MICROCOMPONENTS WORLDWIDE 1995

TABLE OF CONTENTS

Dataquest ALERT

251 River Oaks Parkway • San Jose • CA • 95134-1913 • Phone 408-468-8000 • Fax 408-954-1780

Intel Launches Pentium Pro; New CPU Is All Dressed Up with Nowhere to Go

In the most-anticipated and least-suspenseful product launch since August's debut of Windows 95, Intel today "officially" introduced its next-generation architecture, the Pentium Pro. Now, we know that you can buy all 5.5 million transistors, along with 256KB of level-two cache in a dual-cavity PGA package, running at 150 MHz, for only $974 in 1,000-unit quantities. For only 10 percent more ($1,075), buyers can get a version that runs at 180 MHz and delivers 18 percent more performance. In the day's only surprise, Intel indicated that it was pulling into December availability of a 200-MHz version, with 36 percent more performance at only a 33 percent price premium. Major vendors, including Compaq, Hewlett-Packard, Packard Bell, IBM, Gateway, Dell, DEC, NEC, and Micron are ready to ship 150-MHz units now. Table 1 summarizes the key parameters of Intel's announcement.

Table 1
Pentium Pro Facts

Clock Speed (MHz)	150	166	180	200
Bus Speed (MHz)	60	66	60	66
L2 Cache (KB)	256	512	256	256
Manufacturing Process (Microns)	0.6	0.35	0.35	0.35
Die Size (Mils/Side	691	552	552	552
SPECint92	276.3	327.1	327.4	366.0
SPECfp92	220.0	261.3	254.6	283.3
Production	Q4/95	Q1/96	Q4/95	Q4/95
Price (U.S.$)	974	1,682	1,075	1,325

Source: Intel

The design, implementation, and production of this device represents an incredible technological achievement, one that few corporations other than Intel could even consider. Given its complexity, this undertaking has proceeded incredibly smoothly over the past 48 months. The engineers at Intel have earned a few days off, or even a sabbatical, before they climb back onto their technological treadmills.

The earlier- than-expected availability of the 200-MHz part (December 1995 versus June 1996) demonstrates that Intel's new 0.35 micron BiCMOS process has reached maturity without any major hiccups. The pricing at 180 MHz (18 percent more performance at only a 10 percent premium) should gently nudge many customers to this speed and suggests that yields in the new process, combined with the smaller die size of the 0.35-micron part, create an economic incentive for Intel to shift customers away from the 0.6-micron part quickly. Much of this 0.6-micron capacity will be redirected toward chipset production, one of the positive side effects of Intel's participation in this part of the business. (Note that in 1994, Intel continued to make 0.8-micron Pentiums, even after the 0.6-micron parts were available in volume, to keep its fabs busy. At that point, Intel used external foundries to support its chipset production requirements.)

Fortunately for Intel's competitors, the Pentium Pro has not achieved total perfection in its first incarnation. Its most serious limitation stems from an assumption made by P6 architects many years ago, that by 1996 the desktop world would have shed its 16-bit roots and evolved to a 32-bit orientation. When push came to shove, and the developers were forced to trade off 16-bit performance to gain 32-bit performance, it seemed like a reasonable compromise. It isn't. Windows 3.1 remains a 16-bit world; even the much ballyhooed Windows 95 merely begins the several-year transition to 32 bits. And until this transition occurs, the Pentium Pro has the unenviable distinction of being the only new x86 chip that cannot outperform earlier-generation devices when running performance-intensive applications. Of course, power users running Windows NT, OS/2, or UNIX will experience improved performance if they upgrade to Pentium Pro, and the installed base of such users numbers several million. But, the one hundred million (or so) users still running DOS, Windows 3.1, or Windows 95 will not see any performance benefit and will be unlikely candidates for such an upgrade. Many of these users will spend disproportionately to gain small performance advantages, as the rapid adoption of the 60 MHz Pentium demonstrated two years ago. It appears unlikely that these users will spend more money to gain less performance. Dataquest believes that this characteristic of the Pentium Pro will seriously constrain demand throughout 1996 and into 1997.

A second fly in the Pentium Pro's ointment stems from the inherent difficulty in attaining completely reliable operation in complex multiprocessor environments. Nothing short of completely reliable operation will do in mission-critical applications supporting hundreds or thousands of users, and there are few shortcuts for achieving this. Although the Pentium Pro program focused on "enterprise server" requirements from its very inception, the chip and its supporting chipset are not quite ready for prime time. Consequently, Intel has encouraged its system OEMs to restrict initial Pentium Pro configurations to uni- and dual-processor environments, with the expectation that four-way multiprocessor systems will be available in the second quarter of 1996. This will further constrain demand for Pentium Pro CPUs for at least six months.

The Pentium Pro's price/performance characteristics will make it very appealing to customers who formerly had to abandon x86 architecture and move to a RISC alternative to obtain the performance they needed for their work. These users were willing to sacrifice virtually all compatibility with the Windows environment, and 16-bit application performance will rarely concern them . The Pentium Pro will allow such users to gain the benefits of high-end RISC workstation performance while retaining the ability to use inexpensive personal computer productivity software for their less performance-intensive needs. Dataquest estimates that this group, largely the technical workstation market, contains less than one million users. Many of them should find the Pentium Pro compelling.

The initial customer base for each new generation of Intel architecture comprises mostly users whose time is so valuable that they will pay almost any price for improved performance. Alternatively, when many users share the CPU's cost, price is rarely a concern. At present, the Pentium Pro addresses the needs of only a small part of these niche markets, and the markets it addresses well are relatively small, compared to the unit volumes expected in the personal computer market.

With these observations in mind, Dataquest believes that the Pentium Pro will enter the market far more slowly than the Pentium processor did in 1993 and 1994. That CPU got off to the quickest start in history, and Intel delivered over five million units in its first fifteen months of production. Dataquest estimates that demand for the Pentium Pro will total only 100,000 units in the remainder of 1995 and will ramp to 1 million units in the fourth quarter of 1996, with demand for all of 1996 coming in at about 2.5 million units.

Although the Pentium Pro may get off to a slow start, compared with its earlier namesake, Intel will not give its competitors a free ride. AMD/NexGen and Cyrix have yet to demonstrate that they can deliver any sixth-generation chip in meaningful quantities and that their Nx686 and 6x86 devices can outperform the Pentium Pro, even in 16-bit environments. Intel is likely to push harder on clock rate scaling for its P54C and P55C products to compensate for the Pentium Pro's deficiencies on the desktop. Intel still enjoys a comfortable lead in its overall campaign. But that lead is narrower than it might have been, had Pentium Pro's 16-bit performance been a bit less lackluster.

By Nathan Brookwood
Microprocessor Analyst

Dataquest ALERT

1290 Ridder Park Drive • San Jose • CA • 95131-2398 • Phone 408-437-8000 • Fax 408-437-0292

Dataquest Telebriefing: Intel's P6

Topic: On Thursday, February 16, Intel will disclose key features of its upcoming P6 processor at the ISSCC. Dataquest will hold a teleconference at 8:00 a.m. February 17 to discuss the P6 disclosure and the implications for the industry. Dataquest analysts Martin Reynolds, Jerry Banks, Kimball Brown, Nancy Stewart, Philippe de Marcillac, and Dominic Ricchetti will present the material. The briefing will spend about one hour covering architecture, silicon, and system aspects of the P6. It will be followed by a Q&A session.

Agenda: **The Architecture of the P6**

A brief technical discussion of the features of the P6. We will cover key similarities and differences between the P6 and the Pentium, AMD's K5, Cyrix's M1, NexGen's 586, and the latest RISC processors.

The Performance of the P6

Expected performance at introduction compared to both x86 and RISC processors. Projected performance of the P6 and other processors.

The Cost and Manufacturing Parameters of the P6

Projected manufacturing costs, expected pricing, and manufacturing capacity available to build the P6 over time. Implications and future of the rumored dual-cavity package.

Competing Processor Manufacturers

How the P6 will affect other processor manufacturers including AMD, Cyrix, NexGen, Sun, MIPS, Digital, and Hewlett-Packard. A comment on the P7 and the Intel-HP alliance.

P6 Systems

Implications for PC, server, and workstation systems. Design features and implementation issues that will affect adoption of the P6 in the marketplace. Availability and penetration of the P6 into the market.

Questions and Answers

When: Friday, February 17, 1995 at 8:00 a.m. PST

How: To confirm attendance, please contact Carole Phillips at (408) 437-8376 or (408) 437-7941 (fax) by **February 16 a.m.** The number to call in on will be given at the time of you registration.

Dataquest ALERT

1290 Ridder Park Drive • San Jose • CA • 95131-2398 • Phone 408-437-8000 • Fax 408-437-0292

Intel Solidifies its Position in PCI Core Logic

Intel has once again jumped ahead in the PCI chipset market with the announcement of the internally code-named "Triton," or 82430 chipset. Much to the chagrin of its PC core logic chipset competitors, Intel is poised to ship its second-generation PCI chipset as other manufacturers are just ramping up the volume curve on their first iterations.

The bottom line is that the product is fast, feature-rich, and aggressively priced at $41 per set. The volume ramp of Triton should be very rapid because it is being manufactured in Intel's 486-generation, 0.8-micron CMOS process. Intel is rapidly moving its mainstream microprocessor process technology over to 0.6-micron BiCMOS; this is resulting in plenty of low-cost capacity for the Triton. Although this may be good news for the PC OEMs that will probably migrate to Triton as soon as possible, it is a blow to the many independent chipset manufacturers trying to service this same market.

Intel's prior investment in PCI; its substantial motherboard business; its cooperation among processor, core logic, and motherboard groups; and its enormous manufacturing resources combine to give Intel an overpowering advantage in the core logic market. Such an occurrence could be a precursor to another major Intel thrust into the systems market.

Key Features

Triton's PCI-to-ISA bridge incorporates a high-speed (22 MB/sec) IDE-to-PCI controller and a plug-and-play port for motherboard peripherals. These features add value of about $4 to $8 to the chipset, further enhancing its cost-effectiveness. The chipset incorporates several features that undoubtedly improve memory performance to some extent, mostly in the area of write buffers and write management. Good implementation of these features can certainly improve performance in any system, and is needed to get the full benefit of burst-mode memories.

Intel also places substantial emphasis on the improved PCI streaming performance of the chipset, again a function of the improved memory management. Triton is billed as being twice as fast as Neptune, delivering 100 MB/sec from the PCI bus to DRAM.

Is It Triton Alone Providing the Performance?

Performance numbers indicate that Triton with EDO DRAM but no secondary cache performs at the same level as the very best Pentium systems based on Intel's first-generation chipset, known as "Neptune," with 256K of secondary cache. However, because the Neptune does not support EDO, all Neptune systems are configured with standard DRAM, thus preventing an apples-to-apples comparison with Triton. Adding an L2 cache to the Triton-based system boosts performance another 20 percent. Intel did not release performance numbers for Triton systems configured with standard DRAM and L2 cache, leading us to suspect that the performance benefits stem more from the use of EDO DRAM than the Triton chipset itself.

The hype does not detract from the product, however. The configuration flexibility and performance of Triton will place its host systems at the top of the performance ratings.

Manufacturing

The Neptune chipset was always somewhat handicapped by its incorporation of cache tag memory into the system controller. We estimate that Neptune had to incorporate perhaps 32KB of static memory into its logic, ballooning the die size and restricting production to the few vendors able to supply mixed logic and memory functions. These limitations prevent Neptune from collapsing in price because the inherent cost is high. Triton, on the other hand, has more logic but eliminates the cache tags. Therefore it costs less and can be built in higher quantities. Furthermore, Intel plans to build the devices on its 0.8-micron 486 lines and to purchase from outside suppliers. This approach allows Intel to rapidly ramp volume production as the 486 volumes fall off later in the year. This manufacturing strategy implies that Triton will be very competitive in the market, dropping in price as necessary to balance supply, demand, profitability, and competition.

Dataquest Perspective

Triton will permit the design of systems that can be configured with standard or EDO DRAM, and standard cache, burst cache, or no cache at all. This flexibility will allow a single design to migrate along price/performance curves as the market changes. In particular, the trade-offs between EDO DRAM and standard DRAM and among the three cache options become very easy to manage. We believe that, as the low-end Pentium market matures later in the year, Intel will become quite aggressive in the pricing of the chipset to make it pervasive in the market as soon as possible.

Triton also raises a red flag for those few manufacturers still designing their own chipsets. The fruits of these labors must be fast, inexpensive and available to make the effort worthwhile. Perhaps internal efforts could be better used by partnering with external chipset companies to keep the market alive. Nobody—including Intel, in the long run—will benefit from another Intel-dominated segment of the market.

Triton has a relatively low price for its feature set, and the pricing umbrella is set to drop rapidly. Although supply, demand, and market inertia will prevent Triton from displacing other chipsets, 1996 will be a tough year for manufacturers without competitive products. As Intel's 486 production dies down, Intel will be able to saturate the market with core logic built on manufacturing lines that have already been paid for by the 486. Chipset manufacturers, therefore, must plan innovative features and performance advantages just to stay in the game.

Intel's market position also makes it worthwhile to clone the Intel pinout, as long as the replacement parts offer performance, cost, or feature advantages. In particular, a lower-performance, lower-cost system controller could find a place at the low end of the product spectrum late in the year.
Jerry J. Banks

Dataquest ALERT

1290 Ridder Park Drive • San Jose • CA • 95131-2398 • Phone 408-437-8000 • Fax 408-437-0292

AMD and Intel Bury the Hatchet: Lawyers Mourn

In a rare event for the semiconductor industry, a case of common sense has spontaneously and simultaneously broken out between two companies that have been battling each other on the legal front for the past seven years.

Intel and AMD yesterday announced that they have settled the long-standing legal dispute related to AMD's use of Intel's intellectual property to build 386 and 486 microprocessors. AMD will pay Intel $58 million, drop all outstanding legal actions, and build no more than 20 percent of its 486 products in external foundries. Intel will pay AMD $18 million in costs and drop all further legal action against AMD, and Intel will grant AMD and its customers the right to use Intel's Crawford system-level patent.

Although neither side can be declared a winner, the only real losers in this long-overdue agreement are the lawyers for both parties. Both of these legal combatants have been the source of many billable hours over the past seven years. If you listen really closely you just might hear the collective sighs of relief coming from the companies. Of course, this will be difficult to pick out from the din created from the hysterical sobbing of the lawyers.

This settlement was made possible by AMD's decision to forgo using Intel microcode in its next generation of x86 microprocessors. Starting with the upcoming K5 member of AMD's K86 family, AMD will cease to use any Intel intellectual property in the design of its x86-compatible microprocessors. Because AMD's impact on the 486 market is severely hampered by its limited manufacturing capacity for 486 microprocessors, and because the 486 microprocessor family saw its peak production year in 1994, and because any potentially successful litigation by Intel intended to stop AMD from manufacturing the product could take many months if not years, the 486 microprocessor will be near the end of its profit-making life by the time such a case is decided and all appeals have been attempted. In the meantime, AMD would continue to ship as many 486s as it could manufacture. What would Intel have to gain under such a scenario? Precious little, is the apparent conclusion it has reached.

There exists historical precedence that would seem to indicate that AMD's presence in the 486 market will be of great benefit to Intel. When Intel introduced the 486 microprocessor, it was able to pull out of the lower-margin 386 market much more rapidly than it would have if AMD were not there to ship 386s to the significant trailing-edge market and to the manufacturers of entry-level machines. Similarly, now Intel will be able to focus on moving its manufacturing focus over to the Pentium with the knowledge that a credible supplier of 486s exists in AMD. Such a scenario is beneficial to both companies.

This legal wrangling has been a major thorn in the sides of both companies, and now that they have helped each other remove the thorns each will now be able to focus its energies on more productive work. Although AMD is still lagging its larger competitor in the x86 marketplace, perhaps the future will find attention more drawn to the standard market issues of price, performance, branding, and market share, among others, than to the netherworld of the courtroom.

We would note that the 486 is available from many alternate sources other than AMD, including Cyrix, SGS, Texas Instruments, IBM, and UMC.

The only losers are the lawyers. With the 1997 antitrust suit now eliminated and no further likelihood of court action on this matter, a major source of revenue has been eliminated. The lawyers will have to retire to designing legal protection into the next generation of Intel processors.

Implications for System Manufacturers

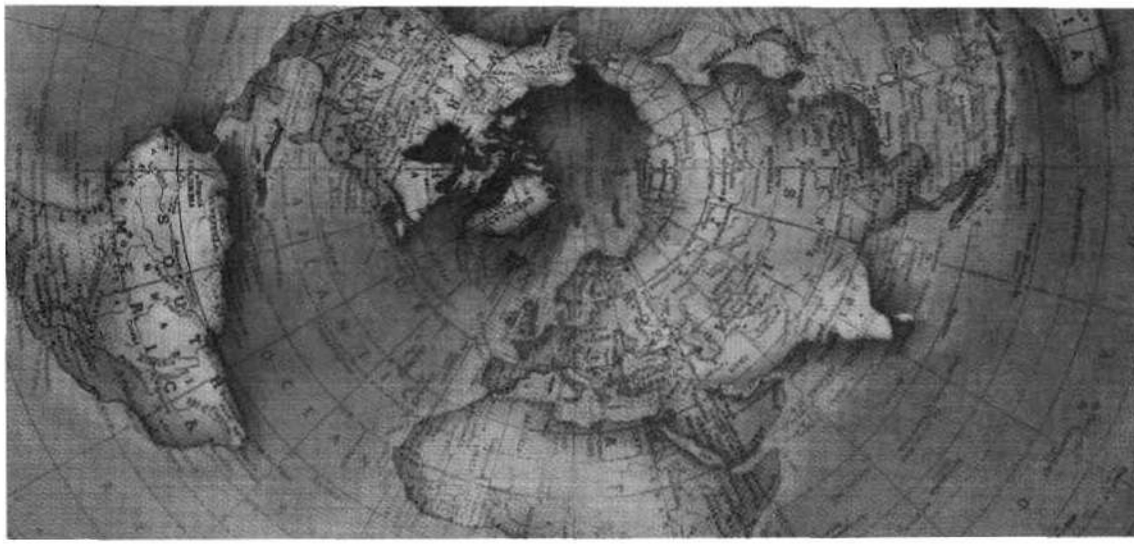
With the specter of a legal victory vanquished, system manufacturers can introduce or continue to use AMD's 486 parts in their product lines without fear of a sudden cessation of supply. Handheld devices built with AMD's Elan-class integrated devices now carry no risk in terms of availability of the sole-sourced core; however, the handheld market presents greater risks of its own.

The signs remain clear that Pentium is the processor of choice for new product designs, except at the low end. 486 processors will continue to drop in price, devaluing the systems built around them.

The 20 percent limit to foundry parts may force AMD to use internal capacity to build 486 parts instead of K5s, possibly delaying volume availability of the K5. This factor will not hurt AMD; we believe that the 486 will be more profitable for production-constrained AMD to build than the K5, well into 1996.

It seems that Intel is unlikely to aggressively pursue legal action against the other 486 cloners, although the shadow of the threat remains. The threat is probably sufficient to keep UMC out of the United States, but UMC will find plenty of opportunity in the rest of the world.
Jerry J. Banks

Dataquest



Perspective

Microcomponents Worldwide

Dataquest Predicts

Intel and x86 Dominance to Continue through Decade's End

Abstract: *Let sleeping dogs lie is an old saying that the now-defunct ACE initiative should have listened to. Several years ago, the initiative was formed to break down Intel's dominance by exploiting certain perceived weaknesses of Intel with the hope of turning these weaknesses into strengths for the initiative. Intel, however, spurred on by the initiative's intentions, has systematically turned each of its perceived weaknesses into an evermore dominant position of strength in the industry. This newsletter discusses how Intel has increased its dominance—there seems to be no end in sight.*
By Jerry Banks

Perception Is Reality

When the now infamous ACE initiative first reared its head in the early 1990s, it grabbed the attention of Intel. The ACE initiative was born when a broad conglomeration of industry participants, spanning all regions of the world and covering all aspects of the PC industry, banded together with the sole intent of breaking down the seemingly insurmountable market-entry barriers erected by Intel. The main theme of this loosely knit cooperative was to exploit Intel's perceived lack of high-performance processors, slow time to market, lack of creative leadership, second-tier technology/manufacturing capability, and high prices. Although the ACE initiative is now defunct, its strategy of capitalizing on Intel's perceived weaknesses and the very fact that it was able to form at all, caused the microprocessor giant to regroup. Spurred on by this threat of competition from multiple angles, Intel is trying to fix its weaknesses and in so doing, to run away from the pack before the pack even forms. The company is doing this by systematically addressing each of the perceived weaknesses that the ACE initiative tried to exploit.

Dataquest

Program: Microcomponents Worldwide
Product Code: MCRO-WW-PD-9502
Publication Date: June 19, 1995
Filing: Perspective

For the short term, we are purposively ignoring the importance of the desktop operating system and focusing solely on the microprocessor. The assumption is that at some point around the end of the decade, at least one mainstream cross-platform operating system will be in production. At that point, one of the critical market-entry barriers protecting the x86 architecture from competition will be removed, and the battle will be fought over such issues as price, performance, manufacturing capacity, sales channels, and brand name awareness.

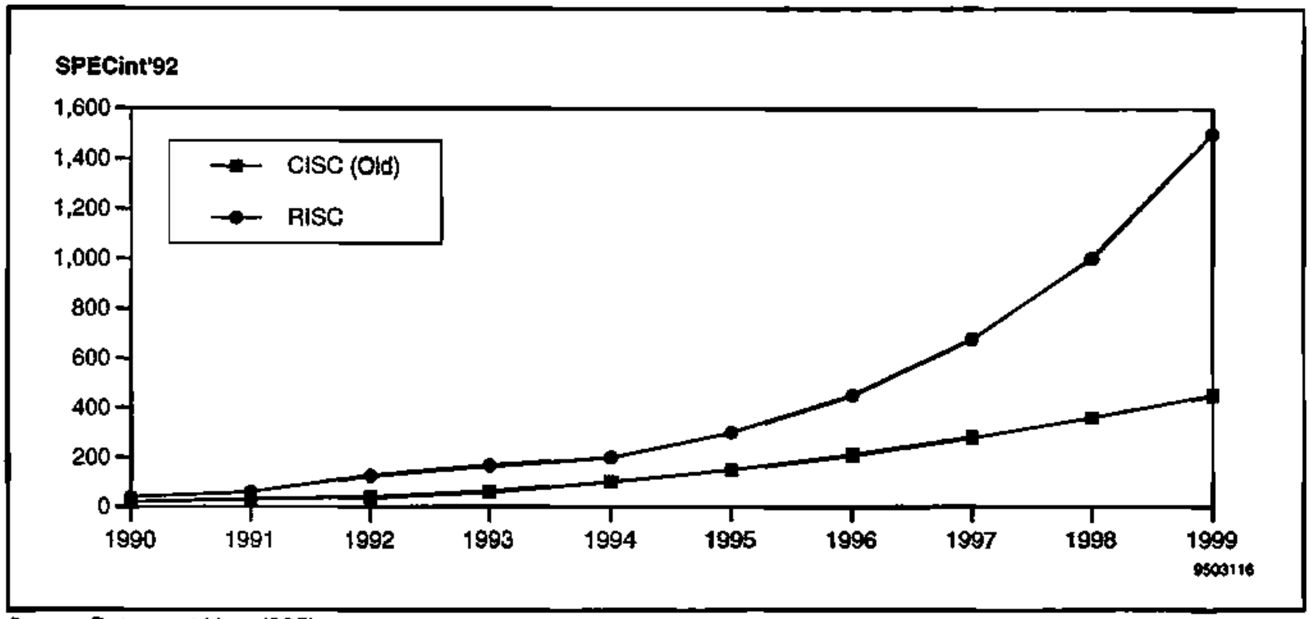
Perception No. 1: CISC versus RISC Performance

The ACE initiative took the RISC versus CISC (which ACE seemed to equate to the x86 family of microprocessors) performance issue to new heights. The main theme of the public relations campaigns was that RISC was good and CISC was bad. RISC uses small, simple, fixed-length instructions, while CISC uses long, variable-length, complex instructions. RISC designs were not limited to the architectures used by the antiquated CISC microprocessors. RISC designs could include the following concepts:

- Superscalar
  - More than one execution unit per processor
- Superpipelining
  - Multiple pipe stages in the instruction execution process (This allows for higher-frequency clocks than a nonsuperpipelined architecture.)
- Branch prediction
  - Assuming whether or not a branch will be taken
- Speculative execution
  - Operating on instructions before the results of the branch condition are known
- Out-of-order execution
  - Operating on an instruction based on when its data is ready, and not upon its order in the instruction stream; completed instructions are reordered later in the process

Consequently, RISC processors could run faster and more efficiently than CISC processors. Over time, the performance gap would continue to grow, and CISC microprocessors would fall further behind in the race for high performance. This, in turn, would make the RISC microprocessors the obvious choice for all computing applications (see Figure 1). However, that hypothesis was based on empirical evidence known at the time of the statements. Most of the most vocal proponents of this hypothesis based their assumptions on the fact that most RISC microprocessors were implementing or publicly stating that they would implement most or all of the above "RISC" architectural techniques and because no CISC (read x86) microprocessors were implementing these techniques, CISC microprocessors must be incapable of implementing them. However, the proponents of this argument are guilty of jumping to conclusions with limited data. As has happened over and over in the history of man, new observations lead to further investigation, which leads to new facts, which leads to a revised hypothesis.

Figure 1
RISC versus CISC: Traditional View

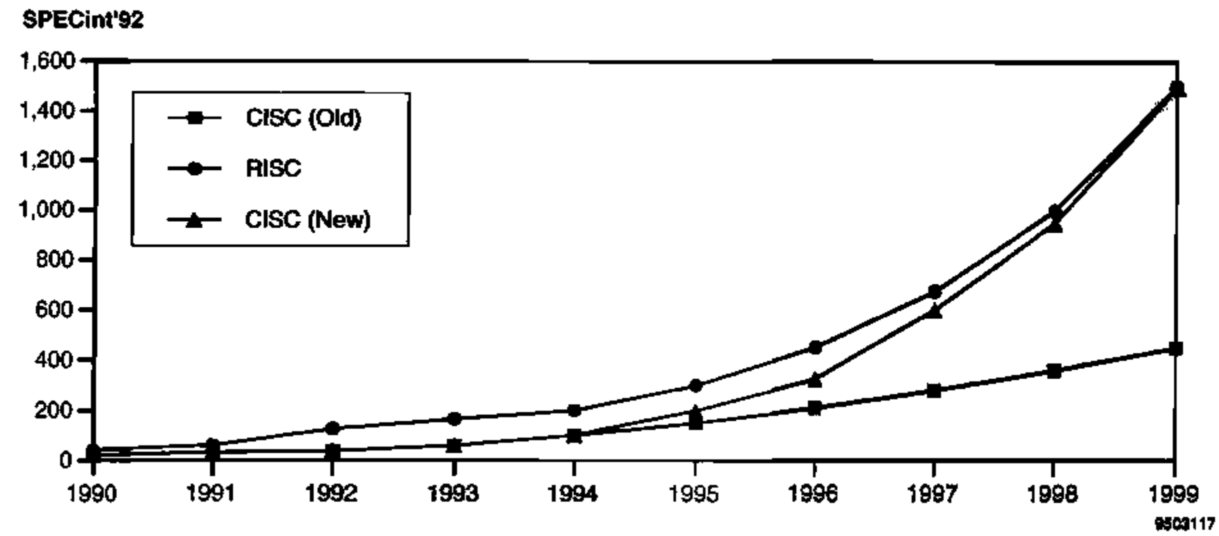


Source: Dataquest (June 1995)

In 1993, Intel introduced the Pentium microprocessor, which contained two integer units, and the superscalar argument disappeared. In 1995, Intel introduced the "P6," and the rest of the argument crumbled away. The "P6" contains multiple execution units; has a fine-grain multistage pipe; and performs branch prediction, speculative execution, and out-of-order execution. In fact, the fine granularity of the pipeline in the "P6" causes speculation that the "P6" will not only hit its specified target clock rate of 133 MHz, but it will also rapidly be scaled upward and will go a long way toward closing the performance gap between RISC and CISC microprocessors. Most of the other x86 vendors have also introduced or announced versions of the x86 architecture that use these same architectural techniques, which the RISC proponents had once proclaimed as belonging solely in the various RISC architecture camps. We do not mean to state that a CISC microprocessor will match the performance of a RISC microprocessor with a given transistor budget, but as long as the CISC vendors are willing and able to pay what is now becoming a slight penalty in extra transistors, then there is nothing fundamentally preventing CISC architectures from matching the performance of RISC microprocessors by the end of the decade (see Figure 2).

The "P6" from Intel has gone a long way toward this end; the 786-series will cut the gap even more; and by the time the 886-series is introduced, the mainstream RISC microprocessors will have no inherent performance advantages. One exception to the rule may be the ALPHA microprocessor from Digital Semiconductor, which sacrifices nothing for speed. We expect that it will maintain a performance leadership position over its competitors. But the heavy emphasis on speed comes with a price. The high power consumption and high-performance motherboard requirements mean that the ALPHA will probably be relegated to the very high end of the PC market, where performance comes at a premium.

Figure 2
RISC versus CISC: Enlightened View



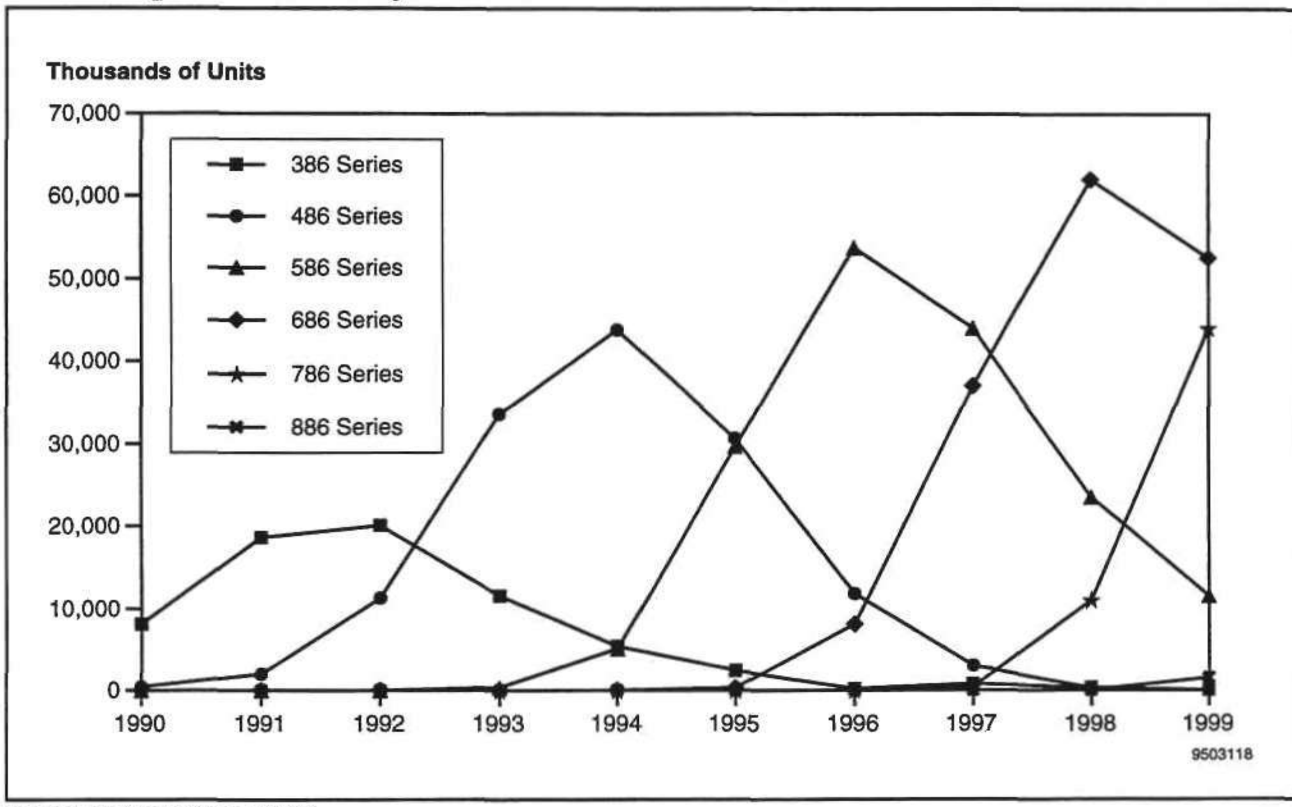
Source: Dataquest (June 1995)

Perception No. 2: Time to Market

One of the main themes pounded on by the ACE initiative was Intel's rather lackadaisical pace of introducing a new microprocessor architecture every four to five years. The members of the ACE initiative believed that this was presented critical weakness to exploit. The members believed that Intel's single microprocessor design team could not compete with the multiple design teams and combined resources of the initiatives members. The initiative team was never able to effectively utilize the combined resources it touted, and most members were effectively operating solo without any effective cooperation between the various members. However, Intel did not wait to see if the initiative would succeed or self-destruct. Instead, Intel built a second microprocessor design team. Instead of trying to force creativity by cutting down on the time it took internally to develop a next-generation microprocessor, the company employs two separate design and development teams that operate 180° out of phase on a time basis. The result is that each design team still takes about four years to develop a next-generation architecture, but the outside world sees a next-generation architecture every two years instead of every four years.

The predictable result is that newer generations of microprocessors will have life cycles about one-half as long as those of prior generations of microprocessors. The introduction of the "P6" (see Figure 3) marks the first of this new introduction strategy. The "P6" is being introduced only two years after the original Pentium microprocessor, which was introduced four years after the 486.

Figure 3
x86 Microprocessor Life Cycles



Source: Dataquest (June 1995)

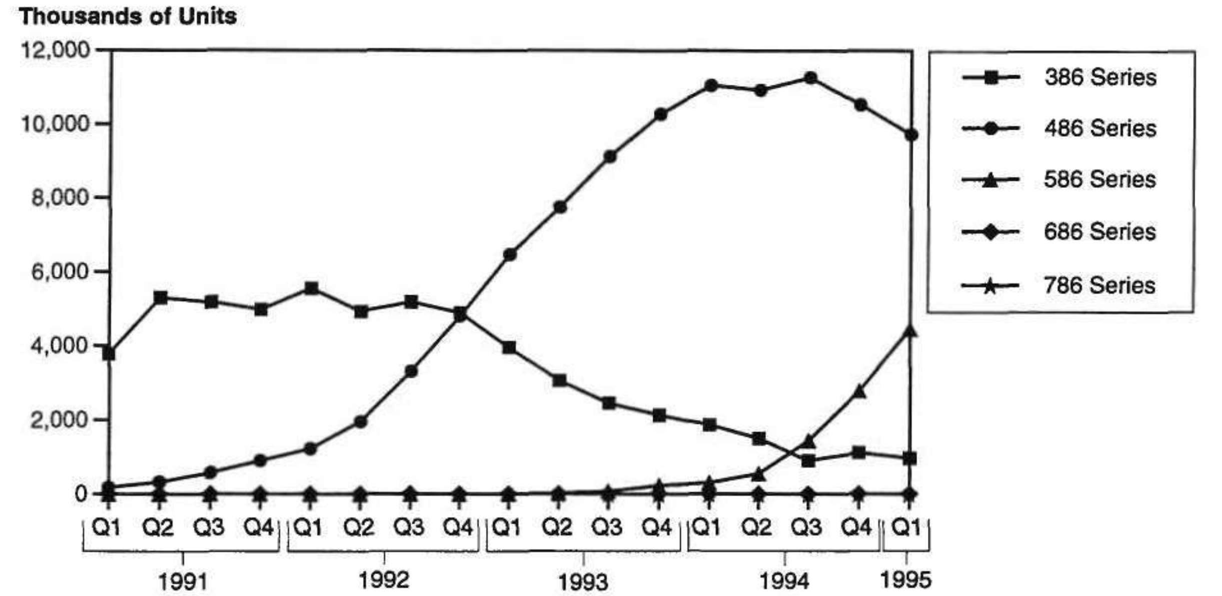
Pentium to Peak in the Third Quarter of 1996

A mere three years after its introduction, the 586 series microprocessor, under pressure from the newly emerging 686 series microprocessors, will have reached its production peak. Contrast this with the 486 series microprocessor, which took five years to reach its production zenith. On a quarterly basis, Dataquest believes that the 586 series will reach its shipment peak in the third quarter of 1996 (see Figure 4 and Table 1). The 586 series microprocessor will be the first PC processor to have its life cycle shortened in comparison to prior generations, but it will not be the last.

Even within specific families of x86 microprocessors, we are witnessing competition as higher-performance versions of a processor are introduced (see Figure 5 and Table 2). The pace Intel has set will make it difficult for any but the very strong and very resourceful to survive in the microprocessor market share battle of the desktop PC.

When the competitive pressures of other vendors start to impact Intel, it makes massive moves to the next-generation microprocessor. The company did this when Advanced Micro Devices entered the 386 market in earnest, and now that AMD is beginning to show signs of increasing its position in the 486 market, we see Intel making a rapid exit from the 486 market to the Pentium. This move is evident in Figure 6, which shows Intel beginning to lose market share in terms of unit shipments in the first quarter of 1995. The same figure in terms of revenue would show Intel, at a minimum, maintaining market share.

Figure 4
x86 Series Quarterly Shipments



Source: Dataquest (June 1995)

Table 1
x86 Series Quarterly Forecast (Thousands of Units)

	Q2/95	Q3/95	Q4/95	Q1/96	Q2/96	Q3/96	Q4/96
486 Series	7,532	6,227	5,280	4,178	3,409	2,527	1,668
586 Series	6,083	8,448	10,968	12,950	14,170	14,455	13,359
686 Series	0	50	250	625	1,250	2,290	3,998

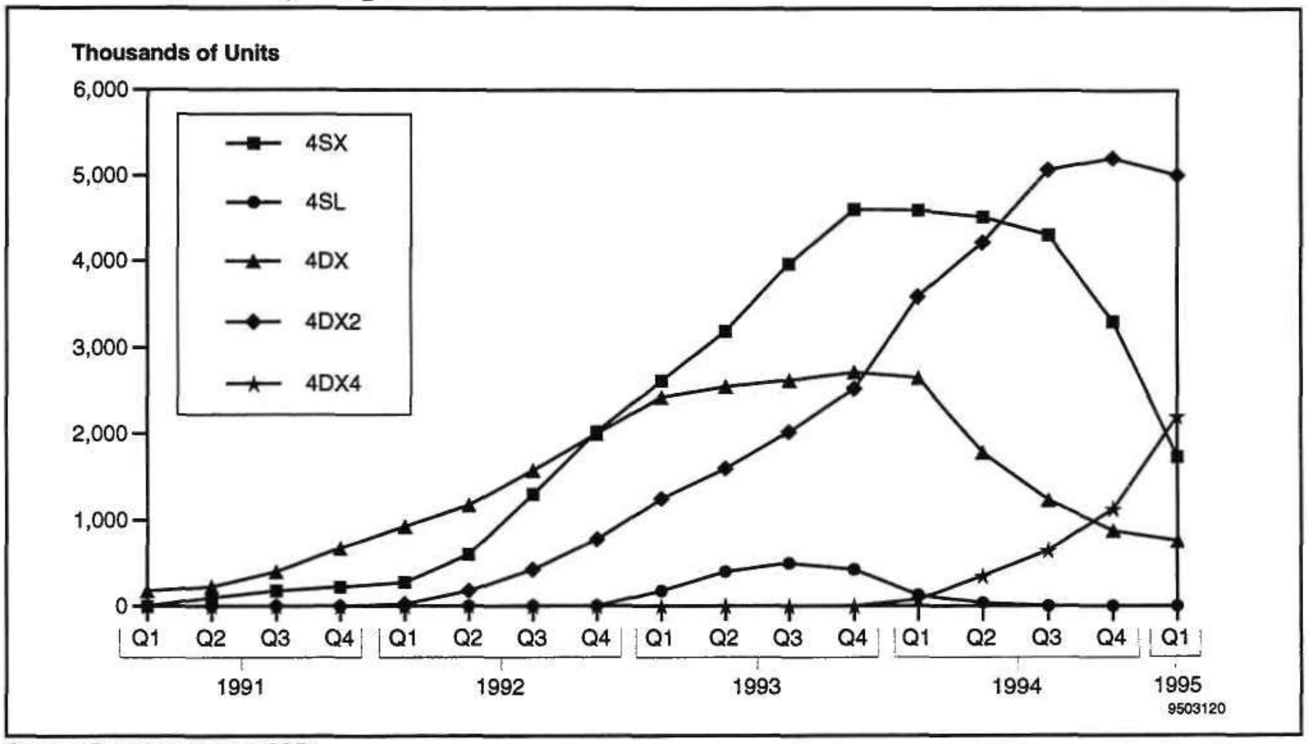
Source: Dataquest (June 1995)

Perception No. 3: Lack of Creative Leadership

Intel was perceived as bringing nothing to the party in terms of innovation. It was thought that the company had "lucked out" when IBM chose the x86 architecture on which to base its standard setting PC, and Intel was not adding significant new value.

If this was the case in the early 1990s, Intel has certainly overcome that perception. The Intel Architecture Labs in Oregon is chartered not only with helping Intel develop next-generation x86 architectures, but it is also chartered to advise the PC industry at large where to go in terms of architectural enhancements, performance, and features. This group is responsible for the telephony standard known as TAPI and the high-performance industry standard peripherals component interface bus known as PCI, and it is now proposing NSP as the minimal standard for a multimedia platform.

Figure 5
486 Series Quarterly Shipments



Source: Dataquest (June 1995)

Table 2
486 Series Quarter Shipment Forecast (Thousands of Units)

	Q2/95	Q3/95	Q4/95	Q1/96	Q2/96	Q3/96	Q4/96
4SX	998	694	510	282	153	68	23
4DX	719	683	339	49	25	12	0
4DX2	3,070	1,793	1,144	471	286	185	198
4DX4	2,745	3,056	3,287	3,376	2,945	2,262	1,446

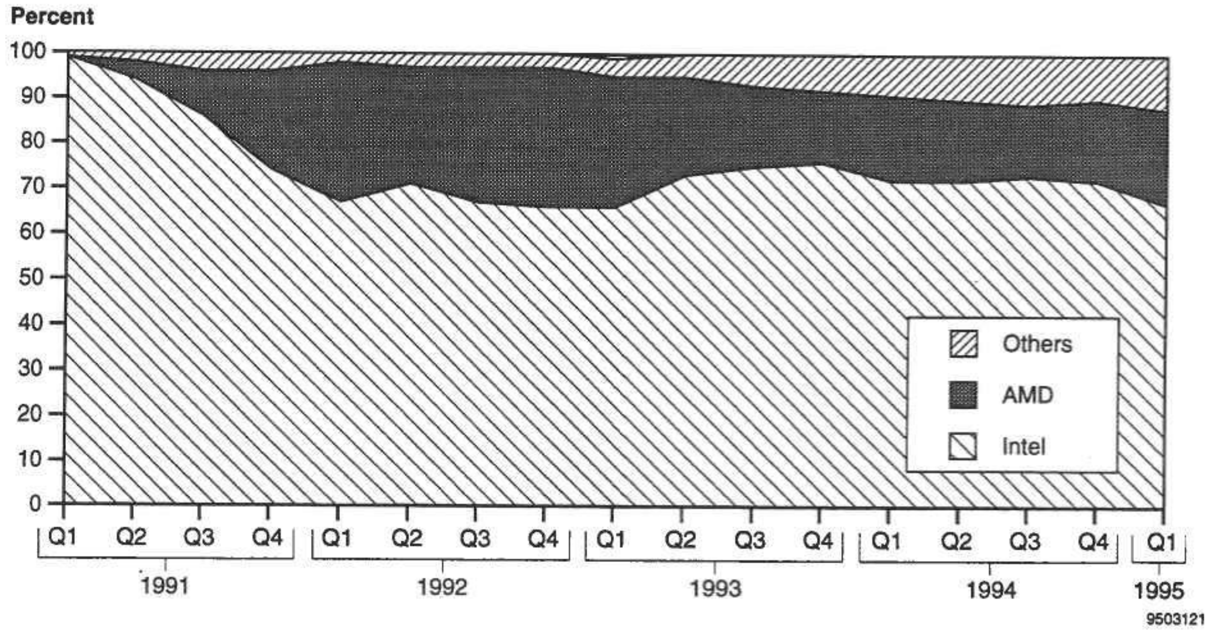
Source: Dataquest (June 1995)

Perception No. 4: Second-Tier Technology/Manufacturing Capability

Although this came as a surprise to those inside the company, Intel had long been looked upon as a follower in terms of technology and manufacturing issues in general. One could argue that the company was the leading supplier of large, high-volume microprocessors. But, it was slow in moving to three layers of metal, and it was always trailing ASIC and memory manufacturers in terms of moving to the next-generation process.

Today, it is hard to believe that Intel was once considered a laggard in this race. The company is trailing no one in terms of manufacturing capability, and its aggressive moves in technology currently place it in a leadership capacity. Today, Dataquest estimates that, with over 10,000, Intel has more 8-inch wafer starts per week than any other company in the world. By the end of 1996, this total should exceed 25,000 8-inch wafer starts per week.

Figure 6
X86 Vendor Quarterly Shipment Market Share



Source: Dataquest (June 1995)

The company's speed of transferring to new technologies is best exemplified in the following, which shows the progession in process geometry:

- 1993 — 0.8 microns
- 1994 — 0.6 microns
- 1995 — 0.35 microns

Performing such aggressive moves is unprecedented. The company is simultaneously transitioning from 6- to 8-inch wafers, mixing BiCMOS and CMOS processes, rapidly moving down the lithography road map, adding several new megafabs (more than 2,500 wafer starts per week), and moving to next-generation microprocessor designs. Such a rapid and aggressive pace is not for the faint of heart or the undercapitalized.

Perception No. 5: High Pricing

Intel seems intent on capturing all of the profit associated with hardware going into the PC. Although the x86 microprocessor remains a main cost component in the PC, Intel makes a strong argument that it is cutting the price performance point in half every 18 months or sooner. The average selling prices of Intel's microprocessors continue to climb, but the street prices of the systems seem to hover in the same range although performance is routinely doubling. Intel's argument is factual, but the area of price is still perceived as a weakness to be exploited by competitors. However, as prices can be changed overnight, we would not expect Intel to stand pat with existing pricing policies if a competitor is able to provide a competitive product in a part of the market in which Intel is not ready to vacate. The high pricing perception is still a weak point, but it can be rectified overnight if need be.

Dataquest Perspective

As stated at the beginning of this article, we purposively ignored the critical issue of the operating system. Without a mainstream operating system that supports multiple microprocessor architectures, comparing the performance of the x86 to any non-x86 competitor seems to be a moot point. The operating system is the most critical component of this issue. The ACE initiative was based on Windows NT from Microsoft. Prior to its release, Windows NT was surrounded by as much marketing preannouncement fanfare as we have seen for Windows 95. Windows NT was to be the platform on which rested the hopes of the various RISC architectures. Unfortunately, many people either misunderstood what Microsoft intended to do with Windows NT or made some bad assumptions. Windows NT was not intended to jump onto mainstream desktops and replace Windows on DOS, at least not right away. Windows NT is a ground-up operating system built for stability, performance, and security, to name a few. It was not intended to directly support the innumerable "legacy" software applications that many users still run on their PCs. It was also not designed with today's desktop PC system resources in mind. Windows NT is a solid server operating system today and will gradually move into higher-end PCs and then finally onto the desktop. This transition takes time and may not occur until the end of the decade.

In the meantime, Microsoft is introducing a replacement to Windows 3.x this year, which we all know as Windows 95. Windows 95, as DOS and Windows 3.x were before it, is dedicated to the x86 instruction set. The feature set promised by Windows 95 when combined with the rapid strides made by Intel and the rest of the x86 vendors should further push out the need to switch to Windows NT on the desktop. If this transition does not occur before the end of the decade, what arguments will the non-x86 vendors use against Intel at that time? Intel has addressed every issue the ACE initiative was using to attack the company. In fact, Intel has gone beyond by establishing new sales channels for its microprocessor and by successfully inserting itself into the PC motherboard business. Intel is now the single largest manufacturer of motherboards for the PC, giving it a tremendous advantage over any future competitors. It is also on its way to become the single largest vendor of PC Core logic in 1995. Intel has world leadership in microprocessors, PC Core logic, and motherboards, and anyone of these positions by itself is a commendable achievement. The combination of all three, when combined with the fact that the only mainstream desktop operating system is dedicated to its microprocessor architecture, puts Intel in the driver seat for many years to come. Any future "ACE initiative" had better be more prepared than the last one, or Intel may well continue this dominance into the next century.

MCRO-WW-PD-9502 Qty: 1
Ms. Maria Valenzuela
Dataquest Incorporated
1-1100

--INTERNAL DIST.--

For More Information...

Tom Starnes, Principal Analyst .... (408) 437-8366
Internet address .... tstarnes@dataquest.com
Via fax .... (408) 437-0292

Perspective

Microcomponents Worldwide

Research Brief

A Review of the International Solid State Circuits Conference (ISSCC)

Abstract: *The IEEE's recent annual International Solid State Circuits Conference, ISSCC 1995, is a showcase of the R&D efforts of the leaders in the semiconductor industry. This year's conference was a fascinating show heralding the "giga" era. Gigabit DRAMs took center stage, while gigabaud communications, gigaflop DSPs, and giga-instructions-per-second CPUs will fill out the rest of the information superhighway chip complement. Intel announced the next-generation x86 microprocessor at this San Francisco conference. Many other extremely interesting innovations in memories, communication, data conversion, and even neural networks were presented, along with papers selected on their value, innovation, and the fact that a device was made to work in a laboratory environment.*
By Jim Handy (Memories Worldwide) and Jerry Banks (Microcomponents Worldwide)

The Conference Is Over, but Many Interesting Memories Linger On

DRAM

In light of the new era of gigabit DRAMs (2 to the 30th power, or 1,073,741,824 bits), NEC, Hitachi, and even Toshiba (the last of which was the only one of the three to not show a gigabit device) had evening parties to show off the cream of their research staffs to the press and analysts. At the NEC showing, one general manager waved in front of the audience a tie bar built around a gigabit die that looked to be almost two inches on each side. NEC's approach to producing this behemoth is to manufacture a wafer full of 256Mb DRAMs, find four adjacent working devices, and saw the wafer in such a way as to leave these four together, effectively making a 1Gb monolithic device. Surprisingly, NEC does not call this wafer-scale integration.

Dataquest

Program: Microcomponents Worldwide
Product Code: MCRO-WW-RB-9502
Publication Date: May 29, 1995
Filing: Perspective

A more interesting trend in the show was the embracing of the concept of merging ASIC and DRAM technologies. There was a workshop about this subject the day before the conference, a paper by Toshiba showing an "Embedded DRAM" to be used with a sea of gates, and a position taken in the "DRAMs for Graphics" evening panel that the best choice for future graphics controllers would be to combine the frame buffer with the graphics accelerator ASIC.

What would drive this? Certain DRAM applications, such as MPEG decoders for set-top boxes and multimedia, and graphics accelerator cards, use a relatively fixed amount of DRAM on the order of 24Mb. This is limited by the resolution of the display, a statistic that does not change much over an extended period. Soon (before the turn of the century), 24Mb will be less than half of the density of a standard 64Mb DRAM, leading researchers to wonder how to use the rest of the die. It certainly looks as though this approach could catch on, but we still do not see too much SRAM added to today's ASICs (with rare exceptions, such as Sony's cache chip). So we cannot truly tell whether the DRAM/ASIC approach will be well accepted down the road.

One evening session promised to be an honest debate about the best DRAM architecture to use when implementing video systems. The session promised so much that it played to a packed auditorium. Unfortunately, six of the seven panelists were from semiconductor companies whose corporate position advocated one architecture or another, with only one company being an actual user of the devices, so the session ended up looking like the sort of posturing usually seen in trade shows. The sentiment we heard from audience members we later encountered was one of disappointment.

SRAM

Three extremely fast SRAMs were revealed by Toshiba (with Hewlett-Packard), NEC, and Hitachi, spanning access times from 3ns to 1ns. The scariest was a wave-pipelined device of Hitachi's that used a multiphase phase-locked loop incorporating a voltage-controlled oscillator made out of a rectangular array of 96 amplifiers. This design actually came from another ISSCC paper presented in an earlier year.

Flash Memory

As usual, everybody in the industry seemed to be ready to show off some new flash memory design. This is encouraging, but it would be refreshing to see some real activity in the market, enough to pose a threat to the stranglehold Intel and AMD have on flash, with a combined market share of almost 90 percent.

Seven flash papers were presented by Intel, Mitsubishi, Hitachi, Matsushita (with SunDisk), Toshiba, and, for the first time, Samsung. All but one featured 3.3V operation, indicating the resounding agreement that flash is destined for portable operation. Intel presented its experimental approach of storing multiple bits on a single cell, thereby multiplying the bit storage and slashing the per-bit price. Two of the remaining six papers dealt with 16Mb designs, and the rest with 32Mb designs, showing a sincere desire on the part of the flash manufacturers to get into business on the highest rational densities.

Ferroelectrics

Two papers (one from Rohm and one from Matsushita, Symetrix, and the University of Colorado) focused on the use of ferroelectrics. It surprised us a little that the 1Gb DRAMs presented by Hitachi and NEC in the DRAM session did not use ferroelectric dielectrics, as we have been predicting for years. The ferroelectric papers were about techniques to design nonvolatile memories using this technology. One offered a lifetime of 10^{12} cycles (1 trillion), while the other offered 10^{13} (10 trillion), highlighting the major strength of ferroelectrics over flash of a much higher number of read/write cycles. Today's flash devices offer about 10^6 (1 million) cycles, or a 10-millionth as many.

The P6: Not Just Another x86

Intel's new microprocessor, now known as the P6, is proof positive that Intel has truly halved the development time of succeeding generations of x86 microprocessors. The P6 comes just two years after the Pentium. All prior generations of x86 microprocessors had taken four to five years between generations.

Intel does not call its approach to the newly revealed P6 CPU a multichip module, although the difference between Intel's approach and an MCM was utterly lost on us, as well as on others in the audience. The P6 uses a CPU chip with level-one caches similar in size and construction to those on the Pentium, then augments this with a 256KB secondary cache SRAM die mounted in the same package. Lots of fancy new architectural twists, many borrowed from the more advanced variations of the i960, have been added to push the performance significantly above that of the Pentium. The processor is designed to be connected to as many as three other CPUs on the same bus, supporting tightly coupled multiprocessing architectures. (Ironically enough, Intel Scientific Computers only uses loosely coupled processor arrays, so this twist will not be of any help to it.)

The heart of the architecture is what Intel refers to as "Dynamic Execution," the unique combination of three processing techniques the P6 uses to speed up software—multiple branch prediction, data-flow analysis, and speculative execution:

- Multiple branch prediction: First, the processor looks multiple steps ahead in the software and predicts which branches, or groups of instructions, are likely to be processed next. This increases the amount of work fed to the processor.
- Data-flow analysis: Next, the P6 analyzes which instructions are dependent on each other's results, or data, to create an optimized schedule of instructions.
- Speculative execution: Instructions are then carried out speculatively, and possibly out of order, based on this optimized schedule, keeping all the chip's superscalar processing power busy and boosting overall software performance.

The P6 is very fast, will rapidly scale to higher frequencies, and is built for high-volume manufacture. It uses a fine-grain 11-stage pipeline in which no single stage is required to perform a significant amount of work. This will allow Intel to rapidly increase the performance by simply increasing the clock. We believe that the present product announcement of 200 SPECint92 at 133 MHz is quite conservative. We would not be too surprised to see the P6 approach 400 SPECint92 in 12 to 18 months.

A detailed manufacturing and capacity analysis gives us reason to believe that Intel is bringing enough fab capacity online to support a production ramp for the P6 that could exceed that of the rapidly ramping Pentium.

This basically is a very fast scalable design. It is intended for the mainstream desktop and will be a mainstream notebook processor in 1997. Intel has the manufacturing muscle in place, and the closest significant competitor is still a generation behind.

Dataquest Perspective

As always, memories played an important role at the ISSCC, and we expect them to continue to do so. The job of the Dataquest analysts, then, is to sort out which ones should enjoy success, and to try to determine when and how their success will be attained. This will figure into any long-term prognostications we will make in future publications.

All in all, it was a fascinating show. There were lots of stunning advancements, like the mere fact that the 1Gb DRAM was introduced two—not three—years after the first paper heralding a 256Mb DRAM, or NexGen's use of IBM's five-layer metallization, along with C4 bonding and more precise layout tools, to reduce its die size by more than 40 percent without reducing process geometries.

For More Information...

Jerry J. Banks, Director/Principal Analyst .... (408) 437-8677
Internet address .... jbanks@dataquest.com
Via fax .... (408) 437-0292

Perspective

Microcomponents Worldwide

Research Brief

1994 PC Core Logic Market Share Leadership—Uneasy Lies the Head That Wears the Crown

Abstract: *In this Research Brief, Dataquest lists the top 10 vendors in the market for PC core logic chipsets. We also analyze the various competitors and provide our expectations for success in 1995.*
By Jerry Banks

Still No. 1: VLSI Technology

A familiar name is at the top of the list of PC core logic market leaders, according to a recent Dataquest survey. VLSI Technology is once again No. 1 in terms of overall PC core logic unit shipments (see Table 1). In 1994 VLSI held off all challengers vying for the No. 1 position in total PC core logic chips. Although the company's market share fell from 21 percent in 1993 to 17.9 percent in 1994, VLSI was still able to hold off the hard charge of Taiwan-based Silicon Integrated Systems (SIS). In 1994 SIS grew at a pace nearly double that of the PC core logic industry, leaping over both United Microelectronics (UMC) and Opti. At its current pace, SIS should overtake VLSI in 1995 in terms of total PC core logic chipsets shipped. Both UMC and Opti grew in the 20 percent range and were able to hold off the challenge of Intel, whose meteoric rise may propel it above both SIS and VLSI into the No. 1 position before 1995 is finished. The only company to outperform Intel in terms of growth was the Cirrus Logic subsidiary, Pico Power. Its 469 percent growth rate, based entirely upon the company's notebook product offerings, propelled the company from the No. 10 position to No. 8.

Dataquest

Program: Microcomponents Worldwide
Product Code: MCRO-WW-RB-9501
Publication Date: May 29, 1995
Filing: Perspective

Table 1
Top 10 Core Logic Chipset Producers, Worldwide (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Total	1994 Total	Percentage Change	Market Share (%)
1	1	VLSI	7,392	9,047	22.4	17.9
2	4	Silicon Integrated Systems	4,652	8,600	84.9	17.0
3	2	UMC	6,800	8,200	20.6	16.2
4	3	Opti	6,344	7,775	22.6	15.4
5	7	Intel	1,500	5,300	253.3	10.5
6	5	Acer	3,900	4,200	7.7	8.3
7	6	ACC Microelectronics	1,983	2,563	29.2	5.1
8	10	Cirrus/Pico Power	325	1,850	469.2	3.7
9	8	Chips & Technologies	1,400	1,700	21.4	3.4
10	9	Symphony	410	860	109.8	1.7
		Others	800	535	-33.1	1.1
		Total Shipments	35,506	50,630	42.6	

Source: Dataquest (May 1995)

Growth Adjusted

The 43 percent market growth is skewed somewhat by the rapid transition of PC OEMs, Compaq and IBM, switching from the use of custom PC core logic to standard, off-the-shelf PC core logic. As was estimated in an earlier report from Dataquest's Semiconductor Directions in PCs program, the use of custom PC core logic in desktop PCs fell from 15 percent in 1993 to 9 percent in 1994 and is expected to fall to less than 5 percent in 1995, while the use of custom PC core logic in notebook PCs fell from 41 percent in 1993 to 32 percent in 1994 and is expected to approach 15 percent in 1995. We expect this trend to continue into the future because major OEMs are rapidly disbanding, or significantly reducing, internal PC core logic R&D efforts. Because Dataquest does not include the captive PC core logic shipments in its market share calculations, the growth of the overall PC core logic market is overstated by about 6.3 percent for 1994. Adjusting for this, the overall market for PC core logic grew by 37 percent. The 43 percent growth figure reflects the average growth experienced by the merchant market suppliers that were able to replace the custom products previously used, in addition to the growth of the PC and motherboard upgrade markets.

Dataquest Perspective

PC core logic chipsets are as critical to the overall performance of the PC as any other component in the system. The PC core logic chips are the interface between the MPU complex (microprocessor and cache memory) and the rest of the PC. These chips manage the system resources that make up the PC. Many of the critical performance bottlenecks—such as the cache algorithms, DRAM refresh, memory management, power management, expansion bus control, local bus control, and DMA control—are handled directly by the PC core logic chips. A poorly designed chipset architecture will severely cripple a PC's performance, completely independent of the microprocessor used in the system.

The PC core logic market is undergoing significant changes. In order to compete in this arena it is essential to understand where the market has been, how it has changed, the dynamics affecting that change, and where the PC core logic market is going. In an upcoming publication, Dataquest will provide further details on this dynamic market. This report will start with a historical backdrop featuring the players, the product features, desktop versus notebook feature requirements, market size, and market share. It then will work forward to the present, where it discusses the issues changing the market, and finally will take a look at the future in terms of market size and feature set, and then give the foundation of what it will take to win in this highly competitive market.

The dynamics of this market are such that, if one of today's leaders loses track of the market for the briefest of moments, the entire makeup of the leader board shown in Table 1 will change. It is essential to track this market closely and measure competitors' progress and determine which of the players is best positioned for the future and why.

For More Information...

Jerry Banks, Director/Principal Analyst .... (408) 437-8677
Internet address .... jbanks@dataquest.com
Via fax .... (408) 437-0292

Dataquest

a company of The Dun & Bradstreet Corporation

Market
Analysis

Semiconductors

Market Analysis

1994 Semiconductor Market: Memory and Microcomponent Muscle Market

Abstract: *This article discusses the impact of the 29 percent growth seen in the 1994 semiconductor market. The growth has been seen in all regions and all product types. But because of the impact of the PC as a major driving force, two product types—memory and microcomponent ICs—have dominated the growth and gained market share. Vendor market share positions have changed because of this skewed product growth pattern.*
By Gary Grandbois

Two-Year Growth Trend Continues

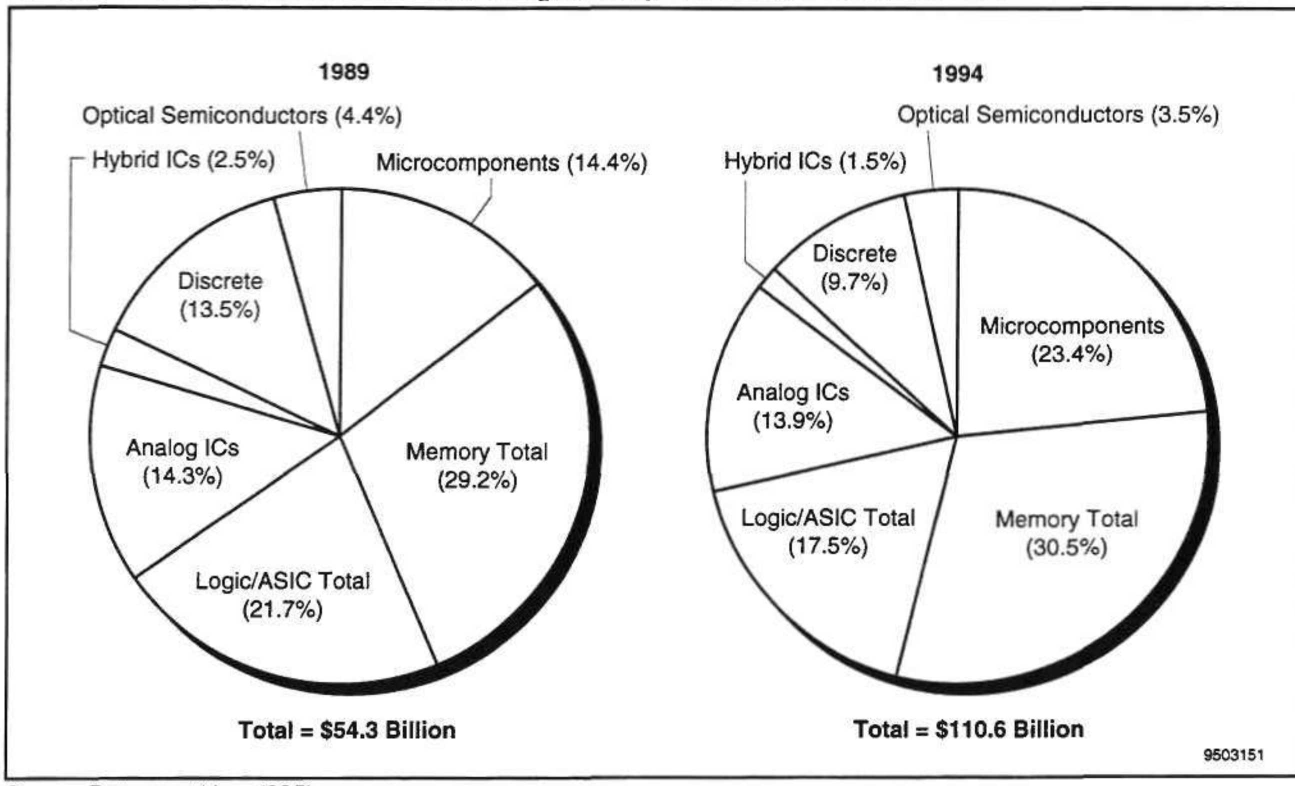
With a worldwide growth exceeding 29 percent, 1994 continued the two-year trend in which all four regions and all six main product families have shown double-digit growth. Beyond the top-line growth, however, 1994 provided the third year of a product shift in the makeup of the semiconductor market as the advancing wave of PC products and peripherals continued to grow the microcomponent and memory IC market share at the expense of all other product categories.

Figure 1 shows the product growth differences and displays the worldwide market for 1989 and 1994 in terms of the major product families. Microcomponents and memory ICs combined grew from 44 percent of the total market in 1989 to 54 percent in 1994. The two products that lost large shares were logic ICs (mainly because of bipolar logic) and discrete devices (because of integration of small-signal devices). This change has been accelerating; in 1992, memory and microcomponent ICs accounted for 46 percent of the business, an increase in share of 8 percent in four years. From 1992 to 1994, an 8 percent share was gained in only two years as the memory and microcomponent stampede was further provoked by supply limitations.

Dataquest

Program: Semiconductors
Product Code: SCND-WW-MA-9501
Publication Date: June 26, 1995
Filing: Newsletters

Figure 1
Worldwide Semiconductor Consumption by Product, 1989 and 1994



Source: Dataquest (June 1995)

Table 1 summarizes the growth by product category for the past year and over the past five years. Comparison of the five-year and one-year growths shows how memory has burst out of the 1989 to 1992 slowdown to maintain revenue dominance in the market.

Figure 2 shows the vagaries of the memory IC market over the past eight years, along with the revenue history of the other product families. Although microcomponents have shown a more consistent growth pattern, quite unlike the more volatile memory category, both microcomponents and memory ICs have shown similar compounded growth rates since 1987. The rising price-per-bit seen in 1994 is increasing the growth rate gap between these two products, but only for a limited time, as memory average selling prices (ASPs) are expected to decline in 1997.

As with the 1993 market, the growth differences by product in 1994, as well as individual company performance, resulted in shifting market rankings. Table 2 shows the top 20 ranked semiconductor suppliers.

A 30 percent growth in microcomponent consumption in 1994, down from 39 percent in 1993, limited Intel's ability to gain market share in 1994. However, Intel's 57 percent growth in 1993, riding on the x86 growth spurt, placed it a comfortable distance ahead of No. 2 NEC, which showed greater growth than Intel in 1994.

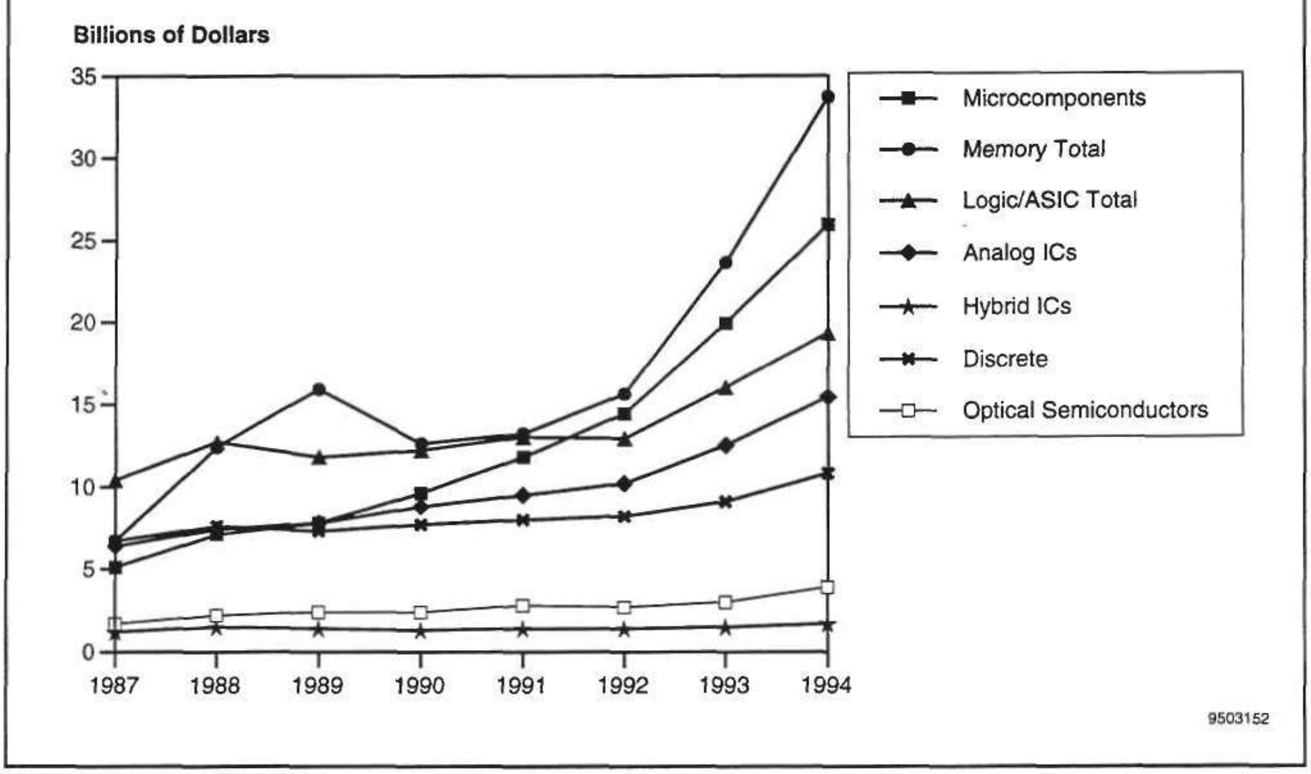
The stronger 43 percent growth in memory IC consumption (60 percent in DRAMs) favored Samsung and Goldstar, with 59 percent and 79 percent growth, respectively, over 1993 and assisted the higher-than-market growth of NEC, Toshiba, Hitachi, Fujitsu, and Texas Instruments.

Table 1
Revenue Summary by Product

Worldwide	1994 Revenue ($M)	1993-1994 Growth (%)	1989-1994 CAGR (%) Actual
Microcomponents	25,868	29.7	27.1
Memory Total	33,679	43.0	16.2
Logic/ASIC Total	19,310	21.0	10.4
Analog ICs	15,407	23.1	14.6
Monolithic IC Total	94,264	31.0	16.9
Hybrid ICs	1,664	13.7	4.0
Total ICs	95,928	30.6	16.5
Discrete	10,758	18.4	8.0
Optical Semiconductors	3,894	29.5	10.1
Total Semiconductor	110,580	29.3	15.3

Source: Dataquest (June 1995)

Figure 2
Semiconductor Revenue History



Source: Dataquest (June 1995)

Table 2
Total Semiconductor, 1994 Worldwide Market Share Estimates and Ranking (Revenue in Millions of Dollars)

1994 Rank	1993 Rank	Company	1994 Market Share (%)	1994 Revenue	1993 Revenue	1993-1994 Growth (%)
1	1	Intel	9.1	10,099	7,970	27
2	2	NEC	7.2	7,961	6,141	30
3	4	Toshiba	6.8	7,556	5,727	32
4	3	Motorola	6.5	7,238	5,957	22
5	5	Hitachi	6.0	6,644	5,015	32
6	6	Texas Instruments	5.0	5,552	4,083	36
7	7	Samsung	4.4	4,832	3,044	59
8	8	Fujitsu	3.5	3,869	2,928	32
9	9	Mitsubishi	3.4	3,772	2,823	34
10	10	IBM	2.7	3,035	2,510	21
11	12	Philips	2.6	2,920	2,300	27
12	11	Matsushita	2.6	2,896	2,344	24
13	14	SGS-Thomson	2.4	2,640	2,038	30
14	15	Sanyo	2.1	2,321	1,843	26
15	16	Sharp	2.0	2,188	1,760	24
16	17	Advanced Micro Devices	1.9	2,134	1,660	29
17	18	Siemens	1.9	2,090	1,509	39
18	13	National Semiconductor	1.8	2,023	2,060	-2
19	19	Sony	1.7	1,876	1,398	34
20	22	Goldstar	1.5	1,697	946	79
		All Others	24.6	27,237	21,462	27
		Total Semiconductor	100	110,580	85,518	29

Source: Dataquest (June 1995)

The following sections describe market share by product family.

Microcomponent ICs

Microprocessors remain the main driving force in the microcomponents category, although microcontrollers contributed comparably strong growth in 1994. Intel grew by $2.1 billion and held onto the 37 percent market share gained in 1993 (Intel had a 30 percent share of the market in 1992). In 1993, Intel absorbed nearly 49 percent of the total revenue growth in microcomponents, but in 1994 was able to grab only 36 percent as revenue growth was more evenly spread among microcomponent suppliers. Motorola had good growth in microcontrollers but was hurt by the decline in 680xx business displaced by the PowerPC. AMD rebounded from a 12 percent revenue decline in microcomponent revenue in 1993 to an 81 percent growth in 1994 as the company moved into the higher-ASP 486 market. Because of this strong growth, AMD moved up two positions in rank. Table 3 lists the top 10 suppliers of microcomponent ICs.

Table 3
Microcomponent ICs, 1994 Worldwide Market Share Estimates and Ranking (Revenue in Millions of Dollars)

1994 Rank	1993 Rank	Company	1994 Market Share (%)	1994 Revenue	1993 Revenue	1993-1994 Growth (%)
1	1	Intel	37.1	9,595	7,444	29
2	2	Motorola	9.1	2,363	2,065	14
3	3	NEC	6.5	1,678	1,341	25
4	6	Advanced Micro Devices	3.9	1,021	563	81
5	4	Texas Instruments	3.9	1,006	781	29
6	5	Hitachi	3.9	998	718	39
7	7	Toshiba	2.8	718	540	33
8	8	Mitsubishi	2.7	698	532	31
9	10	Cirrus Logic	2.6	681	371	84
10	13	Matsushita	1.8	460	286	61
		All Others	25.7	6,650	5,306	25
		Total Microcomponent	100.0	25,868	19,947	30

Source: Dataquest (June 1995)

Memory ICs

With a growth of 43 percent, the 1994 memory market showed growth very similar to that of 1993, growth being paced again by a 60 percent DRAM revenue growth.

DRAMs continued to be the major growth product for Japanese suppliers. As in 1992 and 1993, however, Korean suppliers derived the greater benefit from the 1994 DRAM growth. With 67 percent revenue growth, Samsung continued to distance itself from No. 2 Hitachi, while Goldstar moved up three positions. Table 4 shows the 1994 memory market share.

Logic ICs

Logic ICs remain the only digital category where bipolar processing still represents a significant part of the revenue. Bipolar logic traditionally has shown a 10 percent rate of decline in recent years, but this rate of decline has been slowed in the past two years as increased product demand combined with a shortage in bipolar standard logic to temporarily enhance this market. As a result, bipolar logic only declined 1 percent in 1993 and 4 percent in 1994. MOS logic showed stronger growth with a 27 percent revenue growth in 1994. The combined 1994 logic growth (bipolar and MOS logic together) was 21 percent, a little less than the 24 percent seen in 1993 but still a great improvement over the single-digit growth trend seen prior to 1993. Unlike in 1993, TI saw a decline in bipolar logic revenue, but with a 52 percent growth seen in MOS logic, TI was still able to maintain the No. 2 position with a combined logic IC growth of 40 percent.

Table 5 provides the combined bipolar and MOS revenue for the top 10 logic suppliers.

