6	10
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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MOS EEPROM--Data

Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	150	200	300	300	950
Hughes	64 x 4 CMOS	S	S	S	S	10
Intel	1K, 4K NMOS	5	10	20	25	60
NCR	256-4K Bits	200	200	250	250	900
Rockwell	256 Bits CMOS	S	S	0	0	0
SGS	1K NMOS	100	50	20	80	250
Xicor	256-4K Bits NMOS	600	640	800	850	2,890
Total		1,055	1,100	1,395	1,510	5,060
Percentage Change from Previous Quarter		(23%)	4%	27%	8%	
Cumulative Total		5,880	6,980	8,375	9,885	
Average Selling Price		$3.80	$3.30	$3.50	$3.60	$3.55
Revenue ($M)		4.0	3.6	4.9	5.4	18.0

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	95%	99%	95%	95%
Japan	0	0	0	0	0
Europe	9	5	1	5	5
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	1K NMOS	N/A	N/A	S	5	5
General Instrument	4K MNOS	150	100	50	50	350
Hughes	64x4 CMOS	25	25	25	25	100
Intel	1K, 4K NMOS	10	10	5	5	30
NCR	256, 4K Bits	28	25	25	25	103
SGS	1K	65	50	75	50	240
Xicor	Many NMOS	700	700	650	650	2,700
Total		978	910	830	810	3,528
Percentage Change from Previous Quarter		(35%)	(7%)	(9%)	(2%)	
Cumulative Total		10,863	11,773	12,603	13,413	
Average Selling Price		$3.70	$4.00	$4.50	$4.25	$4.09
Revenue ($M)		3.6	3.6	3.7	3.4	14.4

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	93%	95%	91%	93%	93%
Japan	0	0	0	1	0
Europe	7	5	9	6	7
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	256 Bits, 1K CMOS	S	5	5	5	15
Fujitsu	1K CMOS	5	5	5	5	20
Hughes	256 Bits CMOS	25	50	75	75	225
NCR	256 Bits, 4K	45	50	50	58	203
SGS	256 Bits, 1K CMOS	50	50	50	50	200
Xicor	256-4K Bits NMOS	780	740	710	670	2,900
Total		905	900	895	863	3,563
Percentage Change from Previous Quarter		12%	(1)	1%	(4%)	
Cumulative Total		14,318	15,218	16,113	16,976	
Average Selling Price		$4.25	$4.15	$4.00	$4.00	$4.10
Revenue ($M)		3.8	3.7	3.6	3.5	14.6

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	94%	94%	94%	94%	94%
Japan	1	1	1	1	1
Europe	5	5	5	6	6
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

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

(Continued)

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MOS EEPROM—Data

Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	256 Bits, 1K CMOS	5	5	10	10	30
Fujitsu	1K NMOS	5	10	10	20	45
Hughes	256 Bits CMOS	50	25	25	25	125
NCR	256 Bits, 1K SNOS	5	7	8	7	27
SGS-Thomson	1K CMOS	12	18	6	27	63
Xicor	256-4K Bits NMOS	708	892	900	1,100	3,600
Total		785	957	959	1,189	3,890
Percentage Change from Previous Quarter		(9%)	22%	0	24%	
Cumulative Total		17,761	18,718	19,677	20,866	
Average Selling Price		$4.15	$4.28	$4.46	$4.68	$4.42
Revenue ($M)		3.3	4.1	4.3	5.6	17.2

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	97.8%	97.1%	98.3%	96.0%	97.2%
Japan	0.6	1.0	1.0	1.7	1.2
Europe	1.5	1.9	0.6	2.3	1.6
Asia/Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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MOS EEPROM--Data

Table 2

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	3,600	3,840	4,200	4,800	16,440
Hughes	Many CMOS	0	0	0	0	0
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	N/A	S	S	5	5
National Semiconductor	Many	100	220	500	850	1,670
Xicor	Many	400	500	600	700	2,200
Total		5,600	6,060	6,800	7,855	26,315
Percentage Change from Previous Quarter			8.2%	12.2%	15.5%	
Cumulative Total		5,600	11,660	18,460	26,315	
Average Selling Price		$1.65	$1.55	$1.45	$1.35	$1.49
Revenue ($M)		9.2	9.4	9.9	10.6	39.1

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	73%	75%	78%	81%	77%
Japan	27	25	22	19	23
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	4,800	5,040	5,040	5,400	20,280
Hughes	Many CMOS	0	10	10	25	45
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	10	25	50	50	135
National Semiconductor	Many	1,100	1,600	2,400	3,200	8,300
NCR	Many	700	700	800	850	3,050
Xicor	4K	250	350	400	500	1,500
Total		8,360	9,225	10,200	11,525	39,310
Percentage Change from Previous Quarter		6.4%	10.3%	10.6%	13.0%	
Cumulative Total		34,675	43,900	54,100	65,625	
Average Selling Price		$1.35	$1.30	$1.25	$1.25	$1.28
Revenue ($M)		11.3	12.0	12.8	14.4	50.4

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	82%	84%	85%	87%	85%
Japan	18	16	15	13	15
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many MNOS	5,000	4,500	4,000	3,200	16,700
Hughes	Many CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	S	5	5
ICT	1K CMOS	N/A	S	5	10	15
Matsushita	Many MNOS	1,000	800	500	200	2,500
Mitsubishi	Many MNOS	100	100	50	50	300
Motorola	256 Bits	50	50	50	50	200
National Semiconductor	Many	2,400	3,000	3,500	3,750	12,650
NCR	256, 1K SNOS	100	113	135	155	503
SGS	256-Bit CMOS	N/A	N/A	N/A	S	0
Sierra Semiconductor	256, 1K CMOS	N/A	N/A	S	0	0
Xicor	4K	250	225	225	200	900
Total		8,925	8,813	8,490	7,645	33,873
Percentage Change from Previous Quarter		(22.6%)	(1.3%)	(3.7%)	(10.0%)	
Cumulative Total		74,550	83,363	91,853	99,498	
Average Selling Price		$1.20	$1.15	$1.00	$1.10	$1.11
Revenue ($M)		10.7	10.1	8.5	8.4	37.7

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	88%	90%	94%	97%	92%
Japan	12	10	6	3	8
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	1K CMOS	N/A	N/A	N/A	S	0
General Instrument	Many MNOS	2,000	3,000	3,000	3,000	11,000
Hughes	256-Bit CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	N/A	S	0
ICT	1K CMOS	10	10	10	10	40
Matsushita	MNOS	500	200	50	0	750
Mitsubishi	MNOS	0	0	0	0	0
Motorola	256 Bits	251	370	322	301	1,244
National Semiconductor	Many	2,500	3,000	3,200	3,200	11,900
NCR	256, 1K SNOS	175	200	240	275	890
NEC	8K CMOS	N/A	N/A	S	S	0
Oki	1K CMOS	N/A	N/A	N/A	S	0
Philips	1K CMOS	N/A	N/A	N/A	S	0
SEEQ	4K NMOS	N/A	N/A	N/A	S	0
SGS	256, 1K CMOS	55	160	530	340	1,085
Sierra Semiconductor	256, 1K CMOS	0	5	5	20	30
Sony	1K, 2K CMOS	N/A	N/A	S	S	0
Xicor	2K, 4K	350	350	250	200	1,150
Total		5,866	7,320	7,632	7,371	28,189
Percentage Change from Previous Quarter		(23.3%)	24.8%	4.3%	(3.4%)	
Cumulative Total		105,364	112,684	120,316	127,687	
Average Selling Price		$1.05	$1.00	$1.00	$1.00	$1.01
Revenue ($M)		6.2	7.3	7.6	7.4	28.5

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	95%	92%	95%	93%
Japan	9	3	1	0	3
Europe	1	2	7	5	4
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

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

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	1K,2K,4K CMOS	0	2	5	5	12
Hughes	256-Bit CMOS	0	0	0	0	0
Hyundai	1K CMOS	2	5	5	5	17
ICT	1K CMOS	50	100	150	200	500
Matsushita	MNOS	0	0	0	0	0
Microchip Tech., Inc.	MNOS & SNOS	2,007	1,716	1,687	2,020	7,430
Mitsubishi	MNOS	5,500	5,300	5,300	5,700	21,800
Motorola	256-1K	400	425	425	475	1,725
National Semiconductor	Many	2,432	4,941	3,177	3,610	14,160
NCR	256, 1K SNOS	133	145	130	170	578
NEC	8K CMOS	0	0	0	0	0
Oki	1K CMOS	0	50	120	230	400
Philips	2K CMOS	0	0	2	5	7
SEEQ	4K NMOS	10	12	15	20	57
SGS-Thomson	256-1K CMOS	332	463	388	370	1,553
Sierra Semiconductor	256-1K CMOS	10	15	20	25	70
Sony	1K, 2K CMOS	0	5	10	10	25
Xicor	2K, 4K	1,600	1,295	850	780	4,525
Total		12,476	14,474	12,284	13,625	52,859
Percentage Change from Previous Quarter		69.3%	16.0%	(15.1%)	10.9%	
Cumulative Total		140,163	154,637	166,921	180,546	
Average Selling Price		$0.70	$0.73	$0.76	$0.79	$0.75
Revenue ($M)		8.7	10.6	9.3	10.8	39.4

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	53.2%	59.8%	52.6%	53.6%	55.0%
Japan	44.1	37.0	44.2	43.6	42.0
Europe	2.7	3.2	3.2	2.8	3.0
Asia/Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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MOS EEPROM--Data

Table 3

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	N/A	N/A	S	S	0
Hitachi	MNOS	10	25	35	40	110
Hughes	CMOS	N/A	N/A	N/A	S	0
Intel	NMOS	60	80	80	140	360
Motorola	NMOS	2	5	10	10	27
NCR	MNOS	5	5	5	5	20
SEEQ	NMOS	N/A	N/A	5	15	20
Xicor	NMOS	N/A	N/A	S	20	20
Total		77	115	135	230	557
Percentage Change from Previous Quarter		28%	49%	17%	70%	
Cumulative Total		137	252	387	617	
Average Selling Price		$30.00	$25.00	$23.00	$20.00	$23.11
Revenue ($M)		2.3	2.9	3.1	4.6	12.9

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	87%	78%	74%	83%	80%
Japan	13	22	26	17	20
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	S	S	0	0	0
Hitachi	MNOS	50	60	60	30	200
Hughes	CMOS	S	S	0	0	0
Intel	NMOS	180	200	220	250	850
Motorola	NMOS	10	10	10	10	40
NEC	NMOS	N/A	N/A	N/A	S	0
NCR	MNOS	5	5	5	5	20
Rockwell	NMOS	N/A	N/A	N/A	S	0
SEEQ	NMOS	15	80	95	120	310
Xicor	NMOS	35	50	90	170	345
Total		295	405	480	585	1,765
Percentage Change from Previous Quarter		28%	37%	19%	22%	
Cumulative Total		912	1,317	1,797	2,382	
Average Selling Price		$20.00	$18.00	$15.00	$13.50	$16.01
Revenue ($M)		5.9	7.3	7.2	7.9	28.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	84%	86%	88%	95%	89%
Japan	16	14	12	5	11
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	NMOS	N/A	N/A	S	200	200
General Instrument	MNOS	0	0	0	0	0
Hitachi	MNOS	0	0	0	0	0
Hughes	CMOS	0	0	0	0	0
Intel	NMOS	300	375	400	425	1,500
Motorola	NMOS	15	15	10	10	50
National Semiconductor	CMOS	N/A	N/A	N/A	S	0
NEC	NMOS	S	S	5	5	10
NCR	MNOS	0	0	0	0	0
Rockwell	NMOS	5	5	0	0	10
SEEQ	NMOS	150	200	235	270	855
Xicor	NMOS	250	350	450	500	1,550
Total		720	945	1,100	1,410	4,175
Percentage Change from Previous Quarter		23%	31%	16%	28%	
Cumulative Total		3,102	4,047	5,147	6,557	
Average Selling Price		$14.50	$13.00	$11.50	$10.50	$12.02
Revenue ($M)		10.4	12.3	12.7	14.8	50.2

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	N/A	N/A	S	10	10
Exel	NMOS	75	75	100	35	285
	CMOS fast	N/A	S	S	0	0
General Instrument	MNOS	0	0	0	0	0
Intel	NMOS	140	130	125	120	515
Motorola	NMOS	10	10	10	10	40
National Semiconductor	CMOS	0	0	0	1	1
Rockwell	NMOS	0	0	0	0	0
Samsung	NMOS	S	0	5	5	10
SEEQ	NMOS	200	250	325	400	1,175
Xicor	NMOS	400	350	325	300	1,375
Total		825	815	890	881	3,411
Percentage Change from Previous Quarter		(25%)	(1%)	9%	(1%)	
Cumulative Total		7,382	8,197	9,087	9,968	
Average Selling Price		$9.50	$8.25	$7.00	$6.00	$7.60
Revenue ($M)		7.8	6.7	6.2	5.3	26.1

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	91%	88%	95%	91%
Japan	9	9	11	4	8
Europe	0	0	0	0	0
Asia/Pacific	0	0	1	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	12	15	20	27	74
Atmel	CMOS fast	N/A	S	0	0	0
Catalyst	CMOS fast	N/A	N/A	N/A	S	0
Exel	CMOS fast	S	5	5	5	20
General Instrument	CMOS fast	5	0	5	5	10
Intel	NMOS	150	100	100	50	400
National Semiconductor	CMOS	0	0	0	0	0
Samsung	NMOS	0	1	5	5	11
SEEQ	NMOS	400	400	450	500	1,750
Xicor	NMOS	500	500	550	650	2,200
Total		1,067	1,021	1,135	1,242	4,465
Percentage Change from Previous Quarter		21%	(4%)	11%	9%	
Cumulative Total		11,035	12,056	13,191	14,433	
Average Selling Price		$6.50	$6.00	$5.50	$5.00	$5.70
Revenue ($M)		6.9	6.1	6.2	6.2	25.5

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	99%	99%	99%	99%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	18	33	35	10	96
Atmel	CMOS fast	0	0	0	0	0
Catalyst	CMOS	S	0	0	0	0
	CMOS fast	N/A	N/A	N/A	N/A	0
Exel	NMOS fast	20	20	25	25	90
Microchip Tech., Inc.	CMOS	15	22	28	12	77
IDT	CMOS fast	N/A	N/A	N/A	S	0
Intel	NMOS	75	75	25	20	195
Oki	NMOS	30	30	20	N/A	80
	CMOS fast	N/A	N/A	S	20	20
Samsung	NMOS	5	5	7	9	26
SEEQ	NMOS	420	470	500	569	1,959
	CMOS fast	N/A	N/A	N/A	S	0
Xicor	NMOS	660	790	820	855	3,125
	CMOS	N/A	N/A	N/A	S	0
	NMOS	1,228	1,423	1,423	1,488	5,571
	CMOS	15	22	28	32	97
Total		1,243	1,445	1,460	1,520	5,668
Percentage Change from Previous Quarter		(1%)	17%	1%	5%	
Cumulative Total		15,676	17,121	18,581	20,101	
Average Selling Price	NMOS	$ 4.75	$ 5.00	$ 5.05	$ 5.10	$ 4.98
	CMOS	$17.00	$15.00	$13.00	$11.00	$13.41
	Overall	$ 4.90	$ 5.15	$ 5.20	$ 5.22	$ 5.13
Revenue ($M)		6.1	7.4	7.6	7.9	29.1

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	95.6%	96.2%	96.4%	96.4%	96.2%
Japan	4.0	3.5	3.1	3.0	3.4
Europe	0	0	0	0	0
Asia/Pacific	0.4	0.3	0.5	0.6	0.5
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

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Table 4

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Motorola	HMOS	N/A	N/A	S	S	S
NCR	MNOS	N/A	N/A	N/A	S	S
SEEQ	NMOS	N/A	N/A	S	S	S
Total		0	0	0	0	0
Percentage Change from Previous Quarter						
Cumulative Total		0	0	0	0	
Average Selling Price				$50.00	$45.00	
Revenue ($M)						

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	N/A	N/A	S	S	S
Motorola	HMOS	5	10	10	10	35
NCR	MNOS	5	10	10	10	35
SEEQ	NMOS	0	0	0	0	0
Total		10	20	20	20	70
Percentage Change from Previous Quarter		0	100%	0	0	
Cumulative Total		10	30	50	70	
Average Selling Price		$35.00	$25.00	$20.00	$15.00	$22.14
Revenue ($M)		0.4	0.5	0.4	0.3	1.6

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	0	0	0	0	0
Motorola	HMOS	5	5	0	0	10
NCR	MNOS	0	0	0	1	1
SEEQ	NMOS	0	0	0	0	0
Total		5	5	0	1	11
Percentage Change from Previous Quarter		(75%)	0	(100%)	0	
Cumulative Total		75	80	80	81	316
Average Selling Price		$15.00	$15.00	$14.00	$14.00	$14.91
Revenue ($M)		0.1	0.1	0.0	0.0	0.2

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	0	100%	100%

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NCR	MNOS	1	1	3	3	8
SEEQ	NMOS	0	0	0	0	0
Total		1	1	3	3	8
Percentage Change from Previous Quarter		0	0	200%	0	
Cumulative Total		317	318	321	324	1,280
Average Selling Price		$14.00	$12.00	$10.00	$10.00	$10.75
Revenue ($M)		0	0	0	0	0.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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MOS EEPROM--Data

Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NCR	MNOS	0	0	0	0	0
SEEQ	CMOS 35ns	N/A	N/A	N/A	S	0
Total		0	0	0	0	0
Percentage Change from Previous Quarter		(100%)				
Cumulative Total		1,280	1,280	1,280	1,280	
Average Selling Price					$16.00	
Revenue ($M)		0	0	0	0	0

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	0	0	0
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	0	0	0	0	0

S = Sample

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MOS EEPROM--Data

Table 5

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	MNOS	N/A	N/A	N/A	N/A	0
Inmos	MNOS	N/A	N/A	N/A	N/A	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
SEEQ	NMOS	N/A	N/A	N/A	3	3
Xicor	NMOS	N/A	N/A	N/A	N/A	0
Total		0	0	0	3	3
Percentage Change from Previous Quarter		0	0	0	0	
Cumulative Total		0	0	0	3	
Average Selling Price		0	$150	$150	$100	$100
Revenue ($M)		0.0	0.0	0.0	0.3	0.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	S	S	1	1	2
Exel	CMOS	N/A	S	S	0	0
Hitachi	MNOS	N/A	N/A	N/A	S	0
Inmos	MNOS	N/A	N/A	S	S	0
NCR	SNOS	N/A	N/A	S	S	0
SEEQ	NMOS	10	20	20	35	85
Xicor	NMOS	2	7	15	30	54
Total		12	27	36	66	141
Percentage Change from Previous Quarter		300%	125%	33%	83%	
Cumulative Total		15	42	78	144	
Average Selling Price		$80	$70	$50	$40	$52
Revenue ($M)		1.0	1.9	1.8	2.6	7.3

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	2	8	15	20	45
Atmel	CMOS	N/A	N/A	N/A	S	0
Exel	CMOS	0	0	0	0	0
Fujitsu	CMOS	N/A	N/A	N/A	S	0
Hitachi	SNOS	10	15	25	100	150
Inmos	MNOS	0	0	0	0	0
Lattice	CMOS fast	N/A	S	S	0	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
SEEQ	NMOS	40	55	80	115	290
Xicor	NMOS	50	60	100	140	350
	NMOS fast	N/A	S	0	10	10
	CMOS fast	N/A	N/A	N/A	N/A	0
Total		102	138	220	385	845
Percentage Change from Previous Quarter		55%	35%	59%	75%	
Cumulative Total		246	384	604	989	
Average Selling Price		$35	$20	$25	$20	$23
Revenue ($M)		3.6	2.8	5.5	7.7	19.5

