PC Graphics Chip Sets---Product Analysis

PRODUCT MARKET SHARE ANALYSIS

The low-end PC graphics market is broken down into four implementations of the graphics solution: merchant chip sets, captive chip sets, proprietary chip sets, and non-VLSI implementations. Data in this section is presented in figure form to compare 1987 and 1988 actual with 1993 forecast data.

Low-End PC Graphics Market Shares by Implementation

The Dataquest estimates for the share of implementations, broken down by VLSI and non-VLSI, are presented in Table 1 and Figure 1. VLSI (chip set) implementations are expected to be used in about 86 percent of solutions by the end of 1989. The shift toward VLSI is expected to approach saturation in the 1992 time frame.

Table 1
Low-End PC Graphics Market Share by Implementation
Estimated Worldwide History and Forecast
(Millions of Units)

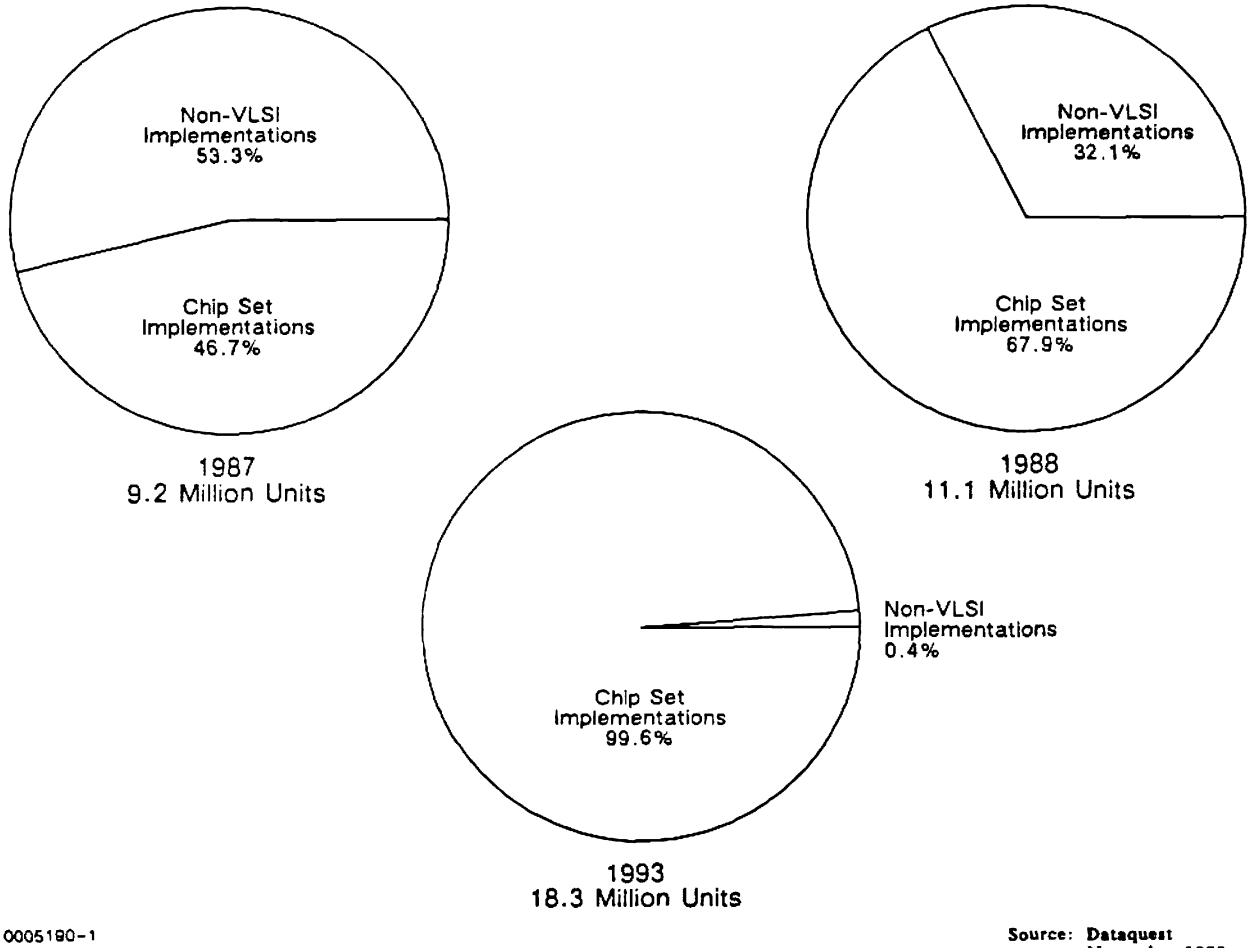
	1987	1988	1989	1990	1991	1992	1993
Total Chip Sets	46.7%	67.9%	86.0%	91.0%	95.0%	98.0%	99.6%
Merchant Chip Sets	49.0%	60.0%	69.0%	78.0%	82.8%	85.0%	86.5%
Captive Chip Sets	8.0%	14.2%	14.5%	10.0%	7.3%	5.8%	5.0%
Proprietary Chip Sets	43.0%	25.8%	16.3%	12.0%	9.9%	9.2%	8.5%
Non-VLSI Implementations	53.3%	32.1%	14.0%	9.0%	5.0%	2.0%	0.4%
Total Low-End Graphics Devices	9.2	11.1	13.7	14.3	15.8	16.4	18.3