Table 4
Memory ICs, 1994 Worldwide Market Share Estimates and Ranking (Revenue in Millions of Dollars)

1994 Rank	1993 Rank	Company	1994 Market Share (%)	1994 Revenue	1993 Revenue	1993-1994 Growth (%)
1	1	Samsung	12.5	4,194	2,512	67
2	2	Hitachi	9.9	3,325	2,454	35
3	3	NEC	9.2	3,112	2,189	42
4	4	Toshiba	9.0	3,018	2,101	44
5	5	Texas Instruments	5.7	1,936	1,278	51
6	6	Fujitsu	5.1	1,724	1,216	42
7	7	Mitsubishi	4.9	1,652	1,206	37
8	11	Goldstar	4.5	1,525	804	90
9	8	IBM	4.5	1,520	1,133	34
10	10	Hyundai	4.5	1,515	851	78
		All Others	30.2	10,158	7,806	30
		Total Memory	100.0	33,679	23,550	43

Source: Dataquest (June 1995)

Table 5
Logic ICs, 1994 Worldwide Market Share Estimates and Ranking (Revenue in Millions of Dollars)

1994 Rank	1993 Rank	Company	1994 Market Share (%)	1994 Revenue	1993 Revenue	1993-1994 Growth (%)
1	1	NEC	9.1	1,765	1,439	22.7
2	2	Texas Instruments	8.7	1,687	1,324	27.4
3	3	Motorola	8.5	1,634	1,215	34.5
4	4	Toshiba	7.0	1,347	1,070	25.9
5	6	Fujitsu	6.0	1,157	966	19.8
6	5	IBM	5.8	1,116	1,040	7.3
7	7	Hitachi	4.9	941	732	28.6
8	8	LSI Logic	4.3	823	642	28.2
9	9	Philips	3.7	717	549	30.6
10	11	AT&T	2.8	540	475	13.7
		All Others	39.3	7,583	6,504	16.6
		Total Logic	100.0	19,310	15,956	21.0

Source: Dataquest (June 1995)

Analog ICs

A continuing strength for linear ICs in the consumer market added to the growth seen by mixed-signal ICs in the computer peripherals market. European suppliers were especially aggressive in growing their share of the market, going from 20 percent in 1993 to nearly 23 percent in 1994. National Semiconductor and Analog Devices showed lower-than-average growth and moved down in the rankings. Table 6 shows the 1994 rankings for analog ICs.

Discrete Devices

Both discrete devices and optical semiconductors have staged strong comebacks in the past two years. Like analog ICs, discrete devices have been helped by a healthier consumer electronics market (more than 35 percent of discrete revenue is from the consumer market). Discrete device growth has been especially strong in the MOSFET and IGBT power devices. Table 7 gives the top 10 discrete device suppliers in 1994.

Optical Semiconductors

As with analog ICs and discrete devices, optical semiconductors were helped by a healthier consumer electronics market (more than 50 percent of optical semiconductors go into the consumer market). On top of a more vital consumer market, optical semiconductors have been moving into data processing applications rapidly with CD-ROMs, laser printers, scanners, fax machines, and other peripherals products providing new growth markets. Table 8 gives the top 10 optical semiconductor device suppliers in 1994. Mitsubishi showed stunning growth in laser diodes in 1994, which brought it into the top 10 from a relatively minor position in 1993.

Table 6
Analog ICs, 1994 Worldwide Market Share Estimates and Ranking (Revenue in Millions of Dollars)

1994 Rank	1993 Rank	Company	1994 Market Share (%)	1994 Revenue	1993 Revenue	1993-1994 Growth (%)
1	1	SGS-Thomson	7.8	1,197	858	40
2	3	Philips	6.2	957	752	27
3	4	Motorola	6.0	924	707	31
4	2	National Semiconductor	5.8	891	788	13
5	6	Texas Instruments	5.5	842	617	36
6	5	Sanyo	5.3	811	633	28
7	7	Toshiba	5.1	789	615	28
8	9	Matsushita	4.0	611	473	29
9	8	Analog Devices	3.9	602	526	14
10	11	Siemens	3.5	546	382	43
		All Others	47.0	7,237	6,162	17
		Total Analog	100.0	15,407	12,513	23

Source: Dataquest (June 1995)

Table 7
Discrete Devices, 1994 Worldwide Market Share Estimates and Ranking (Revenue in Millions of Dollars)

1994 Rank	1993 Rank	Company	1994 Market Share (%)	1994 Revenue	1993 Revenue	1993-1994 Growth (%)
1	1	Toshiba	11.2	1,204	1,017	18
2	2	Motorola	10.2	1,097	994	10
3	3	Hitachi	7.4	798	662	21
4	4	Philips	7.1	761	604	26
5	5	NEC	6.1	652	579	13
6	8	Rohm	4.9	524	380	38
7	6	Matsushita	4.7	511	450	14
8	7	SGS-Thomson	4.0	433	384	13
9	9	Mitsubishi	3.9	424	380	12
10	10	Sanyo	3.6	389	336	16
		All Others	36.9	3,965	3,297	20
		Total Discrete Devices	100.0	10,758	9,083	18

Source: Dataquest (June 1995)

Table 8
Optical Semiconductors, 1994 Worldwide Market Share Estimates and Ranking (Revenue in Millions of Dollars)

1994 Rank	1993 Rank	Company	1994 Market Share (%)	1994 Revenue	1993 Revenue	1993-1994 Growth (%)
1	1	Sharp	13.1	510	418	22
2	3	Toshiba	10.8	421	326	29
3	2	Matsushita	10.7	417	358	16
4	5	Hewlett-Packard	9.2	360	190	89
5	4	Sony	8.0	313	236	33
6	6	Siemens	5.6	220	170	29
7	10	Rohm	4.6	178	112	59
8	19	Mitsubishi	4.5	176	30	487
9	7	Sanyo	3.9	150	137	9
10	9	NEC	3.9	150	118	27
		All Others	25.7	999	911	10
		Total Optical Semiconductors	100.0	3,894	3,006	30

Source: Dataquest (June 1995)

Dataquest Perspective

The memory and microcomponent market share growth continued strongly into 1994. We expected no less. Major semiconductor vendors move up in market share rank largely on the basis of the growth of these two product types. The downside is that we are experiencing a continuous warping of our product perspective as we look at the semiconductor market as an extension of the PC market. The result is that logic ICs, analog ICs, discrete devices, and optical semiconductors seem to be relegated to a second-class "other" semiconductor market status, even as they grew revenue by 21, 23, 18, and 30 percent, respectively, in 1994 (a combined growth of 21 percent). Although the spotlight will continue to follow the memory/ microcomponent/ PC juggernaut, it is important that we do not lose sight of the broad spectrum of semiconductor products, including products such as ASICs, converters, sensors, and drivers, that provide important functions (and growing markets) in the digital age.

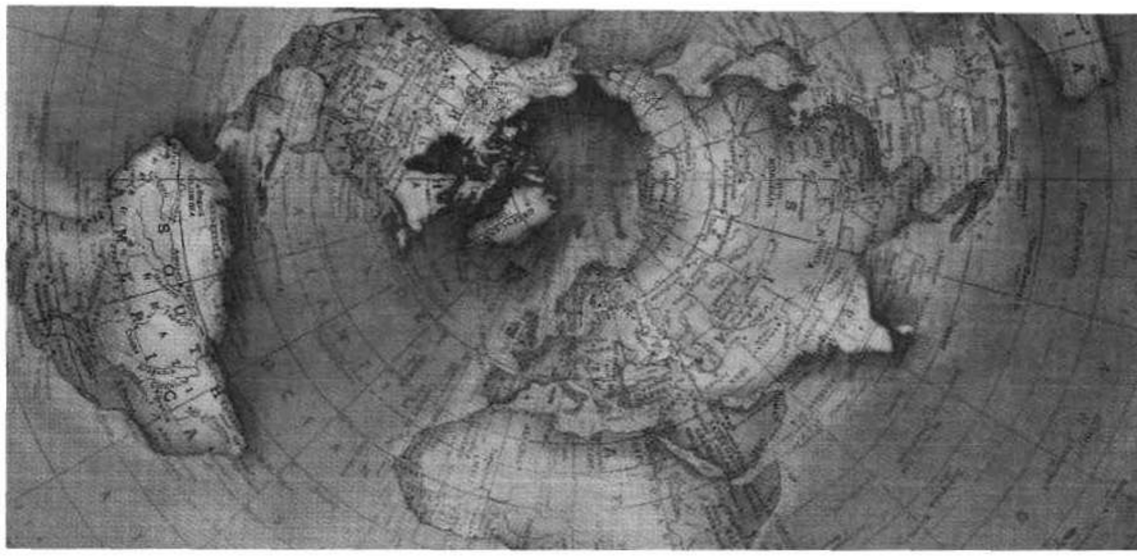
SCND-WW-MA-9501 Qty: 1
Ms. Sue Kapoor
Dataquest Incorporated
1-8500

--INTERNAL DIST.--

For More Information...

Gary Grandbois, Director/Principal Analyst .... (408) 437-8251
Internet address .... ggrandbois@dataquest.com
Via fax .... (408) 437-0292

Dataquest
a company of The Dun & Bradstreet Corporation



Perspective

Microcomponents Worldwide

Research Brief

1994 PC Core Logic Market Share Leadership—Uneasy Lies the Head That Wears the Crown

Abstract: *In this Research Brief, Dataquest lists the top 10 vendors in the market for PC core logic chipsets. We also analyze the various competitors and provide our expectations for success in 1995.*
By Jerry Banks

Still No. 1: VLSI Technology

A familiar name is at the top of the list of PC core logic market leaders, according to a recent Dataquest survey. VLSI Technology is once again No. 1 in terms of overall PC core logic unit shipments (see Table 1). In 1994 VLSI held off all challengers vying for the No. 1 position in total PC core logic chips. Although the company's market share fell from 21 percent in 1993 to 17.9 percent in 1994, VLSI was still able to hold off the hard charge of Taiwan-based Silicon Integrated Systems (SIS). In 1994 SIS grew at a pace nearly double that of the PC core logic industry, leaping over both United Microelectronics (UMC) and Opti. At its current pace, SIS should overtake VLSI in 1995 in terms of total PC core logic chipsets shipped. Both UMC and Opti grew in the 20 percent range and were able to hold off the challenge of Intel, whose meteoric rise may propel it above both SIS and VLSI into the No. 1 position before 1995 is finished. The only company to outperform Intel in terms of growth was the Cirrus Logic subsidiary, Pico Power. Its 469 percent growth rate, based entirely upon the company's notebook product offerings, propelled the company from the No. 10 position to No. 8.

Dataquest

Program: Microcomponents Worldwide
Product Code: MCRO-WW-RB-9501
Publication Date: May 29, 1995
Filing: Perspective

Table 1
Top 10 Core Logic Chipset Producers, Worldwide (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Total	1994 Total	Percentage Change	Market Share (%)
1	1	VLSI	7,392	9,047	22.4	17.9
2	4	Silicon Integrated Systems	4,652	8,600	84.9	17.0
3	2	UMC	6,800	8,200	20.6	16.2
4	3	Opti	6,344	7,775	22.6	15.4
5	7	Intel	1,500	5,300	253.3	10.5
6	5	Acer	3,900	4,200	7.7	8.3
7	6	ACC Microelectronics	1,983	2,563	29.2	5.1
8	10	Cirrus/Pico Power	325	1,850	469.2	3.7
9	8	Chips & Technologies	1,400	1,700	21.4	3.4
10	9	Symphony	410	860	109.8	1.7
		Others	800	535	-33.1	1.1
		Total Shipments	35,506	50,630	42.6	

Source: Dataquest (May 1995)

Growth Adjusted

The 43 percent market growth is skewed somewhat by the rapid transition of PC OEMs, Compaq and IBM, switching from the use of custom PC core logic to standard, off-the-shelf PC core logic. As was estimated in an earlier report from Dataquest's Semiconductor Directions in PCs program, the use of custom PC core logic in desktop PCs fell from 15 percent in 1993 to 9 percent in 1994 and is expected to fall to less than 5 percent in 1995, while the use of custom PC core logic in notebook PCs fell from 41 percent in 1993 to 32 percent in 1994 and is expected to approach 15 percent in 1995. We expect this trend to continue into the future because major OEMs are rapidly disbanding, or significantly reducing, internal PC core logic R&D efforts. Because Dataquest does not include the captive PC core logic shipments in its market share calculations, the growth of the overall PC core logic market is overstated by about 6.3 percent for 1994. Adjusting for this, the overall market for PC core logic grew by 37 percent. The 43 percent growth figure reflects the average growth experienced by the merchant market suppliers that were able to replace the custom products previously used, in addition to the growth of the PC and motherboard upgrade markets.

Dataquest Perspective

PC core logic chipsets are as critical to the overall performance of the PC as any other component in the system. The PC core logic chips are the interface between the MPU complex (microprocessor and cache memory) and the rest of the PC. These chips manage the system resources that make up the PC. Many of the critical performance bottlenecks—such as the cache algorithms, DRAM refresh, memory management, power management, expansion bus control, local bus control, and DMA control—are handled directly by the PC core logic chips. A poorly designed chipset architecture will severely cripple a PC's performance, completely independent of the microprocessor used in the system.

The PC core logic market is undergoing significant changes. In order to compete in this arena it is essential to understand where the market has been, how it has changed, the dynamics affecting that change, and where the PC core logic market is going. In an upcoming publication, Dataquest will provide further details on this dynamic market. This report will start with a historical backdrop featuring the players, the product features, desktop versus notebook feature requirements, market size, and market share. It then will work forward to the present, where it discusses the issues changing the market, and finally will take a look at the future in terms of market size and feature set, and then give the foundation of what it will take to win in this highly competitive market.

The dynamics of this market are such that, if one of today's leaders loses track of the market for the briefest of moments, the entire makeup of the leader board shown in Table 1 will change. It is essential to track this market closely and measure competitors' progress and determine which of the players is best positioned for the future and why.

MCRO-WW-RB-9501 Qty: 1
Ms. Sue Kapoor
Dataquest Incorporated
1-8500

--INTERNAL DIST.--

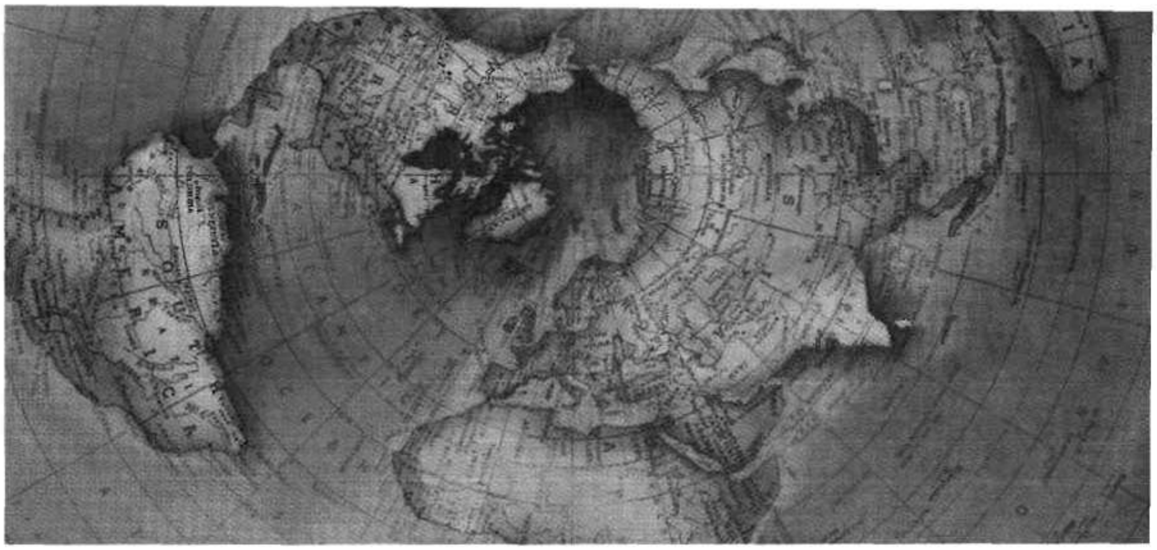
For More Information...

Jerry Banks, Director/Principal Analyst .... (408) 437-8677
Internet address .... jbanks@dataquest.com
Via fax .... (408) 437-0292

Dataquest

a company of The Dun & Bradstreet Corporation

Perspective



Microcomponents Worldwide

Dataquest Predicts

Intel and x86 Dominance to Continue through Decade's End

Abstract: *Let sleeping dogs lie is an old saying that the now-defunct ACE initiative should have listened to. Several years ago, the initiative was formed to break down Intel's dominance by exploiting certain perceived weaknesses of Intel with the hope of turning these weaknesses into strengths for the initiative. Intel, however, spurred on by the initiative's intentions, has systematically turned each of its perceived weaknesses into an evermore dominant position of strength in the industry. This newsletter discusses how Intel has increased its dominance—there seems to be no end in sight.*
By Jerry Banks

Perception Is Reality

When the now infamous ACE initiative first reared its head in the early 1990s, it grabbed the attention of Intel. The ACE initiative was born when a broad conglomeration of industry participants, spanning all regions of the world and covering all aspects of the PC industry, banded together with the sole intent of breaking down the seemingly insurmountable market-entry barriers erected by Intel. The main theme of this loosely knit cooperative was to exploit Intel's perceived lack of high-performance processors, slow time to market, lack of creative leadership, second-tier technology/manufacturing capability, and high prices. Although the ACE initiative is now defunct, its strategy of capitalizing on Intel's perceived weaknesses and the very fact that it was able to form at all, caused the microprocessor giant to regroup. Spurred on by this threat of competition from multiple angles, Intel is trying to fix its weaknesses and in so doing, to run away from the pack before the pack even forms. The company is doing this by systematically addressing each of the perceived weaknesses that the ACE initiative tried to exploit.

Dataquest

Program: Microcomponents Worldwide
Product Code: MCRO-WW-PD-9502
Publication Date: June 19, 1995
Filing: Perspective

For the short term, we are purposively ignoring the importance of the desktop operating system and focusing solely on the microprocessor. The assumption is that at some point around the end of the decade, at least one mainstream cross-platform operating system will be in production. At that point, one of the critical market-entry barriers protecting the x86 architecture from competition will be removed, and the battle will be fought over such issues as price, performance, manufacturing capacity, sales channels, and brand name awareness.

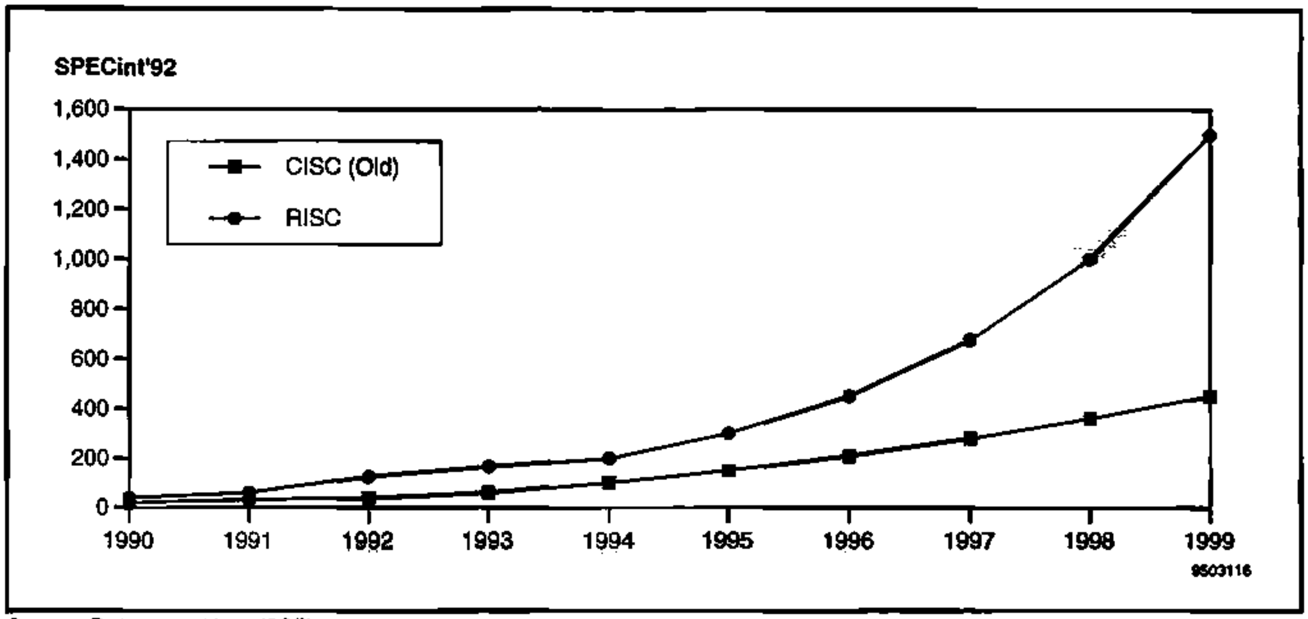
Perception No. 1: CISC versus RISC Performance

The ACE initiative took the RISC versus CISC (which ACE seemed to equate to the x86 family of microprocessors) performance issue to new heights. The main theme of the public relations campaigns was that RISC was good and CISC was bad. RISC uses small, simple, fixed-length instructions, while CISC uses long, variable-length, complex instructions. RISC designs were not limited to the architectures used by the antiquated CISC microprocessors. RISC designs could include the following concepts:

- Superscalar
  - More than one execution unit per processor
- Superpipelining
  - Multiple pipe stages in the instruction execution process (This allows for higher-frequency clocks than a nonsuperpipelined architecture.)
- Branch prediction
  - Assuming whether or not a branch will be taken
- Speculative execution
  - Operating on instructions before the results of the branch condition are known
- Out-of-order execution
  - Operating on an instruction based on when its data is ready, and not upon its order in the instruction stream; completed instructions are reordered later in the process

Consequently, RISC processors could run faster and more efficiently than CISC processors. Over time, the performance gap would continue to grow, and CISC microprocessors would fall further behind in the race for high performance. This, in turn, would make the RISC microprocessors the obvious choice for all computing applications (see Figure 1). However, that hypothesis was based on empirical evidence known at the time of the statements. Most of the most vocal proponents of this hypothesis based their assumptions on the fact that most RISC microprocessors were implementing or publicly stating that they would implement most or all of the above "RISC" architectural techniques and because no CISC (read x86) microprocessors were implementing these techniques, CISC microprocessors must be incapable of implementing them. However, the proponents of this argument are guilty of jumping to conclusions with limited data. As has happened over and over in the history of man, new observations lead to further investigation, which leads to new facts, which leads to a revised hypothesis.

Figure 1
RISC versus CISC: Traditional View

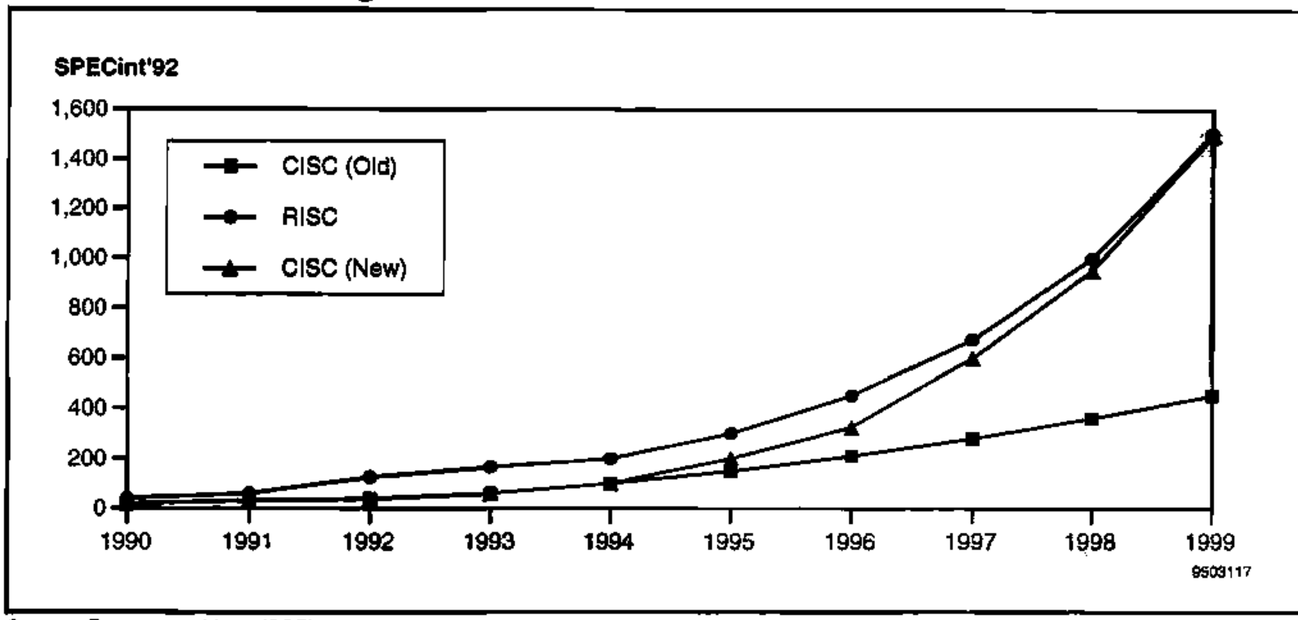


Source: Dataquest (June 1995)

In 1993, Intel introduced the Pentium microprocessor, which contained two integer units, and the superscalar argument disappeared. In 1995, Intel introduced the "P6," and the rest of the argument crumbled away. The "P6" contains multiple execution units; has a fine-grain multistage pipe; and performs branch prediction, speculative execution, and out-of-order execution. In fact, the fine granularity of the pipeline in the "P6" causes speculation that the "P6" will not only hit its specified target clock rate of 133 MHz, but it will also rapidly be scaled upward and will go a long way toward closing the performance gap between RISC and CISC microprocessors. Most of the other x86 vendors have also introduced or announced versions of the x86 architecture that use these same architectural techniques, which the RISC proponents had once proclaimed as belonging solely in the various RISC architecture camps. We do not mean to state that a CISC microprocessor will match the performance of a RISC microprocessor with a given transistor budget, but as long as the CISC vendors are willing and able to pay what is now becoming a slight penalty in extra transistors, then there is nothing fundamentally preventing CISC architectures from matching the performance of RISC microprocessors by the end of the decade (see Figure 2).

The "P6" from Intel has gone a long way toward this end; the 786-series will cut the gap even more; and by the time the 886-series is introduced, the mainstream RISC microprocessors will have no inherent performance advantages. One exception to the rule may be the ALPHA microprocessor from Digital Semiconductor, which sacrifices nothing for speed. We expect that it will maintain a performance leadership position over its competitors. But the heavy emphasis on speed comes with a price. The high power consumption and high-performance motherboard requirements mean that the ALPHA will probably be relegated to the very high end of the PC market, where performance comes at a premium.

Figure 2
RISC versus CISC: Enlightened View



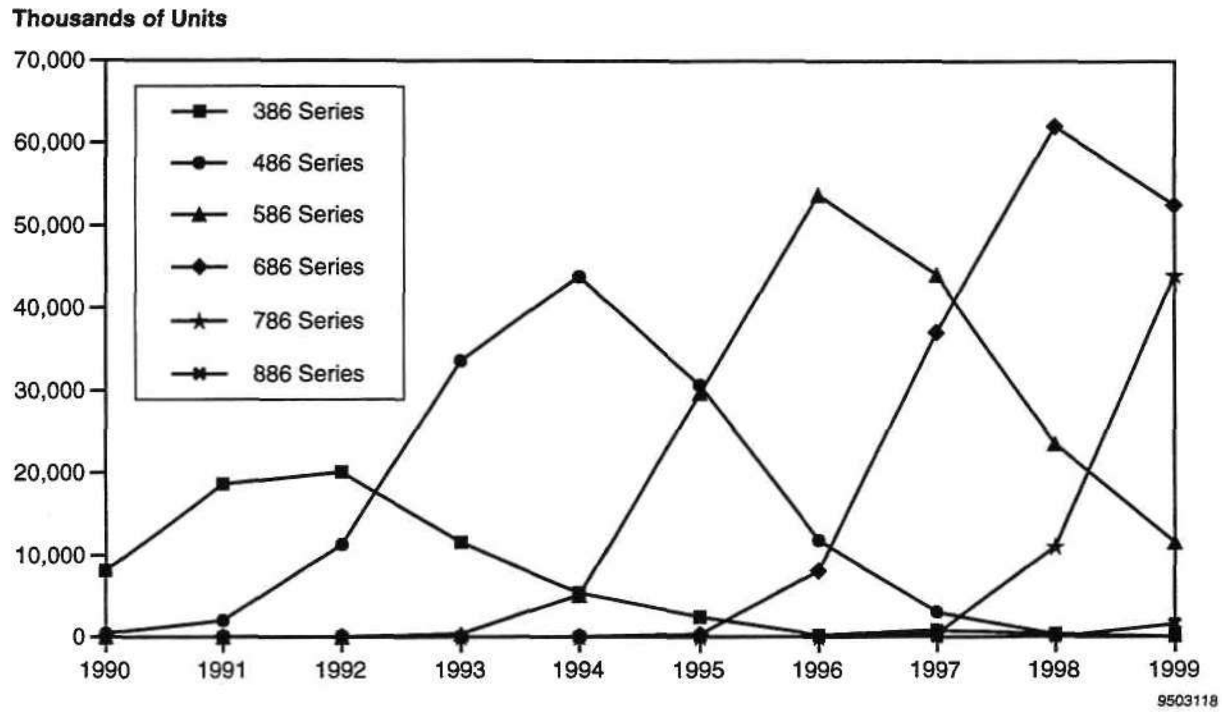
Source: Dataquest (June 1995)

Perception No. 2: Time to Market

One of the main themes pounded on by the ACE initiative was Intel's rather lackadaisical pace of introducing a new microprocessor architecture every four to five years. The members of the ACE initiative believed that this was presented critical weakness to exploit. The members believed that Intel's single microprocessor design team could not compete with the multiple design teams and combined resources of the initiatives members. The initiative team was never able to effectively utilize the combined resources it touted, and most members were effectively operating solo without any effective cooperation between the various members. However, Intel did not wait to see if the initiative would succeed or self-destruct. Instead, Intel built a second microprocessor design team. Instead of trying to force creativity by cutting down on the time it took internally to develop a next-generation microprocessor, the company employs two separate design and development teams that operate 180° out of phase on a time basis. The result is that each design team still takes about four years to develop a next-generation architecture, but the outside world sees a next-generation architecture every two years instead of every four years.

The predictable result is that newer generations of microprocessors will have life cycles about one-half as long as those of prior generations of microprocessors. The introduction of the "P6" (see Figure 3) marks the first of this new introduction strategy. The "P6" is being introduced only two years after the original Pentium microprocessor, which was introduced four years after the 486.

Figure 3
x86 Microprocessor Life Cycles



Source: Dataquest (June 1995)

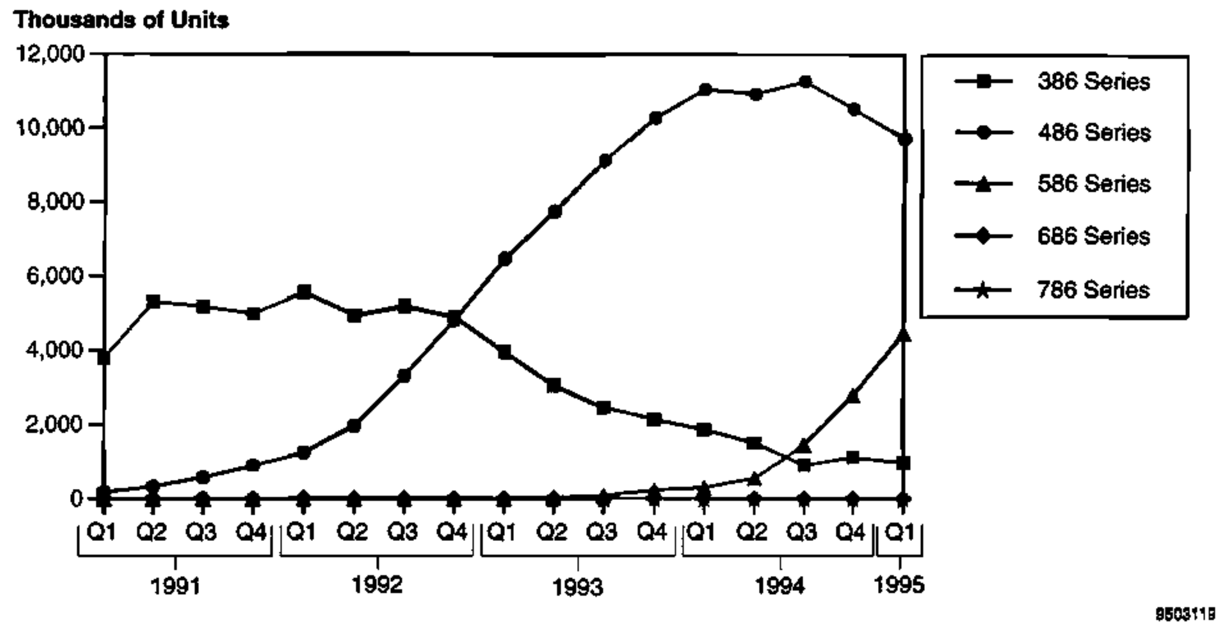
Pentium to Peak in the Third Quarter of 1996

A mere three years after its introduction, the 586 series microprocessor, under pressure from the newly emerging 686 series microprocessors, will have reached its production peak. Contrast this with the 486 series microprocessor, which took five years to reach its production zenith. On a quarterly basis, Dataquest believes that the 586 series will reach its shipment peak in the third quarter of 1996 (see Figure 4 and Table 1). The 586 series microprocessor will be the first PC processor to have its life cycle shortened in comparison to prior generations, but it will not be the last.

Even within specific families of x86 microprocessors, we are witnessing competition as higher-performance versions of a processor are introduced (see Figure 5 and Table 2). The pace Intel has set will make it difficult for any but the very strong and very resourceful to survive in the microprocessor market share battle of the desktop PC.

When the competitive pressures of other vendors start to impact Intel, it makes massive moves to the next-generation microprocessor. The company did this when Advanced Micro Devices entered the 386 market in earnest, and now that AMD is beginning to show signs of increasing its position in the 486 market, we see Intel making a rapid exit from the 486 market to the Pentium. This move is evident in Figure 6, which shows Intel beginning to lose market share in terms of unit shipments in the first quarter of 1995. The same figure in terms of revenue would show Intel, at a minimum, maintaining market share.

Figure 4
x86 Series Quarterly Shipments



Source: Dataquest (June 1995)

Table 1
x86 Series Quarterly Forecast (Thousands of Units)

	Q2/95	Q3/95	Q4/95	Q1/96	Q2/96	Q3/96	Q4/96
486 Series	7,532	6,227	5,280	4,178	3,409	2,527	1,668
586 Series	6,083	8,448	10,968	12,950	14,170	14,455	13,359
686 Series	0	50	250	625	1,250	2,290	3,998

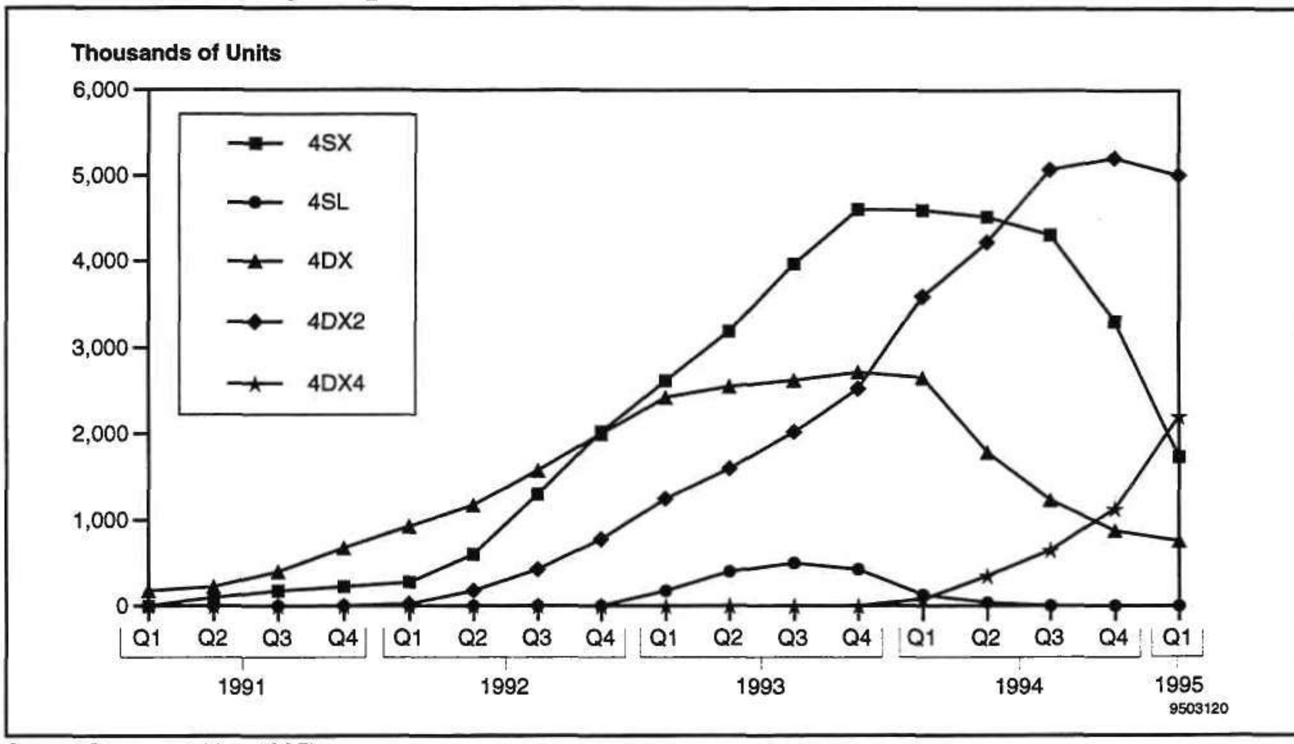
Source: Dataquest (June 1995)

Perception No. 3: Lack of Creative Leadership

Intel was perceived as bringing nothing to the party in terms of innovation. It was thought that the company had "lucked out" when IBM chose the x86 architecture on which to base its standard setting PC, and Intel was not adding significant new value.

If this was the case in the early 1990s, Intel has certainly overcome that perception. The Intel Architecture Labs in Oregon is chartered not only with helping Intel develop next-generation x86 architectures, but it is also chartered to advise the PC industry at large where to go in terms of architectural enhancements, performance, and features. This group is responsible for the telephony standard known as TAPI and the high-performance industry standard peripherals component interface bus known as PCI, and it is now proposing NSP as the minimal standard for a multimedia platform.

Figure 5
486 Series Quarterly Shipments



Source: Dataquest (June 1995)

Table 2
486 Series Quarter Shipment Forecast (Thousands of Units)

	Q2/95	Q3/95	Q4/95	Q1/96	Q2/96	Q3/96	Q4/96
4SX	998	694	510	282	153	68	23
4DX	719	683	339	49	25	12	0
4DX2	3,070	1,793	1,144	471	286	185	198
4DX4	2,745	3,056	3,287	3,376	2,945	2,262	1,446

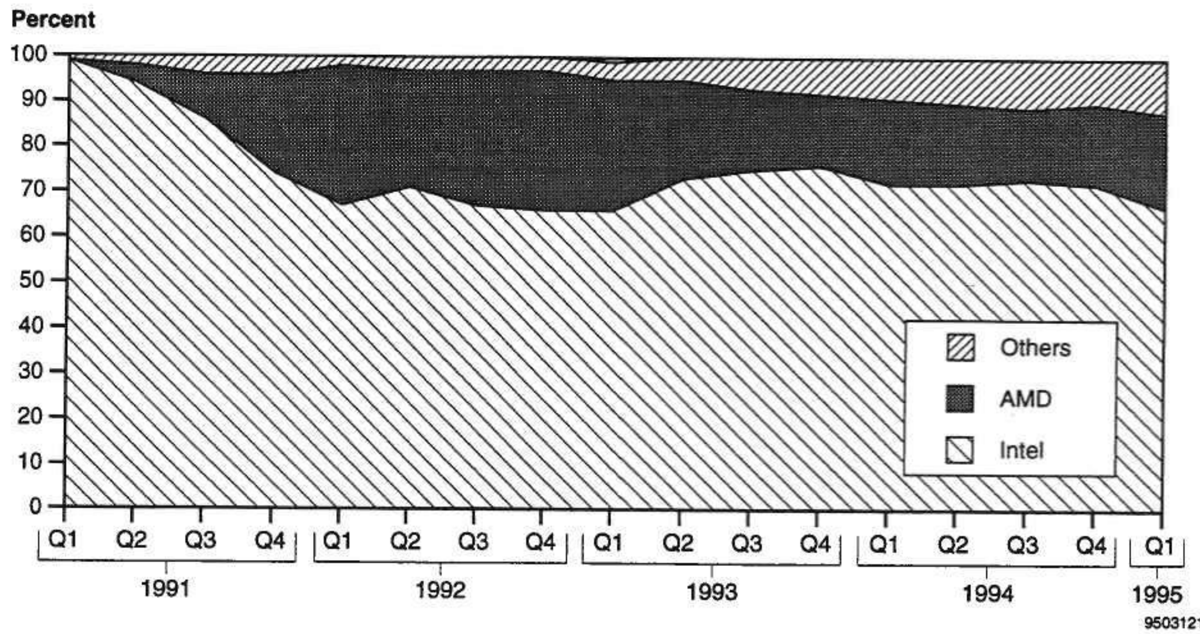
Source: Dataquest (June 1995)

Perception No. 4: Second-Tier Technology/Manufacturing Capability

Although this came as a surprise to those inside the company, Intel had long been looked upon as a follower in terms of technology and manufacturing issues in general. One could argue that the company was the leading supplier of large, high-volume microprocessors. But, it was slow in moving to three layers of metal, and it was always trailing ASIC and memory manufacturers in terms of moving to the next-generation process.

Today, it is hard to believe that Intel was once considered a laggard in this race. The company is trailing no one in terms of manufacturing capability, and its aggressive moves in technology currently place it in a leadership capacity. Today, Dataquest estimates that, with over 10,000, Intel has more 8-inch wafer starts per week than any other company in the world. By the end of 1996, this total should exceed 25,000 8-inch wafer starts per week.

Figure 6
X86 Vendor Quarterly Shipment Market Share



Source: Dataquest (June 1995)

The company's speed of transferring to new technologies is best exemplified in the following, which shows the progession in process geometry:

- 1993—0.8 microns
- 1994—0.6 microns
- 1995—0.35 microns

Performing such aggressive moves is unprecedented. The company is simultaneously transitioning from 6- to 8-inch wafers, mixing BiCMOS and CMOS processes, rapidly moving down the lithography road map, adding several new megafabs (more than 2,500 wafer starts per week), and moving to next-generation microprocessor designs. Such a rapid and aggressive pace is not for the faint of heart or the undercapitalized.

Perception No. 5: High Pricing

Intel seems intent on capturing all of the profit associated with hardware going into the PC. Although the x86 microprocessor remains a main cost component in the PC, Intel makes a strong argument that it is cutting the price performance point in half every 18 months or sooner. The average selling prices of Intel's microprocessors continue to climb, but the street prices of the systems seem to hover in the same range although performance is routinely doubling. Intel's argument is factual, but the area of price is still perceived as a weakness to be exploited by competitors. However, as prices can be changed overnight, we would not expect Intel to stand pat with existing pricing policies if a competitor is able to provide a competitive product in a part of the market in which Intel is not ready to vacate. The high pricing perception is still a weak point, but it can be rectified overnight if need be.

Dataquest Perspective

As stated at the beginning of this article, we purposively ignored the critical issue of the operating system. Without a mainstream operating system that supports multiple microprocessor architectures, comparing the performance of the x86 to any non-x86 competitor seems to be a moot point. The operating system is the most critical component of this issue. The ACE initiative was based on Windows NT from Microsoft. Prior to its release, Windows NT was surrounded by as much marketing preannouncement fanfare as we have seen for Windows 95. Windows NT was to be the platform on which rested the hopes of the various RISC architectures. Unfortunately, many people either misunderstood what Microsoft intended to do with Windows NT or made some bad assumptions. Windows NT was not intended to jump onto mainstream desktops and replace Windows on DOS, at least not right away. Windows NT is a ground-up operating system built for stability, performance, and security, to name a few. It was not intended to directly support the innumerable "legacy" software applications that many users still run on their PCs. It was also not designed with today's desktop PC system resources in mind. Windows NT is a solid server operating system today and will gradually move into higher-end PCs and then finally onto the desktop. This transition takes time and may not occur until the end of the decade.

In the meantime, Microsoft is introducing a replacement to Windows 3.x this year, which we all know as Windows 95. Windows 95, as DOS and Windows 3.x were before it, is dedicated to the x86 instruction set. The feature set promised by Windows 95 when combined with the rapid strides made by Intel and the rest of the x86 vendors should further push out the need to switch to Windows NT on the desktop. If this transition does not occur before the end of the decade, what arguments will the non-x86 vendors use against Intel at that time? Intel has addressed every issue the ACE initiative was using to attack the company. In fact, Intel has gone beyond by establishing new sales channels for its microprocessor and by successfully inserting itself into the PC motherboard business. Intel is now the single largest manufacturer of motherboards for the PC, giving it a tremendous advantage over any future competitors. It is also on its way to become the single largest vendor of PC Core logic in 1995. Intel has world leadership in microprocessors, PC Core logic, and motherboards, and anyone of these positions by itself is a commendable achievement. The combination of all three, when combined with the fact that the only mainstream desktop operating system is dedicated to its microprocessor architecture, puts Intel in the driver seat for many years to come. Any future "ACE initiative" had better be more prepared than the last one, or Intel may well continue this dominance into the next century.

For More Information...

Tom Starnes, Principal Analyst .... (408) 437-8366
Internet address .... tstarnes@dataquest.com
Via fax .... (408) 437-0292

Dataquest
a company of
The Dun & Bradstreet Corporation

Perspective

Microcomponents Worldwide

Dataquest Predicts

The PC Processor: What's Hot, What's Not

Abstract: *This report discusses the hottest issues taking place in the PC microprocessor market. Included is an analysis of the quarterly shipment history and an eight-quarter forecast for the 486, Pentium, and P6 microprocessors. We discuss the major players as well as the latest status on their various PC microprocessor product offerings. This report also analyzes the ever-shrinking product life cycles of the x86 microprocessors and the ever-shrinking performance gap between the RISC and CISC microprocessor architectures.*
By Jerry Banks

Setting the Stage—1994: The Year of the 486, the Quarter of the Pentium

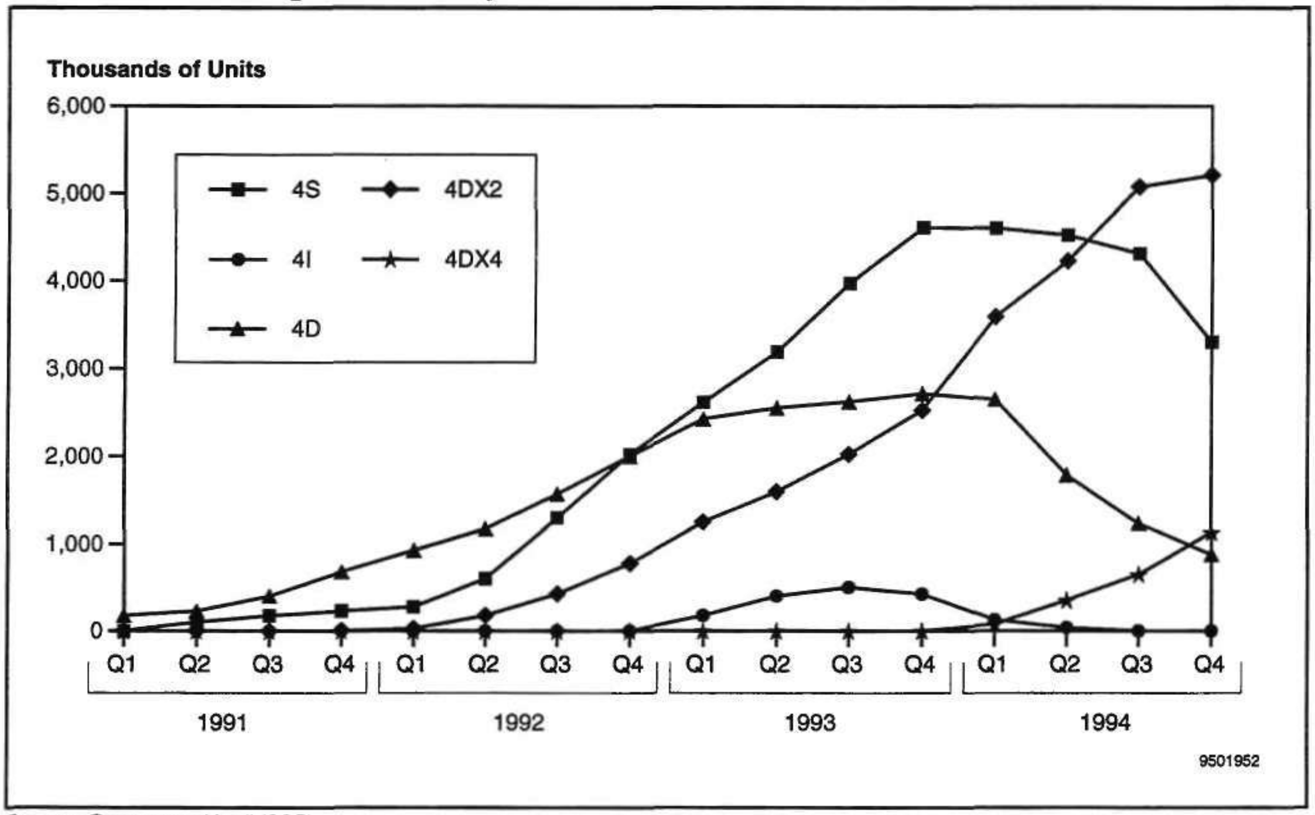
Although 1994 saw record shipments of 486 microprocessors, the phenomenal acceptance of the Pentium in the fourth quarter of 1994 provides an indication that the 486 has already seen its peak. More than 43 million units of 486 microprocessors were shipped, with the 486DX2 family making up the bulk of those shipments (see Figure 1).With the advent of the clock-multiplier technology for x86 microprocessors, single-clock variations of the 486 microprocessor began a rapid falloff beginning in the first quarter of 1994 (see Figure 1). This rapid decline continued throughout the year. We expect it to accelerate in 1995.

In conjunction with the 486 unit shipment life cycles, the 486 average selling price has been in a state of decline. The 486DX2 has declined to the point where it sits on top of the single-clocked 486DX, thus all but eliminating the original 486DX as a product category. The 486SX also has fallen off rapidly. Some high-volume purchasers were able to purchase a clock-doubled version of the 486SX for $50 or less by the end of 1994. This is clearly an area where Intel, Advanced Micro Devices (AMD), and Cyrix do not want to participate: Intel because of its need to protect its high margins, AMD because of its limited fab capacity and need to maximize revenue, and

Dataquest

Program: Microcomponents Worldwide
Product Code: MCRO-WW-PD-9501
Publication Date: April 24, 1995
Filing: Perspective

Figure 1
486 Series Unit Shipment History



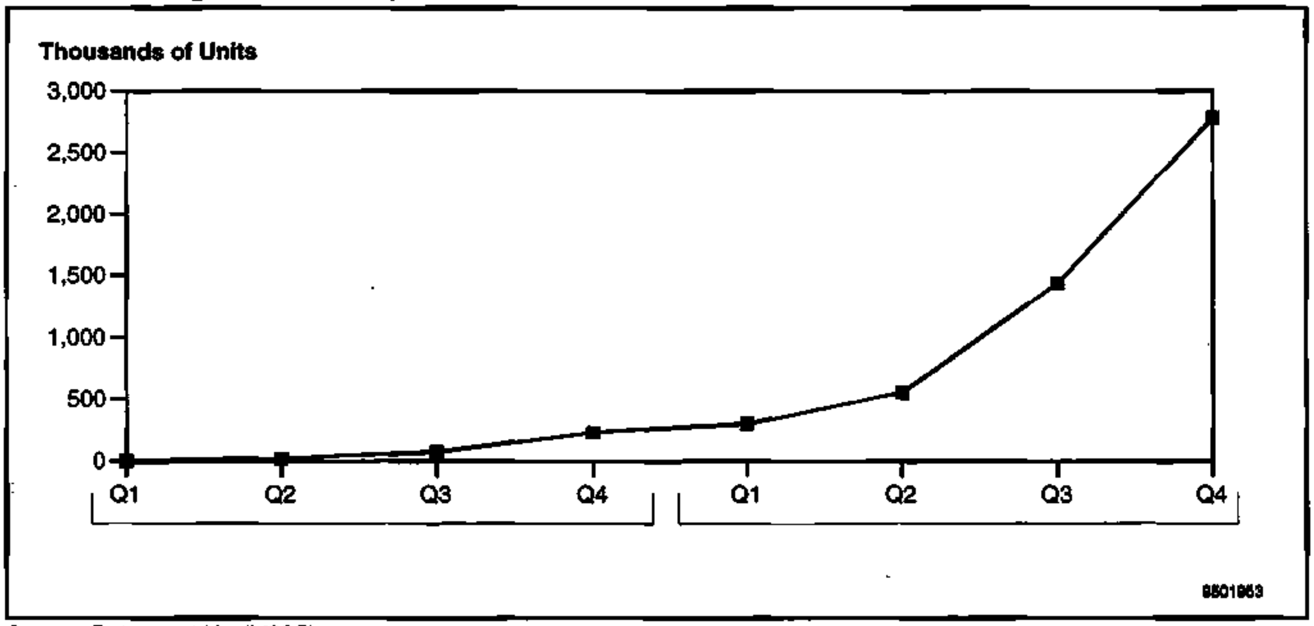
Source: Dataquest (April 1995)

Cyrix because designing and manufacturing small, low-cost die is not its forte. Perhaps only Texas Instruments has the ability and/or desire to continue to drive this low-cost market.

When Is a "Flaw" Not a "Flaw"?

The Pentium processors' success seemed anything but assured as late as December 1994. The now infamous Pentium "flaw" definitely caused a few Pentium users a lot of grief, but more than a few Intel employees worked many hours and lost much sleep during the fourth quarter of 1994 trying to resolve this potentially disastrous issue. The history of how this incident initially was mishandled by Intel has been well documented. But despite Intel's earlier mishandling, it did come clean with its solution and most, if not all, parties are now quite satisfied with Intel's final response. The world also learned that it is worth at least $475 million to ensure the design integrity of a microprocessor. Despite the uproar in the media and on the Internet, Intel still was able to ship 5 million Pentium processors in 1994, with the bulk of that coming in the fourth quarter (see Figure 2). This tremendous acceptance was driven by a user community consumed with the desire for more performance. Few, if any, seemed concerned with all the flap about a flaw that the average layperson could not understand. Perhaps the "Field of Dreams" theory espoused by Intel is true: "Build it and they will come." The Pentium is the most successful microprocessor in history at this stage of its life cycle.

Figure 2
Pentium Shipment History



Source: Dataquest (April 1995)

Although the second generation of the Pentium (referred to as the P54C) began to rapidly gain on the first-generation product (also known as P5), the P5 still shipped more than half the total Pentium volume in the year.

Dataquest Predicts

The 586-series microprocessor, led by Intel's Pentium processor, will overtake the 486 as the processor of choice in 1995 and will continue as the processor of choice through 1996. It will ship in record unit volumes during that time frame, with shipments peaking in late 1996.

What Does the Future Hold?

The clock-tripled 486 series (also known as the DX4) is the new growth category within the 486 series microprocessor. This variation of the 486 is providing 100-MHz performance with a 33-MHz bus, thus carrying on the tradition of maintaining the use of low-cost 33-MHz motherboard ICs while milking more performance out of the microprocessor. This allows the MPU manufacturer to increase prices for the added value of 100-MHz performance without impacting the end system cost. All of the necessary system cost reductions are coming out of the other motherboard components that continue down on the 33-MHz learning curve (the non-MPU exception to this is DRAM, which is in the midst of a continuing shortage situation). The only alternative to the motherboard left for the non-MPU and non-DRAM suppliers is to move up in the performance realm of the Pentium and/or integrate more functions in order to add sufficient value to stem the rapid price erosion.

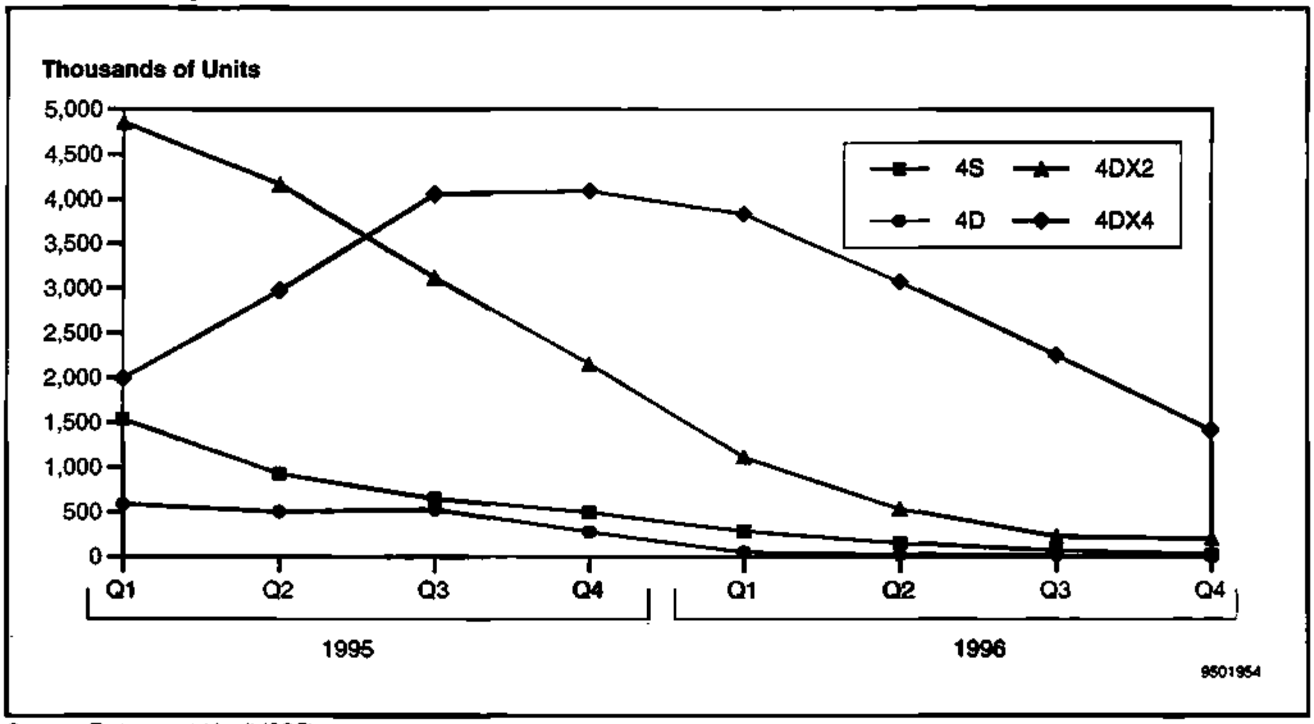
As is seen in Table 1 and Figure 3, only the clock-tripled 486 products are expected to show any growth in 1995. We expect the growth to tail off by late 1995, with a rapid decline continuing into 1996. Although the 486 is in decline, it will still ship nearly 33 million units in 1995 and nearly 8 million units in 1996.

Table 1
486 Quarterly Forecast (Thousands of Units)

	Q1/95	Q2/95	Q3/95	Q4/95	Q1/96	Q2/96	Q3/96	Q4/96
4S	1,537	929	650	493	286	155	69	24
4D	589	505	528	275	49	25	12	0
4D2	4,853	4,167	3,121	2,159	1,116	536	226	201
4DX4	1,990	2,974	4,054	4,088	3,830	3,073	2,254	1,414

Source: Dataquest (April 1995)

Figure 3
486 Quarterly Forecast



Source: Dataquest (April 1995)

Pentium Futures

The Pentium is on an unprecedented rise. Despite its shaky fourth quarter in 1994 (from a public relations viewpoint), the Pentium seems destined to break all previous shipment records. It was often speculated during the fracas caused by the flaw that the Pentium processor's reputation was permanently damaged and that the production ramp rate for the Pentium would be severely impacted. The latter speculation, as it turns out, is exactly on the mark, although the impact is not quite what the doomsayers (Dataquest was not in this group) were predicting. The Pentium shipped 5 million units in 1994 and is on a run rate to exceed 25 million 1995—what an impact the flaw had on the Pentium's run rate! The 5 million unit shipments in its first full year of production is a world's record, and the run rate it is on for 1995 indicates it will break all previous records in its second full year of production as well. Once again the old adage is proven: The only bad publicity is no publicity. The Pentium is on an unprecedented volume ramp. We are sure that Intel would have preferred that the whole issue had never come up, but one could argue that the current run rates would not have been possible without the massive manufacturing effort Intel put together at the end of last year. This accelerated effort was organized as part of a recovery plan to get the fixed Pentium into production as fast as possible and develop replacement products for the potential returns of the flawed product. Without this monumental effort, the company would probably still be on its prior plan to ship only in the low-20 million-unit range (which would still have been a world record run rate).

So, Intel once again lands on its feet. Was this luck or planning? Having a problem with your flagship product dragged across all forms of media all over the world is not exactly a lucky thing to have happen. Yet it is also difficult to give Intel a lot of planning credit. What is remarkable is how quickly the company reacted. Nearly the entire microprocessor group was mobilized to support the effort to resolve the problem, and the management team reacted quickly to modify its position until it finally came up with a very acceptable resolution in a relatively short time.

The Pentium Clones Arrive

Although the expected shipment of the upcoming K5 microprocessor from AMD is being touted as the first real competitor to the Pentium processor, the first company to ship a Pentium-class processor outside of Intel is the oft-maligned Nexgen. This eight-year-old company has always had the dream to be the first with the next-generation x86 microprocessor. For nearly its entire existence, the company has been thwarted in its efforts by Intel's product introductions and then by AMD's entry in the market as the only real x86 competitor. Nexgen was constantly resetting itself and looking to the future.

The time for joking apparently has ended. With its announcement of the Nx586 in 1994, Nexgen became the first non-Intel manufacturer of a Pentium-class product. In fact, with the first quarter of 1995 now being finished, Nexgen still holds that title. The company still needs to add a floating-point unit to its current product because the current coprocessor strategy is giving some doubts to the OEM community. The recent announcement of an agreement between Compaq and Nexgen should help Nexgen gain some credibility with more tier-one and tier-two PC OEMs. The next biggest hurdle that Nexgen must overcome is the timely introduction of a 686-series product. It took eight years for this product—can Nexgen match or beat today's current two-year development cycle for next-generation products? Only time will tell, but so far the word is that it is well on its way.

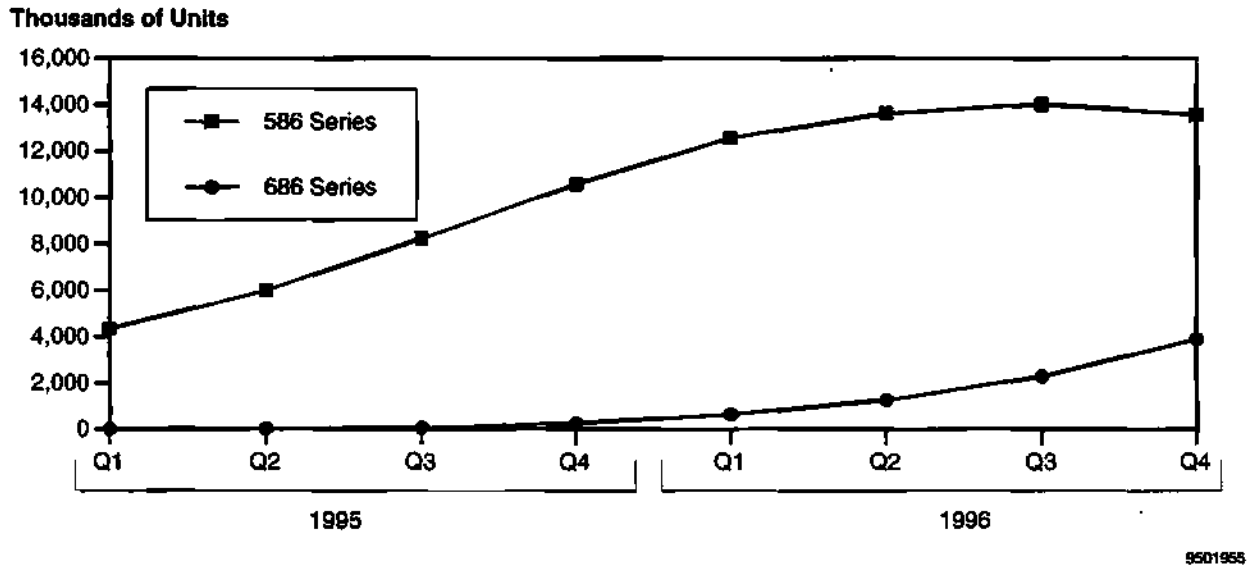
AMD's K5 is coming. Our best estimates are that it will start shipping in the second half of 1995 and will contribute at least 300,000 units to the Pentium series shipments for 1995. The only real obstacle holding up the K5 appears to be manufacturing capacity. The company's long-awaited Fab 25 in Austin, Texas, will give it a much-needed boost. This 8-inch, or 200mm, submicron facility is expected to propel AMD into a much more competitive position. The facility will be able to turn out 486s by the millions and should be sufficient to launch the K5 effort in earnest. The K5 is a more efficient architecture than Intel's Pentium and should provide up to a 30 percent performance edge at similar clock frequencies. This performance advantage does pose a slight marketing challenge for the company. The company historically has introduced an x86 product with a higher clock rate than a similar Intel product. It would then offer this product at the same price as the lower-frequency Pentium product. This higher-performance, lower-price strategy was quite successfully employed by AMD in the 286-, 386-, and 486-generation products. The problem it faces now is that the earlier-generation products used clock frequency as the measure of performance and the K5 achieves its performance advantage at the same clock frequency as Intel's Pentium. It will be a difficult educational process to convince buyers that the AMD part has superior performance when they have been trained to look for clock frequency as the metric for performance. One option is the route taken by Nexgen. Nexgen claims that its performance operating at 93 MHz is the same as the Pentium operating at 100 MHz. So, it markets its 93-MHz products as Nx586-100. This option is not perceived by all as the most optimum solution. For one thing, the buying public may perceive this as deceptive. For another, using nonstandard clock frequencies poses new challenges for designers. It will be interesting to see how AMD overcomes this marketing problem created by engineering innovation.

The third expected entrant into the Pentium clone wars is Cyrix. The introduction of the much-heralded M1 microprocessor was overshadowed by its monstrous die size. The M1 measures 19.3 x 20.2mm. The only known die larger is the experimental digital signal processor chip from Analog Devices, which contains 4Mb of SRAM and was developed for MIT. The M1's die size is not suited for volume manufacture. The company has launched a massive die reduction effort that should get it into a competitive position when the product is expected to sample in late 1995. In the meantime, Cyrix has scaled down the original M1 architecture to get a product to market sooner. This new product is known as the M1-SC and is not a Pentium-class product. It will be targeted at DX4 sockets. The 100-MHz version is expected to provide the performance of a 75-MHz Pentium. The M1 should start shipping sometime late in the second quarter. Cyrix has stated that it will stop the manufacture of all current-generation 486 products by the fourth quarter of 1995 and devote all of its manufacturing capacity to the M1-SC and M1 when it is available. As more of a marketing statement, Cyrix has reclassified the M1 as a 686-class processor than the 586 or Pentium class at which it was originally announced. Our position is that we will leave the M1 as part of our 586-series forecast.

1995: Pentium Growth Explosion

The widespread user acceptance of Pentium-based PCs is driving the unit volumes for this class of product to record levels (see Figure 4 and Table 2). Intel will represent the lion's share of this volume, but the introduction of 586-series product by AMD, Cyrix, and Nexgen also will help fuel this growth phenomenon. Our forecast calls for 29 million 586-series product to ship in 1995. This explosive growth is expected to continue into 1996, and the only event that can slow the 586-series growth expectation is the production of the next-generation 686 series, which already has been kicked off with Intel's P6 product announcement. For a comprehensive look at the P6, please refer to Dataquest's Focus Report entitled, *P6: A Summary for Systems Manufacturers* (NGPC-WW-FR-9501, published April 10, 1995).

Figure 4
Pentium Forecast



Source: Dataquest (April 1995)

Table 2
Pentium Forecast (Thousands of Units)

	Q1/95	Q2/95	Q3/95	Q4/95	Q1/96	Q2/96	Q3/96	Q4/96
586 Series	4,328	5,986	8,238	10,588	12,564	13,622	14,023	13,560
686 Series	0	0	50	250	625	1,250	2,290	3,885

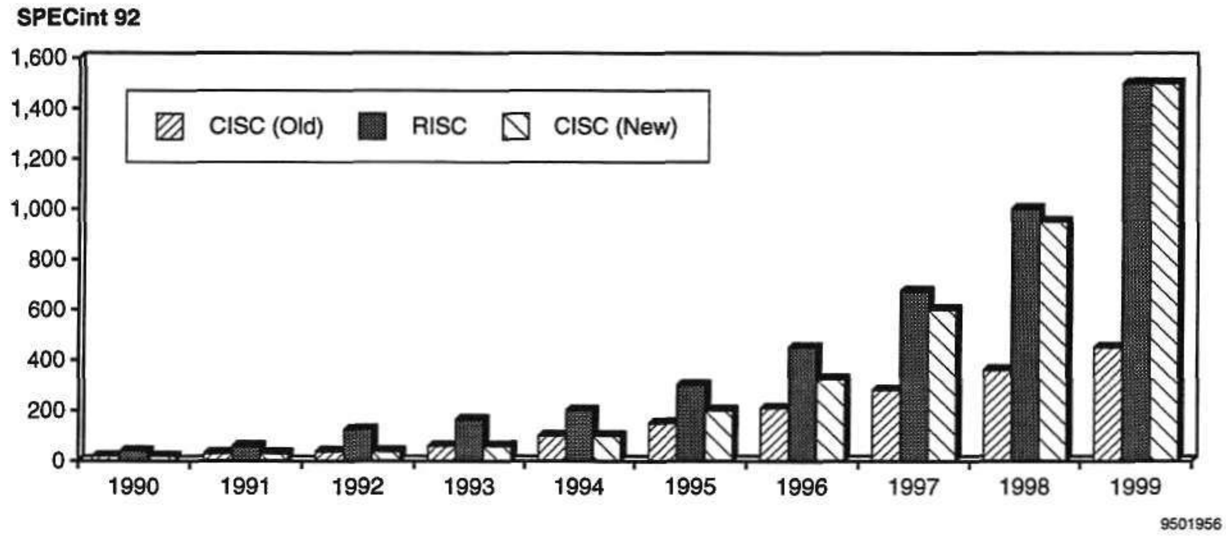
Source: Dataquest (April 1995)

Uncharted Territory

The introduction of the P6 microprocessor a mere two years after the introduction of the Pentium establishes a new benchmark in microprocessor introductions. The speed of the technology treadmill has doubled. Viewed another way, the time to develop a next-generation microprocessor has been cut in half. This puts tremendous pressure on all microprocessor vendors with an eye on the desktop that Intel now dominates. Most, if not all, of these competitors already had established design flows that would allow them to either maintain a performance lead or surpass Intel in the near future. Intel has just raised the bar, and it is not at all clear whether all the current competitors can match this effort.

The P6 also has introduced new architectural techniques that until now had been relegated to the realm of RISC microprocessors. The P6 makes use of branch prediction, out-of-order execution, and speculative execution, has six execution units, and is superpipelined with a fine-grain strategy that will allow rapid scaling of the processor clock. Traditional thinking would have the current performance gap between RISC microprocessors and CISC microprocessors rapidly increasing over time (see Figure 5).

Figure 5
RISC versus CISC: Traditional View



Source: Dataquest (April 1995)

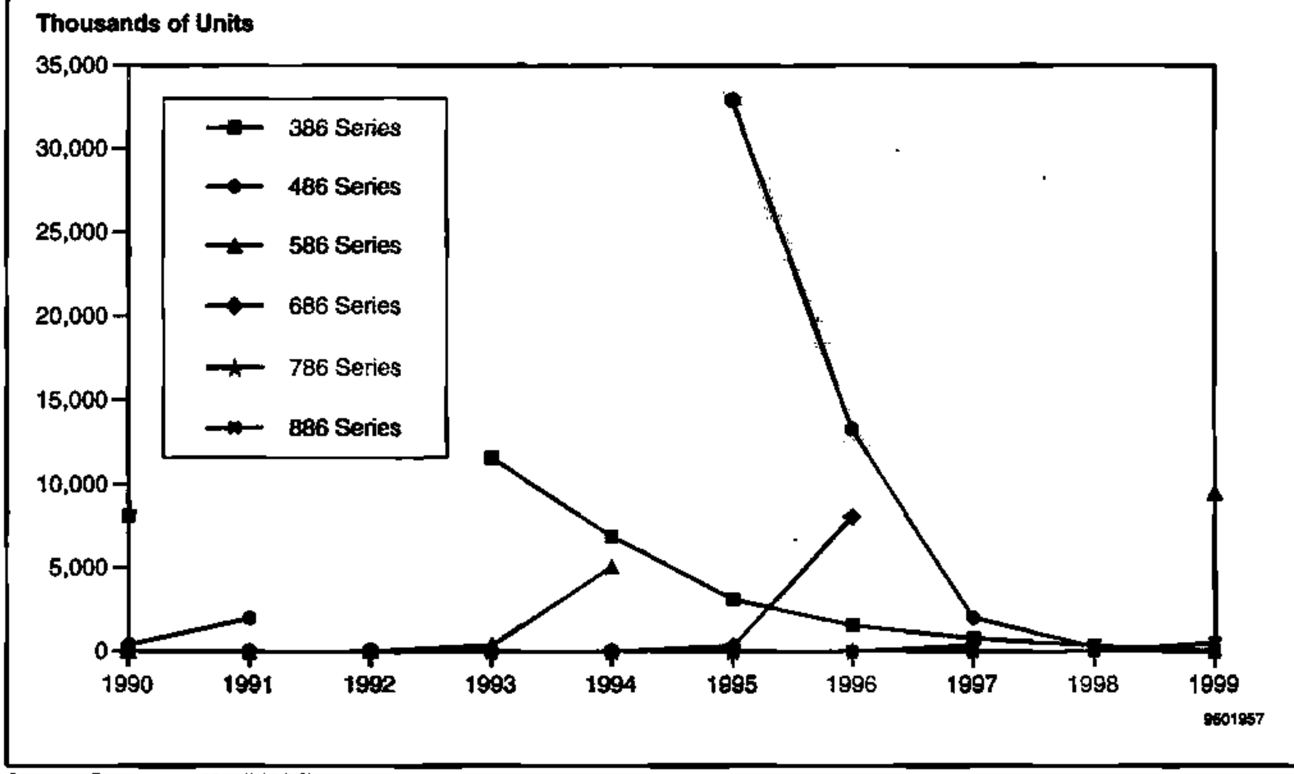
The performance gains of the P6 and future expectations for P7 and the continuing work being performed by the Intel-HP alliance for the P8 give reason to believe that the performance advantage of RISC microprocessors will be short-lived. The first P6 product will be introduced at a clock frequency of 133 MHz and an integer benchmark rating of 200 SPECint92. This clearly places Intel at the top of the x86 performance charts. The P6 also is beginning to make serious inroads into the RISC camp on the basis of integer performance. We should see a P6 integer benchmark of about 300 SPECint'92 by this time next year, and the x86 performance ramp should bring it onto a par with the highest-performance RISC microprocessors by the end of the decade.

New Marketing Challenges

When the first P6 products begin shipping in volume in the third quarter of 1995, it will mark the first year we will see three distinct generations of x86 microprocessors having significant impact on the PC market in the same year. With each distinct generation spawning higher-performance derivatives, price and positioning strategies have to be completely reworked. As is shown in Figure 6, each successive generation of x86 is reaching volume production faster than the prior generation. In addition to reaching volume production status sooner, the production ramp itself is steeper for each succeeding generation.

Marketing teams that were learning how to deal with this shortening of time to production are now seeing the product retirement rate also begin to accelerate. With the two-year development cycle in place, we will see much steeper declines after the microprocessors' peak shipment year, which will result in much shorter life cycles. Managing product price and positioning in this new scenario takes on new challenges. How long can a company extract revenue out of a product without stepping too hard on the prior generation while not slowing the acceptance of the new generation? How

Figure 6
x86 Product Life Cycles



Source: Dataquest (April 1995)

does a company introduce a new-generation product without making the existing revenue stream obsolete? These are questions that have plagued the electronics industry for well more than a decade (how many remember the "Osborne Effect"?) and are becoming more complex. Product marketing has been taking on an increasingly important role as companies strive to maximize revenue without sacrificing the future. This balancing act, which has never been an exact science, is becoming less exact all the time and requires careful management. Product marketeers that understand the market, the competitive forces, and their companies' capabilities will become critical assets to any corporation.

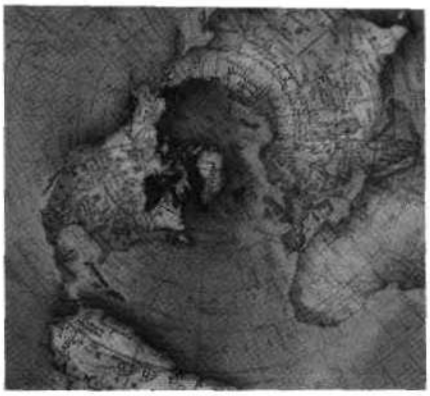
For More Information...

Jerry Banks, Director/Principal Analyst .... (408) 437-8677
Internet address .... jbanks@dataquest.com
Via fax .... (408) 437-0292

Dataquest
a company of The Dun & Bradstreet Corporation

Market Analysis

Dataquest



Dataquest

Microcomponent Forecast and Trends, 1995 to 1999

Market Trends

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MT-9504
Publication Date: February 19, 1996
Filing: Market Analysis

Microcomponent Forecast and Trends, 1995 to 1999

Market Trends

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MT-9504
Publication Date: February 19, 1996
Filing: Market Analysis

Table of Contents

List of Figures

List of Figures (Continued)

List of Tables

Chapter 1
Overview

Introduction

The microcomponent market will reach almost $75 billion in 1999, becoming over 25 percent of the total semiconductor market. This report summarizes Dataquest's five-year forecast of this very important market. Only DRAMs have a higher growth rate and end point than microcomponents. Characteristics and trends of the microcomponent market are analyzed. Forecasts of revenue through 1999 are given for the categories of microprocessors, microcontrollers, programmable digital signal processors, and microperipherals. Projections for North America, Japan, Europe, and Asia/Pacific-Rest of World regions are presented by category. Greater detail on the microprocessor forecast is available in Dataquest's *Microprocessor Forecast and Assumptions: June 1995* (MCRO-WW-MT-9502). Greater detail on the microcontroller forecast is available in Dataquest's *The Microcontrollers March On—The Forecast* (MCRO-WW-MT-9503).