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	90%	89%	89%	74%	82%
Japan	10	11	11	26	18
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	35	50	50	50	185
Atmel	CMOS	0	0	0	0	0
Catalyst	CMOS	N/A	N/A	N/A	N/A	0
Fujitsu	CMOS	S	5	10	10	25
General Instrument	CMOS	S	5	10	10	25
	CMOS fast	N/A	N/A	S	0	0
Hitachi	NMOS	75	100	100	100	375
	CMOS	N/A	N/A	N/A	S	0
Hyundai	CMOS	N/A	N/A	N/A	S	0
ICT	CMOS	N/A	N/A	N/A	N/A	0
Intel	NMOS	N/A	S	10	20	30
Lattice	CMOS fast	0	0	5	5	10
Mitsubishi	CMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	N/A	N/A	N/A	N/A	0
Oki	CMOS	N/A	N/A	N/A	N/A	0
Samsung	NMOS	N/A	N/A	S	0	0
SEEQ	NMOS	115	125	125	125	490
Siemens	CMOS	N/A	N/A	N/A	N/A	0
Toshiba	CMOS fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS	200	200	250	250	900
	NMOS fast	5	10	10	20	45
	CMOS	N/A	N/A	N/A	S	0
Total		430	495	570	590	2,085
Percentage Change from Previous Quarter		12%	15%	15%	4%	
Cumulative Total		1,419	1,914	2,484	3,074	
Average Selling Price		$20	$18	$15	$12	$16
Revenue ($M)		8.6	8.9	8.6	7.1	33.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	83%	79%	81%	81%	81%
Japan	17	21	19	19	19
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	70	115	95	125	405
Atmel	CMOS	0	0	0	0	0
Catalyst	CMOS	1	2	5	4	12
Exel	NMOS	25	25	30	30	110
Fujitsu	CMOS	1	2	3	5	11
Hitachi	NMOS	40	55	70	70	235
	CMOS	6	0	0	0	0
Hyundai	CMOS	2	3	4	6	15
ICT	CMOS	N/A	N/A	N/A	N/A	0
Intel	NMOS	20	25	15	15	75
Microchip Tech., Inc.	CMOS	15	30	48	40	133
Mitsubishi	CMOS	N/A	N/A	N/A	S	0
Motorola	HMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	N/A	N/A	N/A	N/A	0
Oki	CMOS	S	0	0	0	0
Samsung	NMOS	2	4	5	8	19
SEEQ	NMOS	121	145	160	207	633
	NMOS fast	S	4	8	11	23
	CMOS	3	9	19	26	57
Toshiba	CMOS fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS	211	239	306	389	1,145
	NMOS fast	0	2	5	8	15
	CMOS	9	4	7	9	20
	NMOS	489	614	694	863	2,660
	CMOS	21	53	93	95	262
Total		510	667	787	958	2,922
Percentage Change from Previous Quarter		(14%)	31%	18%	22%	
Cumulative Total		3,584	4,251	5,038	5,996	
Average Selling Price	NMOS	$15	$13	$11	$ 8	$11
	CMOS	$35	$32	$29	$24	$28
	Overall	$16	$15	$13	$10	$13
Revenue ($M)		8.1	9.7	10.3	9.2	37.3

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	86.5%	86.2%	84.9%	87.1%	86.2%
Japan	12.7	12.7	14.0	11.5	12.7
Europe	0	0	0	0	0
Asia/Pacific	0.8	1.0	1.1	1.5	1.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

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MOS EEPROM--Data

Table 6

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
SEEQ	CMOS/NMOS	S	0	3	5	8
Xicor	NMOS	S	0	5	10	15
Total		0	0	8	15	23
Percentage Change from Previous Quarter		0	0	0	88%	
Cumulative Total			0	8	23	
Average Selling Price			$400	$350	$300	$317
Revenue ($M)		0.0	0.0	2.8	4.5	7.3

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia/Pacific	0	0	0	0	0
Total	0	0	100%	100%	100%

S = Sample

(Continued)

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Table 6 (Continued)

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	0	0	0	0	0
Atmel	CMOS	0	0	0	0	0
NEC	CMOS	S	S	0	0	0
SEEQ	CMOS	9	12	19	22	62
Sharp	CMOS	S	0	0	0	0
Xicor	NMOS/CMOS	10	15	26	29	80
	NMOS	10	13	23	26	72
	CMOS	9	14	22	25	70
Total		19	27	45	51	142
Percentage Change from Previous Quarter		27%	42%	67%	13%	
Cumulative Total		42	69	114	165	
Average Selling Price	NMOS	$258	$212	$158	$109	$164
	CMOS	$286	$248	$199	$156	$205
	Overall	$271	$231	$178	$132	$184
Revenue ($M)		5.2	6.2	8.0	6.7	26.1

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	1
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

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MOS EEPROM--Data

QUARTERLY COMPANY MOS EEPROM SHIPMENT DATA

This section contains unit shipment data on MOS EEPROMs and NVRAMs from 1982 through 1987. In addition to unit shipments for NVRAMs and low-density (<16K), 16K, 32K, 64K, and 256K EEPROMs, we have added our estimates of the worldwide billing prices for each product during the four quarters of the year. At the bottom of the table, we show market share data (units, not revenue) for companies based in the United States, Japan, Europe, and Asia/Pacific. The tables are organized as follows:

- Table 1—NVRAM Shipment Data, 1982–1987
- Table 2—Low-Density MOS EEPROM Shipment Data, 1983–1987
- Table 3—16K MOS EEPROM Shipment Data, 1982–1987
- Table 4—32K MOS EEPROM Shipment Data, 1983–1987
- Table 5—64K MOS EEPROM Shipment Data, 1983–1987
- Table 6—256K MOS EEPROM Shipment Data, 1986–1987

Definitions

Prices

Prices are Dataquest estimates of the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and the entire speed mix, and they represent sales to both military and commercial accounts. Because prices vary from company to company, and according to volume and contract orders, our prices should not be used to calculate the company revenue.

Unit Shipments

The unit shipment data have been gathered from the manufacturers and represent actual product movements to all market channels. Actual user consumption may be greater than or less than the estimated unit shipments as a result of distributor stocking and manufacturers' inventories for internal use.

Quarterly Revenue

Quarterly revenue is calculated as units shipped times the prevailing price during that period.

Sample

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 or column calculations in the table.

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MOS EEPROM--Data

Table 1

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	10	25	50	100	185
NCR	4K SNOS	10	10	25	60	105
SGS-Ates	1K NMOS	N/A	N/A	S	10	10
Xicor	256-4K Bits NMOS	70	100	170	250	590
Total		90	135	245	420	890
Percentage Change from Previous Quarter			50%	81%	71%	
Cumulative Total		90	225	470	890	
Average Selling Price		$4.30	$4.00	$3.53	$3.20	$3.52
Revenue ($M)		0.4	0.5	0.9	1.3	3.1

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	98%	99%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	80	100	100	150	430
Hughes	64x4 CMOS	N/A	N/A	N/A	S	0
Intel	1K, 4K NMOS	N/A	N/A	S	5	5
NCR	256-4K Bits	100	150	200	300	750
Rockwell	256 Bits CMOS	N/A	N/A	N/A	S	0
SGS-Ates	1K NMOS	80	140	100	80	400
Xicor	256-4K Bits NMOS	330	590	600	830	2,350
Total		590	980	1,000	1,365	3,935
Percentage Change from Previous Quarter		40%	66%	2%	37%	
Cumulative Total		1,480	2,460	3,460	4,825	
Average Selling Price		$3.60	$3.56	$3.50	$3.98	$3.70
Revenue ($M)		2.1	3.5	3.5	5.4	14.5

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	86%	86%	90%	94%	90%
Japan	0	0	0	0	0
Europe	14	14	10	6	10
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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MOS EEPROM--Data

Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	150	200	300	300	950
Hughes	64 x 4 CMOS	S	S	S	S	10
Intel	1K, 4K NMOS	5	10	20	25	60
NCR	256-4K Bits	200	200	250	250	900
Rockwell	256 Bits CMOS	S	S	0	0	0
SGS	1K NMOS	100	50	20	80	250
Xicor	256-4K Bits NMOS	600	640	800	850	2,890
Total		1,055	1,100	1,395	1,510	5,060
Percentage Change from Previous Quarter		(23%)	4%	27%	8%	
Cumulative Total		5,880	6,980	8,375	9,885	
Average Selling Price		$3.80	$3.30	$3.50	$3.60	$3.55
Revenue ($M)		4.0	3.6	4.9	5.4	18.0

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	95%	99%	95%	95%
Japan	0	0	0	0	0
Europe	9	5	1	5	5
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	1K NMOS	N/A	N/A	S	5	5
General Instrument	4K MNOS	150	100	50	50	350
Hughes	64x4 CMOS	25	25	25	25	100
Intel	1K, 4K NMOS	10	10	5	5	30
NCR	256, 4K Bits	28	25	25	25	103
SGS	1K	65	50	75	50	240
Xicor	Many NMOS	700	700	650	650	2,700
Total		978	910	830	810	3,528
Percentage Change from Previous Quarter		(35%)	(7%)	(9%)	(2%)	
Cumulative Total		10,863	11,773	12,603	13,413	
Average Selling Price		$3.70	$4.00	$4.50	$4.25	$4.09
Revenue ($M)		3.6	3.6	3.7	3.4	14.4

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	93%	95%	91%	93%	93%
Japan	0	0	0	1	0
Europe	7	5	9	6	7
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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MOS EEPROM--Data

Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	256 Bits, 1K CMOS	S	5	5	5	15
Fujitsu	1K CMOS	5	5	5	5	20
Hughes	256 Bits CMOS	25	50	75	75	225
NCR	256 Bits, 4K	45	50	50	58	203
SGS	256 Bits, 1K CMOS	50	50	50	50	200
Xicor	256-4K Bits NMOS	780	740	710	670	2,900
Total		905	900	895	863	3,563
Percentage Change from Previous Quarter		12%	(1)	1%	(4%)	
Cumulative Total		14,318	15,218	16,113	16,976	
Average Selling Price		$4.25	$4.15	$4.00	$4.00	$4.10
Revenue ($M)		3.8	3.7	3.6	3.5	14.6

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	94%	94%	94%	94%	94%
Japan	1	1	1	1	1
Europe	5	5	5	6	6
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

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

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	256 Bits, 1K CMOS	5	5	10	10	30
Fujitsu	1K NMOS	5	10	10	20	45
Hughes	256 Bits CMOS	50	25	25	25	125
NCR	256 Bits, 1K SNOS	5	7	8	7	27
SGS-Thomson	1K CMOS	12	18	6	27	63
Xicor	256-4K Bits NMOS	708	892	900	1,100	3,600
Total		785	957	959	1,189	3,890
Percentage Change from Previous Quarter		(9%)	22%	0	24%	
Cumulative Total		17,761	18,718	19,677	20,866	
Average Selling Price		$4.15	$4.28	$4.46	$4.68	$4.42
Revenue ($M)		3.3	4.1	4.3	5.6	17.2

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	97.8%	97.1%	98.3%	96.0%	97.2%
Japan	0.6	1.0	1.0	1.7	1.2
Europe	1.5	1.9	0.6	2.3	1.6
Asia/Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

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MOS EEPROM—Data

Table 2

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	3,600	3,840	4,200	4,800	16,440
Hughes	Many CMOS	0	0	0	0	0
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	N/A	S	S	5	5
National Semiconductor	Many	100	220	500	850	1,670
Xicor	Many	400	500	600	700	2,200
Total		5,600	6,060	6,800	7,855	26,315
Percentage Change from Previous Quarter			8.2%	12.2%	15.5%	
Cumulative Total		5,600	11,660	18,460	26,315	
Average Selling Price		$1.65	$1.55	$1.45	$1.35	$1.49
Revenue ($M)		9.2	9.4	9.9	10.6	39.1

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	73%	75%	78%	81%	77%
Japan	27	25	22	19	23
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	4,800	5,040	5,040	5,400	20,280
Hughes	Many CMOS	0	10	10	25	45
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	10	25	50	50	135
National Semiconductor	Many	1,100	1,600	2,400	3,200	8,300
NCR	Many	700	700	800	850	3,050
Xicor	4K	250	350	400	500	1,500
Total		8,360	9,225	10,200	11,525	39,310
Percentage Change from Previous Quarter		6.4%	10.3%	10.6%	13.0%	
Cumulative Total		34,675	43,900	54,100	65,625	
Average Selling Price		$1.35	$1.30	$1.25	$1.25	$1.28
Revenue ($M)		11.3	12.0	12.8	14.4	50.4

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	82%	84%	85%	87%	85%
Japan	18	16	15	13	15
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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MOS EEPROM--Data

Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many MNOS	5,000	4,500	4,000	3,200	16,700
Hughes	Many CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	S	5	5
ICT	1K CMOS	N/A	S	5	10	15
Matsushita	Many MNOS	1,000	800	500	200	2,500
Mitsubishi	Many MNOS	100	100	50	50	300
Motorola	256 Bits	50	50	50	50	200
National Semiconductor	Many	2,400	3,000	3,500	3,750	12,650
NCR	256, 1K SNOS	100	113	135	155	503
SGS	256-Bit CMOS	N/A	N/A	N/A	S	0
Sierra Semiconductor	256, 1K CMOS	N/A	N/A	S	0	0
Xicor	4K	250	225	225	200	900
Total		8,925	8,813	8,490	7,645	33,873
Percentage Change from Previous Quarter		(22.6%)	(1.3%)	(3.7%)	(10.0%)	
Cumulative Total		74,550	83,363	91,853	99,498	
Average Selling Price		$1.20	$1.15	$1.00	$1.10	$1.11
Revenue ($M)		10.7	10.1	8.5	8.4	37.7

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	88%	90%	94%	97%	92%
Japan	12	10	6	3	8
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	1K CMOS	N/A	N/A	N/A	S	0
General Instrument	Many MNOS	2,000	3,000	3,000	3,000	11,000
Hughes	256-Bit CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	N/A	S	0
ICT	1K CMOS	10	10	10	10	40
Matsushita	MNOS	500	200	50	0	750
Mitsubishi	MNOS	0	0	0	0	0
Motorola	256 Bits	251	370	322	301	1,244
National Semiconductor	Many	2,500	3,000	3,200	3,200	11,900
NCR	256, 1K SNOS	175	200	240	275	890
NEC	8K CMOS	N/A	N/A	S	S	0
Oki	1K CMOS	N/A	N/A	N/A	S	0
Philips	1K CMOS	N/A	N/A	N/A	S	0
SEEQ	4K NMOS	N/A	N/A	N/A	S	0
SGS	256, 1K CMOS	55	160	530	340	1,085
Sierra Semiconductor	256, 1K CMOS	0	5	5	20	30
Sony	1K, 2K CMOS	N/A	N/A	S	S	0
Xicor	2K, 4K	350	350	250	200	1,150
Total		5,866	7,320	7,632	7,371	28,189
Percentage Change from Previous Quarter		(23.3%)	24.8%	4.3%	(3.4%)	
Cumulative Total		105,364	112,684	120,316	127,687	
Average Selling Price		$1.05	$1.00	$1.00	$1.00	$1.01
Revenue ($M)		6.2	7.3	7.6	7.4	28.5

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	95%	92%	95%	93%
Japan	9	3	1	0	3
Europe	1	2	7	5	4
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

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

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	1K,2K,4K CMOS	0	2	5	5	12
Hughes	256-Bit CMOS	0	0	0	0	0
Hyundai	1K CMOS	2	5	5	5	17
ICT	1K CMOS	50	100	150	200	500
Matsushita	MNOS	0	0	0	0	0
Microchip Tech., Inc.	MNOS & SNOS	2,007	1,716	1,687	2,020	7,430
Mitsubishi	MNOS	5,500	5,300	5,300	5,700	21,800
Motorola	256-1K	400	425	425	475	1,725
National Semiconductor	Many	2,432	4,941	3,177	3,610	14,160
NCR	256, 1K SNOS	133	145	130	170	578
NEC	8K CMOS	0	0	0	0	0
Oki	1K CMOS	0	50	120	230	400
Philips	2K CMOS	0	0	2	5	7
SEEQ	4K NMOS	10	12	15	20	57
SGS-Thomson	256-1K CMOS	332	463	388	370	1,553
Sierra Semiconductor	256-1K CMOS	10	15	20	25	70
Sony	1K, 2K CMOS	0	5	10	10	25
Xicor	2K, 4K	1,600	1,295	850	780	4,525
Total		12,476	14,474	12,284	13,625	52,859
Percentage Change from Previous Quarter		69.3%	16.0%	(15.1%)	10.9%	
Cumulative Total		140,163	154,637	166,921	180,546	
Average Selling Price		$0.70	$0.73	$0.76	$0.79	$0.75
Revenue ($M)		8.7	10.6	9.3	10.8	39.4

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	53.2%	59.8%	52.6%	53.6%	55.0%
Japan	44.1	37.0	44.2	43.6	42.0
Europe	2.7	3.2	3.2	2.8	3.0
Asia/Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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MOS EEPROM--Data

Table 3

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	N/A	N/A	S	S	0
Hitachi	MNOS	10	25	35	40	110
Hughes	CMOS	N/A	N/A	N/A	S	0
Intel	NMOS	60	80	80	140	360
Motorola	NMOS	2	5	10	10	27
NCR	MNOS	5	5	5	5	20
SEEQ	NMOS	N/A	N/A	5	15	20
Xicor	NMOS	N/A	N/A	S	20	20
Total		77	115	135	230	557
Percentage Change from Previous Quarter		28%	49%	17%	70%	
Cumulative Total		137	252	387	617	
Average Selling Price		$30.00	$25.00	$23.00	$20.00	$23.11
Revenue ($M)		2.3	2.9	3.1	4.6	12.9

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	87%	78%	74%	83%	80%
Japan	13	22	26	17	20
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	S	S	0	0	0
Hitachi	MNOS	50	60	60	30	200
Hughes	CMOS	S	S	0	0	0
Intel	NMOS	180	200	220	250	850
Motorola	NMOS	10	10	10	10	40
NEC	NMOS	N/A	N/A	N/A	S	0
NCR	MNOS	5	5	5	5	20
Rockwell	NMOS	N/A	N/A	N/A	S	0
SEEQ	NMOS	15	80	95	120	310
Xicor	NMOS	35	50	90	170	345
Total		295	405	480	585	1,765
Percentage Change from Previous Quarter		28%	37%	19%	22%	
Cumulative Total		912	1,317	1,797	2,382	
Average Selling Price		$20.00	$18.00	$15.00	$13.50	$16.01
Revenue ($M)		5.9	7.3	7.2	7.9	28.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	84%	86%	88%	95%	89%
Japan	16	14	12	5	11
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	NMOS	N/A	N/A	S	200	200
General Instrument	MNOS	0	0	0	0	0
Hitachi	MNOS	0	0	0	0	0
Hughes	CMOS	0	0	0	0	0
Intel	NMOS	300	375	400	425	1,500
Motorola	NMOS	15	15	10	10	50
National Semiconductor	CMOS	N/A	N/A	N/A	S	0
NEC	NMOS	S	S	5	5	10
NCR	MNOS	0	0	0	0	0
Rockwell	NMOS	5	5	0	0	10
SEEQ	NMOS	150	200	235	270	855
Xicor	NMOS	250	350	450	500	1,550
Total		720	945	1,100	1,410	4,175
Percentage Change from Previous Quarter		23%	31%	16%	28%	
Cumulative Total		3,102	4,047	5,147	6,557	
Average Selling Price		$14.50	$13.00	$11.50	$10.50	$12.02
Revenue ($M)		10.4	12.3	12.7	14.8	50.2