Source: Dataquest
November 1989

PC Graphics Chip Sets--Product Analysis

Figure 1

Low-End PC Graphics Market Share
VLSI versus Non-VLSI Implementations



0005190-1

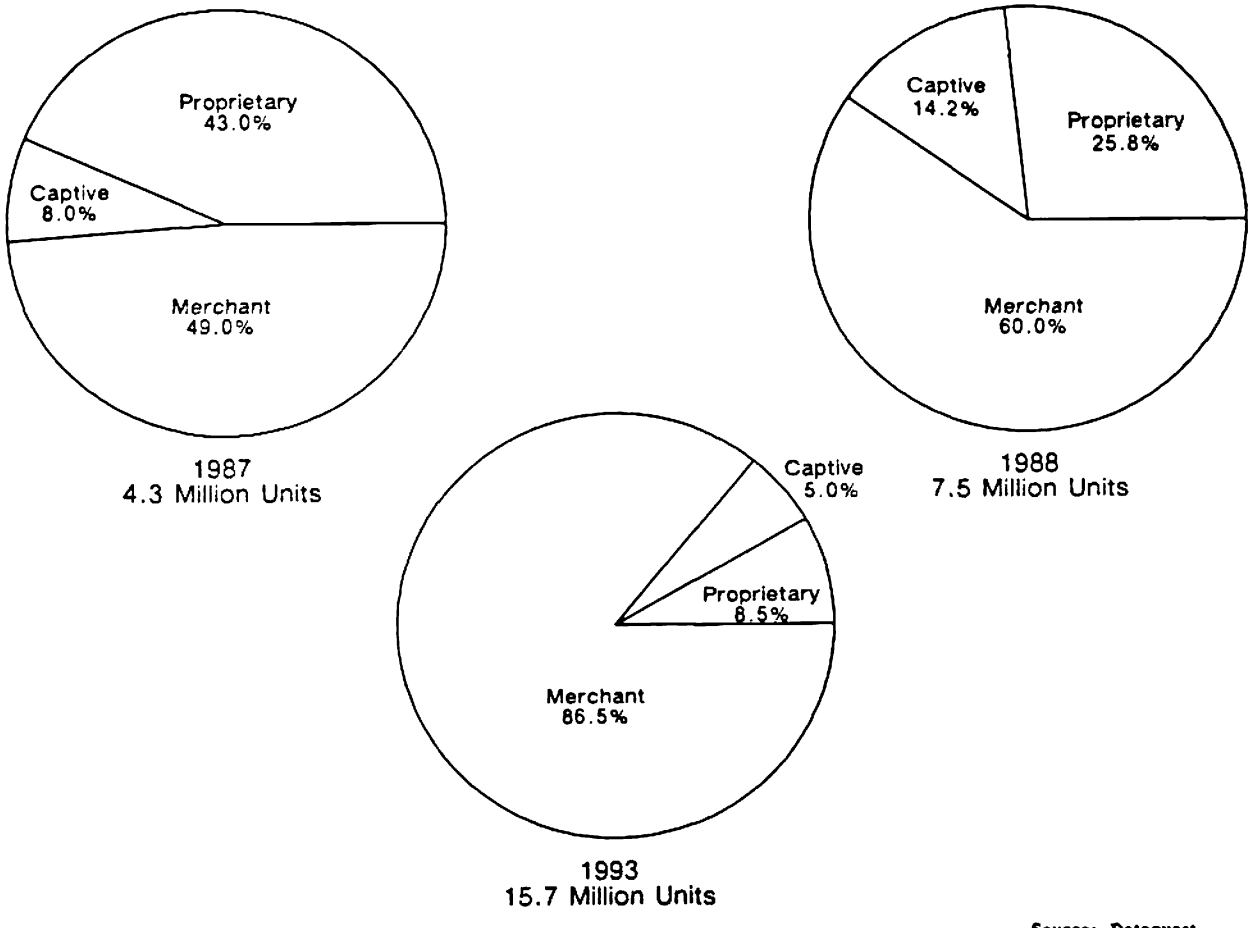
Source: Dataquest
November 1989

PC Graphics Chip Sets--Product Analysis

The further breakdown of VLSI implementations into merchant, captive, and proprietary is presented in Figure 2. Merchant implementations are expected to account for 69 percent of all chip sets by the end of 1989 and 86.5 percent by 1993.

Figure 2

Low-End PC Graphics Chip Set Market Share by Implementation



0005190-2

Source: Dataquest
November 1989

Low-End PC Graphics Market Shares by Standard Type

The Dataquest estimates for market share by standard type are presented in Table 2 and Figure 3. VGA accounted for only 16.4 percent of the market in 1987 but is expected to rise to almost 55 percent by the end of 1989. By 1993, the low-end graphics market is expected to be about 92 percent VGA, with the older standards becoming obsolete.