Definitions of terms are in Appendix A, and exchange rates used for this document can be found in Appendix B.

It Just Keeps Growing, and Growing, and Growing ...

Business has been booming for semiconductors for years now. In fact, it has been booming for so long that pundits in Wall Street and in the industry wonder when there will be a slowdown. Stock market analysts are skittish, regularly taking fright and "taking profits," but they are back the next week investing in the semiconductor-driven technology stocks. Every time any semiconductor or semiconductor equipment manufacturer mentions the slightest slowdown or hiccup, the industry's stocks take a hit for a while. But most of the stocks soon recover as investors realize that 30 percent growth is really good.

The traditionally cyclical nature of the semiconductor business is not panning out in this boom period. The expectation of a significant drop in orders has always loomed two to three years out, but now such a drop appears to be nowhere in sight. As many as 200 new fabs are expected to be built by the end of the year 2000 to meet the additional demand for all semiconductors. No one within the industry can foresee any events that will significantly change the growth in demand that the industry has been experiencing. Keeping up with that demand will continue to be a challenge—getting manufacturing equipment, obtaining bulk silicon, constructing buildings, hiring and training qualified people, supporting customers, and managing a business growing at greater than 20 percent per year. Vendors are thrilled to be making money, with fabs bursting at the seams. They would also be secretly relieved to have some tempering of the boom to let them catch their collective breath, catch up to orders, and rebuild customer good will.

But demand is not likely to ease. In 1993, a significant increase occurred in the buying level in the personal computer segment. The strength in 1995 personal computer (PC) sales spurred by excitement over CD-ROMs, Pentium and Pentium Pro, and Windows 95 is driving a hefty part of the overall microcomponent and memory growth. Meanwhile, embedded applications of microprocessors, microcontrollers, and digital signal processors (DSPs) have been quietly and steadily growing for over a decade. The breadth and depth of the embedded systems market, from telecommunications infrastructure to consumer products, assures that any softness in one market area will be quickly absorbed by another part of the market.

The prevalence of video games in the home and of PCs in the home and the office has opened huge new markets. Consumers are aware that microprocessors are critical components in these products. The reliability of these products and the utility of products like pagers and cellular phones has made consumers more comfortable with digital electronic products. These products continue to operate for years, building confidence that a purchase of electronic goods provides a long-term benefit. While few understand the miracles these products perform, they are quite comfortable using them and are likely to buy more.

Two primary factors in this marketplace are growth rate and total revenue. Microprocessors, microcontrollers, and DRAM are the top three product categories when revenue and growth are considered together. Other products may have higher growth rates, but only with much lower starting points. It is commendable to double a $50 million business, but to build a $25 billion business to $35 billion in a year is a phenomenal accomplishment.

The Prevalence of the Personal Computer

The segment leading microprocessors (MPUs) and microcontrollers (MCUs) is that almost singular product that Intel ships in such enviable quantities and prices: the heart of the PC, the Pentium. The 486, Pentium, and the Pentium Pro have a unique marketplace that ensures continued high volume and high prices—a situation that should be taught in business courses as an anomaly rather than the norm. With the help of many PC OEMs, software application vendors, and the mighty Microsoft, a product that didn't even exist 15 years ago ships over 60 million units annually. So far, 90 percent of these 60 million units requires something close to the best that technology has to offer in the x86 microprocessor family. The strict code-compatibility requirements of these PCs means that no other processor architecture can fill all those sockets, though many have tried.

Intel has effectively deflected all attempts to unseat its products in the PC. A very successful marketing campaign has built an aura around the Intel brand to stave off competitors building same-architecture products as well as vendors trying to outrun the x86 with RISC-based alternatives that might be able to execute the very same code just about as fast. The PC-buying public looks for that Intel and Pentium trademark before making a purchase. That demand allows the supplier to charge what the market will bear for its product. It turns out that that supplier is not the PC vendor, because there are so many to choose from, but the chip vendor—the one chip vendor with the patents, compatibility, and ability to stay one giant leap ahead of all contenders producing the fastest and the most advanced products. In many cases, the need for these most advanced MPUs is imaginary. However, the excitement of technology and the threat of being left behind motivates people to buy the best they can afford. There is little on the horizon, either in the marketplace or in Intel's own strategies, to indicate that Intel will lose its dominance of the PC industry and, thus, the microcomponent product category.

So where does that leave all the other products that make up the microcomponents marketplace? True computer-like products like the PC, its big stepbrother, the workstation (with a different mother), and its well-named servant, the server, all fall into a category of computers or compute applications. The central processors in all of these run an operating system (OS), sometimes DOS or Windows, sometimes UNIX. The OS is less concerned with getting to tasks instantaneously than with getting to all tasks in priority and protecting each task from the effects of sloppy programming in the other tasks. It's sort of like the government. A need can probably be filled by an office somewhere in the structure, but it may be necessary to wait hours or months, and complaints fall on deaf ears. And perhaps 5 percent of those in need just fall into the cracks. And sometimes the whole system just closes its doors and doesn't restart until Monday, or January. And it may have lost the paperwork by the time it finally gets around to serving the need, so it all starts over again.

But additional processing elements can be found even within the PC or workstation. Separate processors run the keyboard, control the monitor, pull data off the hard drive, or run the network connection. These uses of MPUs and MCUs are but a small part of the entire embedded application field.

Embedded Applications

The vast majority of applications beyond the PC and workstation are typically referred to as "embedded" by those in microprocessor, microcomputer, and microcontroller businesses. A microcomponent in these products will do one set of tasks dedicated to a single purpose for its entire life. These tasks may simply be to show the correct messages on an LCD display and watch the keypad for any new inputs to convert. Or the microprocessor might grab all the data coming down a TV cable, steering only the desired data to an MPEG decoder chip. Or it might take the data pouring out of an interoffice trunk, determine its destination, and direct it to the cheapest available transmission method and route that avoids the congested Chicago toll office.

Or the microcomponent may be slowing down the pickup head to position it precisely over the correct track on the tiny new disk surface, which is spinning at exactly the right speed for the data stream to be sensed and decoded quickly—so that the user barely notices that the data had to come from a disk rather than out of RAM. Or it is programmed to monitor satellite transmissions until at least three are captured and the data can be correlated, calibrated, and extrapolated to determine and display the instrument's location on the surface of the earth with an accuracy of 1 meter (remember that the distance from the equator to the earth's pole was supposed to be 10,000 meters.) With additional calculation using a fourth satellite's data, the microprocessor can also determine the height above sea level. Or a microprocessor periodically runs a series of complex tests on the equipment, possibly sending a "maintenance needed" message to the operator, along with a diagnosis of the problem. But the microprocessor or microcontroller does only one of these tasks because it lives in only one type of equipment.

In each of these cases, the program controlling the processor is predetermined, often programmed into ROM. Each time the instrument is powered up, the processor performs the same operation, possibly refined by some new settings or buttons on the user panel, but still performing the same general function. The user of the equipment does not insert a floppy disk with different programs to perform with each use. The MCU running the automobile engine will not suddenly be reprogrammed to cook the turkey in the microwave oven. In fact, rarely does the user even know that there is an MPU or MCU in the equipment, let alone which it is or how to reprogram it.

The limitless variety of embedded applications makes this market ripe for specialization and full of opportunity for the entrepreneurial semiconductor manufacturer wanting a portion of the microcomponent business. Just the right combination of performance, features, size, and price can be extremely attractive to just the right application. If all aspects of this new chip are just right, it can win the design over a more general-purpose microcomponent. Alternatively, the best chip for a robot controller is not necessarily the right chip for a video decoder. The lock of code compatibility might apply within certain OEMs, but not usually within a market. Even protocols and standards rarely require a particular processor, controller, or architecture. In fact, the purpose of these standards is to allow freedom among the OEMs to select the best controller for each particular product criteria, be it cost, performance, or quality.

Just Where Are These Products Going?

The momentum that some architectures have established must be overcome before a new MPU/MCU architecture can take root, but this is possible. The 8051, uPD, 6805, and 68000 architectures have prospered for years (decades?) with a solid architecture, variety of chip offerings, and continuous effort to adapt to changing marketplaces. The popular architectures have many advantages. Millions of lines of code exist for the chips, all of which can be easily ported to a new application when used on the same architecture. Operating systems have been fine-tuned to run optimally on the established architectures. Performance and capabilities are well established and understood, rather than suspect and mysterious. Development tools are in place to aid in debugging. Interface chips exist, making hardware interconnects and designs easier. Programmers and hardware designers can readily be found to work on projects.

Philips is capitalizing on its license to build 8051s and is extending its product line to 16-bit MCUs. Intel, which developed the 8051, has far better name recognition in microcomponents, but focuses much more attention on its x86 product family. In the microprocessor business, the newfangled reduced-instruction-set computer (RISC) processors managed to break the 8086 and 68000 stronghold some years ago and take a lot of attention (though not so many dollars) from the established products. RISCs are still a formidable product, but only when taken as a body of many architectures. Some are fast and furious; others are small, nimble, and frugal. The Advanced RISC Machines (ARM) architecture seems to be sprouting new limbs on a quarterly basis, each from a different vendor, each to fill a different need.

But the microprocessor and microcontroller business is evolving and is a long way from maturity. Many changes can and will occur in the coming decade. Fuzzy logic, Tron processors, artificial intelligence, and neural nets have been interesting diversions, but have not changed the market significantly. They may some day, but more likely candidates are speech recognition, video compression/decompression, wireless, and DSP.

In fact, most of the more promising areas for growth are oriented toward the human interface (along with the more mundane areas of speed, cost, and battery drain.) While video is mostly used for entertainment, it is also being used to enrich the visual input to the human. Speech recognition and speech generation may use a slower interface to the human, but are vastly more comfortable and friendly (it is amazing how many people still use hunt-and-peck typing on keyboards.) The ability to manipulate the fingers has put a limit on the size of keyboards and therefore the size of notebook computers, personal digital assistants (PDAs), and telephones. In many cases, antiquated requirements and habits will continue to limit the vision of designers to enhance products. Advances will always be hindered by the pace of human acceptance, and this must be considered cautiously in new ventures.

The microcomponents, old or new, that best support such new, growing applications areas will be the survivors. Existing architectures sometimes fit well in new applications. Sometimes the older architectures win new applications because of the benefits they offer by being so well established. Other times, a new architecture will win the new applications because the architecture was specifically designed for it. Or the new architecture may have more current thinking implemented in its design and may therefore accommodate the new application better. A new architecture today with hooks or support for DSP and video in its design has a better chance of capturing fresh embedded applications.

The availability of the microprocessor architecture as a core processor in a customer-specified, ASIC-like component will be particularly important in the near future as larger customers want to gain more control over the functions integrated onto their silicon. Other key design criteria for microcomponents are the traditional ones: raw performance, low power consumption (and its companion, heat dissipation), small die size (and its benefit, low price), and packaging that takes up minimal board space but can still be handled by the pick-and-place equipment. The on-chip peripherals, memory (including cache), and interface and support circuits will also determine the applications for which the microcomponent is best suited.

Note that digital signal processing is an important part of microcomponents. This specialized technology is becoming more critical in many of the growth applications. Compression techniques for modems, voice and video, speech and voice recognition, video enhancement, and many human interfaces require sophisticated digital signal processing to perform their magic. Sometimes a simple multiply and accumulate (MAC) instruction in an MCU or MPU will suffice to speed up simple signal processing chores. But the processing of most real-world signals requires a dedicated DSP with a variety of specialized instructions, dedicated registers, sophisticated addressing modes, and high-speed, multipath buses to attain critical real-time processing performance. Ignoring this type of product may lock a vendor out of a rapidly growing part of the business; development and support of a DSP is equivalent to the effort involved with any MPU or MCU architecture.

While a significant investment would be needed for a vendor to break into or expand in the microcomponent business, there are rewards. Winning even a fairly small part of a business growing $9 billion a year can be very nice.

Overall Forecast

An overview of Dataquest's forecast of microcomponents by product type is given in Table 1-1. From a base of $110 billion in 1994, all semiconductors worldwide are expected to grow over 35 percent in 1995, with a 20.1 percent compound annual growth rate (CAGR) for 1994 through 1999. Microcomponents are expected to follow a similar trend, with a 34.2 percent growth in 1995 and a CAGR of 22.8 percent. Microcomponents, given their unique characteristics, greater capabilities, higher perceived value, and demand from the PC industry, are expected to lead the growth of general semiconductors. The portion of microcomponents destined for embedded applications is shown separately in the table with the difference in 1995 and later accounted for primarily by many 486s, all Pentiums, and most PowerPC processors. Embedded microcomponents are MPUs used in embedded systems and all MCUs, DSPs, and microperipherals (MPRs) (see Figure 1-1).

Figure 1-1
Categorization of Microcomponents

<table>
<tr><th colspan="8">Semiconductors</th></tr>
<tr><th colspan="5">Microcomponents</th><th rowspan="4">Memories</th><th rowspan="4">ASIC</th><th rowspan="4">Others</th></tr>
<tr><th></th><th colspan="4">Embedded Microcomponents</th></tr>
<tr><th>Computational MPU</th><th>Embedded MPU</th><th>MCU</th><th>DSP</th><th>MPR</th></tr>
<tr><td>x86 (partial)
68K (partial)
PowerPC
SPARC
Others</td><td>x86 (partial)
68K (partial)
32xxx
29K
Others</td><td>(Many)</td><td>(Many)</td><td>(Many)</td><td></td><td></td><td></td></tr>
</table>

Dataquest's Embedded Microcomponents Worldwide Service Coverage

- Computational microprocessors perform the central processing unit (CPU) function of personal computers, workstations, and servers.
- Embedded microprocessors perform dedicated processing and controlling tasks as programmed by the OEM.

9507315

Source: Dataquest (December 1995)

Table 1-1
Worldwide Revenue Forecast of Microcomponent Shipments by Product Family (Millions of Dollars)

	1992	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Total Worldwide Semiconductors	65,261	85,518	110,580	149,788	182,908	210,361	238,599	275,744	
Growth (%)	-	31.0	29.3	35.5	22.1	15.0	13.4	15.6	20.1
Total Worldwide Microcomponents	14,359	19,947	25,868	34,720	43,945	51,959	61,541	72,285	
Growth (%)	-	38.9	29.7	34.2	26.6	18.2	18.4	17.5	22.8
Percentage of Worldwide Semiconductors	22.0	23.3	23.4	23.2	24.0	24.7	25.8	26.2	
Embedded Microcomponent	9,906	12,287	15,709	21,500	26,799	30,949	36,318	42,774	
Growth (%)	-	24.0	27.9	36.9	24.6	15.5	17.3	17.8	22.2
Percentage of Worldwide Microcomponents	69.0	61.6	60.7	61.9	61.0	59.6	59.0	59.2	
Percentage of Worldwide Semiconductors	15.2	14.4	14.2	14.4	14.7	14.7	15.2	15.5	
Microprocessor	5,501	8,783	11,436	15,514	20,055	24,225	28,819	33,811	
Growth (%)	-	59.7	30.2	35.7	29.3	20.8	19.0	17.3	24.2
Percentage of Worldwide Microcomponents	38.3	44.0	44.2	44.7	45.6	46.6	46.8	46.8	
Percentage of Worldwide Semiconductors	8.4	10.3	10.3	10.4	11.0	11.5	12.1	12.3	
Microcontroller	4,613	5,904	7,517	10,005	12,209	14,430	17,157	20,099	
Growth (%)	-	28.0	27.3	33.1	22.0	18.2	18.9	17.1	21.7
Percentage of Worldwide Microcomponents	32.1	29.6	29.1	28.8	27.8	27.8	27.9	27.8	
Percentage of Worldwide Semiconductors	7.1	6.9	6.8	6.7	6.7	6.9	7.2	7.3	
Digital Signal Processor	444	679	1,030	1,484	1,976	2,451	3,014	3,746	
Growth (%)	-	52.9	51.7	44.1	33.2	24.0	23.0	24.3	29.5
Percentage of Worldwide Microcomponents	3.1	3.4	4.0	4.3	4.5	4.7	4.9	5.2	
Percentage of Worldwide Semiconductors	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	
Microperipheral	3,801	4,581	5,885	7,717	9,705	10,853	12,551	14,629	
Growth (%)	-	20.5	28.5	31.1	25.8	11.8	15.6	16.6	20.0
Percentage of Worldwide Microcomponents	26.5	23.0	22.8	22.2	22.1	20.9	20.4	20.2	
Percentage of Worldwide Semiconductors	5.8	5.4	5.3	5.2	5.3	5.2	5.3	5.3	

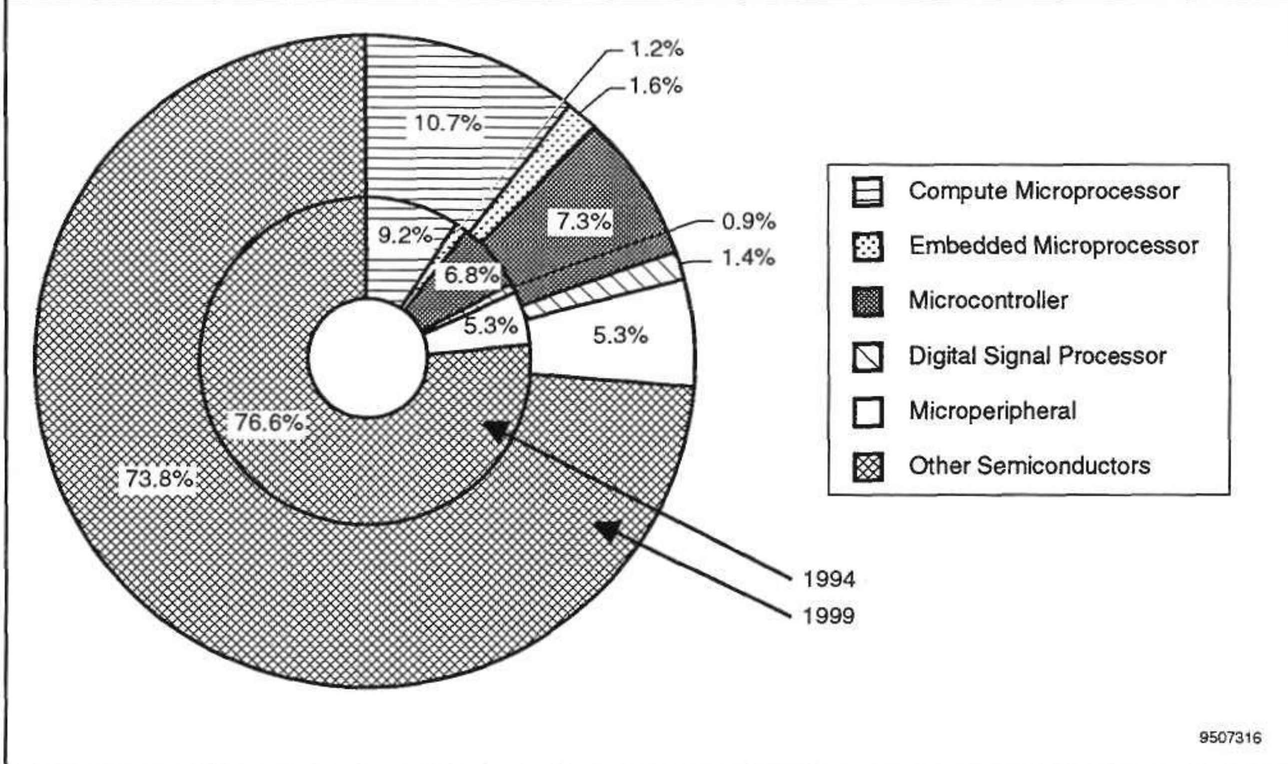
Source: Dataquest (December 1995)

Figure 1-2 shows the different microcomponents as a proportion of all semiconductors. Nearly a quarter of the dollar value of all semiconductors is microcomponents. Computational MPUs make up the largest part, with those lucrative x86 chips being the lion's share. In embedded microcomponents, microcontrollers are the driving force and are expected to remain so. Figure 1-3 illustrates the growth of individual microcomponent product families and microcomponents overall. DSPs and MPUs clearly lead microcomponent growth, but DSPs, coming from a relatively low revenue base of $1 billion, will not contribute as much to overall microcomponents growth.

The growth rate of embedded microcomponents is about equivalent to that of all microcomponents (shown in Figure 1-3), though there will certainly be pockets of applications with extremely high growth rates (wireless communications) and extremely low growth rates (PDAs) within the broad category of embedded microcomponents, just as there may be in computational microprocessors. There are also many opportunities in embedded microcomponents for extremely high-volume applications to appear that are unavailable today. Digital broadcast satellite systems, unheard of four years ago, have grown substantially (although in the early 1980s there were grand forecasts for sub-$500 analog satellite receivers).

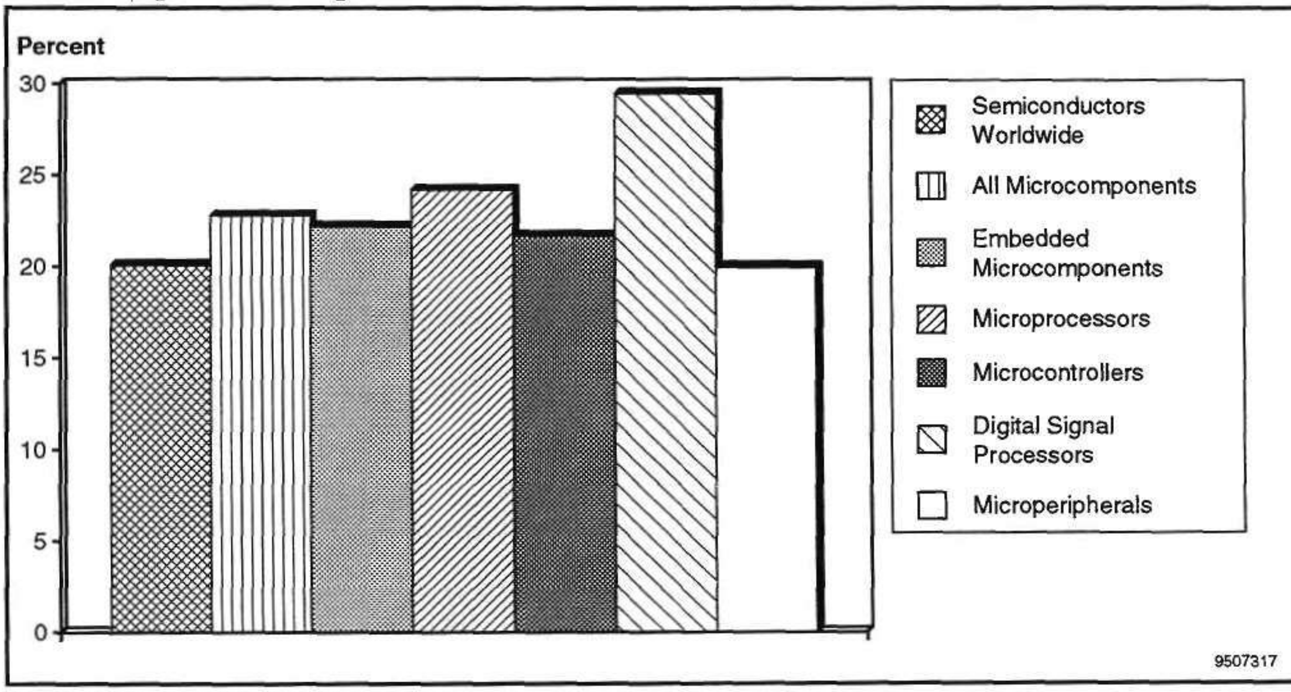
Additional graphs contrasting the product families within microcomponents are found in Chapter 2.

Figure 1-2
Microcomponents as a Portion of All Semiconductors, 1994 and 1999



Source: Dataquest (December 1995)

Figure 1-3
Microcomponent Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

The forecast for microcomponents going into the four regions, North America, Japan, Europe, and Asia/Pacific-Rest of World (ROW), can be found in Table 1-2. North America is the largest microcomponent market and is expected to beat the growth average, following a long-standing trend, as shown in Figure 1-4. Asia/Pacific should have the highest overall growth rate, driven by the trend for OEMs to build their products in lower-cost plants and using lower-cost labor in the Far East, plus expectations for growth in China and some emerging Asian countries. Japan's short-term growth rate is inflated because of the effects of severe currency fluctuations. Overall, Japan will fall a little short but has shown resiliency in the global market in spite of some local softness.

Europe will lag in microcomponent consumption and growth. There are some bright spots in Europe, such as smart cards, the Groupe Speciale Mobile (GSM) digital cellular phone system, and some affordable satellite receivers for broadcast TV. However, the fractured nature of the European market, in spite of the "European Community," continues to hinder market growth. The tremendous variation in cultures, tastes, languages, habits, standards, and regulations may be a fascinating social study, but they make for an evasive market for global economies of scale. Europe's anticipated low growth shows up as a decline in its regional market share over time (refer to Figure 2-3), and it was already in last place.

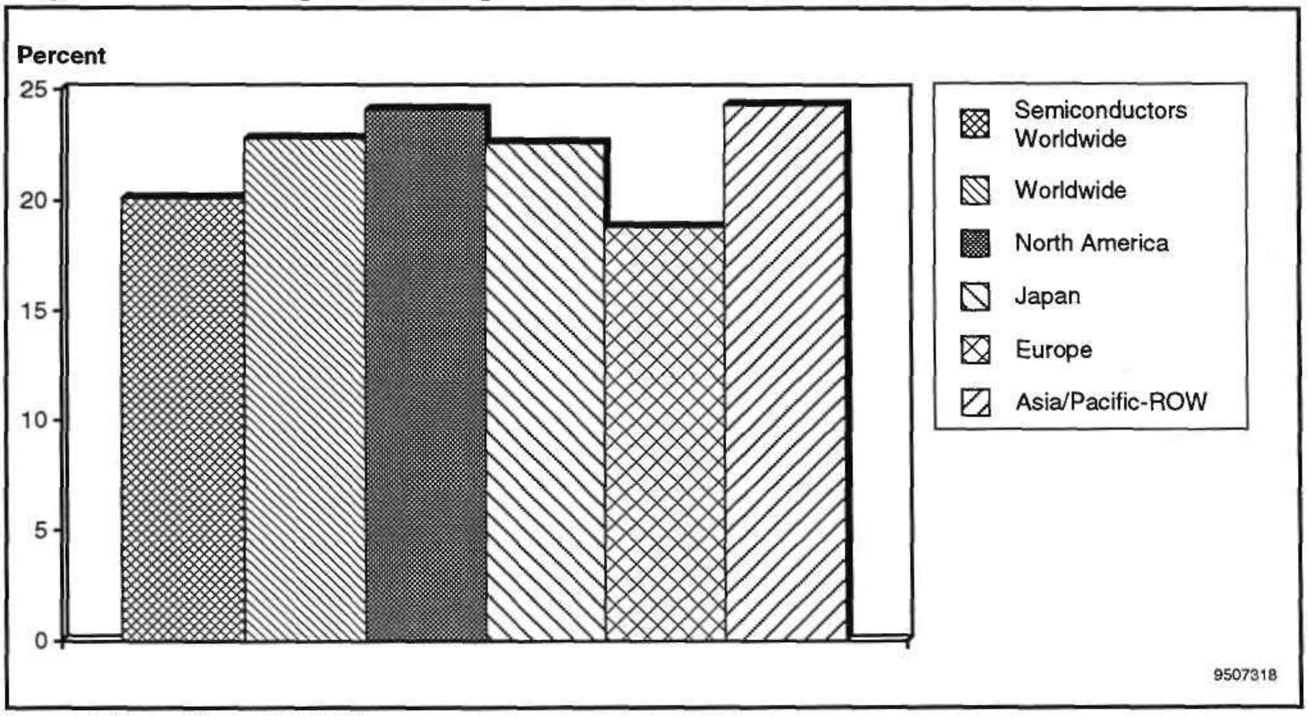
As shown in Figure 1-5, North America consumes almost 5 percent more microcomponents than it does all semiconductors. On the other hand, proportionately, Japan consumes far fewer microcomponents (7 percent) than it does all semiconductors. Indeed, Japan's share of microcomponents is on par with Europe and Asia/Pacific, different from the command that Japan has on semiconductors overall. Additional figures contrasting the regional distribution of microcomponents can be found in Chapter 3.

Table 1-2
Total Microcomponent Revenue Forecast by Region (Millions of Dollars)

	1992	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Total Worldwide Semiconductors	65,261	85,518	110,580	149,788	182,908	210,361	238,599	275,744	
Growth (%)	-	31.0	29.3	35.5	22.1	15.0	13.4	15.6	20.1
Worldwide Microcomponents	14,359	19,947	25,868	34,720	43,945	51,959	61,541	72,285	
Growth (%)	-	38.9	29.7	34.2	26.6	18.2	18.4	17.5	22.8
Percentage of Worldwide Semiconductors	22.0	23.3	23.4	23.2	24.0	24.7	25.8	26.2	
North America	5,282	7,620	9,657	12,880	16,960	20,740	24,650	28,445	
Growth (%)	-	44.3	26.7	33.4	31.7	22.3	18.9	15.4	24.1
Percentage of Worldwide Microcomponents	36.8	38.2	37.3	37.1	38.6	39.9	40.1	39.4	
Percentage of Worldwide Semiconductors	8.1	8.9	8.7	8.6	9.3	9.9	10.3	10.3	
Japan	3,269	3,987	5,439	7,821	9,426	10,963	12,997	15,054	
Growth (%)	-	22.0	36.4	43.8	20.5	16.3	18.6	15.8	22.6
Percentage of Worldwide Microcomponents	22.8	20.0	21.0	22.5	21.4	21.1	21.1	20.8	
Percentage of Worldwide Semiconductors	5.0	4.7	4.9	5.2	5.2	5.2	5.4	5.5	
Europe	2,723	4,037	5,309	6,902	8,529	9,559	10,837	12,550	
Growth (%)	-	48.3	31.5	30.0	23.6	12.1	13.4	15.8	18.8
Percentage of Worldwide Microcomponents	19.0	20.2	20.5	19.9	19.4	18.4	17.6	17.4	
Percentage of Worldwide Semiconductors	4.2	4.7	4.8	4.6	4.7	4.5	4.5	4.6	
Asia/Pacific-ROW	3,085	4,303	5,463	7,117	9,030	10,697	13,057	16,236	
Growth (%)	-	39.5	27.0	30.3	26.9	18.5	22.1	24.3	24.3
Percentage of Worldwide Microcomponents	21.5	21.6	21.1	20.5	20.5	20.6	21.2	22.5	
Percentage of Worldwide Semiconductors	4.7	5.0	4.9	4.8	4.9	5.1	5.5	5.9	

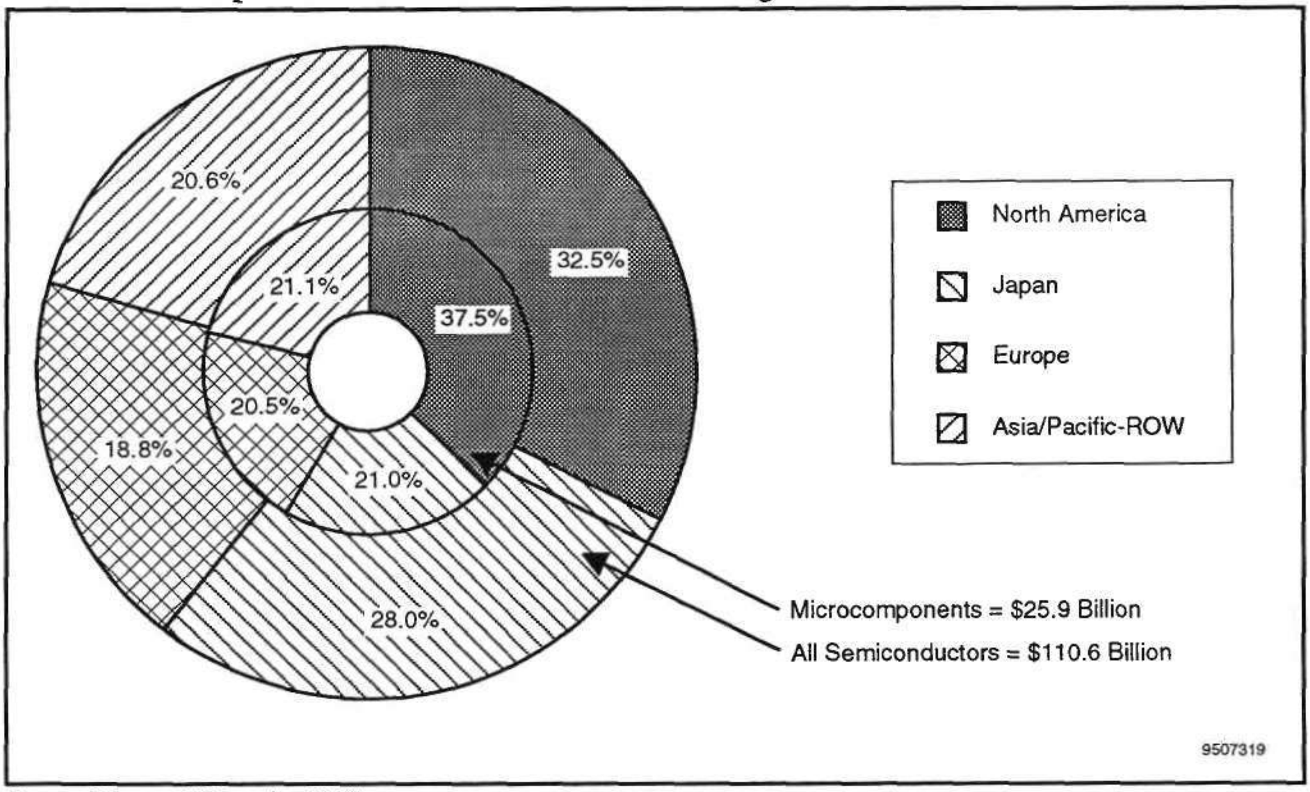
Source: Dataquest (December 1995)

Figure 1-4
Regional Microcomponent Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Figure 1-5
1994 Microcomponent and Total Semiconductor Regional Distribution



Source: Dataquest (December 1995)

Further division of revenue of microprocessors, microcontrollers, digital signal processors, and microperipherals for North America, Japan, Europe, and Asia/Pacific-ROW are forecast in later chapters of this document.

The Biggest Vendors

As shown in Table 1-3 and Figure 1-6, Intel is far and away the No. 1 vendor of microcomponents. This is because of Intel's lead in microprocessors and the fact that its 8086 architecture continues to rule the PC industry. Intel, with a handful of carefully crafted products, makes sure that its x86s are far enough ahead of any competition to command nearly $1 of every $12 spent on all semiconductors. Figure 1-7, which shows the split of MPUs, MCUs, DSPs, and microperipherals that each company produces, reveals Intel's keen focus on the PC market. Intel's position shifts to No. 3 when only the embedded portion of the microcomponent market is considered, as seen in Figure 1-8. When the computational portion of the x86 family is removed from the Intel numbers, a more normal ratio between the families is seen (see Figure 1-9). Intel is also in the business of microperipherals and is expected to increase this as it expands further into PC logic circuits. However, Intel has no components it sells as DSPs, except for the famous but poorly named native signal processing (NSP). NSP embodies the concept of using an otherwise-idle Pentium to perform signal processing.

Table 1-3
Top Five Microcomponent Vendors' Market Share, 1994
(Millions of Dollars and Percentage)

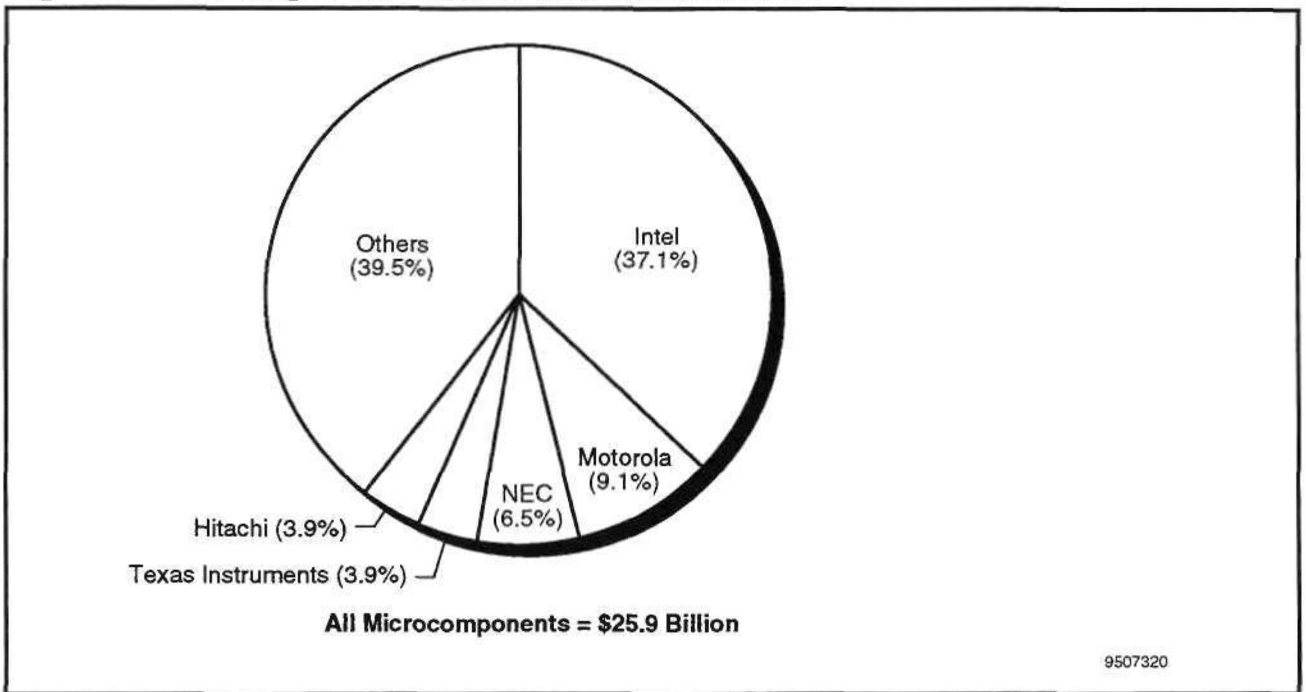
	Millions of Dollars	Percentage
Intel	9,595	37.1
Motorola	2,363	9.1
NEC	1,678	6.5
Texas Instruments	1,006	3.9
Hitachi	998	3.9
All Others	10,228	39.5
All Microcomponents	25,868	100.0

Source: Dataquest (December 1995)

Motorola produces the second-largest quantity of microcomponents in the industry. While its 68000 family is changing over to the PowerPC products of Motorola and IBM as the MPU in Apple's Macintoshes, in the embedded world Motorola holds the No. 1 position. Motorola's position is largely because of its dominance in microcontrollers (18.9 percent). However, the 68000 is generally considered to be the standard in embedded processors. (Perception may reign over reality here—the 68000 family has been essentially dedicated to embedded processing for the last several years, and the x86 is largely considered a PC processor.) Motorola also has a strong position in DSPs, as well as having some peripheral circuits.

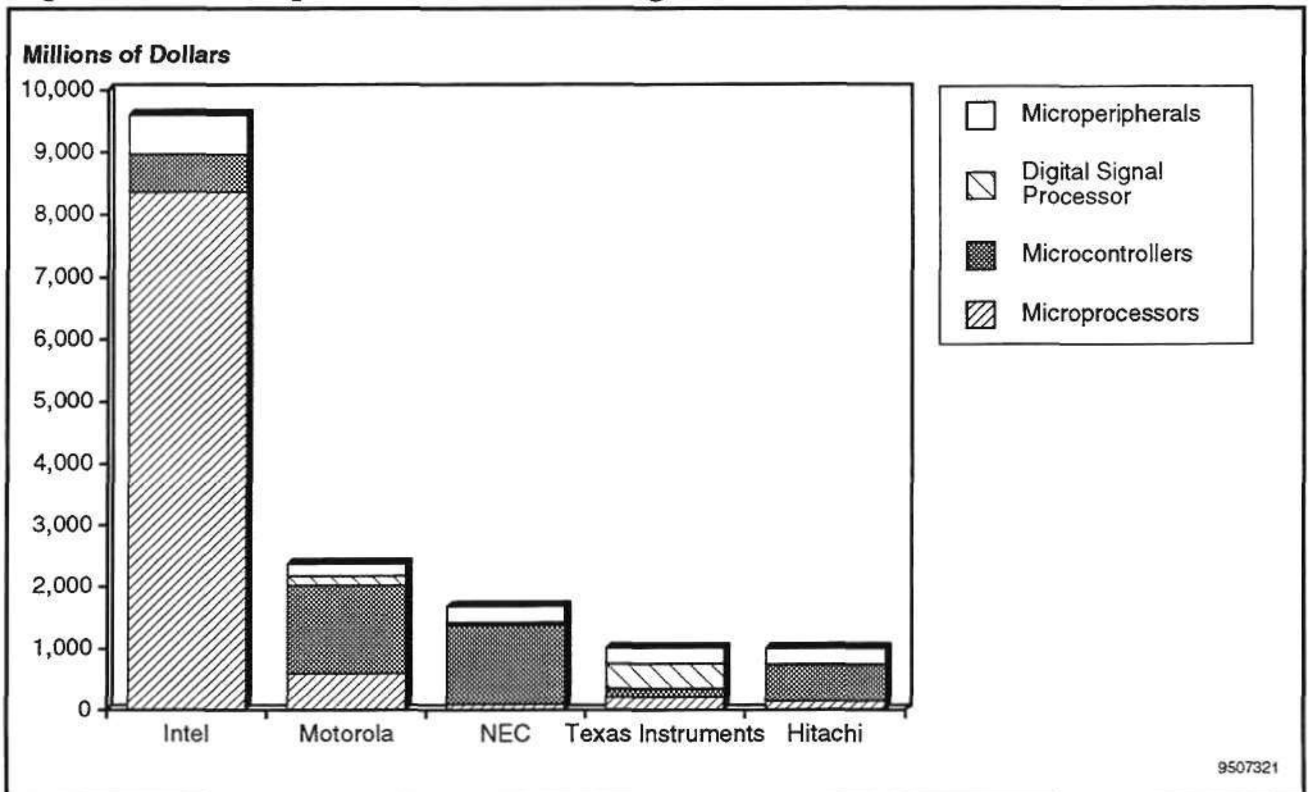
NEC and Hitachi have strengths in microcontrollers with some microprocessor offerings and reasonable microperipherals products. Hitachi's SH

Figure 1-6
Top Five Microcomponent Vendors' Market Share, 1994



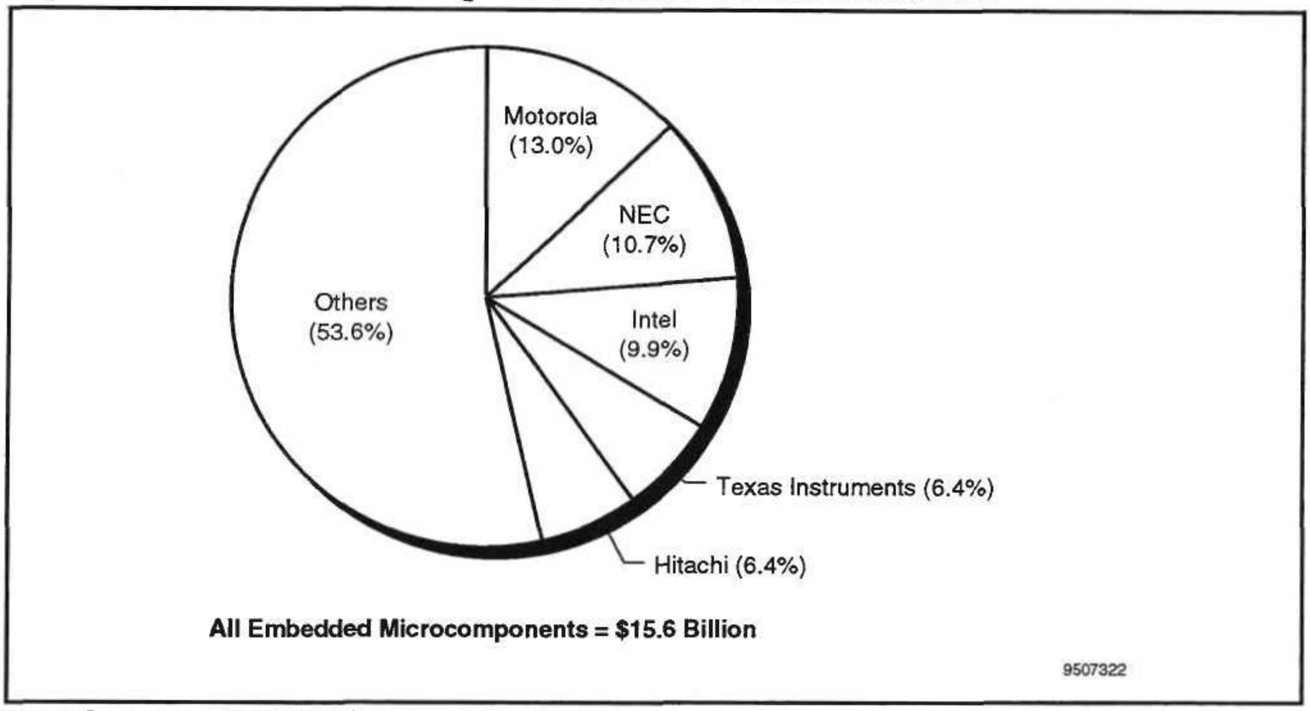
Source: Dataquest (December 1995)

Figure 1-7
Top Five Microcomponent Vendors Showing Product Families, 1994



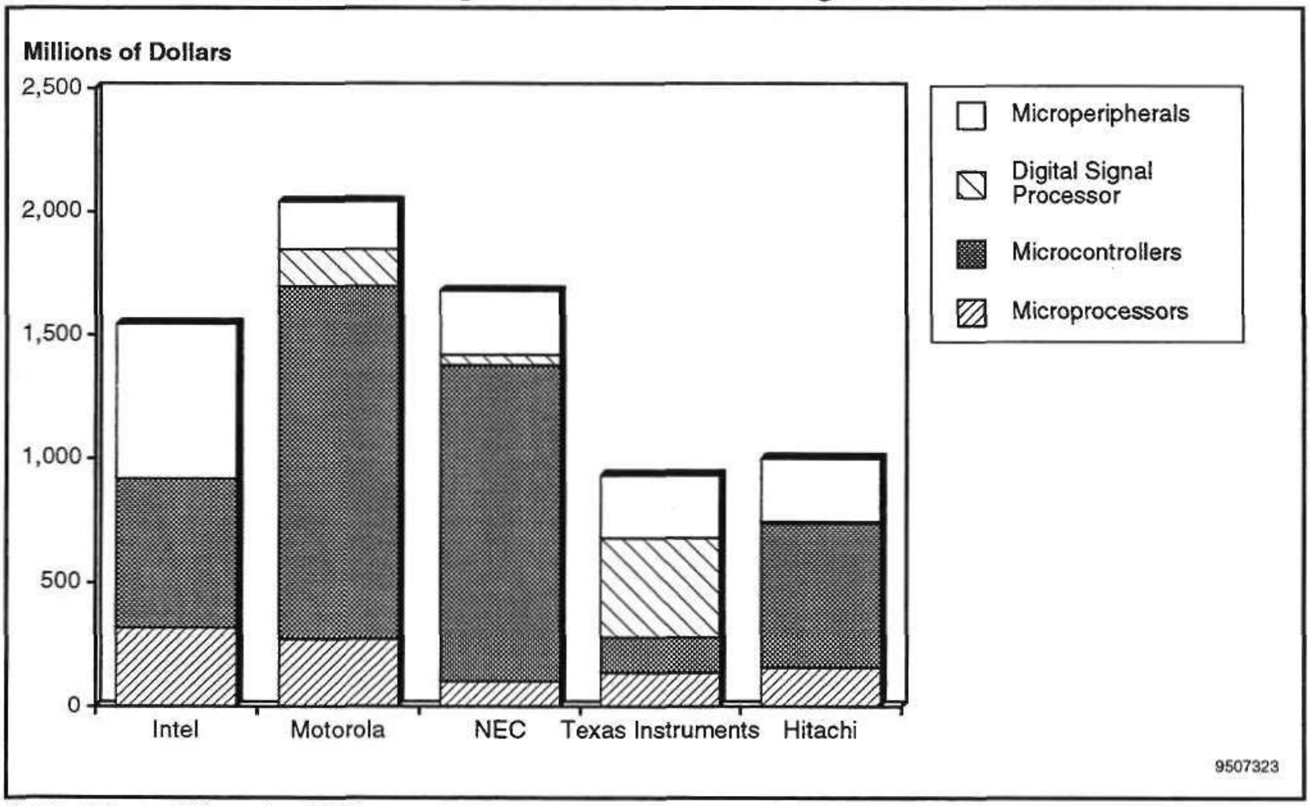
Source: Dataquest (December 1995)

Figure 1-8
Top Five Embedded Microcomponent Vendors' Market Share, 1994



Source: Dataquest (December 1995)

Figure 1-9
Top Five Embedded Microcomponent Vendors Showing Product Families, 1994



Source: Dataquest (December 1995)

processors grew in 1995, driven by a single design-win in a very high-volume product: the Sega Saturn video game. Texas Instruments (TI) is an anomaly in that its strength is in digital signal processing. Indeed, TI is No. 1 in DSP and shows no signs of relinquishing that position. However, TI's MCUs appear only in a few automotive applications, and it has struggled with an identity crisis in the MPU arena for two decades. The next 10 years, however, could be the decade of the DSP, so TI's diligence there could pay off handsomely.

Chapter 2
A Closer Look at Microcomponents by Product Family

In this chapter, the forecast for microcomponents is broken into microprocessors, microcontrollers, digital signal processors, and microperipherals, showing distribution into North America, Japan, Europe, and Asia/Pacific-ROW. A section is dedicated to each product family: all microcomponents, microprocessors, microcontrollers, digital signal processors, and microperipherals. Within each section, the revenue forecast for the product family is given in tables and related figures contrasting North America, Japan, Europe, and Asia/Pacific-ROW.

Microcomponents

The forecast of all microcomponent revenue (see Table 2-1) shows how microcomponents are expected to ship into each of the four geographic regions for the next five years (Table 2-1 is a subset of Table 1-2). Percentages are given for each region's microcomponent revenue as a portion of the worldwide revenue for all microcomponents and total semiconductors.

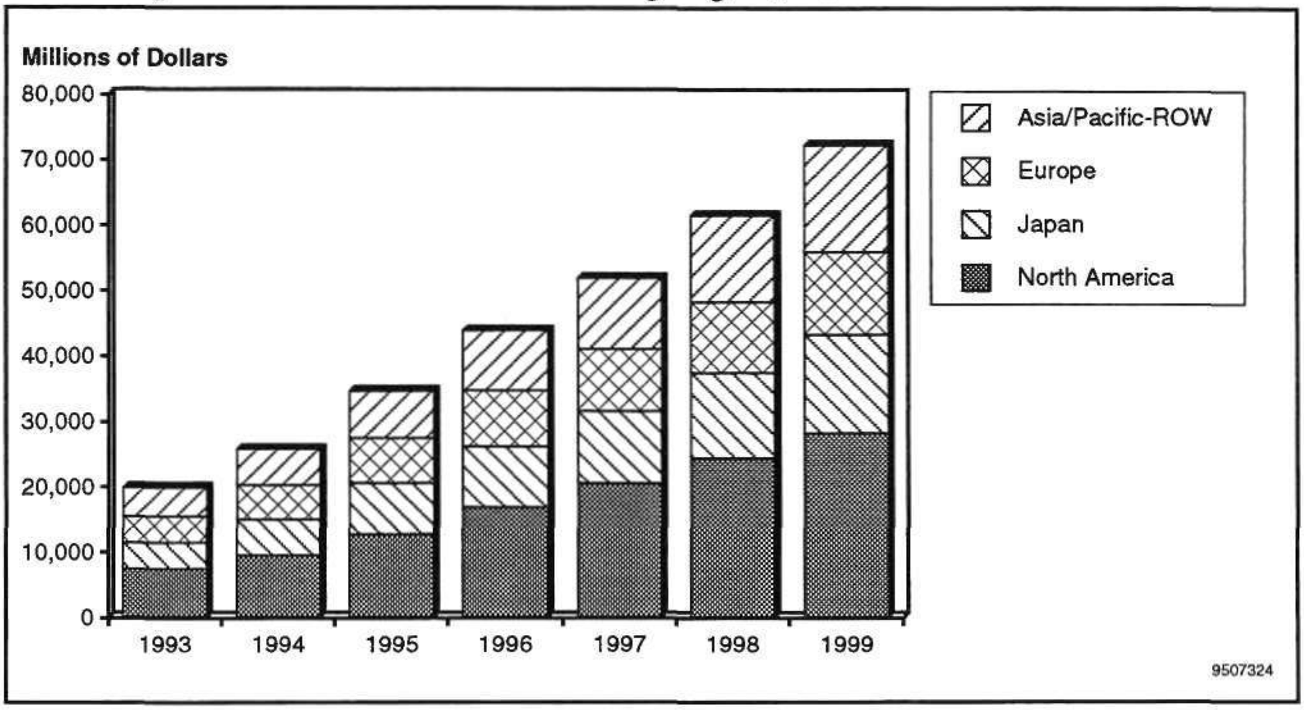
Figure 2-1 shows each region's microcomponent revenue as a portion of worldwide microcomponent revenue. Figure 2-2 illustrates each region's microcomponent revenue. Figure 2-3 shows the change expected in the distribution of microcomponent revenue among the regions in 1994 and in 1999. Figure 2-4 compares the CAGR of microcomponent revenue for each region.

Table 2-1
Microcomponent Revenue Forecast by Region (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Worldwide	19,947	25,868	34,720	43,945	51,959	61,541	72,285	
Growth (%)	-	29.7	34.2	26.6	18.2	18.4	17.5	22.8
Percentage of Worldwide Semiconductors	23.3	23.4	23.2	24.0	24.7	25.8	26.2	
North America	7,620	9,657	12,880	16,960	20,740	24,650	28,445	
Growth (%)	-	26.7	33.4	31.7	22.3	18.9	15.4	24.1
Percentage of Worldwide Microcomponents	38.2	37.3	37.1	38.6	39.9	40.1	39.4	
Percentage of Worldwide Semiconductors	8.9	8.7	8.6	9.3	9.9	10.3	10.3	
Japan	3,987	5,439	7,821	9,426	10,963	12,997	15,054	
Growth (%)	-	36.4	43.8	20.5	16.3	18.6	15.8	22.6
Percentage of Worldwide Microcomponents	20.0	21.0	22.5	21.4	21.1	21.1	20.8	
Percentage of Worldwide Semiconductors	4.7	4.9	5.2	5.2	5.2	5.4	5.5	
Europe	4,037	5,309	6,902	8,529	9,559	10,837	12,550	
Growth (%)	-	31.5	30.0	23.6	12.1	13.4	15.8	18.8
Percentage of Worldwide Microcomponents	20.2	20.5	19.9	19.4	18.4	17.6	17.4	
Percentage of Worldwide Semiconductors	4.7	4.8	4.6	4.7	4.5	4.5	4.6	
Asia/Pacific-ROW	4,303	5,463	7,117	9,030	10,697	13,057	16,236	
Growth (%)	-	27.0	30.3	26.9	18.5	22.1	24.3	24.3
Percentage of Worldwide Microcomponents	21.6	21.1	20.5	20.5	20.6	21.2	22.5	
Percentage of Worldwide Semiconductors	5.0	4.9	4.8	4.9	5.1	5.5	5.9	

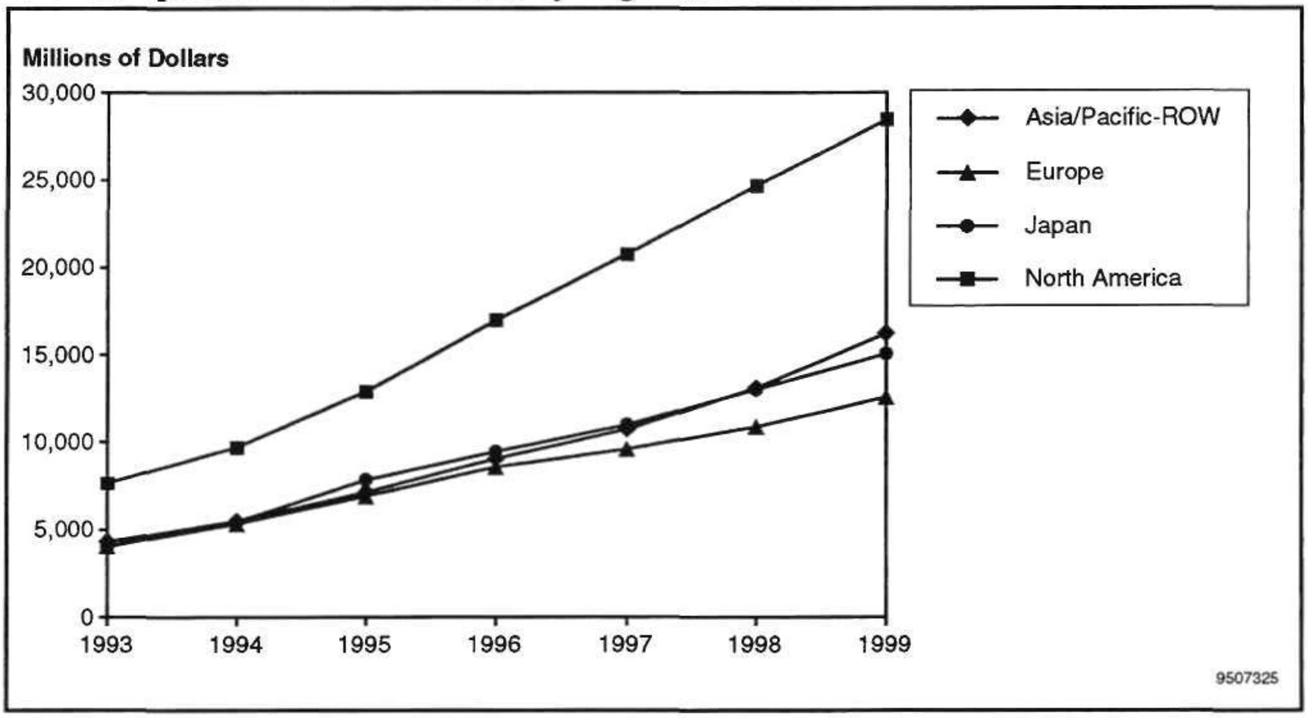
Source: Dataquest (December 1995)

Figure 2-1
Microcomponent Revenue Forecast Showing Region, 1993-1999



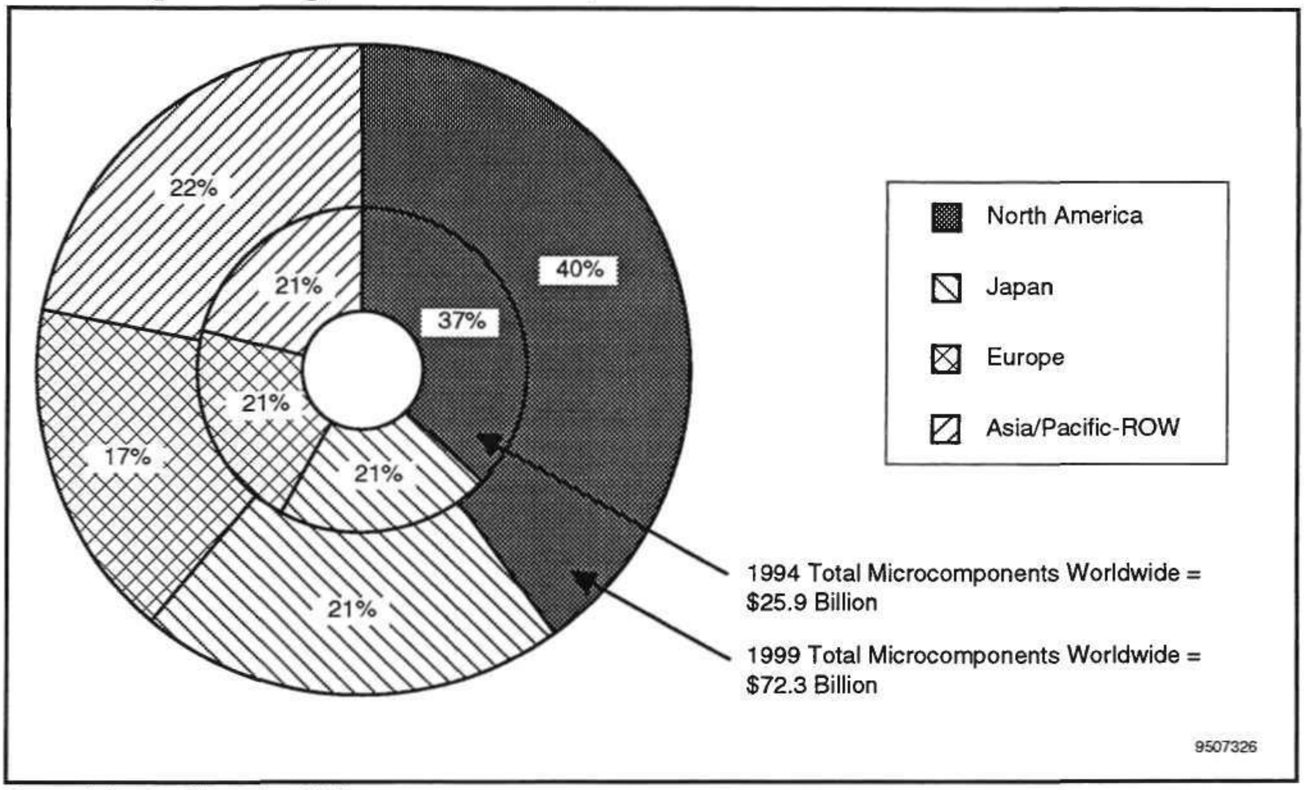
Source: Dataquest (December 1995)

Figure 2-2
Microcomponent Revenue Forecast by Region, 1993-1999



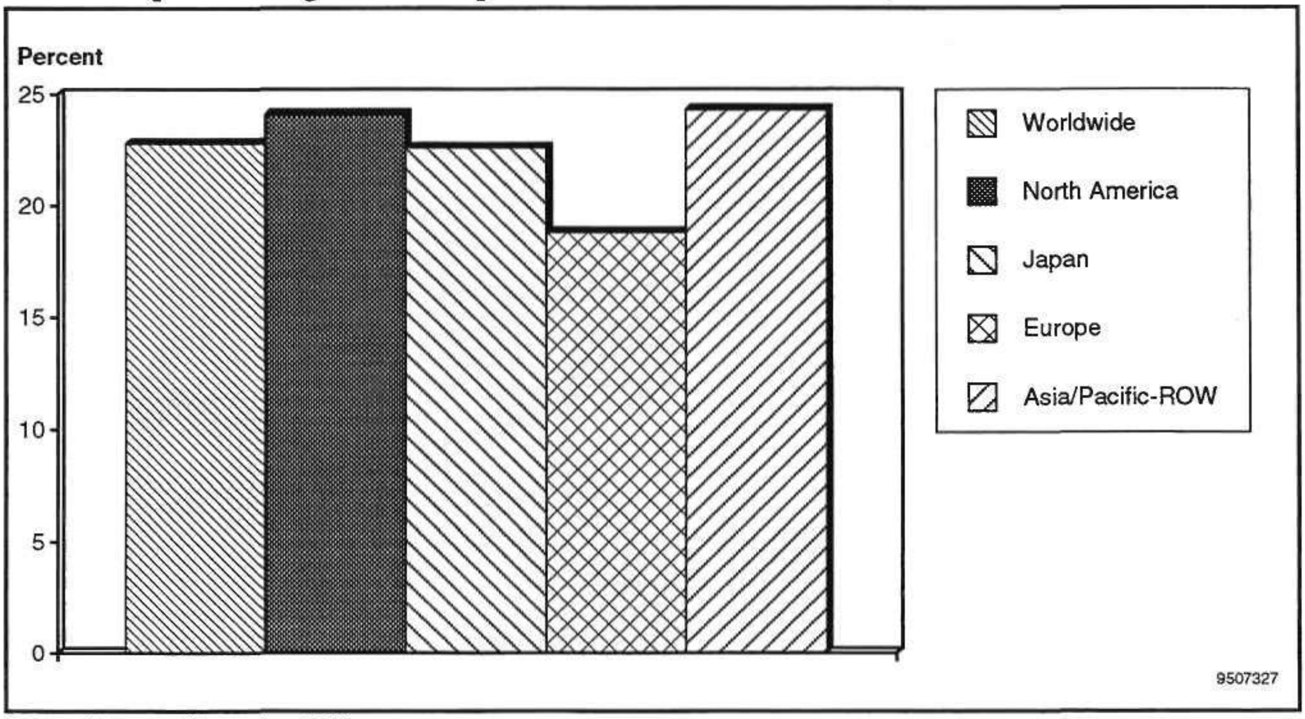
Source: Dataquest (December 1995)

Figure 2-3
Microcomponent Regional Distribution, 1994 and 1999



Source: Dataquest (December 1995)

Figure 2-4
Microcomponent Regional Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Microprocessors

The forecast of all microprocessor revenue is shown in Table 2-2 as microprocessors are expected to ship into each of the four geographic regions for the next five years. Percentages are given for each region's microprocessor revenue as a portion of worldwide revenue for microprocessors, all microcomponents, and total semiconductors. All figures are for microprocessors destined for both computational and embedded systems, RISC or CISC.

Figure 2-5 shows each region's microprocessor revenue as a portion of worldwide microprocessor revenue. Figure 2-6 illustrates each region's microprocessor revenue. Figure 2-7 depicts the change expected in the distribution of microprocessor revenue among the regions in 1994 and in 1999. Figure 2-8 compares the compound annual growth rate of microprocessor revenue for each region.

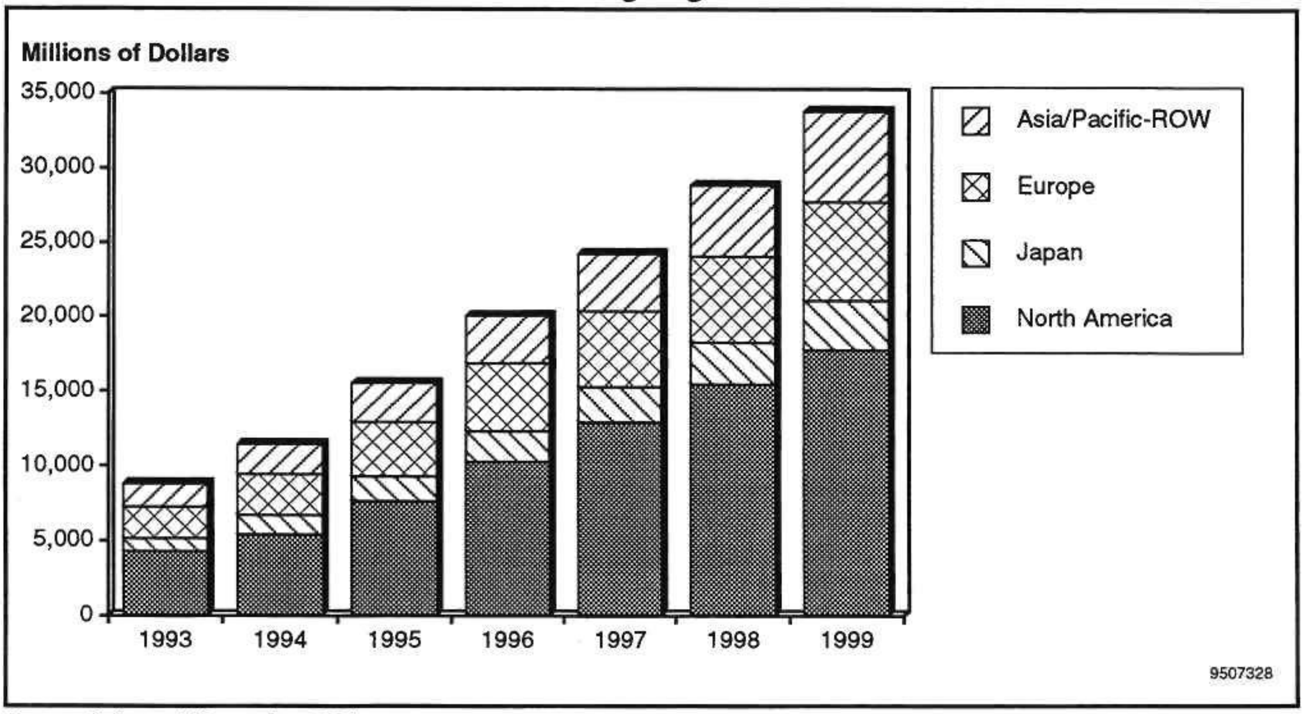
Greater detail of the microprocessor forecast is available in Dataquest's document *Microprocessor Forecast and Assumptions: June 1995* (MCRO-WW-MT-9502). It presents forecasts for RISC and CISC and for 8-bit, 16-bit, and 32-bit MPUs, as well as compute and embedded applications. The x86 family is further dissected.

Table 2-2
Microprocessor Revenue Forecast by Region (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Worldwide	8,783	11,436	15,514	20,055	24,225	28,819	33,811	
Growth (%)	-	30.2	35.7	29.3	20.8	19.0	17.3	24.2
Percentage of Worldwide Microcomponents	44.0	44.2	44.7	45.6	46.6	46.8	46.8	
Percentage of Worldwide Semiconductors	10.3	10.3	10.4	11.0	11.5	12.1	12.3	
North America	4,323	5,446	7,645	10,300	12,950	15,470	17,800	
Growth (%)	-	26.0	40.4	34.7	25.7	19.5	15.1	26.7
Percentage of Worldwide Microprocessors	49.2	47.6	49.3	51.4	53.5	53.7	52.6	
Percentage of Worldwide Microcomponents	21.7	21.1	22.0	23.4	24.9	25.1	24.6	
Percentage of Worldwide Semiconductors	5.1	4.9	5.1	5.6	6.2	6.5	6.5	
Japan	835	1,247	1,684	2,057	2,373	2,825	3,334	
Growth (%)	-	49.3	35.0	22.1	15.4	19.0	18.0	21.7
Percentage of Worldwide Microprocessors	9.5	10.9	10.9	10.3	9.8	9.8	9.9	
Percentage of Worldwide Microcomponents	4.2	4.8	4.9	4.7	4.6	4.6	4.6	
Percentage of Worldwide Semiconductors	1.0	1.1	1.1	1.1	1.1	1.2	1.2	
Europe	2,098	2,774	3,631	4,523	5,091	5,767	6,645	
Growth (%)	-	32.2	30.9	24.6	12.6	13.3	15.2	19.1
Percentage of Worldwide Microprocessors	23.9	24.3	23.4	22.6	21.0	20.0	19.7	
Percentage of Worldwide Microcomponents	10.5	10.7	10.5	10.3	9.8	9.4	9.2	
Percentage of Worldwide Semiconductors	2.5	2.5	2.4	2.5	2.4	2.4	2.4	
Asia/Pacific-ROW	1,527	1,969	2,554	3,175	3,811	4,757	6,032	
Growth (%)	-	28.9	29.7	24.3	20.0	24.8	26.8	25.1
Percentage of Worldwide Microprocessors	17.4	17.2	16.5	15.8	15.7	16.5	17.8	
Percentage of Worldwide Microcomponents	7.7	7.6	7.4	7.2	7.3	7.7	8.3	
Percentage of Worldwide Semiconductors	1.8	1.8	1.7	1.7	1.8	2.0	2.2	

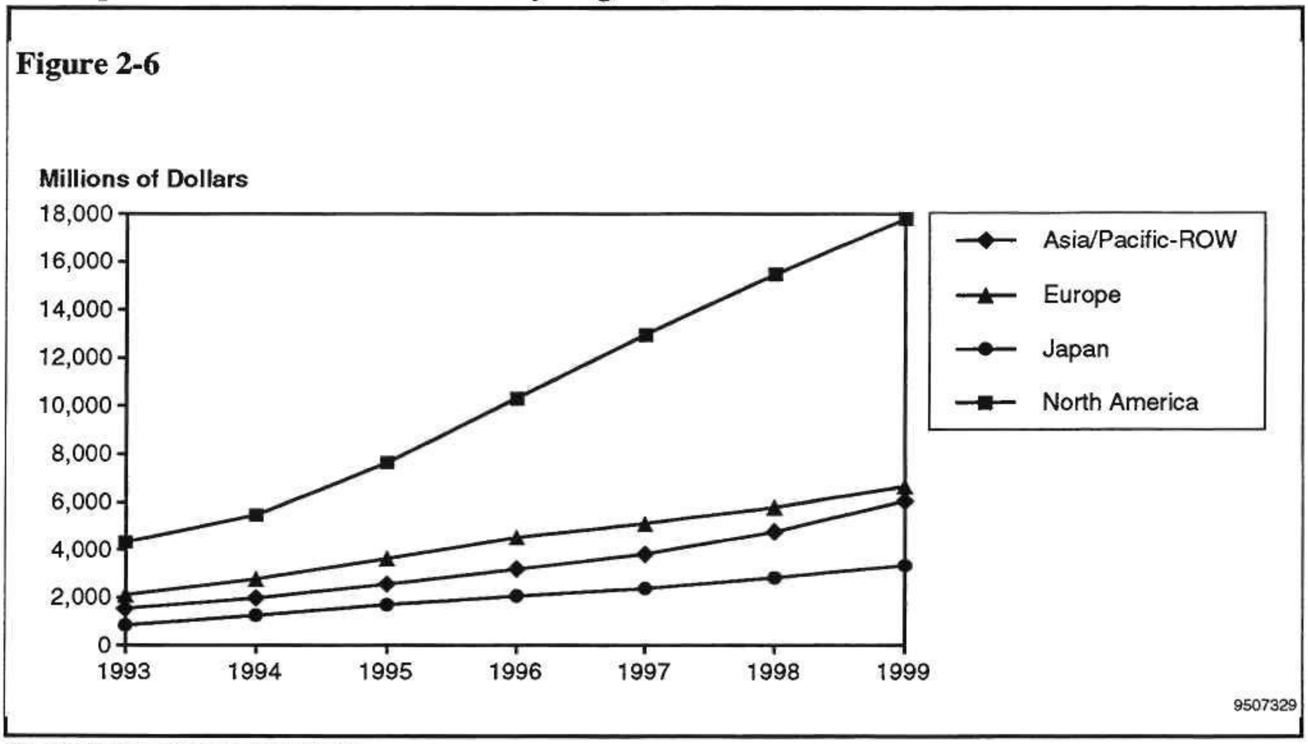
Source: Dataquest (December 1995)

Figure 2-5
Microprocessor Revenue Forecast Showing Region, 1993-1999



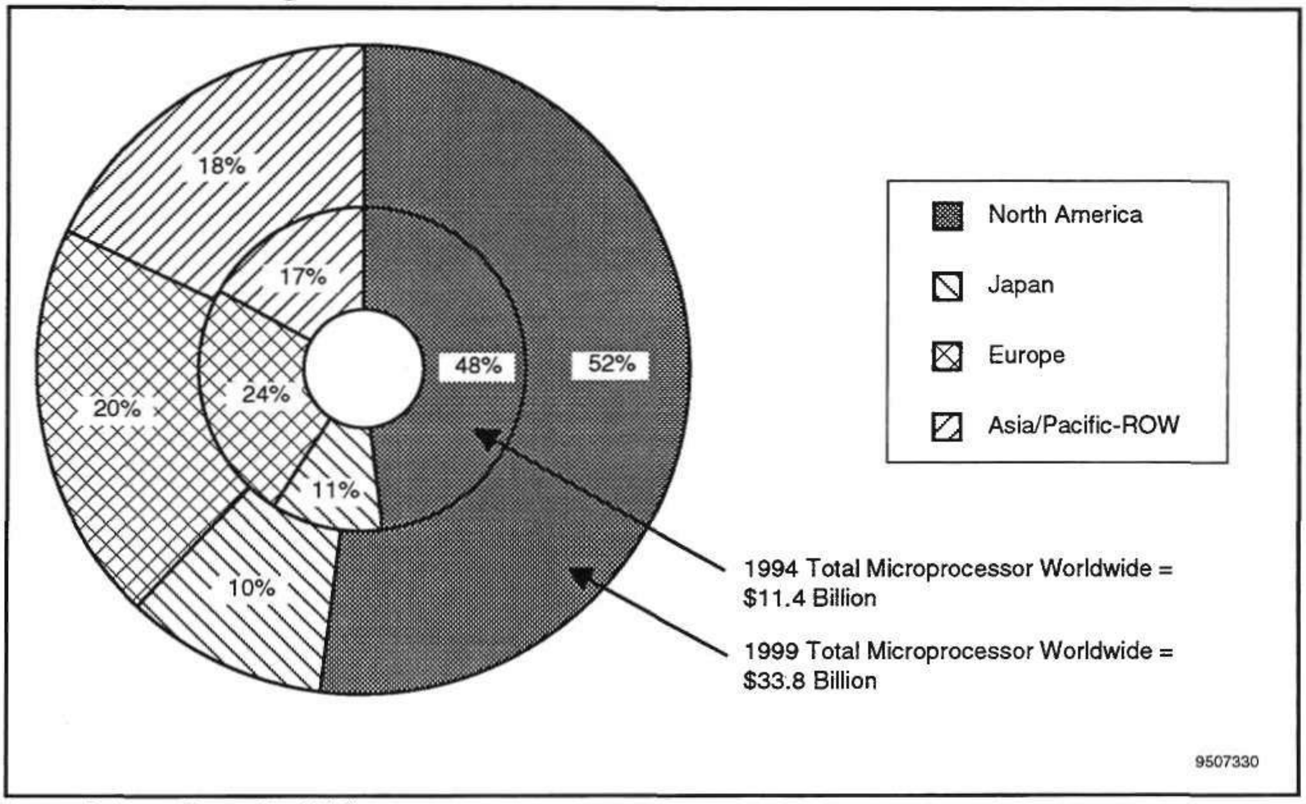
Source: Dataquest (December 1995)

Figure 2-6
Microprocessor Revenue Forecast by Region, 1993-1999



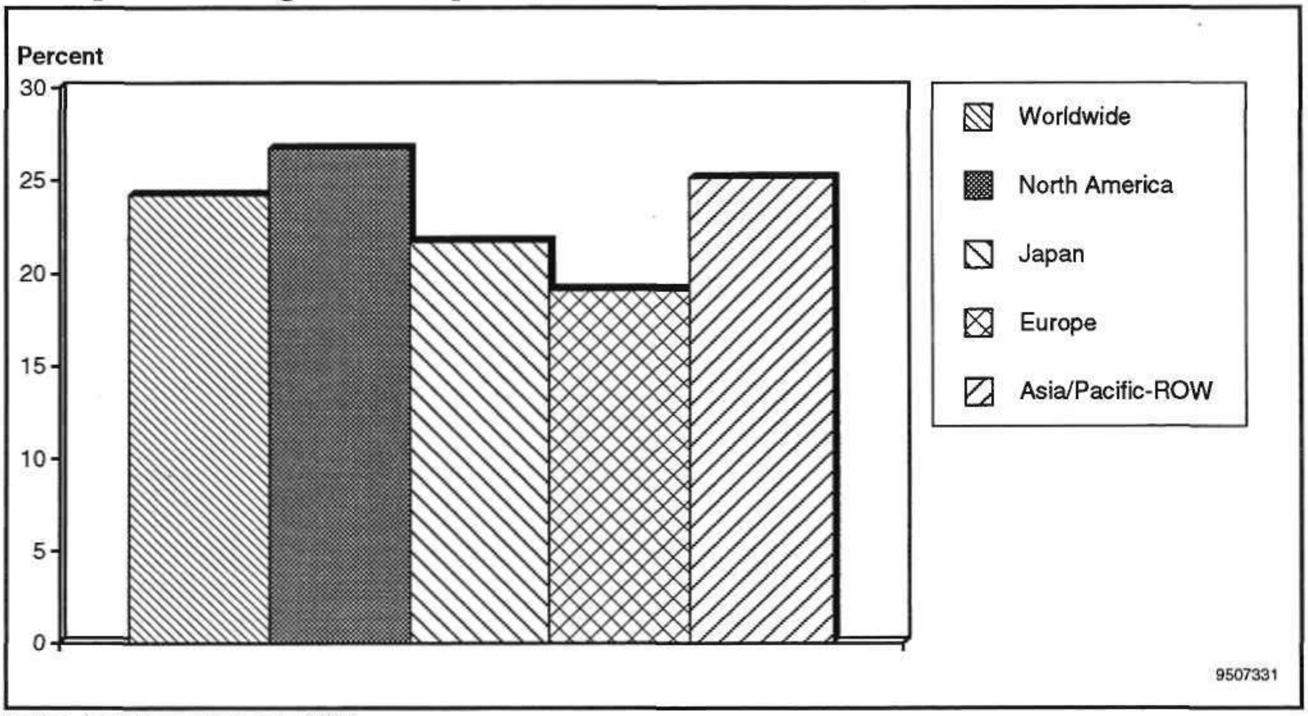
Source: Dataquest (December 1995)

Figure 2-7
Microprocessor Regional Distribution, 1994 and 1999



Source: Dataquest (December 1995)

Figure 2-8
Microprocessor Regional Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Microcontrollers

The forecast for all microcontroller revenue (see Table 2-3) shows how microcontrollers are expected to ship into each of the four geographic regions for the next five years. Percentages are given for each region's microcontroller revenue as a portion of worldwide revenue for microcontrollers, all microcomponents, and total semiconductors.