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	N/A	N/A	S	10	10
Exel	NMOS	75	75	100	35	285
	CMOS fast	N/A	S	S	0	0
General Instrument	MNOS	0	0	0	0	0
Intel	NMOS	140	130	125	120	515
Motorola	NMOS	10	10	10	10	40
National Semiconductor	CMOS	0	0	0	1	1
Rockwell	NMOS	0	0	0	0	0
Samsung	NMOS	S	0	5	5	10
SEEQ	NMOS	200	250	325	400	1,175
Xicor	NMOS	400	350	325	300	1,375
Total		825	815	890	881	3,411
Percentage Change from Previous Quarter		(25%)	(1%)	9%	(1%)	
Cumulative Total		7,382	8,197	9,087	9,968	
Average Selling Price		$9.50	$8.25	$7.00	$6.00	$7.60
Revenue ($M)		7.8	6.7	6.2	5.3	26.1

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	91%	88%	95%	91%
Japan	9	9	11	4	8
Europe	0	0	0	0	0
Asia/Pacific	0	0	1	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	12	15	20	27	74
Atmel	CMOS fast	N/A	S	0	0	0
Catalyst	CMOS fast	N/A	N/A	N/A	S	0
Exel	CMOS fast	S	5	5	5	20
General Instrument	CMOS fast	5	0	5	5	10
Intel	NMOS	150	100	100	50	400
National Semiconductor	CMOS	0	0	0	0	0
Samsung	NMOS	0	1	5	5	11
SEEQ	NMOS	400	400	450	500	1,750
Xicor	NMOS	500	500	550	650	2,200
Total		1,067	1,021	1,135	1,242	4,465
Percentage Change from Previous Quarter		21%	(4%)	11%	9%	
Cumulative Total		11,035	12,056	13,191	14,433	
Average Selling Price		$6.50	$6.00	$5.50	$5.00	$5.70
Revenue ($M)		6.9	6.1	6.2	6.2	25.5

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	99%	99%	99%	99%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	18	33	35	10	96
Atmel	CMOS fast	0	0	0	0	0
Catalyst	CMOS	S	0	0	0	0
	CMOS fast	N/A	N/A	N/A	N/A	0
Exel	NMOS fast	20	20	25	25	90
Microchip Tech., Inc.	CMOS	15	22	28	12	77
IDT	CMOS fast	N/A	N/A	N/A	S	0
Intel	NMOS	75	75	25	20	195
Oki	NMOS	30	30	20	N/A	80
	CMOS fast	N/A	N/A	S	20	20
Samsung	NMOS	5	5	7	9	26
SEEQ	NMOS	420	470	500	569	1,959
	CMOS fast	N/A	N/A	N/A	S	0
Xicor	NMOS	660	790	820	855	3,125
	CMOS	N/A	N/A	N/A	S	0
	NMOS	1,228	1,423	1,423	1,488	5,571
	CMOS	15	22	28	32	97
Total		1,243	1,445	1,460	1,520	5,668
Percentage Change from Previous Quarter		(1%)	17%	1%	5%	
Cumulative Total		15,676	17,121	18,581	20,101	
Average Selling Price	NMOS	$ 4.75	$ 5.00	$ 5.05	$ 5.10	$ 4.98
	CMOS	$17.00	$15.00	$13.00	$11.00	$13.41
	Overall	$ 4.90	$ 5.15	$ 5.20	$ 5.22	$ 5.13
Revenue ($M)		6.1	7.4	7.6	7.9	29.1

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	95.6%	96.2%	96.4%	96.4%	96.2%
Japan	4.0	3.5	3.1	3.0	3.4
Europe	0	0	0	0	0
Asia/Pacific	0.4	0.3	0.5	0.6	0.5
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

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MOS EEPROM--Data

Table 4

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Motorola	HMOS	N/A	N/A	S	S	S
NCR	MNOS	N/A	N/A	N/A	S	S
SEEQ	NMOS	N/A	N/A	S	S	S
Total		0	0	0	0	0
Percentage Change from Previous Quarter						
Cumulative Total		0	0	0	0	
Average Selling Price				$50.00	$45.00	
Revenue ($M)						

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	N/A	N/A	S	S	S
Motorola	HMOS	5	10	10	10	35
NCR	MNOS	5	10	10	10	35
SEEQ	NMOS	0	0	0	0	0
Total		10	20	20	20	70
Percentage Change from Previous Quarter		0	100%	0	0	
Cumulative Total		10	30	50	70	
Average Selling Price		$35.00	$25.00	$20.00	$15.00	$22.14
Revenue ($M)		0.4	0.5	0.4	0.3	1.6

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	0	0	0	0	0
Motorola	HMOS	5	5	0	0	10
NCR	MNOS	0	0	0	1	1
SEEQ	NMOS	0	0	0	0	0
Total		5	5	0	1	11
Percentage Change from Previous Quarter		(75%)	0	(100%)	0	
Cumulative Total		75	80	80	81	316
Average Selling Price		$15.00	$15.00	$14.00	$14.00	$14.91
Revenue ($M)		0.1	0.1	0.0	0.0	0.2

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	0	100%	100%

(Continued)

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MOS EEPROM--Data

Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NCR	MNOS	1	1	3	3	8
SEEQ	NMOS	0	0	0	0	0
Total		1	1	3	3	8
Percentage Change from Previous Quarter		0	0	200%	0	
Cumulative Total		317	318	321	324	1,280
Average Selling Price		$14.00	$12.00	$10.00	$10.00	$10.75
Revenue ($M)		0	0	0	0	0.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NCR	MNOS	0	0	0	0	0
SEEQ	CMOS 35ns	N/A	N/A	N/A	S	0
Total		0	0	0	0	0
Percentage Change from Previous Quarter		(100%)				
Cumulative Total		1,280	1,280	1,280	1,280	
Average Selling Price					$16.00	
Revenue ($M)		0	0	0	0	0

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	0	0	0
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	0	0	0	0	0

S = Sample

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MOS EEPROM--Data

Table 5

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	MNOS	N/A	N/A	N/A	N/A	0
Inmos	MNOS	N/A	N/A	N/A	N/A	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
SEEQ	NMOS	N/A	N/A	N/A	3	3
Xicor	NMOS	N/A	N/A	N/A	N/A	0
Total		0	0	0	3	3
Percentage Change from Previous Quarter		0	0	0	0	
Cumulative Total		0	0	0	3	
Average Selling Price		0	$150	$150	$100	$100
Revenue ($M)		0.0	0.0	0.0	0.3	0.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	S	S	1	1	2
Exel	CMOS	N/A	S	S	0	0
Hitachi	MNOS	N/A	N/A	N/A	S	0
Inmos	MNOS	N/A	N/A	S	S	0
NCR	SNOS	N/A	N/A	S	S	0
SEEQ	NMOS	10	20	20	35	85
Xicor	NMOS	2	7	15	30	54
Total		12	27	36	66	141
Percentage Change from Previous Quarter		300%	125%	33%	83%	
Cumulative Total		15	42	78	144	
Average Selling Price		$80	$70	$50	$40	$52
Revenue ($M)		1.0	1.9	1.8	2.6	7.3

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	2	8	15	20	45
Atmel	CMOS	N/A	N/A	N/A	S	0
Exel	CMOS	0	0	0	0	0
Fujitsu	CMOS	N/A	N/A	N/A	S	0
Hitachi	SNOS	10	15	25	100	150
Inmos	MNOS	0	0	0	0	0
Lattice	CMOS fast	N/A	S	S	0	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
SEEQ	NMOS	40	55	80	115	290
Xicor	NMOS	50	60	100	140	350
	NMOS fast	N/A	S	0	10	10
	CMOS fast	N/A	N/A	N/A	N/A	0
Total		102	138	220	385	845
Percentage Change from Previous Quarter		55%	35%	59%	75%	
Cumulative Total		246	384	604	989	
Average Selling Price		$35	$20	$25	$20	$23
Revenue ($M)		3.6	2.8	5.5	7.7	19.5

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	90%	89%	89%	74%	82%
Japan	10	11	11	26	18
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	35	50	50	50	185
Atmel	CMOS	0	0	0	0	0
Catalyst	CMOS	N/A	N/A	N/A	N/A	0
Fujitsu	CMOS	S	5	10	10	25
General Instrument	CMOS	S	5	10	10	25
	CMOS fast	N/A	N/A	S	0	0
Hitachi	NMOS	75	100	100	100	375
	CMOS	N/A	N/A	N/A	S	0
Hyundai	CMOS	N/A	N/A	N/A	S	0
ICT	CMOS	N/A	N/A	N/A	N/A	0
Intel	NMOS	N/A	S	10	20	30
Lattice	CMOS fast	0	0	S	5	10
Mitsubishi	CMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	N/A	N/A	N/A	N/A	0
Oki	CMOS	N/A	N/A	N/A	N/A	0
Samsung	NMOS	N/A	N/A	S	0	0
SEEQ	NMOS	115	125	125	125	490
Siemens	CMOS	N/A	N/A	N/A	N/A	0
Toshiba	CMOS fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS	200	200	250	250	900
	NMOS fast	5	10	10	20	45
	CMOS	N/A	N/A	N/A	S	0
Total		430	495	570	590	2,085
Percentage Change from Previous Quarter		12%	15%	15%	4%	
Cumulative Total		1,419	1,914	2,484	3,074	
Average Selling Price		$20	$18	$15	$12	$16
Revenue ($M)		8.6	8.9	8.6	7.1	33.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	83%	79%	81%	81%	81%
Japan	17	21	19	19	19
Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	70	115	95	125	405
Atmel	CMOS	0	0	0	0	0
Catalyst	CMOS	1	2	5	4	12
Exel	NMOS	25	25	30	30	110
Fujitsu	CMOS	1	2	3	5	11
Hitachi	NMOS	40	55	70	70	235
	CMOS	S	0	0	0	0
Hyundai	CMOS	2	3	4	6	15
ICT	CMOS	N/A	N/A	N/A	N/A	0
Intel	NMOS	20	25	15	15	75
Microchip Tech., Inc.	CMOS	15	30	48	40	133
Mitsubishi	CMOS	N/A	N/A	N/A	S	0
Motorola	NMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	N/A	N/A	N/A	N/A	0
Oki	CMOS	S	0	0	0	0
Samsung	NMOS	2	4	5	8	19
SEEQ	NMOS	121	145	160	207	633
	NMOS fast	S	4	8	11	23
	CMOS	3	9	19	26	57
Toshiba	CMOS fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS	211	239	306	389	1,145
	NMOS fast	0	2	5	8	15
	CMOS	9	4	7	9	20
	NMOS	489	614	694	863	2,660
	CMOS	21	53	93	95	262
Total		510	667	787	958	2,922
Percentage Change from Previous Quarter		(14%)	31%	18%	22%	
Cumulative Total		3,584	4,251	5,038	5,996	
Average Selling Price	NMOS	$15	$13	$11	$ 8	$11
	CMOS	$35	$32	$29	$24	$28
	Overall	$16	$15	$13	$10	$13
Revenue ($M)		8.1	9.7	10.3	9.2	37.3

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	86.5%	86.2%	84.9%	87.1%	86.2%
Japan	12.7	12.7	14.0	11.5	12.7
Europe	0	0	0	0	0
Asia/Pacific	0.8	1.0	1.1	1.5	1.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

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MOS EEPROM—Data

Table 6

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
SEEQ	CMOS/NMOS	S	0	3	5	8
Xicor	NMOS	S	0	5	10	15
Total		0	0	8	15	23
Percentage Change from Previous Quarter		0	0	0	88%	
Cumulative Total			0	8	23	
Average Selling Price			$400	$350	$300	$317
Revenue ($M)		0.0	0.0	2.8	4.5	7.3

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia/Pacific	0	0	0	0	0
Total	0	0	100%	100%	100%

S = Sample

(Continued)

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MOS EEPROM--Data

Table 6 (Continued)

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	0	0	0	0	0
Atmel	CMOS	0	0	0	0	0
NEC	CMOS	S	S	0	0	0
SEEQ	CMOS	9	12	19	22	62
Sharp	CMOS	S	0	0	0	0
Xicor	NMOS/CMOS	10	15	26	29	80
	NMOS	10	13	23	26	72
	CMOS	9	14	22	25	70
Total		19	27	45	51	142
Percentage Change from Previous Quarter		27%	42%	67%	13%	
Cumulative Total		42	69	114	165	
Average Selling Price	NMOS	$258	$212	$158	$109	$164
	CMOS	$286	$248	$199	$156	$205
	Overall	$271	$231	$178	$132	$184
Revenue ($M)		5.2	6.2	8.0	6.7	26.1

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	1
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

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MOS EEPROM--Data

QUARTERLY COMPANY MOS EEPROM SHIPMENT DATA

This section contains unit shipment data on MOS EEPROMs and NVRAMs from 1982 through 1987. In addition to unit shipments for NVRAMs and low-density (<16K), 16K, 32K, 64K, and 256K EEPROMS, we have added our estimates of the worldwide billing prices for each product during the four quarters of the year. At the bottom of the table, we show market share data (units, not revenue) for companies based in the United States, Japan, Europe, and Asia Pacific. The tables are organized as follows:

- Table 1—NVRAM Shipment Data, 1982-1987
- Table 2—Low-Density MOS EEPROM Shipment Data, 1983-1987
- Table 3—16K MOS EEPROM Shipment Data, 1982-1987
- Table 4—32K MOS EEPROM Shipment Data, 1983-1987
- Table 5—64K MOS EEPROM Shipment Data, 1983-1987
- Table 6—256K MOS EEPROM Shipment Data, 1986-1987

Definitions

Prices

Prices are Dataquest estimates of the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and the entire speed mix, and they represent sales to both military and commercial accounts. Since prices vary from company to company, and according to volume and contract orders, our prices should not be used to calculate the company revenue.

Unit Shipments

The unit shipment data have been gathered from the manufacturers and represent actual product movements to all market channels. Actual user consumption may be greater than or less than the estimated unit shipments as a result of distributor stocking and manufacturers' inventories for internal use.

Quarterly Revenue

Quarterly revenue is calculated as units shipped times the prevailing price during that period.

Sample

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 or column calculations in the table.

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MOS EEPROM--Data

Table 1

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	10	25	50	100	185
NCR	4K SNOS	10	10	25	60	105
SGS-Ates	1K NMOS	N/A	N/A	S	10	10
Xicor	256-4K Bits NMOS	70	100	170	250	590
Total		90	135	245	420	890
Percentage Change from Previous Quarter			50%	81%	71%	
Cumulative Total		90	225	470	890	
Average Selling Price		$4.30	$4.00	$3.53	$3.20	$3.52
Revenue ($M)		0.4	0.5	0.9	1.3	3.1

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	98%	99%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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MOS EEPROM--Data

Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	80	100	100	150	430
Hughes	64x4 CMOS	N/A	N/A	N/A	S	0
Intel	1K, 4K NMOS	N/A	N/A	S	5	5
NCR	256-4K Bits	100	150	200	300	750
Rockwell	256 Bits CMOS	N/A	N/A	N/A	S	0
SGS-Ates	1K NMOS	80	140	100	80	400
Xicor	256-4K Bits NMOS	330	590	600	830	2,350
Total		590	980	1,000	1,365	3,935
Percentage Change from Previous Quarter		40%	66%	2%	37%	
Cumulative Total		1,480	2,460	3,460	4,825	
Average Selling Price		$3.60	$3.56	$3.50	$3.98	$3.70
Revenue ($M)		2.1	3.5	3.5	5.4	14.5

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	86%	86%	90%	94%	90%
Japan	0	0	0	0	0
Europe	14	14	10	6	10
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	150	200	300	300	950
Hughes	64 x 4 CMOS	S	S	S	S	10
Intel	1K, 4K NMOS	5	10	20	25	60
NCR	256-4K Bits	200	200	250	250	900
Rockwell	256 Bits CMOS	S	S	0	0	0
SGS	1K NMOS	100	50	20	80	250
Xicor	256-4K Bits NMOS	600	640	800	850	2,890
Total		1,055	1,100	1,395	1,510	5,060
Percentage Change from Previous Quarter		(23%)	4%	27%	8%	
Cumulative Total		5,880	6,980	8,375	9,885	
Average Selling Price		$3.80	$3.30	$3.50	$3.60	$3.55
Revenue ($M)		4.0	3.6	4.9	5.4	18.0

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	95%	99%	95%	95%
Japan	0	0	0	0	0
Europe	9	5	1	5	5
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	1K NMOS	N/A	N/A	S	5	5
General Instrument	4K MNOS	150	100	50	50	350
Hughes	64x4 CMOS	25	25	25	25	100
Intel	1K, 4K NMOS	10	10	5	5	30
NCR	256, 4K Bits	28	25	25	25	103
SGS	1K	65	50	75	50	240
Xicor	Many NMOS	700	700	650	650	2,700
Total		978	910	830	810	3,528
Percentage Change from Previous Quarter		(35%)	(7%)	(9%)	(2%)	
Cumulative Total		10,863	11,773	12,603	13,413	
Average Selling Price		$3.70	$4.00	$4.50	$4.25	$4.09
Revenue ($M)		3.6	3.6	3.7	3.4	14.4

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	93%	95%	91%	93%	93%
Japan	0	0	0	1	0
Europe	7	5	9	6	7
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	256 Bits, 1K CMOS	S	5	5	5	15
Fujitsu	1K CMOS	5	5	5	5	20
Hughes	256 Bits CMOS	25	50	75	75	225
NCR	256 Bits, 4K	45	50	50	58	203
SGS	256 Bits, 1K CMOS	50	50	50	50	200
Xicor	256-4K Bits NMOS	780	740	710	670	2,900
Total		905	900	895	863	3,563
Percentage Change from Previous Quarter		12%	(1)	1%	(4%)	
Cumulative Total		14,318	15,218	16,113	16,976	
Average Selling Price		$4.25	$4.15	$4.00	$4.00	$4.10
Revenue ($M)		3.8	3.7	3.6	3.5	14.6

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	94%	94%	94%	94%	94%
Japan	1	1	1	1	1
Europe	5	5	5	6	6
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

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

(Continued)

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MOS EEPROM--Data

Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	256 Bits, 1K CMOS	5	5	10	10	30
Fujitsu	1K NMOS	5	10	10	20	45
Hughes	256 Bits CMOS	50	25	25	25	125
NCR	256 Bits, 1K SNOS	5	7	8	7	27
SGS-Thomson	1K CMOS	12	18	6	27	63
Xicor	256-4K Bits NMOS	708	892	900	1,100	3,600
Total		785	957	959	1,189	3,890
Percentage Change from Previous Quarter		(9%)	22%	0	24%	
Cumulative Total		17,761	18,718	19,677	20,866	
Average Selling Price		$4.15	$4.28	$4.46	$4.68	$4.42
Revenue ($M)		3.3	4.1	4.3	5.6	17.2

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	97.8%	97.1%	98.3%	96.0%	97.2%
Japan	0.6%	1.0%	1.0%	1.7%	1.2%
Europe	1.5%	1.9%	0.6%	2.3%	1.6%
Asia Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
May 1988