Table 2

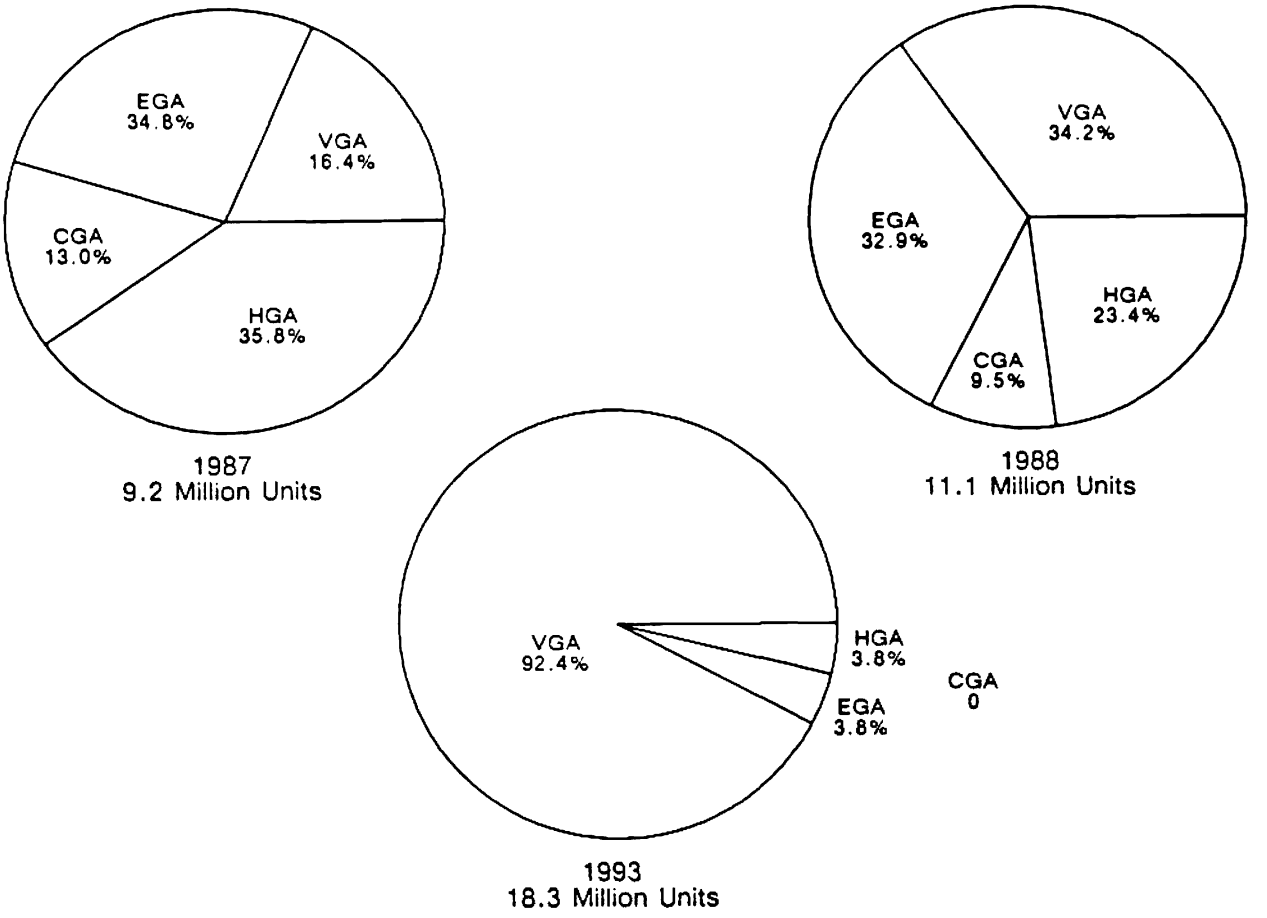
Low-End PC Graphics Market Share by Standard Type
Estimated Worldwide History and Forecast
(Millions of Units)

	1987	1988	1989	1990	1991	1992	1993
HGA	35.8%	23.4%	15.4%	13.6%	10.1%	7.3%	3.8%
CGA	13.0%	9.5%	6.6%	3.1%	1.9%	1.2%	0
EGA	34.8%	32.9%	23.4%	16.8%	11.4%	7.3%	3.8%
VGA	16.4%	34.2%	54.6%	66.4%	76.6%	84.2%	92.4%
Total Low-End Graphics Devices	9.2	11.1	13.7	14.3	15.8	16.4	18.3

Source: Dataquest
November 1989

Figure 3

Low-End PC Graphics Market Share by Standard Type



0005190-3

Source: Dataquest
November 1989

Low-End PC Graphics Market Shares by Implementation within Standard Types

The Dataquest estimates for the different implementations for HGA are presented in Table 3 and Figures 4; for CGA, in Table 4 and Figure 5; for EGA in Table 5 and Figure 6; and for VGA, in Table 6 and Figure 7. This information reflects the same shift toward merchant chip set implementations within each type as is seen in the data for total implementations (Table 1).

Table 3

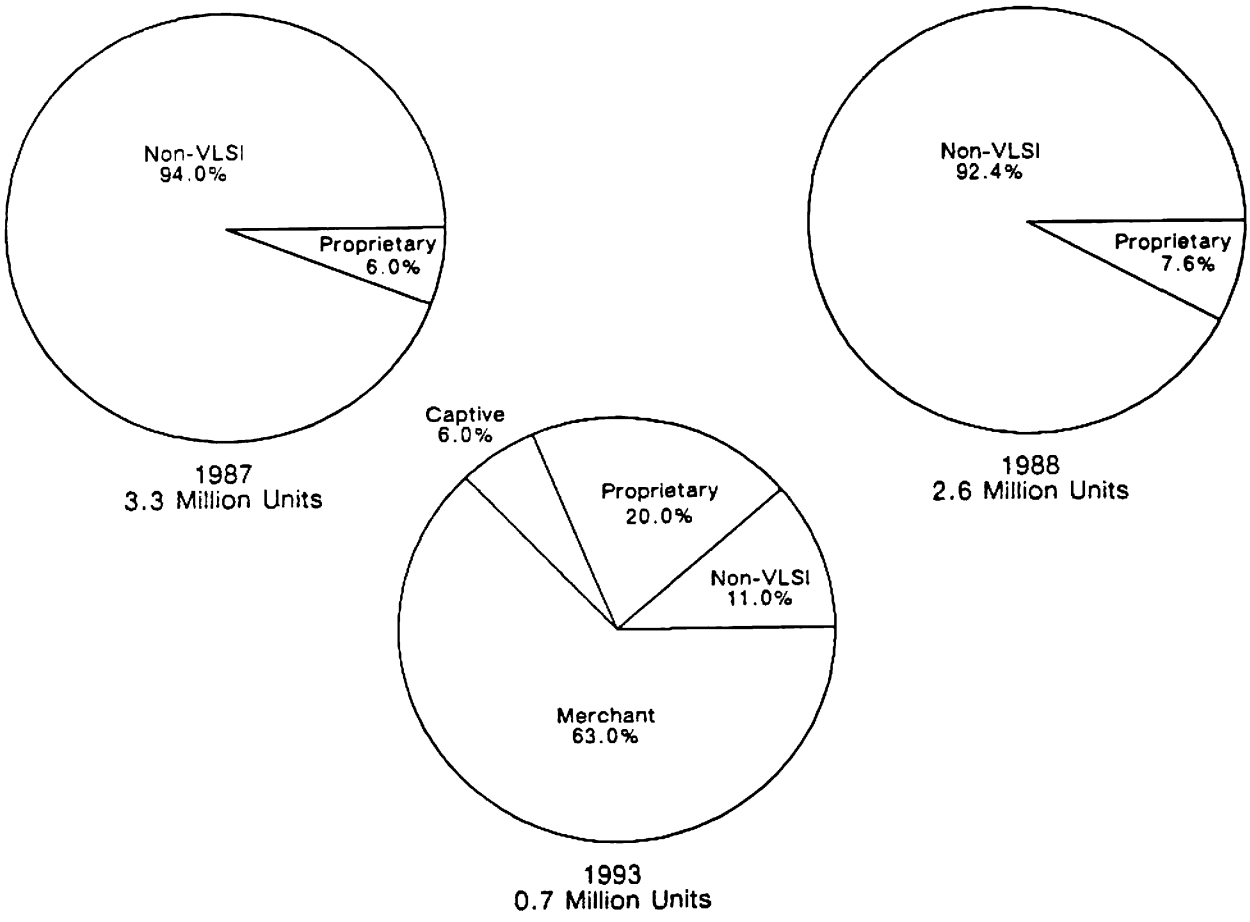
HGA Market Share by Implementation
Estimated Worldwide History and Forecast
(Thousands of Units)