Figure 2-9 shows each region's microcontroller revenue as a portion of worldwide microcontroller revenue. Figure 2-10 shows each region's microcontroller revenue. Figure 2-11 depicts the change expected in the distribution of microcontroller revenue among the regions in 1994 and in 1999. Figure 2-12 compares the CAGR of microcontroller revenue for each region.

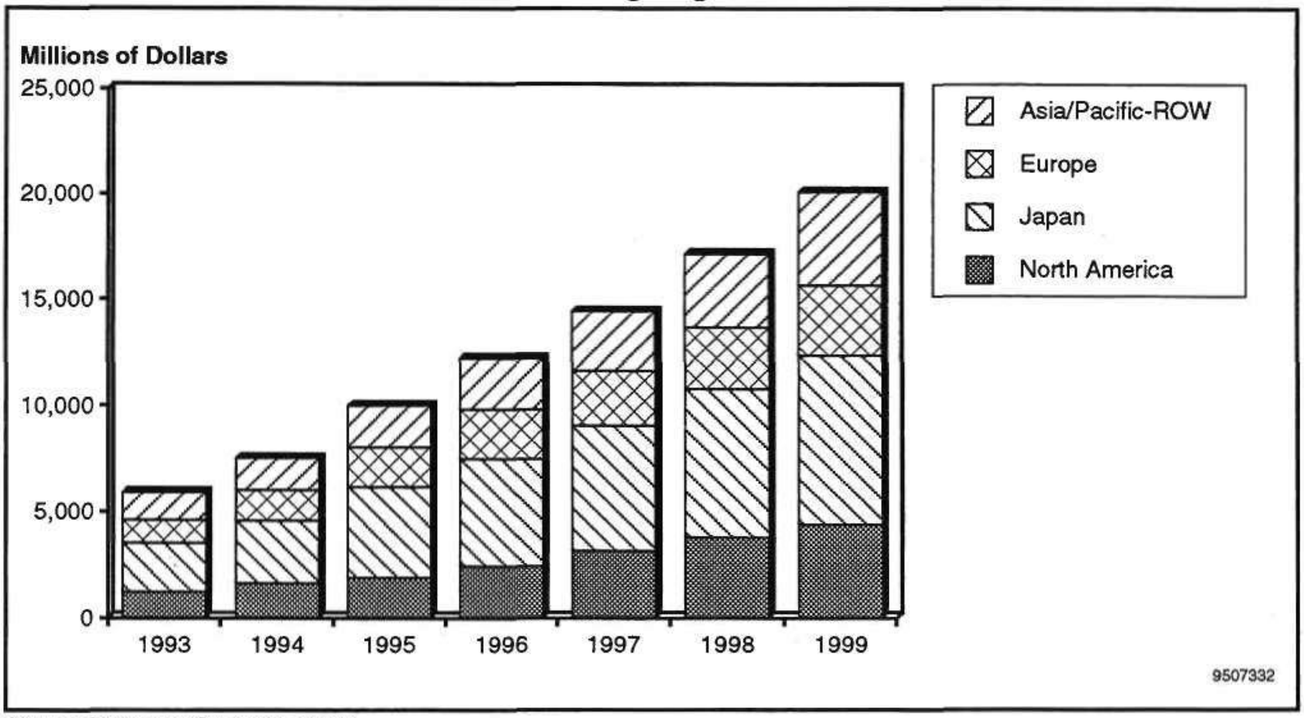
Greater detail on the microcontroller forecast is available in Dataquest's document *The Microcontrollers March On—The Forecast* (MCRO-WW-MT-9503). It gives forecasts for 4-bit, 8-bit, and 16-bit and greater MCUs forecasts, as well as for MCUs in data processing, communications, industrial, consumer, civil aerospace, and transportation applications.

Table 2-3
Microcontroller Revenue Forecast by Region (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Worldwide	5,904	7,517	10,005	12,209	14,430	17,157	20,099	
Growth (%)	-	27.3	33.1	22.0	18.2	18.9	17.1	21.7
Percentage of Worldwide Microcomponents	29.6	29.1	28.8	27.8	27.8	27.9	27.8	
Percentage of Worldwide Semiconductors	6.9	6.8	6.7	6.7	6.9	7.2	7.3	
North America	1,254	1,652	1,910	2,450	3,175	3,825	4,425	
Growth (%)	-	31.7	15.6	28.3	29.6	20.5	15.7	21.8
Percentage of Worldwide Microcontrollers	21.2	22.0	19.1	20.1	22.0	22.3	22.0	
Percentage of Worldwide Microcomponents	6.3	6.4	5.5	5.6	6.1	6.2	6.1	
Percentage of Worldwide Semiconductors	1.5	1.5	1.3	1.3	1.5	1.6	1.6	
Japan	2,284	2,964	4,283	5,075	5,911	6,985	7,968	
Growth (%)	-	29.8	44.5	18.5	16.5	18.2	14.1	21.9
Percentage of Worldwide Microcontrollers	38.7	39.4	42.8	41.6	41.0	40.7	39.6	
Percentage of Worldwide Microcomponents	11.5	11.5	12.3	11.5	11.4	11.4	11.0	
Percentage of Worldwide Semiconductors	2.7	2.7	2.9	2.8	2.8	2.9	2.9	
Europe	1,106	1,432	1,888	2,334	2,574	2,890	3,322	
Growth (%)	-	29.5	31.8	23.6	10.3	12.3	14.9	18.3
Percentage of Worldwide Microcontrollers	18.7	19.1	18.9	19.1	17.8	16.8	16.5	
Percentage of Worldwide Microcomponents	5.5	5.5	5.4	5.3	5.0	4.7	4.6	
Percentage of Worldwide Semiconductors	1.3	1.3	1.3	1.3	1.2	1.2	1.2	
Asia/Pacific-ROW	1,260	1,469	1,924	2,350	2,770	3,457	4,384	
Growth (%)	-	16.6	31.0	22.1	17.9	24.8	26.8	24.4
Percentage of Worldwide Microcontrollers	21.3	19.5	19.2	19.2	19.2	20.1	21.8	
Percentage of Worldwide Microcomponents	6.3	5.7	5.5	5.3	5.3	5.6	6.1	
Percentage of Worldwide Semiconductors	1.5	1.3	1.3	1.3	1.3	1.4	1.6	

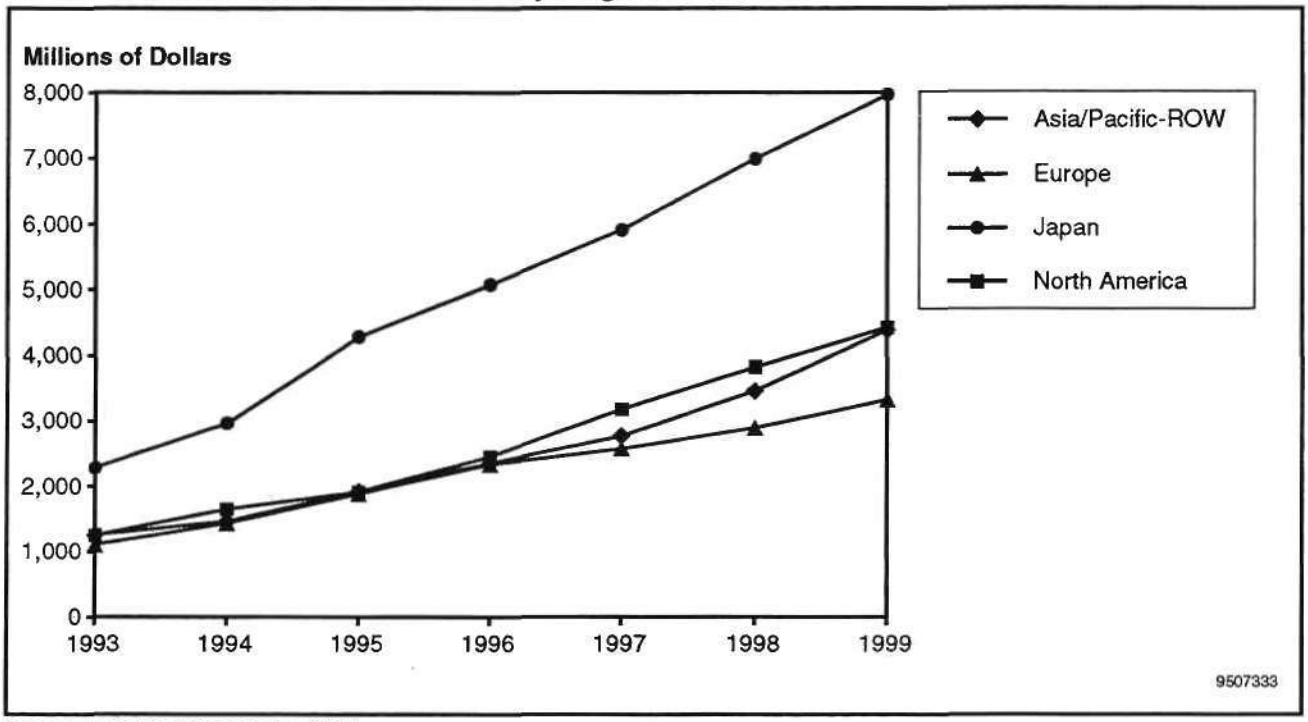
Source: Dataquest (December 1995)

Figure 2-9
Microcontroller Revenue Forecast Showing Region, 1993-1999



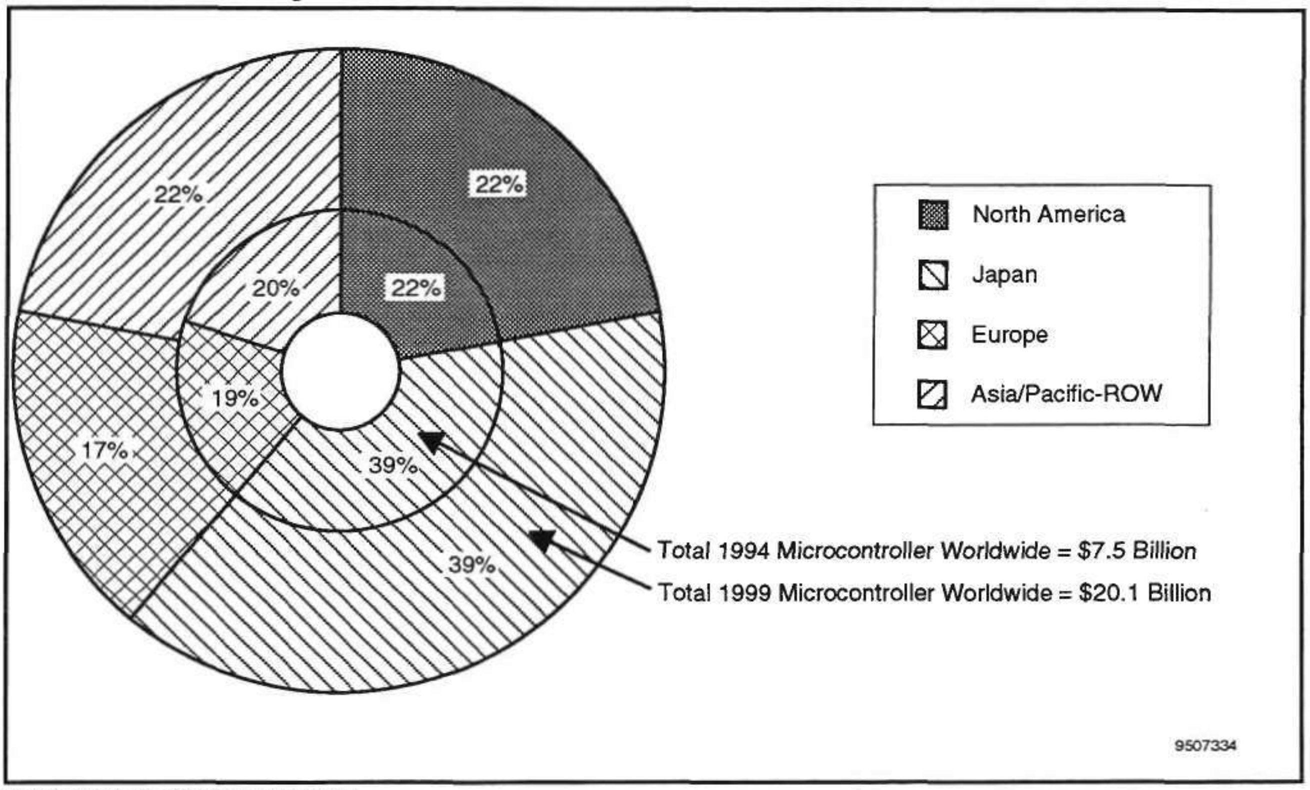
Source: Dataquest (December 1995)

Figure 2-10
Microcontroller Revenue Forecast by Region, 1993-1999



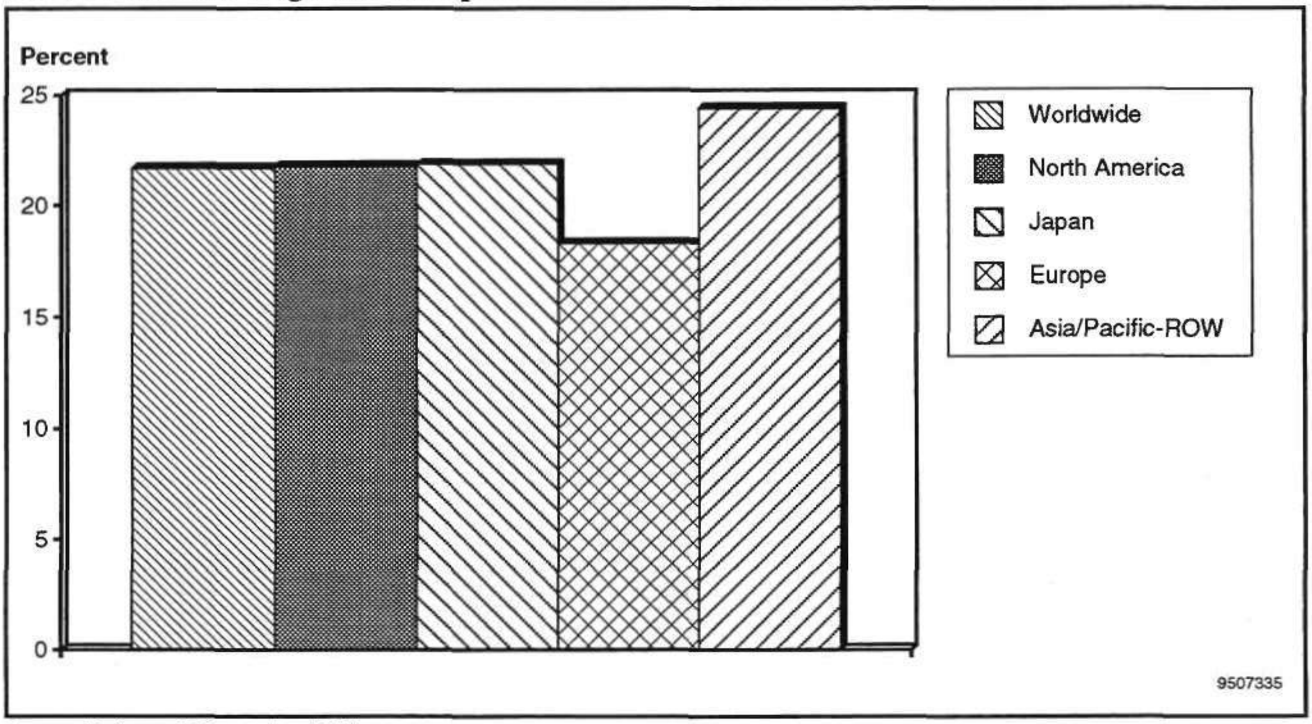
Source: Dataquest (December 1995)

Figure 2-11
Microcontroller Regional Distribution, 1994 and 1999



Source: Dataquest (December 1995)

Figure 2-12
Microcontroller Regional Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Digital Signal Processors

The forecast of all programmable DSP revenue (see Table 2-4) shows how DSPs are expected to ship into each of the four geographic regions for the next five years. Percentages are given for each region's DSP revenue as a portion of the worldwide revenue for DSPs, all microcomponents, and total semiconductors.

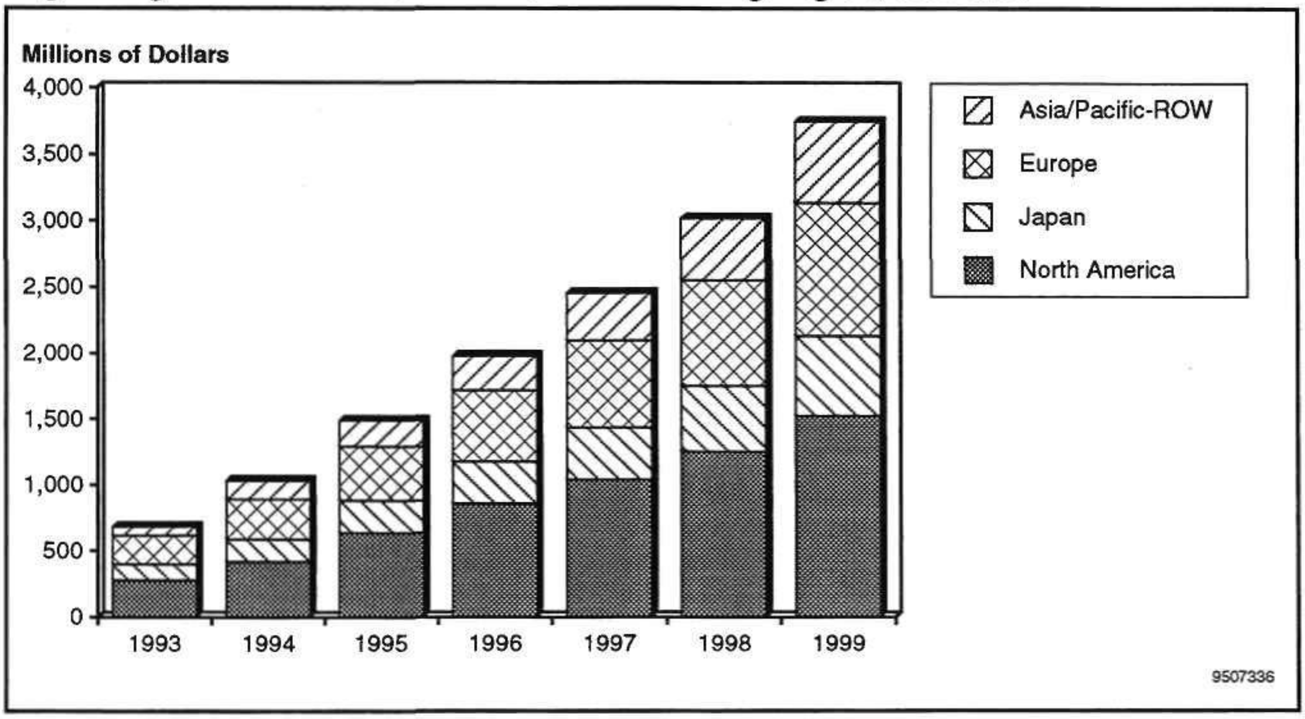
Figure 2-13 shows each region's programmable DSP revenue as a portion of worldwide DSP revenue. Figure 2-14 shows each region's DSP revenue. Figure 2-15 depicts the change expected in the distribution of DSP revenue among the regions in 1994 and 1999. Figure 2-16 compares the CAGR of DSP revenue for each region. The primary contributors to DSP revenue continue to be the general-purpose DSPs from TI, AT&T, Motorola, and Analog Devices.

Table 2-4
Digital Signal Processor Revenue Forecast by Region (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Worldwide	679	1,030	1,484	1,976	2,451	3,014	3,746	
Growth (%)	-	51.7	44.1	33.2	24.0	23.0	24.3	29.5
Percentage of Worldwide Microcomponents	3.4	4.0	4.3	4.5	4.7	4.9	5.2	
Percentage of Worldwide Semiconductors	0.8	0.9	1.0	1.1	1.2	1.3	1.4	
North America	279	421	635	860	1,040	1,255	1,525	
Growth (%)	-	50.9	50.8	35.4	20.9	20.7	21.5	29.4
Percentage of Worldwide DSPs	41.1	40.9	42.8	43.5	42.4	41.6	40.7	
Percentage of Worldwide Microcomponents	1.4	1.6	1.8	2.0	2.0	2.0	2.1	
Percentage of Worldwide Semiconductors	0.3	0.4	0.4	0.5	0.5	0.5	0.6	
Japan	119	166	249	316	396	497	610	
Growth (%)	-	39.5	50.0	26.9	25.3	25.5	22.7	29.7
Percentage of Worldwide DSPs	17.5	16.1	16.8	16.0	16.2	16.5	16.3	
Percentage of Worldwide Microcomponents	0.6	0.6	0.7	0.7	0.8	0.8	0.8	
Percentage of Worldwide Semiconductors	0.1	0.2	0.2	0.2	0.2	0.2	0.2	
Europe	218	305	410	540	664	801	1,001	
Growth (%)	-	39.9	34.4	31.7	23.0	20.6	25.0	26.8
Percentage of Worldwide DSPs	32.1	29.6	27.6	27.3	27.1	26.6	26.7	
Percentage of Worldwide Microcomponents	1.1	1.2	1.2	1.2	1.3	1.3	1.4	
Percentage of Worldwide Semiconductors	0.3	0.3	0.3	0.3	0.3	0.3	0.4	
Asia/Pacific-ROW	63	138	190	260	351	461	610	
Growth (%)	-	119.0	37.7	36.8	35.0	31.3	32.3	34.6
Percentage of Worldwide DSPs	9.3	13.4	12.8	13.2	14.3	15.3	16.3	
Percentage of Worldwide Microcomponents	0.3	0.5	0.5	0.6	0.7	0.7	0.8	
Percentage of Worldwide Semiconductors	0.1	0.1	0.1	0.1	0.2	0.2	0.2	

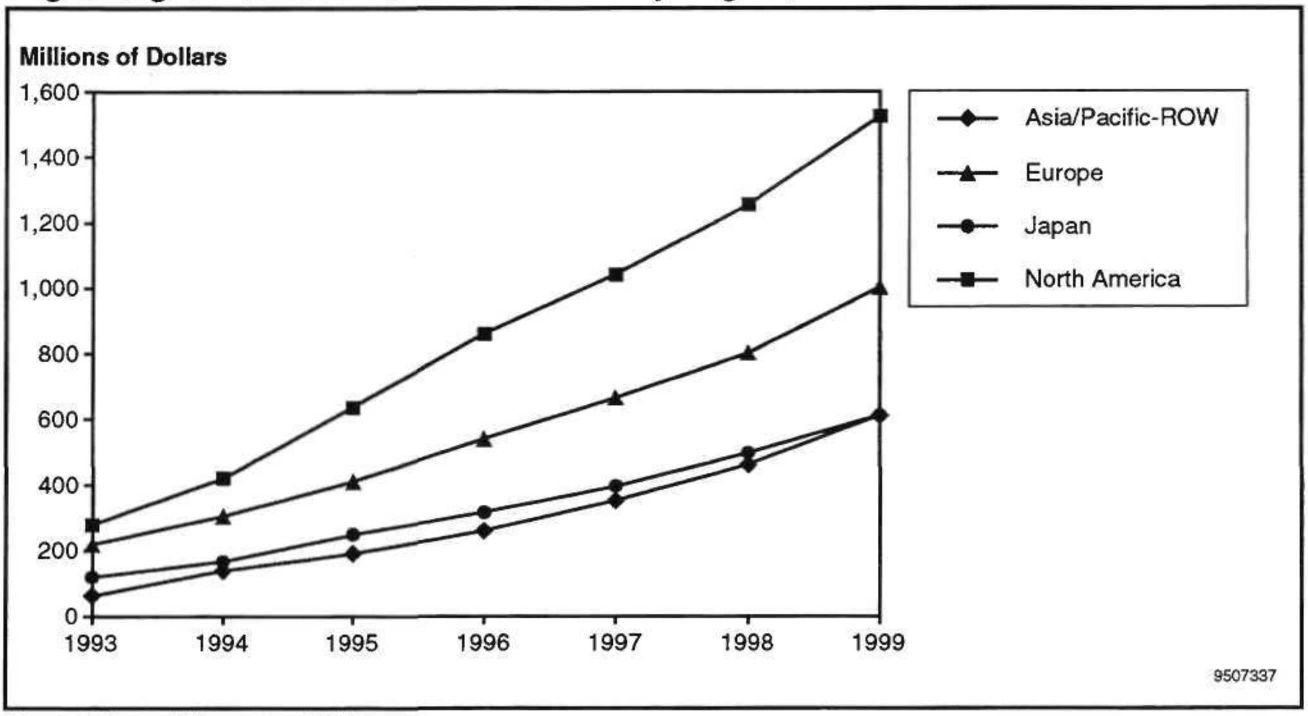
Source: Dataquest (December 1995)

Figure 2-13
Digital Signal Processor Revenue Forecast Showing Region, 1993-1999



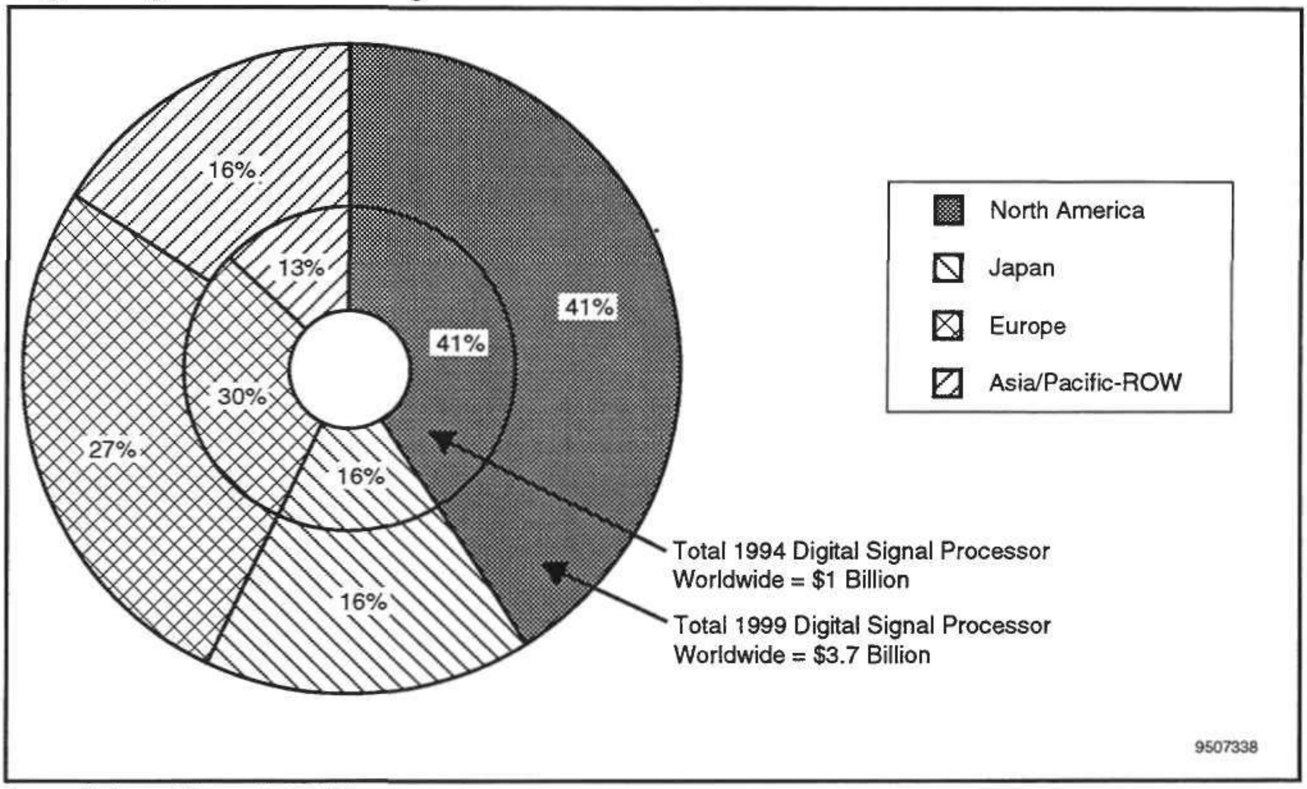
Source: Dataquest (December 1995)

Figure 2-14
Digital Signal Processor Revenue Forecast by Region, 1993-1999



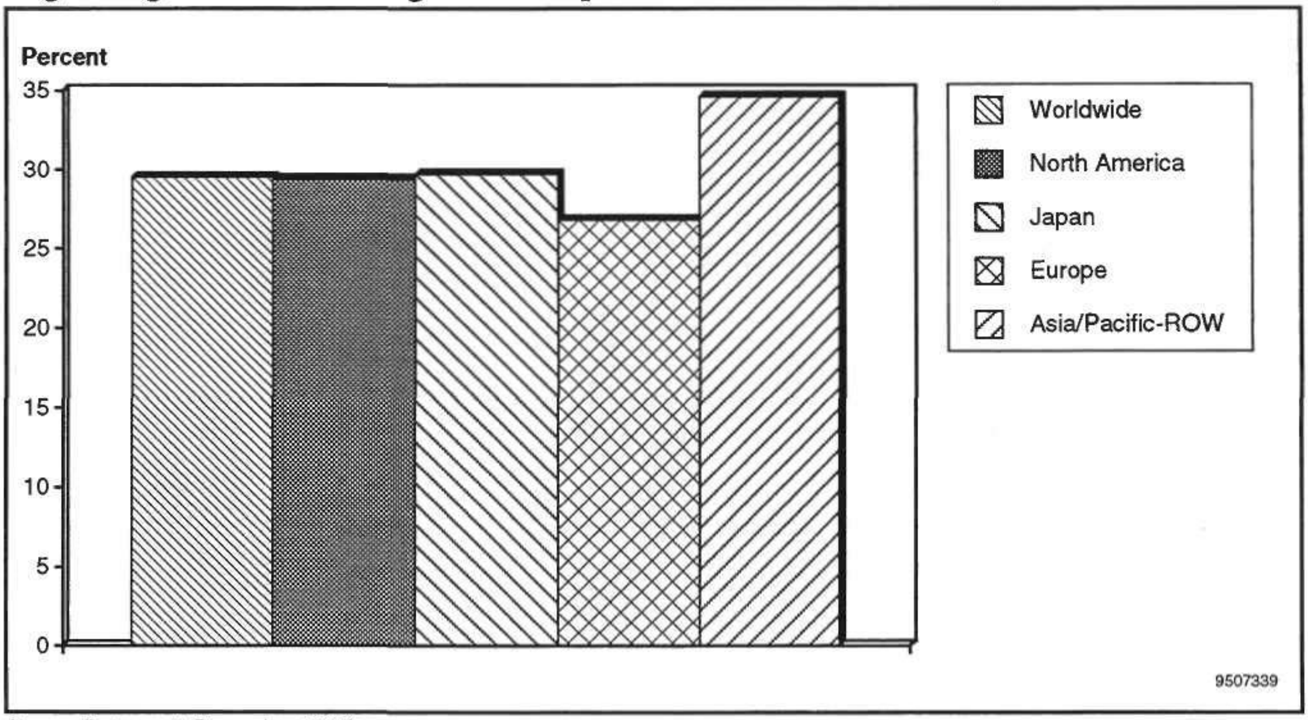
Source: Dataquest (December 1995)

Figure 2-15
Digital Signal Processor Regional Distribution, 1994 and 1999



Source: Dataquest (December 1995)

Figure 2-16
Digital Signal Processor Regional Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Microperipherals

The forecast for all microperipherals revenue is shown in Table 2-5 as microperipherals are expected to ship into each of the four geographic regions for the next five years. Percentages are given for each region's microperipherals revenue as a portion of the worldwide revenue for microperipherals, all microcomponents, and total semiconductors.

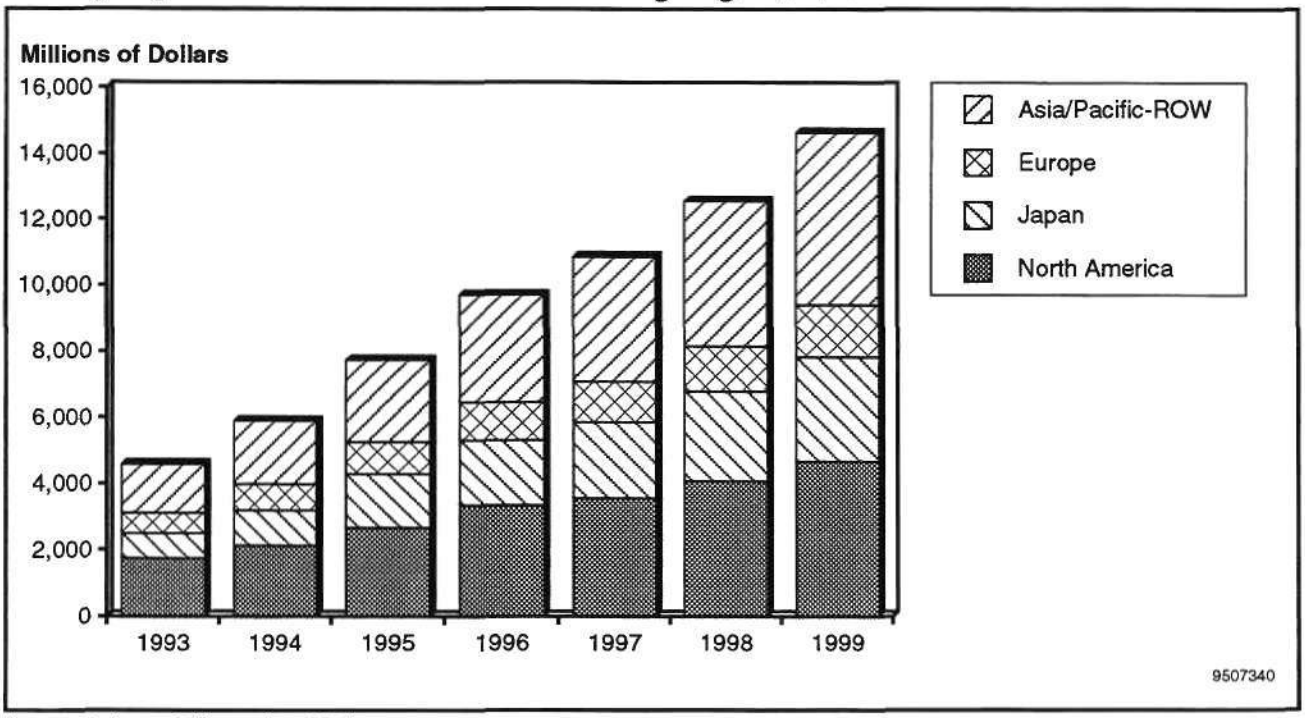
Figure 2-17 shows each region's microperipherals revenue as a portion of worldwide microperipherals revenue. Figure 2-18 shows each region's microperipherals revenue. Figure 2-19 depicts the change expected in the distribution of microperipherals revenue among the regions in 1994 and 1999. Figure 2-20 compares the CAGR of microperipherals revenue for each region.

Table 2-5
Microperipherals Revenue Forecast by Region (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Worldwide	4,581	5,885	7,717	9,705	10,853	12,551	14,629	
Growth (%)	-	28.5	31.1	25.8	11.8	15.6	16.6	20.0
Percentage of Worldwide Microcomponents	23.0	22.8	22.2	22.1	20.9	20.4	20.2	
Percentage of Worldwide Semiconductors	5.4	5.3	5.2	5.3	5.2	5.3	5.3	
North America	1,764	2,138	2,690	3,350	3,575	4,100	4,695	
Growth (%)	-	21.2	25.8	24.5	6.7	14.7	14.5	17.0
Percentage of Worldwide Microperipherals	38.5	36.3	34.9	34.5	32.9	32.7	32.1	
Percentage of Worldwide Microcomponents	8.8	8.3	7.7	7.6	6.9	6.7	6.5	
Percentage of Worldwide Semiconductors	2.1	1.9	1.8	1.8	1.7	1.7	1.7	
Japan	749	1,062	1,605	1,978	2,283	2,690	3,142	
Growth (%)	-	41.8	51.1	23.2	15.4	17.8	16.8	24.2
Percentage of Worldwide Microperipherals	16.4	18.0	20.8	20.4	21.0	21.4	21.5	
Percentage of Worldwide Microcomponents	3.8	4.1	4.6	4.5	4.4	4.4	4.3	
Percentage of Worldwide Semiconductors	0.9	1.0	1.1	1.1	1.1	1.1	1.1	
Europe	615	798	973	1,132	1,230	1,379	1,582	
Growth (%)	-	29.8	21.9	16.3	8.7	12.1	14.7	14.7
Percentage of Worldwide Microperipherals	13.4	13.6	12.6	11.7	11.3	11.0	10.8	
Percentage of Worldwide Microcomponents	3.1	3.1	2.8	2.6	2.4	2.2	2.2	
Percentage of Worldwide Semiconductors	0.7	0.7	0.6	0.6	0.6	0.6	0.6	
Asia/Pacific-ROW	1,453	1,887	2,449	3,245	3,765	4,382	5,210	
Growth (%)	-	29.9	29.8	32.5	16.0	16.4	18.9	22.5
Percentage of Worldwide Microperipherals	31.7	32.1	31.7	33.4	34.7	34.9	35.6	
Percentage of Worldwide Microcomponents	7.3	7.3	7.1	7.4	7.2	7.1	7.2	
Percentage of Worldwide Semiconductors	1.7	1.7	1.6	1.8	1.8	1.8	1.9	

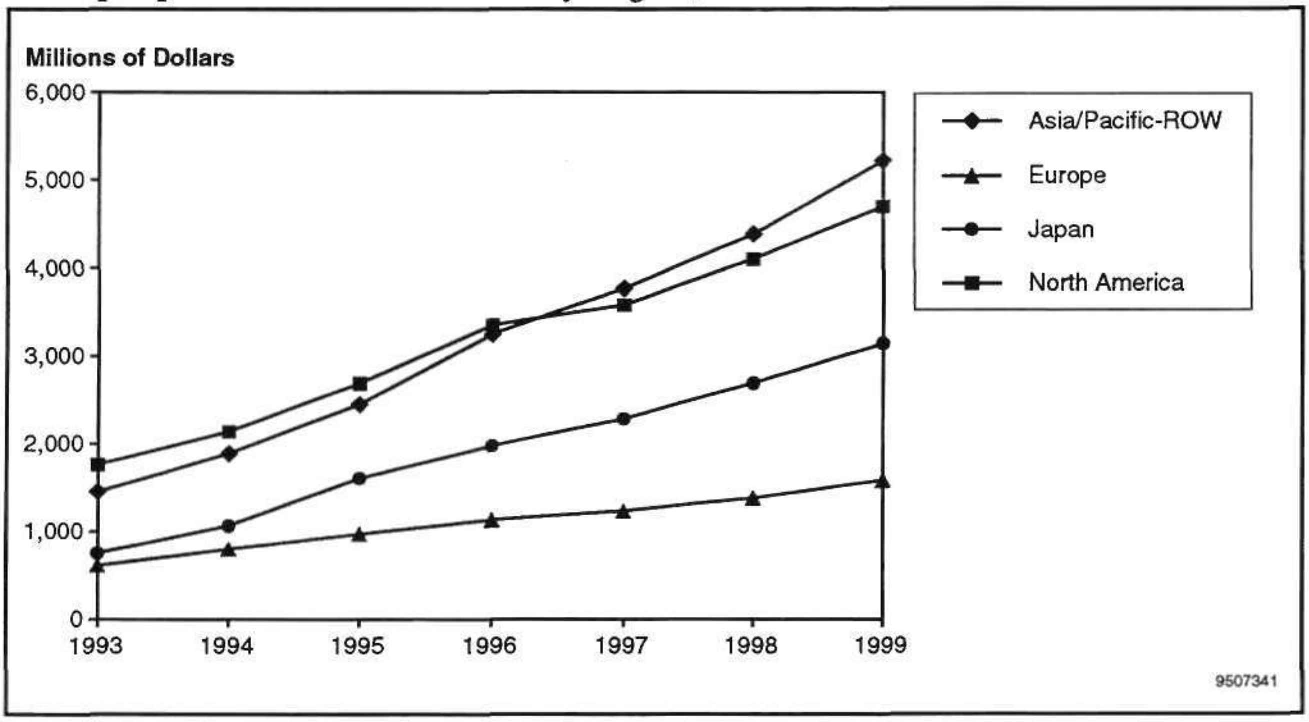
Source: Dataquest (December 1995)

Figure 2-17
Microperipherals Revenue Forecast Showing Region, 1993-1999



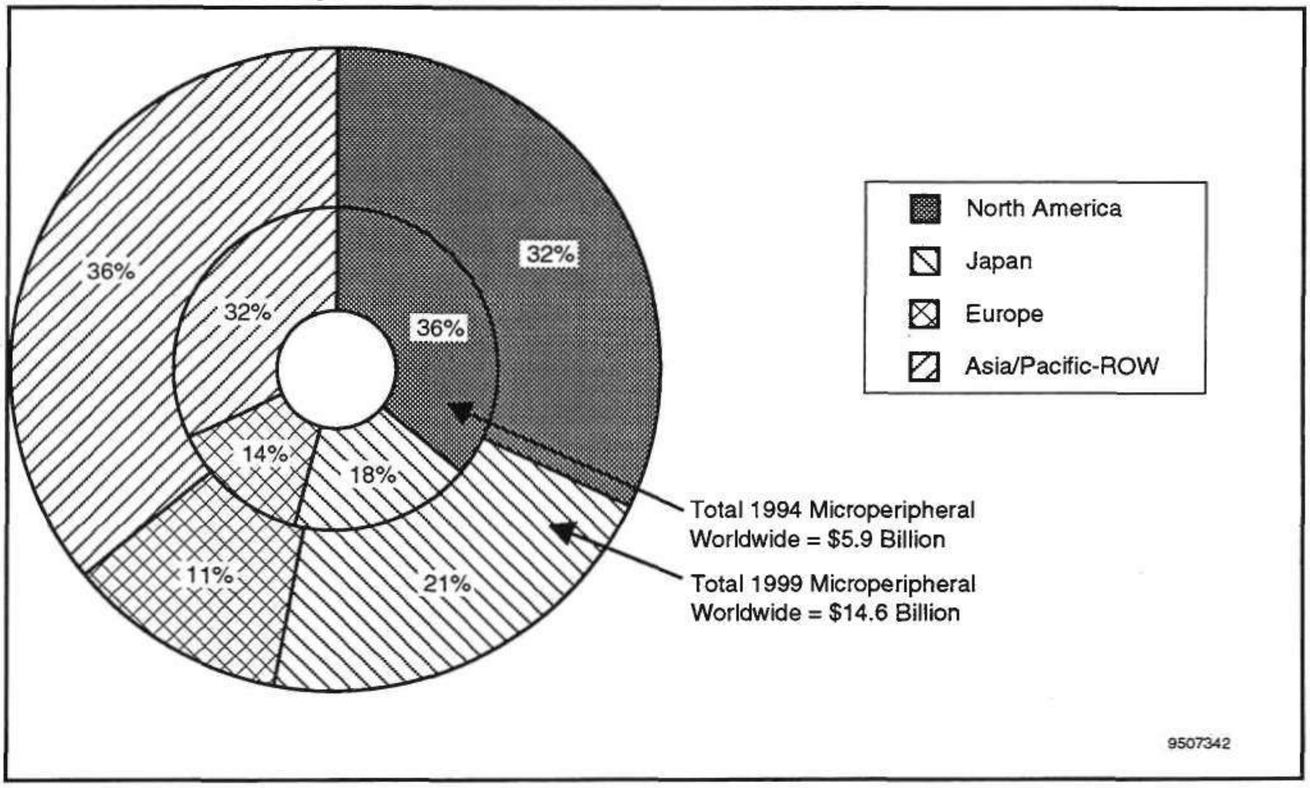
Source: Dataquest (December 1995)

Figure 2-18
Microperipherals Revenue Forecast by Region, 1993-1999



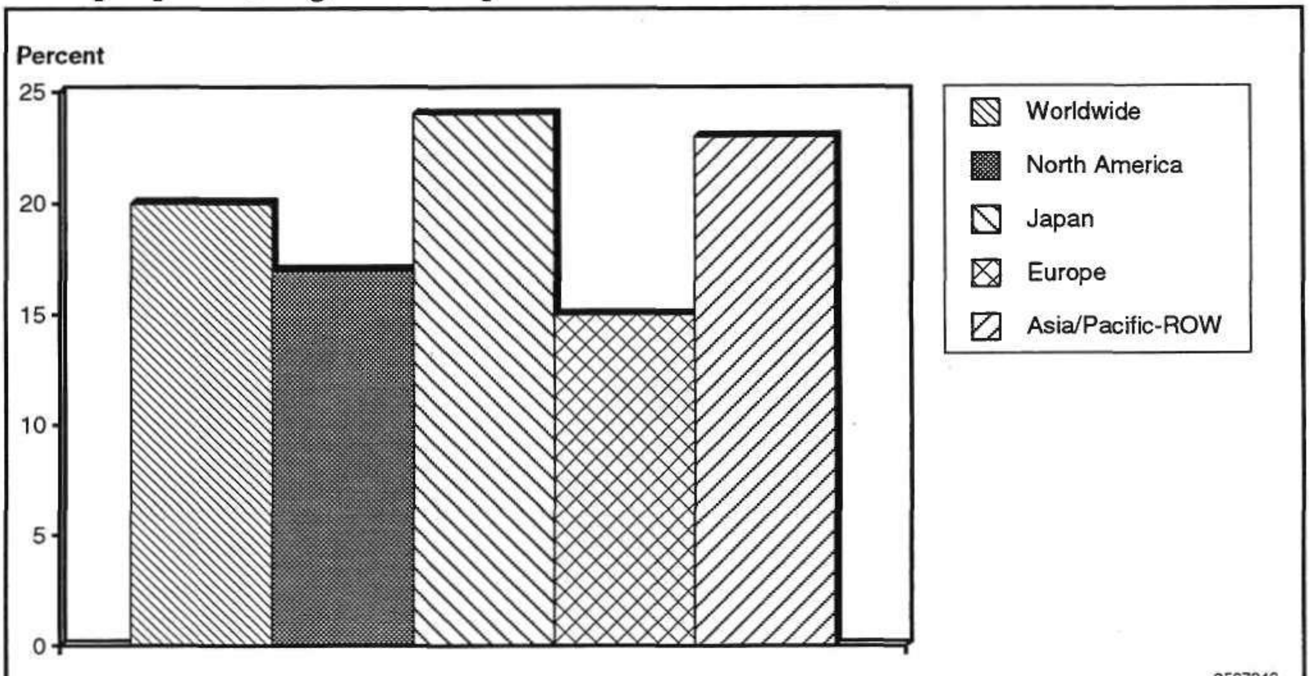
Source: Dataquest (December 1995)

Figure 2-19
Microperipherals Regional Distribution, 1994 and 1999



Source: Dataquest (December 1995)

Figure 2-20
Microperipherals Regional Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Chapter 3
How Microcomponent Families Will Grow in Each Geographic Region

Microcomponents comprise microprocessors, microcontrollers, DSPs, and microperipherals. In this chapter, Dataquest forecasts how each geographic region—North America, Japan, Europe, and Asia/Pacific-ROW—will consume microcomponents by product family. Within each section, the region's revenue forecast is given in tables and related figures highlighting MPUs, MCUs, DSPs, and microperipherals. Numbers for microprocessors include both compute and embedded products.

Worldwide Microcomponents

The revenue forecast for microcomponents sold throughout the world for the next five years is shown in Table 3-1 according to the product family: all microprocessors, microcontrollers, DSPs, and microperipherals (Table 3-1 is a subset of Table 1-1). Percentages are given for each product family's worldwide revenue as a portion of the total semiconductor worldwide revenue.

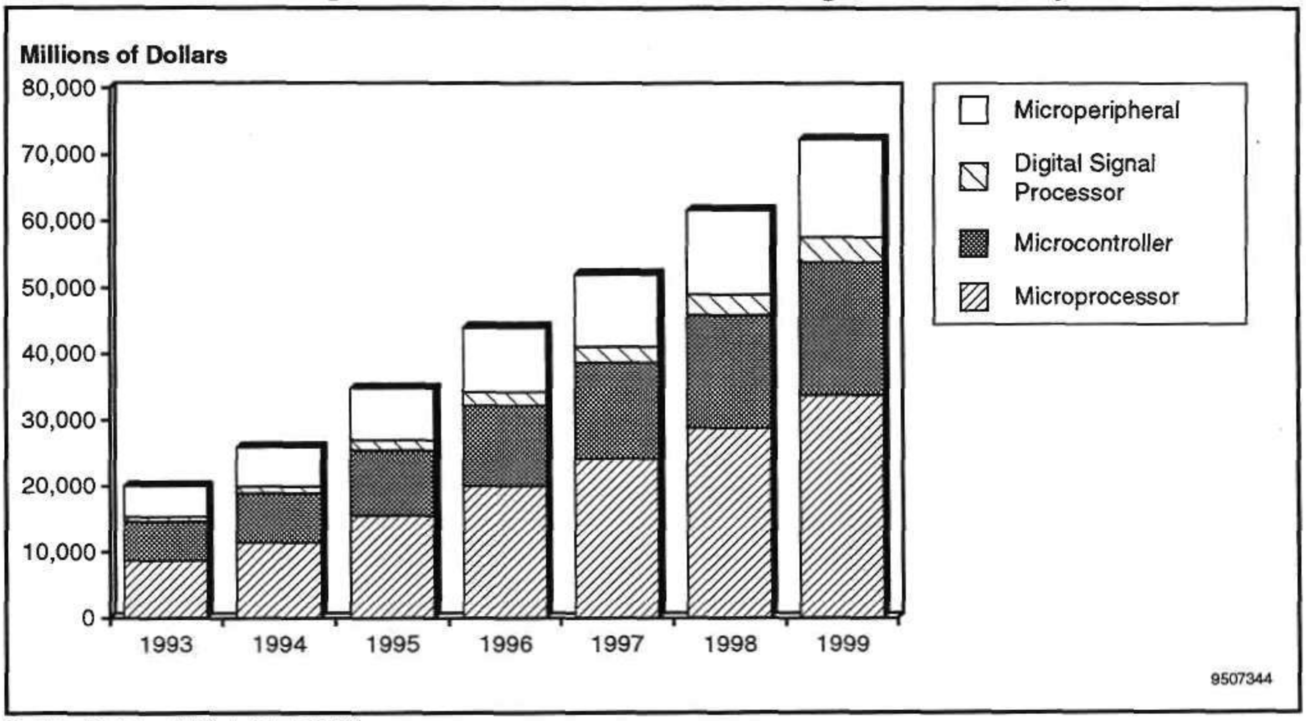
Figure 3-1 shows each product family's revenue as a portion of the entire microcomponent global revenue. Figure 3-2 shows each product family's revenue worldwide. Figure 3-3 illustrates how the microcomponent product mix will change worldwide from 1994 to 1999. Figure 3-4 shows the CAGR expected from 1994 through 1999 for sales of each product family globally.

Table 3-1
Revenue Forecast of Microcomponent Shipments to the World by Product Family (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Total Worldwide Microcomponents	19,947	25,868	34,720	43,945	51,959	61,541	72,285	
Growth (%)	-	29.7	34.2	26.6	18.2	18.4	17.5	22.8
Percentage of Worldwide Semiconductors	23.3	23.4	23.2	24.0	24.7	25.8	26.2	
Microprocessor	8,783	11,436	15,514	20,055	24,225	28,819	33,811	
Growth (%)	-	30.2	35.7	29.3	20.8	19.0	17.3	24.2
Percentage of Worldwide Microcomponents	44.0	44.2	44.7	45.6	46.6	46.8	46.8	
Percentage of Worldwide Semiconductors	10.3	10.3	10.4	11.0	11.5	12.1	12.3	
Microcontroller	5,904	7,517	10,005	12,209	14,430	17,157	20,099	
Growth (%)	-	27.3	33.1	22.0	18.2	18.9	17.1	21.7
Percentage of Worldwide Microcomponents	29.6	29.1	28.8	27.8	27.8	27.9	27.8	
Percentage of Worldwide Semiconductors	6.9	6.8	6.7	6.7	6.9	7.2	7.3	
Digital Signal Processor	679	1,030	1,484	1,976	2,451	3,014	3,746	
Growth (%)	-	51.7	44.1	33.2	24.0	23.0	24.3	29.5
Percentage of Worldwide Microcomponents	3.4	4.0	4.3	4.5	4.7	4.9	5.2	
Percentage of Worldwide Semiconductors	0.8	0.9	1.0	1.1	1.2	1.3	1.4	
Microperipheral	4,581	5,885	7,717	9,705	10,853	12,551	14,629	
Growth (%)	-	28.5	31.1	25.8	11.8	15.6	16.6	20.0
Percentage of Worldwide Microcomponents	23.0	22.8	22.2	22.1	20.9	20.4	20.2	
Percentage of Worldwide Semiconductors	5.4	5.3	5.2	5.3	5.2	5.3	5.3	

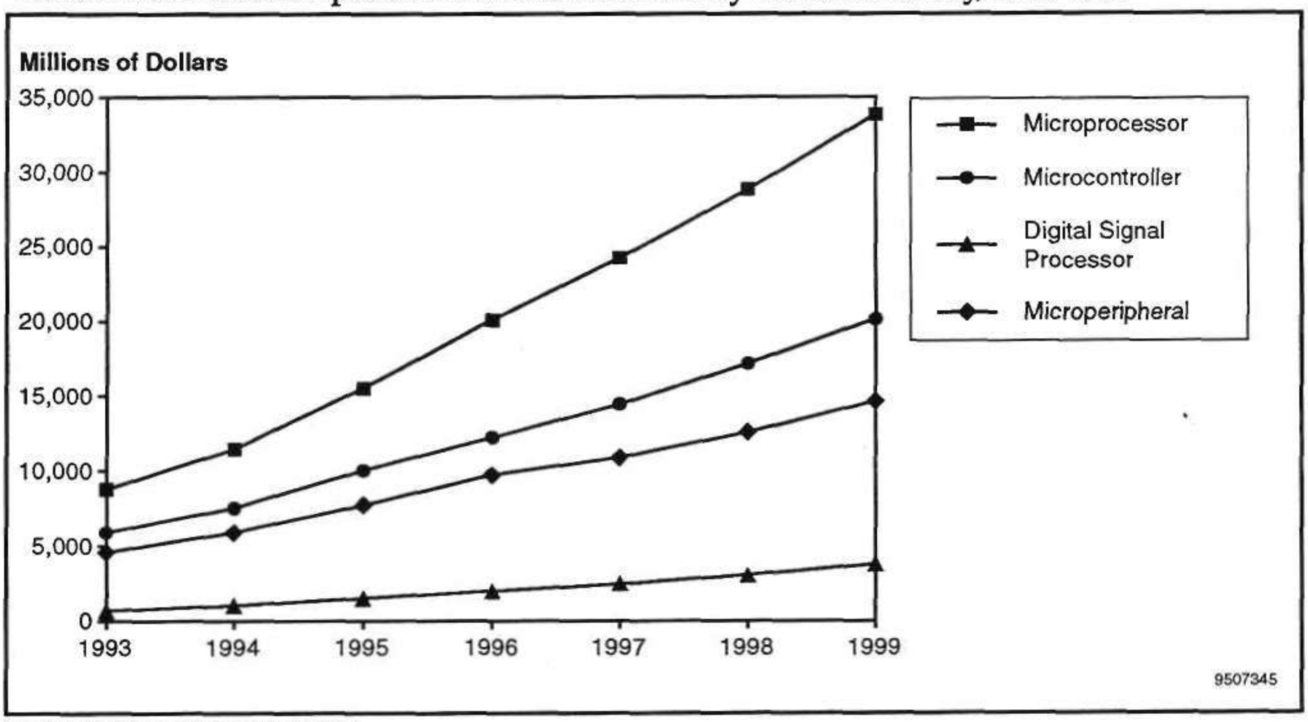
Source: Dataquest (December 1995)

Figure 3-1
Worldwide Microcomponent Revenue Forecast Showing Product Family, 1993-1999



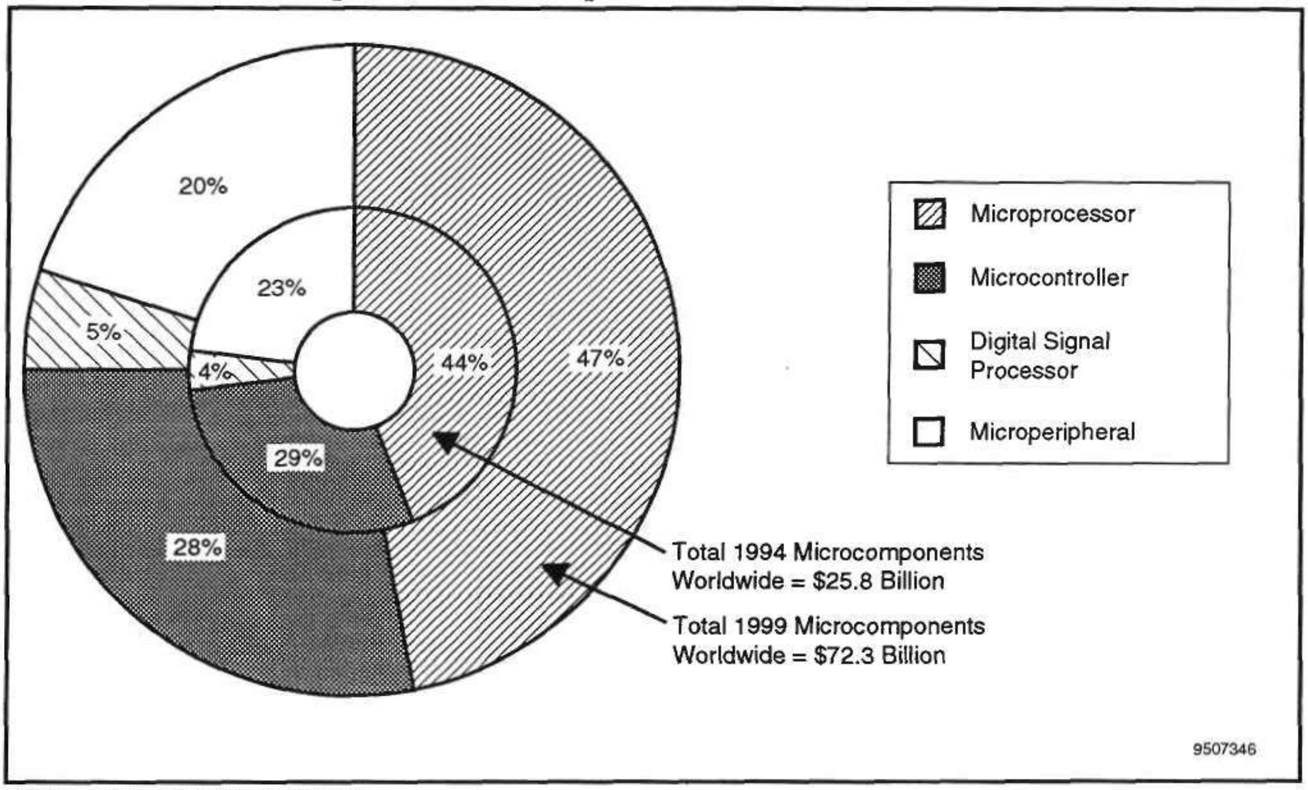
Source: Dataquest (December 1995)

Figure 3-2
Worldwide Microcomponent Revenue Forecast by Product Family, 1993-1999



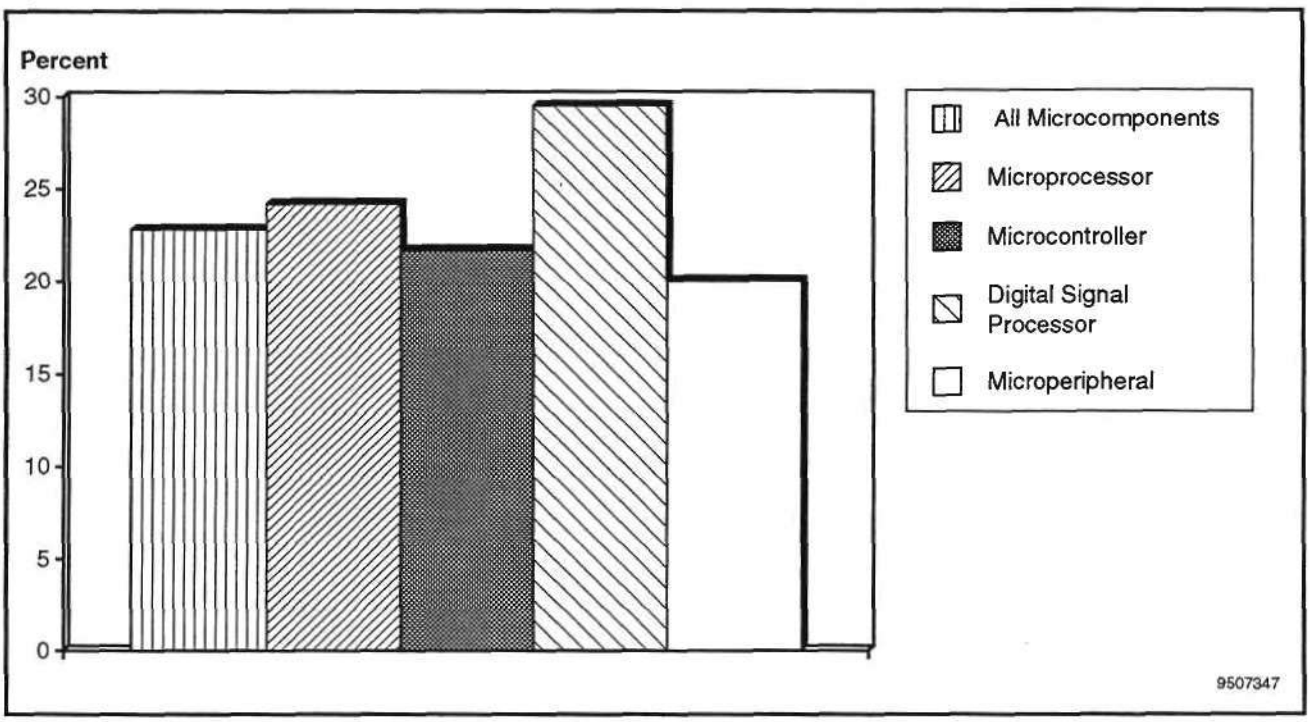
Source: Dataquest (December 1995)

Figure 3-3
Worldwide Microcomponent Product Split, 1994 and 1999



Source: Dataquest (December 1995)

Figure 3-4
Worldwide Microcomponent Product Family Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

North America

The revenue forecast for microcomponents sold into North America for the next five years is shown in Table 3-2 by product family: all microprocessors, microcontrollers, DSPs, or microperipherals. Percentages are given for the product family's revenue in North America as a portion of all microcomponent and total semiconductor revenue in the region, as well as in the world.

Figure 3-5 shows each product family's revenue as a portion of microcomponent revenue in North America. Figure 3-6 shows each product family's revenue from North America. Figure 3-7 illustrates how the microcomponent product mix will change in North America from 1994 to 1999. Figure 3-8 shows the CAGR expected from 1994 through 1999 for sales of each product family into North America.

Table 3-2
Revenue Forecast of Microcomponent Shipments to North America by Product Family (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Total Semiconductors to North America	27,926	35,939	47,805	60,307	71,508	80,947	92,908	
Growth (%)	-	28.7	33.0	26.2	18.6	13.2	14.8	20.9
Percentage of Worldwide Semiconductors	32.7	32.5	31.9	33.0	34.0	33.9	33.7	
Total Microcomponents to North America	7,620	9,657	12,880	16,960	20,740	24,650	28,445	
Growth (%)	-	26.7	33.4	31.7	22.3	18.9	15.4	24.1
Percentage of North America Semiconductors	27.3	26.9	26.9	28.1	29.0	30.5	30.6	
Percentage of Worldwide Microcomponents	38.2	37.3	37.1	38.6	39.9	40.1	39.4	
Percentage of Worldwide Semiconductors	8.9	8.7	8.6	9.3	9.9	10.3	10.3	
Microprocessor	4,323	5,446	7,645	10,300	12,950	15,470	17,800	
Growth (%)	-	26.0	40.4	34.7	25.7	19.5	15.1	26.7
Percentage of North America Microcomponents	56.7	56.4	59.4	60.7	62.4	62.8	62.6	
Percentage of North America Semiconductors	15.5	15.2	16.0	17.1	18.1	19.1	19.2	
Percentage of Worldwide Microcomponents	21.7	21.1	22.0	23.4	24.9	25.1	24.6	
Percentage of Worldwide Semiconductors	5.1	4.9	5.1	5.6	6.2	6.5	6.5	
Microcontroller	1,254	1,652	1,910	2,450	3,175	3,825	4,425	
Growth (%)	-	31.7	15.6	28.3	29.6	20.5	15.7	21.8
Percentage of North America Microcomponents	16.5	17.1	14.8	14.4	15.3	15.5	15.6	
Percentage of North America Semiconductors	4.5	4.6	4.0	4.1	4.4	4.7	4.8	
Percentage of Worldwide Microcomponents	6.3	6.4	5.5	5.6	6.1	6.2	6.1	
Percentage of Worldwide Semiconductors	1.5	1.5	1.3	1.3	1.5	1.6	1.6	
Digital Signal Processor	279	421	635	860	1,040	1,255	1,525	
Growth (%)	-	50.9	50.8	35.4	20.9	20.7	21.5	29.4
Percentage of North America Microcomponents	3.7	4.4	4.9	5.1	5.0	5.1	5.4	
Percentage of North America Semiconductors	1.0	1.2	1.3	1.4	1.5	1.6	1.6	
Percentage of Worldwide Microcomponents	1.4	1.6	1.8	2.0	2.0	2.0	2.1	
Percentage of Worldwide Semiconductors	0.3	0.4	0.4	0.5	0.5	0.5	0.6	

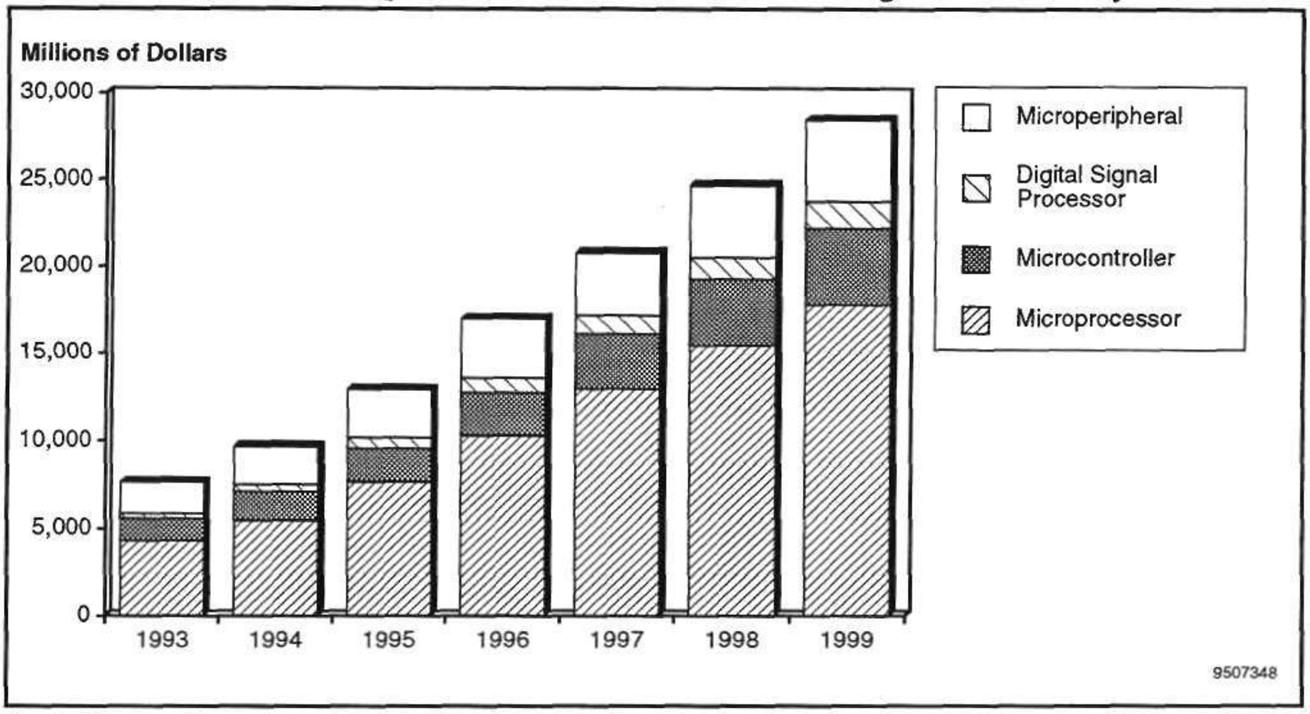
(Continued)

Table 3-2 (Continued)
Revenue Forecast of Microcomponent Shipments to North America by Product Family (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Microperipheral	1,764	2,138	2,690	3,350	3,575	4,100	4,695	
Growth (%)	-	21.2	25.8	24.5	6.7	14.7	14.5	17.0
Percentage of North America Microcomponents	23.1	22.1	20.9	19.8	17.2	16.6	16.5	
Percentage of North America Semiconductors	6.3	5.9	5.6	5.6	5.0	5.1	5.1	
Percentage of Worldwide Microcomponents	8.8	8.3	7.7	7.6	6.9	6.7	6.5	
Percentage of Worldwide Semiconductors	2.1	1.9	1.8	1.8	1.7	1.7	1.7	

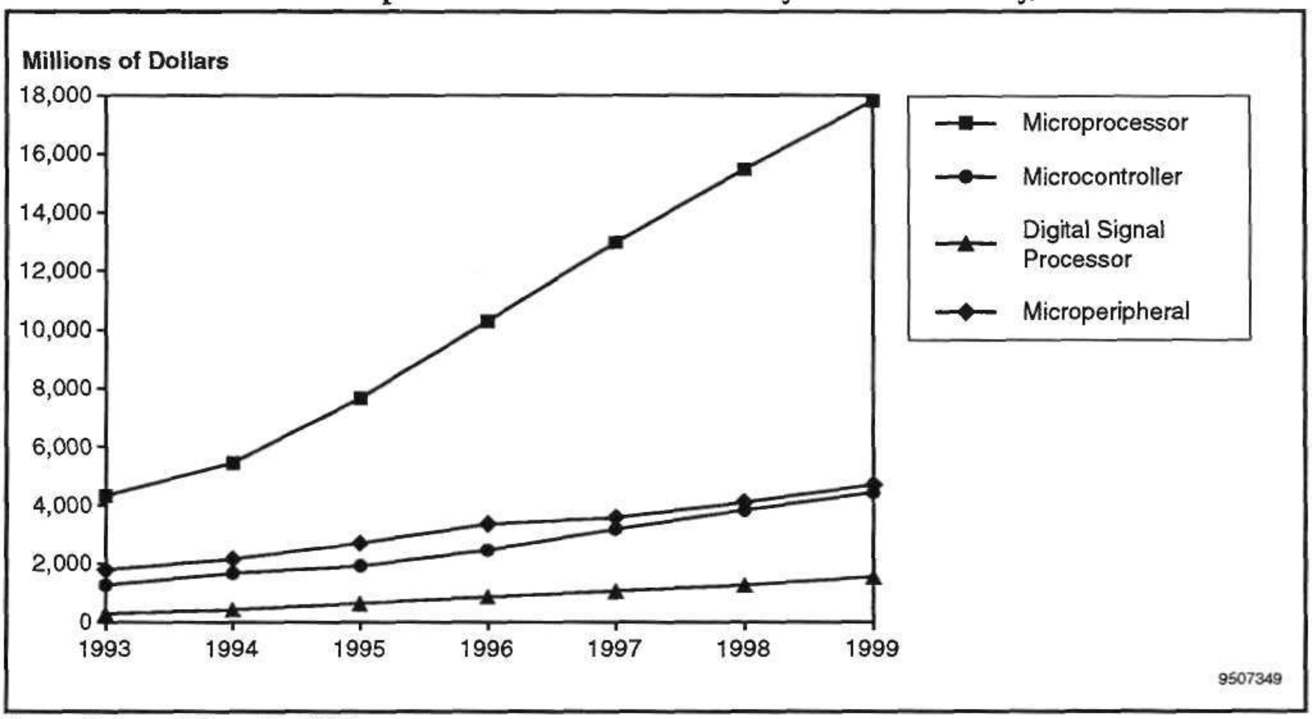
Source: Dataquest (December 1995)

Figure 3-5
North America Microcomponent Revenue Forecast Showing Product Family, 1993-1999



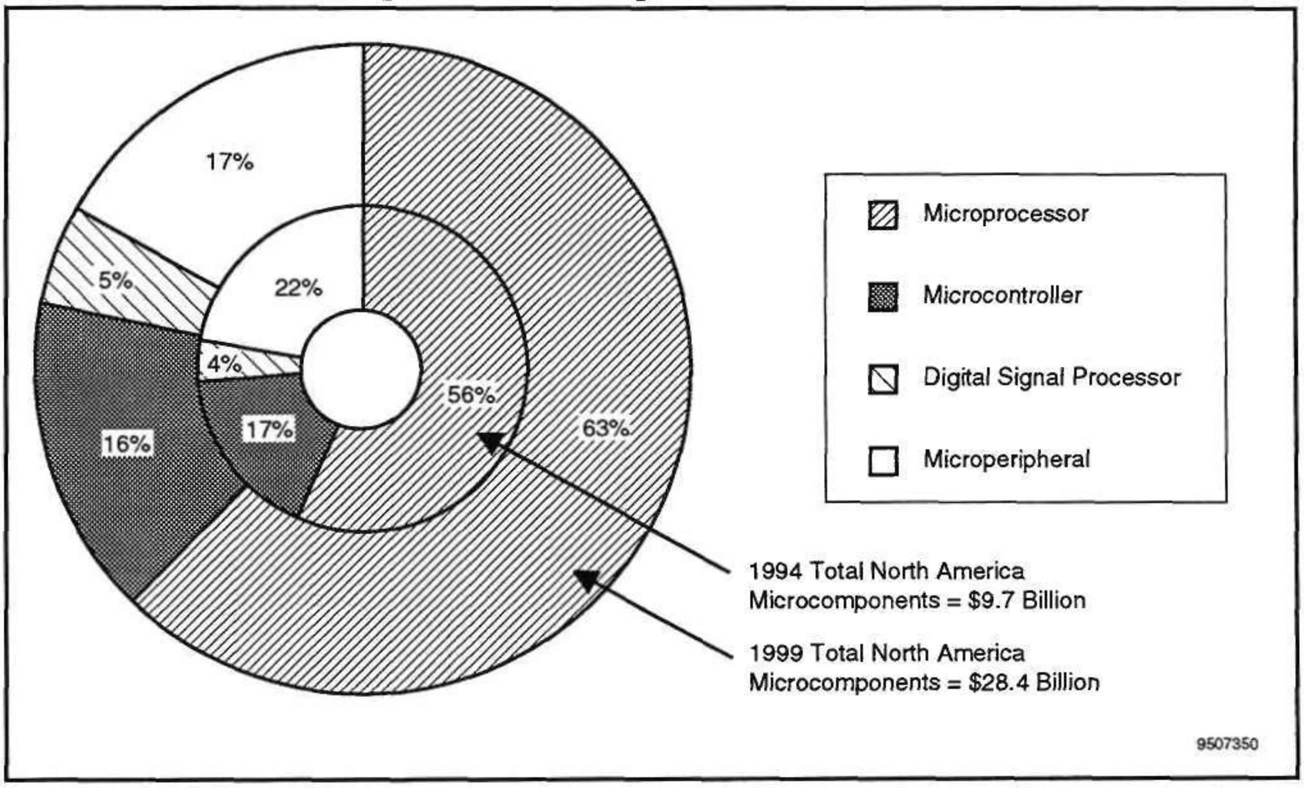
Source: Dataquest (December 1995)

Figure 3-6
North America Microcomponent Revenue Forecast by Product Family, 1993-1999



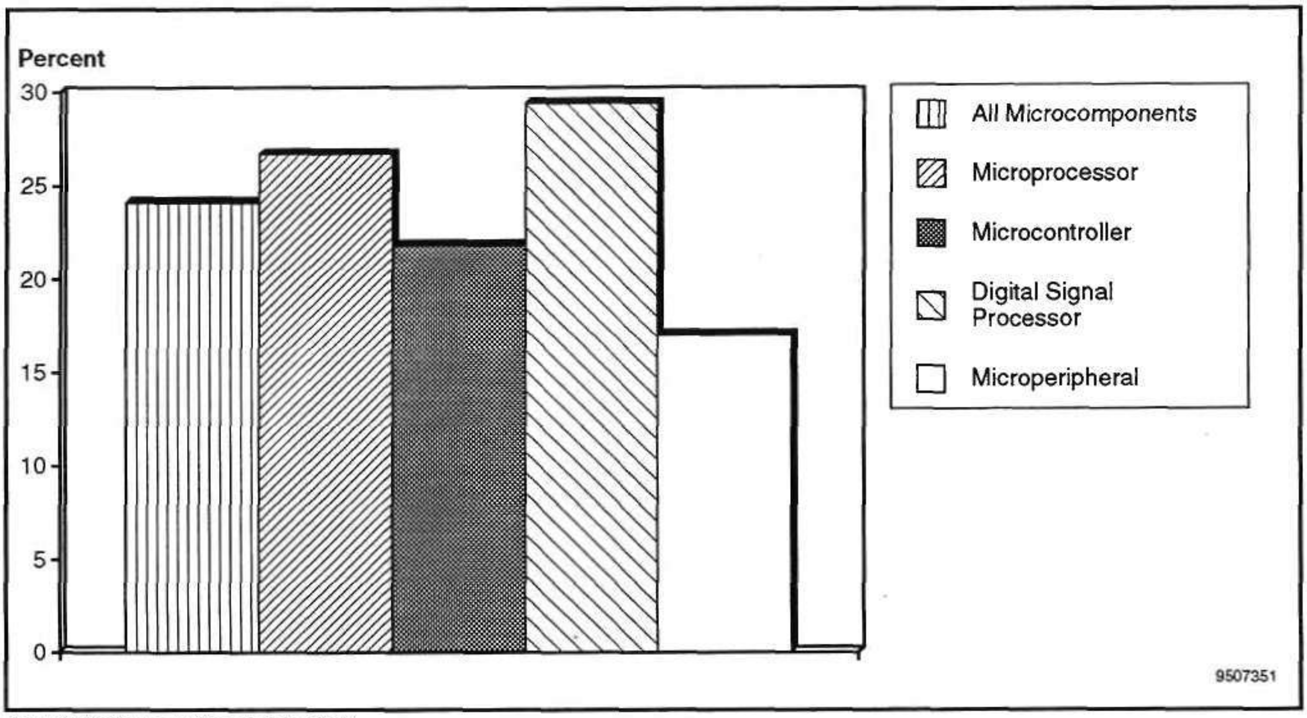
Source: Dataquest (December 1995)

Figure 3-7
North America Microcomponent Product Split, 1994 and 1999



Source: Dataquest (December 1995)

Figure 3-8
North America Microcomponent Product Family Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Japan

The revenue forecast for microcomponents sold into Japan for the next five years is shown in Table 3-3 by the product family: all microprocessors, microcontrollers, DSPs, or microperipherals. Percentages are given for the product family's revenue in Japan as a portion of all microcomponent and total semiconductor revenue in Japan, as well as in the world.