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MOS EEPROM--Data

Table 2

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	3,600	3,840	4,200	4,800	16,440
Hughes	Many CMOS	0	0	0	0	0
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	N/A	S	S	5	5
National Semiconductor	Many	100	220	500	850	1,670
Xicor	Many	400	500	600	700	2,200
Total		5,600	6,060	6,800	7,855	26,315
Percentage Change from Previous Quarter			8.2%	12.2%	15.5%	
Cumulative Total		5,600	11,660	18,460	26,315	
Average Selling Price		$1.65	$1.55	$1.45	$1.35	$1.49
Revenue ($M)		9.2	9.4	9.9	10.6	39.1

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	73%	75%	78%	81%	77%
Japan	27	25	22	19	23
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	4,800	5,040	5,040	5,400	20,280
Hughes	Many CMOS	0	10	10	25	45
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	10	25	50	50	135
National Semiconductor	Many	1,100	1,600	2,400	3,200	8,300
NCR	Many	700	700	800	850	3,050
Xicor	4K	250	350	400	500	1,500
Total		8,360	9,225	10,200	11,525	39,310
Percentage Change from Previous Quarter		6.4%	10.3%	10.6%	13.0%	
Cumulative Total		34,675	43,900	54,100	65,625	
Average Selling Price		$1.35	$1.30	$1.25	$1.25	$1.28
Revenue ($M)		11.3	12.0	12.8	14.4	50.4

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	82%	84%	85%	87%	85%
Japan	18	16	15	13	15
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many MNOS	5,000	4,500	4,000	3,200	16,700
Hughes	Many CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	S	5	5
ICT	1K CMOS	N/A	S	5	10	15
Matsushita	Many MNOS	1,000	800	500	200	2,500
Mitsubishi	Many MNOS	100	100	50	50	300
Motorola	256 Bits	50	50	50	50	200
National Semiconductor	Many	2,400	3,000	3,500	3,750	12,650
NCR	256, 1K SNOS	100	113	135	155	503
SGS	256-bit CMOS	N/A	N/A	N/A	S	0
Sierra Semiconductor	256, 1K CMOS	N/A	N/A	S	0	0
Xicor	4K	250	225	225	200	900
Total		8,925	8,813	8,490	7,645	33,873
Percentage Change from Previous Quarter		(22.6%)	(1.3%)	(3.7%)	(10.0%)	
Cumulative Total		74,550	83,363	91,853	99,498	
Average Selling Price		$1.20	$1.15	$1.00	$1.10	$1.11
Revenue ($M)		10.7	10.1	8.5	8.4	37.7

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	88%	90%	94%	97%	92%
Japan	12	10	6	3	8
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	1K CMOS	N/A	N/A	N/A	S	0
General Instrument	Many MNOS	2,000	3,000	3,000	3,000	11,000
Hughes	256-Bit CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	N/A	S	0
ICT	1K CMOS	10	10	10	10	40
Matsushita	MNOS	500	200	50	0	750
Mitsubishi	MNOS	0	0	0	0	0
Motorola	256 Bits	251	370	322	301	1,244
National Semiconductor	Many	2,500	3,000	3,200	3,200	11,900
NCR	256, 1K SNOS	175	200	240	275	890
NEC	8K CMOS	N/A	N/A	S	S	0
Oki	1K CMOS	N/A	N/A	N/A	S	0
Philips	1K CMOS	N/A	N/A	N/A	S	0
Seeq	4K NMOS	N/A	N/A	N/A	S	0
SGS	256, 1K CMOS	55	160	530	340	1,085
Sierra Semiconductor	256, 1K CMOS	0	5	5	20	30
Sony	1K, 2K CMOS	N/A	N/A	S	S	0
Xicor	2K, 4K	350	350	250	200	1,150
Total		5,866	7,320	7,632	7,371	28,189
Percentage Change from Previous Quarter		(23.3%)	24.8%	4.3%	(3.4%)	
Cumulative Total		105,364	112,684	120,316	127,687	
Average Selling Price		$1.05	$1.00	$1.00	$1.00	$1.01
Revenue ($M)		6.2	7.3	7.6	7.4	28.5

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	95%	92%	95%	93%
Japan	9	3	1	0	3
Europe	1	2	7	5	4
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

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

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	1K,2K,4K CMOS	0	2	5	5	12
Hughes	256-Bit CMOS	0	0	0	0	0
Hyundai	1K CMOS	2	5	5	5	17
ICT	1K CMOS	50	100	150	200	500
Matsushita	MNOS	0	0	0	0	0
Microchip Tech., Inc.	MNOS & SNOS	2,007	1,716	1,687	2,020	7,430
Mitsubishi	MNOS	6,000	5,000	6,000	6,000	23,000
Motorola	256-1K	400	425	425	475	1,725
National Semiconductor	Many	2,432	4,941	3,177	3,610	14,160
NCR	256, 1K SNOS	133	145	130	170	578
NEC	8K CMOS	0	0	0	0	0
Oki	1K CMOS	0	50	120	230	400
Philips	2K CMOS	0	0	2	5	7
Seeq	4K NMOS	10	12	15	20	57
SGS-Thomson	256-1K CMOS	332	463	388	370	1,553
Sierra Semiconductor	256-1K CMOS	10	15	20	25	70
Sony	1K, 2K CMOS	0	5	10	10	25
Xicor	2K, 4K	1,600	1,295	850	780	4,525
Total		12,976	14,174	12,984	13,925	54,059
Percentage Change from Previous Quarter		76.0%	9.2%	(8.4%)	7.2%	
Cumulative Total		140,663	154,837	167,821	181,746	
Average Selling Price		$0.70	$0.73	$0.76	$0.79	$0.75
Revenue ($M)		9.1	10.3	9.9	11.0	40.3

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	51.2%	61.0%	49.7%	52.5%	53.8%
Japan	46.2%	35.7%	47.2%	44.8%	43.3%
Europe	2.6%	3.3%	3.0%	2.7%	2.9%
Asia Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
May 1988

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MOS EEPROM--Data

Table 3

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	N/A	N/A	S	S	0
Hitachi	MNOS	10	25	35	40	110
Hughes	CMOS	N/A	N/A	N/A	S	0
Intel	NMOS	60	80	80	140	360
Motorola	NMOS	2	5	10	10	27
NCR	MNOS	5	5	5	5	20
Seeq	NMOS	N/A	N/A	5	15	20
Xicor	NMOS	N/A	N/A	S	20	20
Total		77	115	135	230	557
Percentage Change from Previous Quarter		28%	49%	17%	70%	
Cumulative Total		137	252	387	617	
Average Selling Price		$30.00	$25.00	$23.00	$20.00	$23.11
Revenue ($M)		2.3	2.9	3.1	4.6	12.9

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	87%	78%	74%	83%	80%
Japan	13	22	26	17	20
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	S	S	0	0	0
Hitachi	MNOS	50	60	60	30	200
Hughes	CMOS	S	S	0	0	0
Intel	NMOS	180	200	220	250	850
Motorola	NMOS	10	10	10	10	40
NEC	NMOS	N/A	N/A	N/A	S	0
NCR	MNOS	5	5	5	5	20
Rockwell	NMOS	N/A	N/A	N/A	S	0
Seeq	NMOS	15	80	95	120	310
Xicor	NMOS	35	50	90	170	345
Total		295	405	480	585	1,765
Percentage Change from Previous Quarter		28%	37%	19%	22%	
Cumulative Total		912	1,317	1,797	2,382	
Average Selling Price		$20.00	$18.00	$15.00	$13.50	$16.01
Revenue ($M)		5.9	7.3	7.2	7.9	28.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	84%	86%	88%	95%	89%
Japan	16	14	12	5	11
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	NMOS	N/A	N/A	S	200	200
General Instrument	MNOS	0	0	0	0	0
Hitachi	MNOS	0	0	0	0	0
Hughes	CMOS	0	0	0	0	0
Intel	NMOS	300	375	400	425	1,500
Motorola	NMOS	15	15	10	10	50
National Semiconductor	CMOS	N/A	N/A	N/A	S	0
NEC	NMOS	S	S	5	5	10
NCR	MNOS	0	0	0	0	0
Rockwell	NMOS	5	5	0	0	10
Seeq	NMOS	150	200	235	270	855
Xicor	NMOS	250	350	450	500	1,550
Total		720	945	1,100	1,410	4,175
Percentage Change from Previous Quarter		23%	31%	16%	28%	
Cumulative Total		3,102	4,047	5,147	6,557	
Average Selling Price		$14.50	$13.00	$11.50	$10.50	$12.02
Revenue ($M)		10.4	12.3	12.7	14.8	50.2

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	N/A	N/A	S	10	10
Exel	NMOS	75	75	100	35	285
	CMOS fast	N/A	S	S	0	0
General Instrument	MNOS	0	0	0	0	0
Intel	NMOS	140	130	125	120	515
Motorola	NMOS	10	10	10	10	40
National Semiconductor	CMOS	0	0	0	1	1
Rockwell	NMOS	0	0	0	0	0
Samsung	NMOS	S	0	5	5	10
Seeq	NMOS	200	250	325	400	1,175
Xicor	NMOS	400	350	325	300	1,375
Total		825	815	890	881	3,411
Percentage Change from Previous Quarter		(25%)	(1%)	9%	(1%)	
Cumulative Total		7,382	8,197	9,087	9,968	
Average Selling Price		$9.50	$8.25	$7.00	$6.00	$7.60
Revenue ($M)		7.8	6.7	6.2	5.3	26.1

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	91%	88%	95%	91%
Japan	9	9	11	4	8
Europe	0	0	0	0	0
Asia Pacific	0	0	1	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	12	15	20	27	74
Atmel	CMOS fast	N/A	S	0	0	0
Catalyst	CMOS fast	N/A	N/A	N/A	S	0
Exel	CMOS fast	S	5	5	5	20
General Instrument	CMOS fast	5	0	5	5	10
Intel	NMOS	150	100	100	50	400
National Semiconductor	CMOS	0	0	0	0	0
Samsung	NMOS	0	1	5	5	11
Seeq	NMOS	400	400	450	500	1,750
Xicor	NMOS	500	500	550	650	2,200
Total		1,067	1,021	1,135	1,242	4,465
Percentage Change from Previous Quarter		21%	(4%)	11%	9%	
Cumulative Total		11,035	12,056	13,191	14,433	
Average Selling Price		$6.50	$6.00	$5.50	$5.00	$5.70
Revenue ($M)		6.9	6.1	6.2	6.2	25.5

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	99%	99%	99%	99%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

(Continued)

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MOS EEPROM--Data

Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	18	33	35	10	96
Atmel	CMOS fast	0	0	0	0	0
Catalyst	CMOS	S	0	0	0	0
	CMOS fast	N/A	N/A	N/A	N/A	0
Exel	CMOS fast	5	8	8	6	27
Microchip Tech., Inc.	CMOS	15	22	28	32	97
IDT	CMOS fast	N/A	N/A	N/A	S	0
Intel	NMOS	75	75	25	20	195
Oki	NMOS	30	30	20	N/A	80
	CMOS fast	N/A	N/A	S	20	20
Samsung	NMOS	5	5	7	9	26
Seeq	NMOS	420	470	500	569	1,959
	CMOS fast	N/A	N/A	N/A	S	0
Xicor	NMOS	660	790	820	855	3,125
	CMOS	N/A	N/A	N/A	S	0
	NMOS	1,208	1,403	1,407	1,463	5,481
	CMOS	20	30	36	58	144
Total		1,228	1,433	1,443	1,521	5,625
Percentage Change from Previous Quarter		(1%)	17%	1%	5%	
Cumulative Total		15,661	17,094	18,537	20,058	
Average Selling Price	NMOS	$ 4.75	$ 5.00	$ 5.05	$ 5.10	$ 4.98
	CMOS	$17.00	$15.00	$13.00	$11.00	$13.17
	Overall	$ 4.95	$ 5.21	$ 5.25	$ 5.32	$ 5.19
Revenue ($M)		6.1	7.5	7.6	8.1	29.2

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	96.7%	97.0%	97.6%	97.7%	97.3%
Japan	2.9%	2.7%	1.9%	1.7%	2.3%
Europe	0	0	0	0	0
Asia Pacific	0.4%	0.3%	0.5%	0.6%	0.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
May 1988

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Table 4

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Motorola	HMOS	N/A	N/A	S	S	S
NCR	MNOS	N/A	N/A	N/A	S	S
Seeq	NMOS	N/A	N/A	S	S	S
Total		0	0	0	0	0
Percentage Change from Previous Quarter						
Cumulative Total		0	0	0	0	
Average Selling Price				$50.00	$45.00	

Revenue ($M)

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	N/A	N/A	S	S	S
Motorola	HMOS	5	10	10	10	35
NCR	MNOS	5	10	10	10	35
Seeq	NMOS	0	0	0	0	0
Total		10	20	20	20	70
Percentage Change from Previous Quarter		0	100%	0	0	
Cumulative Total		10	30	50	70	
Average Selling Price		$35.00	$25.00	$20.00	$15.00	$22.14
Revenue ($M)		0.4	0.5	0.4	0.3	1.6

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM SHIPMENT DATA
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	0	0	0	0	0
Motorola	HMOS	5	5	0	0	10
NCR	MNOS	0	0	0	1	1
Seeq	NMOS	0	0	0	0	0
Total		5	5	0	1	11
Percentage Change from Previous Quarter		(75%)	0	(100%)	0	
Cumulative Total		75	80	80	81	316
Average Selling Price		$15.00	$15.00	$14.00	$14.00	$14.91
Revenue ($M)		0.1	0.1	0.0	0.0	0.2

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	0	100%	100%

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NCR	MNOS	1	1	3	3	8
Seeq	NMOS	0	0	0	0	0
Total		1	1	3	3	8
Percentage Change from Previous Quarter		0	0	200%	0	
Cumulative Total		317	318	321	324	1,280
Average Selling Price		$14.00	$12.00	$10.00	$10.00	$10.75
Revenue ($M)		0	0	0	0	0.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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MOS EEPROM--Data

Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NCR	MNOS	0	0	0	0	0
Seeq	CMOS 35ns	N/A	N/A	N/A	S	0
Total		0	0	0	0	0
Percentage Change from Previous Quarter		(100%)				
Cumulative Total		1,280	1,280	1,280	1,280	
Average Selling Price					$16.00	
Revenue ($M)		0	0	0	0	0

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	0	0	0
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	0	0	0	0	0

S = Sample

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May 1988

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Table 5

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	MNOS	N/A	N/A	N/A	N/A	0
Inmos	MNOS	N/A	N/A	N/A	N/A	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
Seeq	NMOS	N/A	N/A	N/A	3	3
Xicor	NMOS	N/A	N/A	N/A	N/A	0
Total		0	0	0	3	3
Percentage Change from Previous Quarter		0	0	0	0	
Cumulative Total		0	0	0	3	
Average Selling Price		0	$150	$150	$100	$100
Revenue ($M)		0.0	0.0	0.0	0.3	0.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	S	S	1	1	2
Exel	CMOS	N/A	S	S	0	0
Hitachi	MNOS	N/A	N/A	N/A	S	0
Inmos	MNOS	N/A	N/A	S	S	0
NCR	SNOS	N/A	N/A	S	S	0
Seeq	NMOS	10	20	20	35	85
Xicor	NMOS	2	7	15	30	54
Total		12	27	36	66	141
Percentage Change from Previous Quarter		300%	125%	33%	83%	
Cumulative Total		15	42	78	144	
Average Selling Price		$80	$70	$50	$40	$52
Revenue ($M)		1.0	1.9	1.8	2.6	7.3

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	2	8	15	20	45
Atmel	CMOS	N/A	N/A	N/A	S	0
Exel	CMOS	0	0	0	0	0
Fujitsu	CMOS	N/A	N/A	N/A	S	0
Hitachi	SNOS	10	15	25	100	150
Inmos	MNOS	0	0	0	0	0
Lattice	CMOS fast	N/A	S	S	0	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
Seeq	NMOS	40	55	80	115	290
Xicor	NMOS	50	60	100	140	350
	NMOS fast	N/A	S	0	10	10
	CMOS fast	N/A	N/A	N/A	N/A	0
Total		102	138	220	385	845
Percentage Change from Previous Quarter		55%	35%	59%	75%	
Cumulative Total		246	384	604	989	
Average Selling Price		$35	$20	$25	$20	$23
Revenue ($M)		3.6	2.8	5.5	7.7	19.5

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	90%	89%	89%	74%	82%
Japan	10	11	11	26	18
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	35	50	50	50	185
Atmel	CMOS	0	0	0	0	0
Catalyst	CMOS	N/A	N/A	N/A	N/A	0
Fujitsu	CMOS	S	5	10	10	25
General Instrument	CMOS	S	5	10	10	25
	CMOS fast	N/A	N/A	S	0	0
Hitachi	NMOS	75	100	100	100	375
	CMOS	N/A	N/A	N/A	S	0
Hyundai	CMOS	N/A	N/A	N/A	S	0
ICT	CMOS	N/A	N/A	N/A	N/A	0
Intel	NMOS	N/A	S	10	20	30
Lattice	CMOS fast	0	0	5	5	10
Mitsubishi	CMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	N/A	N/A	N/A	N/A	0
Oki	CMOS	N/A	N/A	N/A	N/A	0
Samsung	NMOS	N/A	N/A	S	0	0
Seeq	NMOS	115	125	125	125	490
Siemens	CMOS	N/A	N/A	N/A	N/A	0
Toshiba	CMOS fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS	200	200	250	250	900
	NMOS fast	5	10	10	20	45
	CMOS	N/A	N/A	N/A	S	0
Total		430	495	570	590	2,085
Percentage Change from Previous Quarter		12%	15%	15%	4%	
Cumulative Total		1,419	1,914	2,484	3,074	
Average Selling Price		$20	$18	$15	$12	$16
Revenue ($M)		8.6	8.9	8.6	7.1	33.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	83%	79%	81%	81%	81%
Japan	17	21	19	19	19
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	50	105	100	205	460
Atmel	CMOS	0	0	0	0	0
Catalyst	CMOS	1	2	5	4	12
Fujitsu	CMOS	1	2	3	5	11
Hitachi	NMOS	40	55	70	70	235
	CMOS	S	0	10	15	25
Hyundai	CMOS	2	3	4	6	15
ICT	CMOS	N/A	N/A	N/A	N/A	0
Intel	NMOS	20	25	15	15	75
Microchip Tech., Inc.	CMOS	15	30	48	50	143
Mitsubishi	CMOS	N/A	N/A	N/A	S	0
Motorola	NMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	N/A	N/A	N/A	N/A	0
Oki	CMOS	S	0	0	5	5
Samsung	NMOS	2	4	5	8	19
Seeq	NMOS	121	145	160	207	633
	NMOS fast	S	4	8	11	23
	CMOS	3	9	19	26	57
Toshiba	CMOS fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS	211	239	306	389	1,145
	NMOS fast	0	2	5	8	15
	CMOS	0	4	7	9	20
	NMOS	444	579	669	913	2,605
	CMOS	22	50	96	120	288
Total		466	629	765	1,033	2,893
Percentage Change from Previous Quarter		(21%)	35%	22%	35%	
Cumulative Total		3,540	4,169	4,934	5,967	
Average Selling Price	NMOS	$15	$13	$11	$ 8	$11
	CMOS	$35	$32	$29	$24	$28
	Overall	$16	$15	$13	$10	$13
Revenue ($M)		7.4	9.1	10.1	10.2	36.9

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	90.3%	89.8%	88.0%	89.4%	89.3%
Japan	8.8%	9.1%	10.8%	9.2%	9.5%
Europe	0	0	0	0	0
Asia Pacific	0.9%	1.1%	1.2%	1.4%	1.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample

Source: Dataquest
May 1988

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MOS EEPROM--Data

Table 6

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seeq	CMOS/NMOS	S	0	3	5	8
Xicor	NMOS	S	0	5	10	15
Total		0	0	8	15	23
Percentage Change from Previous Quarter		0	0	0	88%	
Cumulative Total			0	8	23	
Average Selling Price			$400	$350	$300	$317
Revenue ($M)		0.0	0.0	2.8	4.5	7.3

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia Pacific	0	0	0	0	0
Total	0	0	100%	100%	100%

S = Sample

(Continued)

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Table 6 (Continued)

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	0	0	0	0	0
Atmel	CMOS	0	0	0	0	0
NEC	CMOS	S	S	0	0	0
Seeq	CMOS	9	12	19	22	62
Sharp	CMOS	S	0	0	0	0
Xicor	NMOS/CMOS	10	15	26	29	80
	NMOS	10	13	23	26	72
	CMOS	9	14	22	25	70
Total		19	27	45	51	142
Percentage Change from Previous Quarter		27%	42%	67%	13%	
Cumulative Total		42	69	114	165	
Average Selling Price	NMOS	$258	$212	$158	$109	$164
	CMOS	$286	$248	$199	$156	$205
	Overall	$271	$231	$178	$132	$184
Revenue ($M)		5.2	6.2	8.0	6.7	26.1

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	1
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

Source: Dataquest
May 1988

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MOS EEPROM--Data

QUARTERLY COMPANY MOS EEPROM SHIPMENT DATA

This section contains unit shipment data on MOS EEPROMs and NVRAMs from 1982 through 1987. In addition to unit shipments for NVRAMs and low-density (<16K), 16K, 32K, 64K, and 256K EEPROMS, we have added our estimates of the worldwide billing prices for each product during the four quarters of the year. At the bottom of the table, we show market share data (units, not revenue) for companies based in the United States, Japan, Europe, and Asia Pacific. The tables are organized as follows:

- Table 1--NVRAM Shipment Data, 1982-1987
- Table 2—Low-Density MOS EEPROM Shipment Data, 1983-1987
- Table 3—16K MOS EEPROM Shipment Data, 1982-1987
- Table 4—32K MOS EEPROM Shipment Data, 1983-1987
- Table 5—64K MOS EEPROM Shipment Data, 1983-1987
- Table 6—256K MOS EEPROM Shipment Data, 1986-1987

Definitions

Prices

Prices are Dataquest estimates of the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and the entire speed mix, and they represent sales to both military and commercial accounts. Since prices vary from company to company, and according to volume and contract orders, our prices should not be used to calculate the company revenue.