	1987	1988	1989	1990	1991	1992	1993
Merchant	0	0	3.5%	18.4%	30.6%	51.7%	63.0%
Captive	0	0	0.5%	3.4%	6.7%	5.5%	6.0%
Proprietary	6.0%	7.6%	13.0%	13.4%	13.0%	15.5%	20.0%
Discrete	94.0%	92.4%	83.0%	64.7%	49.7%	27.3%	11.0%
Total HGA Graphics Devices	3.3	2.6	2.1	2.0	1.6	1.2	0.7

Source: Dataquest
November 1989

Figure 4

Estimated HGA Market Share by Implementation



0005190-4

Source: Dataquest
November 1989

Table 4

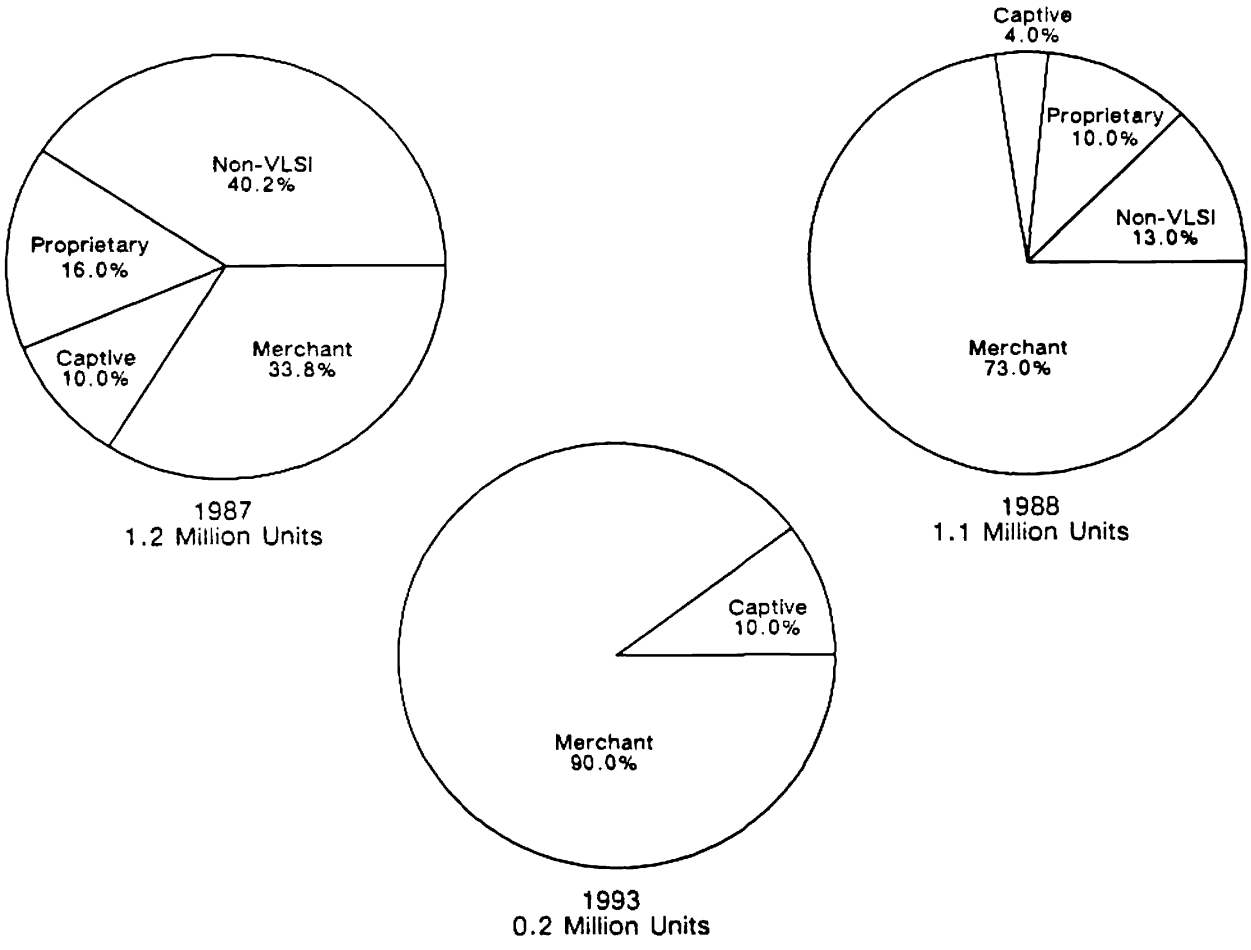
CGA Market Share by Implementation
Estimated Worldwide History and Forecast
(Thousands of Units)