Figure 3-9 shows each product family's revenue as a portion of microcomponent revenue in Japan. Figure 3-10 shows each product family's revenue from Japan. Figure 3-11 illustrates how the microcomponent product mix will change in Japan from 1994 to 1999. Figure 3-12 shows the CAGR expected from 1994 through 1999 for sales of each product family into Japan.

Table 3-3
Revenue Forecast of Microcomponent Shipments to Japan by Product Family (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Total Semiconductors to Japan	24,645	31,010	41,843	47,638	52,760	58,446	65,241	
Growth (%)	-	25.8	34.9	13.8	10.8	10.8	11.6	16.0
Percentage of Worldwide Semiconductors	28.8	28.0	27.9	26.0	25.1	24.5	23.7	
Total Microcomponents to Japan	3,987	5,439	7,821	9,426	10,963	12,997	15,054	
Growth (%)	-	36.4	43.8	20.5	16.3	18.6	15.8	22.6
Percentage of Japan Semiconductors	16.2	17.5	18.7	19.8	20.8	22.2	23.1	
Percentage of Worldwide Microcomponents	20.0	21.0	22.5	21.4	21.1	21.1	20.8	
Percentage of Worldwide Semiconductors	4.7	4.9	5.2	5.2	5.2	5.4	5.5	
Microprocessor	835	1,247	1,684	2,057	2,373	2,825	3,334	
Growth (%)	-	49.3	35.0	22.1	15.4	19.0	18.0	21.7
Percentage of Japan Microcomponents	20.9	22.9	21.5	21.8	21.6	21.7	22.1	
Percentage of Japan Semiconductors	3.4	4.0	4.0	4.3	4.5	4.8	5.1	
Percentage of Worldwide Microcomponents	4.2	4.8	4.9	4.7	4.6	4.6	4.6	
Percentage of Worldwide Semiconductors	1.0	1.1	1.1	1.1	1.1	1.2	1.2	
Microcontroller	2,284	2,964	4,283	5,075	5,911	6,985	7,968	
Growth (%)	-	29.8	44.5	18.5	16.5	18.2	14.1	21.9
Percentage of Japan Microcomponents	57.3	54.5	54.8	53.8	53.9	53.7	52.9	
Percentage of Japan Semiconductors	9.3	9.6	10.2	10.7	11.2	12.0	12.2	
Percentage of Worldwide Microcomponents	11.5	11.5	12.3	11.5	11.4	11.4	11.0	
Percentage of Worldwide Semiconductors	2.7	2.7	2.9	2.8	2.8	2.9	2.9	
Digital Signal Processor	119	166	249	316	396	497	610	
Growth (%)	-	39.5	50.0	26.9	25.3	25.5	22.7	29.7
Percentage of Japan Microcomponents	3.0	3.1	3.2	3.4	3.6	3.8	4.1	
Percentage of Japan Semiconductors	0.5	0.5	0.6	0.7	0.8	0.9	0.9	
Percentage of Worldwide Microcomponents	0.6	0.6	0.7	0.7	0.8	0.8	0.8	
Percentage of Worldwide Semiconductors	0.1	0.2	0.2	0.2	0.2	0.2	0.2	

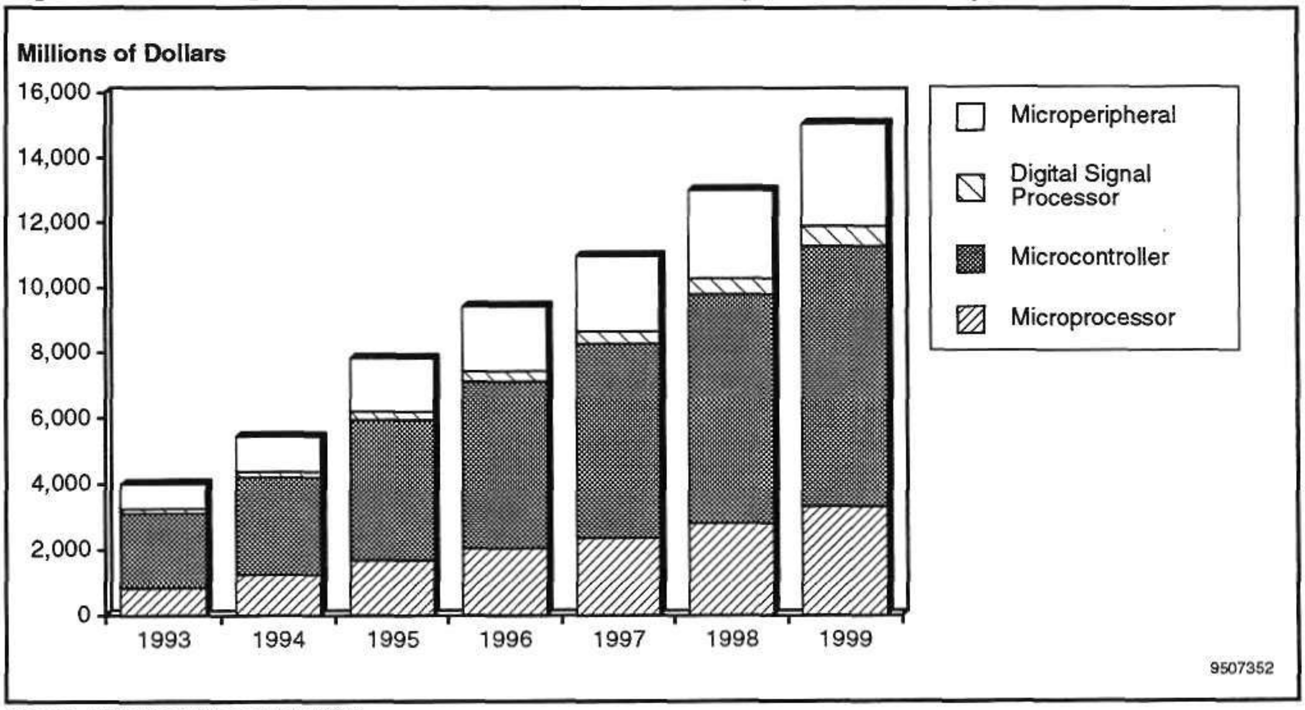
(Continued)

Table 3-3 (Continued)
Revenue Forecast of Microcomponent Shipments to Japan by Product Family
(Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Microperipheral	749	1,062	1,605	1,978	2,283	2,690	3,142	
Growth (%)	-	41.8	51.1	23.2	15.4	17.8	16.8	24.2
Percentage of Japan Microcomponents	18.8	19.5	20.5	21.0	20.8	20.7	20.9	
Percentage of Japan Semiconductors	3.0	3.4	3.8	4.2	4.3	4.6	4.8	
Percentage of Worldwide Microcomponents	3.8	4.1	4.6	4.5	4.4	4.4	4.3	
Percentage of Worldwide Semiconductors	0.9	1.0	1.1	1.1	1.1	1.1	1.1	

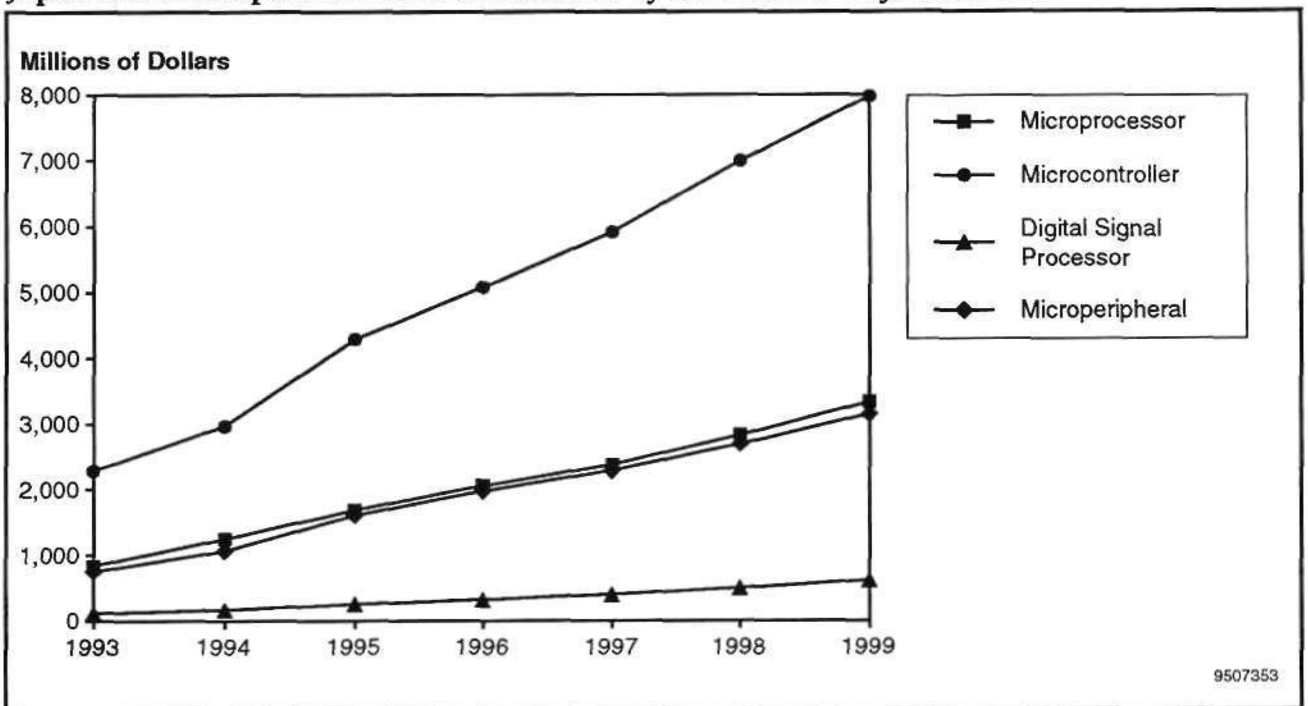
Source: Dataquest (December 1995)

Figure 3-9
Japan Microcomponent Revenue Forecast Showing Product Family, 1993-1999



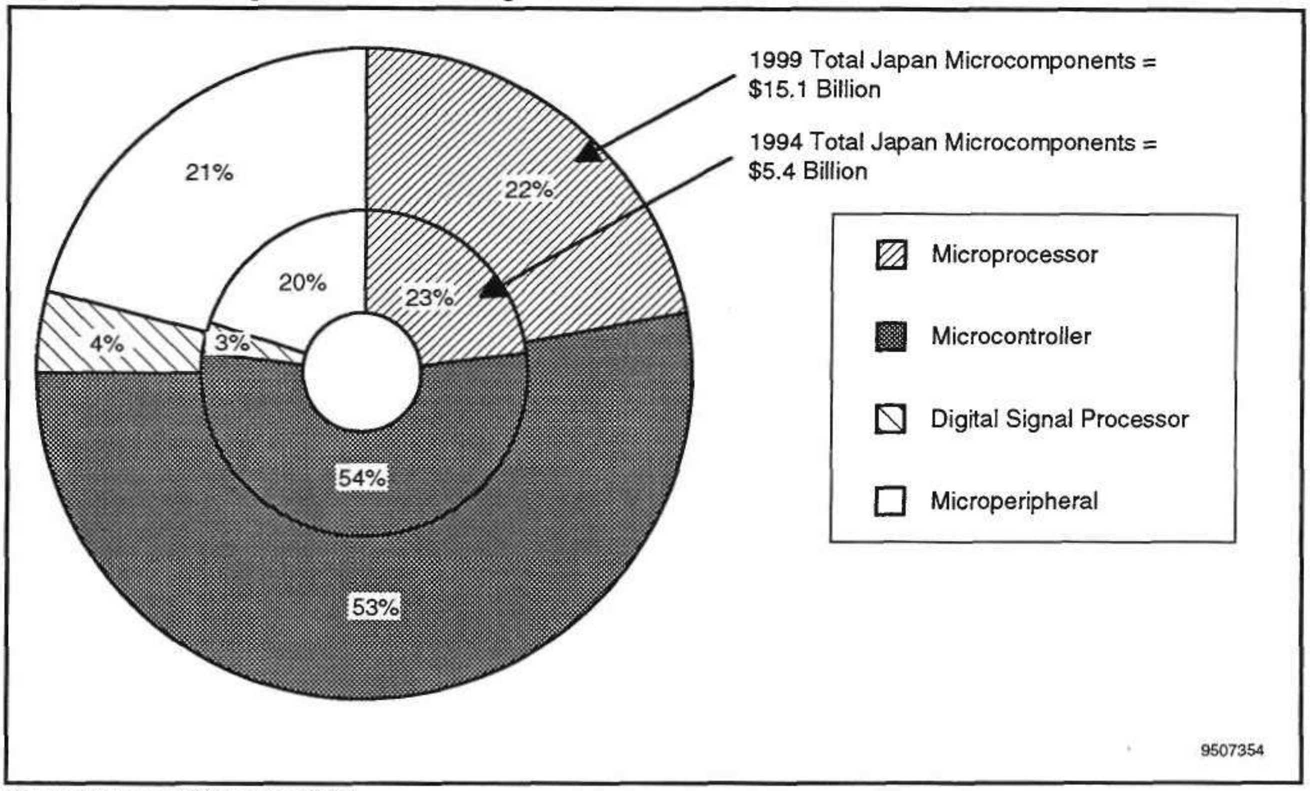
Source: Dataquest (December 1995)

Figure 3-10
Japan Microcomponent Revenue Forecast by Product Family, 1993-1999



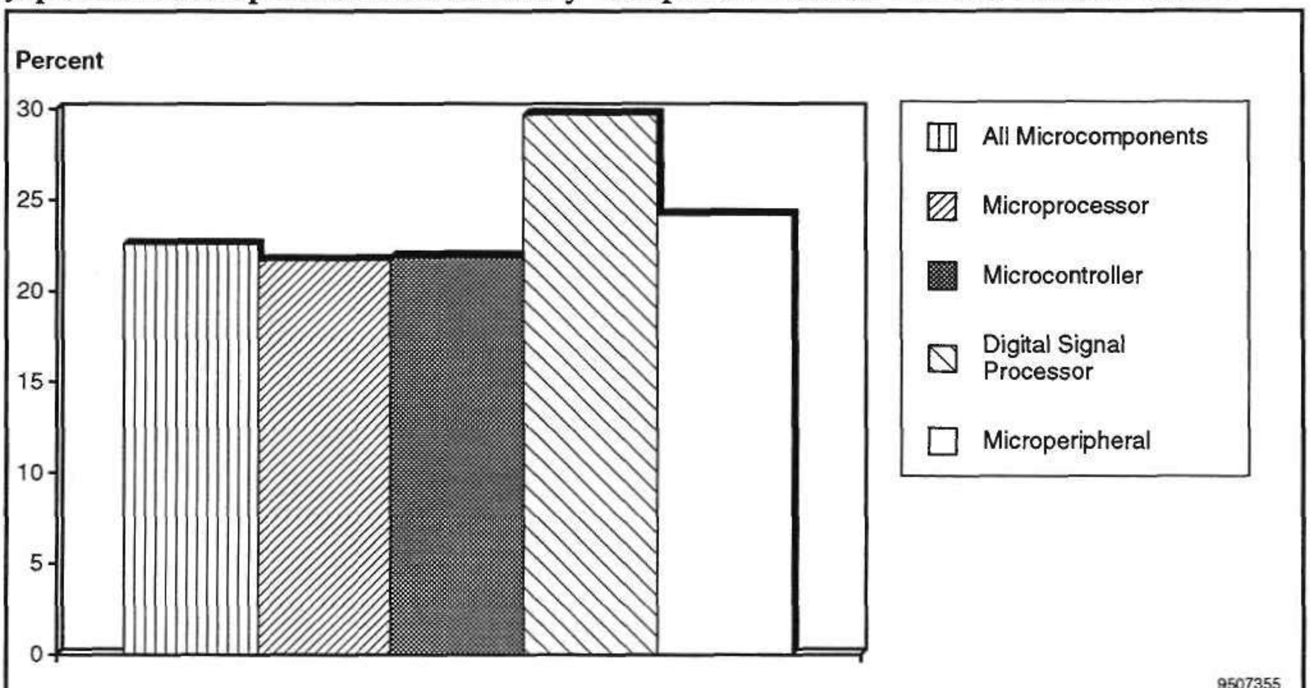
Source: Dataquest (December 1995)

Figure 3-11
Japan Microcomponent Product Split, 1994 and 1999



Source: Dataquest (December 1995)

Figure 3-12
Japan Microcomponent Product Family Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Europe

The revenue forecast for microcomponents sold in Europe for the next five years is shown in Table 3-4 by product family: all microprocessors, microcontrollers, DSPs, or microperipherals. Percentages are given for the product family's revenue in Europe as a portion of all microcomponent and total semiconductor revenue in Europe, as well as in the world.

Figure 3-13 shows each product family's European revenue as a portion of microcomponent revenue in Europe. Figure 3-14 shows each product family's revenue from Europe. Figure 3-15 illustrates how the microcomponent product mix will change in Europe from 1994 to 1999. Figure 3-16 shows the CAGR expected from 1994 through 1999 for sales of each product family into Europe.

Table 3-4
Revenue Forecast of Microcomponent Shipments to Europe by Product Family
(Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Total Semiconductors to Europe	15,461	20,819	28,995	35,517	39,674	44,895	51,859	
Growth (%)	-	34.7	39.3	22.5	11.7	13.2	15.5	20.0
Percentage of Worldwide Semiconductors	18.1	18.8	19.4	19.4	18.9	18.8	18.8	
Total Microcomponents to Europe	4,037	5,309	6,902	8,529	9,559	10,837	12,550	
Growth (%)	-	31.5	30.0	23.6	12.1	13.4	15.8	18.8
Percentage of Europe Semiconductors	26.1	25.5	23.8	24.0	24.1	24.1	24.2	
Percentage of Worldwide Microcomponents	20.2	20.5	19.9	19.4	18.4	17.6	17.4	
Percentage of Worldwide Semiconductors	4.7	4.8	4.6	4.7	4.5	4.5	4.6	
Microprocessor	2,098	2,774	3,631	4,523	5,091	5,767	6,645	
Growth (%)	-	32.2	30.9	24.6	12.6	13.3	15.2	19.1
Percentage of Europe Microcomponents	52.0	52.3	52.6	53.0	53.3	53.2	52.9	
Percentage of Europe Semiconductors	13.6	13.3	12.5	12.7	12.8	12.8	12.8	
Percentage of Worldwide Microcomponents	10.5	10.7	10.5	10.3	9.8	9.4	9.2	
Percentage of Worldwide Semiconductors	2.5	2.5	2.4	2.5	2.4	2.4	2.4	
Microcontroller	1,106	1,432	1,888	2,334	2,574	2,890	3,322	
Growth (%)	-	29.5	31.8	23.6	10.3	12.3	14.9	18.3
Percentage of Europe Microcomponents	27.4	27.0	27.4	27.4	26.9	26.7	26.5	
Percentage of Europe Semiconductors	7.2	6.9	6.5	6.6	6.5	6.4	6.4	
Percentage of Worldwide Microcomponents	5.5	5.5	5.4	5.3	5.0	4.7	4.6	
Percentage of Worldwide Semiconductors	1.3	1.3	1.3	1.3	1.2	1.2	1.2	
Digital Signal Processor	218	305	410	540	664	801	1,001	
Growth (%)	-	39.9	34.4	31.7	23.0	20.6	25.0	26.8
Percentage of Europe Microcomponents	5.4	5.7	5.9	6.3	6.9	7.4	8.0	
Percentage of Europe Semiconductors	1.4	1.5	1.4	1.5	1.7	1.8	1.9	
Percentage of Worldwide Microcomponents	1.1	1.2	1.2	1.2	1.3	1.3	1.4	
Percentage of Worldwide Semiconductors	0.3	0.3	0.3	0.3	0.3	0.3	0.4	

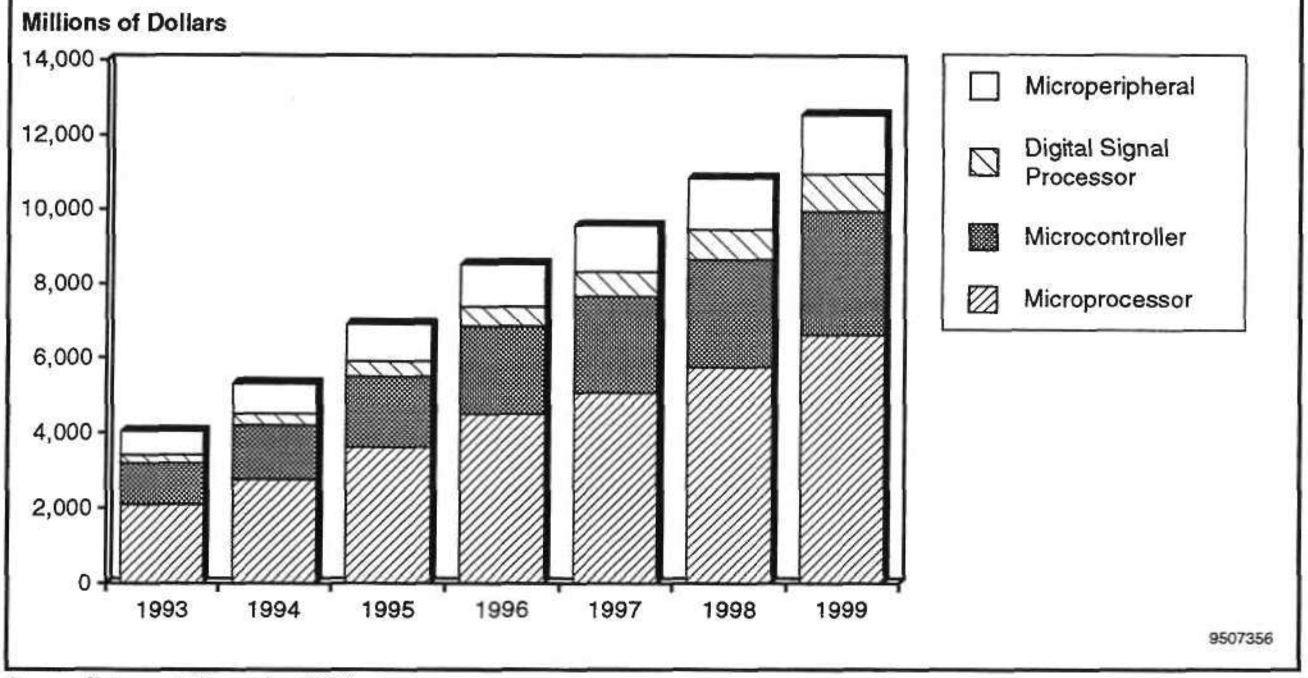
(Continued)

Table 3-4 (Continued)
Revenue Forecast of Microcomponent Shipments to Europe by Product Family
(Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Microperipheral	615	798	973	1,132	1,230	1,379	1,582	
Growth (%)	-	29.8	21.9	16.3	8.7	12.1	14.7	14.7
Percentage of Europe Microcomponents	15.2	15.0	14.1	13.3	12.9	12.7	12.6	
Percentage of Europe Semiconductors	4.0	3.8	3.4	3.2	3.1	3.1	3.1	
Percentage of Worldwide Microcomponents	3.1	3.1	2.8	2.6	2.4	2.2	2.2	
Percentage of Worldwide Semiconductors	0.7	0.7	0.6	0.6	0.6	0.6	0.6	

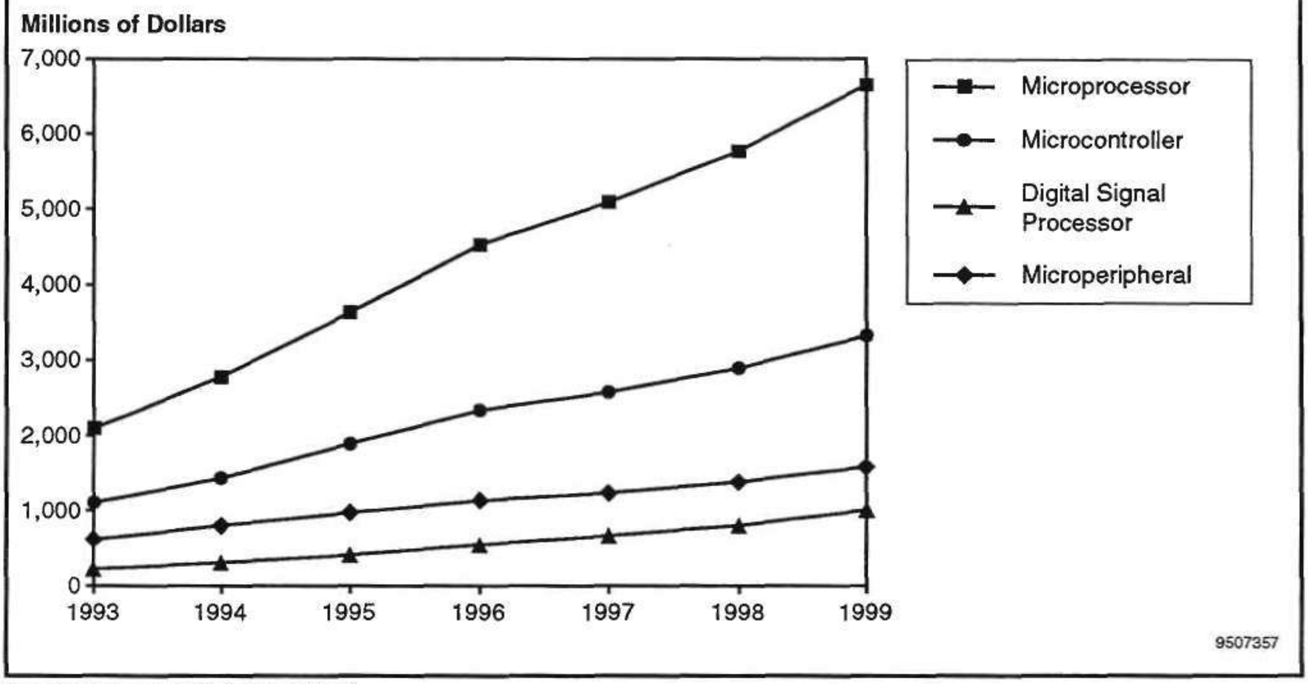
Source: Dataquest (December 1995)

Figure 3-13
Europe Microcomponent Revenue Forecast Showing Product Family, 1993-1999



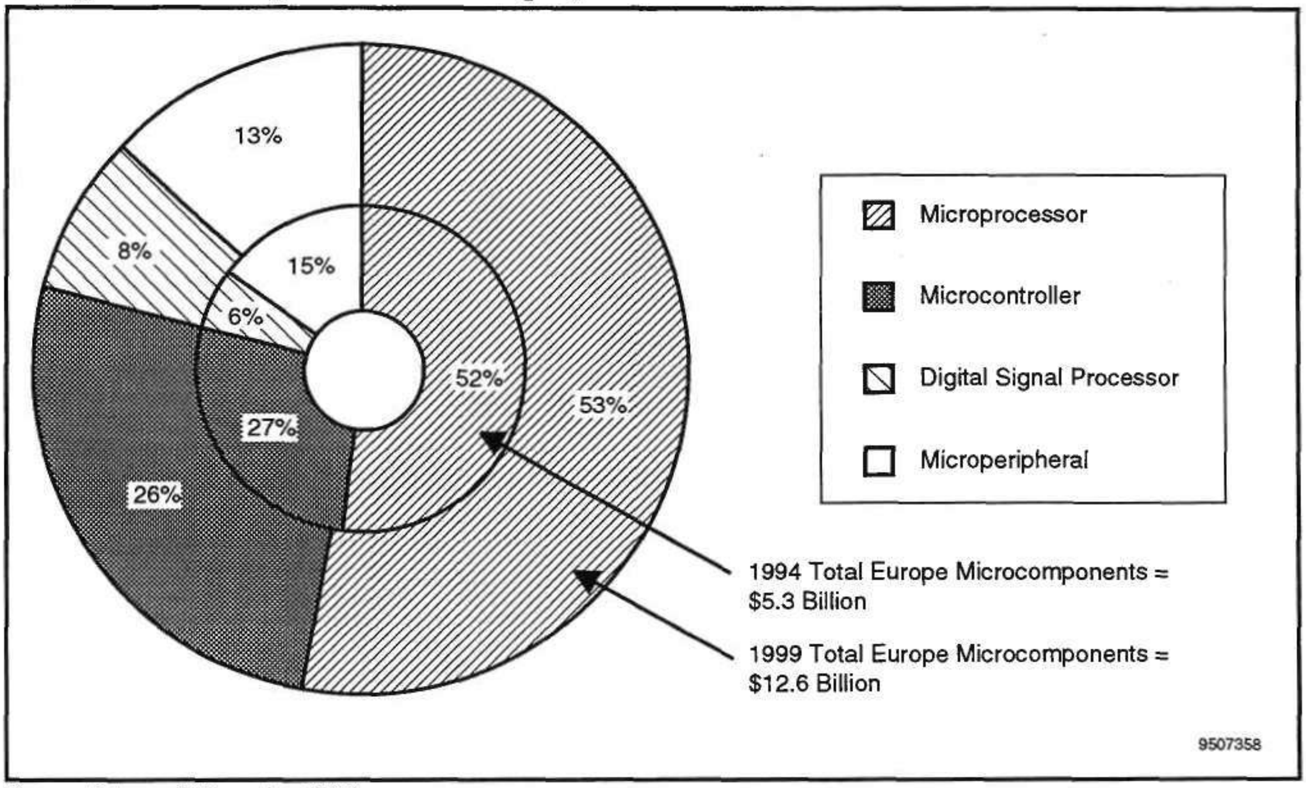
Source: Dataquest (December 1995)

Figure 3-14
Europe Microcomponent Revenue Forecast by Product Family, 1993-1999



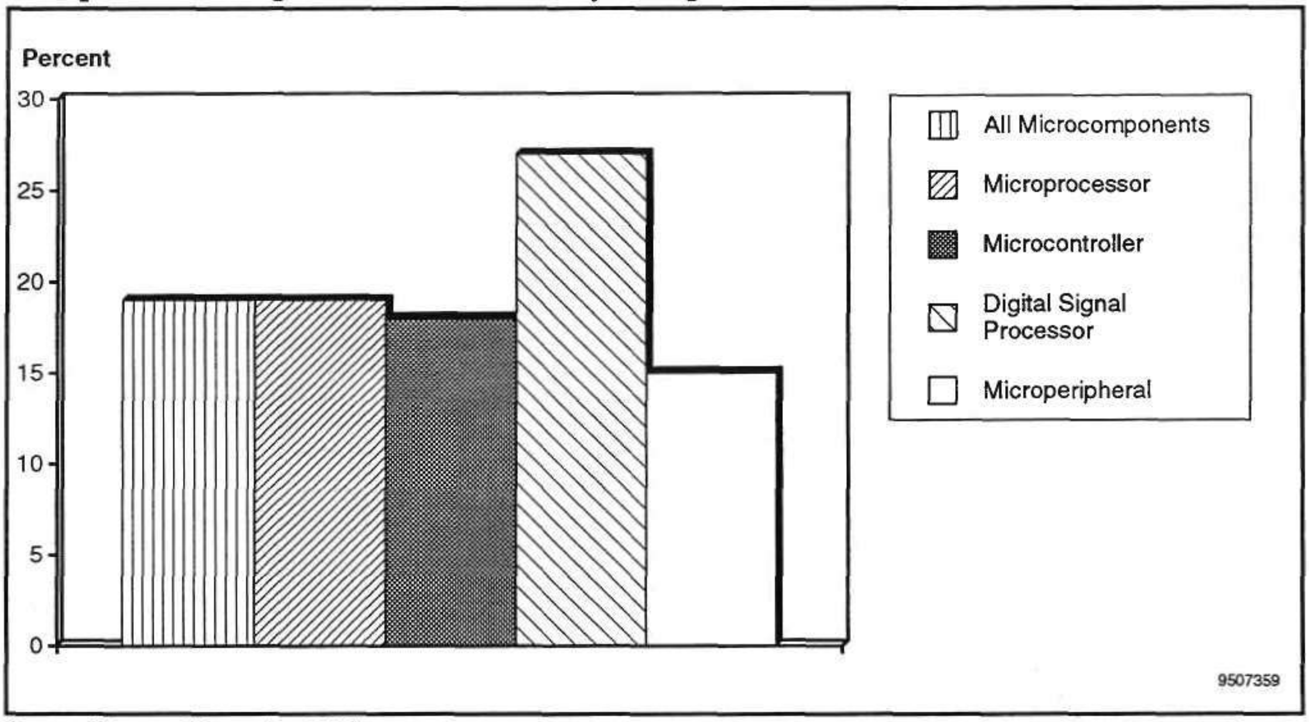
Source: Dataquest (December 1995)

Figure 3-15
Europe Microcomponent Product Split, 1994 and 1999



Source: Dataquest (December 1995)

Figure 3-16
Europe Microcomponent Product Family Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Asia/Pacific-ROW

The revenue forecast for microcomponents sold into Asia/Pacific-ROW for the next five years is shown in Table 3-5 by product family: all microprocessors, microcontrollers, DSPs, or microperipherals. Percentages are given for the product family's revenue in Asia/Pacific-ROW as a portion of all microcomponent and total semiconductor revenue in the region, as well as in the entire world.

Figure 3-17 shows each product family's revenue as a portion of microcomponent revenue in Asia/Pacific-ROW. Figure 3-18 shows each product family's revenue from Asia/Pacific-ROW. Figure 3-19 illustrates how the microcomponent product mix will change in Asia/Pacific-ROW from 1994 to 1999. Figure 3-20 shows the CAGR expected from 1994 through 1999 for sales of each product family into Asia/Pacific-ROW.

Table 3-5
Revenue Forecast of Microcomponent Shipments to Asia/Pacific-ROW by Product Family (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Total Semiconductors to Asia/Pacific-ROW	17,486	22,812	31,145	39,446	46,419	54,311	65,736	
Growth (%)	-	30.5	36.5	26.7	17.7	17.0	21.0	23.6
Percentage of Worldwide Semiconductors	20.4	20.6	20.8	21.6	22.1	22.8	23.8	
Total Microcomponents to Asia/Pacific-ROW	4,303	5,463	7,117	9,030	10,697	13,057	16,236	
Growth (%)	-	27.0	30.3	26.9	18.5	22.1	24.3	24.3
Percentage of Asia/Pacific-ROW Semiconductors	24.6	23.9	22.9	22.9	23.0	24.0	24.7	
Percentage of Worldwide Microcomponents	21.6	21.1	20.5	20.5	20.6	21.2	22.5	
Percentage of Worldwide Semiconductors	5.0	4.9	4.8	4.9	5.1	5.5	5.9	
Microprocessor	1,527	1,969	2,554	3,175	3,811	4,757	6,032	
Growth (%)	-	28.9	29.7	24.3	20.0	24.8	26.8	25.1
Percentage of Asia/Pacific-ROW Microcomponents	35.5	36.0	35.9	35.2	35.6	36.4	37.2	
Percentage of Asia/Pacific-ROW Semiconductors	8.7	8.6	8.2	8.0	8.2	8.8	9.2	
Percentage of Worldwide Microcomponents	7.7	7.6	7.4	7.2	7.3	7.7	8.3	
Percentage of Worldwide Semiconductors	1.8	1.8	1.7	1.7	1.8	2.0	2.2	
Microcontroller	1,260	1,469	1,924	2,350	2,770	3,457	4,384	
Growth (%)	-	16.6	31.0	22.1	17.9	24.8	26.8	24.4
Percentage of Asia/Pacific-ROW Microcomponents	29.3	26.9	27.0	26.0	25.9	26.5	27.0	
Percentage of Asia/Pacific-ROW Semiconductors	7.2	6.4	6.2	6.0	6.0	6.4	6.7	
Percentage of Worldwide Microcomponents	6.3	5.7	5.5	5.3	5.3	5.6	6.1	
Percentage of Worldwide Semiconductors	1.5	1.3	1.3	1.3	1.3	1.4	1.6	
Digital Signal Processor	63	138	190	260	351	461	610	
Growth (%)	-	119.0	37.7	36.8	35.0	31.3	32.3	34.6
Percentage of Asia/Pacific-ROW Microcomponents	1.5	2.5	2.7	2.9	3.3	3.5	3.8	
Percentage of Asia/Pacific-ROW Semiconductors	0.4	0.6	0.6	0.7	0.8	0.8	0.9	
Percentage of Worldwide Microcomponents	0.3	0.5	0.5	0.6	0.7	0.7	0.8	
Percentage of Worldwide Semiconductors	0.1	0.1	0.1	0.1	0.2	0.2	0.2	

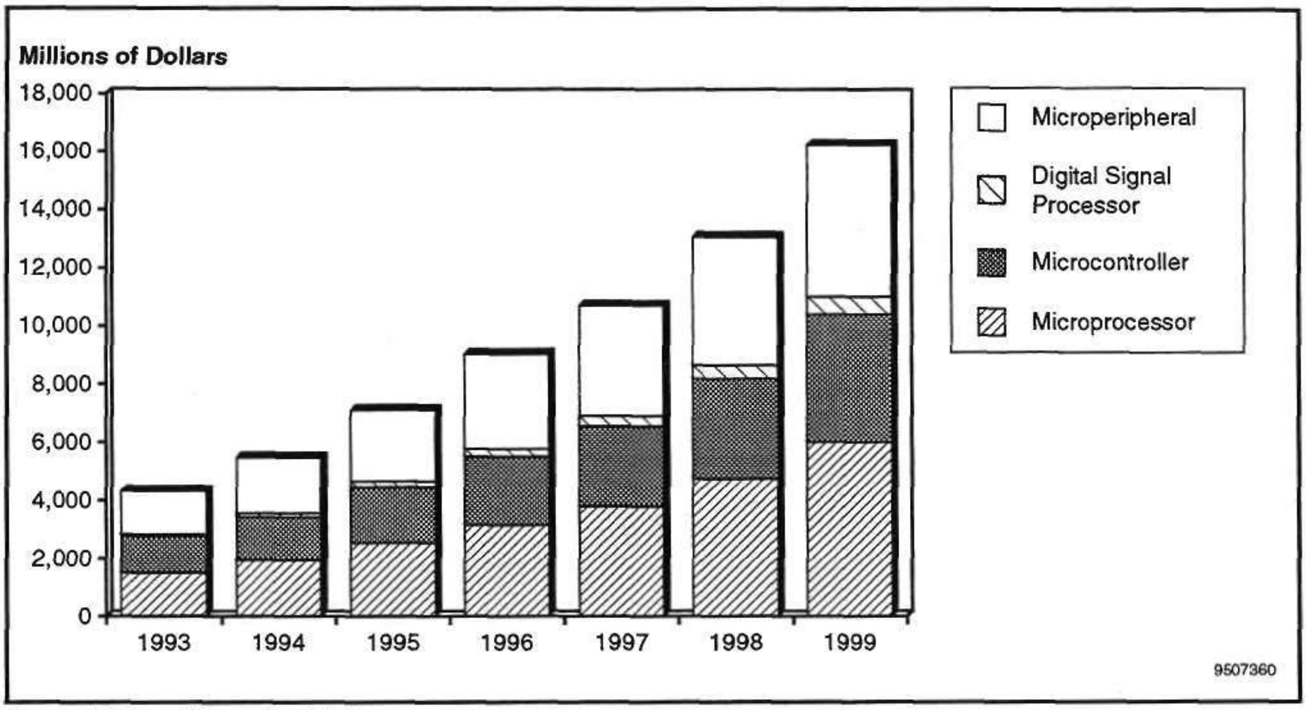
(Continued)

Table 3-5 (Continued)
Revenue Forecast of Microcomponent Shipments to Asia/Pacific-ROW by Product Family (Millions of Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Microperipheral	1,453	1,887	2,449	3,245	3,765	4,382	5,210	
Growth (%)	-	29.9	29.8	32.5	16.0	16.4	18.9	22.5
Percentage of Asia/Pacific-ROW Microcomponents	33.8	34.5	34.4	35.9	35.2	33.6	32.1	
Percentage of Asia/Pacific-ROW Semiconductors	8.3	8.3	7.9	8.2	8.1	8.1	7.9	
Percentage of Worldwide Microcomponents	7.3	7.3	7.1	7.4	7.2	7.1	7.2	
Percentage of Worldwide Semiconductors	1.7	1.7	1.6	1.8	1.8	1.8	1.9	

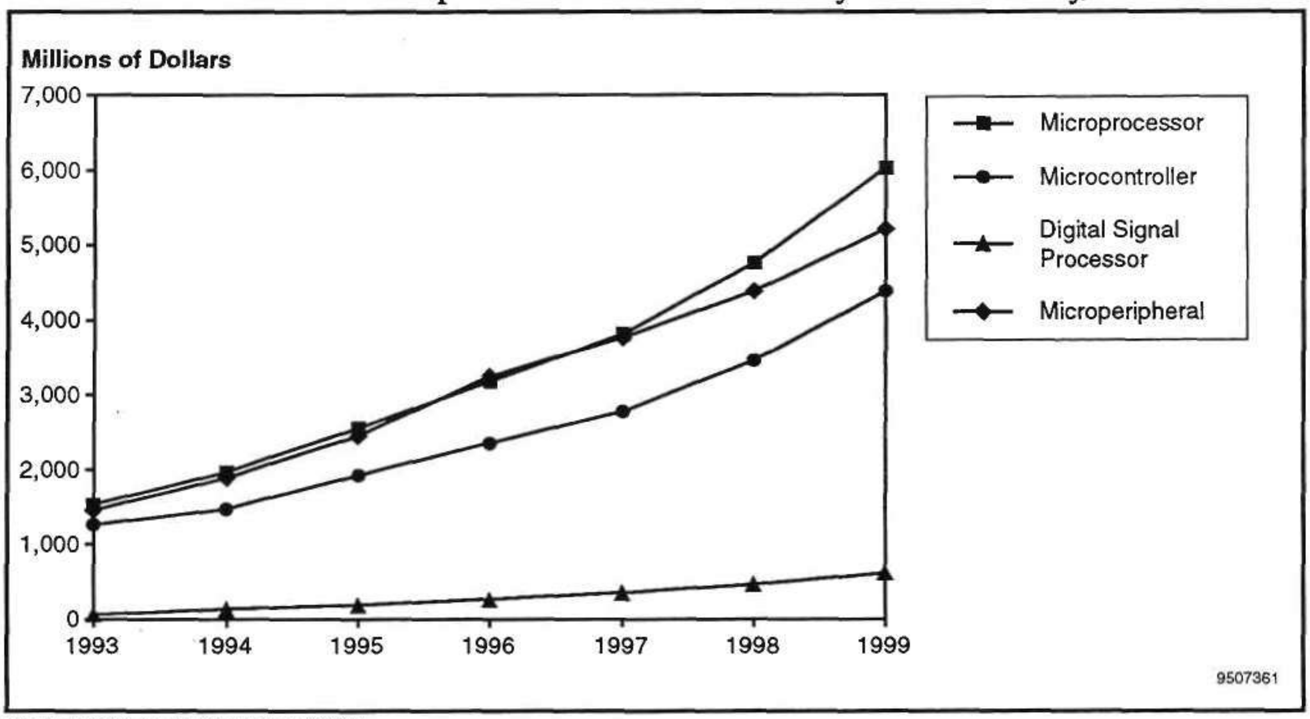
Source: Dataquest (December 1995)

Figure 3-17
Asia/Pacific-ROW Microcomponent Revenue Forecast Showing Product Family, 1993-1999



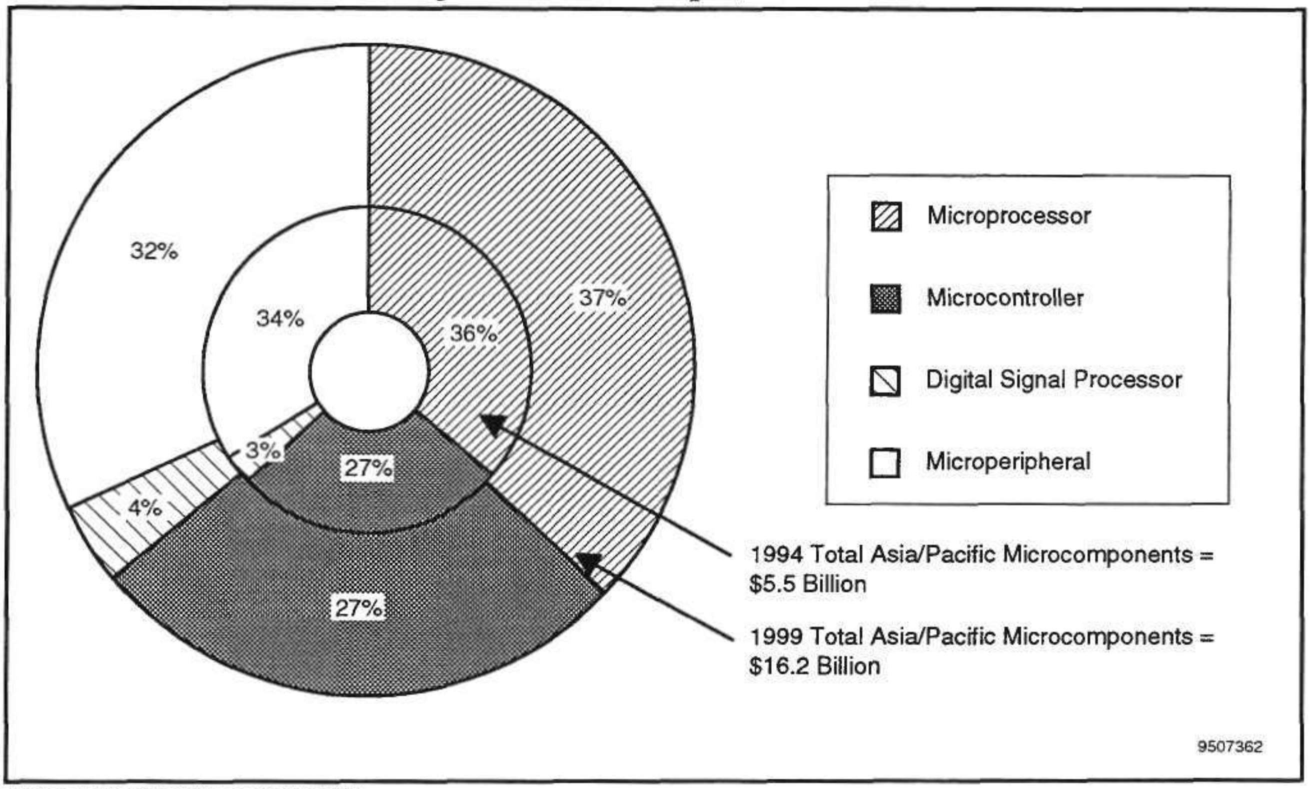
Source: Dataquest (December 1995)

Figure 3-18
Asia/Pacific-ROW Microcomponent Revenue Forecast by Product Family, 1993-1999



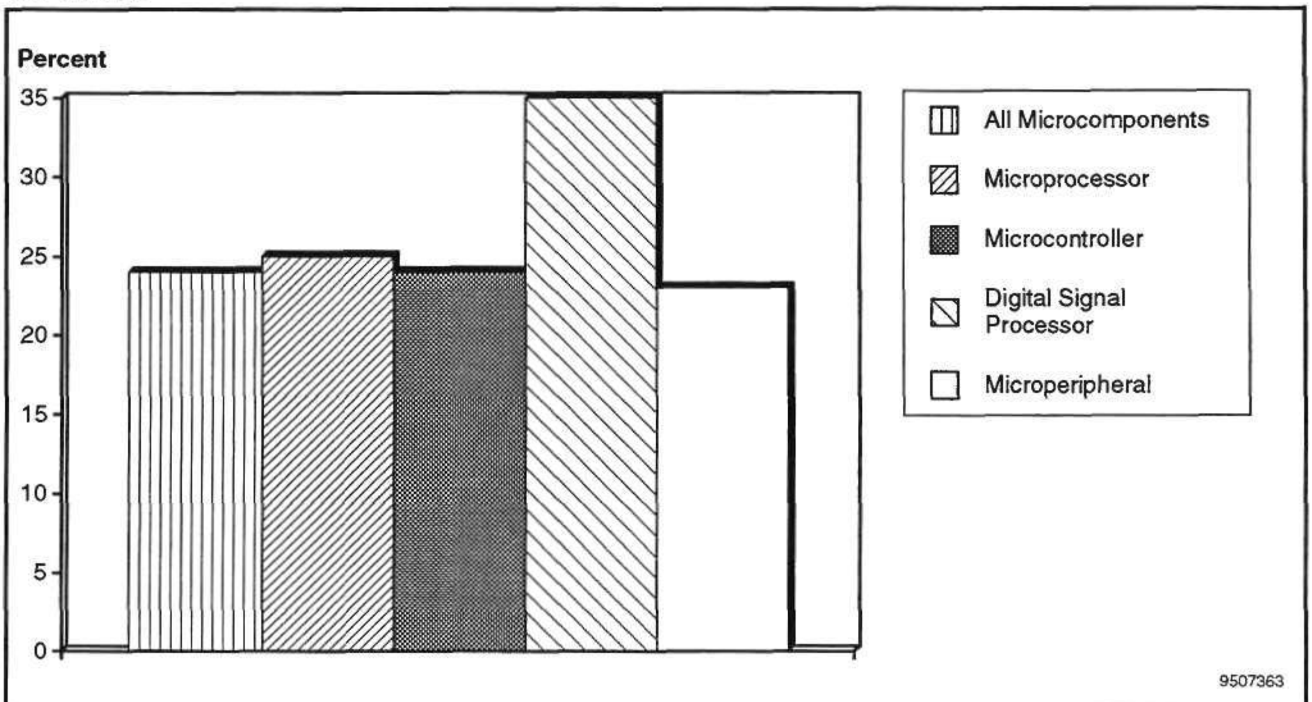
Source: Dataquest (December 1995)

Figure 3-19
Asia/Pacific-ROW Microcomponent Product Split, 1994 and 1999



Source: Dataquest (December 1995)

Figure 3-20
Asia/Pacific-ROW Microcomponent Product Family Compound Annual Growth Rate, 1994-1999



Source: Dataquest (December 1995)

Appendix A
Definitions of Terms and Regions

Definitions of Terms

Below are some definitions that will be helpful in understanding this document better.

Microcomponent: A category of digital integrated circuits (ICs) made up of microprocessors (MPUs), microcontrollers (MCUs), programmable digital signal processors (DSPs), and microperipherals (MPRs).

Microprocessor (MPU): An IC that includes an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic. It may contain an instruction cache or data cache. An MPU's functions are determined by fetching and executing instructions and manipulating data held in external memory or an internal cache. The MPU category includes MPUs incorporating, or originating from, an ASIC design. MPUs are divided into complex-instruction-set computer (CISC) or reduced-instruction-set computer (RISC) and 8-bit, 16-bit, or 32-bit and greater word width. MPUs are designed into compute or into embedded applications. A similar term is: processor.

Microcontroller (MCU): An IC similar to an MPU, the primary exception being that it is designed to operate from on-chip program and data memory (not including cache memories). Peripherals may be included on chip. MCU devices must be available with on-chip program or data store. As an option, some MCU devices can be purchased without on-chip memory. The MCU category includes MCUs incorporating, or originating from, an ASIC design. Standalone DSPs are not included with MCUs. MCUs are divided into 4-bit, 8-bit, or 16-bit and greater word width. All MCUs are designed into embedded applications. A similar term is: microcomputer.

Programmable Digital Signal Processor (DSP, pDSP): An IC composed of a high-speed arithmetic unit (typically a multiplier-accumulator unit) used for performing complex mathematical operations for manipulating signal data, such as Fourier transforms. Digital signal processors having no version that can be reprogrammed by the user are not included, but are categorized as application-specific special products (ASSPs). When integrated on chip with an MPU or MCU, DSPs are classified as either MPUs or MCUs, respectively. All DSPs are designed into embedded applications.

Microperipheral (MPR): An IC that serves as a logical support function to an MPU in a system. This definition includes MPRs comprising more than one device, such as PC or core logic chipsets. The MPR category includes MPRs incorporating, or originating from, an ASIC design. All microperipherals are designed into embedded applications. A similar term is: peripheral.

Merchant versus Captive Consumption: Dataquest includes all revenue, both merchant and captive, for semiconductor suppliers selling to the merchant market. The data excludes completely captive suppliers where devices are manufactured solely for the company's own use. A product that is used internally is valued at market price rather than at transfer or factory price.

Regional Definitions

The regional definitions are expected to change somewhat in 1996.

North America Region: Includes Canada, Mexico, and the United States.

Japan Region: Japan is the only single-country region.

Europe Region: Includes Western Europe and Eastern Europe regions.

- Western Europe Region: Includes Austria, Belgium, Denmark, Eire (Ireland), Finland, France, Germany (including former East Germany), Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and rest of western Europe (Andorra, Cyprus, Gibraltar, Liechtenstein, Monaco, San Marino, Vatican City, Iceland, Malta, and Turkey).
- Eastern Europe Region: Includes Albania, Bulgaria, the Czech Republic and Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the republics of the former Yugoslavia, and the republics of the former USSR (Belarus, Russian Federation, Ukraine, Georgia, Moldavia, Armenia, Azerbaijan, Kazakhstan, Uzbekistan, Tadjikistan, Kyrgyzstan, and Turkmenistan).

Asia/Pacific Region: Includes Asia/Pacific's newly industrialized economies (NIEs) and the rest of Asia/Pacific regions. NIEs include Hong Kong, Singapore, Korea, and Taiwan. The rest of the Asia/Pacific region includes Australia, Brunei, Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam.

Rest of World (ROW) Region: Includes Africa, Caribbean, Central America, Middle East, Oceania, and South America. Usually included with Asia/Pacific.

Appendix B
Exchange Rates

Average annual exchange rates are used for revenue history as outlined in Table B-1; the 1995 "average" exchange rate is extended into the 1995-to-1999 forecast horizon. Dataquest does not forecast exchange rates. Unless noted otherwise, all revenue amounts are given in U.S. dollars.

Table B-1
Exchange Rates

	1992	1993	1994	1995
Japan (Yen/U.S.$)	126.45	112.20	101.96	88.12
France (Franc/U.S.$)	5.27	5.67	5.91	4.94
Germany (Deutsche Mark/U.S.$)	1.56	1.66	1.74	1.41
United Kingdom (U.S.$/Pound Sterling)	1.77	1.50	1.49	1.61
European Community (U.S.$/ECU)	0.770	0.858	0.896	0.770

Source: Dataquest (November 1995)

For More Information...

Tom Starnes, Director/Principal Analyst .... (512) 794-7755
Internet address .... tstarnes@dataquest.com
Via fax .... (512) 794-7778

Dataquest
A Gartner Group Company

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA
Worldwide Headquarters
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: 1-408-468-8000
Facsimile: 1-408-954-1780

East Coast Headquarters
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6262

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

Sales Offices:
Washington, DC (Federal)
New York, NY (Financial)
Dallas, TX

LATIN AMERICA
Research Affiliates and Sales Offices:
Buenos Aires, Argentina
Sao Paulo, Brazil
Santiago, Chile
Mexico City, Mexico

EUROPE
European Headquarters
Holmers Farm Way
High Wycombe, Bucks HP12 4XH
United Kingdom
Phone: +44 1494 422 722
Facsimile: +44 1494 422 742

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33 1 41 35 13 00
Facsimile: +33 1 41 35 13 13

Dataquest Germany
Kronstadter Strasse 9
81677 München
Germany
Phone: +49 89 93 09 09 0
Facsimile: +49 89 93 03 27 7

Sales Offices:
Brussels, Belgium
Kfar Saba, Israel
Milan, Italy
Randburg, South Africa
Madrid, Spain

JAPAN
Japan Headquarters
Shinkawa Sanko Building
6th Floor
1-3-17, Shinkawa
Chuo-ku, Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

ASIA/PACIFIC
Asia/Pacific Headquarters
7/F China Underwriters Centre
88 Gloucester Road
Wan Chai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei
Taiwan, R.O.C.
Phone: 8862-756-0389
Facsimile: 8862-756-2663

Dataquest Singapore
105 Cecil Street
#06-01/02 The Octagon
Singapore 069534
Phone: 65-227-1213
Facsimile: 65-227-4607

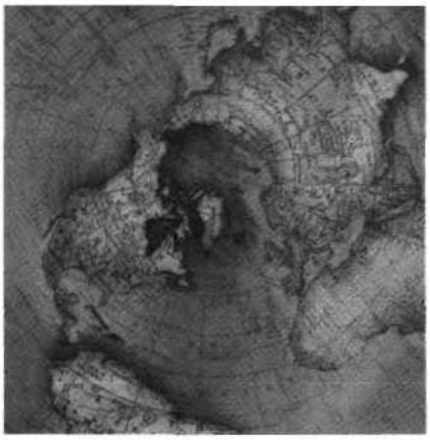
Dataquest Thailand
12/F, Vanissa Building
29 Soi Chidlom
Ploenchit Road
Patumwan, Bangkok 10330
Thailand
Phone: 662-655-0577
Facsimile: 662-655-0576

Research Affiliates and Sales Offices:
Melbourne, Australia
Beijing, China

Dataquest
A Gartner Group Company

MCRO-WW-MT-9504 Qty: 1
Ms. Maria Valenzuela
Dataquest Incorporated
1-1100

--INTERNAL DIST.--



Dataquest

The Microcontrollers March On—The Forecast

Market Trends

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MT-9503
Publication Date: December 25, 1995
Filing: Market Analysis

The Microcontrollers March On—The Forecast

Market Trends

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MT-9503
Publication Date: December 25, 1995
Filing: Market Analysis

Table of Contents

List of Figures

List of Tables

Chapter 1
Introduction

Like the insects that thrive in warm, moist climates, microcontrollers (MCUs) aren't seen very often but lie just below the surface of most of the electronic products you see. There are no warning labels of something "inside," but you can almost hear them scratching. And they're growing as you watch. And multiplying when you're not. Although all those real bugs must be good for our lives somehow, it can be stated with more confidence that our lives are better with all those MCUs around. And there are no ice ages on the horizon to thin out the population of microcontrollers. So they'll be here for a while.

In this report, Dataquest forecasts the changes expected for the microcontroller market in the next five years. MCUs continue to be one of the top growth areas in semiconductors. Eight-bit MCUs continue to dominate, 4-bit MCUs are leveling off, and 16-bit and larger MCUs are in rapid growth. This report projects the future of microcontrollers in word width, regions, and applications, and gives insight into factors that influence this future. Leading vendors are reviewed, and overall trends are discussed.

Definitions

The following are some definitions that will be helpful in understanding this document better. Note that the definitions of the regions are expected to change somewhat in 1996.

Microcontroller (MCU): An IC that includes an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic and is designed to operate from on-chip program and data memory (not including cache memories). The MCU's functions are determined by fetching and executing instructions and manipulating data held in on-chip program and data memory (not including cache memories). Peripherals may be included on-chip. MCU devices must be available with on-chip program or data store. As an option, some MCU devices can be purchased without on-chip memory. The MCU category includes MCUs incorporating, or originating from, an ASIC design. Microcomputer is an acceptable equivalent term for microcontroller. Standalone digital signal processors are not included with MCUs. All MCUs are designed into embedded applications.

Word Width: The width, in bits, of the on-chip integer unit. This measurement is independent of the data bus width or any other bus associated with the device being discussed. Sometimes referred to as bit size. MCUs are categorized as 4-bit, 8-bit, or 16-bit and greater word width.

North America Region: Includes Canada, Mexico, and the United States.

Japan Region: Japan is the only single-country region.

Western Europe Region: Includes Austria, Belgium, Denmark, Eire (Ireland), Finland, France, Germany (including former East Germany), Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the rest of western Europe (Andorra, Cyprus, Gibraltar, Liechtenstein, Monaco, San Marino, Vatican City, Iceland, Malta, and Turkey).

Eastern Europe Region: Includes Albania, Bulgaria, the Czech Republic and Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the republics of the former Yugoslavia, and the republics of the former USSR (Belarus, Russian Federation, Ukraine, Georgia, Moldova, Armenia, Azerbaijan, Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, and Turkmenistan).

Asia/Pacific Region: Includes Asia/Pacific's newly industrialized economies (NIEs) and the rest of the Asia/Pacific region. NIEs include Hong Kong, Singapore, Korea, and Taiwan. The rest of the Asia/Pacific region includes Australia, Brunei, Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam.

Rest of World (ROW) Region: Includes Africa, Caribbean, Central America, Middle East, Oceania, and South America. Usually included with Asia/Pacific.

Exchange Rates. Average annual exchange rates are used for revenue history as outlined in Table 1-1; the 1995 "average" exchange rate is extended into the 1995-to-1999 forecast horizon. Dataquest does not forecast exchange rates.

Table 1-1
Exchange Rates

	1993	1994	1995
Japan (Yen/U.S.$)	112.20	101.96	88.12
France (Franc/U.S.$)	5.67	5.91	4.94
Germany (Deutsche Mark/U.S.$)	1.66	1.74	1.41
United Kingdom (U.S.$/Pound)	1.50	1.49	1.61
European Community (U.S.$/ECU)	0.858	0.896	0.770

Source: Dataquest (November 1995)

Chapter 2
Regions and Vendors

Business has simply been booming for semiconductors in general and microcontrollers in particular. The revenue projection for microcontrollers in five years is over $20 billion (see Table 2-1 and Figure 2-1). This is 30 percent higher than last year's five-year forecast. The growth in the microcontroller business for 1994 was another astounding 27.3 percent, and 1995 promises to grow even more, hampered mostly by the ability of the producers to supply sufficient product. Only DRAMs and microprocessors (MPUs) outshine microcontrollers for growth coupled with revenue, and those product categories are obviously driven most strongly by the personal computer industry. Microcontrollers, on the other hand, go into a vast array of products, spanning all electronics industries and insulating them from a single industry's ups and downs.

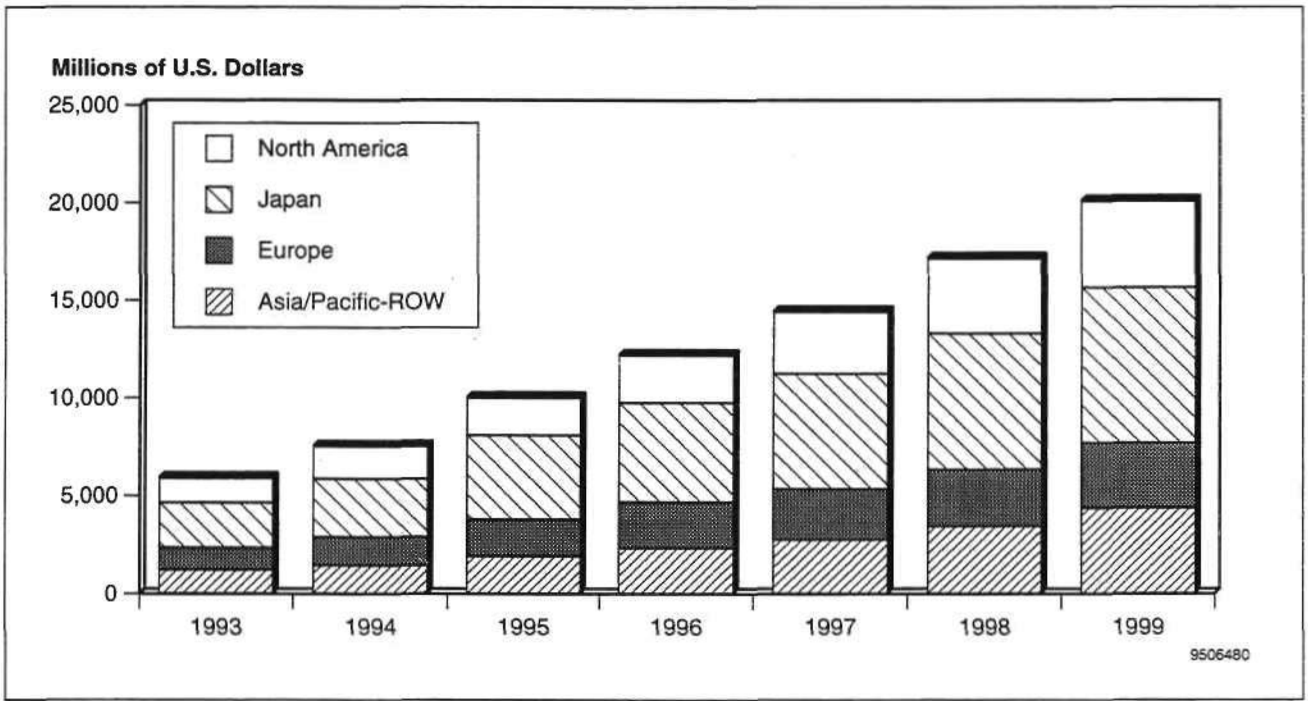
Japan continues to consume the highest dollar value of microcontrollers (see Figure 2-2), as well as 60 percent of the units shipped in the world, skewed heavily by the low-cost 4-bit MCUs. Market shares for Japan as well as North America are expected to remain fairly constant over the foreseeable future. Europe should lose a couple of percentage points, and Asia/Pacific should gain a couple over the next five years, with Europe and Asia/Pacific reflecting lower and higher compound annual growth rates (CAGR), respectively (see Figures 2-3 and 2-4).

Table 2-1
Microcontroller Revenue Forecast by Region (Millions of U.S. Dollars)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Worldwide	5,904	7,517	10,005	12,209	14,430	17,157	20,099	21.7
Growth (%)		27.3	33.1	22.0	18.2	18.9	17.1	
North America	1,254	1,652	1,910	2,450	3,175	3,825	4,425	21.8
Growth (%)		31.7	15.6	28.3	29.6	20.5	15.7	
Japan	2,284	2,964	4,283	5,075	5,911	6,985	7,968	21.9
Growth (%)		29.8	44.5	18.5	16.5	18.2	14.1	
Europe	1,106	1,432	1,888	2,334	2,574	2,890	3,322	18.3
Growth (%)		29.5	31.8	23.6	10.3	12.3	14.9	
Asia/Pacific—ROW	1,260	1,469	1,924	2,350	2,770	3,457	4,384	24.4
Growth (%)		16.6	31.0	22.1	17.9	24.8	26.8	

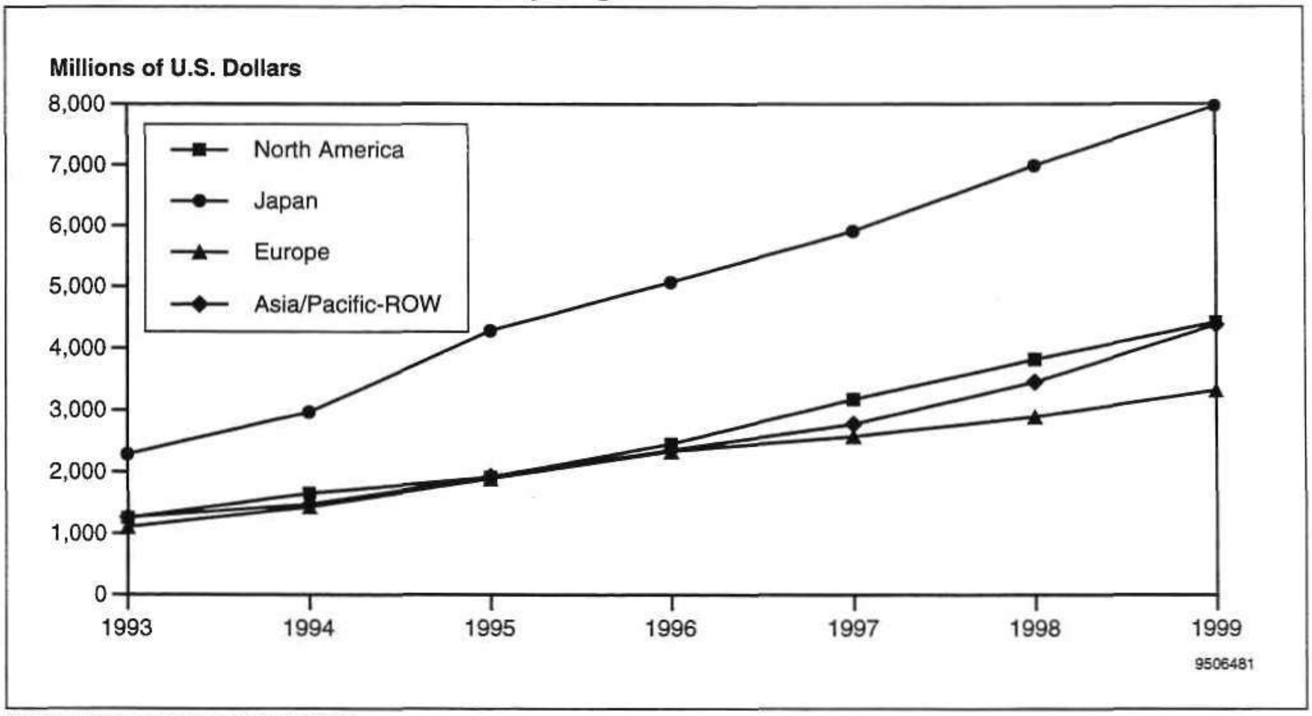
Source: Dataquest (November 1995)

Figure 2-1
Microcontroller Revenue Forecast



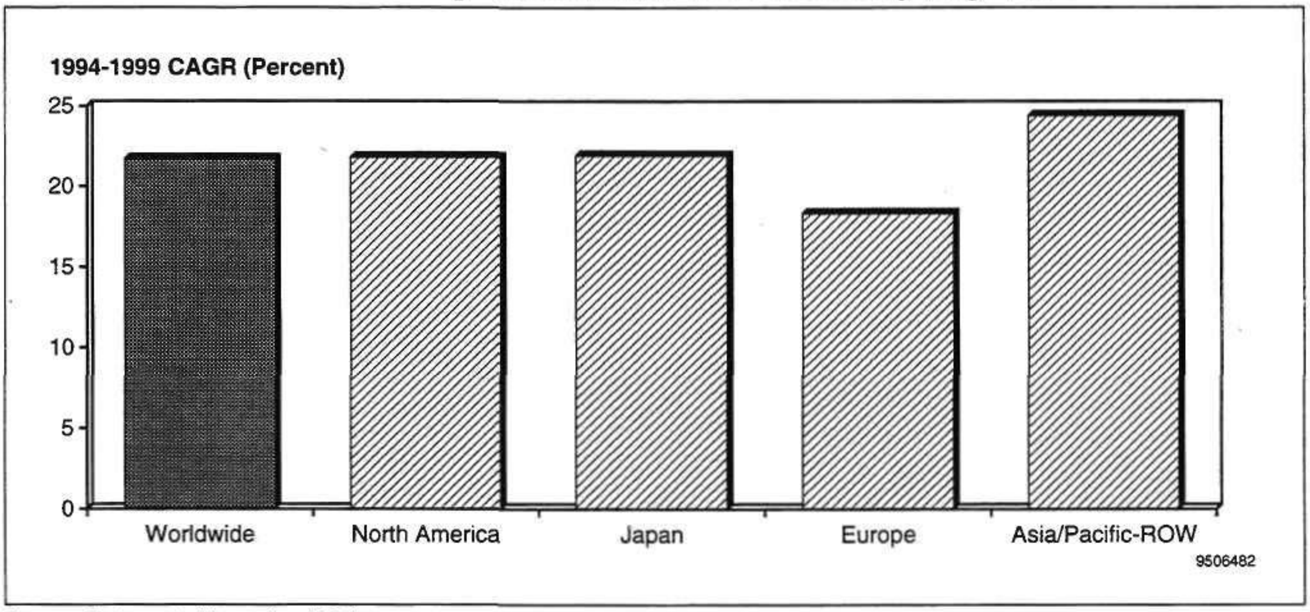
Source: Dataquest (November 1995)

Figure 2-2
Microcontroller Revenue Forecast by Region



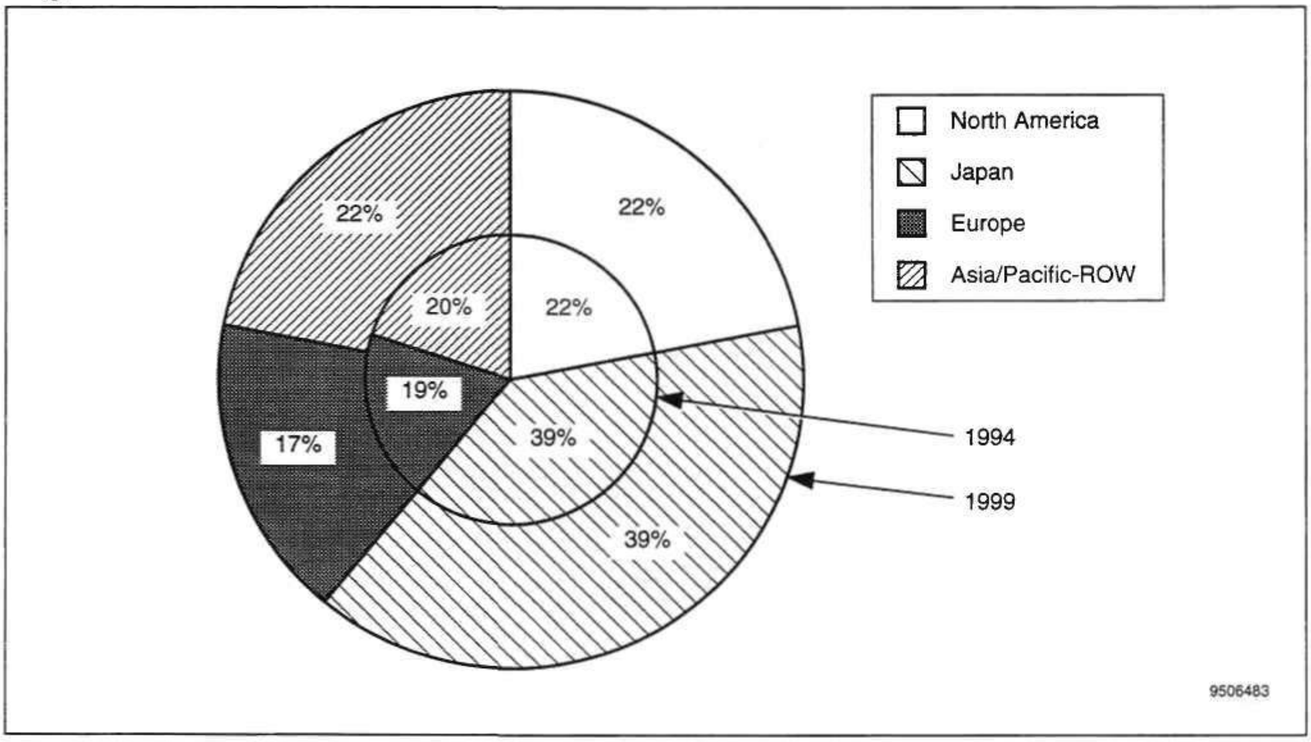
Source: Dataquest (November 1995)

Figure 2-3
Microcontroller Revenue Compound Annual Growth Rate by Region, 1994-1999



Source: Dataquest (November 1995)

Figure 2-4
Regional Microcontroller Market Share



Source: Dataquest (November 1995)

It's Stable at the Top

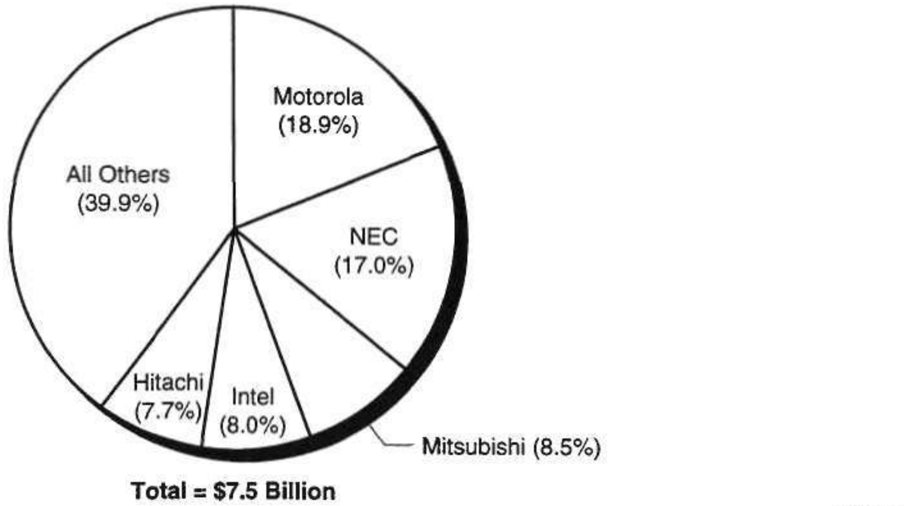
Motorola continues to hold the No. 1 position in the microcontroller marketplace, which it gained in 1993 in spite of not even participating in the 4-bit arena and only starting to play on the 16-bit field (see Table 2-2 and Figure 2-5). (Greater detail is available in Dataquest's *Final 1994 Microcontroller Market Share and Shipments*, MCRO-WW-MS-9502, June 19, 1995.) Motorola has amassed a repertoire of hundreds of varieties of 8-bit microcontrollers, from low-end MCUs selling for less than a dollar to peripherals-rich parts for more sophisticated applications. Many of these products are very focused on specific applications, ideally hitting feature/price points. Motorola addresses virtually every 8-bit marketplace with its microcontrollers, dominating some markets, such as automotive.