Unit Shipments

The unit shipment data have been gathered from the manufacturers and represent actual product movements to all market channels. Actual user consumption may be greater than or less than the estimated unit shipments as a result of distributor stocking and manufacturers' inventories for internal use.

Quarterly Revenue

Quarterly revenue is calculated as units shipped times the prevailing price during that period.

Sample

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 or column calculations in the table.

MOS EEPROM--Data

Table 1

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	10	25	50	100	185
NCR	4K SNOS	10	10	25	60	105
SGS-Ates	1K NMOS	N/A	N/A	S	10	10
Xicor	256-4K Bits NMOS	70	100	170	250	590
Total		90	135	245	420	890
Percentage Change from Previous Quarter			50%	81%	71%	
Cumulative Total		90	225	470	890	
Average Selling Price		$4.30	$4.00	$3.53	$3.20	$3.52
Revenue ($M)		0.4	0.5	0.9	1.3	3.1

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	98%	99%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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MOS EEPROM--Data

Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	80	100	100	150	430
Hughes	64x4 CMOS	N/A	N/A	N/A	S	0
Intel	1K, 4K NMOS	N/A	N/A	S	5	5
NCR	256-4K Bits	100	150	200	300	750
Rockwell	256 Bits CMOS	N/A	N/A	N/A	S	0
SGS-Ates	1K NMOS	80	140	100	80	400
Xicor	256-4K Bits NMOS	330	590	600	830	2,350
Total		590	980	1,000	1,365	3,935
Percentage Change from Previous Quarter		40%	66%	2%	37%	
Cumulative Total		1,480	2,460	3,460	4,825	
Average Selling Price		$3.60	$3.56	$3.50	$3.98	$3.70
Revenue ($M)		2.1	3.5	3.5	5.4	14.5

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	86%	86%	90%	94%	90%
Japan	0	0	0	0	0
Europe	14	14	10	6	10
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	150	200	300	300	950
Hughes	64 x 4 CMOS	S	S	S	S	10
Intel	1K, 4K NMOS	5	10	20	25	60
NCR	256-4K Bits	200	200	250	250	900
Rockwell	256 Bits CMOS	S	S	0	0	0
SGS	1K NMOS	100	50	20	80	250
Xicor	256-4K Bits NMOS	600	640	800	850	2,890
Total		1,055	1,100	1,395	1,510	5,060
Percentage Change from Previous Quarter		(23%)	4%	27%	8%	
Cumulative Total		5,880	6,980	8,375	9,885	
Average Selling Price		$3.80	$3.30	$3.50	$3.60	$3.55
Revenue ($M)		4.0	3.6	4.9	5.4	18.0

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	95%	99%	95%	95%
Japan	0	0	0	0	0
Europe	9	5	1	5	5
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

(Continued)

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MOS EEPROM--Data

Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	1K NMOS	N/A	N/A	S	5	5
General Instrument	4K MNOS	150	100	50	50	350
Hughes	64x4 CMOS	25	25	25	25	100
Intel	1K, 4K NMOS	10	10	5	5	30
NCR	256, 4K Bits	28	25	25	25	103
SGS	1K	65	50	75	50	240
Xicor	Many NMOS	700	700	650	650	2,700
Total		978	910	830	810	3,528
Percentage Change from Previous Quarter		(35%)	(7%)	(9%)	(2%)	
Cumulative Total		10,863	11,773	12,603	13,413	
Average Selling Price		$3.70	$4.00	$4.50	$4.25	$4.09
Revenue ($M)		3.6	3.6	3.7	3.4	14.4

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	93%	95%	91%	93%	93%
Japan	0	0	0	1	0
Europe	7	5	9	6	7
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	256 Bits, 1K CMOS	S	5	5	5	15
Fujitsu	1K CMOS	5	5	5	5	20
Hughes	256 Bits CMOS	25	50	75	75	225
NCR	256 Bits, 4K	45	50	50	58	203
SGS	256 Bits, 1K CMOS	50	50	50	50	200
Xicor	256-4K Bits NMOS	780	740	710	670	2,900
Total		905	900	895	863	3,563
Percentage Change from Previous Quarter		12%	(1)	1%	(4%)	
Cumulative Total		14,318	15,218	16,113	16,976	
Average Selling Price		$4.25	$4.15	$4.00	$4.00	$4.10
Revenue ($M)		3.8	3.7	3.6	3.5	14.6

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	94%	94%	94%	94%	94%
Japan	1	1	1	1	1
Europe	5	5	5	6	6
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

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

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	256 Bits, 1K CMOS	5	5	10	10	30
Fujitsu	1K NMOS	5	10	10	20	45
Hughes	256 Bits CMOS	50	25	25	25	125
NCR	256 Bits, 1K SNOS	5	7	8	7	27
SGS-Thomson	1K CMOS	12	18	6	27	63
Xicor	256-4K Bits NMOS	708	892	900	1,100	3,600
Total		785	957	959	1,189	3,890
Percentage Change from Previous Quarter		(9%)	22%	0	24%	
Cumulative Total		17,761	18,718	19,677	20,866	
Average Selling Price		$4.15	$4.28	$4.46	$4.68	$4.42
Revenue ($M)		3.3	4.1	4.3	5.6	17.2

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	97.8%	97.1%	98.3%	96.0%	97.2%
Japan	0.6%	1.0%	1.0%	1.7%	1.2%
Europe	1.5%	1.9%	0.6%	2.3%	1.6%
Asia Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

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

Source: Dataquest
May 1988

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Table 2

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	3,600	3,840	4,200	4,800	16,440
Hughes	Many CMOS	0	0	0	0	0
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	N/A	S	S	5	5
National Semiconductor	Many	100	220	500	850	1,670
Xicor	Many	400	500	600	700	2,200
Total		5,600	6,060	6,800	7,855	26,315
Percentage Change from Previous Quarter			8.2%	12.2%	15.5%	
Cumulative Total		5,600	11,660	18,460	26,315	
Average Selling Price		$1.65	$1.55	$1.45	$1.35	$1.49
Revenue ($M)		9.2	9.4	9.9	10.6	39.1

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	73%	75%	78%	81%	77%
Japan	27	25	22	19	23
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	4,800	5,040	5,040	5,400	20,280
Hughes	Many CMOS	0	10	10	25	45
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	10	25	50	50	135
National Semiconductor	Many	1,100	1,600	2,400	3,200	8,300
NCR	Many	700	700	800	850	3,050
Xicor	4K	250	350	400	500	1,500
Total		8,360	9,225	10,200	11,525	39,310
Percentage Change from Previous Quarter		6.4%	10.3%	10.6%	13.0%	
Cumulative Total		34,675	43,900	54,100	65,625	
Average Selling Price		$1.35	$1.30	$1.25	$1.25	$1.28
Revenue ($M)		11.3	12.0	12.8	14.4	50.4

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	82%	84%	85%	87%	85%
Japan	18	16	15	13	15
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many MNOS	5,000	4,500	4,000	3,200	16,700
Hughes	Many CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	S	5	5
ICT	1K CMOS	N/A	S	5	10	15
Matsushita	Many MNOS	1,000	800	500	200	2,500
Mitsubishi	Many MNOS	100	100	50	50	300
Motorola	256 Bits	50	50	50	50	200
National Semiconductor	Many	2,400	3,000	3,500	3,750	12,650
NCR	256, 1K SNOS	100	113	135	155	503
SGS	256-bit CMOS	N/A	N/A	N/A	S	0
Sierra Semiconductor	256, 1K CMOS	N/A	N/A	S	0	0
Xicor	4K	250	225	225	200	900
Total		8,925	8,813	8,490	7,645	33,873
Percentage Change from Previous Quarter		(22.6%)	(1.3%)	(3.7%)	(10.0%)	
Cumulative Total		74,550	83,363	91,853	99,498	
Average Selling Price		$1.20	$1.15	$1.00	$1.10	$1.11
Revenue ($M)		10.7	10.1	8.5	8.4	37.7

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	88%	90%	94%	97%	92%
Japan	12	10	6	3	8
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	1K CMOS	N/A	N/A	N/A	S	0
General Instrument	Many MNOS	2,000	3,000	3,000	3,000	11,000
Hughes	256-Bit CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	N/A	S	0
ICT	1K CMOS	10	10	10	10	40
Matsushita	MNOS	500	200	50	0	750
Mitsubishi	MNOS	0	0	0	0	0
Motorola	256 Bits	251	370	322	301	1,244
National Semiconductor	Many	2,500	3,000	3,200	3,200	11,900
NCR	256, 1K SNOS	175	200	240	275	890
NEC	8K CMOS	N/A	N/A	S	S	0
Oki	1K CMOS	N/A	N/A	N/A	S	0
Philips	1K CMOS	N/A	N/A	N/A	S	0
Seeq	4K NMOS	N/A	N/A	N/A	S	0
SGS	256, 1K CMOS	55	160	530	340	1,085
Sierra Semiconductor	256, 1K CMOS	0	5	5	20	30
Sony	1K, 2K CMOS	N/A	N/A	S	S	0
Xicor	2K, 4K	350	350	250	200	1,150
Total		5,866	7,320	7,632	7,371	28,189
Percentage Change from Previous Quarter		(23.3%)	24.8%	4.3%	(3.4%)	
Cumulative Total		105,364	112,684	120,316	127,687	
Average Selling Price		$1.05	$1.00	$1.00	$1.00	$1.01
Revenue ($M)		6.2	7.3	7.6	7.4	28.5

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	95%	92%	95%	93%
Japan	9	3	1	0	3
Europe	1	2	7	5	4
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

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

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	1K,2K,4K CMOS	0	2	5	5	12
Hughes	256-Bit CMOS	0	0	0	0	0
Hyundai	1K CMOS	2	5	5	5	17
ICT	1K CMOS	50	100	150	200	500
Matsushita	MNOS	0	0	0	0	0
Microchip Tech., Inc.	MNOS & SNOS	2,007	1,716	1,687	2,020	7,430
Mitsubishi	MNOS	6,000	5,000	6,000	6,000	23,000
Motorola	256-1K	400	425	425	475	1,725
National Semiconductor	Many	2,432	4,941	3,177	3,610	14,160
NCR	256, 1K SNOS	133	145	130	170	578
NEC	8K CMOS	0	0	0	0	0
Oki	1K CMOS	0	50	120	230	400
Philips	2K CMOS	0	0	2	5	7
Seeq	4K NMOS	10	12	15	20	57
SGS-Thomson	256-1K CMOS	332	463	388	370	1,553
Sierra Semiconductor	256-1K CMOS	10	15	20	25	70
Sony	1K, 2K CMOS	0	5	10	10	25
Xicor	2K, 4K	1,600	1,295	850	780	4,525
Total		12,976	14,174	12,984	13,925	54,059
Percentage Change from Previous Quarter		76.0%	9.2%	(8.4%)	7.2%	
Cumulative Total		140,663	154,837	167,821	181,746	
Average Selling Price		$0.70	$0.73	$0.76	$0.79	$0.75
Revenue ($M)		9.1	10.3	9.9	11.0	40.3

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	51.2%	61.0%	49.7%	52.5%	53.8%
Japan	46.2%	35.7%	47.2%	44.8%	43.3%
Europe	2.6%	3.3%	3.0%	2.7%	2.9%
Asia Pacific	0	0	0	0	0
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
May 1988

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MOS EEPROM--Data

Table 3

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	N/A	N/A	S	S	0
Hitachi	MNOS	10	25	35	40	110
Hughes	CMOS	N/A	N/A	N/A	S	0
Intel	NMOS	60	80	80	140	360
Motorola	NMOS	2	5	10	10	27
NCR	MNOS	5	5	5	5	20
Seeq	NMOS	N/A	N/A	5	15	20
Xicor	NMOS	N/A	N/A	S	20	20
Total		77	115	135	230	557
Percentage Change from Previous Quarter		28%	49%	17%	70%	
Cumulative Total		137	252	387	617	
Average Selling Price		$30.00	$25.00	$23.00	$20.00	$23.11
Revenue ($M)		2.3	2.9	3.1	4.6	12.9

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	87%	78%	74%	83%	80%
Japan	13	22	26	17	20
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	S	S	0	0	0
Hitachi	MNOS	50	60	60	30	200
Hughes	CMOS	S	S	0	0	0
Intel	NMOS	180	200	220	250	850
Motorola	NMOS	10	10	10	10	40
NEC	NMOS	N/A	N/A	N/A	S	0
NCR	MNOS	5	5	5	5	20
Rockwell	NMOS	N/A	N/A	N/A	S	0
Seeq	NMOS	15	80	95	120	310
Xicor	NMOS	35	50	90	170	345
Total		295	405	480	585	1,765
Percentage Change from Previous Quarter		28%	37%	19%	22%	
Cumulative Total		912	1,317	1,797	2,382	
Average Selling Price		$20.00	$18.00	$15.00	$13.50	$16.01
Revenue ($M)		5.9	7.3	7.2	7.9	28.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	84%	86%	88%	95%	89%
Japan	16	14	12	5	11
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	NMOS	N/A	N/A	S	200	200
General Instrument	MNOS	0	0	0	0	0
Hitachi	MNOS	0	0	0	0	0
Hughes	CMOS	0	0	0	0	0
Intel	NMOS	300	375	400	425	1,500
Motorola	NMOS	15	15	10	10	50
National Semiconductor	CMOS	N/A	N/A	N/A	S	0
NEC	NMOS	S	S	5	5	10
NCR	MNOS	0	0	0	0	0
Rockwell	NMOS	5	5	0	0	10
Seeq	NMOS	150	200	235	270	855
Xicor	NMOS	250	350	450	500	1,550
Total		720	945	1,100	1,410	4,175
Percentage Change from Previous Quarter		23%	31%	16%	28%	
Cumulative Total		3,102	4,047	5,147	6,557	
Average Selling Price		$14.50	$13.00	$11.50	$10.50	$12.02
Revenue ($M)		10.4	12.3	12.7	14.8	50.2

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	N/A	N/A	S	10	10
Exel	NMOS	75	75	100	35	285
	CMOS fast	N/A	S	S	0	0
General Instrument	MNOS	0	0	0	0	0
Intel	NMOS	140	130	125	120	515
Motorola	NMOS	10	10	10	10	40
National Semiconductor	CMOS	0	0	0	1	1
Rockwell	NMOS	0	0	0	0	0
Samsung	NMOS	S	0	5	5	10
Seeq	NMOS	200	250	325	400	1,175
Xicor	NMOS	400	350	325	300	1,375
Total		825	815	890	881	3,411
Percentage Change from Previous Quarter		(25%)	(1%)	9%	(1%)	
Cumulative Total		7,382	8,197	9,087	9,968	
Average Selling Price		$9.50	$8.25	$7.00	$6.00	$7.60
Revenue ($M)		7.8	6.7	6.2	5.3	26.1

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	91%	88%	95%	91%
Japan	9	9	11	4	8
Europe	0	0	0	0	0
Asia Pacific	0	0	1	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	12	15	20	27	74
Atmel	CMOS fast	N/A	S	0	0	0
Catalyst	CMOS fast	N/A	N/A	N/A	S	0
Exel	CMOS fast	S	5	5	5	20
General Instrument	CMOS fast	5	0	5	5	10
Intel	NMOS	150	100	100	50	400
National Semiconductor	CMOS	0	0	0	0	0
Samsung	NMOS	0	1	5	5	11
Seeq	NMOS	400	400	450	500	1,750
Xicor	NMOS	500	500	550	650	2,200
Total		1,067	1,021	1,135	1,242	4,465
Percentage Change from Previous Quarter		21%	(4%)	11%	9%	
Cumulative Total		11,035	12,056	13,191	14,433	
Average Selling Price		$6.50	$6.00	$5.50	$5.00	$5.70
Revenue ($M)		6.9	6.1	6.2	6.2	25.5

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	99%	99%	99%	99%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	18	33	35	10	96
Atmel	CMOS fast	0	0	0	0	0
Catalyst	CMOS	S	0	0	0	0
	CMOS fast	N/A	N/A	N/A	N/A	0
Exel	CMOS fast	5	8	8	6	27
Microchip Tech., Inc.	CMOS	15	22	28	32	97
IDT	CMOS fast	N/A	N/A	N/A	S	0
Intel	NMOS	75	75	25	20	195
Oki	NMOS	30	30	20	N/A	80
	CMOS fast	N/A	N/A	S	20	20
Samsung	NMOS	5	5	7	9	26
Seeq	NMOS	420	470	500	569	1,959
	CMOS fast	N/A	N/A	N/A	S	0
Xicor	NMOS	660	790	820	855	3,125
	CMOS	N/A	N/A	N/A	S	0
	NMOS	1,208	1,403	1,407	1,463	5,481
	CMOS	20	30	36	58	144
Total		1,228	1,433	1,443	1,521	5,625
Percentage Change from Previous Quarter		(1%)	17%	1%	5%	
Cumulative Total		15,661	17,094	18,537	20,058	
Average Selling Price	NMOS	$ 4.75	$ 5.00	$ 5.05	$ 5.10	$ 4.98
	CMOS	$17.00	$15.00	$13.00	$11.00	$13.17
	Overall	$ 4.95	$ 5.21	$ 5.25	$ 5.32	$ 5.19
Revenue ($M)		6.1	7.5	7.6	8.1	29.2