	1987	1988	1989	1990	1991	1992	1993
Merchant	33.8%	73.0%	87.0%	92.0%	92.0%	90.0%	0
Captive	10.0%	4.0%	7.0%	8.0%	8.0%	10.0%	0
Proprietary	16.0%	10.0%	6.0%	0	0	0	0
Discrete	40.2%	13.0%	0	0	0	0	0
Total CGA Graphics Devices	1.2	1.1	0.9	0.5	0.3	0.2	0

Source: Dataquest
November 1989

Figure 5

Estimated CGA Market Share by Implementation



0005190-5

Source: Dataquest
November 1989

Table 5

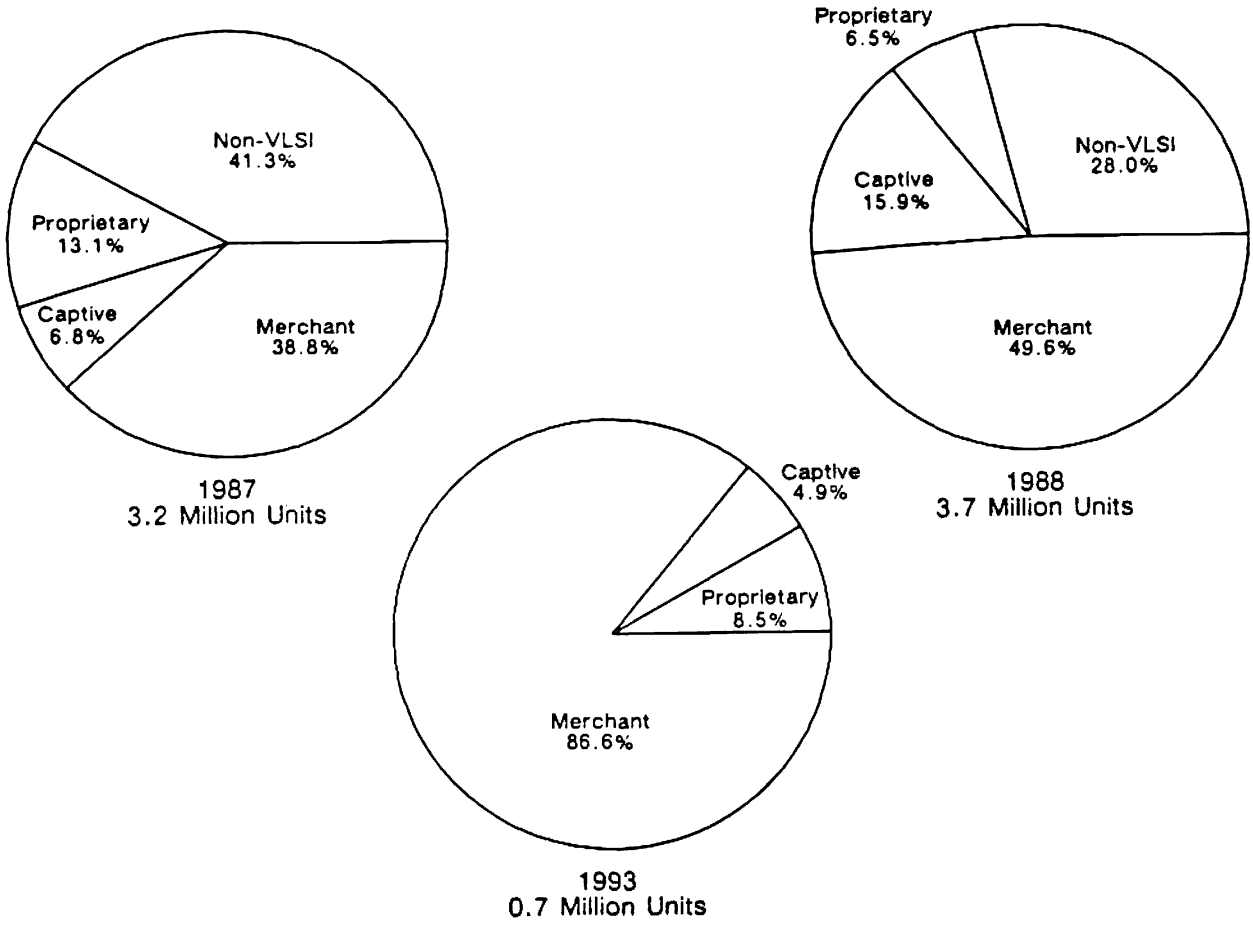
EGA Market Share by Implementation
Estimated Worldwide History and Forecast
(Thousands of Units)

	1987	1988	1989	1990	1991	1992	1993
Merchant	38.8%	49.6%	70.9%	78.0%	83.0%	83.8%	86.6%
Captive	6.8%	15.9%	13.0%	10.0%	8.0%	6.3%	4.9%
Proprietary	13.1%	6.5%	10.0%	11.0%	9.0%	9.9%	8.5%
Discrete	41.3%	28.0%	6.1%	1.0%	0	0	0
Total EGA Graphics Devices	3.2	3.7	3.2	2.4	1.8	1.2	0.7