Table 2-2
Top Five Microcontroller Vendors (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1994 Revenue	1993 Revenue	Change (%)	1994 Market Share (%)
1	1	Motorola	1,424	1,107	29	18.9
2	2	NEC	1,275	1,100	16	17.0
3	3	Mitsubishi	637	465	37	8.5
4	5	Intel	600	450	33	8.0
5	4	Hitachi	577	458	26	7.7

Source: Dataquest (November 1995)

Figure 2-5
Top Five Microcontroller Vendors' Market Share, 1994



Source: Dataquest (November 1995)

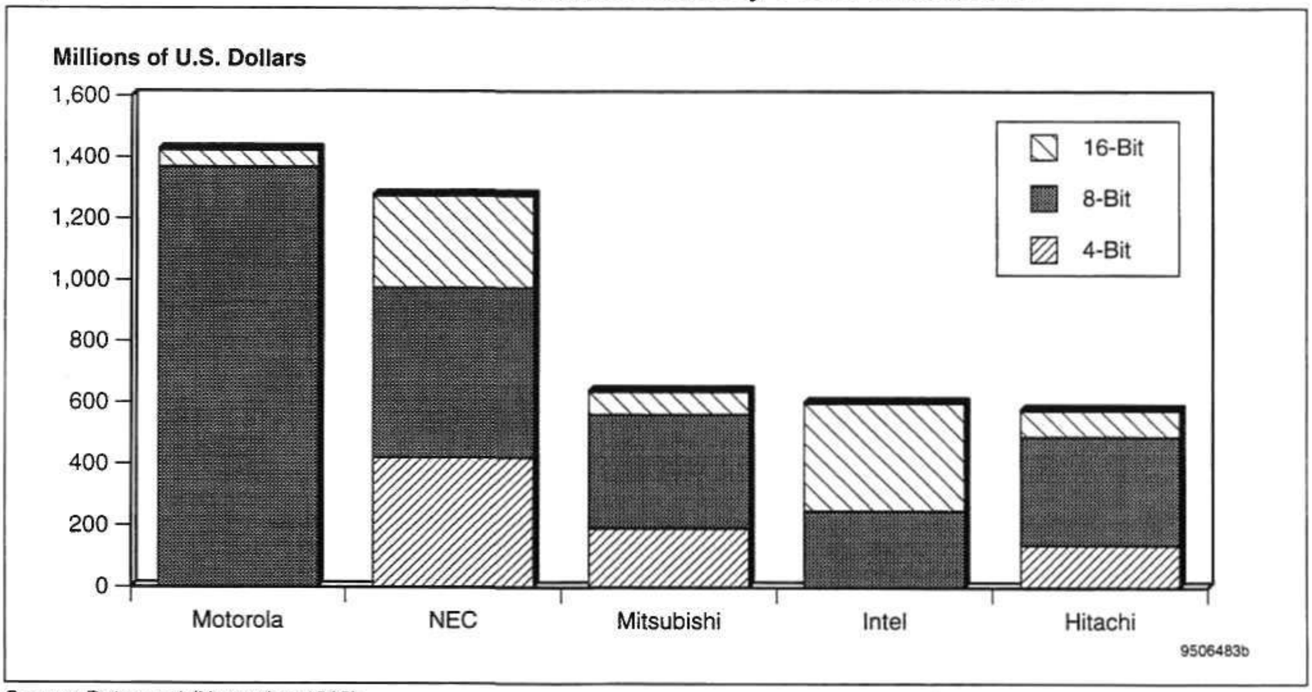
Motorola's MCUs outsell others by 60 percent to 110 percent in all regions except Japan, where less than 5 percent of the market has been secured. This pervasiveness has allowed Motorola to ship more than 2 billion microcontrollers, essentially all 8-bit, and it shows no signs of slowing down.

NEC follows in the No. 2 position with its uPD products, not far behind Motorola. NEC has instituted a strategy of covering all three sizes of microcontrollers. Motorola's and NEC's different strategies are graphically illustrated in Figure 2-6. NEC holds on to the No. 1 position in 4-bit MCUs, leading any other vendor by twice as much. In 8-bit MCUs, NEC is firmly No. 2 behind Motorola, although it would have to increase its revenue by 2.5 times to catch No. 1. On the other hand, it is head and shoulders above any other 8-bit vendor. NEC also holds the No. 2 position in 16-bit microcontrollers, 15 percent behind Intel in this smaller, growing market. NEC sells two-thirds of its microcontrollers within its home-base country, Japan, and could extend its market share if it better penetrated the North America and Asia/Pacific regions.

Psst! Want to Buy an MCU?

The ability of vendors to supply the needs of their customers continues to limit the microcontroller marketplace, as is true of many semiconductor markets. A watchful eye over the mix of products being produced and an accurate forecast of customers' short-term needs will help vendors to maximize the return on their fab investments. The inability of vendors to satisfy the demands of their customers sets up ripe opportunities for more nimble, focused, or dedicated competitors to win business. This business is more difficult to win back when times are not so good.

Figure 2-6
Top Five Microcontroller Vendors' Market Share by Word Width, 1994



Source: Dataquest (November 1995)

Inadequate supply can also slow the movement from lower- to higher-performance MCUs. This factor helped delay the transition from 4-bit to 8-bit MCUs. When a vendor cannot make enough 8-bit microcontrollers to meet demand, there is little motivation to lower prices. Lower prices would attract more 4-bit designs to upgrade. But steady prices hold the upgrades to those designs requiring features or performance available only on 8-bit MCUs. Also, the customer might think it best to stick with the old 4-bit vendor with which there is an established relationship. If the 4-bit vendor does not have a strong 8-bit microcontroller, regardless of the state of capacity, that vendor is going to work hard to satisfy the customer's needs or risk losing the customer to a higher-performing product, which could easily be a competitor's. Indeed, the last year has seen a 20 percent increase in 4-bit revenue.

Chapter 3
Bit by Bit

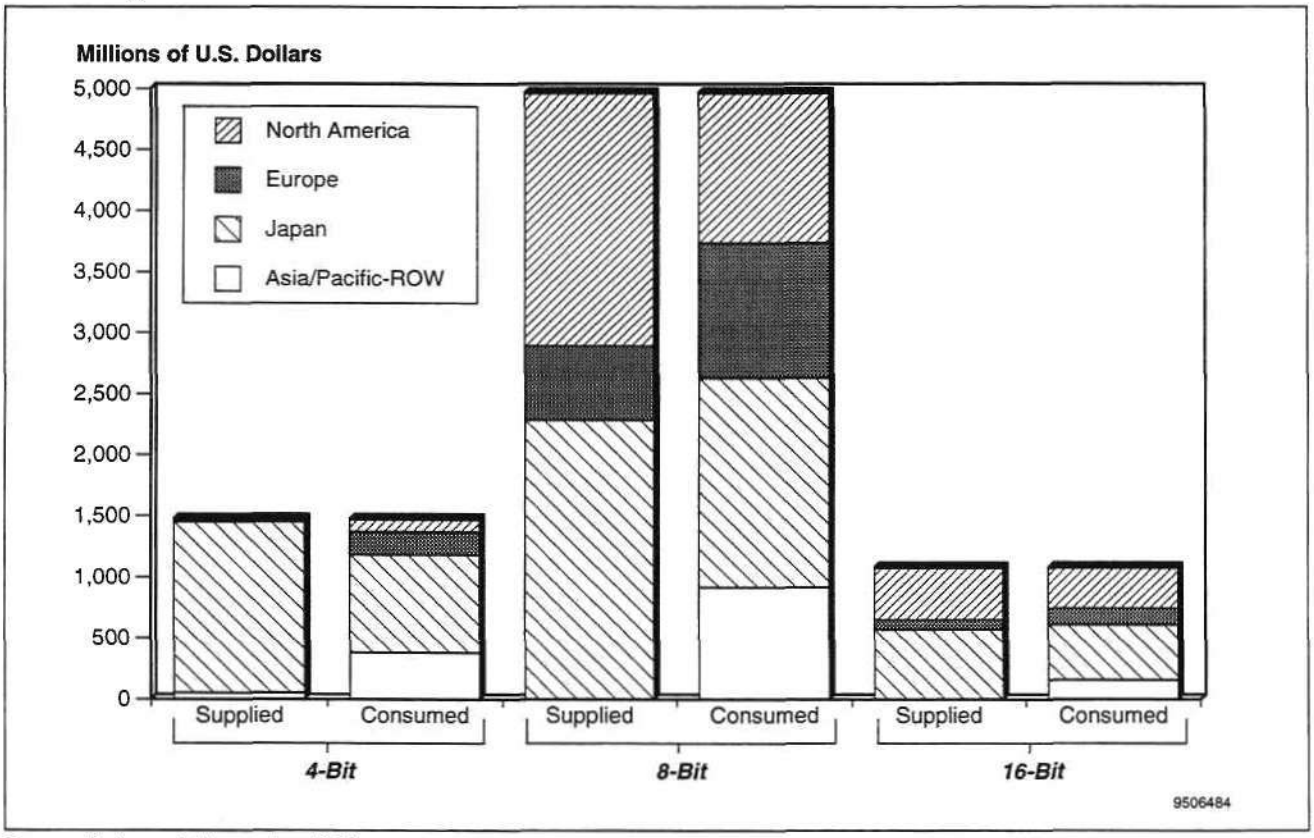
Microcontrollers fall into a classification based on the number of bits that the arithmetic logic unit (ALU) can process in a single cycle. MCUs are classed as 4-bit, 8-bit, or 16-bit and up and are forecast accordingly. Projections for 4-, 8-, and 16-bit and up microcontrollers for the next five years and for revenue and unit shipments are provided later in this chapter.

Those 4-Bitters Are Still Around

Previously, 4-bit microcontrollers were expected to taper off fairly sharply. However, the tenacity of the vendors seems to have proven that prior forecasts were premature. New uses of the simplest of MCUs continue to appear, and a chip for ¥50 is pretty hard to turn down. Remote controls are on everything from the traditional TVs and stereos to car door locks and auto and home security systems. The aftermarket universal remote control market also continues. For $10 to $20, a consumer can collapse three or four remotes into one (while the original three or four sit in a drawer, their MCUs rarely operating—but they got sold).

As indicated in Figure 3-1, 4-bit microcontrollers are sold almost exclusively by Japanese companies, and the great bulk of 4-bit MCUs is bought by Japanese companies. The natural desire of Japanese companies to

Figure 3-1
1994 Microcontroller Revenue by Word Width Showing Region of Supply and Region of Consumption



Source: Dataquest (November 1995)

purchase from regional vendors would also slow the move to 8-bit microcontrollers, which are supplied by a much wider base of vendors.

Also contributing to what appears to be a 4-bit resurgence, as well as resurgence of Japanese vendors in general, is the continuing decline of Japan's currency. With more than a 10 percent degradation in the yen in the last year, both the near term and the more distant years in the revenue forecast for Japan are automatically more than 10 percent higher than earlier expectations. Four-bit MCU revenue is expected to level off at just over $2 billion in about two years before starting to drop, although significant increases in unit volume will be necessary to support even these levels.

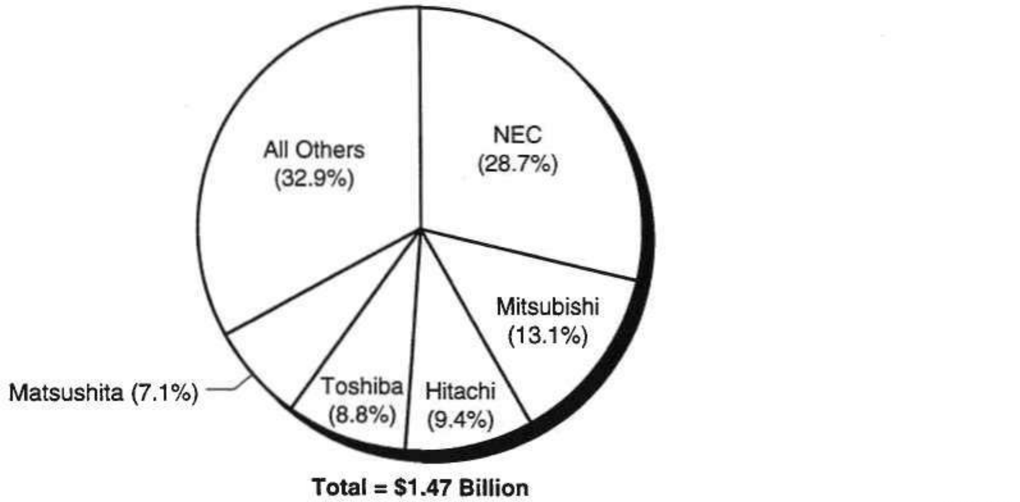
NEC continues to lead the providers of 4-bit microcontrollers, Toshiba overtook Matsushita, and there were only minor changes in ranking for the top 10, where $5 million or $10 million may separate contenders (see Table 3-1 and Figure 3-2).

Table 3-1
Top Five 4-Bit Microcontroller Vendors (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1994 Revenue	1993 Revenue	Change (%)	1994 Market Share (%)
1	1	NEC	422	650	-35	28.7
2	2	Mitsubishi	192	170	13	13.0
3	3	Hitachi	139	161	-14	9.4
4	5	Toshiba	129	114	13	8.8
5	4	Matsushita	105	132	-20	7.1

Source: Dataquest (November 1995)

Figure 3-2
Top Five 4-Bit Microcontroller Vendors' Market Share, 1994



Source: Dataquest (November 1995)

8-Bit: The Winner and Still Champion . . .

The 8-bit microcontroller market surged 38 percent in 1994, providing $1,375 million of the $1.6 billion that the entire microcontroller market gained in 1994. 8-bit microcontrollers are king and are expected to stay on top of 4-bit and even the higher-priced 16-bit products for the foreseeable future. The boundaries of 8-bit MCUs continue to expand as, at one end of the spectrum, simpler and smaller versions come out and, at the higher end, 16-bit capabilities, DSP functionality, and more sophisticated peripherals become available. The combination of features and price seems to be ideal at the 8-bit level for the applications that microcontrollers typically support so well.

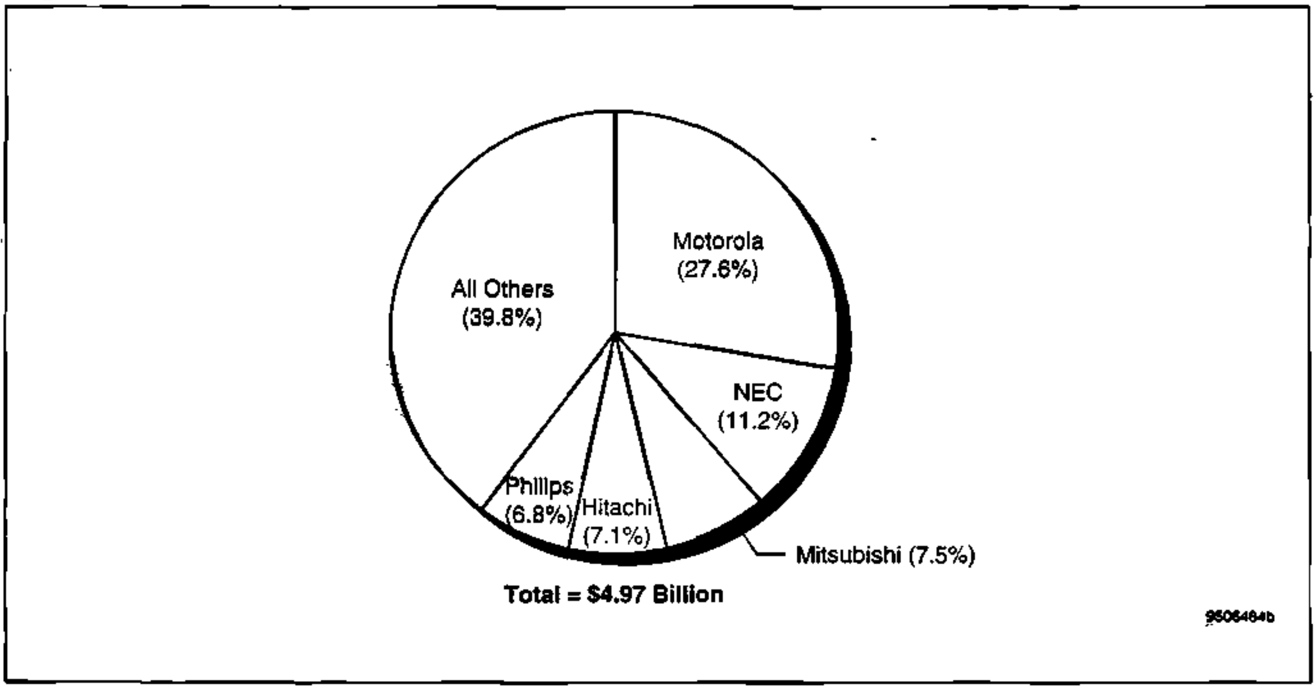
Motorola continues to lead the pack in 8-bit microcontrollers, commanding over 27 percent market share, with more than 25 contenders following a good distance behind (see Table 3-2 and Figure 3-3.) However, in 1994,

Table 3-2
Top Five 8-Bit Microcontroller Vendors (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1994 Revenue	1993 Revenue	Change (%)	1994 Market Share (%)
1	1	Motorola	1,369	1,097	25	27.6
2	2	NEC	554	274	102	11.2
3	5	Mitsubishi	371	250	48	7.5
4	4	Hitachi	352	257	37	7.1
5	3	Philips	340	258	32	6.8

Source: Dataquest (November 1995)

Figure 3-3
Top Five 8-Bit Microcontroller Vendors' Market Share, 1994



Source: Dataquest (November 1995)

No. 2 NEC doubled its 8-bit revenue, extending its lead over the top-10 pack, although currency fluctuations account for some of that gain. Mitsubishi moved from No. 5 to No. 3, but the repositioning of No. 2 through No. 10 should change frequently in the coming years. The horse moving up from the back of the pack is Microchip Technology, executing a successful strategy that could make it a major player in the top five.

The Big Ones Are Growing

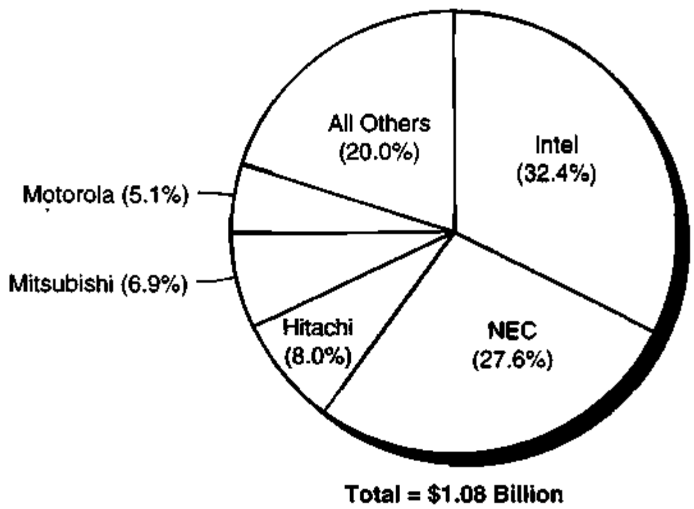
The use of 16-bit microcontrollers is expected to increase in the next few years, with even some 32-bit microcontrollers hitting the streets. The 196 and others in disk controllers continue to be big in the 16-bit market, although applications such as auto engine control and digital cellular phones will be growth areas. Intel continues to lead in 16-bit MCUs (see Table 3-3 and Figure 3-4), but in this growing, immature market has

Table 3-3
Top Five 16-Bit Microcontroller Vendors (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1994 Revenue	1993 Revenue	Change (%)	1994 Market Share (%)
1	1	Intel	350	250	40	32.4
2	2	NEC	299	176	70	27.7
3	4	Hitachi	86	40	115	8.0
4	3	Mitsubishi	74	45	64	6.9
5	9	Motorola	55	10	450	5.1

Source: Dataquest (November 1995)

Figure 3-4
Top Five 16-Bit Microcontroller Vendors' Market Share, 1994



Source: Dataquest (November 1995)

slipped from 45 percent to 33 percent market share, with NEC only 5 percent behind. Behind those two are a dozen companies in positions that could change very quickly. Motorola seems to be coming to life with its 68HC16 products, while Fujitsu has made inroads into the disk drive business. Hitachi's H8/500 series has had some success, and Microchip Technology has just introduced its 16-bit lines. The higher average selling prices (ASPs) and relative openness in the 16-bit marketplace make it an attractive playing field for vendors. Established relationships and listening to customers will improve the chances for success here.

But What about 32-Bit Microcontrollers?

A traditional microcontroller with 32-bit data is still an anomaly. Although the depth of the memory will generally remain in the same ballpark as with a 16-bit microcontroller, the gain in precision causes a doubling of the memory requirements in width. Because the program and data memory are typically wholly on-chip for a microcontroller, this will usually throw the transistor budget over the top for price effectiveness. In fact, the transition point from microcontroller to microprocessor can be fairly well drawn between 16-bit and 32-bit products. For the most part, 32-bit processing is going to require more memory than it is affordable to put on the same piece of silicon as the processor. This is not expected to change in the foreseeable future. (Digital signal processors—DSPs—are an exception to this because they spend 99 percent of their time in code that could be only 12 words long and surely less than 2K words.) However, there may be performance advantages to using a 32-bit MCU in an MPU mode where the on-chip ROM would contain operating system (OS) or other time-critical or stable code, supplemented by off-chip memory for the general program.

So do not look for much action in MPUs less than 32-bits or for MCUs greater than 16-bits. However, there are 32-bit microcontrollers. Motorola has some 683xx-family parts that contain 64KB of ROM and have a 32-bit arithmetic logic unit. NEC also has a 32-bit V850 series of microcontrollers with up to 90K of on-chip ROM. Both of these families are designed with an interface to external memories, as well (over a 16-bit bus). They are at the high end of the price chart and are used for functions such as automobile engine control. When a drive train, cellular phone, or disk drive design of a 32-bit microcontroller goes into production, 32-bit MCUs could quickly gain prominence with their naturally higher prices.

Microcontrollers by Word Width

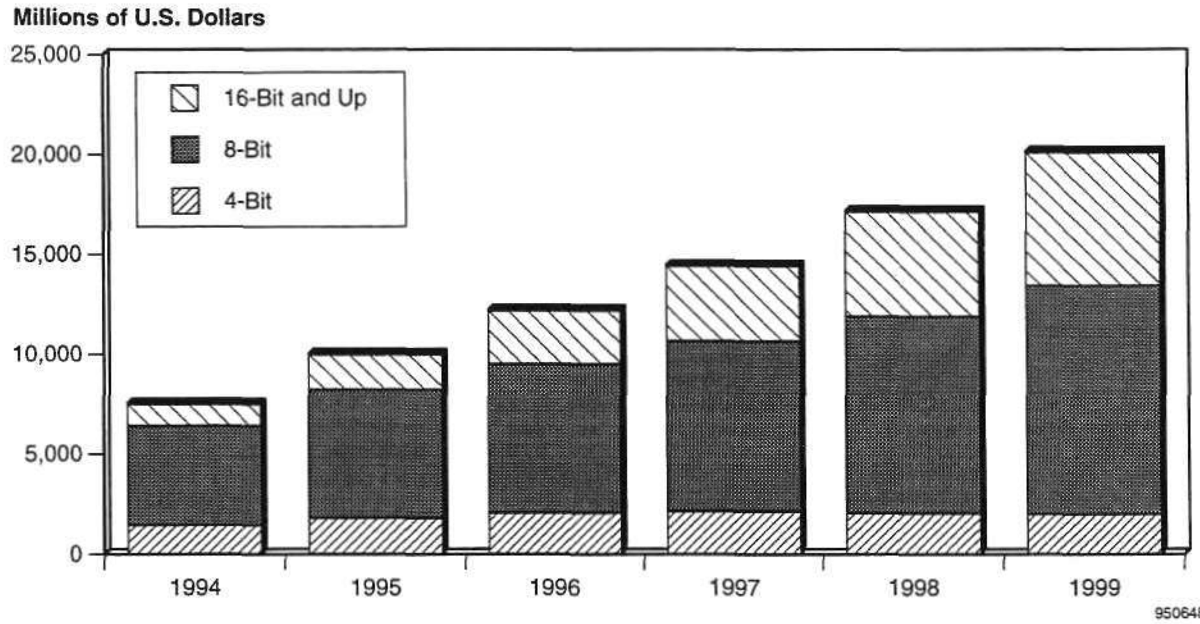
Projections for 4-, 8-, and 16-bit and up microcontrollers for the next five years are given in Tables 3-4 and 3-5, and revenue and unit shipments are illustrated in Figures 3-5, 3-6, 3-7, and 3-8.

Table 3-4
Microcontroller Revenue Forecast by Word Width (Millions of U.S. Dollars)

	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
All Microcontrollers	7,517	10,005	12,209	14,430	17,157	20,099	
Growth (%)		33.1	22.0	18.2	18.9	17.1	21.7
4-Bit MCU	1,472	1,820	2,076	2,165	2,059	2,010	
Growth (%)		23.7	14.0	4.3	-4.9	-2.4	6.4
Percentage of Total		18.2	17.0	15.0	12.0	10.0	
8-Bit MCU	4,965	6,424	7,447	8,514	9,865	11,416	
Growth (%)		29.4	15.9	14.3	15.9	15.7	18.1
Percentage of Total		64.2	61.0	59.0	57.5	56.8	
16-Bit and Up MCU	1,080	1,761	2,686	3,752	5,233	6,673	
Growth (%)		63.0	52.5	39.7	39.5	27.5	43.9
Percentage of Total		17.6	22.0	26.0	30.5	33.2	

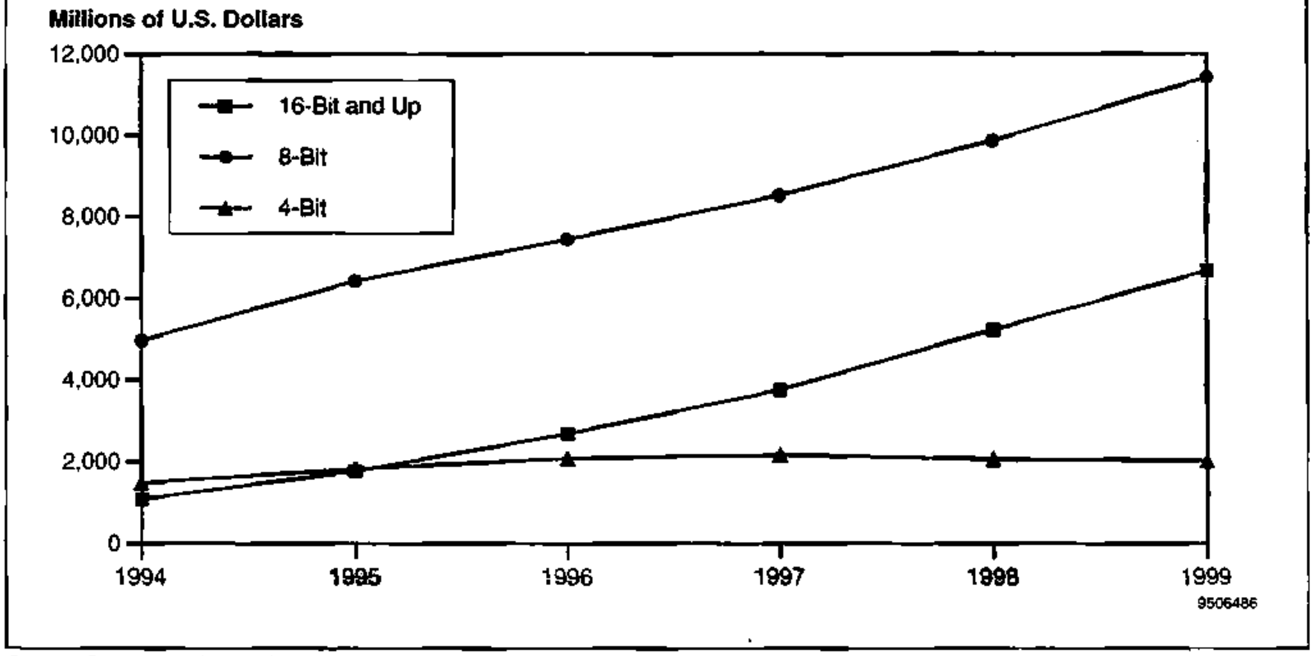
Source: Dataquest (November 1995)

Figure 3-5
Microcontroller Revenue Showing Word Width



Source: Dataquest (November 1995)

Figure 3-6
Microcontroller Revenue by Word Width



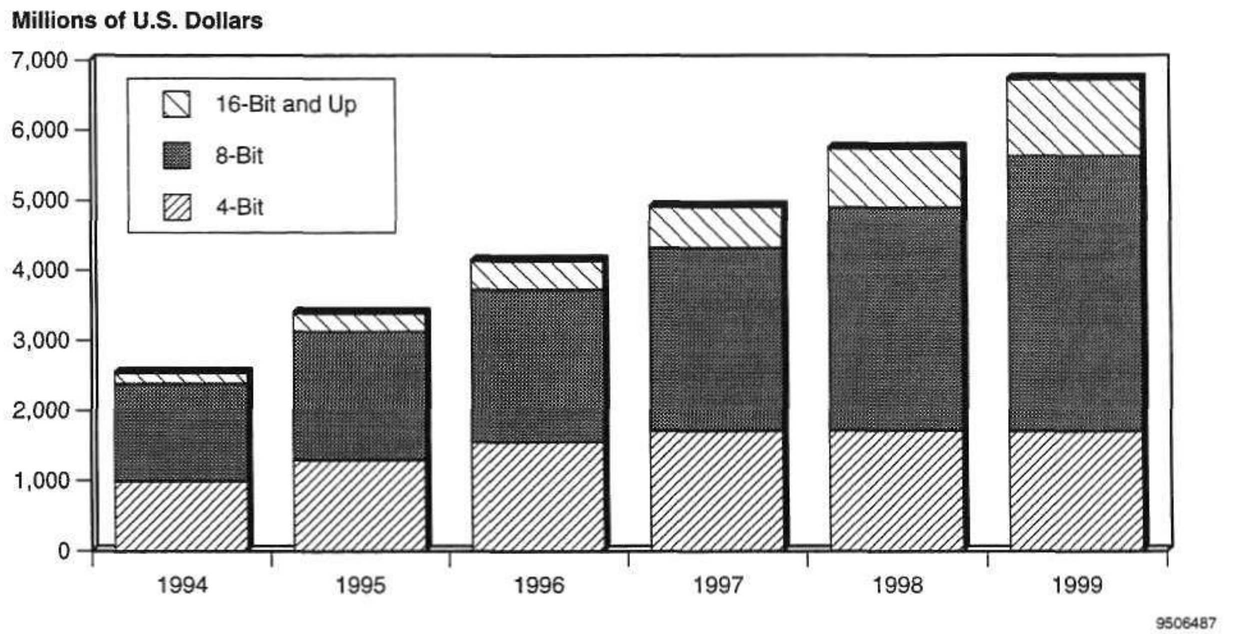
Source: Dataquest (November 1995)

Table 3-5
Microcontroller Unit Shipment Forecast by Word Width (Millions of Units)

	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
All Microcontrollers	2,540	3,391	4,134	4,911	5,743	6,725	
Growth (%)		33.5	21.9	18.8	16.9	17.1	21.5
4-Bit MCU	999	1,300	1,561	1,713	1,715	1,709	
Growth (%)		30.2	20.0	9.8	0.1	-0.4	11.3
Percentage of Total		38.3	37.8	34.9	29.9	25.4	
8-Bit MCU	1,386	1,834	2,174	2,616	3,190	3,927	
Growth (%)		32.3	18.5	20.3	22.0	23.1	23.2
Percentage of Total		54.1	52.6	53.3	55.6	58.4	
16-Bit and Up MCU	154	257	400	582	837	1,089	
Growth (%)		66.4	55.7	45.5	43.8	30.1	47.8
Percentage of Total		7.6	9.7	11.9	14.6	16.2	

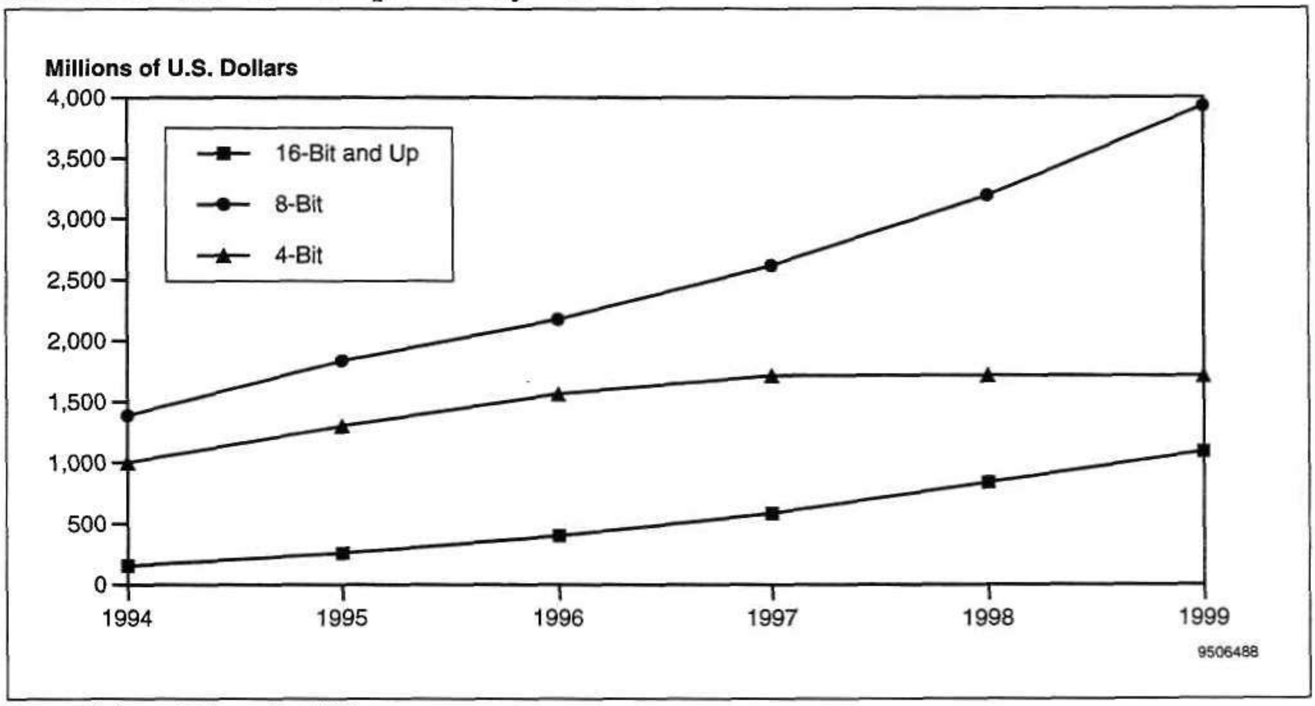
Source: Dataquest (November 1995)

Figure 3-7
Microcontroller Unit Shipments Showing Word Width



Source: Dataquest (November 1995)

Figure 3-8
Microcontroller Unit Shipments by Word Width



Source: Dataquest (November 1995)

Line Extension

Most 4- or 8-bit vendors have 8- or 16-bit line extensions designed to assure that customers stay with the company as they require greater performance from their microcontrollers. The key factors here vary, but generally involve compatibility and familiarity. Vendors try to be as compatible as possible while providing additional instructions, registers, memory, and features. Often the same or slightly upgraded peripherals are offered on the 16-bit products. Straying too far from the familiar can cause a customer to consider other vendors' options.

There is a definite trend toward higher-performance microcontrollers. More sophisticated and flexible OEM products will continue to demand more from the microcontrollers that control them—greater performance from the processor, larger memories to contain the more complex programs, and more exotic or more specific peripherals to off-load the processor unit.

High-level languages (HLLs) such as C are now being used to develop code in over 30 percent of microcontroller designs, especially in new designs. The code expansion expected from an HLL program versus an assembly-code program will require up to double the ROM space to contain it. The trade-off today tilts more frequently toward getting a product to market faster by programming in an HLL and paying a bit more for the MCU that can hold the larger code. The benefits of improved long-term software maintenance when using C or object-oriented programming (OOP) also offset any incremental hardware costs.

Chapter 4
Applications

The variety of applications in which microcontrollers are designed grows on a daily basis. This broad spectrum provides a solid base for MCU growth.

Microcontrollers Are Everywhere

Few consumers realize the sophisticated electronics contained in many of the products they buy. Most wouldn't begin to guess at the microcontrollers lurking in their automobiles. They just know that gas mileage is better and pollution from the engine is less than a decade ago and that they do not have to keep fiddling with the heating and air conditioning to hold the temperature at 72°F. Somehow the clothes iron and the curling iron turn themselves off. A $35 digital answering machine sounds pretty good and does not have a cassette tape to wait for or gum up. And the cordless phones keep getting better sound.

However, some digital devices continue to befuddle all but the more logically inclined. Watch for the word "program" to identify suspect products. Anyone can play a tape in the VCR, but probably only one in 10 can program a VCR to record the right broadcast program. Although setback thermostats can save considerable costs of energy for heating and air conditioning, long instructions for programming them to match a family's schedule keep many of them unused . . . or unpurchased. In fact, most microwave ovens are probably used to thaw meat or reheat leftovers for some number of seconds at full bore, with few people using the multistage heating sequences available.

Camcorders are an amazing assemblage of technology. Each new model sports new beneficial features: quicker and better focusing, more zoom, image stabilization, image enhancement, color viewfinders, and video LCDs rather than viewfinders—all under the watchful eye of microcontrollers.

Pagers and cellular phones still sell like hotcakes. Digital GSM cellular phones are starting to hit in Europe and promise very big sales. Higher-end MCUs and DSPs are critical in cellular phones. Corded and cordless telephones use new features and low prices to push more phones into a fairly saturated market. Four-bit and some 8-bit microcontrollers provide these features.

PCs Are Not Just Good for Intel

The healthy PC industry is driving associated products. Disk drives continue to become more compact and higher density, with street prices passing through $0.50 per megabyte. DSPs will begin to supplement high-end microcontrollers in disk drives. The prices of laser and ink jet printers get lower as they turn out better print, so more people buy them. Color ink jet printers in the home are not uncommon and readily sell under $300. High-quality color printers still cost thousands of dollars; although the use of color in office printers and copiers increases each year, it lags behind the use of color in PC monitors. Fast microprocessors perform the formatting, but microcontrollers run the mechanics and front panel functions on printers.

The widespread interest in e-mail, the Internet, and the World Wide Web and the prevalence of fax are boosting sales of higher-speed fax and data modems for computers. The rise of the small office/home office (SOHO) on top of traditional small businesses is motivating the market for combination office products. These so-called multifunction peripherals may combine in a single chassis a fax machine, data modem, printer, scanner, copier, and telephone answering machine. Whether these machines offer the best of all possible worlds or provide the lowest common denominator may determine their fate. However, Hewlett-Packard offers a fax modem as a $200 add-on unit for some models of its laser printers, attempting to address a similar market from a different angle—one where it rules.

Driving an MCU Market

Automobiles today contain an average of 14 microcontrollers per car. Certain European luxury automobiles can use up to 45 microcontrollers. Most of these are 8-bit microcontrollers with a few 4-bit MCUs and one or two 16- or 32-bit microcontrollers to control the engine and transmission. These numbers are expected to rise because MCUs have proven to be reliable, flexible controllers that provide sellable features on the vehicles.

The advent of more sophisticated airbags and side-impact airbags, traction control, object detection, and navigation systems, as well as many creative uses of the microcontroller in convenience and comfort systems in the car, give assurance that 20 to 30 MCUs could end up in the average vehicle by the end of the decade. Standalone DSPs may show up in vehicles in which microcontrollers with multiply-accumulate (MAC) functions are not sufficient.

The drive train is the most likely place to find 16- and 32-bit MCUs, while some microprocessors (with separate memory systems) may find their way into the vehicle in memory-intensive systems such as navigation systems. Trucks and even trains benefit today from better microcontroller-based communications and tracking systems. More pollution is expelled by mowing the average lawn than is generated by driving five miles in a modern automobile. Will we see engine controllers on lawn mowers and chain saws soon?

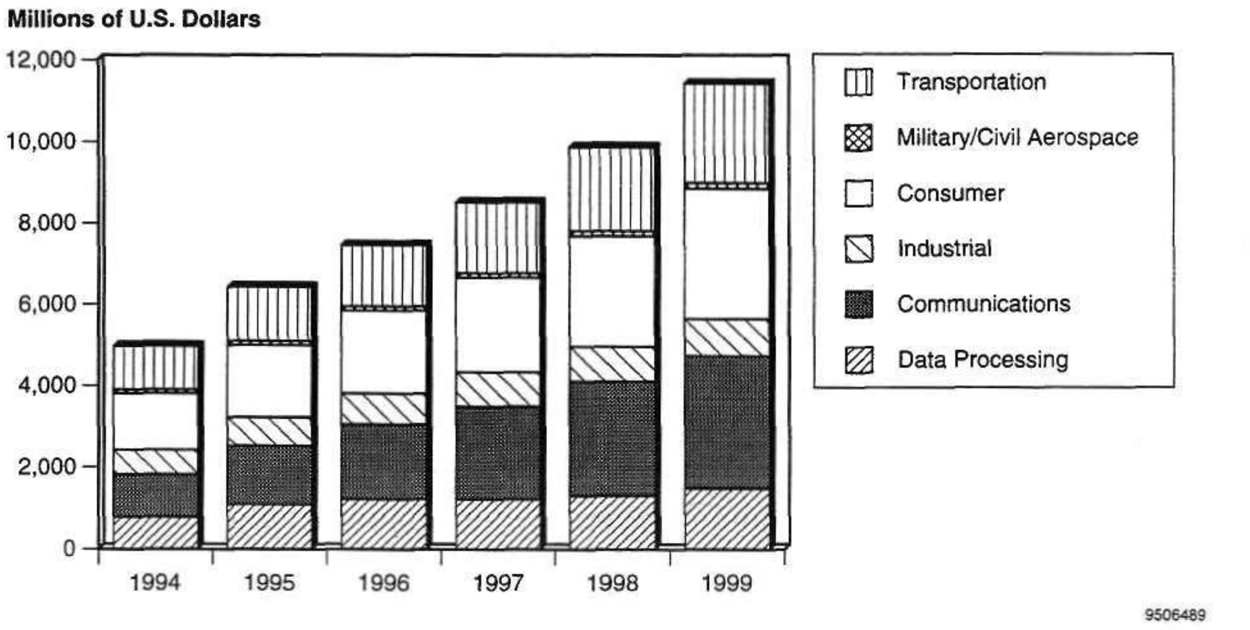
Dataquest presents microcontroller use by general application market in this document. Further investigation into specific applications will be published in future documents of the Microcomponents Worldwide service. Projections of the applications in which 8-bit and 16-bit and larger microcontrollers are used appear in Tables 4-1 and 4-2 and Figures 4-1 and 4-2.

Table 4-1
8-Bit Microcontroller Revenue Forecast by Application (Millions of U.S. Dollars)

	1994	1995	1996	1997	1998	1999
All 8-Bit MCUs	4,965	6,424	7,447	8,514	9,865	11,416
Data Processing	781	1,096	1,224	1,227	1,310	1,487
Communications	1,052	1,434	1,835	2,278	2,803	3,253
Industrial	597	701	758	836	858	910
Consumer	1,388	1,775	2,039	2,327	2,723	3,212
Military/Civil Aerospace	93	100	105	113	126	135
Transportation	1,053	1,317	1,487	1,733	2,045	2,419

Source: Dataquest (November 1995)

Figure 4-1
8-Bit Microcontroller Revenue by Application



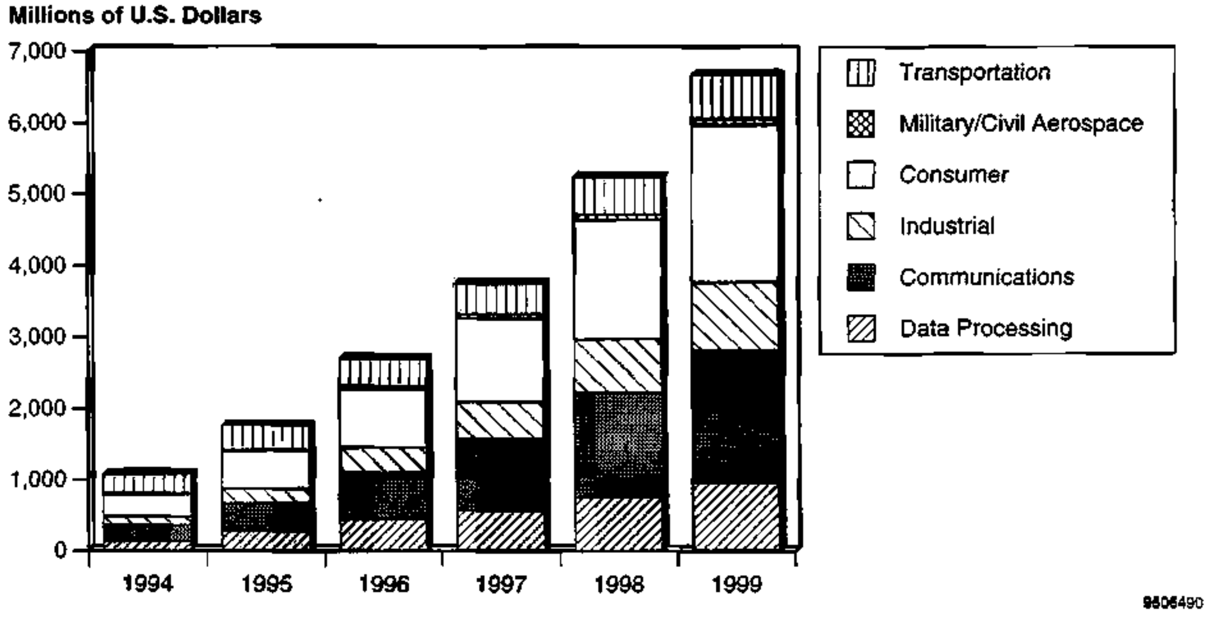
Source: Dataquest (November 1995)

Table 4-2
16-Bit Microcontroller Revenue Forecast by Application (Millions of U.S. Dollars)

	1994	1995	1996	1997	1998	1999
All 16-Bit and Up MCUs	1,080	1,761	2,686	3,752	5,233	6,673
Data Processing	146	284	450	574	763	970
Communications	217	384	657	999	1,468	1,850
Industrial	128	214	350	525	743	958
Consumer	307	520	817	1,165	1,673	2,199
Military/Civil Aerospace	19	28	41	55	76	91
Transportation	263	329	372	433	511	605

Source: Dataquest (November 1995)

Figure 4-2
16-Bit Microcontroller Revenue by Application



Source: Dataquest (November 1995)

For More Information...

Tom Starnes, Principal Analyst .... (512) 794-7755
Internet address .... tstarnes@dataquest.com
Via fax .... (512) 794-7778

Dataquest
a company of
The Dun & Bradstreet Corporation

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
Dataquest Incorporated
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: 1-408-468-8000
Facsimile: 1-408-954-1780

Dataquest Incorporated
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6262

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

Sales Offices:
- Washington, DC (Federal)
- New York, NY (Financial)
- Dallas, TX

LATIN AMERICA

Research Affiliates and Sales Offices:
Buenos Aires, Argentina
Sao Paulo, Brazil
Santiago, Chile
Mexico City, Mexico

EUROPE

European Headquarters
Dataquest Europe Limited
Holmers Farm Way
High Wycombe, Bucks HP12 4XH
United Kingdom
Phone: +44 1494 422 722
Facsimile: +44 1494 422 742

Dataquest Europe SA
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33 1 41 35 13 00
Facsimile: +33 1 41 35 13 13

Dataquest GmbH
Kronstadter Strasse 9
81677 München
Germany
Phone: +49 89 93 09 09 0
Facsimile: +49 89 93 03 27 7

Sales Offices:
- Brussels, Belgium
- Kfar Saba, Israel
- Milan, Italy
- Randburg, South Africa
- Madrid, Spain

JAPAN

Japan Headquarters
Dataquest Japan K.K.
Shinkawa Sanko Building
6th Floor
1-3-17, Shinkawa
Chuo-ku, Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

ASIA/PACIFIC

Asia/Pacific Headquarters
7/F China Underwriters Centre
88 Gloucester Road
Wan Chai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

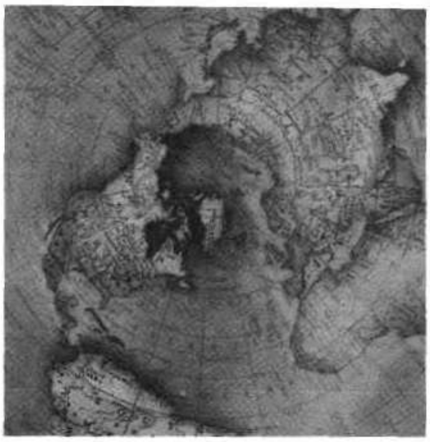
Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei
Taiwan, R.O.C.
Phone: 8862-756-0389
Facsimile: 8862-756-2663

Dataquest Singapore
105 Cecil Street
#06-01/02 The Octagon
Singapore 069534
Phone: 65-227-1213
Facsimile: 65-227-4607

Dataquest Thailand
12/F, Vanissa Building
29 Soi Chidlom
Ploenchit Road
Patumwan, Bangkok 10330
Thailand
Phone: 662-655-0577
Facsimile: 662-655-0576

Research Affiliates and Sales Offices:
- Melbourne, Australia
- Beijing, China

Dataquest
a company of
The Dun & Bradstreet Corporation



Dataquest

Final 1994 Microcomponent Market Share

Market Statistics

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MS-9503
Publication Date: June 26, 1995
Filing: Market Analysis

Final 1994 Microcomponent Market Share

Market Statistics

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MS-9503
Publication Date: June 26, 1995
Filing: Market Analysis

Table of Contents

List of Tables

Note: All tables show estimated data.

List of Tables (Continued)

Note: All tables show estimated data.

Final 1994 Microcomponent Market Share

Introduction

This document contains detailed information on Dataquest's view of the microcomponent market. Included in this document are the following:

- 1992-1994 market share estimates
- 1993-1994 market share rankings

Analyses of market share by company provide insight into high-technology markets and reinforce estimates of consumption, production, and company revenue.

Microcomponent market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. Refer to the section entitled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in Dataquest documents located in the binder of the same name.

Segmentation

This section outlines the market segments that are specific to this document. Dataquest's objective is to provide data along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients.

For market share purposes, Dataquest defines the microcomponent market according to the following functional segmentation scheme:

- Digital Microcomponent IC
- Digital Microprocessor (MPU)
- Digital Microcontroller (MCU)
- Digital Microperipheral (MPR)
- Programmable Digital Signal Processor (pDSP)

Definitions

MOS Digital Microprocessor is defined as a semiconductor product serving as the central processing unit (CPU) of a system. Consists of an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic. An MPU performs general-purpose computing functions by executing external instructions and manipulating data held in external memory. Includes MOS digital MPUs incorporating or originating from an ASIC design.

MOS Digital Microcontroller is defined as a semiconductor product serving as a dedicated or embedded controller in a system. Consists of an integral MPU, nonvolatile memory for use as Program Store, and volatile memory for temporary storage of code or data. MCUs typically contain microperipherals and, as a result, an MCU can perform basic computing functions without support from microperipheral (MPR) products. Includes MOS digital MCUs incorporating or originating from an ASIC design.

MOS Digital Microperipheral is defined as a semiconductor product serving as a logical support function to an MPU in a system. An MPR provides enhancement of system performance and/or interface with external systems. Includes MOS digital MPRs comprising more than one device, such as PC chipsets. Examples of a MOS digital MPR include: memory and bus controllers (for example, PC logic chipsets, DRAM controllers, memory management units (MMU), and DMA controllers; peripherals interface controllers (for example, graphics controllers, LAN controllers, UARTs, keyboard controllers, and mass storage controllers); and coprocessors (for example, math coprocessors—or FPUs—and other coprocessors).

Programmable Digital Signal Processor is defined as a high-speed programmable general-purpose arithmetic unit used for performing complex mathematical operations such as Fourier transforms. DSPs embedded into an MPU or MCU are classified as either an MPU or MCU, respectively.

Regional Definitions

North America: Includes Canada, Mexico, and the United States.

Japan: Japan is the only single-country region.

Western Europe: Includes Austria, Belgium, Denmark, Eire (Ireland), Finland, France, Germany (including former East Germany), Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and rest of western Europe (Andorra, Cyprus, Gibraltar, Liechtenstein, Monaco, San Marino, Vatican City, Iceland, Malta, and Turkey).

Eastern Europe: Includes Albania, Bulgaria, the Czech Republic and Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the republics of the former Yugoslavia, and the republics of the former USSR (Belarus, Russian Federation, Ukraine, Georgia, Moldavia, Armenia, Azerbaijan, Kazakhstan, Uzbekistan, Tadjikistan, Kyrgyzstan, and Turkenistan).

Asia/Pacific: Includes Asia/Pacific's newly industrialized economies (NIEs) and the rest of Asia/Pacific regions. NIEs include Hong Kong, Singapore, Korea, and Taiwan. The rest of Asia/Pacific region includes Australia, Brunei, Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam.

Rest of World: Includes Africa, Caribbean, Central America, Middle East, Oceania, and South America.

Line Item Definitions

Factory revenue is defined as the money value received by a semiconductor manufacturer for its products. Revenue from the sale of semiconductors sold either as finished goods, die, or wafers to another semiconductor vendor for resale is attributed to the semiconductor vendor that sells the product to a distributor or equipment manufacturer.

Market Share Methodology

Dataquest utilizes both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data utilized by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press
- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other suppliers.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

1. Analog Devices' revenue includes Precision Monolithics' revenue from 1991 forward.

2. Cirrus Logic's revenue includes Acumos' and Crystal Semiconductor's revenue from 1992 forward.

3. Cypress Semiconductor acquired the logic division of Performance Semiconductor in 1993.

4. Dialog, Eurosil, Matra, Telefunken, and Siliconix are now known as TEMIC.

5. Fujitsu acquired Ross Semiconductor from Cypress Semiconductor in 1993.

6. IBM's merchant revenue will be included in our Market Statistics beginning in 1993, which was the first complete year that IBM sold product on the merchant market.

7. IMP was formerly known as International Microelectronic Products.

8. Inmos' revenue is included in SGS-Thomson revenue.

9. Macronix's revenue, beginning in 1991, was moved from the North American Companies area and is now included under the Asia/Pacific Companies section.

10. Mitsubishi's revenue includes Powerex's European revenue beginning in 1993.

11. Philips' revenue includes Signetics revenue.

12. SGS-Thomson's revenue includes TAG in 1993.

13. Thomson Semiconductors Specific (TCS) was formed through the merger of Thomson Composants Microndes (TCM) and Thomson Composants Militaires et Spatiaux (TMS).

14. The following companies were added to worldwide market share tables starting in 1993, and may result in higher 1993 market growth rates in certain product areas:

- Acer Labs
- DSP Semiconductor
- Holtek
- IBM
- Q Logic

15. Revenue in 1993 for NEC, National Semiconductor, SGS-Thomson, and Siemens was re-evaluated and restated.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1 outlines these rates for 1992 through 1994.

Table 1
Exchange Rates

	1992	1993	1994
Japan (Yen/U.S.$)	126.45	111.20	101.81
France (Franc/U.S.$)	5.27	5.67	5.54
Germany (Deutsche Mark/U.S.$)	1.56	1.66	1.62
United Kingdom (U.S.$/Pound Sterling)	1.77	1.50	1.53

Source: Dataquest (June 1995)

Table 1-1
Factory Revenue from Shipments of Microcomponent ICs by Product and Regional Company Base (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Microcomponent						
North American Companies	9,879	14,395	18,303	68.8	72.2	70.8
Japanese Companies	3,649	4,585	6,137	25.4	23	23.7
European Companies	637	640	851	4.4	3.2	3.3
Asia/Pacific Companies	194	327	577	1.4	1.6	2.2
Total Market	14,359	19,947	25,868	100.0	100.0	100.0
Microprocessor						
North American Companies	5,157	8,408	10,897	93.7	95.7	95.3
Japanese Companies	265	311	461	4.8	3.5	4.0
European Companies	78	61	67	1.4	0.7	0.6
Asia/Pacific Companies	1	3	11	0	0	0.1
Total Market	5,501	8,783	11,436	100.0	100.0	100.0
Microcontroller						
North American Companies	1,544	1,984	2,514	33.5	33.6	33.4
Japanese Companies	2,619	3,363	4,261	56.8	57.0	56.7
European Companies	433	510	685	9.4	8.6	9.1
Asia/Pacific Companies	17	47	57	0.4	0.8	0.8
Total Market	4,613	5,904	7,517	100.0	100.0	100.0
Microperipheral						
North American Companies	2,799	3,400	3,981	73.6	74.2	67.6
Japanese Companies	704	835	1,301	18.5	18.2	22.1
European Companies	122	69	94	3.2	1.5	1.6
Asia/Pacific Companies	176	277	509	4.6	6.0	8.6
Total Market	3,801	4,581	5,885	100.0	100.0	100.0
Programmable Digital Signal Processor						
North American Companies	379	603	911	85.4	88.8	88.4
Japanese Companies	61	76	114	13.7	11.2	11.1
European Companies	4	0	5	0.9	0	0.5
Asia/Pacific Companies	0	0	0	0	0	0
Total Market	444	679	1,030	100.0	100.0	100.0

Source: Dataquest (June 1995)

Table 1-2
Each Company's Factory Revenue from Shipments of MOS Microcomponent ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	14,359	19,947	25,868	100.0	100.0	100.0
North American Companies	9,879	14,395	18,303	68.8	72.2	70.8
ACC Microelectronics	26	36	49	0.2	0.2	0.2
Adaptec	89	122	125	0.6	0.6	0.5
Advanced Micro Devices	642	563	1,021	4.5	2.8	3.9
Analog Devices	39	69	85	0.3	0.3	0.3
Appian Technology	6	7	7	0	0	0
AT&T	115	246	305	0.8	1.2	1.2
Atmel	5	5	5	0	0	0
California Micro Devices	5	6	5	0	0	0
Chips & Technologies	116	86	89	0.8	0.4	0.3
Cirrus Logic	246	371	681	1.7	1.9	2.6
Cypress Semiconductor	40	8	40	0.3	0	0.2
Cyrix	63	125	241	0.4	0.6	0.9
Dallas Semiconductor	55	56	22	0.4	0.3	0.1
ETEQ Microsystems	20	19	0	0.1	0.1	0
Harris	57	47	52	0.4	0.2	0.2
Hughes	2	3	3	0	0	0
IBM	0	337	399	0	1.7	1.5
Integrated Device Technology	31	48	51	0.2	0.2	0.2
Integrated Information Tech.	42	40	35	0.3	0.2	0.1
Intel	4,721	7,444	9,595	32.9	37.3	37.1
Int'l Microelectronic Prod.	0	6	8	0	0	0
ITT	29	25	12	0.2	0.1	0
LSI Logic	51	77	78	0.4	0.4	0.3
Micro Linear	0	0	6	0	0	0
Microchip Technology	32	72	130	0.2	0.4	0.5
Motorola	1,464	2,065	2,363	10.2	10.4	9.1
NCR	71	63	81	0.5	0.3	0.3
National Semiconductor	383	477	409	2.7	2.4	1.6
Oak Technology	50	50	62	0.3	0.3	0.2
Opti	98	86	130	0.7	0.4	0.5
Performance Semiconductor	21	18	15	0.1	0.1	0.1
Q Logic	0	21	45	0	0.1	0.2
Rockwell	13	17	12	0.1	0.1	0
S3	31	113	130	0.2	0.6	0.5
SEEQ Technology	5	4	17	0	0	0.1

(Continued)

Table 1-2 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponent ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Sierra Semiconductor	1	0	35	0	0	0.1
Standard Microsystems	35	43	100	0.2	0.2	0.4
Supertex	2	2	1	0	0	0
Symphony Laboratories	26	66	12	0.2	0.3	0
Texas Instruments	530	781	1,006	3.7	3.9	3.9
Trident Microsystems	80	60	87	0.6	0.3	0.3
Tseng Labs	74	71	83	0.5	0.4	0.3
VLSI Technology	141	173	216	1.0	0.9	0.8
WaferScale Integration	6	5	3	0	0	0
Weitek	26	33	28	0.2	0.2	0.1
Western Digital	190	218	184	1.3	1.1	0.7
Zilog	146	203	222	1.0	1.0	0.9
Other North American Companies	54	8	18	0.4	0	0.1
Japanese Companies	3,649	4,585	6,137	25.4	23.0	23.7
Fuji Electric	1	1	2	0	0	0
Fujitsu	233	282	390	1.6	1.4	1.5
Hitachi	596	718	998	4.2	3.6	3.9
Matsushita	275	286	460	1.9	1.4	1.8
Mitsubishi	456	532	698	3.2	2.7	2.7
NEC	1,130	1,341	1,678	7.9	6.7	6.5
New JRC	0	0	2	0	0	0
OKI	124	180	217	0.9	0.9	0.8
Ricoh	56	89	83	0.4	0.4	0.3
Rohm	20	23	50	0.1	0.1	0.2
Sanyo	100	145	161	0.7	0.7	0.6
Seiko Epson	16	17	21	0.1	0.1	0.1
Sharp	129	170	192	0.9	0.9	0.7
Sony	73	112	194	0.5	0.6	0.7
Toshiba	440	540	718	3.1	2.7	2.8
Yamaha	0	149	273	0	0.7	1.1
European Companies	637	640	851	4.4	3.2	3.3
Elex	0	0	15	0	0	0.1
GEC Plessey	8	7	11	0.1	0	0
Matra MHS	47	0	0	0.3	0	0
Philips	287	305	403	2.0	1.5	1.6
SGS-Thomson	167	162	227	1.2	0.8	0.9
Siemens	116	107	128	0.8	0.5	0.5

(Continued)

Table 1-2 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponent ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
TEMIC	0	44	51	0	0.2	0.2
TCS	12	15	16	0.1	0.1	0.1
Asia/Pacific Companies	194	327	577	1.4	1.6	2.2
Acer	0	50	68	0	0.3	0.3
Daewoo	4	7	17	0	0	0.1
Goldstar	14	12	29	0.1	0.1	0.1
Hualon Microelectronics Corporation	10	10	0	0.1	0.1	0
Holtek	0	18	20	0	0.1	0.1
Hyundai	0	0	2	0	0	0
Macronix	12	15	21	0.1	0.1	0.1
Samsung	24	46	44	0.2	0.2	0.2
Silicon Integrated Systems	19	26	101	0.1	0.1	0.4
United Microelectronics	69	113	227	0.5	0.6	0.9
Winbond Electronics	42	30	48	0.3	0.2	0.2

Source: Dataquest (June 1995)

Table 1-3
Each Company's Factory Revenue from Shipments of MOS Microcomponents to North America (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	5,282	7,620	9,657	100.0	100.0	100.0
North American Companies	4,826	7,037	8,799	91.4	92.3	91.1
ACC Microelectronics	6	7	13	0.1	0.1	0.1
Adaptec	59	74	82	1.1	1.0	0.8
Advanced Micro Devices	242	207	387	4.6	2.7	4.0
Analog Devices	13	28	37	0.2	0.4	0.4
Appian Technology	5	6	6	0.1	0.1	0.1
AT&T	63	117	166	1.2	1.5	1.7
Atmel	3	4	2	0.1	0.1	0
California Micro Devices	4	3	3	0.1	0	0
Chips & Technologies	41	32	32	0.8	0.4	0.3
Cirrus Logic	111	139	293	2.1	1.8	3.0
Cypress Semiconductor	32	6	28	0.6	0.1	0.3
Cyrix	23	62	122	0.4	0.8	1.3
Dallas Semiconductor	38	34	9	0.7	0.4	0.1
ETEQ Microsystems	7	6	0	0.1	0.1	0
Harris	32	29	29	0.6	0.4	0.3
Hughes	2	3	3	0	0	0
IBM	0	218	240	0	2.9	2.5
Integrated Device Technology	23	35	33	0.4	0.5	0.3
Integrated Information Tech.	18	17	16	0.3	0.2	0.2
Intel	2,434	3,733	4,680	46.1	49.0	48.5
Int'l Microelectronic Prod.	0	5	7	0	0.1	0.1
ITT	7	6	0	0.1	0.1	0
LSI Logic	32	47	26	0.6	0.6	0.3
Micro Linear	0	0	5	0	0	0.1
Microchip Technology	10	30	55	0.2	0.4	0.6
Motorola	682	957	1,132	12.9	12.6	11.7
NCR	64	57	64	1.2	0.7	0.7
National Semiconductor	206	242	209	3.9	3.2	2.2
Oak Technology	9	7	9	0.2	0.1	0.1
Opti	28	36	56	0.5	0.5	0.6
Performance Semiconductor	16	17	15	0.3	0.2	0.2
Q Logic	0	9	19	0	0.1	0.2
Rockwell	8	11	9	0.2	0.1	0.1
S3	16	53	75	0.3	0.7	0.8
SEEQ Technology	4	3	15	0.1	0	0.2

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponents to North America (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Sierra Semiconductor	1	0	17	0	0	0.2
Standard Microsystems	16	18	50	0.3	0.2	0.5
Supertex	2	2	1	0	0	0
Symphony Laboratories	6	7	1	0.1	0.1	0
Texas Instruments	255	422	517	4.8	5.5	5.4
Trident Microsystems	8	5	12	0.2	0.1	0.1
Tseng Labs	50	49	58	0.9	0.6	0.6
VLSI Technology	62	90	72	1.2	1.2	0.7
WaferScale Integration	3	2	1	0.1	0	0
Weitek	23	29	25	0.4	0.4	0.3
Western Digital	71	78	66	1.3	1.0	0.7
Zilog	68	93	100	1.3	1.2	1.0
Other North American Companies	23	2	2	0.4	0	0
Japanese Companies	310	402	580	5.9	5.3	6.0
Fujitsu	20	25	64	0.4	0.3	0.7
Hitachi	79	93	135	1.5	1.2	1.4
Matsushita	8	8	10	0.2	0.1	0.1
Mitsubishi	17	21	37	0.3	0.3	0.4
NEC	94	115	143	1.8	1.5	1.5
OKI	15	23	31	0.3	0.3	0.3
Rohm	2	2	3	0	0	0
Sanyo	1	4	15	0	0.1	0.2
Seiko Epson	1	1	1	0	0	0
Sharp	7	8	9	0.1	0.1	0.1
Sony	3	4	6	0.1	0.1	0.1
Toshiba	63	77	88	1.2	1.0	0.9
Yamaha	0	21	38	0	0.3	0.4
European Companies	140	173	267	2.7	2.3	2.8
GEC Plessey	2	1	3	0	0	0
Matra MHS	10	0	0	0.2	0	0
Philips	69	104	149	1.3	1.4	1.5
SGS-Thomson	36	38	76	0.7	0.5	0.8
Siemens	20	11	12	0.4	0.1	0.1
TEMIC	0	13	21	0	0.2	0.2
TCS	3	6	6	0.1	0.1	0.1

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponents to North America (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Asia/Pacific Companies	6	8	11	0.1	0.1	0.1
Goldstar	2	0	0	0	0	0
Macronix	0	1	2	0	0	0
Samsung	3	5	6	0.1	0.1	0.1
Silicon Integrated Systems	1	1	0	0	0	0
Winbond Electronics	0	1	3	0	0	0

Source: Dataquest (June 1995)

Table 1-4
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	3,269	3,987	5,439	100.0	100.0	100.0
North American Companies	847	1,151	1,628	25.9	28.9	29.9
ACC Microelectronics	1	1	1	0	0	0
Adaptec	4	5	5	0.1	0.1	0.1
Advanced Micro Devices	29	21	24	0.9	0.5	0.4
Analog Devices	4	5	5	0.1	0.1	0.1
AT&T	6	12	17	0.2	0.3	0.3
Chips & Technologies	12	7	6	0.4	0.2	0.1
Cirrus Logic	36	46	102	1.1	1.2	1.9
Cypress Semiconductor	2	0	4	0.1	0	0.1
Cyrix	16	11	17	0.5	0.3	0.3
Dallas Semiconductor	0	5	2	0	0.1	0
Harris	2	2	3	0.1	0.1	0.1
IBM	0	50	30	0	1.3	0.6
Integrated Device Technology	2	4	5	0.1	0.1	0.1
Intel	412	610	912	12.6	15.3	16.8
ITT	2	2	0	0.1	0.1	0
LSI Logic	1	0	36	0	0	0.7
Microchip Technology	0	2	2	0	0.1	0
Motorola	145	178	206	4.4	4.5	3.8
NCR	5	4	8	0.2	0.1	0.1
National Semiconductor	26	25	32	0.8	0.6	0.6
Oak Technology	2	2	23	0.1	0.1	0.4
Opti	1	2	5	0	0.1	0.1
Performance Semiconductor	1	1	0	0	0	0
Q Logic	0	5	15	0	0.1	0.3
S3	1	4	13	0	0.1	0.2
Sierra Semiconductor	0	0	2	0	0	0
Standard Microsystems	1	1	1	0	0	0
Symphony Laboratories	1	1	0	0	0	0
Texas Instruments	69	92	100	2.1	2.3	1.8
VLSI Technology	4	3	7	0.1	0.1	0.1
Weitek	2	2	2	0.1	0.1	0
Western Digital	38	36	31	1.2	0.9	0.6
Zilog	10	11	11	0.3	0.3	0.2

(Continued)

Table 1-4 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Other North American Companies	12	1	1	0.4	0	0
Japanese Companies	2,397	2,818	3,772	73.3	70.7	69.4
Fuji Electric	1	1	2	0	0	0
Fujitsu	165	190	232	5.0	4.8	4.3
Hitachi	365	422	588	11.2	10.6	10.8
Matsushita	236	242	403	7.20	6.1	7.4
Mitsubishi	296	316	443	9.1	7.9	8.1
NEC	751	867	1,083	23.0	21.7	19.9
New JRC	0	0	2	0	0	0
OKI	60	83	103	1.8	2.1	1.9
Ricoh	56	77	70	1.7	1.9	1.3
Rohm	15	17	39	0.5	0.4	0.7
Sanyo	48	54	67	1.5	1.4	1.2
Seiko Epson	13	12	15	0.4	0.3	0.3
Sharp	102	126	136	3.1	3.2	2.5
Sony	70	81	153	2.1	2.0	2.8
Toshiba	219	253	348	6.7	6.3	6.4
Yamaha	0	77	88	0	1.9	1.6
European Companies	16	17	18	0.5	0.4	0.3
GEC Plessey	1	3	4	0	0.1	0.1
Matra MHS	1	0	0	0	0	0
Philips	3	7	6	0.1	0.2	0.1
SGS-Thomson	4	4	3	0.1	0.1	0.1
Siemens	7	2	2	0.2	0.1	0
TEMIC	0	1	3	0	0	0.1
Asia/Pacific Companies	9	1	21	0.3	0	0.4
Goldstar	1	0	0	0	0	0
Macronix	7	0	0	0.2	0	0
Samsung	1	1	1	0	0	0
United Microelectronics	0	0	20	0	0	0.4

Source: Dataquest (June 1995)