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	96.7%	97.0%	97.6%	97.7%	97.3%
Japan	2.9%	2.7%	1.9%	1.7%	2.3%
Europe	0	0	0	0	0
Asia Pacific	0.4%	0.3%	0.5%	0.6%	0.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
May 1988

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MOS EEPROM--Data

Table 4

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Motorola	HMOS	N/A	N/A	S	S	S
NCR	MNOS	N/A	N/A	N/A	S	S
Seeq	NMOS	N/A	N/A	S	S	S
Total		0	0	0	0	0
Percentage Change from Previous Quarter						
Cumulative Total		0	0	0	0	
Average Selling Price				$50.00	$45.00	
Revenue ($M)						

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	N/A	N/A	S	S	S
Motorola	HMOS	5	10	10	10	35
NCR	MNOS	5	10	10	10	35
Seeq	NMOS	0	0	0	0	0
Total		10	20	20	20	70
Percentage Change from Previous Quarter		0	100%	0	0	
Cumulative Total		10	30	50	70	
Average Selling Price		$35.00	$25.00	$20.00	$15.00	$22.14
Revenue ($M)		0.4	0.5	0.4	0.3	1.6

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM SHIPMENT DATA
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	0	0	0	0	0
Motorola	HMOS	5	5	0	0	10
NCR	MNOS	0	0	0	1	1
Seeq	NMOS	0	0	0	0	0
Total		5	5	0	1	11
Percentage Change from Previous Quarter		(75%)	0	(100%)	0	
Cumulative Total		75	80	80	81	316
Average Selling Price		$15.00	$15.00	$14.00	$14.00	$14.91
Revenue ($M)		0.1	0.1	0.0	0.0	0.2

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	0	100%	100%

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NCR	MNOS	1	1	3	3	8
Seeq	NMOS	0	0	0	0	0
Total		1	1	3	3	8
Percentage Change from Previous Quarter		0	0	200%	0	
Cumulative Total		317	318	321	324	1,280
Average Selling Price		$14.00	$12.00	$10.00	$10.00	$10.75
Revenue ($M)		0	0	0	0	0.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NCR	MNOS	0	0	0	0	0
Seeq	CMOS 35ns	N/A	N/A	N/A	S	0
Total		0	0	0	0	0
Percentage Change from Previous Quarter		(100%)				
Cumulative Total		1,280	1,280	1,280	1,280	
Average Selling Price					$16.00	
Revenue ($M)		0	0	0	0	0

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	0	0	0
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	0	0	0	0	0

S = Sample

Source: Dataquest
May 1988

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Table 5

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	MNOS	N/A	N/A	N/A	N/A	0
Inmos	MNOS	N/A	N/A	N/A	N/A	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
Seeq	NMOS	N/A	N/A	N/A	3	3
Xicor	NMOS	N/A	N/A	N/A	N/A	0
Total		0	0	0	3	3
Percentage Change from Previous Quarter		0	0	0	0	
Cumulative Total		0	0	0	3	
Average Selling Price		0	$150	$150	$100	$100
Revenue ($M)		0.0	0.0	0.0	0.3	0.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	S	S	1	1	2
Exel	CMOS	N/A	S	S	0	0
Hitachi	MNOS	N/A	N/A	N/A	S	0
Inmos	MNOS	N/A	N/A	S	S	0
NCR	SNOS	N/A	N/A	S	S	0
Seeq	NMOS	10	20	20	35	85
Xicor	NMOS	2	7	15	30	54
Total		12	27	36	66	141
Percentage Change from Previous Quarter		300%	125%	33%	83%	
Cumulative Total		15	42	78	144	
Average Selling Price		$80	$70	$50	$40	$52
Revenue ($M)		1.0	1.9	1.8	2.6	7.3

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	2	8	15	20	45
Atmel	CMOS	N/A	N/A	N/A	S	0
Exel	CMOS	0	0	0	0	0
Fujitsu	CMOS	N/A	N/A	N/A	S	0
Hitachi	SNOS	10	15	25	100	150
Inmos	MNOS	0	0	0	0	0
Lattice	CMOS fast	N/A	S	S	0	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
Seeq	NMOS	40	55	80	115	290
Xicor	NMOS	50	60	100	140	350
	NMOS fast	N/A	S	0	10	10
	CMOS fast	N/A	N/A	N/A	N/A	0
Total		102	138	220	385	845
Percentage Change from Previous Quarter		55%	35%	59%	75%	
Cumulative Total		246	384	604	989	
Average Selling Price		$35	$20	$25	$20	$23
Revenue ($M)		3.6	2.8	5.5	7.7	19.5

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	90%	89%	89%	74%	82%
Japan	10	11	11	26	18
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	35	50	50	50	185
Atmel	CMOS	0	0	0	0	0
Catalyst	CMOS	N/A	N/A	N/A	N/A	0
Fujitsu	CMOS	S	5	10	10	25
General Instrument	CMOS	S	5	10	10	25
	CMOS fast	N/A	N/A	S	0	0
Hitachi	NMOS	75	100	100	100	375
	CMOS	N/A	N/A	N/A	S	0
Hyundai	CMOS	N/A	N/A	N/A	S	0
ICT	CMOS	N/A	N/A	N/A	N/A	0
Intel	NMOS	N/A	S	10	20	30
Lattice	CMOS fast	0	0	5	5	10
Mitsubishi	CMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	N/A	N/A	N/A	N/A	0
Oki	CMOS	N/A	N/A	N/A	N/A	0
Samsung	NMOS	N/A	N/A	S	0	0
Seeq	NMOS	115	125	125	125	490
Siemens	CMOS	N/A	N/A	N/A	N/A	0
Toshiba	CMOS fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS	200	200	250	250	900
	NMOS fast	5	10	10	20	45
	CMOS	N/A	N/A	N/A	S	0
Total		430	495	570	590	2,085
Percentage Change from Previous Quarter		12%	15%	15%	4%	
Cumulative Total		1,419	1,914	2,484	3,074	
Average Selling Price		$20	$18	$15	$12	$16
Revenue ($M)		8.6	8.9	8.6	7.1	33.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	83%	79%	81%	81%	81%
Japan	17	21	19	19	19
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	50	105	100	205	460
Atmel	CMOS	0	0	0	0	0
Catalyst	CMOS	1	2	5	4	12
Fujitsu	CMOS	1	2	3	5	11
Hitachi	NMOS	40	55	70	70	235
	CMOS	S	0	10	15	25
Hyundai	CMOS	2	3	4	6	15
ICT	CMOS	N/A	N/A	N/A	N/A	0
Intel	NMOS	20	25	15	15	75
Microchip Tech., Inc.	CMOS	15	30	48	50	143
Mitsubishi	CMOS	N/A	N/A	N/A	S	0
Motorola	HMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	N/A	N/A	N/A	N/A	0
Oki	CMOS	S	0	0	5	5
Samsung	NMOS	2	4	5	8	19
Seeq	NMOS	121	145	160	207	633
	NMOS fast	S	4	8	11	23
	CMOS	3	9	19	26	57
Toshiba	CMOS fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS	211	239	306	389	1,145
	NMOS fast	0	2	5	8	15
	CMOS	0	4	7	9	20
	NMOS	444	579	669	913	2,605
	CMOS	22	50	96	120	288
Total		466	629	765	1,033	2,893
Percentage Change from Previous Quarter		(21%)	35%	22%	35%	
Cumulative Total		3,540	4,169	4,934	5,967	
Average Selling Price	NMOS	$15	$13	$11	$ 8	$11
	CMOS	$35	$32	$29	$24	$28
	Overall	$16	$15	$13	$10	$13
Revenue ($M)		7.4	9.1	10.1	10.2	36.9

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	90.3%	89.8%	88.0%	89.4%	89.3%
Japan	8.8%	9.1%	10.8%	9.2%	9.5%
Europe	0	0	0	0	0
Asia Pacific	0.9%	1.1%	1.2%	1.4%	1.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

N/A = Not Available
S = Sample

Source: Dataquest
May 1988

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MOS EEPROM--Data

Table 6

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seeq	CMOS/NMOS	S	0	3	5	8
Xicor	NMOS	S	0	5	10	15
Total		0	0	8	15	23
Percentage Change from Previous Quarter		0	0	0	88%	
Cumulative Total			0	8	23	
Average Selling Price			$400	$350	$300	$317
Revenue ($M)		0.0	0.0	2.8	4.5	7.3

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia Pacific	0	0	0	0	0
Total	0	0	100%	100%	100%

S = Sample

(Continued)

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Table 6 (Continued)

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	0	0	0	0	0
Atmel	CMOS	0	0	0	0	0
NEC	CMOS	S	S	0	0	0
Seeq	CMOS	9	12	19	22	62
Sharp	CMOS	S	0	0	0	0
Xicor	NMOS/CMOS	10	15	26	29	80
	NMOS	10	13	23	26	72
	CMOS	9	14	22	25	70
Total		19	27	45	51	142
Percentage Change from Previous Quarter		27%	42%	67%	13%	
Cumulative Total		42	69	114	165	
Average Selling Price	NMOS	$258	$212	$158	$109	$164
	CMOS	$286	$248	$199	$156	$205
	Overall	$271	$231	$178	$132	$184
Revenue ($M)		5.2	6.2	8.0	6.7	26.1

	1987 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	1
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

Source: Dataquest
May 1988

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MOS EEPROM--Data

QUARTERLY COMPANY MOS EEPROM SHIPMENT DATA

This section contains unit shipment data on MOS EEPROMs and NVRAMs from 1982 through 1986. In addition to unit shipments for NVRAMs and low-density (<16K), 16K, 32K, 64K, and 256K EEPROMS, we have added our estimates of the worldwide billing prices for each product during the four quarters of the year. At the bottom of the table, we show market share data (units, not revenue) for companies based in the United States, Japan, Europe, and Asia Pacific. The shipment data for 1984 has been adjusted since the April 1, 1985, publication of shipment data, based on actual data gathered from the manufacturers. The tables are organized as follows:

- Table 1—NVRAM Shipment Data, 1982-1986
- Table 2--Low-Density MOS EEPROM Shipment Data, 1983-1986
- Table 3—16K MOS EEPROM Shipment Data, 1982-1986
- Table 4—32K MOS EEPROM Shipment Data, 1983-1986
- Table 5—64K MOS EEPROM Shipment Data, 1983-1986
- Table 6--256K MOS EEPROM Shipment Data, 1986

Definitions

Prices

Prices are Dataquest estimates of the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and the entire speed mix, and they represent sales to both military and commercial accounts.

Unit Shipments

The unit shipment data have been gathered from the manufacturers and represent actual product movements to all market channels. Actual user consumption may be greater than or less than the estimated unit shipments as a result of distributor stocking and manufacturers' inventories for internal use.

Quarterly Revenue

Quarterly revenue is calculated as units shipped times the prevailing price during that period.

Sample

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 or column calculations in the table.

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MOS EEPROM--Data

Table 1

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	10	25	50	100	185
NCR	4K SNOS	10	10	25	60	105
SGS-Ates	1K NMOS	N/A	N/A	S	10	10
Xicor	256-4K Bits NMOS	70	100	170	250	590
Total		90	135	245	420	890
Percentage Change from Previous Quarter			50%	81%	71%	
Cumulative Total		90	225	470	890	
Average Selling Price		$4.30	$4.00	$3.53	$3.20	$3.52
Revenue ($M)		0.4	0.5	0.9	1.3	3.1

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	98%	99%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	80	100	100	150	430
Hughes	64x4 CMOS	N/A	N/A	N/A	S	0
Intel	1K, 4K NMOS	N/A	N/A	S	5	5
NCR	256-4K Bits	100	150	200	300	750
Rockwell	256 Bits CMOS	N/A	N/A	N/A	S	0
SGS-Ates	1K NMOS	80	140	100	80	400
Xicor	256-4K Bits NMOS	330	590	600	830	2,350
Total		590	980	1,000	1,365	3,935
Percentage Change from Previous Quarter		40%	66%	2%	37%	
Cumulative Total		1,480	2,460	3,460	4,825	
Average Selling Price		$3.60	$3.56	$3.50	$3.98	$3.70
Revenue ($M)		2.1	3.5	3.5	5.4	14.5

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	86%	86%	90%	94%	90%
Japan	0	0	0	0	0
Europe	14	14	10	6	10
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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MOS EEPROM--Data

Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	4K MNOS	150	200	300	300	950
Hughes	64 x 4 CMOS	S	S	S	S	10
Intel	1K, 4K NMOS	5	10	20	25	60
NCR	256-4K Bits	200	200	250	250	900
Rockwell	256 Bits CMOS	S	S	0	0	0
SGS	1K NMOS	100	50	20	80	250
Xicor	256-4K Bits NMOS	600	640	800	850	2,890
Total		1,055	1,100	1,395	1,510	5,060
Percentage Change from Previous Quarter		(23%)	4%	27%	8%	
Cumulative Total		5,880	6,980	8,375	9,885	
Average Selling Price		$3.80	$3.30	$3.50	$3.60	$3.55
Revenue ($M)		4.0	3.6	4.9	5.4	18.0

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	95%	99%	95%	95%
Japan	0	0	0	0	0
Europe	9	5	1	5	5
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Fujitsu	1K NMOS	N/A	N/A	S	5	5
General Instrument	4K MNOS	150	100	50	50	350
Hughes	64x4 CMOS	25	25	25	25	100
Intel	1K, 4K NMOS	10	10	5	5	30
NCR	256, 4K Bits	28	25	25	25	103
SGS	1K	65	50	75	50	240
Xicor	Many NMOS	700	700	650	650	2,700
Total		978	910	830	810	3,528
Percentage Change from Previous Quarter		(35%)	(7%)	(9%)	(2%)	
Cumulative Total		10,863	11,773	12,603	13,413	
Average Selling Price		$3.70	$4.00	$4.50	$4.25	$4.09
Revenue ($M)		3.6	3.6	3.7	3.4	14.4

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	93%	95%	91%	93%	93%
Japan	0	0	0	1	0
Europe	7	5	9	6	7
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 1 (Continued)

NVRAM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst	256 Bits, 1K CMOS	S	5	5	5	15
Fujitsu	1K CMOS	5	5	5	5	20
Hughes	256 Bits CMOS	25	50	75	75	225
NCR	256 Bits, 4K	45	50	50	58	203
SGS	256 Bits, 1K CMOS	50	50	50	50	200
Xicor	256-4K Bits NMOS	780	740	710	670	2,900
Total		905	900	895	863	3,563
Percentage Change from Previous Quarter		12%	(1)	1%	(4%)	
Cumulative Total		14,318	15,218	16,113	16,976	
Average Selling Price		$4.25	$4.15	$4.00	$4.00	$4.10
Revenue ($M)		3.8	3.7	3.6	3.5	14.6

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	94%	94%	94%	94%	94%
Japan	1	1	1	1	1
Europe	5	5	5	6	6
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

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

Source: Dataquest
November 1987

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Table 2

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	3,600	3,840	4,200	4,800	16,440
Hughes	Many CMOS	0	0	0	0	0
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	N/A	S	S	5	5
National Semiconductor	Many	100	220	500	850	1,670
Xicor	Many	400	500	600	700	2,200
Total		5,600	6,060	6,800	7,855	26,315
Percentage Change from Previous Quarter			8.2%	12.2%	15.5%	
Cumulative Total		5,600	11,660	18,460	26,315	
Average Selling Price		$1.65	$1.55	$1.45	$1.35	$1.49
Revenue ($M)		9.2	9.4	9.9	10.6	39.1

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	73%	75%	78%	81%	77%
Japan	27	25	22	19	23
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many	4,800	5,040	5,040	5,400	20,280
Hughes	Many CMOS	0	10	10	25	45
Matsushita	MNOS	1,000	1,000	1,000	1,000	4,000
Mitsubishi	MNOS	500	500	500	500	2,000
Motorola	256 Bits	10	25	50	50	135
National Semiconductor	Many	1,100	1,600	2,400	3,200	8,300
NCR	Many	700	700	800	850	3,050
Xicor	4K	250	350	400	500	1,500
Total		8,360	9,225	10,200	11,525	39,310
Percentage Change from Previous Quarter		6.4%	10.3%	10.6%	13.0%	
Cumulative Total		34,675	43,900	54,100	65,625	
Average Selling Price		$1.35	$1.30	$1.25	$1.25	$1.28
Revenue ($M)		11.3	12.0	12.8	14.4	50.4

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	82%	84%	85%	87%	85%
Japan	18	16	15	13	15
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	Many MNOS	5,000	4,500	4,000	3,200	16,700
Hughes	Many CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	S	5	5
ICT	1K CMOS	N/A	S	5	10	15
Matsushita	Many MNOS	1,000	800	500	200	2,500
Mitsubishi	Many MNOS	100	100	50	50	300
Motorola	256 Bits	50	50	50	50	200
National Semiconductor	Many	2,400	3,000	3,500	3,750	12,650
NCR	256, 1K SNOS	100	113	135	155	503
SGS	256-bit CMOS	N/A	N/A	N/A	S	0
Sierra Semiconductor	256, 1K CMOS	N/A	N/A	S	0	0
Xicor	4K	250	225	225	200	900
Total		8,925	8,813	8,490	7,645	33,873
Percentage Change from Previous Quarter		(22.6%)	(1.3%)	(3.7%)	(10.0%)	
Cumulative Total		74,550	83,363	91,853	99,498	
Average Selling Price		$1.20	$1.15	$1.00	$1.10	$1.11
Revenue ($M)		10.7	10.1	8.5	8.4	37.7

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	88%	90%	94%	97%	92%
Japan	12	10	6	3	8
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 2 (Continued)

Low-Density MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Catalyst Semiconductor	1K CMOS	N/A	N/A	N/A	S	0
General Instrument	Many MNOS	2,000	3,000	3,000	3,000	11,000
Hughes	256-Bit CMOS	25	25	25	25	100
Hyundai	1K CMOS	N/A	N/A	N/A	S	0
ICT	1K CMOS	10	10	10	10	40
Matsushita	MNOS	500	200	50	0	750
Mitsubishi	MNOS	0	0	0	0	0
Motorola	256 Bits	251	370	322	301	1,244
National Semiconductor	Many	2,500	3,000	3,200	3,200	11,900
NCR	256, 1K SNOS	175	200	240	275	890
NEC	8K CMOS	N/A	N/A	S	S	0
Oki	1K CMOS	N/A	N/A	N/A	S	0
Philips	1K CMOS	N/A	N/A	N/A	S	0
Seeq	4K NMOS	N/A	N/A	N/A	S	0
SGS	256, 1K CMOS	5	10	20	20	55
Sierra Semiconductor	256, 1K CMOS	0	5	5	20	30
Sony	1K, 2K CMOS	N/A	N/A	S	S	0
Xicor	2K, 4K	350	350	250	200	1,150
Total		5,816	7,170	7,122	7,051	27,159
Percentage Change from Previous Quarter		(23.9%)	23.3%	(0.7%)	(1.0%)	
Cumulative Total		105,314	112,484	119,606	126,657	
Average Selling Price		$1.05	$1.00	$1.00	$1.00	$1.01
Revenue ($M)		6.1	7.2	7.1	7.1	27.4

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	97%	99%	100%	97%
Japan	9	3	1	0	3
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