Source: Dataquest
November 1989

Figure 6

Estimated EGA Market Share by Implementation



0005190-6

Source: Dataquest
November 1989

Table 6

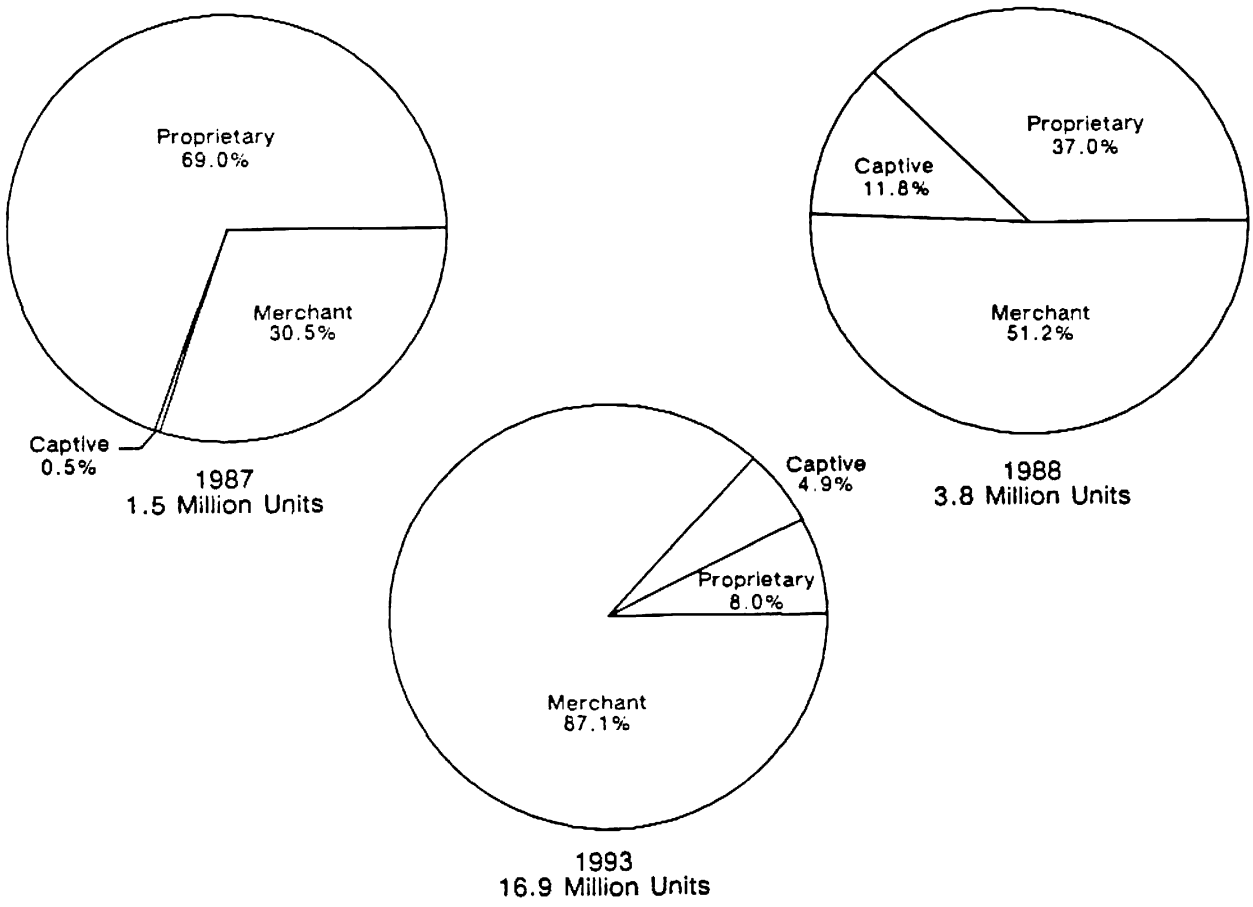
VGA Market Share by Implementation
Estimated Worldwide History and Forecast
(Thousands of Units)

	1987	1988	1989	1990	1991	1992	1993
Merchant	30.5%	51.2%	66.7%	79.0%	84.0%	85.9%	87.1%
Captive	0.5%	11.8%	16.3%	10.1%	6.8%	5.6%	4.9%
Proprietary	69.0%	37.0%	17.0%	10.9%	9.2%	8.5%	8.0%
Discrete	0	0	0	0	0	0	0
Total VGA Graphics Devices	1.5	3.8	7.5	9.5	12.1	13.8	16.9

Source: Dataquest
November 1989

Figure 7

Estimated VGA Market Share by Implementation



0005190-7

Source: Dataquest
November 1989

MERCHANT CHIP SET PRICING

The Dataquest estimates for average selling prices (ASPs) for merchant chip sets by standard type are presented in Table 7 and Figure 8. Points worth noting include the following:

- Prices are expected to drop sharply between 1989 and 1990. This is due to new vendors coming into the market and creating a situation of oversupply. Competition for VGA market share has driven prices for VGA chip sets down to the level of EGA prices, causing severe price erosion in EGA.
- The weighted average ASP for all merchant graphics chip sets is expected to continue to decline rapidly through 1993, approaching the prices of other commodity VLSI devices. As more high-volume, low-cost producers enter the market, pricing will be cost-based rather than market-based, as it has been until now.
- The ASP forecast was prepared by making assumptions about VGA manufacturing costs, expected premiums required to move up from one standard to the next, and by making comparisons to price trends in similar devices. As VGA becomes the dominant standard, the weighted average ASP begins to reflect VGA pricing.