Table 1-5
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Europe (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	2,723	4,037	5,309	100.0	100.0	100.0
North American Companies	1,958	3,210	4,225	71.9	79.5	79.6
Adaptec	2	2	2	0.1	0	0
Advanced Micro Devices	101	129	301	3.7	3.2	5.7
Analog Devices	16	29	35	0.6	0.7	0.7
AT&T	42	84	85	1.5	2.1	1.6
Atmel	0	0	1	0	0	0
Chips & Technologies	5	5	5	0.2	0.1	0.1
Cirrus Logic	7	10	54	0.3	0.2	1.0
Cypress Semiconductor	5	2	6	0.2	0	0.1
Cyrix	3	27	62	0.1	0.7	1.2
Dallas Semiconductor	7	9	4	0.3	0.2	0.1
ETEQ Microsystems	1	1	0	0	0	0
Harris	16	13	16	0.6	0.3	0.3
IBM	0	25	16	0	0.6	0.3
Integrated Device Technology	6	9	10	0.2	0.2	0.2
Integrated Information Tech.	16	13	11	0.6	0.3	0.2
Intel	1,018	1,928	2,491	37.4	47.8	46.9
Int'l Microelectronic Prod.	0	1	1	0	0	0
ITT	15	12	12	0.6	0.3	0.2
LSI Logic	8	14	12	0.3	0.3	0.2
Micro Linear	0	0	1	0	0	0
Microchip Technology	11	20	44	0.4	0.5	0.8
Motorola	363	489	569	13.3	12.1	10.7
NCR	2	2	4	0.1	0	0.1
National Semiconductor	59	90	92	2.2	2.2	1.7
Oak Technology	3	3	4	0.1	0.1	0.1
Opti	5	5	6	0.2	0.1	0.1
Performance Semiconductor	3	0	0	0.1	0	0
Q Logic	0	0	4	0	0	0.1
Rockwell	3	4	2	0.1	0.1	0
S3	4	12	18	0.1	0.3	0.3
SEEQ Technology	1	1	2	0	0	0
Sierra Semiconductor	0	0	8	0	0	0.2
Standard Microsystems	5	5	18	0.2	0.1	0.3
Symphony Laboratories	5	5	0	0.2	0.1	0
Texas Instruments	125	149	221	4.6	3.7	4.2

(Continued)

Table 1-5 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Europe (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Trident Microsystems	1	1	0	0	0	0
Tseng Labs	7	6	7	0.3	0.1	0.1
VLSI Technology	32	33	31	1.2	0.8	0.6
WaferScale Integration	1	1	1	0	0	0
Weitek	1	2	1	0	0	0
Western Digital	34	36	32	1.2	0.9	0.6
Zilog	25	33	36	0.9	0.8	0.7
Japanese Companies	387	474	641	14.2	11.7	12.1
Fujitsu	20	37	53	0.7	0.9	1.0
Hitachi	80	87	132	2.9	2.2	2.5
Matsushita	19	10	12	0.7	0.2	0.2
Mitsubishi	16	26	33	0.6	0.6	0.6
NEC	173	209	278	6.4	5.2	5.2
OKI	19	24	31	0.7	0.6	0.6
Rohm	1	1	1	0	0	0
Sanyo	1	2	3	0	0	0.1
Seiko Epson	0	1	1	0	0	0
Sharp	1	1	1	0	0	0
Toshiba	57	74	94	2.1	1.8	1.8
Yamaha	0	2	2	0	0	0
European Companies	376	350	427	13.8	8.7	8.0
Elex	0	0	15	0	0	0.3
GEC Plessey	5	1	2	0.2	0	0
Matra MHS	32	0	0	1.2	0	0
Philips	141	130	150	5.2	3.2	2.8
SGS-Thomson	107	95	120	3.9	2.4	2.3
Siemens	82	90	108	3.0	2.2	2.0
TEMIC	0	25	22	0	0.6	0.4
TCS	9	9	10	0.3	0.2	0.2
Asia/Pacific Companies	2	3	16	0.1	0.1	0.3
Holtek	0	1	1	0	0	0
Samsung	1	0	4	0	0	0.1
United Microelectronics	1	2	11	0	0	0.2

Source: Dataquest (June 1995)

Table 1-6
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	3,085	4,303	5,463	100.0	100.0	100.0
North American Companies	2,248	2,997	3,651	72.9	69.6	66.8
ACC Microelectronics	19	28	35	0.6	0.7	0.6
Adaptec	24	41	36	0.8	1.0	0.7
Advanced Micro Devices	270	206	309	8.8	4.8	5.7
Analog Devices	6	7	8	0.2	0.2	0.1
Appian Technology	1	1	1	0	0	0
AT&T	4	33	37	0.1	0.8	0.7
Atmel	2	1	2	0.1	0	0
California Micro Devices	1	3	2	0	0.1	0
Chips & Technologies	58	42	46	1.9	1.0	0.8
Cirrus Logic	92	176	232	3.0	4.1	4.2
Cypress Semiconductor	1	0	2	0	0	0
Cyrix	21	25	40	0.7	0.6	0.7
Dallas Semiconductor	10	8	7	0.3	0.2	0.1
ETEQ Microsystems	12	12	0	0.4	0.3	0
Harris	7	3	4	0.2	0.1	0.1
IBM	0	44	113	0	1.0	2.1
Integrated Device Technology	0	0	3	0	0	0.1
Integrated Information Tech.	8	10	8	0.3	0.2	0.1
Intel	857	1,173	1,512	27.8	27.3	27.7
ITT	5	5	0	0.2	0.1	0
LSI Logic	10	16	4	0.3	0.4	0.1
Microchip Technology	11	20	29	0.4	0.5	0.5
Motorola	274	441	456	8.9	10.2	8.3
NCR	0	0	5	0	0	0.1
National Semiconductor	92	120	76	3.0	2.8	1.4
Oak Technology	36	38	26	1.2	0.9	0.5
Opti	64	43	63	2.1	1.0	1.2
Performance Semiconductor	1	0	0	0	0	0
Q Logic	0	7	7	0	0.2	0.1
Rockwell	2	2	1	0.1	0	0
S3	10	44	24	0.3	1.0	0.4
Sierra Semiconductor	0	0	8	0	0	0.1
Standard Microsystems	13	19	31	0.4	0.4	0.6
Symphony Laboratories	14	53	11	0.5	1.2	0.2
Texas Instruments	81	118	168	2.6	2.7	3.1

(Continued)

Table 1-6 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Trident Microsystems	71	54	75	2.3	1.3	1.4
Tseng Labs	17	16	18	0.6	0.4	0.3
VLSI Technology	43	47	106	1.4	1.1	1.9
WaferScale Integration	2	2	1	0.1	0	0
Western Digital	47	68	55	1.5	1.6	1.0
Zilog	43	66	75	1.4	1.5	1.4
Other North American Companies	19	5	15	0.6	0.1	0.3
Japanese Companies	555	891	1,144	18.0	20.7	20.9
Fujitsu	28	30	41	0.9	0.7	0.8
Hitachi	72	116	143	2.3	2.7	2.6
Matsushita	12	26	35	0.4	0.6	0.6
Mitsubishi	127	169	185	4.1	3.9	3.4
NEC	112	150	174	3.6	3.5	3.2
OKI	30	50	52	1.0	1.2	1.0
Ricoh	0	12	13	0	0.3	0.2
Rohm	2	3	7	0.1	0.1	0.1
Sanyo	50	85	76	1.6	2.0	1.4
Seiko Epson	2	3	4	0.1	0.1	0.1
Sharp	19	35	46	0.6	0.8	0.8
Sony	0	27	35	0	0.6	0.6
Toshiba	101	136	188	3.3	3.2	3.4
Yamaha	0	49	145	0	1.1	2.7
European Companies	105	100	139	3.4	2.3	2.5
GEC Plessey	0	2	2	0	0	0
Matra MHS	4	0	0	0.1	0	0
Philips	74	64	98	2.4	1.5	1.8
SGS-Thomson	20	25	28	0.6	0.6	0.5
Siemens	7	4	6	0.2	0.1	0.1
TEMIC	0	5	5	0	0.1	0.1
Asia/Pacific Companies	177	315	529	5.7	7.3	9.7
Acer	0	50	68	0	1.2	1.2
Daewoo	4	7	17	0.1	0.2	0.3
Goldstar	11	12	29	0.4	0.3	0.5
Hualon Microelectronics Corporation	10	10	0	0.3	0.2	0
Holtek	0	17	19	0	0.4	0.3
Hyundai	0	0	2	0	0	0

(Continued)

Table 1-6 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Macronix	5	14	19	0.2	0.3	0.3
Samsung	19	40	33	0.6	0.9	0.6
Silicon Integrated Systems	18	25	101	0.6	0.6	1.8
United Microelectronics	68	111	196	2.2	2.6	3.6
Winbond Electronics	42	29	45	1.4	0.7	0.8

Source: Dataquest (June 1995)

Table 1-7
Each Company's Factory Revenue from Shipments of Microprocessor ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	5,501	8,783	11,436	100.0	100.0	100.0
North American Companies	5,157	8,408	10,897	93.7	95.7	95.3
Advanced Micro Devices	565	511	985	10.3	5.8	8.6
AT&T	1	2	0	0	0	0
California Micro Devices	1	2	2	0	0	0
Chips & Technologies	5	6	7	0.1	0.1	0.1
Cypress Semiconductor	38	6	0	0.7	0.1	0
Cyrix	27	95	231	0.5	1.1	2.0
Harris	18	11	12	0.3	0.1	0.1
Hughes	2	3	3	0	0	0
IBM	0	88	246	0	1.0	2.2
Integrated Device Technology	25	43	51	0.5	0.5	0.4
Intel	3,794	6,569	8,370	69.0	74.8	73.2
LSI Logic	33	47	51	0.6	0.5	0.4
Motorola	428	705	597	7.8	8.0	5.2
National Semiconductor	83	38	49	1.5	0.4	0.4
Performance Semiconductor	19	16	15	0.3	0.2	0.1
Rockwell	3	5	5	0.1	0.1	0
Texas Instruments	64	200	214	1.2	2.3	1.9
VLSI Technology	2	3	2	0	0	0
Weitek	13	19	14	0.2	0.2	0.1
Zilog	36	39	43	0.7	0.4	0.4
Japanese Companies	265	311	461	4.8	3.5	4.0
Fujitsu	18	25	56	0.3	0.3	0.5
Hitachi	74	79	160	1.3	0.9	1.4
Matsushita	9	11	14	0.2	0.1	0.1
Mitsubishi	17	17	9	0.3	0.2	0.1
NEC	78	87	105	1.4	1.0	0.9
OKI	8	9	9	0.1	0.1	0.1
Ricoh	3	4	4	0.1	0	0
Sharp	9	11	12	0.2	0.1	0.1
Toshiba	49	68	92	0.9	0.8	0.8
European Companies	78	61	67	1.4	0.7	0.6
GEC Plessey	2	7	6	0	0.1	0.1
Philips	1	1	0	0	0	0
SGS-Thomson	49	39	51	0.9	0.4	0.4

(Continued)

Table 1-7 (Continued)
Each Company's Factory Revenue from Shipments of Microprocessor ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Siemens	19	4	0	0.3	0	0
TCS	7	10	10	0.1	0.1	0.1
Asia/Pacific Companies	1	3	11	0	0	0.1
Goldstar	1	3	1	0	0	0
United Microelectronics	0	0	10	0	0	0.1

Source: Dataquest (June 1995)

Table 1-8
Each Company's Factory Revenue from Shipments of Microprocessor ICs to North America (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	2,674	4,323	5,446	100.0	100.0	100.0
North American Companies	2,627	4,269	5,351	98.2	98.8	98.3
Advanced Micro Devices	212	187	371	7.9	4.3	6.8
AT&T	1	2	0	0	0	0
California Micro Devices	1	1	1	0	0	0
Chips & Technologies	3	4	5	0.1	0.1	0.1
Cypress Semiconductor	31	5	0	1.2	0.1	0
Cyrix	8	50	118	0.3	1.2	2.2
Harris	7	5	5	0.3	0.1	0.1
Hughes	2	3	3	0.1	0.1	0.1
IBM	0	44	133	0	1.0	2.4
Integrated Device Technology	18	30	33	0.7	0.7	0.6
Intel	1,950	3,343	4,135	72.9	77.3	75.9
LSI Logic	24	33	11	0.9	0.8	0.2
Motorola	231	337	305	8.6	7.8	5.6
National Semiconductor	46	13	12	1.7	0.3	0.2
Performance Semiconductor	14	15	15	0.5	0.3	0.3
Rockwell	2	3	4	0.1	0.1	0.1
Texas Instruments	51	159	167	1.9	3.7	3.1
Weitek	11	16	12	0.4	0.4	0.2
Zilog	15	19	21	0.6	0.4	0.4
Japanese Companies	30	39	71	1.1	0.9	1.3
Fujitsu	3	4	30	0.1	0.1	0.6
Hitachi	5	8	11	0.2	0.2	0.2
Mitsubishi	1	1	0	0	0	0
NEC	15	18	21	0.6	0.4	0.4
OKI	2	3	3	0.1	0.1	0.1
Toshiba	4	5	6	0.1	0.1	0.1
European Companies	17	15	24	0.6	0.3	0.4
GEC Plessey	0	1	1	0	0	0
SGS-Thomson	14	9	18	0.5	0.2	0.3
Siemens	1	0	0	0	0	0
TCS	2	5	5	0.1	0.1	0.1

Source: Dataquest (June 1995)

Table 1-9
Each Company's Factory Revenue from Shipments of Microprocessor ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	604	835	1,247	100.0	100.0	100.0
North American Companies	443	651	963	73.3	78.0	77.2
Advanced Micro Devices	26	19	23	4.3	2.3	1.8
Cypress Semiconductor	2	0	0	0.3	0	0
Cyrix	9	6	16	1.5	0.7	1.3
Harris	2	2	2	0.3	0.2	0.2
Integrated Device Technology	2	4	5	0.3	0.5	0.4
Intel	333	530	801	55.1	63.5	64.2
LSI Logic	1	0	33	0.2	0	2.6
Motorola	43	68	53	7.1	8.1	4.3
National Semiconductor	16	7	11	2.6	0.8	0.9
Performance Semiconductor	1	1	0	0.2	0.1	0
Texas Instruments	1	9	13	0.2	1.1	1.0
VLSI Technology	0	0	1	0	0	0.1
Weitek	1	1	1	0.2	0.1	0.1
Zilog	6	4	4	1.0	0.5	0.3
Japanese Companies	159	178	279	26.3	21.3	22.4
Fujitsu	7	8	9	1.2	1.0	0.7
Hitachi	48	54	129	7.9	6.5	10.3
Matsushita	9	10	13	1.5	1.2	1.0
Mitsubishi	13	11	8	2.2	1.3	0.6
NEC	49	56	70	8.1	6.7	5.6
OKI	2	2	2	0.3	0.2	0.2
Ricoh	3	4	4	0.5	0.5	0.3
Sharp	9	11	12	1.5	1.3	1.0
Toshiba	19	22	32	3.1	2.6	2.6
European Companies	2	6	5	0.3	0.7	0.4
GEC Plessey	0	3	2	0	0.4	0.2
SGS-Thomson	2	3	3	0.3	0.4	0.2

Source: Dataquest (June 1995)

Table 1-10
Each Company's Factory Revenue from Shipments of Microprocessor ICs to Europe (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	1,088	2,098	2,774	100.0	100.0	100.0
North American Companies	996	2,015	2,677	91.5	96.0	96.5
Advanced Micro Devices	69	109	288	6.3	5.2	10.4
Cypress Semiconductor	4	1	0	0.4	0	0
Cyrix	1	26	62	0.1	1.2	2.2
Harris	4	3	4	0.4	0.1	0.1
Integrated Device Technology	5	9	10	0.5	0.4	0.4
Intel	780	1,673	2,131	71.7	79.7	76.8
LSI Logic	8	14	6	0.7	0.7	0.2
Motorola	90	139	123	8.3	6.6	4.4
National Semiconductor	17	10	17	1.6	0.5	0.6
Performance Semiconductor	3	0	0	0.3	0	0
Rockwell	1	2	1	0.1	0.1	0
Texas Instruments	6	17	25	0.6	0.8	0.9
VLSI Technology	2	3	1	0.2	0.1	0
Weitek	1	2	1	0.1	0.1	0
Zilog	5	7	8	0.5	0.3	0.3
Japanese Companies	39	47	61	3.6	2.2	2.2
Fujitsu	4	8	11	0.4	0.4	0.4
Hitachi	12	6	8	1.1	0.3	0.3
Matsushita	0	1	1	0	0	0
Mitsubishi	1	1	0	0.1	0	0
NEC	8	5	6	0.7	0.2	0.2
OKI	1	1	1	0.1	0	0
Toshiba	13	25	34	1.2	1.2	1.2
European Companies	53	36	34	4.9	1.7	1.2
GEC Plessey	2	1	1	0.2	0	0
Philips	1	1	0	0.1	0	0
SGS-Thomson	27	25	28	2.5	1.2	1.0
Siemens	18	4	0	1.7	0.2	0
TCS	5	5	5	0.5	0.2	0.2
Asia/Pacific Companies	0	0	2	0	0	0.1
United Microelectronics	0	0	2	0	0	0.1

Source: Dataquest (June 1995)

Table 1-11
Each Company's Factory Revenue from Shipments of Microprocessor ICs to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	1,135	1,527	1,969	100.0	100.0	100.0
North American Companies	1,091	1,473	1,906	96.1	96.5	96.8
Advanced Micro Devices	258	196	303	22.7	12.8	15.4
California Micro Devices	0	1	1	0	0.1	0.1
Chips & Technologies	2	2	2	0.2	0.1	0.1
Cypress Semiconductor	1	0	0	0.1	0	0
Cyrix	9	13	35	0.8	0.9	1.8
Harris	5	1	1	0.4	0.1	0.1
IBM	0	44	113	0	2.9	5.7
Integrated Device Technology	0	0	3	0	0	0.2
Intel	731	1,023	1,303	64.4	67.0	66.2
LSI Logic	0	0	1	0	0	0.1
Motorola	64	161	116	5.6	10.5	5.9
National Semiconductor	4	8	9	0.4	0.5	0.5
Performance Semiconductor	1	0	0	0.1	0	0
Texas Instruments	6	15	9	0.5	1.0	0.5
Zilog	10	9	10	0.9	0.6	0.5
Japanese Companies	37	47	50	3.3	3.1	2.5
Fujitsu	4	5	6	0.4	0.3	0.3
Hitachi	9	11	12	0.8	0.7	0.6
Mitsubishi	2	4	1	0.2	0.3	0.1
NEC	6	8	8	0.5	0.5	0.4
OKI	3	3	3	0.3	0.2	0.2
Toshiba	13	16	20	1.1	1.0	1.0
European Companies	6	4	4	0.5	0.3	0.2
GEC Plessey	0	2	2	0	0.1	0.1
SGS-Thomson	6	2	2	0.5	0.1	0.1
Asia/Pacific Companies	1	3	9	0.1	0.2	0.5
Goldstar	1	3	1	0.1	0.2	0.1
United Microelectronics	0	0	8	0	0	0.4

Source: Dataquest (June 1995)

Table 1-12
Each Company's Factory Revenue from Shipments of Microcontroller ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	4,613	5,904	7,517	100.0	100.0	100.0
North American Companies	1,544	1,984	2,514	33.5	33.6	33.4
Advanced Micro Devices	14	11	5	0.3	0.2	0.1
Atmel	0	2	5	0	0	0.1
Dallas Semiconductor	13	15	12	0.3	0.3	0.2
Harris	7	9	8	0.2	0.2	0.1
Intel	416	450	600	9.0	7.6	8.0
ITT	29	25	12	0.6	0.4	0.2
Microchip Technology	31	70	130	0.7	1.2	1.7
Motorola	801	1,107	1,424	17.4	18.8	18.9
National Semiconductor	94	105	100	2.0	1.8	1.3
Rockwell	6	8	7	0.1	0.1	0.1
Sierra Semiconductor	1	0	0	0	0	0
Texas Instruments	95	120	143	2.1	2.0	1.9
Zilog	37	62	68	0.8	1.1	0.9
Japanese Companies	2,619	3,363	4,261	56.8	57.0	56.7
Fujitsu	109	129	180	2.4	2.2	2.4
Hitachi	378	458	577	8.2	7.8	7.7
Matsushita	205	251	405	4.4	4.3	5.4
Mitsubishi	388	465	637	8.4	7.9	8.5
NEC	840	1,100	1,275	18.2	18.6	17.0
OKI	98	149	178	2.1	2.5	2.4
Ricoh	51	82	76	1.1	1.4	1.0
Rohm	17	20	46	0.4	0.3	0.6
Sanyo	92	138	154	2.0	2.3	2.0
Seiko Epson	16	17	21	0.3	0.3	0.3
Sharp	112	149	169	2.4	2.5	2.2
Sony	67	104	140	1.5	1.8	1.9
Toshiba	246	301	403	5.3	5.1	5.4
European Companies	433	510	685	9.4	8.6	9.1
Matra MHS	47	0	0	1.0	0	0
Philips	213	258	345	4.6	4.4	4.6
SGS-Thomson	91	113	161	2.0	1.9	2.1
Siemens	82	95	128	1.8	1.6	1.7
TEMIC	0	44	51	0	0.7	0.7

(Continued)

Table 1-12 (Continued)
Each Company's Factory Revenue from Shipments of Microcontroller ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Asia/Pacific Companies	17	47	57	0.4	0.8	0.8
Goldstar	1	3	9	0	0.1	0.1
Holtek	0	15	20	0	0.3	0.3
Samsung	16	29	28	0.3	0.5	0.4

Source: Dataquest (June 1995)

Table 1-13
Each Company's Factory Revenue from Shipments of Microcontroller ICs to North America (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	938	1,254	1,652	100.0	100.0	100.0
North American Companies	671	883	1,138	71.5	70.4	68.9
Advanced Micro Devices	6	5	3	0.6	0.4	0.2
Atmel	0	2	2	0	0.2	0.1
Dallas Semiconductor	9	10	5	1.0	0.8	0.3
Harris	5	6	5	0.5	0.5	0.3
Intel	216	225	302	23.0	17.9	18.3
ITT	7	6	0	0.7	0.5	0
Microchip Technology	9	28	55	1.0	2.2	3.3
Motorola	317	477	632	33.8	38.0	38.3
National Semiconductor	53	50	52	5.7	4.0	3.1
Rockwell	4	6	5	0.4	0.5	0.3
Sierra Semiconductor	1	0	0	0.1	0	0
Texas Instruments	32	47	53	3.4	3.7	3.2
Zilog	12	21	24	1.3	1.7	1.5
Japanese Companies	182	244	321	19.4	19.5	19.4
Fujitsu	10	12	21	1.1	1.0	1.3
Hitachi	49	59	87	5.2	4.7	5.3
Matsushita	6	7	8	0.6	0.6	0.5
Mitsubishi	16	20	37	1.7	1.6	2.2
NEC	50	79	77	5.3	6.3	4.7
OKI	11	16	23	1.2	1.3	1.4
Rohm	2	2	3	0.2	0.2	0.2
Sanyo	1	4	15	0.1	0.3	0.9
Seiko Epson	1	1	1	0.1	0.1	0.1
Sharp	7	8	9	0.7	0.6	0.5
Sony	3	4	5	0.3	0.3	0.3
Toshiba	26	32	35	2.8	2.6	2.1
European Companies	84	127	191	9.0	10.1	11.6
Matra MHS	10	0	0	1.1	0	0
Philips	40	78	108	4.3	6.2	6.5
SGS-Thomson	16	25	50	1.7	2.0	3.0
Siemens	18	11	12	1.9	0.9	0.7
TEMIC	0	13	21	0	1.0	1.3
Asia/Pacific Companies	1	0	2	0.1	0	0.1
Samsung	1	0	2	0.1	0	0.1

Source: Dataquest (June 1995)

Table 1-14
Each Company's Factory Revenue from Shipments of Microcontroller ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	1,913	2,284	2,964	100.0	100.0	100.0
North American Companies	147	166	214	7.7	7.3	7.2
Dallas Semiconductor	0	0	1	0	0	0
Intel	36	45	59	1.9	2.0	2.0
ITT	2	2	0	0.1	0.1	0
Microchip Technology	0	2	2	0	0.1	0.1
Motorola	86	98	136	4.5	4.3	4.6
National Semiconductor	8	2	1	0.4	0.1	0
Texas Instruments	14	16	14	0.7	0.7	0.5
Zilog	1	1	1	0.1	0	0
Japanese Companies	1,753	2,108	2,740	91.6	92.3	92.4
Fujitsu	77	85	109	4.0	3.7	3.7
Hitachi	244	289	345	12.8	12.7	11.6
Matsushita	173	214	361	9.0	9.4	12.2
Mitsubishi	257	287	413	13.4	12.6	13.9
NEC	573	707	838	30.0	31.0	28.3
OKI	52	75	90	2.7	3.3	3.0
Ricoh	51	70	63	2.7	3.1	2.1
Rohm	12	14	35	0.6	0.6	1.2
Sanyo	42	47	60	2.2	2.1	2.0
Seiko Epson	13	12	15	0.7	0.5	0.5
Sharp	85	105	113	4.4	4.6	3.8
Sony	64	73	114	3.3	3.2	3.8
Toshiba	110	130	184	5.8	5.7	6.2
European Companies	13	10	10	0.7	0.4	0.3
Matra MHS	1	0	0	0.1	0	0
Philips	3	6	5	0.2	0.3	0.2
SGS-Thomson	2	1	0	0.1	0	0
Siemens	7	2	2	0.4	0.1	0.1
TEMIC	0	1	3	0	0	0.1

Source: Dataquest (June 1995)

Table 1-15
Each Company's Factory Revenue from Shipments of Microcontroller ICs to Europe (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	934	1,106	1,432	100.0	100.0	100.0
North American Companies	414	472	616	44.3	42.7	43.0
Advanced Micro Devices	7	5	2	0.7	0.5	0.1
Atmel	0	0	1	0	0	0.1
Dallas Semiconductor	1	2	2	0.1	0.2	0.1
Harris	1	1	1	0.1	0.1	0.1
Intel	112	90	117	12.0	8.1	8.2
ITT	15	12	12	1.6	1.1	0.8
Microchip Technology	11	20	44	1.2	1.8	3.1
Motorola	206	267	344	22.1	24.1	24.0
National Semiconductor	24	29	30	2.6	2.6	2.1
Rockwell	1	1	1	0.1	0.1	0.1
Texas Instruments	28	30	46	3.0	2.7	3.2
Zilog	8	15	16	0.9	1.4	1.1
Japanese Companies	261	348	459	27.9	31.5	32.1
Fujitsu	9	19	31	1.0	1.7	2.2
Hitachi	41	51	84	4.4	4.6	5.9
Matsushita	18	9	11	1.9	0.8	0.8
Mitsubishi	14	23	32	1.5	2.1	2.2
NEC	126	183	220	13.5	16.5	15.4
OKI	14	19	26	1.5	1.7	1.8
Rohm	1	1	1	0.1	0.1	0.1
Sanyo	1	2	3	0.1	0.2	0.2
Seiko Epson	0	1	1	0	0.1	0.1
Sharp	1	1	1	0.1	0.1	0.1
Toshiba	36	39	49	3.9	3.5	3.4
European Companies	259	285	354	27.7	25.8	24.7
Matra MHS	32	0	0	3.4	0	0
Philips	117	117	138	12.5	10.6	9.6
SGS-Thomson	60	65	86	6.4	5.9	6.0
Siemens	50	78	108	5.4	7.1	7.5
TEMIC	0	25	22	0	2.3	1.5
Asia/Pacific Companies	0	1	3	0	0.1	0.2
Holtek	0	1	1	0	0.1	0.1
Samsung	0	0	2	0	0	0.1

Source: Dataquest (June 1995)

Table 1-16
Each Company's Factory Revenue from Shipments of Microcontroller ICs to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	828	1,260	1,469	100.0	100.0	100.0
North American Companies	312	463	546	37.7	36.7	37.2
Advanced Micro Devices	1	1	0	0.1	0.1	0
Atmel	0	0	2	0	0	0.1
Dallas Semiconductor	3	3	4	0.4	0.2	0.3
Harris	1	2	2	0.1	0.2	0.1
Intel	52	90	122	6.3	7.1	8.3
ITT	5	5	0	0.6	0.4	0
Microchip Technology	11	20	29	1.3	1.6	2.0
Motorola	192	265	312	23.2	21.0	21.2
National Semiconductor	9	24	17	1.1	1.9	1.2
Rockwell	1	1	1	0.1	0.1	0.1
Texas Instruments	21	27	30	2.5	2.1	2.0
Zilog	16	25	27	1.9	2.0	1.8
Japanese Companies	423	663	741	51.1	52.6	50.4
Fujitsu	13	13	19	1.6	1.0	1.3
Hitachi	44	59	61	5.3	4.7	4.2
Matsushita	8	21	25	1.0	1.7	1.7
Mitsubishi	101	135	155	12.2	10.7	10.6
NEC	91	131	140	11.0	10.4	9.5
OKI	21	39	39	2.5	3.1	2.7
Ricoh	0	12	13	0	1.0	0.9
Rohm	2	3	7	0.2	0.2	0.5
Sanyo	48	85	76	5.8	6.7	5.2
Seiko Epson	2	3	4	0.2	0.2	0.3
Sharp	19	35	46	2.3	2.8	3.1
Sony	0	27	21	0	2.1	1.4
Toshiba	74	100	135	8.9	7.9	9.2
European Companies	77	88	130	9.3	7.0	8.8
Matra MHS	4	0	0	0.5	0	0
Philips	53	57	94	6.4	4.5	6.4
SGS-Thomson	13	22	25	1.6	1.7	1.7
Siemens	7	4	6	0.8	0.3	0.4
TEMIC	0	5	5	0	0.4	0.3
Asia/Pacific Companies	16	46	52	1.9	3.7	3.5
Goldstar	1	3	9	0.1	0.2	0.6
Holtek	0	14	19	0	1.1	1.3
Samsung	15	29	24	1.8	2.3	1.6

Source: Dataquest (June 1995)

Table 1-17
Each Company's Factory Revenue from Shipments of Microperipheral ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	3,801	4,581	5,885	100.0	100.0	100.0
North American Companies	2,799	3,400	3,981	73.6	74.2	67.6
ACC Microelectronics	26	36	49	0.7	0.8	0.8
Adaptec	89	122	125	2.3	2.7	2.1
Advanced Micro Devices	63	41	31	1.7	0.9	0.5
Appian Technology	6	7	7	0.2	0.2	0.1
AT&T	9	37	30	0.2	0.8	0.5
Atmel	5	3	0	0.1	0.1	0
California Micro Devices	4	4	3	0.1	0.1	0.1
Chips & Technologies	111	80	82	2.9	1.7	1.4
Cirrus Logic	246	371	681	6.5	8.1	11.6
Cypress Semiconductor	2	2	40	0.1	0	0.7
Cyrix	36	30	10	0.9	0.7	0.2
Dallas Semiconductor	42	41	10	1.1	0.9	0.2
ETEQ Microsystems	20	19	0	0.5	0.4	0
Harris	32	27	32	0.8	0.6	0.5
IBM	0	249	153	0	5.4	2.6
Integrated Device Technology	6	5	0	0.2	0.1	0
Integrated Information Tech.	42	40	35	1.1	0.9	0.6
Intel	511	425	625	13.4	9.3	10.6
Int'l Microelectronic Prod.	0	6	8	0	0.1	0.1
LSI Logic	18	30	27	0.5	0.7	0.5
Micro Linear	0	0	6	0	0	0.1
Motorola	172	159	191	4.5	3.5	3.2
NCR	71	63	81	1.9	1.4	1.4
National Semiconductor	206	334	260	5.4	7.3	4.4
Oak Technology	50	50	62	1.3	1.1	1.1
Opti	98	86	130	2.6	1.9	2.2
Performance Semiconductor	2	2	0	0.1	0	0
Q Logic	0	21	45	0	0.5	0.8
Rockwell	4	4	0	0.1	0.1	0
S3	31	113	130	0.8	2.5	2.2
SEEQ Technology	5	4	17	0.1	0.1	0.3
Sierra Semiconductor	0	0	35	0	0	0.6
Standard Microsystems	35	43	100	0.9	0.9	1.7
Supertex	2	2	1	0.1	0	0
Symphony Laboratories	26	66	12	0.7	1.4	0.2

(Continued)

Table 1-17 (Continued)
Each Company's Factory Revenue from Shipments of Microperipheral ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Texas Instruments	200	230	249	5.3	5.0	4.2
Trident Microsystems	80	60	87	2.1	1.3	1.5
Tseng Labs	74	71	83	1.9	1.5	1.4
VLSI Technology	139	170	214	3.7	3.7	3.6
WaferScale Integration	6	5	3	0.2	0.1	0.1
Weitek	13	14	14	0.3	0.3	0.2
Western Digital	190	218	184	5.0	4.8	3.1
Zilog	73	102	111	1.9	2.2	1.9
Other North American Companies	54	8	18	1.4	0.2	0.3
Japanese Companies	704	835	1,301	18.5	18.2	22.1
Fuji Electric	1	1	2	0	0	0
Fujitsu	85	102	118	2.2	2.2	2.0
Hitachi	140	174	252	3.7	3.8	4.3
Matsushita	60	23	37	1.6	0.5	0.6
Mitsubishi	51	50	52	1.3	1.1	0.9
NEC	190	127	258	5.0	2.8	4.4
New JRC	0	0	2	0	0	0
OKI	18	22	28	0.5	0.5	0.5
Ricoh	2	3	3	0.1	0.1	0.1
Rohm	3	3	4	0.1	0.1	0.1
Sanyo	2	2	0	0.1	0	0
Sharp	8	10	11	0.2	0.2	0.2
Sony	6	8	54	0.2	0.2	0.9
Toshiba	138	161	207	3.6	3.5	3.5
Yamaha	0	149	273	0	3.3	4.6
European Companies	122	69	94	3.2	1.5	1.6
Elex	0	0	15	0	0	0.3
GEC Plessey	2	0	0	0.1	0	0
Philips	73	46	58	1.9	1.0	1.0
SGS-Thomson	27	10	15	0.7	0.2	0.3
Siemens	15	8	0	0.4	0.2	0
TCS	5	5	6	0.1	0.1	0.1
Asia/Pacific Companies	176	277	509	4.6	6.0	8.6
Acer	0	50	68	0	1.1	1.2
Daewoo	4	7	17	0.1	0.2	0.3
Goldstar	12	6	19	0.3	0.1	0.3

(Continued)

Table 1-17 (Continued)
Each Company's Factory Revenue from Shipments of Microperipheral ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Hualon Microelectronics Corporation	10	10	0	0.3	0.2	0
Holtek	0	3	0	0	0.1	0
Hyundai	0	0	2	0	0	0
Macronix	12	15	21	0.3	0.3	0.4
Samsung	8	17	16	0.2	0.4	0.3
Silicon Integrated Systems	19	26	101	0.5	0.6	1.7
United Microelectronics	69	113	217	1.8	2.5	3.7
Winbond Electronics	42	30	48	1.1	0.7	0.8

Source: Dataquest (June 1995)

Table 1-18
Each Company's Factory Revenue from Shipments of Microperipheral ICs to North America (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	1,486	1,764	2,138	100.0	100.0	100.0
North American Companies	1,352	1,617	1,906	91.0	91.7	89.1
ACC Microelectronics	6	7	13	0.4	0.4	0.6
Adaptec	59	74	82	4.0	4.2	3.8
Advanced Micro Devices	24	15	13	1.6	0.9	0.6
Appian Technology	5	6	6	0.3	0.3	0.3
AT&T	7	14	23	0.5	0.8	1.1
Atmel	3	2	0	0.2	0.1	0
California Micro Devices	3	2	2	0.2	0.1	0.1
Chips & Technologies	38	28	27	2.6	1.6	1.3
Cirrus Logic	111	139	293	7.5	7.9	13.7
Cypress Semiconductor	1	1	28	0.1	0.1	1.3
Cyrix	15	12	4	1.0	0.7	0.2
Dallas Semiconductor	29	24	4	2.0	1.4	0.2
ETEQ Microsystems	7	6	0	0.5	0.3	0
Harris	20	18	19	1.3	1.0	0.9
IBM	0	174	107	0	9.9	5.0
Integrated Device Technology	5	5	0	0.3	0.3	0
Integrated Information Tech.	18	17	16	1.2	1.0	0.7
Intel	268	165	243	18.0	9.4	11.4
Int'l Microelectronic Prod.	0	5	7	0	0.3	0.3
LSI Logic	8	14	15	0.5	0.8	0.7
Micro Linear	0	0	5	0	0	0.2
Motorola	101	110	132	6.8	6.2	6.2
NCR	64	57	64	4.3	3.2	3.0
National Semiconductor	107	179	145	7.2	10.1	6.8
Oak Technology	9	7	9	0.6	0.4	0.4
Opti	28	36	56	1.9	2.0	2.6
Performance Semiconductor	2	2	0	0.1	0.1	0
Q Logic	0	9	19	0	0.5	0.9
Rockwell	2	2	0	0.1	0.1	0
S3	16	53	75	1.1	3.0	3.5
SEEQ Technology	4	3	15	0.3	0.2	0.7
Sierra Semiconductor	0	0	17	0	0	0.8
Standard Microsystems	16	18	50	1.1	1.0	2.3
Supertex	2	2	1	0.1	0.1	0
Symphony Laboratories	6	7	1	0.4	0.4	0

(Continued)

Table 1-18 (Continued)
Each Company's Factory Revenue from Shipments of Microperipheral ICs to North America (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Texas Instruments	98	112	136	6.6	6.3	6.4
Trident Microsystems	8	5	12	0.5	0.3	0.6
Tseng Labs	50	49	58	3.4	2.8	2.7
VLSI Technology	62	90	72	4.2	5.1	3.4
WaferScale Integration	3	2	1	0.2	0.1	0
Weitek	12	13	13	0.8	0.7	0.6
Western Digital	71	78	66	4.8	4.4	3.1
Zilog	41	53	55	2.8	3.0	2.6
Other North American Companies	23	2	2	1.5	0.1	0.1
Japanese Companies	92	108	173	6.2	6.1	8.1
Fujitsu	6	7	9	0.4	0.4	0.4
Hitachi	23	22	32	1.5	1.2	1.5
Matsushita	2	1	2	0.1	0.1	0.1
NEC	27	15	41	1.8	0.9	1.9
OKI	2	4	5	0.1	0.2	0.2
Sony	0	0	1	0	0	0
Toshiba	32	38	45	2.2	2.2	2.1
Yamaha	0	21	38	0	1.2	1.8
European Companies	37	31	50	2.5	1.8	2.3
Philips	29	26	41	2.0	1.5	1.9
SGS-Thomson	6	4	8	0.4	0.2	0.4
Siemens	1	0	0	0.1	0	0
TCS	1	1	1	0.1	0.1	0
Asia/Pacific Companies	5	8	9	0.3	0.5	0.4
Goldstar	2	0	0	0.1	0	0
Macronix	0	1	2	0	0.1	0.1
Samsung	2	5	4	0.1	0.3	0.2
Silicon Integrated Systems	1	1	0	0.1	0.1	0
Winbond Electronics	0	1	3	0	0.1	0.1

Source: Dataquest (June 1995)

Table 1-19
Each Company's Factory Revenue from Shipments of Microperipheral ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	650	749	1,062	100.0	100.0	100.0
North American Companies	199	265	364	30.6	35.4	34.3
ACC Microelectronics	1	1	1	0.2	0.1	0.1
Adaptec	4	5	5	0.6	0.7	0.5
Advanced Micro Devices	3	2	1	0.5	0.3	0.1
AT&T	0	5	0	0	0.7	0
Chips & Technologies	12	7	6	1.8	0.9	0.6
Cirrus Logic	36	46	102	5.5	6.1	9.6
Cypress Semiconductor	0	0	4	0	0	0.4
Cyrix	7	5	1	1.1	0.7	0.1
Dallas Semiconductor	0	5	1	0	0.7	0.1
Harris	0	0	1	0	0	0.1
IBM	0	50	30	0	6.7	2.8
Intel	43	35	52	6.6	4.7	4.9
LSI Logic	0	0	3	0	0	0.3
Motorola	13	10	12	2.0	1.3	1.1
NCR	5	4	8	0.8	0.5	0.8
National Semiconductor	2	16	20	0.3	2.1	1.9
Oak Technology	2	2	23	0.3	0.3	2.2
Opti	1	2	5	0.2	0.3	0.5
Q Logic	0	5	15	0	0.7	1.4
S3	1	4	13	0.2	0.5	1.2
Sierra Semiconductor	0	0	2	0	0	0.2
Standard Microsystems	1	1	1	0.2	0.1	0.1
Symphony Laboratories	1	1	0	0.2	0.1	0
Texas Instruments	9	12	13	1.4	1.6	1.2
VLSI Technology	4	3	6	0.6	0.4	0.6
Weitek	1	1	1	0.2	0.1	0.1
Western Digital	38	36	31	5.8	4.8	2.9
Zilog	3	6	6	0.5	0.8	0.6
Other North American Companies	12	1	1	1.8	0.1	0.1
Japanese Companies	442	482	676	68.0	64.4	63.7
Fuji Electric	1	1	2	0.2	0.1	0.2
Fujitsu	67	81	92	10.3	10.8	8.7
Hitachi	71	77	111	10.9	10.3	10.5
Matsushita	53	17	26	8.2	2.3	2.4

(Continued)

Table 1-19 (Continued)
Each Company's Factory Revenue from Shipments of Microperipheral ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Mitsubishi	26	18	22	4.0	2.4	2.1
NEC	113	86	147	17.4	11.5	13.8
New JRC	0	0	2	0	0	0.2
OKI	6	6	9	0.9	0.8	0.8
Ricoh	2	3	3	0.3	0.4	0.3
Rohm	3	3	4	0.5	0.4	0.4
Sanyo	2	2	0	0.3	0.3	0
Sharp	8	10	11	1.2	1.3	1.0
Sony	6	8	39	0.9	1.1	3.7
Toshiba	84	93	120	12.9	12.4	11.3
Yamaha	0	77	88	0	10.3	8.3
European Companies	0	1	1	0	0.1	0.1
Philips	0	1	1	0	0.1	0.1
Asia/Pacific Companies	9	1	21	1.4	0.1	2.0
Goldstar	1	0	0	0.2	0	0
Macronix	7	0	0	1.1	0	0
Samsung	1	1	1	0.2	0.1	0.1
United Microelectronics	0	0	20	0	0	1.9

Source: Dataquest (June 1995)

Table 1-20
Each Company's Factory Revenue from Shipments of Microperipheral ICs to Europe (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	571	615	798	100.0	100.0	100.0
North American Companies	425	513	638	74.4	83.4	79.9
Adaptec	2	2	2	0.4	0.3	0.3
Advanced Micro Devices	25	15	11	4.4	2.4	1.4
AT&T	0	8	2	0	1.3	0.3
Chips & Technologies	5	5	5	0.9	0.8	0.6
Cirrus Logic	7	10	54	1.2	1.6	6.8
Cypress Semiconductor	1	1	6	0.2	0.2	0.8
Cyrix	2	1	0	0.4	0.2	0
Dallas Semiconductor	6	7	2	1.1	1.1	0.3
ETEQ Microsystems	1	1	0	0.2	0.2	0
Harris	11	9	11	1.9	1.5	1.4
IBM	0	25	16	0	4.1	2.0
Integrated Device Technology	1	0	0	0.2	0	0
Integrated Information Tech.	16	13	11	2.8	2.1	1.4
Intel	126	165	243	22.1	26.8	30.5
Int'l Microelectronic Prod.	0	1	1	0	0.2	0.1
LSI Logic	0	0	6	0	0	0.8
Micro Linear	0	0	1	0	0	0.1
Motorola	42	28	32	7.4	4.6	4.0
NCR	2	2	4	0.4	0.3	0.5
National Semiconductor	18	51	45	3.2	8.3	5.6
Oak Technology	3	3	4	0.5	0.5	0.5
Opti	5	5	6	0.9	0.8	0.8
Q Logic	0	0	4	0	0	0.5
Rockwell	1	1	0	0.2	0.2	0
S3	4	12	18	0.7	2.0	2.3
SEEQ Technology	1	1	2	0.2	0.2	0.3
Sierra Semiconductor	0	0	8	0	0	1.0
Standard Microsystems	5	5	18	0.9	0.8	2.3
Symphony Laboratories	5	5	0	0.9	0.8	0
Texas Instruments	51	52	44	8.9	8.5	5.5
Trident Microsystems	1	1	0	0.2	0.2	0
Tseng Labs	7	6	7	1.2	1.0	0.9
VLSI Technology	30	30	30	5.3	4.9	3.8
WaferScale Integration	1	1	1	0.2	0.2	0.1
Western Digital	34	36	32	6.0	5.9	4.0
Zilog	12	11	12	2.1	1.8	1.5

(Continued)

Table 1-20 (Continued)
Each Company's Factory Revenue from Shipments of Microperipheral ICs to Europe (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Japanese Companies	81	71	111	14.2	11.5	13.9
Fujitsu	3	5	5	0.5	0.8	0.6
Hitachi	27	30	40	4.7	4.9	5.0
Matsushita	1	0	0	0.2	0	0
Mitsubishi	1	2	1	0.2	0.3	0.1
NEC	37	18	48	6.5	2.9	6.0
OKI	4	4	4	0.7	0.7	0.5
Toshiba	8	10	11	1.4	1.6	1.4
Yamaha	0	2	2	0	0.3	0.3
European Companies	63	29	38	11.0	4.7	4.8
Elex	0	0	15	0	0	1.9
GEC Plessey	2	0	0	0.4	0	0
Philips	23	12	12	4.0	2.0	1.5
SGS-Thomson	20	5	6	3.5	0.8	0.8
Siemens	14	8	0	2.5	1.3	0
TCS	4	4	5	0.7	0.7	0.6
Asia/Pacific Companies	2	2	11	0.4	0.3	1.4
Samsung	1	0	2	0.2	0	0.3
United Microelectronics	1	2	9	0.2	0.3	1.1

Source: Dataquest (June 1995)

Table 1-21
Each Company's Factory Revenue from Shipments of Microperipheral ICs to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	1,094	1,453	1,887	100.0	100.0	100.0
North American Companies	823	1,005	1,073	75.2	69.2	56.9
ACC Microelectronics	19	28	35	1.7	1.9	1.9
Adaptec	24	41	36	2.2	2.8	1.9
Advanced Micro Devices	11	9	6	1.0	0.6	0.3
Appian Technology	1	1	1	0.1	0.1	0.1
AT&T	2	10	5	0.2	0.7	0.3
Atmel	2	1	0	0.2	0.1	0
California Micro Devices	1	2	1	0.1	0.1	0.1
Chips & Technologies	56	40	44	5.1	2.8	2.3
Cirrus Logic	92	176	232	8.4	12.1	12.3
Cypress Semiconductor	0	0	2	0	0	0.1
Cyrix	12	12	5	1.1	0.8	0.3
Dallas Semiconductor	7	5	3	0.6	0.3	0.2
ETEQ Microsystems	12	12	0	1.1	0.8	0
Harris	1	0	1	0.1	0	0.1
Integrated Information Tech.	8	10	8	0.7	0.7	0.4
Intel	74	60	87	6.8	4.1	4.6
LSI Logic	10	16	3	0.9	1.1	0.2
Motorola	16	11	15	1.5	0.8	0.8
NCR	0	0	5	0	0	0.3
National Semiconductor	79	88	50	7.2	6.1	2.6
Oak Technology	36	38	26	3.3	2.6	1.4
Opti	64	43	63	5.9	3.0	3.3
Q Logic	0	7	7	0	0.5	0.4
Rockwell	1	1	0	0.1	0.1	0
S3	10	44	24	0.9	3.0	1.3
Sierra Semiconductor	0	0	8	0	0	0.4
Standard Microsystems	13	19	31	1.2	1.3	1.6
Symphony Laboratories	14	53	11	1.3	3.6	0.6
Texas Instruments	42	54	56	3.8	3.7	3.0
Trident Microsystems	71	54	75	6.5	3.7	4.0
Tseng Labs	17	16	18	1.6	1.1	1.0
VLSI Technology	43	47	106	3.9	3.2	5.6
WaferScale Integration	2	2	1	0.2	0.1	0.1

(Continued)

Table 1-21 (Continued)
Each Company's Factory Revenue from Shipments of Microperipheral ICs to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Western Digital	47	68	55	4.3	4.7	2.9
Zilog	17	32	38	1.6	2.2	2.0
Other North American Companies	19	5	15	1.7	0.3	0.8
Japanese Companies	89	174	341	8.1	12.0	18.1
Fujitsu	9	9	12	0.8	0.6	0.6
Hitachi	19	45	69	1.7	3.1	3.7
Matsushita	4	5	9	0.4	0.3	0.5
Mitsubishi	24	30	29	2.2	2.1	1.5
NEC	13	8	22	1.2	0.6	1.2
OKI	6	8	10	0.5	0.6	0.5
Sony	0	0	14	0	0	0.7
Toshiba	14	20	31	1.3	1.4	1.6
Yamaha	0	49	145	0	3.4	7.7
European Companies	22	8	5	2.0	0.6	0.3
Philips	21	7	4	1.9	0.5	0.2
SGS-Thomson	1	1	1	0.1	0.1	0.1
Asia/Pacific Companies	160	266	468	14.6	18.3	24.8
Acer	0	50	68	0	3.4	3.6
Daewoo	4	7	17	0.4	0.5	0.9
Goldstar	9	6	19	0.8	0.4	1.0
Hualon Microelectronics Corporation	10	10	0	0.9	0.7	0
Holtek	0	3	0	0	0.2	0
Hyundai	0	0	2	0	0	0.1
Macronix	5	14	19	0.5	1.0	1.0
Samsung	4	11	9	0.4	0.8	0.5
Silicon Integrated Systems	18	25	101	1.6	1.7	5.4
United Microelectronics	68	111	188	6.2	7.6	10.0
Winbond Electronics	42	29	45	3.8	2.0	2.4

Source: Dataquest (June 1995)

Table 1-22
Each Company's Factory Revenue from Shipments of Digital Signal Processor ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	444	679	1,030	100.0	100.0	100.0
North American Companies	379	603	911	85.4	88.8	88.4
Analog Devices	39	69	85	8.8	10.2	8.3
AT&T	105	207	275	23.6	30.5	26.7
Microchip Technology	1	2	0	0.2	0.3	0
Motorola	63	94	151	14.2	13.8	14.7
Texas Instruments	171	231	400	38.5	34.0	38.8
Japanese Companies	61	76	114	13.7	11.2	11.1
Fujitsu	21	26	36	4.7	3.8	3.5
Hitachi	4	7	9	0.9	1.0	0.9
Matsushita	1	1	4	0.2	0.1	0.4
NEC	22	27	40	5.0	4.0	3.9
OKI	0	0	2	0	0	0.2
Sanyo	6	5	7	1.4	0.7	0.7
Toshiba	7	10	16	1.6	1.5	1.6
European Companies	4	0	5	0.9	0	0.5
GEC Plessey	4	0	5	0.9	0	0.5

Source: Dataquest (June 1995)

Table 1-23
Each Company's Factory Revenue from Shipments of Digital Signal Processor ICs to North America (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	184	279	421	100.0	100.0	100.0
North American Companies	176	268	404	95.7	96.1	96.0
Analog Devices	13	28	37	7.1	10.0	8.8
AT&T	55	101	143	29.9	36.2	34.0
Microchip Technology	1	2	0	0.5	0.7	0
Motorola	33	33	63	17.9	11.8	15.0
Texas Instruments	74	104	161	40.2	37.3	38.2
Japanese Companies	6	11	15	3.3	3.9	3.6
Fujitsu	1	2	4	0.5	0.7	1.0
Hitachi	2	4	5	1.1	1.4	1.2
NEC	2	3	4	1.1	1.1	1.0
Toshiba	1	2	2	0.5	0.7	0.5
European Companies	2	0	2	1.1	0	0.5
GEC Plessey	2	0	2	1.1	0	0.5

Source: Dataquest (June 1995)

Table 1-24
Each Company's Factory Revenue from Shipments of Digital Signal Processor ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	102	119	166	100.0	100.0	100.0
North American Companies	58	69	87	56.9	58.0	52.4
Analog Devices	4	5	5	3.9	4.2	3.0
AT&T	6	7	17	5.9	5.9	10.2
Motorola	3	2	5	2.9	1.7	3.0
Texas Instruments	45	55	60	44.1	46.2	36.1
Japanese Companies	43	50	77	42.2	42.0	46.4
Fujitsu	14	16	22	13.7	13.4	13.3
Hitachi	2	2	3	2.0	1.7	1.8
Matsushita	1	1	3	1.0	0.8	1.8
NEC	16	18	28	15.7	15.1	16.9
OKI	0	0	2	0	0	1.2
Sanyo	4	5	7	3.9	4.2	4.2
Toshiba	6	8	12	5.9	6.7	7.2
European Companies	1	0	2	1.0	0	1.2
GEC Plessey	1	0	2	1.0	0	1.2

Source: Dataquest (June 1995)

Table 1-25
Each Company's Factory Revenue from Shipments of Digital Signal Processor ICs to Europe (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	130	218	305	100.0	100.0	100.0
North American Companies	123	210	294	94.6	96.3	96.4
Analog Devices	16	29	35	12.3	13.3	11.5
AT&T	42	76	83	32.3	34.9	27.2
Motorola	25	55	70	19.2	25.2	23.0
Texas Instruments	40	50	106	30.8	22.9	34.8
Japanese Companies	6	8	10	4.6	3.7	3.3
Fujitsu	4	5	6	3.1	2.3	2.0
NEC	2	3	4	1.5	1.4	1.3
European Companies	1	0	1	0.8	0	0.3
GEC Plessey	1	0	1	0.8	0	0.3

Source: Dataquest (June 1995)

Table 1-26
Each Company's Factory Revenue from Shipments of Digital Signal Processor ICs to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	28	63	138	100.0	100.0	100.0
North American Companies	22	56	126	78.6	88.9	91.3
Analog Devices	6	7	8	21.4	11.1	5.8
AT&T	2	23	32	7.1	36.5	23.2
Motorola	2	4	13	7.1	6.3	9.4
Texas Instruments	12	22	73	42.9	34.9	52.9
Japanese Companies	6	7	12	21.4	11.1	8.7
Fujitsu	2	3	4	7.1	4.8	2.9
Hitachi	0	1	1	0	1.6	0.7
Matsushita	0	0	1	0	0	0.7
NEC	2	3	4	7.1	4.8	2.9
Sanyo	2	0	0	7.1	0	0
Toshiba	0	0	2	0	0	1.4

Source: Dataquest (June 1995)

Section 2: Final 1994 Microcomponent Market Share Ranking

Table 2-1
Top 50 Companies' Factory Revenue from Shipments of MOS Microcomponent ICs Worldwide (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percent Change	1994 Market Share (%)
1	1	Intel	7,444	9,595	29	37.1
2	2	Motorola	2,065	2,363	14	9.1
3	3	NEC	1,341	1,678	25	6.5
4	6	Advanced Micro Devices	563	1,021	81	3.9
5	4	Texas Instruments	781	1,006	29	3.9
6	5	Hitachi	718	998	39	3.9
7	7	Toshiba	540	718	33	2.8
8	8	Mitsubishi	532	698	31	2.7
9	10	Cirrus Logic	371	681	84	2.6
10	13	Matsushita	286	460	61	1.8
11	9	National Semiconductor	477	409	-14	1.6
12	12	Philips	305	403	32	1.6
13	11	IBM	337	399	18	1.5
14	14	Fujitsu	282	390	38	1.5
15	15	AT&T	246	305	24	1.2
16	22	Yamaha	149	273	83	1.1
17	24	Cyrix	125	241	93	0.9
18	21	SGS-Thomson	162	227	40	0.9
19	26	United Microelectronics	113	227	101	0.9
20	17	Zilog	203	222	9	0.9
21	18	OKI	180	217	21	0.8
22	19	VLSI Technology	173	216	25	0.8
23	28	Sony	112	194	73	0.7
24	20	Sharp	170	192	13	0.7
25	16	Western Digital	218	184	-16	0.7
26	23	Sanyo	145	161	11	0.6
27	27	S3	113	130	15	0.5
28	32	Opti	86	130	51	0.5
29	34	Microchip Technology	72	130	81	0.5
30	29	Siemens	107	128	20	0.5
31	25	Adaptec	122	125	2	0.5
32	52	Silicon Integrated Systems	26	101	288	0.4
33	47	Standard Microsystems	43	100	133	0.4
34	31	Chips & Technologies	86	89	3	0.3
35	39	Trident Microsystems	60	87	45	0.3

(Continued)

Table 2-1 (Continued)
Top 50 Companies' Factory Revenue from Shipments of MOS Microcomponent ICs Worldwide (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percent Change	1994 Market Share (%)
36	36	Analog Devices	69	85	23	0.3
37	30	Ricoh	89	83	-7	0.3
38	35	Tseng Labs	71	83	17	0.3
39	38	NCR	63	81	29	0.3
40	33	LSI Logic	77	78	1	0.3
41	42	Acer	50	68	36	0.3
42	41	Oak Technology	50	62	24	0.2
43	44	Harris	47	52	11	0.2
44	43	Integrated Device Technology	48	51	6	0.2
45	46	TEMIC	44	51	16	0.2
46	54	Rohm	23	50	117	0.2
47	49	ACC Microelectronics	36	49	36	0.2
48	51	Winbond Electronics	30	48	60	0.2
49	55	Q Logic	21	45	114	0.2
50	45	Samsung	46	44	-4	0.2
		All Others	430	440	2	1.7
		North American Companies	14,395	18,303	27	70.8
		Japanese Companies	4,585	6,137	34	23.7
		European Companies	640	851	33	3.3
		Asia/Pacific Companies	327	577	76	2.2
		Total Market	19,947	25,868	30	100.0

NM = Not meaningful
Source: Dataquest (June 1995)

Table 2-2
Top 20 Companies' Factory Revenue from Shipments of Microprocessor ICs Worldwide (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percent Change	1994 Market Share (%)
1	1	Intel	6,569	8,370	27	73.2
2	3	Advanced Micro Devices	511	985	93	8.6
3	2	Motorola	705	597	-15	5.2
4	6	IBM	88	246	180	2.2
5	5	Cyrix	95	231	143	2.0
6	4	Texas Instruments	200	214	7	1.9
7	8	Hitachi	79	160	103	1.4
8	7	NEC	87	105	21	0.9
9	9	Toshiba	68	92	35	0.8
10	15	Fujitsu	25	56	124	0.5
11	10	LSI Logic	47	51	9	0.4
12	11	Integrated Device Technology	43	51	19	0.4
13	12	SGS-Thomson	39	51	31	0.4
14	14	National Semiconductor	38	49	29	0.4
15	13	Zilog	39	43	10	0.4
16	18	Performance Semiconductor	16	15	-6	0.1
17	16	Weitek	19	14	-26	0.1
18	19	Matsushita	11	14	27	0.1
19	20	Sharp	11	12	9	0.1
20	21	Harris	11	12	9	0.1
		All Others	82	68	-17	0.6
		North American Companies	8,408	10,897	30	95.3
		Japanese Companies	311	461	48	4.0
		European Companies	61	67	10	0.6
		Asia/Pacific Companies	3	11	267	0.1
		Total Market	8,783	11,436	30	100.0

NM = Not meaningful

Source: Dataquest (June 1995)

Table 2-3
Top 20 Companies' Factory Revenue from Shipments of Microcontroller ICs Worldwide (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percent Change	1994 Market Share (%)
1	1	Motorola	1,107	1,424	29	18.9
2	2	NEC	1,100	1,275	16	17.0
3	3	Mitsubishi	465	637	37	8.5
4	5	Intel	450	600	33	8.0
5	4	Hitachi	458	577	26	7.7
6	8	Matsushita	251	405	61	5.4
7	6	Toshiba	301	403	34	5.4
8	7	Philips	258	345	34	4.6
9	12	Fujitsu	129	180	40	2.4
10	10	OKI	149	178	19	2.4
11	9	Sharp	149	169	13	2.2
12	14	SGS-Thomson	113	161	42	2.1
13	11	Sanyo	138	154	12	2.0
14	13	Texas Instruments	120	143	19	1.9
15	16	Sony	104	140	35	1.9
16	19	Microchip Technology	70	130	86	1.7
17	17	Siemens	95	128	35	1.7
18	15	National Semiconductor	105	100	-5	1.3
19	18	Ricoh	82	76	-7	1.0
20	20	Zilog	62	68	10	0.9
		All Others	198	224	13	3.0
		North American Companies	1,984	2,514	27	33.4
		Japanese Companies	3,363	4,261	27	56.7
		European Companies	510	685	34	9.1
		Asia/Pacific Companies	47	57	21	0.8
		Total Market	5,904	7,517	27	100.0

NM = Not meaningful

Source: Dataquest (June 1995)

Table 2-4
Top 40 Companies' Factory Revenue from Shipments of Microperipheral ICs Worldwide (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percent Change	1994 Market Share (%)
1	2	Cirrus Logic	371	681	84	11.6
2	1	Intel	425	625	47	10.6
3	11	Yamaha	149	273	83	4.6
4	3	National Semiconductor	334	260	-22	4.4
5	12	NEC	127	258	103	4.4
6	7	Hitachi	174	252	45	4.3
7	5	Texas Instruments	230	249	8	4.2
8	14	United Microelectronics	113	217	92	3.7
9	8	VLSI Technology	170	214	26	3.6
10	9	Toshiba	161	207	29	3.5
11	10	Motorola	159	191	20	3.2
12	6	Western Digital	218	184	-16	3.1
13	4	IBM	249	153	-39	2.6
14	15	S3	113	130	15	2.2
15	18	Opti	86	130	51	2.2
16	13	Adaptec	122	125	2	2.1
17	16	Fujitsu	102	118	16	2.0
18	17	Zilog	102	111	9	1.9
19	38	Silicon Integrated Systems	26	101	288	1.7
20	28	Standard Microsystems	43	100	133	1.7
21	23	Trident Microsystems	60	87	45	1.5
22	20	Tseng Labs	71	83	17	1.4
23	19	Chips & Technologies	80	82	2	1.4
24	22	NCR	63	81	29	1.4
25	25	Acer	50	68	36	1.2
26	26	Oak Technology	50	62	24	1.1
27	27	Philips	46	58	26	1.0
28	49	Sony	8	54	575	0.9
29	24	Mitsubishi	50	52	4	0.9
30	33	ACC Microelectronics	36	49	36	0.8
31	36	Winbond Electronics	30	48	60	0.8
32	41	Q Logic	21	45	114	0.8
33	68	Cypress Semiconductor	2	40	1,900	0.7
34	39	Matsushita	23	37	61	0.6
35	31	Integrated Information Tech.	40	35	-13	0.6
36	78	Sierra Semiconductor	0	35	NM	0.6
37	37	Harris	27	32	19	0.5

(Continued)

Table 2-4 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Microperipheral ICs Worldwide (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percent Change	1994 Market Share (%)
38	30	Advanced Micro Devices	41	31	-24	0.5
39	32	AT&T	37	30	-19	0.5
40	40	OKI	22	28	27	0.5
		All Others	350	269	-23	4.6
		North American Companies	3,400	3,981	17	67.6
		Japanese Companies	835	1,301	56	22.1
		European Companies	69	94	36	1.6
		Asia/Pacific Companies	277	509	84	8.6
		Total Market	4,581	5,885	28	100.0

NM = Not meaningful
Source: Dataquest (June 1995)

Table 2-5
Top 10 Companies' Factory Revenue from Shipments of Digital Signal Processor ICs Worldwide (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percent Change	1994 Market Share (%)
1	1	Texas Instruments	231	400	73	38.8
2	2	AT&T	207	275	33	26.7
3	3	Motorola	94	151	61	14.7
4	4	Analog Devices	69	85	23	8.3
5	5	NEC	27	40	48	3.9
6	6	Fujitsu	26	36	38	3.5
7	7	Toshiba	10	16	60	1.6
8	8	Hitachi	7	9	29	0.9
9	9	Sanyo	5	7	40	0.7
10	81	GEC Plessey	0	5	NM	0.5
		All Others	3	6	100	0.6
		North American Companies	603	911	51	88.4
		Japanese Companies	76	114	50	11.1
		European Companies	0	5	NA	0.5
		Asia/Pacific Companies	0	0	NA	0
		Total Market	679	1,030	52	100.0

NM = Not meaningful
Source: Dataquest (June 1995)

For More Information...

Sue Kapoor, Market Research Analyst ....(408) 437-8505

Internet address ....skapoor@dataquest.com

Via fax..(408) 437-0292

Dataquest®

a company of The Dun & Bradstreet Corporation

Dataquest®

a company of
The Dun & Bradstreet Corporation

Corporate Headquarters
Dataquest Incorporated
1290 Ridder Park Drive
San Jose, California 95131-2398
United States
Phone: 1-408-437-8000
Facsimile: 1-408-437-0292

Dataquest Incorporated
Nine Technology Drive
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6180

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

European Headquarters
Dataquest Europe Limited
Holmers Farm Way
High Wycombe, Buckinghamshire
HP12 4XH
United Kingdom
Phone: 44-1494-422722
Facsimile: 44-1494-422742

Dataquest GmbH
Kronstadter Strasse 9
81677 München
Germany
Phone: 49-89-930-9090
Facsimile: 49-89-930-3277

Dataquest Europe SA
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: 33-1-41-35-13-00
Facsimile: 33-1-41-35-13-13

Japan Headquarters
Dataquest Japan K.K.
Shinkawa Sanko Building, 6th Floor
1-3-17, Shinkawa, Chuo-ku
Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

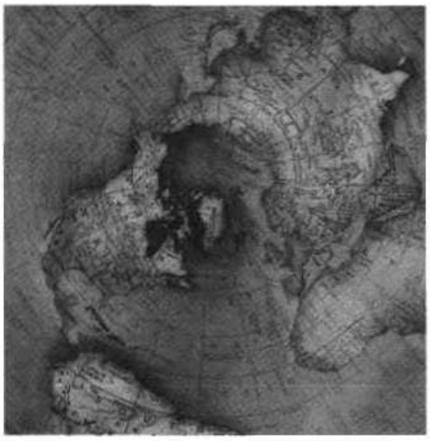
Asia/Pacific Headquarters
7/F China Underwriters Centre
88 Gloucester Road
Wan Chai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei 105
Taiwan, R.O.C.
Phone: 8862-756-0389
Facsimile: 8862-756-2663

Other research offices in Beijing, Singapore, and Thailand

Sales agents in Australia, Belgium, Germany (Kronberg), Israel, Italy, South Africa, and Spain



Dataquest

Microprocessor Forecast and Assumptions: June 1995

Market Trends

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MT-9502
Publication Date: June 26, 1995
Filing: Market Analysis

Microprocessor Forecast and Assumptions: June 1995

Market Trends

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MT-9502
Publication Date: June 26, 1995
Filing: Market Analysis

Table of Contents

List of Figures

List of Tables

Chapter 1
Microprocessor Forecast and Assumptions: June 1995

This report contains a detailed forecast and assumptions for the microprocessor market. It is the first time that we have forecast the microprocessor market to such a level of detail. To those that remember the classifications for microprocessors we have used for the past two years, this document will look different. We hope it will be much more useful. The prior classifications were as follows:

- x86 family: This included all of the microprocessors in the x86 microprocessor family. It included products from the 8086 to the Pentium.
- 68K family: This included all members of the 68xxx microprocessor family. Examples of this family include the 68000 through the 68060. Also included was the embedded family known as the 683xx series of embedded microprocessors.
- Open System RISC (OSR): This included the major workstation RISC microprocessors such as Alpha, MIPS, PA-RISC, SPARC, and PowerPC. This category did not separate the compute microprocessor shipments from those intended for the embedded market.
- Embedded systems focus (ESF): This family included both RISC and CISC microprocessors intended primarily for use in embedded applications.
- Low-end architecture (LEA): This family comprised primarily the 8-bit microprocessors such as the 8080/Z80, 680x, and 6502 families of microprocessors.

This categorization prevented us from providing some product splits that were important for the microprocessor market. It was virtually impossible to provide an embedded versus compute split. Other important splits that were not easy to obtain included splits by wordwidth, and by RISC versus CISC. The many questions we had regarding this procedure for categorizing the microprocessor market caused us to rethink this policy, and the result is the breakout in this report. The breakdown for microprocessors now makes it much easier to find the cuts of data that matter most to the industry. We have broken the market down as follows:

- Total microprocessor
  - Revenue, average selling price (ASP), units
- RISC microprocessor
  - Revenue, ASP, units
  - Compute-oriented RISC microprocessors
    - Revenue, ASP, units
  - Noncompute-oriented RISC microprocessors
    - Revenue, ASP, units
- CISC microprocessor
  - Revenue, ASP, units

- Compute-oriented CISC microprocessors
  - Revenue, ASP, units
- Noncompute-oriented CISC microprocessors
  - Revenue, ASP, units
- x86 family
  - Revenue, ASP, units
- 68K family
  - Revenue, ASP, units
- Other CISC
  - Revenue, ASP, units
- x86 Detailed microprocessor total forecast
  - Revenue, ASP, units
- x86 Detailed microprocessor noncompute forecast
  - Revenue, ASP, units
- x86 detailed microprocessor compute forecast
  - Revenue, ASP, units
- Microprocessor forecast by wordwidth
  - Revenue, ASP, units

We believe that this forecast is the most comprehensive forecast available on the market. We also provide some of the basic assumptions behind the forecast and identify the delta between the number of microprocessors shipped into computing applications versus the personal computer forecast as published by Dataquest's Personal Computers Worldwide service.

We will begin balancing our coverage in the PC portion of the market in the coming months with more detail on the embedded applications market for microprocessors. This new focus from Dataquest's Microcomponents Worldwide service will provide guidance for the many vendors competing for the very broad and often difficult-to-understand market of embedded applications. This focus is backed up with a new principal analyst position that has been filled by an industry veteran with more than 17 years' experience in the embedded marketplace.

Chapter 2
Bottom-Up Analysis

Because the computing applications make up more than 85 percent of the microprocessor market, we believe it is appropriate to provide the assumptions and analysis behind the compute portion of the microprocessor forecast. The compute market for microprocessors is divided into two basic categories, the x86 family and the various RISC processors (we exclude the 68K family in this analysis because the Apple Macintosh has been the only major design win for this family, and Apple is rapidly replacing all 68K designs with the PowerPC).

Dataquest's PC program operates under the following basic assumptions:

- We will not reach a saturation point for PC ownership in this decade.
- Normalized penetration rates will continue at recent historical rates.
- New applications will continue to require more microprocessor power.
- Brand-name advertising will cause additional pull for next-generation microprocessors.
- In the near term, the desktop operating system of choice will be x86-specific.
- Broad acceptance of a non-x86-specific desktop operating system is four to five years away.

Based on these and other assumptions, Dataquest's PC program has developed a PC forecast through the year 1999. This forecast is broken down in several ways, but two we will consider here are the x86-based PCs and RISC-based PCs (not including workstations).

x86 Personal Computer Correlation

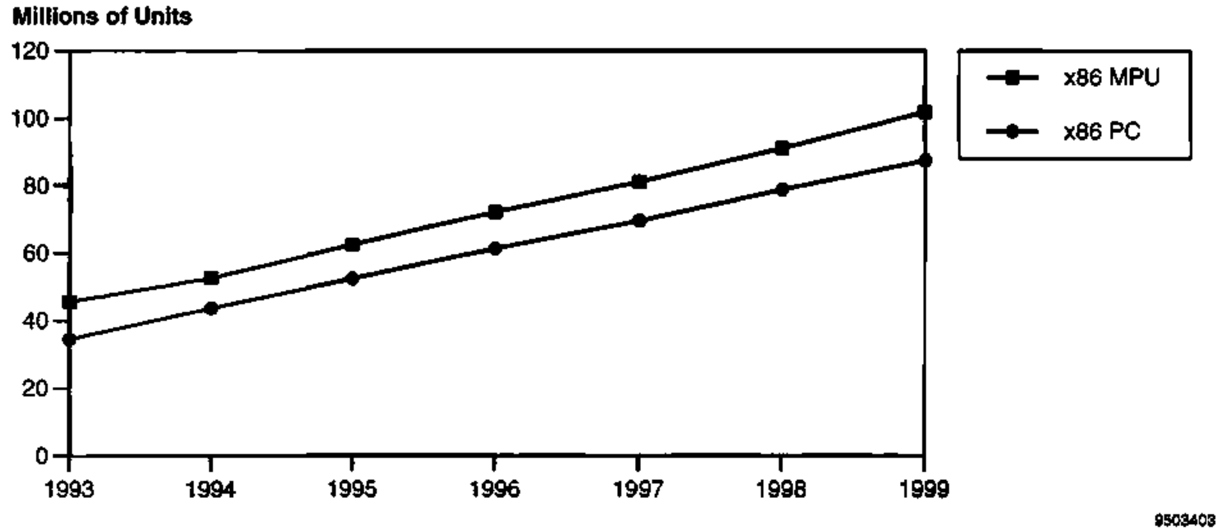
Table 2-1 and Figure 2-1 each show the unit growth ramp for x86-based PCs through the year 1999. Also included is the Dataquest forecast for x86 microprocessors shipped into compute applications. The delta between the two numbers is attributed to the way Dataquest defines a PC versus the way Dataquest defines microprocessors shipping into computing applications. The PC shipments shown in Table 2-1 reflect only complete systems and do not include self-built computers, motherboard upgrades, industrial uses for motherboards such as ATMs and switches, CPU upgrades, and work-in-process. As Table 2-1 shows, this delta was nearly 9 million units in 1994 and will surpass 14 million units in 1999.

Table 2-1
x86 Personal Computer and MPU Shipment Comparison (Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999
x86 MPU	45,574	52,593	62,437	72,094	81,243	91,248	101,900
x86 PC	34,464	43,621	52,378	61,301	69,583	78,915	87,500
Delta	11,111	8,972	10,059	10,792	11,660	12,333	14,400

Source: Dataquest (June 1995)

Figure 2-1
x86 Personal Computer and MPU Shipment Comparison



Source: Dataquest (June 1995)

Mapping this topline unit number into the various x86 microprocessors is a relatively straightforward task. Intel, along with the many x86 competitors, is very open with its microprocessor road map. It is also advertising heavily to make sure that the market perceives a strong need to move to the next-generation microprocessor. We are able to use these factors and map the life cycles of the various x86 microprocessors into the top-line shipment forecast. We also have several groups focusing on the selling price of microprocessors and are able to model this pricing, which allows us to develop the revenue forecast for the x86 portion of the computing market.

RISC PC Correlation

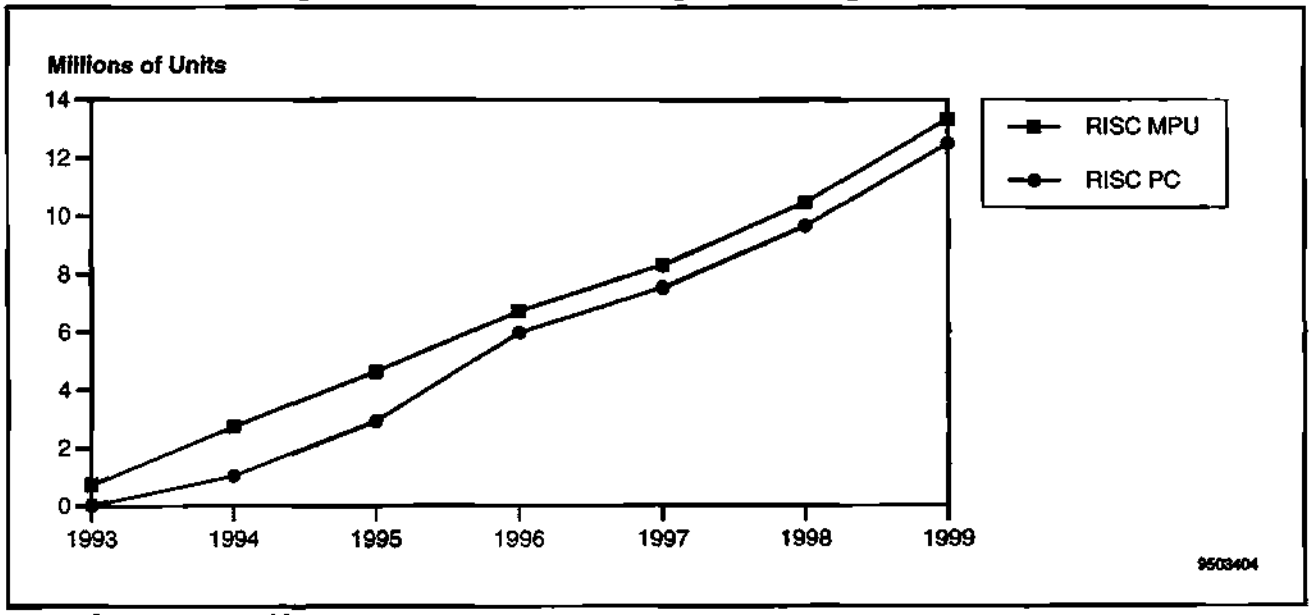
Based on the expected transformation of the Macintosh computer from a 68K-based machine to one based on the PowerPC, we show a quick-step function increase for RISC microprocessor-based PCs (see Table 2-2 and Figure 2-2). The relatively large delta between RISC microprocessor shipments and RISC PC shipments is an anomaly we cannot yet explain. We are quite confident that IBM Microelectronics shipped about 2 million PowerPC microprocessors in 1994. However, we can only account for about 1 million of those going into systems (Macintosh systems). We believe that this overbuild scenario might continue in 1995 as the PowerPC alliance of IBM, Apple, and Motorola tries to jump-start the PowerPC. The delta falls back to a reasonable value in 1997, where it basically reflects work-in-process for PCs as well as workstation shipments not included in the RISC PC forecast.