Source: Dataquest
November 1987

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Table 3

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	N/A	N/A	S	S	0
Hitachi	MNOS	10	25	35	40	110
Hughes	CMOS	N/A	N/A	N/A	S	0
Intel	NMOS	60	80	80	140	360
Motorola	NMOS	2	5	10	10	27
NCR	MNOS	5	5	5	5	20
Seeq	NMOS	N/A	N/A	5	15	20
Xicor	NMOS	N/A	N/A	S	20	20
Total		77	115	135	230	557
Percentage Change from Previous Quarter		28%	49%	17%	70%	
Cumulative Total		137	252	387	617	
Average Selling Price		$30.00	$25.00	$23.00	$20.00	$23.11
Revenue ($M)		2.3	2.9	3.1	4.6	12.9

	1982 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	87%	78%	74%	83%	80%
Japan	13	22	26	17	20
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
General Instrument	MNOS	S	S	0	0	0
Hitachi	MNOS	50	60	60	30	200
Hughes	CMOS	S	S	0	0	0
Intel	NMOS	180	200	220	250	850
Motorola	NMOS	10	10	10	10	40
NEC	NMOS	N/A	N/A	N/A	S	0
NCR	MNOS	5	5	5	5	20
Rockwell	NMOS	N/A	N/A	N/A	S	0
Seeq	NMOS	15	80	95	120	310
Xicor	NMOS	35	50	90	170	345
Total		295	405	480	585	1,765
Percentage Change from Previous Quarter		28%	37%	19%	22%	
Cumulative Total		912	1,317	1,797	2,382	
Average Selling Price		$20.00	$18.00	$15.00	$13.50	$16.01
Revenue ($M)		5.9	7.3	7.2	7.9	28.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	84%	86%	88%	95%	89%
Japan	16	14	12	5	11
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	NMOS	N/A	N/A	S	200	200
General Instrument	MNOS	0	0	0	0	0
Hitachi	MNOS	0	0	0	0	0
Hughes	CMOS	0	0	0	0	0
Intel	NMOS	300	375	400	425	1,500
Motorola	NMOS	15	15	10	10	50
National Semiconductor	CMOS	N/A	N/A	N/A	S	0
NEC	NMOS	S	S	5	5	10
NCR	MNOS	0	0	0	0	0
Rockwell	NMOS	5	5	0	0	10
Seeq	NMOS	150	200	235	270	855
Xicor	NMOS	250	350	450	500	1,550
Total		720	945	1,100	1,410	4,175
Percentage Change from Previous Quarter		23%	31%	16%	28%	
Cumulative Total		3,102	4,047	5,147	6,557	
Average Selling Price		$14.50	$13.00	$11.50	$10.50	$12.02
Revenue ($M)		10.4	12.3	12.7	14.8	50.2

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	N/A	N/A	S	10	10
Exel	NMOS	75	75	100	35	285
	CMOS fast	N/A	S	S	0	0
General Instrument	MNOS	0	0	0	0	0
Intel	NMOS	140	130	125	120	515
Motorola	NMOS	10	10	10	10	40
National Semiconductor	CMOS	0	0	0	1	1
Rockwell	NMOS	0	0	0	0	0
Samsung	NMOS	S	0	5	5	10
Seeq	NMOS	200	250	325	400	1,175
Xicor	NMOS	400	350	325	300	1,375
Total		825	815	890	881	3,411
Percentage Change from Previous Quarter		(25%)	(1%)	9%	(1%)	
Cumulative Total		7,382	8,197	9,087	9,968	
Average Selling Price		$9.50	$8.25	$7.00	$6.00	$7.60
Revenue ($M)		7.8	6.7	6.2	5.3	26.1

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	91%	91%	88%	95%	91%
Japan	9	9	11	4	8
Europe	0	0	0	0	0
Asia Pacific	0	0	1	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

(Continued)

Table 3 (Continued)

16K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	12	15	20	27	74
Atmel	CMOS fast	N/A	S	0	0	0
Catalyst	CMOS fast	N/A	N/A	N/A	S	0
Exel	CMOS fast	S	5	5	5	20
General Instrument	CMOS fast	5	0	5	5	10
Intel	NMOS	150	100	100	50	400
National Semiconductor	CMOS	0	0	0	0	0
Samsung	NMOS	0	1	5	5	11
Seeq	NMOS	400	400	450	500	1,750
Xicor	NMOS	500	500	550	650	2,200
Total		1,067	1,021	1,135	1,242	4,465
Percentage Change from Previous Quarter		21%	(4%)	11%	9%	
Cumulative Total		11,035	12,056	13,191	14,433	
Average Selling Price		$6.50	$6.00	$5.50	$5.00	$5.70
Revenue ($M)		6.9	6.1	6.2	6.2	25.5

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	99%	99%	99%	99%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample
Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
November 1987

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MOS EEPROM--Data

Table 4

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Motorola	HMOS	N/A	N/A	S	S	S
NCR	MNOS	N/A	N/A	N/A	S	S
Seeq	NMOS	N/A	N/A	S	S	S
Total		0	0	0	0	0
Percentage Change from Previous Quarter						
Cumulative Total		0	0	0	0	
Average Selling Price				$50.00	$45.00	
Revenue ($M)						

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	N/A	N/A	S	S	S
Motorola	HMOS	5	10	10	10	35
NCR	MNOS	5	10	10	10	35
Seeq	NMOS	0	0	0	0	0
Total		10	20	20	20	70
Percentage Change from Previous Quarter		0	100%	0	0	
Cumulative Total		10	30	50	70	
Average Selling Price		$35.00	$25.00	$20.00	$15.00	$22.14
Revenue ($M)		0.4	0.5	0.4	0.3	1.6

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 4 (Continued)

32K MOS EEPROM SHIPMENT DATA
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Exel	CMOS	0	0	0	0	0
Motorola	HMOS	5	5	0	0	10
NCR	MNOS	0	0	0	1	1
Seeq	NMOS	0	0	0	0	0
Total		5	5	0	1	11
Percentage Change from Previous Quarter		(75%)	0	(100%)	0	
Cumulative Total		75	80	80	81	316
Average Selling Price		$15.00	$15.00	$14.00	$14.00	$14.91
Revenue ($M)		0.1	0.1	0.0	0.0	0.2

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	0	100%	100%

(Continued)

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Table 4 (Continued)

32K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
NCR	MNOS	1	1	3	3	8
Seeq	NMOS	0	0	0	0	0
Total		1	1	3	3	8
Percentage Change from Previous Quarter		0	0	200%	0	
Cumulative Total		317	318	321	324	1,280
Average Selling Price		$14.00	$12.00	$10.00	$10.00	$10.75
Revenue ($M)		0	0	0	0	0.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

Source: Dataquest
November 1987

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MOS EEPROM--Data

Table 5

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	MNOS	N/A	N/A	N/A	N/A	0
Inmos	MNOS	N/A	N/A	N/A	N/A	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
Seeq	NMOS	N/A	N/A	N/A	3	3
Xicor	NMOS	N/A	N/A	N/A	N/A	0
Total		0	0	0	3	3
Percentage Change from Previous Quarter		0	0	0	0	
Cumulative Total		0	0	0	3	
Average Selling Price		0	$150	$150	$100	$100
Revenue ($M)		0.0	0.0	0.0	0.3	0.3

	1983 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	0	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	S	S	1	1	2
Exel	CMOS	N/A	S	S	0	0
Hitachi	MNOS	N/A	N/A	N/A	S	0
Inmos	MNOS	N/A	N/A	S	S	0
NCR	SNOS	N/A	N/A	S	S	0
Seeq	NMOS	10	20	20	35	85
Xicor	NMOS	2	7	15	30	54
Total		12	27	36	66	141
Percentage Change from Previous Quarter		300%	125%	33%	83%	
Cumulative Total		15	42	78	144	
Average Selling Price		$80	$70	$50	$40	$52
Revenue ($M)		1.0	1.9	1.8	2.6	7.3

	1984 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	0	0	0	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	2	8	15	20	45
Atmel	CMOS	N/A	N/A	N/A	S	0
Exel	CMOS	0	0	0	0	0
Fujitsu	CMOS	N/A	N/A	N/A	S	0
Hitachi	SNOS	10	15	25	100	150
Inmos	MNOS	0	0	0	0	0
Lattice	CMOS fast	N/A	S	S	0	0
NCR	SNOS	N/A	N/A	N/A	N/A	0
Seeq	NMOS	40	55	80	115	290
Xicor	NMOS	50	60	100	140	350
	NMOS fast	N/A	S	0	10	10
	CMOS fast	N/A	N/A	N/A	N/A	0
Total		102	138	220	385	845
Percentage Change from Previous Quarter		55%	35%	59%	75%	
Cumulative Total		246	384	604	989	
Average Selling Price		$35	$20	$25	$20	$23
Revenue ($M)		3.6	2.8	5.5	7.7	19.5

	1985 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	90%	89%	89%	74%	82%
Japan	10	11	11	26	18
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

(Continued)

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Table 5 (Continued)

64K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
AMD	NMOS	35	50	50	50	185
Atmel	CMOS	0	0	0	0	0
Catalyst	CMOS	N/A	N/A	N/A	N/A	0
Fujitsu	CMOS	S	5	10	10	25
General Instrument	CMOS	S	5	10	10	25
	CMOS fast	N/A	N/A	S	0	0
Hitachi	NMOS	75	100	100	100	375
	CMOS	N/A	N/A	N/A	S	0
Hyundai	CMOS	N/A	N/A	N/A	S	0
ICT	CMOS	N/A	N/A	N/A	N/A	0
Intel	NMOS	N/A	S	10	20	30
Lattice	CMOS fast	0	0	5	5	10
Mitsubishi	CMOS	N/A	N/A	N/A	N/A	0
NEC	CMOS	N/A	N/A	N/A	N/A	0
Oki	CMOS	N/A	N/A	N/A	N/A	0
Samsung	NMOS	N/A	N/A	S	0	0
Seeq	NMOS	115	125	125	125	490
Siemens	CMOS	N/A	N/A	N/A	N/A	0
Toshiba	CMOS fast	N/A	N/A	N/A	N/A	0
Xicor	NMOS	200	200	250	250	900
	NMOS fast	5	10	10	20	45
	CMOS	N/A	N/A	N/A	S	0
Total		430	495	570	590	2,085
Percentage Change from Previous Quarter		12%	15%	15%	4%	
Cumulative Total		1,419	1,914	2,484	3,074	
Average Selling Price		$20	$18	$15	$12	$16
Revenue ($M)		8.6	8.9	8.6	7.1	33.1

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	83%	79%	81%	81%	81%
Japan	17	21	19	19	19
Europe	0	0	0	0	0
Asia Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

N/A = Not Available
S = Sample

Source: Dataquest
November 1987

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MOS EEPROM--Data

Table 6

256K MOS EEPROM Shipment Data
(Thousands of Units)

Company	Features/ Organization	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Seeq	CMOS/NMOS	S	0	3	5	8
Xicor	NMOS	S	0	5	10	15
Total		0	0	8	15	23
Percentage Change from Previous Quarter		0	0	0	88%	
Cumulative Total			0	8	23	
Average Selling Price			$400	$350	$300	$317
Revenue ($M)		0.0	0.0	2.8	4.5	7.3

	1986 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
United States	0	0	100%	100%	100%
Japan	0	0	0	0	0
Europe	0	0	0	2	1
Asia Pacific	0	0	0	0	0
Total	0	0	100%	100%	100%

S = Sample

Source: Dataquest
November 1987

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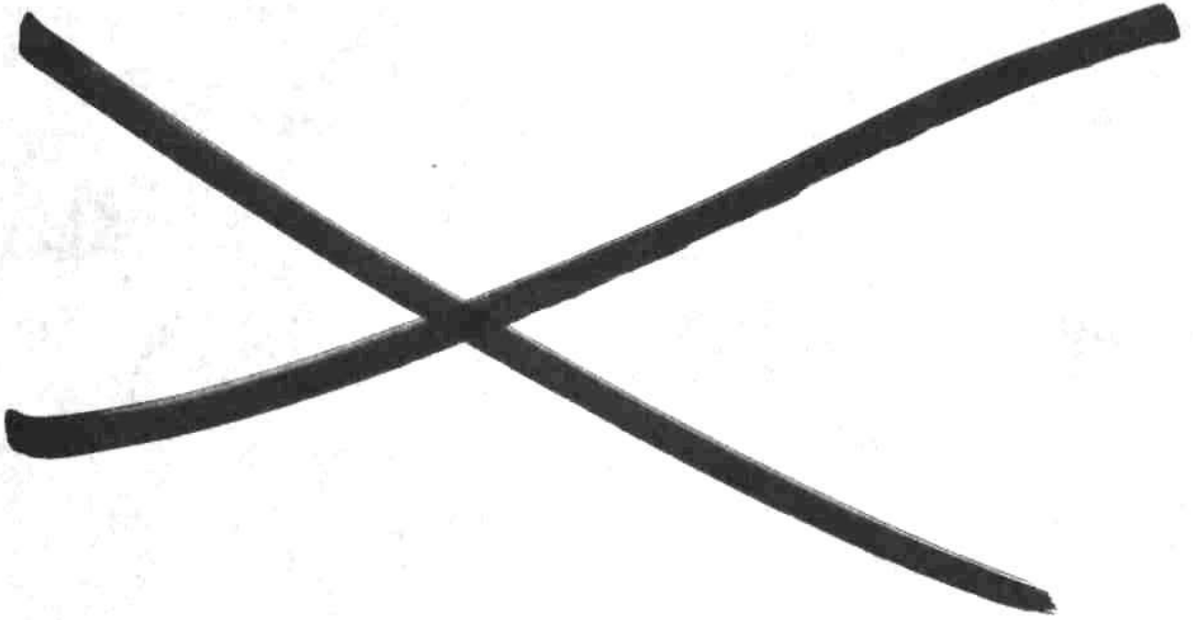

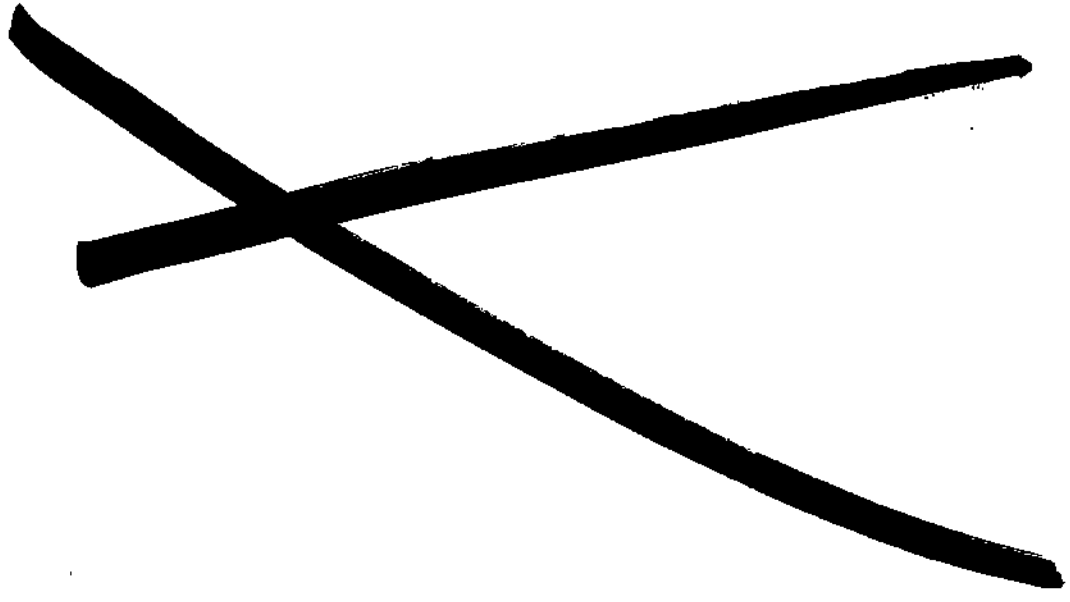

Flash Memory—Forecast

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Flash Memory—Forecast

Dataquest's Flash memory forecast includes actual production data for 1988 and 1989, with six years (1990 through 1995) of predictions. Revenue in dollars—"dollarized units" computed as the product of units and worldwide average selling price (ASP)—unit shipments, and ASP are detailed for each Flash density and process technology. This forecast includes nonvolatile products designated as Flash EPROM/EEPROM that incorporate either 5V or 12V programming supplies and one-transistor (1T) or two-transistor (2T) memory cells with electrical programming and fast bulk/chip erase.

MARKET SUMMARY

Highlights of Flash market developments in 1989 and 1990 are as follows:

- Flash revenue grew to $11.7 million in 1989, with $36.8 million projected for 1990, as shown in Figure 1.
- Although four vendors—Intel, Toshiba, SEEQ, and Atmel—controlled producer market share, eight vendors announced their entry into the market in 1990.
- Movement towards pseudo-standardization was made via AMD's and Catalyst's introductions of Flash products, sourced as Intel-compatible, in 12V memory pinout and software programming routines.
- Philips/Signetics entered the 1Mb Flash market through a manufacturing/technology agreement with SEEQ that included both Flash and EEPROM products.
- Fairly strong market acceptance in the data processing, telecommunications, automotive, and military equipment sectors in both North America and Europe caused unit production to grow to 660,000 in 1989. As shown in Table 1, production is projected to reach 3 million units in 1990.