Table 7

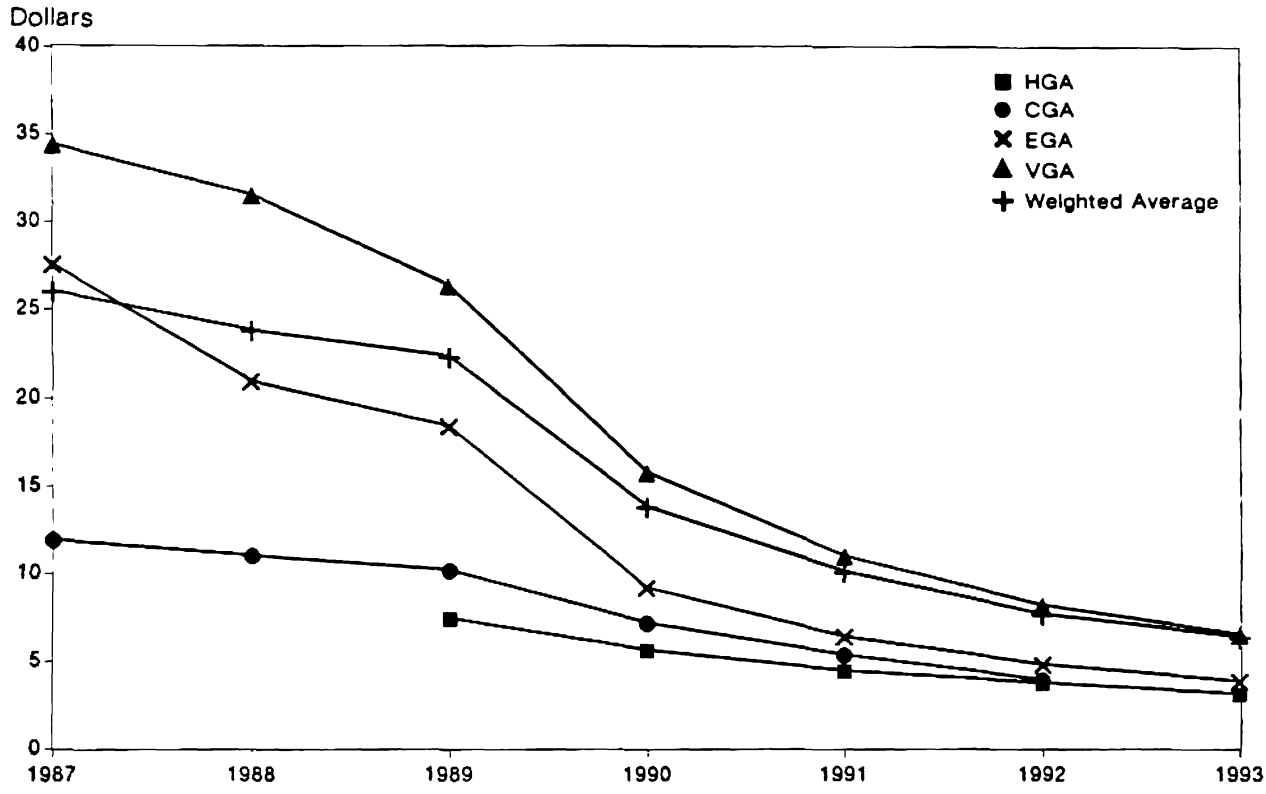
Low-End Merchant PC Graphics Chip Sets
ASPs by Type
Estimated Worldwide History and Forecast

	1987	1988	1989	1990	1991	1992	1993	CAGR 1987-1993
HGA			7.50	5.70	4.55	3.85	3.25	(18.9%)
Growth Rate				(24.0%)	(20.2%)	(15.4%)	(15.6%)	
CGA	12.00	11.10	10.26	7.25	5.45	4.05		(17.0%)
Growth Rate		(7.5%)	(7.6%)	(29.3%)	(24.8%)	(25.7%)	0	
EGA	27.63	20.98	18.44	9.25	6.50	4.90	3.95	(27.7%)
Growth Rate		(24.1%)	(12.1%)	(49.8%)	(29.7%)	(24.6%)	(19.4%)	
VGA	34.50	31.63	26.41	15.85	11.10	8.30	6.65	(24.0%)
Growth Rate		(8.3%)	(16.5%)	(40.0%)	(30.0%)	(25.2%)	(19.9%)	
Weighted Average	26.10	23.90	22.40	13.90	10.20	7.80	6.50	(20.8%)
		(8.6%)	(6.0%)	(38.0%)	(27.0%)	(23.3%)	(17.2%)	

Source: Dataquest
November 1989

Figure 8

Low-End Merchant Graphics Chip Set ASP by Standard Type



0005190-8

Source: Dataquest
November 1989

PRODUCT CHARACTERISTICS AND SEGMENTATION

Currently, PC graphics can be divided into two basic types of products: high end and low end. Essentially, the high-end product is an intelligent graphics controller, whereas the low-end product is a simple bit map or collection of memory.

The characteristics of the high-end graphics controller are as follows:

- It has a sophisticated (and high-level) command set for drawing while off-loading the system CPU.
- It may or may not allow direct access to the bit map--i.e., it may or may not allow the system CPU to go around the command set.
- It is capable of higher resolutions and performance.
- It is medium- to high-priced, and it is implemented on a separate add-on board or on the main CPU motherboard.

The high-end graphics segment contains products at the chip level that are sophisticated VLSI graphics coprocessors. These are devices such as the IBM 8514/A, TI TMS34010, Hitachi ACRTC, and Intel i82786. This segment also contains the board-level products that use these coprocessors.

Off-loading the host CPU from the drawing and font creation tedium directly results in an increase in graphics and overall system performance. However, along with the additional computing power comes the requirement for larger memory arrays due to the higher display resolution.

The characteristics of the low-end frame buffer are as follows:

- The system CPU does all graphics drawing; it is not equipped with a high-level command set.
- Essentially, it is a bit map with an addressing scheme.
- Performance at higher resolutions depends on the host CPU.
- It is low- to medium-priced, and it is implemented on a separate add-on board or on the main CPU motherboard.