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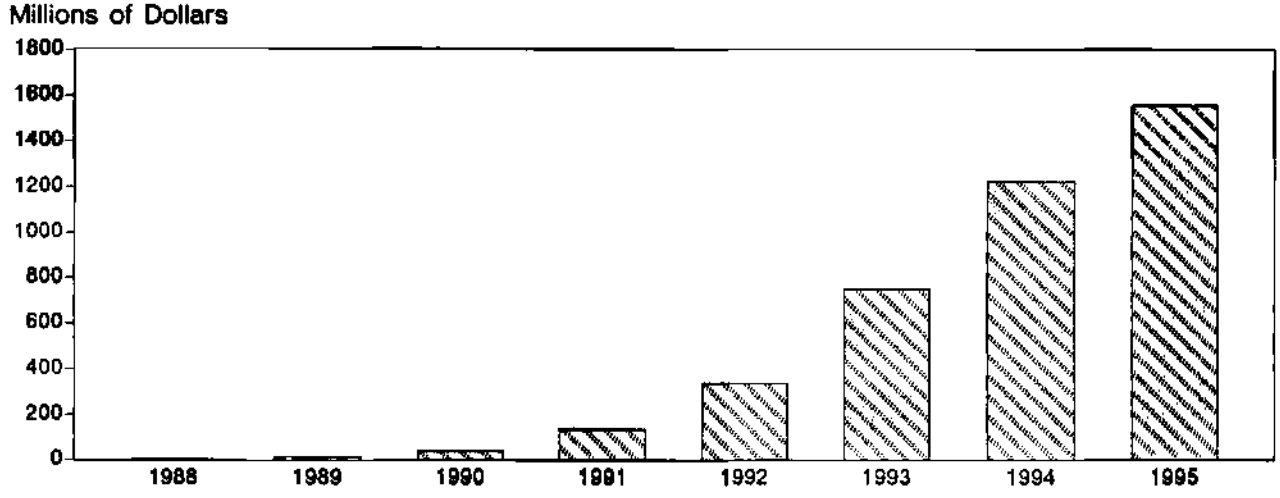
Figure 1

Worldwide Flash Memory Revenue (Millions of Dollars)



Source: Dataquest (December 1990)

Table 1

Worldwide Flash Memory Forecast

	Millions of Dollars							
	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
64K	0.2	0	0	0	0	0	0	0
128K	0	0	0	0	0	0	0	0
256K	2.2	5	10	43	90	127	120	87
512K	0.7	1	7	26	69	143	180	148
1Mb	0	5	19	60	141	292	428	491
2Mb	0	0	0	4	26	90	196	281
4Mb	0	0	0	1	10	99	290	499
8Mb	0	0	0	0	0	1	10	46
16Mb	0	0	0	0	0	0	1	6
Total	3.1	11.7	36.8	133.7	335.0	750.6	1,225.1	1,559.2
Percent Change from Previous Year		276	215	263	151	124	63	27

(Continued)

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Table 1 (Continued)

Worldwide Flash Memory Forecast

	1988	1989	1990	1991	1992	1993	1994	1995
				Millions of Units				
64K	0.03	0	0	0	0	0	0	0
128K	0	0	0	0	0	0	0	0
256K	0.11	0.48	1.4	7.4	18.0	27.0	26.7	20.0
512K	0.02	0.05	0.4	2.0	7.0	19.0	30.0	29.0
1Mb	0	0.14	0.9	4.5	14.0	37.0	68.0	91.0
2Mb	0	0	0	0.2	1.7	8.0	22.0	38.0
4Mb	0	0	0	0	0.5	7.6	30.9	64.0
8Mb	0	0	0	0	0	0	0.3	2.2
16Mb	0	0	0	0	0	0	0	0.2
Total	0.15	0.66	2.70	14.12	41.20	98.61	177.91	244.35
Percent Change from Previous Year		346	312	423	192	139	80	37
				Average Selling Price ($)				
	1988	1989	1990	1991	1992	1993	1994	1995
64K	8.00	0	0	0	0	0	0	0
128K	0	0	0	0	0	0	0	0
256K	20.90	10.86	7.30	5.80	5.00	4.70	4.50	4.35
512K	45.00	26.02	18.00	12.90	9.80	7.50	6.00	5.10
1Mb	0	39.67	21.50	13.35	10.10	7.90	6.30	5.40
2Mb	0	0	37.00	22.00	15.00	11.20	8.90	7.40
4Mb	0	0	0	35.00	19.07	13.00	9.40	7.80
8Mb	0	0	0	0	0	54.00	32.00	21.00
16Mb	0	0	0	0	0	0	68.00	42.00
Total	21.17	17.84	13.63	9.47	8.13	7.61	6.89	6.38
Percent Change from Previous Year		(16)	(24)	(30)	(14)	(6)	(10)	(7)

Source: Dataquest (December 1990)

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PRODUCT SUMMARY

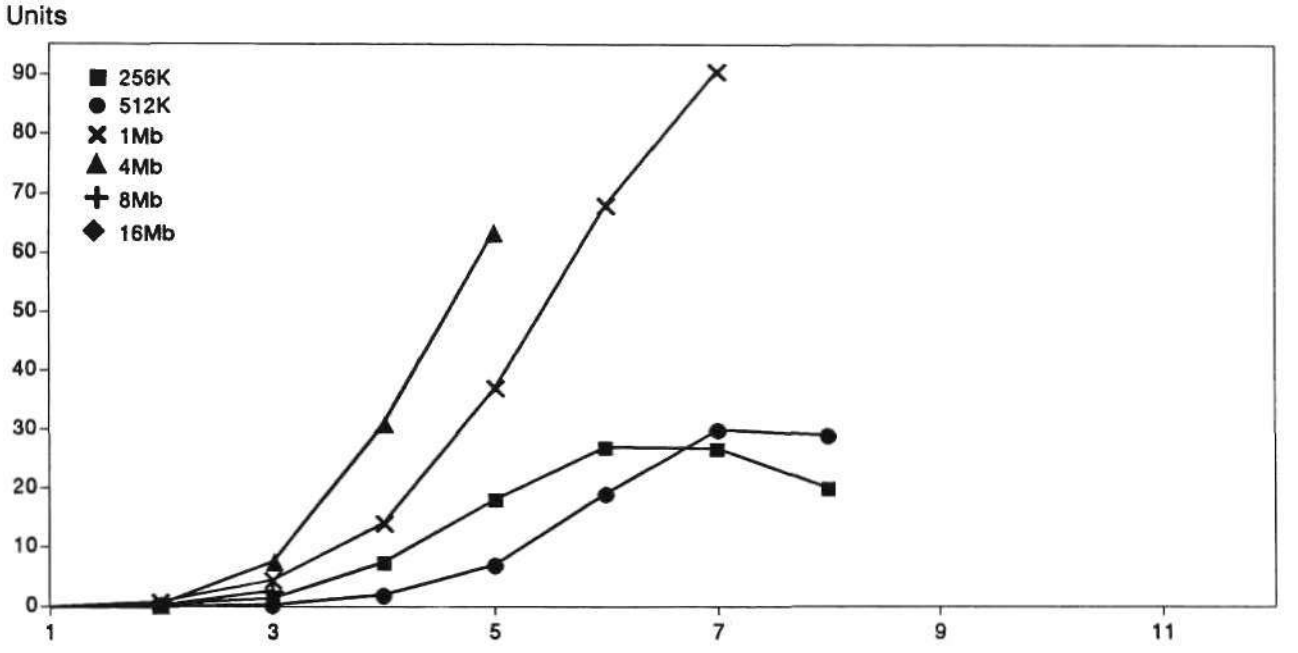
First introduced to the market in 1985, the 256K product is expected to set the stage for market acceptance and development of the high-density 1Mb and 4Mb densities that will ramp up in production during 1991 and 1992. Figure 2 illustrates Dataquest's projected development stage of each Flash device by density. Although Flash technology still is in its infancy, Dataquest has compared it with EPROM product technology in potential life cycle curve development. Traditionally, EPROMs have maintained life cycles that can extend through 12 years, with peak production developing during the sixth year. Figure 2 is merely a forecast of behavior that could develop if the Flash market develops its full potential acceptance.

REGIONAL CONSUMPTION

Regionally, North America maintained an 83 percent consumption rate of total Flash production during 1988 and 1989, with Europe as the second-largest product consumer, as shown in Figure 3. Although data processing is expected to provide the greatest long-term growth of Flash products worldwide, the telecommunications segment was the second-largest Flash user.

Figure 2

Flash Product Life Cycle



Source: Dataquest (December 1990)

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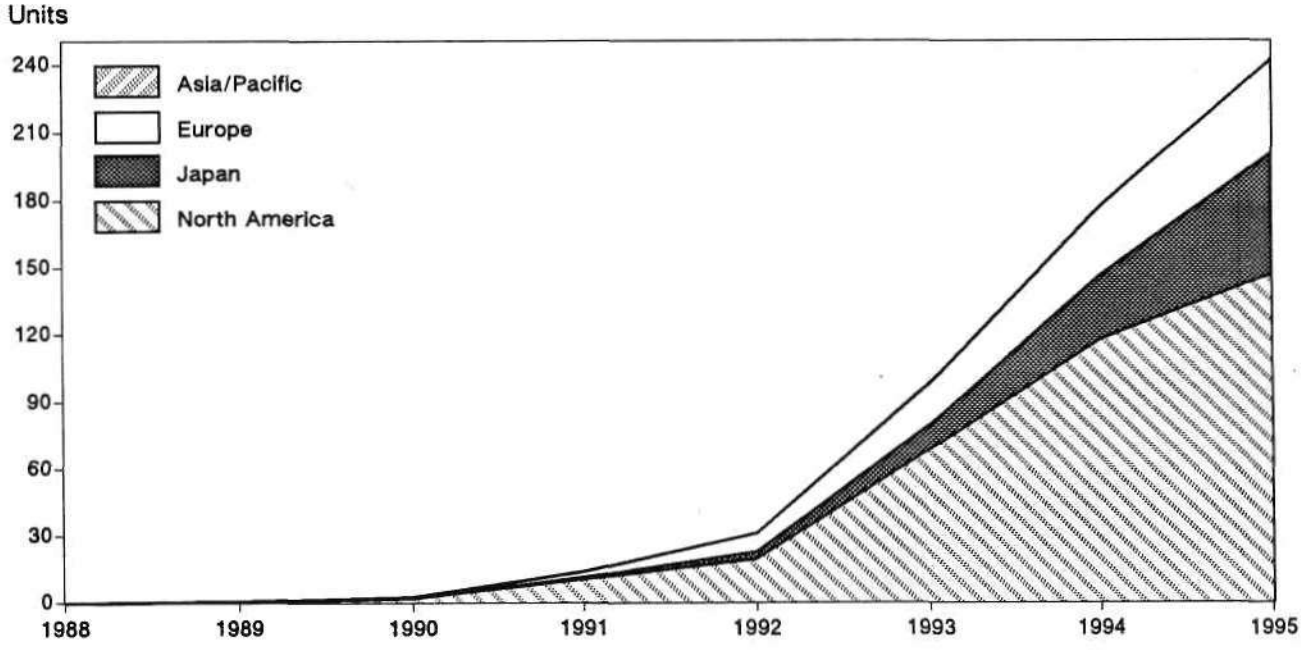
Figure 3

Flash Regional Consumption



Source: Dataquest (December 1990)

MARKET SHARE ANALYSIS

Tables 2 and 3 present an analysis of Flash market share by company and region for all Flash devices. All market share percentages are based on individual company or regional unit shares. The dollarized units represent the sum of all units sold by a company weighted by each density's ASP for that year. Although the resulting numbers are in dollars, they have no relation to the true revenue dollars of a company. They still are units expressed in weighted form in order to have a standard summary for overall Flash market shares. Table 4 illustrates the total product line currently available by supplier.

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Table 2

Flash Market Share—1988

	64K	128K	256K	512K	1Mb	Total
Average Selling Price ($)	8.00	0	20.90	45.00	0	-
Intel	25	-	75	-	-	100
SEEQ	-	-	-	15	-	15
Toshiba	-	-	32	-	-	32
Total (Units)	25	-	107	15	-	147
Intel	200		1,568	0		1,768
SEEQ	-	-	-	675	-	675
Toshiba	0	-	669	0	-	669
Total (Dollars)	200	-	2,236	675	-	3,111
Intel	100	-	70	0	-	68
SEEQ	0	-	0	100	-	10
Toshiba	0	-	30	0	-	22
Total (Percentage)	100	-	100	100	-	100
Regional Market Share						
United States	100	-	70	100	-	78
Japan	0	-	30	0	-	22
Europe	0	-	0	0	-	0
Asia/Pacific	0	-	0	0	-	0
Total	100	0	100	100	0	100

Source: Dataquest (December 1990)

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Table 3

Flash Market Share—1989

	64K	128K	256K	512K	1Mb	Total
Average Selling Price ($)	0	0	10.86	26.02	39.67	
Atmel	-	-	5	-	-	5
Intel	-	-	300	16	124	440
SEEQ	-	-	-	29	11	40
Texas Instruments						
Toshiba	-	-	170	-	-	170
WaferScale						
Total (Units)	-	-	475	45	135	655
Atmel	-	-	54	0	0	54
Intel	-	-	3,258	416	4,919	8,593
SEEQ	-	-	0	755	436	1,191
Texas Instruments	-	-	0	0	0	0
Toshiba	-	-	1,846	0	0	1,846
WaferScale	-	-	0	0	0	0
Total (Dollars)	-	-	5,159	1,171	5,355	11,685
Atmel	-	-	1	0	0	1
Intel	-	-	63	36	92	67
SEEQ	-	-	0	64	8	6
Texas Instruments	-	-	0	0	0	0
Toshiba	-	-	36	0	0	26
WaferScale	-	-	0	0	0	0
Total (Percentage)	-	-	100	100	100	100
Regional Market Share						
United States	-	-	64	100	100	74
Japan	-	-	36	0	0	26
Europe	-	-	0	0	0	0
Asia/Pacific	-	-	0	0	0	0
Total	-	-	100	100	100	100

Source: Dataquest (December 1990)

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Table 4

Flash Vendor Product Availability

Company	Density 256K	512K	1Mb	2Mb	4Mb	8Mb	16Mb
AMD			x				
Atmel	x						
Catalyst			x				
Hitachi			x				
Intel	x	x	x	x			
Mitsubishi			x				
NEC							
Rohm							
SEEQ		x	x				
SGS-Thomson	x						
Sharp			x				
Signetics			x				
Simtek							
Texas Instruments	x		x				
Toshiba	x						
WaferScale							

Source: Dataquest (December 1990)

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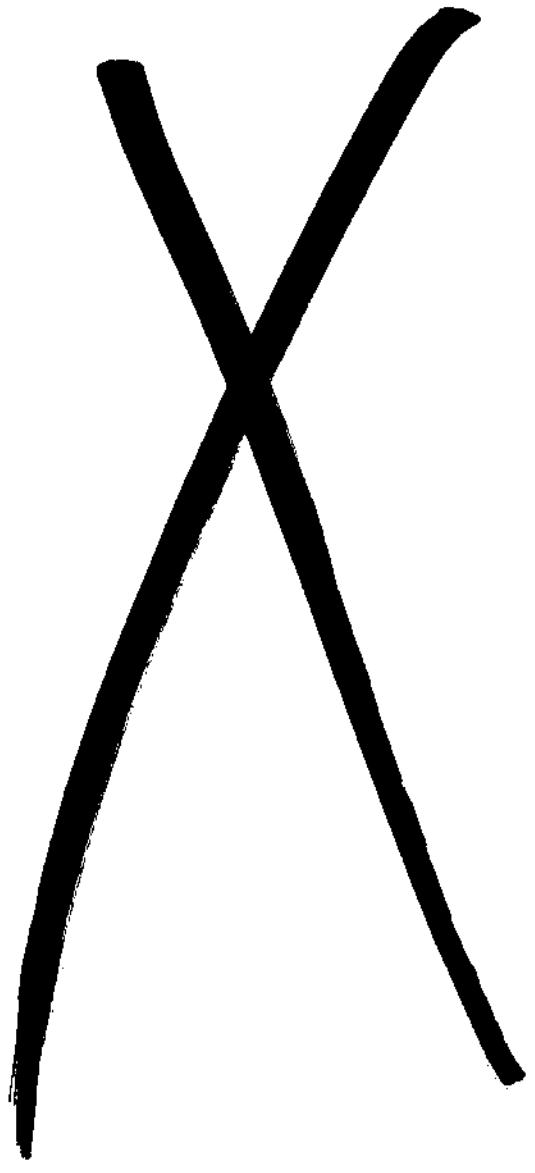

Flash—Data Update

INTRODUCTION

This section contains unit shipment data on Flash devices for 1988 and 1989. These data cover Flash devices based on EPROM and EEPROM technology, including both 5V and 12V devices. In addition to the unit shipment information on 64K, 256K, 512K, and 1-Mbit Flash devices, we have added our estimates of the worldwide billing prices for each product during the four quarters of the year. At the bottom of each table, we show market share data (units, not revenue) for companies based in the United States, Japan, Europe, and the Asia/Pacific region. The tables are organized as follows:

- Table 1—64K Flash Shipment Data, 1988
- Table 2—256K Flash Shipment Data, 1988-1989
- Table 3—512K Flash Shipment Data, 1988-1989
- Table 4—1-Mbit Flash Shipment Data, 1989

DEFINITIONS

Prices

Prices are Dataquest estimates of the billing prices during each quarter. These prices are averaged over all package types, lot sizes, and the entire speed mix, and they represent sales to both military and commercial accounts. Because prices vary from company to company and according to volume and contract orders, our prices should not be used to calculate company revenue.

Unit Shipments

The unit shipment data have been gathered from the manufacturers and represent actual product movements to all market channels. Actual user consumption may be greater or less than the estimated unit shipments as a result of distributor stocking and manufacturers' inventories for internal use.

Quarterly Revenue

Quarterly revenue is calculated as units shipped times the prevailing price during that period.

Sample

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 or column calculations in the table.

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QUARTERLY COMPANY FLASH SHIPMENT DATA

Table 1

Estimated 64K Flash Shipment Data, 1988
(Thousands of Units)

Company	Voltage	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Intel	12V	5	10	5	5	25
Total		5	10	5	5	25
Percentage Change from Previous Quarter			100%	(50%)	0	
Cumulative Total			15	20	25	
Average Selling Price		$8.00	$8.00	$8.00	$8.00	$8.00
Revenue ($M)		0.04	0.08	0.04	0.04	0.20

	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
North America	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Western Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

Source: Dataquest
May 1990

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Table 2

Estimated 256K Flash Shipment Data, 1988-1989
(Thousands of Units)

Company	Voltage	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Intel	12V	5	10	20	40	75
Toshiba	12V		S	10	22	32
Total		5	10	30	62	107
Percentage Change from Previous Quarter			100%	200%	107%	
Cumulative Total			15	45	107	
Average Selling Price		$30.00	$28.00	$23.00	$18.00	$20.90
Revenue ($M)		0.15	0.28	0.69	1.12	2.24

	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
North America	100%	100%	67%	65%	70%
Japan	0	0	33	35	30
Western Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

(Continued)

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Table 2 (Continued)

Estimated 256K Flash Shipment Data, 1988-1989
(Thousands of Units)

Company	Voltage	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Atmel	5V	N/A	N/A	S	5	5
Intel	12V	40	70	90	100	300
SEEQ	12V	0	0	0	0	0
Texas Instruments	5V	0	0	0	0	0
Toshiba	12V	20	50	50	50	170
WSI	5V	0	0	0	0	0
Total		60	120	140	155	475
Percentage Change from Previous Quarter		(3%)	100%	17%	11%	
Cumulative Total		167	287	427	582	
Average Selling Price		$16.00	$13.00	$10.00	$8.00	$10.86
Revenue ($M)		0.96	1.56	1.40	1.24	5.16

	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
North America	67%	58%	64%	68%	64%
Japan	33	42	36	32	36
Western Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample
N/A = Not Available

Source: Dataquest
May 1990

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Table 3

Estimated 512K Flash Shipment Data, 1988-1989
(Thousands of Units)

Company	Voltage	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
SEEQ	12V	S	5	5	5	15
Total			5	5	5	15
Percentage Change from Previous Quarter			0	0	0	
Cumulative Total			5	10	15	
Average Selling Price			$50.00	$45.00	$40.00	$45.00
Revenue ($M)			0.25	0.23	0.20	0.68

	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
North America	0	100%	100%	100%	100%
Japan	0	0	0	0	0
Western Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	0	100%	100%	100%	100%

(Continued)

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Table 3 (Continued)

Estimated 512K Flash Shipment Data, 1988-1989
(Thousands of Units)

Company	Voltage	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Intel	12V	S	2	5	9	16
SEEQ	12V	5	7	7	10	29
Total		5	9	12	19	45
Percentage Change from Previous Quarter		0	80%	33%	58%	
Cumulative Total		20	29	41	60	
Average Selling Price		$40.00	$36.00	$27.00	$17.00	$26.02
Revenue ($M)		0.20	0.32	0.32	0.32	1.17

	1988 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
North America	100%	100%	100%	100%	100%
Japan	0	0	0	0	0
Western Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	100%	100%	100%	100%	100%

S = Sample

Source: Dataquest
May 1990

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Table 4

Estimated 1-Mbit Flash Shipment Data (Thousands of Units)

Company	Voltage	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Intel	12V	S	12	32	80	124
SEEQ	12V	S	1	5	5	11
Toshiba	12V				S	0
Total		0	13	37	85	135
Percentage Change from Previous Quarter				185%	130%	
Cumulative Total			13	50	135	
Average Selling Price		$80.00	$55.00	$45.00	$35.00	$39.67
Revenue ($M)			0.72	1.67	2.98	5.36

	1989 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Market Share					
North America	0	100%	100%	100%	100%
Japan	0	0	0	0	0
Western Europe	0	0	0	0	0
Asia/Pacific	0	0	0	0	0
Total	0	100%	100%	100%	100%

S = Sample

Source: Dataquest May 1990

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