Graphics systems have two characteristics that are reflected in hardware requirements: Large memories are required to support high-resolution displays, and a lot of computing power is required to generate complex graphic images.

Memory requirements increase with the square of the resolution (for example, a 1,000-line monochrome display without gray scale would require 1 million bits of memory storage, whereas a 2,000-line display would require 4 million bits of memory). A further complication is that for high-resolution displays, more bits must be read from memory in a shorter time. As the number of lines increases, the time available to display each line decreases, since all lines must be displayed within 1/60 of a second. In addition, as the number of lines increases, the number of bits per line also increases. The problem of reading more bits from memory in a shorter time can be solved by faster memories, or by reading more bits at a time, or both. The main point is that graphics displays are memory-intensive and are directly tied to advances in memory technology.

Rapid computation is the other critical factor in graphics applications. Vector information has to be converted to bit patterns and written into the display memory. This process requires a lot of computer power. For example, plotting a straight diagonal line given the end-point coordinates requires a multiplication for each pixel. Circles require a square-root computation for each point, and other shapes can require more complex computations. Special processor chips designed to execute such operations directly in hardware can greatly speed up the plotting process.

PC GRAPHICS STANDARDS: AN EVOLUTION IN RESOLUTION

The evolution of graphics adapters has lead us from the original Hercules Graphics Adapter (HGA) to the Video Graphics Array (VGA), which is now the standard on the IBM PS/2 line of computers. Between these two products have been several other graphics iterations such as the Color Graphics Adapter (CGA), the Multi-Color Graphics Adapter (MCGA), and the Enhanced Graphics Adapter (EGA). All of these display products are originations by IBM. Also, as they were improvements on one another, only a few are relevant to today's market requirements, as follows:

- HGA—The Hercules Graphics Adapter was conceived by Hercules Corporation as one of the first third-party add-on boards for the IBM PC. It is monochrome but offers a higher display resolution than the monochrome display adapter (MDA) introduced with the PC. The HGA card was first introduced in 1982. Technically, it fits near the bottom of the display resolution ranks. Though it is a long way from today's VGA products, the Hercules specification is upheld in backward compatibility within existing graphics products. The resolution for the HGA is 720 x 350 pixels.

- CGA—The Color Graphics Adapter was the first color specification after the monochrome Hercules adapter. CGA is very limited in its color offering but began life as an alternative to monochrome display solutions. The resolution for CGA is 320 x 200 pixels with 4 colors.

- EGA--The Enhanced Graphics Adapter builds on the CGA and increases the number of colors available at the same and higher resolutions. The resolution for EGA is 640 x 350 pixels with 16 colors.

- VGA--The Video Graphics Array is the first graphics standard to be included on the system board as an integral feature. VGA offers still higher resolution and more colors than EGA. The resolution for VGA is 320 x 200 pixels with 256 colors or 640 x 480 with 16 colors.

Table 8 presents the PC graphics standards and their various specifications, including enhancements.

Table 8

PC Graphics Standards and Specifications
Including Common Enhancement Modes

Standard	Resolution	Colors
VGA	320 x 200	256
	640 x 480	16
	640 x 480	256
	800 x 600	16
	800 x 600	256
	800 x 600	Monochrome
	960 X 720	4
	960 X 720	16
	960 X 720	Monochrome
	1024 x 768	2
	1024 x 768	4
	1024 x 768	16
	1024 x 768	Monochrome
	1280 x 960	4
	1280 x 960	Monochrome
EGA	640 x 350	16
	640 x 480	16
CGA	320 x 200	4
	640 x 200	2
	640 x 400	Monochrome
HGA	720 x 350	Monochrome

Source: Dataquest
November 1989

The following is a list of PC graphics chip set vendors:

- Acer Laboratories, Inc., USA
  926 Thompson Place
  Sunnyvale, CA 94086
  Phone: 408-733-3174
  Fax: 408-733-2569

- Chips and Technologies, Inc.
  3050 Zanker Rd.
  San Jose, CA 95134
  Phone: 408-343-0600
  Fax: 408-434-9315

- Cirrus Logic, Inc.
  1463 Centre Pointe Dr.
  Milpitas, CA 95035
  Phone: 408-945-8300

- Genoa Systems Corp.
  75 East Trimble Rd.
  San Jose, CA 95131
  Phone: 408-432-9090
  Fax: 408-434-0997

- Headland Technology, Inc.
  (formerly Video-7)
  46335 Landing Parkway
  Fremont, CA 94538
  Phone: 415-656-7800
  Fax: 415-656-0397

- Intel Corp.
  3065 Bowers Ave.
  Santa Clara, CA 95051
  Phone: 408-987-8080

- NSI Logic, Inc.
  259 Cedar Hill Rd.
  Marlboro, MA 01752
  Phone: 508-460-0717
  Fax: 508-460-0847

- Oak Technology, Inc.
  139 Kifer Ct.
  Sunnyvale, CA 94086
  Phone: 408-737-0888
  Fax: 408-737-3838

- Trident Microsystems, Inc.
  321 Soquel Way
  Sunnyvale, CA 94086
  Phone: 408-738-3194
  Fax: 408-738-0905

- Tseng Laboratories, Inc.
  10 Pheasant Run
  Newtown, PA 18940
  Phone: 215-968-0502
  Fax: 215-860-7713

- United Microelectronics Corp. (UMC)
  13th Floor, No. 687
  Min-Sheng East Road
  Taipei, Taiwan, R.O.C.
  Phone: (02) 715-2455
  Fax: (02) 716-6291

- Western Digital Imaging
  800 East Middlefield Rd.
  Mountain View, CA 94043
  Phone: 415-960-3353
  Fax: 415-968-1974