Table 2-2
RISC Personal Computer and RISC MPU Shipment Comparison (Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999
RISC MPU	729	2,743	4,639	6,725	8,311	10,451	13,337
RISC PC	70	1,044	2,934	5,985	7,540	9,640	12,500
Delta	659	1,698	1,705	740	771	811	837

Source: Dataquest (June 1995)

Figure 2-2
RISC Personal Computer and RISC MPU Shipment Comparison



Source: Dataquest (June 1995)

ASP Assumptions

We are seeing a definite change in the ASP strategies in the x86 marketplace. With Intel's introduction of the first 686 series product, the P6, we have seen the first of a series of next-generation microprocessors introduced twice as fast as historical precedent. As a result, price declines must also occur at about twice the rate as historical precedent would indicate, otherwise the market will not be able to keep up with the rapid transition from one microprocessor series to the next. Because Intel wants to facilitate this continuing transition from one generation of x86 microprocessor to the next, it must begin a more aggressive pricing policy for its next-generation microprocessors. Indeed, we are beginning to see evidence of this new pricing model at work. We believe that the overall ASP of the x86 microprocessor has room to continue increasing. However, the RISC microprocessors must continue to slash prices to try to demonstrate radically superior price/performance when compared to the x86 product line.

x86 Competitive Assumptions

Advanced Micro Devices will continue to hold the No. 2 position and will press on with its new strategy of forward-engineering next-generation x86 microprocessors. AMD hopes that by the time its seventh-generation x86 microprocessor is ready to ship it will have caught up with Intel and will be in a position to capture more than 20 percent market share. To this end AMD is rapidly ramping its Texas megafab into production. It simultaneously is converting to 0.35-micron to ensure the highest performance as well as to increase manufacturing capacity.

Cyrix, Nexgen, and IBM will remain the primary contenders to AMD for the No. 2 position and will have a limited short-term impact on Intel's pricing and/or product introduction strategies.

Appendix A
MPU Forecasts

Forecast Details

The detailed forecasts in this appendix are the first MPU forecasts of their kind. They make use of a solid bottom-up methodology for the computing portion of the forecast (which makes up more than 80 percent of the revenue) and a top-down methodology that provides an effective ceiling for the forecast. The resultant noncomputing portion of the forecast most probably will turn out to be a good approximation for the embedded forecast. We are just now beginning our application work for embedded microprocessors and hope to soon begin identifying specific applications for the major portion of the noncomputing forecast. Watch for this information in upcoming documents from Dataquest's Microcomponents Worldwide service.

Tables A-1 through A-9 and Figures A-1 through A-9 detail the MPU forecast.

Table A-1
Total Microprocessor Forecast (Units in Thousands, ASP in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Total CISC								
Units	165,970	171,860	190,505	209,690	220,205	237,202	260,334	9
ASP	50	60	71	82	95	105	112	13
Revenue	8,254,379	10,390,361	13,448,424	17,151,267	20,893,630	24,975,920	29,188,582	23
Total RISC								
Units	7,650	16,568	49,997	58,062	70,137	87,583	109,321	46
ASP	69	59	33	33	31	30	29	-13
Revenue	528,454	974,555	1,635,414	1,900,681	2,200,379	2,637,103	3,204,510	27
Total MPU								
Units	173,620	188,428	240,502	267,752	290,342	324,785	369,656	14
ASP	51	60	63	71	80	85	88	8
Revenue	8,782,833	11,364,915	15,083,838	19,051,948	23,094,009	27,613,023	32,393,093	23
Growth Rates (%)								
Total CISC								
Units	16	4	11	10	5	8	10	
ASP	39	22	17	16	16	11	6	
Revenue	61	26	29	28	22	20	17	
Total RISC								
Units	156	117	202	16	21	25	25	
ASP	-46	-15	-44	0	-4	-4	-3	
Revenue	38	84	68	16	16	20	22	
Total MPU								
Units	19	9	28	11	8	12	14	
ASP	35	19	4	13	12	7	3	
Revenue	60	29	33	26	21	20	17	

Source: Dataquest (June 1995)

Table A-2
RISC Microprocessor Forecast (Units in Thousands, ASP in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Computing RISC Forecast								
Units	729	2,743	4,639	6,725	8,311	10,451	13,337	37
ASP	370	222	183	165	152	141	131	-10
Revenue	269,988	607,763	847,754	1,107,375	1,266,518	1,471,614	1,753,855	24
Noncomputing RISC Forecast								
Units	6,921	13,826	45,358	51,337	61,825	77,131	95,984	47
ASP	37	27	17	15	15	15	15	-11
Revenue	258,466	366,792	787,660	793,306	933,861	1,165,489	1,450,656	32
Total RISC Forecast								
Units	7,650	16,568	49,997	58,062	70,137	87,583	109,321	46
ASP	69	59	33	33	31	30	29	-13
Revenue	528,454	974,555	1,635,414	1,900,681	2,200,379	2,637,103	3,204,510	27

Source: Dataquest (June 1995)

Table A-3
CISC Microprocessor Forecast (Units in Thousands, ASP in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
x86 Forecast								
Units	72,713	83,544	95,203	107,012	117,290	128,265	141,555	11
ASP	100	114	132	152	171	188	199	12
Revenue	7,281,610	9,518,049	12,569,120	16,305,137	20,061,256	24,075,419	28,111,885	24
68K Forecast								
Units	36,954	39,251	46,157	52,771	56,094	61,904	75,059	14
ASP	20	17	15	13	12	13	13	-5
Revenue	727,943	669,592	699,833	689,424	697,842	775,683	966,637	8
Other CISC (32xxx, 8-Bit, Among Others)								
Units	56,303	49,064	49,145	49,907	46,821	47,034	43,720	-2
ASP	4	4	4	3	3	3	3	-9
Revenue	244,825	202,720	179,470	156,706	134,532	124,817	110,060	-11
Total CISC								
Units	165,970	171,860	190,505	209,690	220,205	237,202	260,334	9
ASP	50	60	71	82	95	105	112	13
Revenue	8,254,379	10,390,361	13,448,424	17,151,267	20,893,630	24,975,920	29,188,582	23

Source: Dataquest (June 1995)

Table A-4
80x86 Microprocessor Forecast (Units in Thousands, ASP in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Processor								
8086/88/186/188								
Units	25,997	27,054	29,000	31,500	32,500	34,000	36,000	6
ASP	9	8	8	7	7	7	7	-3
Revenue	224,349	210,728	217,500	228,375	227,500	238,000	243,000	3
80286								
Units	1,244	809	526	263	105	42	17	-54
ASP	13	11	11	11	11	10	10	-1
Revenue	16,172	8,895	5,781	2,825	1,104	431	172	-55
80386								
Units	11,550	6,865	4,050	3,100	3,060	2,398	2,388	-19
ASP	33	23	20	19	17	15	14	-10
Revenue	379,725	156,618	80,589	57,950	52,787	35,587	32,650	-27
80486								
Units	33,597	43,752	32,049	11,187	1,775	825	650	-57
ASP	190	152	101	72	50	38	30	-28
Revenue	6,398,114	6,644,558	3,243,915	804,621	89,540	31,336	19,383	-69
586 Class								
Units	325	5,065	29,278	52,900	41,000	22,000	10,000	15
ASP	810	493	300	208	159	127	102	-27
Revenue	263,250	2,497,250	8,773,835	11,020,075	6,506,700	2,793,120	1,015,680	-16
686 Class								
Units	0	0	300	8,063	38,500	58,000	49,000	NM
ASP	NM	NM	825	520	334	254	185	NM
Revenue	0	0	247,500	4,191,291	12,868,625	14,739,946	9,065,000	NM
786 Class								
Units	0	0	0	0	350	11,000	43,000	NM
ASP	0	0	0	0	900	567	402	NM
Revenue	0	0	0	0	315,000	6,237,000	17,286,000	NM
886 Class								
Units	0	0	0	0	0	0	500	NM
ASP	0	0	0	0	0	0	900	NM
Revenue	0	0	0	0	0	0	450,000	NM
Total x86								
Units	72,713	83,544	95,203	107,012	117,290	128,265	141,555	11
ASP	100	114	132	152	171	188	199	12
Revenue	7,281,610	9,518,049	12,569,120	16,305,137	20,061,256	24,075,419	28,111,885	24

NM = Not meaningful
Source: Dataquest (June 1995)

Table A-5
16-Bit 80x86 Microprocessor Forecast (Units in Thousands, ASP in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Processor								
8086/88/186/188								
Units	25,997	27,054	29,000	31,500	32,500	34,000	36,000	6
ASP	9	8	8	7	7	7	7	-3
Revenue	224,349	210,728	217,500	228,375	227,500	238,000	243,000	3
80286								
Units	1,244	809	526	263	105	42	17	-54
ASP	13	11	11	11	11	10	10	-1
Revenue	16,172	8,895	5,781	2,825	1,104	431	172	-55
Total 16-Bit								
Units	27,241	27,862	29,526	31,763	32,605	34,042	36,017	5
ASP	9	8	8	7	7	7	7	-3
Revenue	240,521	219,623	223,281	231,200	228,604	238,431	243,172	2

Source: Dataquest (June 1995)

Table A-6
32-Bit 80x86 Microprocessor Forecast (Units in Thousands, ASP in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Processor								
80386SX								
Units	5,275	3,215	1,500	700	560	448	358	-36
ASP	29	18	15	14	14	13	13	-6
Revenue	152,975	57,806	22,500	9,800	7,560	5,936	4,659	-40
80386 (Miscellaneous; SL and Embedded)								
Units	425	175	275	400	750	1,250	1,750	58
ASP	38	29	21	17	15	14	13	-14
Revenue	16,150	4,988	5,878	6,840	11,250	16,875	23,188	36
80386DX								
Units	5,850	3,475	2,275	2,000	1,750	700	280	-40
ASP	36	27	23	21	19	18	17	-9
Revenue	210,600	93,825	52,211	41,310	33,977	12,776	4,804	-45
80486SX								
Units	14,385	16,732	3,609	200	0	0	0	-100
ASP	74	64	35	26	20	16	13	-28
Revenue	1,064,490	1,075,868	126,315	5,250	0	0	0	-100

(Continued)

Table A-6 (Continued)
32-Bit 80x86 Microprocessor Forecast (Units in Thousands, ASP in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
80486DX								
Units	11,812	6,722	2,000	87	0	0	0	-100
ASP	222	150	60	33	28	24	20	-33
Revenue	2,622,264	1,008,300	120,000	2,871	0	0	0	-100
80486DX2								
Units	7,400	18,092	13,000	2,500	300	225	200	-59
SP	366	210	60	33	28	24	20	-37
Revenue	2,711,360	3,799,320	780,000	82,500	8,415	5,365	4,053	-75
80486DX4								
Units	0	2,206	13,440	8,400	1,475	600	450	-27
ASP	0	345	165	85	55	43	34	-37
Revenue	0	761,070	2,217,600	714,000	81,125	25,971	15,329	-54
586 Class								
Units	325	5,065	29,278	52,900	41,000	22,000	10,000	15
ASP	810	493	300	208	159	127	102	-27
Revenue	263,250	2,497,250	8,773,835	11,020,075	6,506,700	2,793,120	1,015,680	-16
686 Class								
Units	0	0	300	8,063	38,500	58,000	49,000	NM
ASP	-	-	825	520	334	254	185	NM
Revenue	0	0	247,500	4,191,291	12,868,625	14,739,946	9,065,000	NM
786 Class								
Units	0	0	0	0	350	11,000	43,000	NM
ASP	0	0	0	0	900	567	402	NM
Revenue	0	0	0	0	315,000	6,237,000	17,286,000	NM
886 Class								
Units	0	0	0	0	0	0	500	NM
ASP	0	0	0	0	0	0	900	NM
Revenue	0	0	0	0	0	0	450,000	NM
Total 32-Bit and Up								
Units	45,472	55,682	65,677	75,250	84,685	94,223	105,538	14
ASP	155	167	188	214	234	253	264	10
Revenue	7,041,089	9,298,426	12,345,839	16,073,937	19,832,652	23,836,988	27,868,713	25

NM = Not meaningful
Source: Dataquest (June 1995)

Table A-7
x86 Product Forecast, Computing Applications (Units in Thousands, ASP in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
8086/186/286								
Units	218	0	0	0	0	0	0	NM
ASP	9	NM	NM	NM	NM	NM	NM	NM
Revenue	1,924	0	0	0	0	0	0	NM
386 Class								
Units	11,435	3,776	810	0	0	0	0	NM
ASP	33	23	20	NM	NM	NM	NM	NM
Revenue	375,928	86,140	16,118	0	0	0	0	NM
486 Class								
Units	33,597	43,752	32,049	11,131	1,598	578	0	NM
ASP	190	152	101	72	50	NM	NM	NM
Revenue	6,398,114	6,644,558	3,243,915	800,598	80,586	21,935	0	NM
586 Class								
Units	325	5,065	29,278	52,900	40,795	21,670	9,400	-20
ASP	810	493	300	208	159	127	102	-19
Revenue	263,250	2,497,250	8,773,835	11,020,075	6,474,167	2,751,223	954,739	-36
686 Class								
Units	0	0	300	8,063	38,500	58,000	49,000	NM
ASP	NM	NM	825	520	334	254	185	NM
Revenue	0	0	247,500	4,191,291	12,868,625	14,739,946	9,065,000	NM
786 Class								
Units	0	0	0	0	350	11,000	43,000	NM
ASP	NM	NM	NM	NM	900	567	402	NM
Revenue	0	0	0	0	315,000	6,237,000	17,286,000	NM
886 Class								
Units	0	0	0	0	0	0	500	NM
ASP	NM	NM	NM	NM	NM	NM	900	NM
Revenue	0	0	0	0	0	0	450,000	NM
Total Compute x86								
Units	45,574	52,593	62,437	72,094	81,243	91,248	101,900	14
ASP	154	175	197	222	243	260	272	9
Revenue	7,039,216	9,227,948	12,281,367	16,011,964	19,738,378	23,750,104	27,755,739	25

NM = Not meaningful
Source: Dataquest (June 1995)

Table A-8
x86 Product Forecast, Noncomputing x86 Applications (Units in Thousands, ASP in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
8086/186/286								
Units	27,023	27,862	29,526	31,763	32,605	34,042	36,017	5
ASP	9	8	8	7	7	7	7	-3
Revenue	238,597	219,623	223,281	231,200	228,604	238,431	243,172	2
386 Class								
Units	116	3,089	3,240	3,100	3,060	2,398	2,388	-5
ASP	33	23	20	19	17	15	14	-10
Revenue	3,797	70,478	64,472	57,950	52,787	35,587	32,650	-14
486 Class								
Units	0	0	0	56	178	248	650	NM
ASP	NM	NM	NM	72	50	38	30	NM
Revenue	0	0	0	4,023	8,954	9,401	19,383	NM
586 Class								
Units	0	0	0	0	205	330	600	NM
ASP	NM	NM	NM	NM	159	127	102	NM
Revenue	0	0	0	0	32,534	41,897	60,941	NM
686 Class								
Units	0	0	0	0	0	0	0	NM
ASP	NM	NM	NM	NM	NM	NM	NM	NM
Revenue	0	0	0	0	0	0	0	NM
786 Class								
Units	0	0	0	0	0	0	0	NM
ASP								NM
Revenue	0	0	0	0	0	0	0	NM
886 Class								
Units	0	0	0	0	0	0	0	NM
ASP								NM
Revenue	0	0	0	0	0	0	0	NM
Total Embedded x86								
Units	27,139	30,952	32,766	34,919	36,048	37,018	39,655	5
ASP	9	9	9	8	9	9	9	-1
Revenue	242,394	290,101	287,753	293,173	322,879	325,315	356,146	4

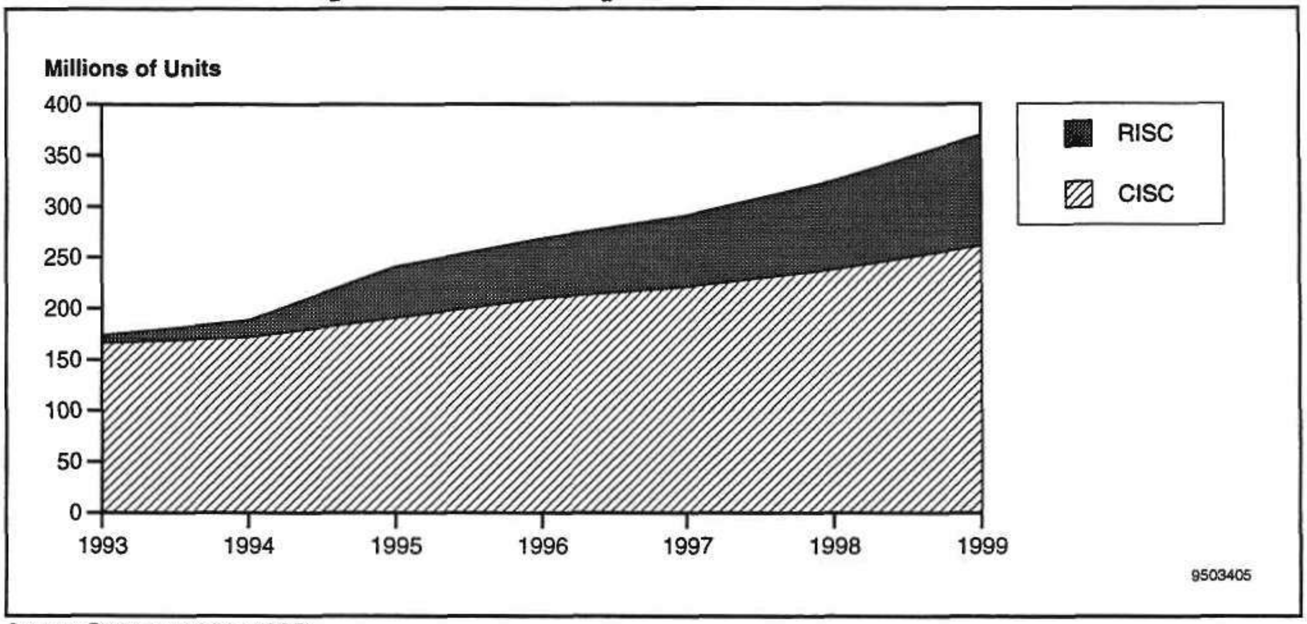
NM = Not meaningful
Source: Dataquest (June 1995)

Table A-9
Microprocessor Forecast by Wordwidth (Units in Thousands, Units in Dollars, Revenue in Thousands)

	1993	1994	1995	1996	1997	1998	1999
8-Bit MPU							
Units	53,337	46,422	47,051	48,519	45,914	46,476	43,373
ASP	2	3	3	3	3	2	2
Revenue	131,693	117,276	121,438	124,340	115,869	114,677	104,497
16-Bit MPU							
Units	27,241	27,862	29,526	31,763	32,605	34,042	36,017
ASP	9	8	8	7	7	7	7
Revenue	240,521	219,623	223,281	231,200	228,604	238,431	243,172
32-Bit and Up							
Units	93,042	114,143	163,925	187,470	211,823	244,267	290,265
ASP	90	97	90	100	107	112	110
Revenue	8,410,618	11,028,016	14,739,118	18,696,407	22,749,536	27,259,915	32,045,423
Total MPU							
Units	173,620	188,428	240,502	267,752	290,342	324,785	369,656
ASP	51	60	63	71	80	85	88
Revenue	8,782,833	11,364,915	15,083,838	19,051,948	23,094,009	27,613,023	32,393,093

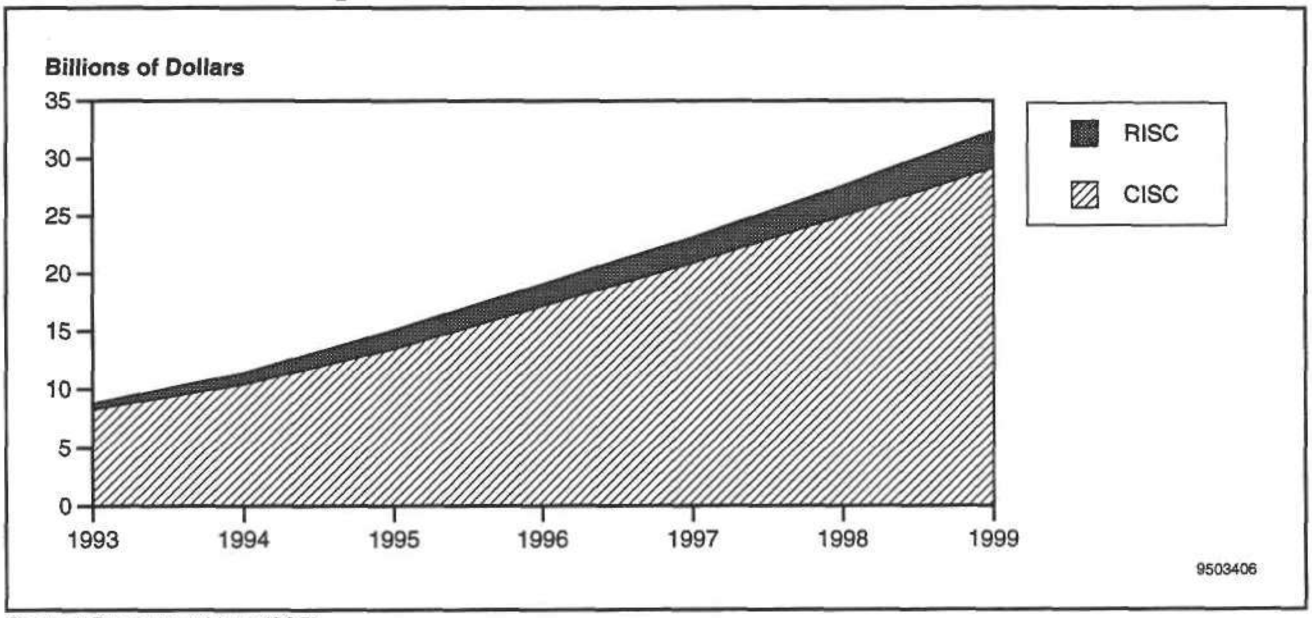
Source: Dataquest (June 1995)

Figure A-1
CISC and RISC Microprocessor Unit Shipments



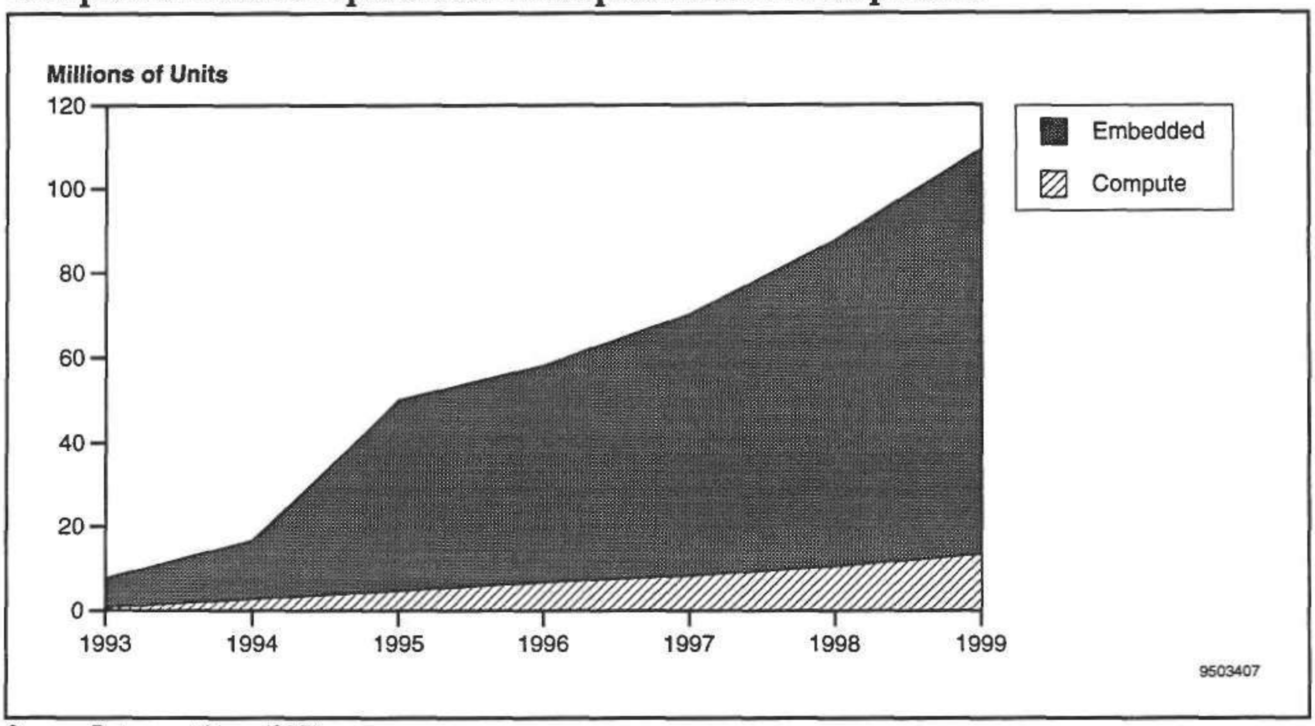
Source: Dataquest (June 1995)

Figure A-2
CISC and RISC Microprocessor Revenue



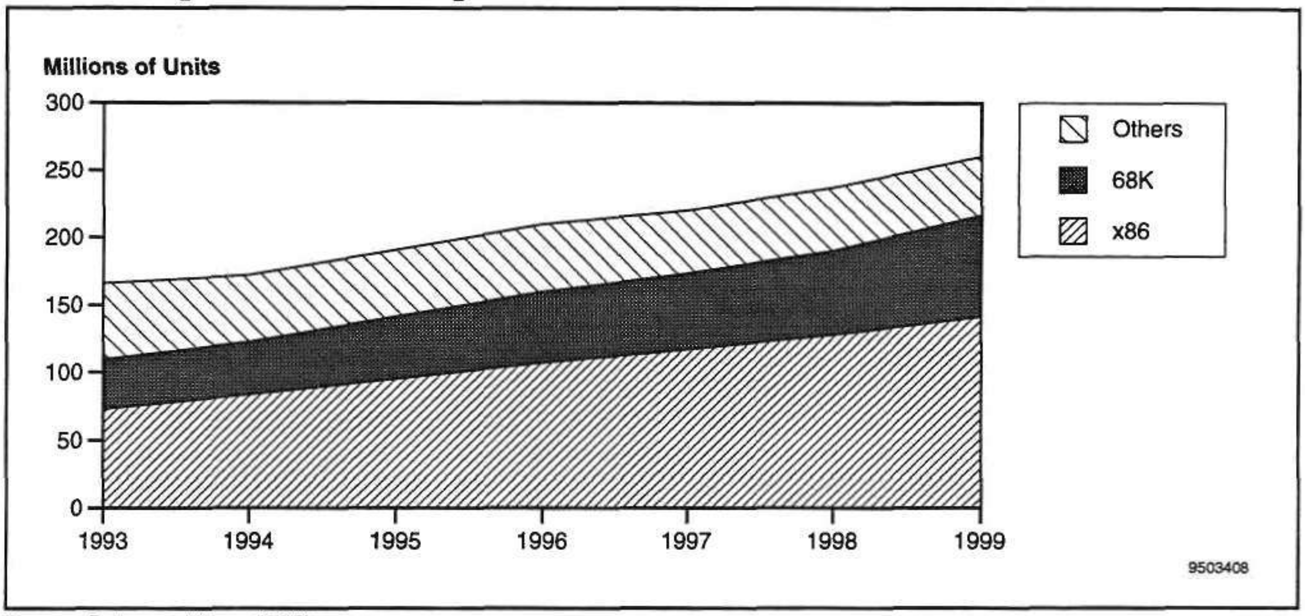
Source: Dataquest (June 1995)

Figure A-3
Compute and Noncompute RISC Microprocessor Unit Shipments



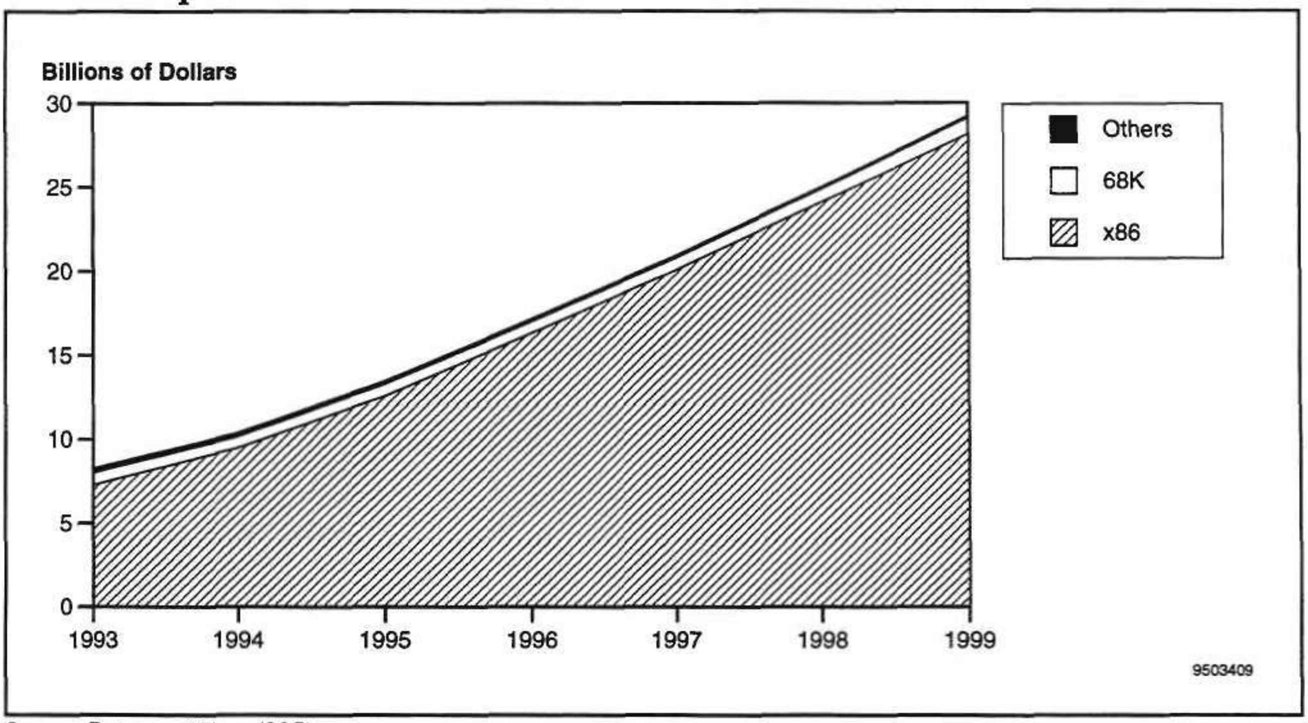
Source: Dataquest (June 1995)

Figure A-4
CISC Microprocessor Unit Shipments



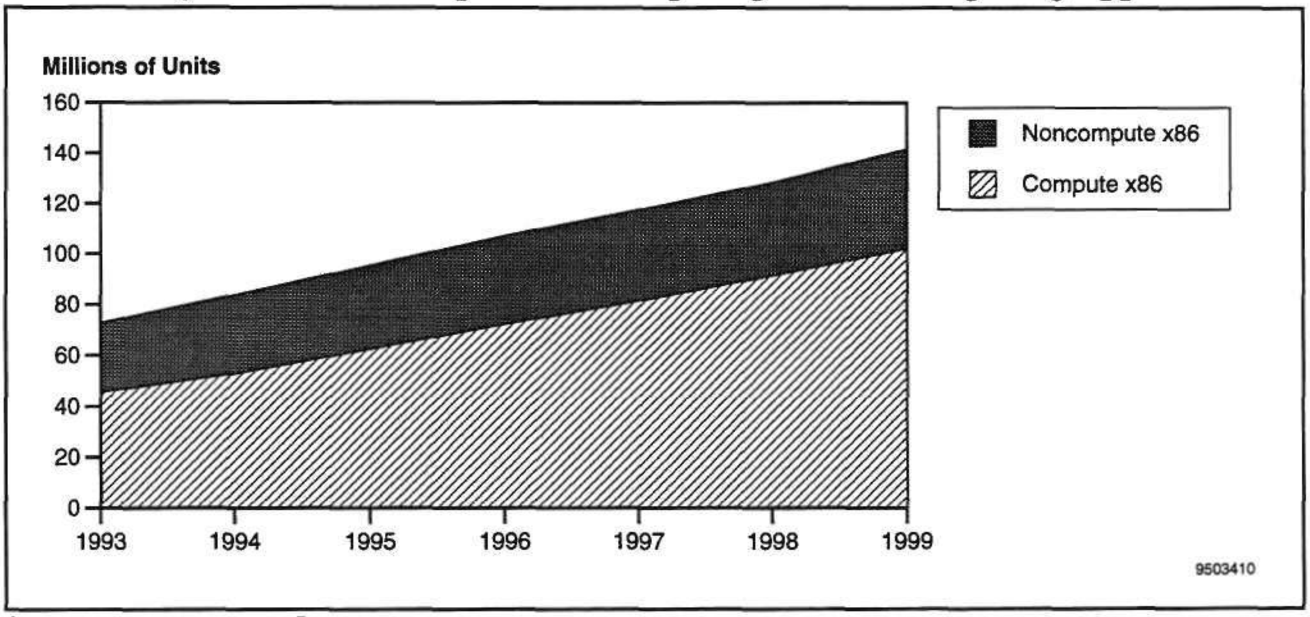
Source: Dataquest (June 1995)

Figure A-5
CISC Microprocessor Revenue



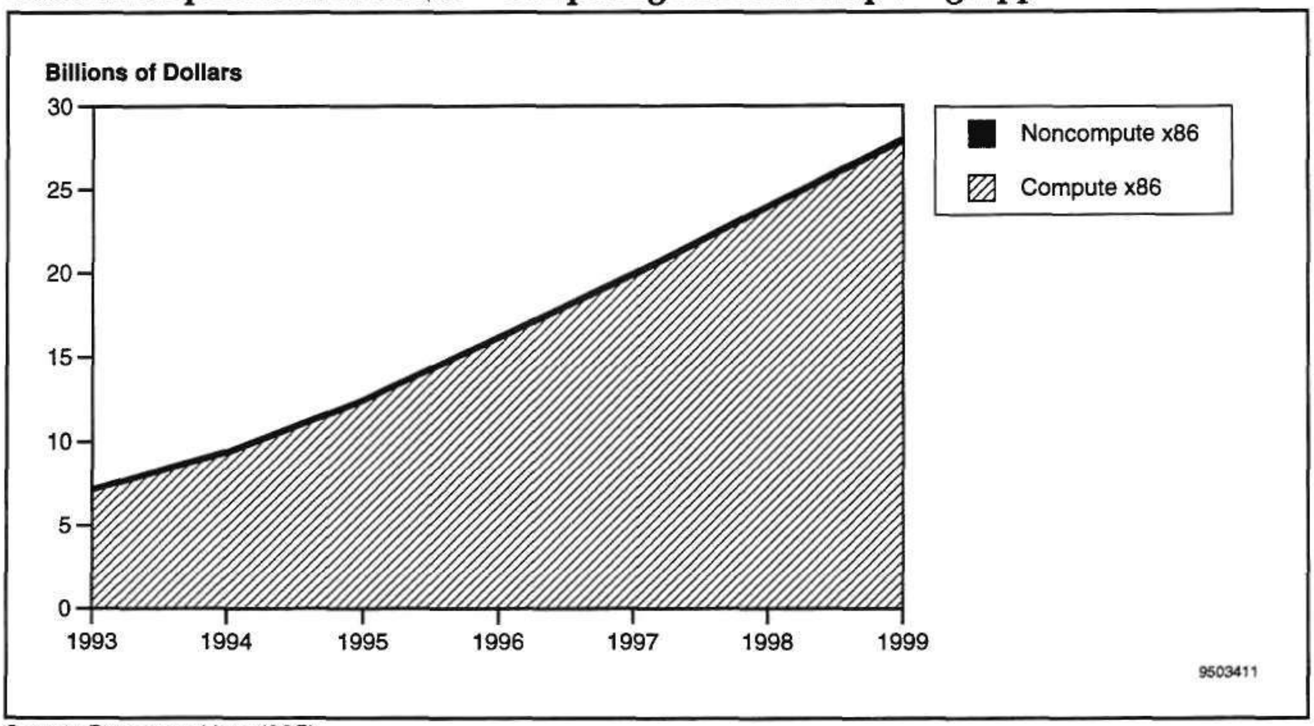
Source: Dataquest (June 1995)

Figure A-6
80x86 Microprocessor Unit Shipments—Computing and Noncomputing Applications



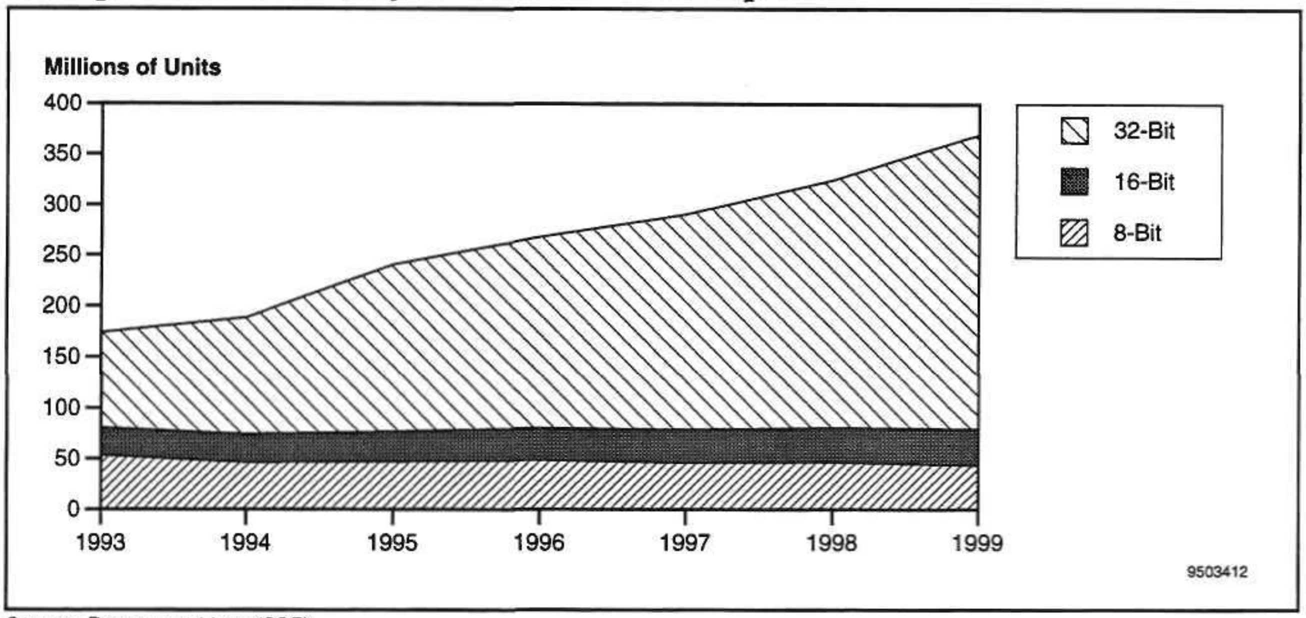
Source: Dataquest (June 1995)

Figure A-7
80x86 Microprocessor Revenue—Computing and Noncomputing Applications



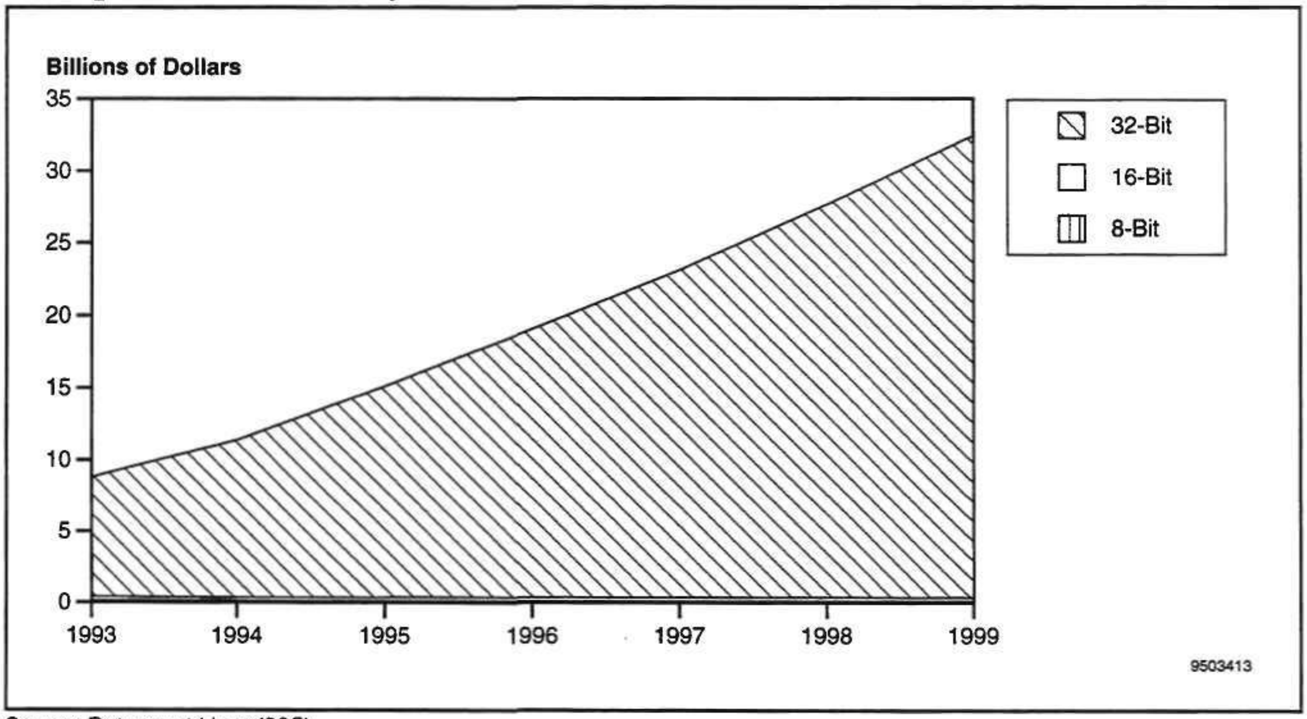
Source: Dataquest (June 1995)

Figure A-8
Microprocessor Forecast by Wordwidth—Unit Shipments



Source: Dataquest (June 1995)

Figure A-9
Microprocessor Forecast by Wordwidth—Revenue



Source: Dataquest (June 1995)

For More Information...

Tom Starnes, Principal Analyst .... (408) 437-8366
Internet address .... tstarnes@dataquest.com
Via fax .... (408) 437-0292

Dataquest
a company of
The Dun & Bradstreet Corporation

Dataquest

a company of
The Dun & Bradstreet Corporation

Corporate Headquarters
Dataquest Incorporated
1290 Ridder Park Drive
San Jose, California 95131-2398
United States
Phone: 1-408-437-8000
Facsimile: 1-408-437-0292

Dataquest Incorporated
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6180

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

European Headquarters
Dataquest Europe Limited
Holmers Farm Way
High Wycombe, Buckinghamshire
HP12 4XH
United Kingdom
Phone: 44-1494-422722
Facsimile: 44-1494-422742

Dataquest GmbH
Kronstadter Strasse 9
81677 München
Germany
Phone: 49-89-930-9090
Facsimile: 49-89-930-3277

Dataquest Europe SA
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: 33-1-41-35-13-00
Facsimile: 33-1-41-35-13-13

Japan Headquarters
Dataquest Japan K.K.
Shinkawa Sanko Building, 6th Floor
1-3-17, Shinkawa, Chuo-ku
Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

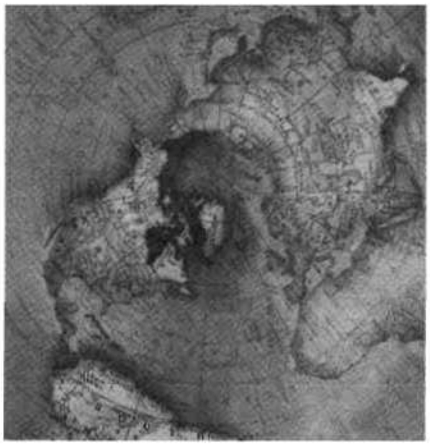
Asia/Pacific Headquarters
7/F China Underwriters Centre
88 Gloucester Road
Wan Chai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei, 105
Taiwan, R.O.C.
Phone: 8862-756-0389
Facsimile: 8862-756-2663

Other research offices in Beijing, Singapore, and Thailand

Sales agents in Australia, Belgium, Germany (Kronberg), Israel, Italy, South Africa, and Spain



Dataquest

Final 1994 Microcontroller Market Share and Shipments

Market Statistics

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MS-9502
Publication Date: June 19, 1995
Filing: Market Analysis

Final 1994 Microcontroller Market Share and Shipments

Market Statistics

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MS-9502
Publication Date: June 19, 1995
Filing: Market Analysis

Table of Contents

List of Tables

Note: All tables show estimated data.

List of Tables (Continued)

Note: All tables show estimated data.

Final 1994 Microcontroller Market Share and Shipments

Introduction

This document contains detailed information on Dataquest's view of the microcontroller market. Included in this document are the following:

- 1993-1994 unit shipment and market share estimates
- 1993-1994 revenue and market share estimates

Analyses of market share by company provide insight into high-technology markets and reinforce estimates of consumption, production, and company revenue.

Microcontroller market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. Refer to the section entitled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in Dataquest documents located in the binder of the same name.

Segmentation

This section outlines the market segments that are specific to this document. Dataquest's objective is to provide data along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients.

For market share purposes, Dataquest defines the microcomponent market according to the following functional segmentation scheme:

- Digital Microcomponent IC
  - Digital Microprocessor (MPU)
  - Digital Microcontroller (MCU)
  - Digital Microperipheral (MPR)
  - Programmable Digital Signal Processor (pDSP)

Definitions

This section lists the definitions that are used by Dataquest to present the data in this document. Complete definitions for semiconductor devices can be found in the Dataquest *Semiconductor Market Definitions Guide.*

Microcomponent. A category of digital ICs made up of microprocessor (MPU), microcontroller (MCU), microperipheral (MPR), and programmable digital signal processor (pDSP).

Microprocessor (MPU). An IC that includes an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic. It may contain an instruction cache or data cache. An MPU's functions are determined by fetching and executing instructions and manipulating data held in external memory or an internal cache. The MPU category includes MPUs incorporating, or originating from, an ASIC design.

Microcontroller (MCU). An IC similar to an MPU with the primary exception being that it is designed to operate from on-chip program and data memory (not including cache memories). MCU devices must be available with on-chip program or data store. As an option, some MCU devices can be purchased without on-chip memory. The MCU category includes MCUs incorporating, or originating from, an ASIC design.

Microperipheral (MPR). An IC that serves as a logical support function to an MPU in a system. This definition includes MPRs comprising more than one device, such as PC or core logic chipsets. The MPR category includes MPRs incorporating, or originating from, an ASIC design.

Programmable Digital Signal Processor (pDSP). An IC composed of a high-speed arithmetic unit (typically a multiplier-accumulator unit) used for performing complex mathematical operations, such as Fourier transforms. pDSPs integrated on-chip with an MPU or MCU are classified as either an MPU or MCU, respectively.

Wordwidth. The width, in bits, of the on-chip integer unit. This measurement is independent of the data bus width or any other bus associated with the device being discussed.

Merchant versus Captive Consumption. Dataquest includes all revenue, both merchant and captive, for semiconductor suppliers selling to the merchant market. The data excludes completely captive suppliers where devices are manufactured solely for the company's own use. A product that is used internally is valued at market price rather than at transfer or factory price.

Regional Definitions

North America: Includes Canada, Mexico, and the United States.

Japan: Japan is the only single-country region.

Western Europe: Includes Austria, Belgium, Denmark, Eire (Ireland), Finland, France, Germany (including former East Germany), Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and rest of western Europe (Andorra, Cyprus, Gibraltar, Liechtenstein, Monaco, San Marino, Vatican City, Iceland, Malta, and Turkey).

Eastern Europe: Includes Albania, Bulgaria, the Czech Republic and Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the republics of the former Yugoslavia, and the republics of the former USSR (Belarus, Russian Federation, Ukraine, Georgia, Moldavia, Armenia, Azerbaijan, Kazakhstan, Uzbekistan, Tadjikistan, Kyrgyzstan, and Turkenistan).

Asia/Pacific: Includes Asia/Pacific's newly industrialized economies (NIEs) and the rest of Asia/Pacific regions. NIEs include Hong Kong, Singapore, Korea, and Taiwan. The rest of Asia/Pacific region includes Australia, Brunei, Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam.

Rest of World: Includes Africa, Caribbean, Central America, Middle East, Oceania, and South America.

Line Item Definitions

Factory revenue is defined as the money value received by a semiconductor manufacturer for its products. Revenue from the sale of semiconductors sold either as finished goods, die, or wafers to another semiconductor vendor for resale is attributed to the semiconductor vendor that sells the product to a distributor or equipment manufacturer.

Shipment is defined as the number of complete products delivered, whether single chips or chipsets.

Market Share Methodology

Dataquest utilizes both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data utilized by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press

- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other suppliers.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

1. NEC's 4-bit microcontroller unit shipments were restated in 1992.

2. Inmos' unit shipments are included in SGS-Thomson.

3. Starting in 1994, Dataquest published microcontroller unit shipments by family rather than by product.

4. Revenue in 1993 was re-evaluated and restated for several companies in 1994.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1 outlines these rates for 1992 through 1994.

Table 1
Exchange Rates

	1992	1993	1994
Japan (Yen/U.S.$)	126.45	111.20	101.81
France (Franc/U.S.$)	5.27	5.67	5.54
Germany (Deutsche Mark/U.S.$)	1.56	1.66	1.62
United Kingdom (U.S.$/Pound Sterling)	1.77	1.50	1.53

Source: Dataquest (June 1995)

Section 1: Final 1994 Microcontroller Revenue Estimates and Rankings

Table 1-1
Each Company's Factory Revenue from Shipments of Microcontrollers Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	4,613	5,904	7,517	100.0	100.0	100.0
North American Companies	1,544	1,984	2,514	33.5	33.6	33.4
Advanced Micro Devices	14	11	5	0.3	0.2	0.1
Atmel	0	2	5	0	0	0.1
Dallas Semiconductor	13	15	12	0.3	0.3	0.2
Harris	7	9	8	0.2	0.2	0.1
Intel	416	450	600	9.0	7.6	8.0
ITT	29	25	12	0.6	0.4	0.2
Microchip Technology	31	70	130	0.7	1.2	1.7
Motorola	801	1,107	1,424	17.4	18.8	18.9
National Semiconductor	94	105	100	2.0	1.8	1.3
Rockwell	6	8	7	0.1	0.1	0.1
Sierra Semiconductor	1	0	0	0	0	0
Texas Instruments	95	120	143	2.1	2.0	1.9
Zilog	37	62	68	0.8	1.0	0.9
Japanese Companies	2,619	3,363	4,261	56.8	57.0	56.7
Fujitsu	109	129	180	2.4	2.2	2.4
Hitachi	378	458	577	8.2	7.7	7.7
Matsushita	205	251	405	4.4	4.2	5.4
Mitsubishi	388	465	637	8.4	7.9	8.5
NEC	840	1,100	1,275	18.2	18.6	17.0
Oki Semiconductor	98	149	178	2.1	2.5	2.4
Ricoh	51	82	76	1.1	1.4	1.0
Rohm	17	20	46	0.4	0.3	0.6
Sanyo	92	138	154	2.0	2.3	2.0
Seiko Epson	16	17	21	0.3	0.3	0.3
Sharp	112	149	169	2.4	2.5	2.2
Sony	67	104	140	1.5	1.8	1.9
Toshiba	246	301	403	5.3	5.1	5.4
European Companies	433	510	685	9.4	8.6	9.1
Matra MHS	47	0	0	1.0	0	0
Philips	213	258	345.0	4.6	4.4	4.6
SGS-Thomson	91	113	161	2.0	1.9	2.1

(Continued)

Table 1-1 (Continued)
Each Company's Factory Revenue from Shipments of Microcontrollers Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Siemens	82	95	128	1.8	1.6	1.7
TEMIC	0	44	51	0	0.7	0.7
Asia/Pacific Companies	17	47	57	0.4	0.8	0.8
Goldstar	1	3	9	0	0.1	0.1
Holtek	0	15	20	0	0.3	0.3
Samsung	16	29	28	0.3	0.5	0.4

Source: Dataquest (June 1995)

Table 1-2
Each Company's Factory Revenue from Shipments of 4-Bit MCUs Worldwide (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	1,691	1,472	100.0	100.0
North American Companies	25	18	1.5	1.2
National Semiconductor	20	13	1.2	0.9
Rockwell	1	0	0.1	0
Texas Instruments	4	5	0.2	0.3
Japanese Companies	1,619	1,397	95.7	94.9
Fujitsu	71	58	4.2	3.9
Hitachi	161	139	9.5	9.4
Matsushita	132	105	7.8	7.1
Mitsubishi	170	192	10.1	13.0
NEC	650	422	38.4	28.7
Oki Semiconductor	77	72	4.6	4.9
Rohm	0	15	0	1.0
Sanyo	88	96	5.2	6.5
Seiko Epson	14	18	0.8	1.2
Sharp	83	88	4.9	6.0
Sony	59	63	3.5	4.3
Toshiba	114	129	6.7	8.8
Asia/Pacific Companies	47	57	2.8	3.9
Goldstar	3	9	0.2	0.6
Holtek	15	20	0.9	1.4
Samsung	29	28	1.7	1.9

Source: Dataquest (June 1995)

Table 1-3
Each Company's Factory Revenue from Shipments of 8-Bit MCUs Worldwide (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	3,590	4,965	100.0	100.0
North American Companies	1,675	2,069	46.7	41.7
Advanced Micro Devices	11	5	0.3	0.1
Atmel	2	5	0.1	0.1
Dallas Semiconductor	15	12	0.4	0.2
Harris	9	8	0.3	0.2
Intel	200	250	5.6	5.0
ITT	25	12	0.7	0.2
Microchip Technology	70	130	1.9	2.6
Motorola	1,097	1,369	30.6	27.6
National Semiconductor	61	65	1.7	1.3
Rockwell	7	7	0.2	0.1
Texas Instruments	116	138	3.2	2.8
Zilog	62	68	1.7	1.4
Japanese Companies	1,454	2,289	40.5	46.1
Fujitsu	53	85	1.5	1.7
Hitachi	257	352	7.2	7.1
Matsushita	118	285	3.3	5.7
Mitsubishi	250	371	7.0	7.5
NEC	274	554	7.6	11.2
Oki Semiconductor	62	83	1.7	1.7
Ricoh	82	76	2.3	1.5
Rohm	20	31	0.6	0.6
Sanyo	50	58	1.4	1.2
Seiko Epson	3	3	0.1	0.1
Sharp	66	81	1.8	1.6
Sony	44	71	1.2	1.4
Toshiba	175	239	4.9	4.8
European Companies	461	607	12.8	12.2
Philips	258	340	7.2	6.8
SGS-Thomson	75	111	2.1	2.2
Siemens	84	105	2.3	2.1
TEMIC	44	51	1.2	1.0

Source: Dataquest (June 1995)

Table 1-4
Each Company's Factory Revenue from Shipments of 16-Bit MCUs Worldwide (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	623	1,080	100.0	100.0
North American Companies	284	427	44.9	39.5
Intel	250	350	40.1	32.4
Motorola	10	55	1.6	5.1
National Semiconductor	24	22	3.8	2.0
Japanese Companies	290	575	47.3	53.2
Fujitsu	5	37	0.8	3.4
Hitachi	40	86	6.3	8.0
Matsushita	1	15	0.2	1.4
Mitsubishi	45	74	7.1	6.9
NEC	176	299	28.4	27.7
Oki Semiconductor	10	23	1.6	2.1
Sony	1	6	0.2	0.6
Toshiba	12	35	1.9	3.2
European Companies	49	78	7.8	7.2
Philips	0	5	0	0.5
SGS-Thomson	38	50	6.0	4.6
Siemens	11	23	1.7	2.1

Source: Dataquest (June 1995)

Table 1-5
Each Company's Factory Revenue from Shipments of Microcontrollers to North America (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	938	1,254	1,652	100.0	100.0	100.0
North American Companies	671	883	1,138	71.5	70.4	68.9
Advanced Micro Devices	6	5	3	0.6	0.4	0.2
Atmel	0	2	2	0	0.2	0.1
Dallas Semiconductor	9	10	5	1.0	0.8	0.3
Harris	5	6	5	0.5	0.5	0.3
Intel	216	225	302	23.0	17.9	18.3
ITT	7	6	0	0.7	0.5	0
Microchip Technology	9	28	55	1.0	2.2	3.3
Motorola	317	477	632	33.8	38.0	38.3
National Semiconductor	53	50	52	5.7	4.0	3.1
Rockwell	4	6	5	0.4	0.5	0.3
Sierra Semiconductor	1	0	0	0.1	0	0
Texas Instruments	32	47	53	3.4	3.7	3.2
Zilog	12	21	24	1.3	1.7	1.5
Japanese Companies	182	244	321	19.4	19.5	19.4
Fujitsu	10	12	21	1.1	1.0	1.3
Hitachi	49	59	87	5.2	4.7	5.3
Matsushita	6	7	8	0.6	0.6	0.5
Mitsubishi	16	20	37	1.7	1.6	2.2
NEC	50	79	77	5.3	6.3	4.7
Oki Semiconductor	11	16	23	1.2	1.3	1.4
Rohm	2	2	3	0.2	0.2	0.2
Sanyo	1	4	15	0.1	0.3	0.9
Seiko Epson	1	1	1	0.1	0.1	0.1
Sharp	7	8	9	0.7	0.6	0.5
Sony	3	4	5	0.3	0.3	0.3
Toshiba	26	32	35	2.8	2.6	2.1
European Companies	84	127	191	9.0	10.1	11.6
Matra MHS	10	0	0	1.1	0	0
Philips	40	78	108	4.3	6.2	6.5
SGS-Thomson	16	25	50	1.7	2.0	3.0
Siemens	18	11	12	1.9	0.9	0.7
TEMIC	0	13	21	0	1.0	1.3
Asia/Pacific Companies	1	0	2	0.1	0	0.1
Samsung	1	0	2	0.1	0	0.1

Source: Dataquest (June 1995)

Table 1-6
Each Company's Factory Revenue from Shipments of Microcontrollers to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	1,913	2,284	2,964	100.0	100.0	100.0
North American Companies	147	166	214	7.7	7.3	7.2
Dallas Semiconductor	0	0	1	0	0	0
Intel	36	45	59	1.9	2.0	2
ITT	2	2	0	0.1	0.1	0
Microchip Technology	0	2	2	0	0.1	0.1
Motorola	86	98	136	4.5	4.3	4.6
National Semiconductor	8	2	1	0.4	0.1	0
Texas Instruments	14	16	14	0.7	0.7	0.5
Zilog	1	1	1	0.1	0	0
Japanese Companies	1,753	2,108	2,740	91.6	91.9	92.4
Fujitsu	77	85	109	4.0	3.7	3.7
Hitachi	244	289	345	12.8	12.6	11.6
Matsushita	173	214	361	9.0	9.3	12.2
Mitsubishi	257	287	413	13.4	12.5	13.9
NEC	573	707	838	30.0	31.0	28.3
Oki Semiconductor	52	75	90	2.7	3.3	3.0
Ricoh	51	70	63	2.7	3.1	2.1
Rohm	12	14	35	0.6	0.6	1.2
Sanyo	42	47	60	2.2	2.0	2.0
Seiko Epson	13	12	15	0.7	0.5	0.5
Sharp	85	105	113	4.4	4.6	3.8
Sony	64	73	114	3.3	3.2	3.8
Toshiba	110	130	184	5.8	5.7	6.2
European Companies	13	10	10	0.7	0.4	0.3
Matra MHS	1	0	0	0.1	0	0
Philips	3	6	5	0.2	0.3	0.2
SGS-Thomson	2	1	0	0.1	0	0
Siemens	7	2	2	0.4	0.1	0.1
TEMIC	0	1	3	0	0	0.1

Source: Dataquest (June 1995)

Table 1-7
Each Company's Factory Revenue from Shipments of Microcontrollers to Europe (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	934	1,106	1,432	100.0	100.0	100.0
North American Companies	414	472	616	44.3	42.7	43.0
Advanced Micro Devices	7	5	2	0.7	0.5	0.1
Atmel	0	0	1	0	0	0.1
Dallas Semiconductor	1	2	2	0.1	0.2	0.1
Harris	1	1	1	0.1	0.1	0.1
Intel	112	90	117	12.0	8.1	8.2
ITT	15	12	12	1.6	1.1	0.8
Microchip Technology	11	20	44	1.2	1.8	3.1
Motorola	206	267	344	22.1	24.1	24.0
National Semiconductor	24	29	30	2.6	2.6	2.1
Rockwell	1	1	1	0.1	0.1	0.1
Texas Instruments	28	30	46	3.0	2.7	3.2
Zilog	8	15	16	0.9	1.4	1.1
Japanese Companies	261	348	459	27.9	31.5	32.1
Fujitsu	9	19	31	1.0	1.7	2.2
Hitachi	41	51	84	4.4	4.6	5.9
Matsushita	18	9	11	1.9	0.8	0.8
Mitsubishi	14	23	32	1.5	2.1	2.2
NEC	126	183	220	13.5	16.5	15.4
Oki Semiconductor	14	19	26	1.5	1.7	1.8
Rohm	1	1	1	0.1	0.1	0.1
Sanyo	1	2	3	0.1	0.2	0.2
Seiko Epson	0	1	1	0	0.1	0.1
Sharp	1	1	1	0.1	0.1	0.1
Toshiba	36	39	49	3.9	3.5	3.4
European Companies	259	285	354	27.7	25.8	24.7
Matra MHS	32	0	0	3.4	0	0
Philips	117	117	138	12.5	10.6	9.6
SGS-Thomson	60	65	86	6.4	5.9	6.0
Siemens	50	78	108	5.4	7.1	7.5
TEMIC	0	25	22	0	2.3	1.5
Asia/Pacific Companies	0	1	3	0	0.1	0.2
Holtek	0	1	1	0	0.1	0.1
Samsung	0	0	2	0	0	0.1

Source: Dataquest (June 1995)

Table 1-8
Each Company's Factory Revenue from Shipments of Microcontrollers to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	828	1,260	1,469	100.0	100.0	100.0
North American Companies	312	463	546	37.7	36.7	37.2
Advanced Micro Devices	1	1	0	0.1	0.1	0
Atmel	0	0	2	0	0	0.1
Dallas Semiconductor	3	3	4	0.4	0.2	0.3
Harris	1	2	2	0.1	0.2	0.1
Intel	52	90	122	6.3	7.1	8.3
ITT	5	5	0	0.6	0.4	0
Microchip Technology	11	20	29	1.3	1.6	2.0
Motorola	192	265	312	23.2	21.0	21.2
National Semiconductor	9	24	17	1.1	1.9	1.2
Rockwell	1	1	1	0.1	0.1	0.1
Texas Instruments	21	27	30	2.5	2.1	2.0
Zilog	16	25	27	1.9	2.0	1.8
Japanese Companies	423	663	741	51.1	52.6	50.4
Fujitsu	13	13	19	1.6	1.0	1.3
Hitachi	44	59	61	5.3	4.7	4.2
Matsushita	8	21	25	1.0	1.7	1.7
Mitsubishi	101	135	155	12.2	10.7	10.6
NEC	91	131	140	11.0	10.4	9.5
Oki Semiconductor	21	39	39	2.5	3.1	2.7
Ricoh	0	12	13	0	1.0	0.9
Rohm	2	3	7	0.2	0.2	0.5
Sanyo	48	85	76	5.8	6.7	5.2
Seiko Epson	2	3	4	0.2	0.2	0.3
Sharp	19	35	46	2.3	2.8	3.1
Sony	0	27	21	0	2.1	1.4
Toshiba	74	100	135	8.9	7.9	9.2
European Companies	77	88	130	9.3	7.0	8.8
Matra MHS	4	0	0	0.5	0	0
Philips	53	57	94	6.4	4.5	6.4
SGS-Thomson	13	22	25	1.6	1.7	1.7
Siemens	7	4	6	0.8	0.3	0.4
TEMIC	0	5	5	0	0.4	0.3
Asia/Pacific Companies	16	46	52	1.9	3.7	3.5
Goldstar	1	3	9	0.1	0.2	0.6
Holtek	0	14	19	0	1.1	1.3
Samsung	15	29	24	1.8	2.3	1.6

Source: Dataquest (June 1995)

Table 1-9
Top 30 Companies' Factory Revenue from Shipments of Microcontrollers Worldwide (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Motorola	1,107	1,424	29	18.9
2	2	NEC	1,100	1,275	16	17.0
3	3	Mitsubishi	465	637	37	8.5
4	5	Intel	450	600	33	8.0
5	4	Hitachi	458	577	26	7.7
6	8	Matsushita	251	405	61	5.4
7	6	Toshiba	301	403	34	5.4
8	7	Philips	258	345	34	4.6
9	12	Fujitsu	129	180	40	2.4
10	9	Oki Semiconductor	149	178	19	2.4
11	10	Sharp	149	169	13	2.2
12	14	SGS-Thomson	113	161	42	2.1
13	11	Sanyo	138	154	12	2.0
14	13	Texas Instruments	120	143	19	1.9
15	16	Sony	104	140	35	1.9
16	19	Microchip Technology	70	130	86	1.7
17	17	Siemens	95	128	35	1.7
18	15	National Semiconductor	105	100	-5	1.3
19	18	Ricoh	82	76	-7	1.0
20	20	Zilog	62	68	10	0.9
21	21	TEMIC	44	51	16	0.7
22	24	Rohm	20	46	130	0.6
23	22	Samsung	29	28	-3	0.4
24	25	Seiko Epson	17	21	24	0.3
25	27	Holtek	15	20	33	0.3
26	23	ITT	25	12	-52	0.2
27	26	Dallas Semiconductor	15	12	-20	0.2
28	31	Goldstar	3	9	200	0.1
29	29	Harris	9	8	-11	0.1
30	30	Rockwell	8	7	-13	0.1
		All Others	13	10	-23	0.1
		North American Companies	1,984	2,514	27	33.4
		Japanese Companies	3,363	4,261	27	56.7
		European Companies	510	685	34	9.1
		Asia/Pacific Companies	47	57	21	0.8
		Total Market	5,904	7,517	27	100.0

Source: Dataquest (June 1995)

Table 1-10
Top 15 Companies' Factory Revenue from Shipments of Microcontrollers to North America (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Motorola	477	632	32	38.3
2	2	Intel	225	302	34	18.3
3	4	Philips	78	108	38	6.5
4	5	Hitachi	59	87	47	5.3
5	3	NEC	79	77	-3	4.7
6	9	Microchip Technology	28	55	96	3.3
7	7	Texas Instruments	47	53	13	3.2
8	6	National Semiconductor	50	52	4	3.1
9	10	SGS-Thomson	25	50	100	3.0
10	12	Mitsubishi	20	37	85	2.2
11	8	Toshiba	32	35	9	2.1
12	11	Zilog	21	24	14	1.5
13	13	Oki Semiconductor	16	23	44	1.4
14	14	TEMIC	13	21	62	1.3
15	15	Fujitsu	12	21	75	1.3
		All Others	72	75	4	4.5
		North American Companies	883	1,138	29	68.9
		Japanese Companies	244	321	32	19.4
		European Companies	127	191	50	11.6
		Asia/Pacific Companies	0	2	NA	0.1
		Total Market	1,254	1,652	32	100.0

NA = Not available
Source: Dataquest (June 1995)

Table 1-11
Top 15 Companies' Factory Revenue from Shipments of Microcontrollers to Japan (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	NEC	707	838	19	28.3
2	3	Mitsubishi	287	413	44	13.9
3	4	Matsushita	214	361	69	12.2
4	2	Hitachi	289	345	19	11.6
5	5	Toshiba	130	184	42	6.2
6	7	Motorola	98	136	39	4.6
7	10	Sony	73	114	56	3.8
8	6	Sharp	105	113	8	3.8
9	8	Fujitsu	85	109	28	3.7
10	9	Oki Semiconductor	75	90	20	3.0
11	11	Ricoh	70	63	-10	2.1
12	12	Sanyo	47	60	28	2.0
13	13	Intel	45	59	31	2.0
14	15	Rohm	14	35	150	1.2
15	16	Seiko Epson	12	15	25	0.5
		All Others	33	29	-12	1.0
		North American Companies	166	214	29	7.2
		Japanese Companies	2,108	2,740	30	92.4
		European Companies	10	10	0	0.3
		Asia/Pacific Companies	0	0	NA	0
		Total Market	2,284	2,964	30	100.0

NA = Not available
Source: Dataquest (June 1995)

Table 1-12
Top 15 Companies' Factory Revenue from Shipments of Microcontrollers to Europe (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Motorola	267	344	29	24.0
2	2	NEC	183	220	20	15.4
3	3	Philips	117	138	18	9.6
4	4	Intel	90	117	30	8.2
5	5	Siemens	78	108	38	7.5
6	6	SGS-Thomson	65	86	32	6.0
7	7	Hitachi	51	84	65	5.9
8	8	Toshiba	39	49	26	3.4
9	9	Texas Instruments	30	46	53	3.2
10	13	Microchip Technology	20	44	120	3.1
11	12	Mitsubishi	23	32	39	2.2
12	14	Fujitsu	19	31	63	2.2
13	10	National Semiconductor	29	30	3	2.1
14	15	Oki Semiconductor	19	26	37	1.8
15	11	TEMIC	25	22	-12	1.5
		All Others	51	55	8	3.8
		North American Companies	472	616	31	43.0
		Japanese Companies	348	459	32	32.1
		European Companies	285	354	24	24.7
		Asia/Pacific Companies	1	3	200	0.2
		Total Market	1,106	1,432	29	100.0

Source: Dataquest (June 1995)

Table 1-13
Top 15 Companies' Factory Revenue from Shipments of Microcontrollers to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Motorola	265	312	18	21.2
2	2	Mitsubishi	135	155	15	10.6
3	3	NEC	131	140	7	9.5
4	4	Toshiba	100	135	35	9.2
5	5	Intel	90	122	36	8.3
6	8	Philips	57	94	65	6.4
7	6	Sanyo	85	76	-11	5.2
8	7	Hitachi	59	61	3	4.2
9	10	Sharp	35	46	31	3.1
10	9	Oki Semiconductor	39	39	0	2.7
11	12	Texas Instruments	27	30	11	2.0
12	18	Microchip Technology	20	29	45	2.0
13	14	Zilog	25	27	8	1.8
14	16	SGS-Thomson	22	25	14	1.7
15	17	Matsushita	21	25	19	1.7
		All Others	149	153	3	10.4
		North American Companies	463	546	18	37.2
		Japanese Companies	663	741	12	50.4
		European Companies	88	130	48	8.8
		Asia/Pacific Companies	46	52	13	3.5
		Total Market	1,260	1,469	17	100.0

Source: Dataquest (June 1995)

Table 1-14
Worldwide 4-Bit MCU Market Share Ranking (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	NEC	650	422	-35	28.7
2	2	Mitsubishi	170	192	13	13.0
3	3	Hitachi	161	139	-14	9.4
4	5	Toshiba	114	129	13	8.8
5	4	Matsushita	132	105	-20	7.1
6	6	Sanyo	88	96	9	6.5
7	7	Sharp	83	88	6	6.0
8	8	Oki Semiconductor	77	72	-6	4.9
9	10	Sony	59	63	7	4.3
10	9	Fujitsu	71	58	-18	3.9
11	11	Samsung	29	28	-3	1.9
12	13	Holtek	15	20	33	1.4
13	14	Seiko Epson	14	18	29	1.2
14	25	Rohm	0	15	NA	1.0
15	12	National Semiconductor	20	13	-35	0.9
16	16	Goldstar	3	9	200	0.6
17	15	Texas Instruments	4	5	25	0.3
18	17	Rockwell	1	0	-100	0
		All Others	0	0	NA	0
		North American Companies	25	18	-28	1.2
		Japanese Companies	1,619	1,397	-14	94.9
		European Companies	0	0	NA	0
		Asia/Pacific Companies	47	57	21	3.9
		Total Market	1,691	1,472	-13	100.0

NA = Not available
Source: Dataquest (June 1995)

Table 1-15
Worldwide 8-Bit MCU Market Share Ranking (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Motorola	1,097	1,369	25	27.6
2	2	NEC	274	554	102	11.2
3	5	Mitsubishi	250	371	48	7.5
4	4	Hitachi	257	352	37	7.1
5	3	Philips	258	340	32	6.8
6	8	Matsushita	118	285	142	5.7
7	6	Intel	200	250	25	5.0
8	7	Toshiba	175	239	37	4.8
9	9	Texas Instruments	116	138	19	2.8
10	13	Microchip Technology	70	130	86	2.6
11	12	SGS-Thomson	75	111	48	2.2
12	10	Siemens	84	105	25	2.1
13	18	Fujitsu	53	85	60	1.7
14	15	Oki Semiconductor	62	83	34	1.7
15	14	Sharp	66	81	23	1.6
16	11	Ricoh	82	76	-7	1.5
17	20	Sony	44	71	61	1.4
18	16	Zilog	62	68	10	1.4
19	17	National Semiconductor	61	65	7	1.3
20	19	Sanyo	50	58	16	1.2
21	21	TEMIC	44	51	16	1.0
22	23	Rohm	20	31	55	0.6
23	22	ITT	25	12	-52	0.2
24	24	Dallas Semiconductor	15	12	-20	0.2
25	26	Harris	9	8	-11	0.2
26	27	Rockwell	7	7	0	0.1
27	25	Advanced Micro Devices	11	5	-55	0.1
28	29	Atmel	2	5	150	0.1
29	28	Seiko Epson	3	3	0	0.1
		All Others	0	0	NA	0
		North American Companies	1,675	2,069	24	41.7
		Japanese Companies	1,454	2,289	57	46.1
		European Companies	461	607	32	12.2
		Asia/Pacific Companies	0	0	NA	0
		Total Market	3,590	4,965	38	100.0

NA = Not available
Source: Dataquest (June 1995)

Table 1-16
Worldwide 16-Bit MCU Market Share Ranking (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	250	350	40	32.4
2	2	NEC	176	299	70	27.7
3	4	Hitachi	40	86	115	8.0
4	3	Mitsubishi	45	74	64	6.9
5	9	Motorola	10	55	450	5.1
6	5	SGS-Thomson	38	50	32	4.6
7	11	Fujitsu	5	37	640	3.4
8	7	Toshiba	12	35	192	3.2
9	8	Siemens	11	23	109	2.1
10	10	Oki Semiconductor	10	23	130	2.1
11	6	National Semiconductor	24	22	-8	2.0
12	12	Matsushita	1	15	1400	1.4
13	13	Sony	1	6	500	0.6
14	14	Philips	0	5	NA	0.5
		All Others	0	0	NA	0
		North American Companies	284	427	50	39.5
		Japanese Companies	290	575	98	53.2
		European Companies	49	78	59	7.2
		Asia/Pacific Companies	0	0	NA	0
		Total Market	623	1,080	73	100.0

NA = Not available
Source: Dataquest (June 1995)

Section 2: Microcontroller Unit Shipments Overview

Table 2-1
Each Company's Shipments of All Microcont 93
(Thousands of Units)

1994 Rank	1993 Rank	R			rcentage Change	1994 Market Share (%)
1	2	Motorola			20	17.0
2	1	NEC			7	16.9
3	3	Mitsubishi			30	7.7
4	4	Toshiba			9	6.3
5	5	Sharp			7	5.9
6	6	Hitachi			33	5.7
7	7	Intel			23	4.8
8	8	Matsushita			15	4.3
9	9	Sanyo	81,540	86,540	6	3.4
10	10	Philips	60,800	83,000	37	3.3
11	12	Fujitsu	55,060	81,870	49	3.2
12	11	Oki Semiconductor	56,375	68,620	22	2.7
13	16	Microchip Technology	35,477	68,023	92	2.7
14	15	SGS-Thomson	42,950	63,000	47	2.5
15	19	Zilog	31,000	60,000	94	2.4
16	13	National Semiconductor	53,884	51,975	-4	2.0
17	14	Sony	45,530	51,390	13	2.0
18	18	Texas Instruments	34,725	38,420	11	1.5
19	17	Ricoh	35,000	32,500	-7	1.3
20	20	Siemens	21,674	24,500	13	1.0
21	21	Samsung	20,677	19,964	-3	0.8
22	22	TEMIC	15,000	17,386	16	0.7
23	25	Rohm	6,500	14,950	130	0.6
24	23	Holtek	10,000	13,333	33	0.5
25	26	Seiko Epson	5,705	6,005	5	0.2
26	28	Goldstar	1,500	4,500	200	0.2
27	24	ITT	8,000	3,840	-52	0.2
28	29	Dallas Semiconductor	1,000	2,500	150	0.1
29	27	Advanced Micro Devices	2,000	2,470	24	0.1
30	32	Atmel	250	625	150	0
31	30	Rockwell	508	331	-35	0
32	31	Harris	300	267	-11	0
		All Others	0	0	0	0
		Total MCU	2,125,197	2,540,060	20	100.0

Source: Dataquest (June 1995)

Table 2-2
Shipments of All Microcontrollers to the World, by Word Length (Thousands of Units)

	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
4-Bit				
North American Companies	21,506	14,970	-30	1
Japanese Companies	903,762	940,470	4	94
European Companies	5,600	6,200	11	1
Asian Companies	32,177	37,797	17	4
Total 4-Bit Market	963,045	999,437	4	100
8-Bit				
North American Companies	571,070	712,831	25	51
Japanese Companies	395,916	493,167	25	36
European Companies	134,024	180,136	34	13
Total 8-Bit Market	1,101,010	1,386,134	26	100
16-Bit and Up				
North American Companies	33,686	54,309	61	35
Japanese Companies	26,656	98,630	270	64
European Companies	800	1,550	94	1
Total 16-Bit Market	61,142	154,489	153	100
Total Microcontrollers	2,125,197	2,540,060	20	

Source: Dataquest (June 1995)

Table 2-3
Top 10 Family Shipments of Microcontrollers to the World (Thousands of Units)

1994 Rank	1993 Rank	Family	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	uPD	384,750	426,400	11	16.8
2	2	6805	298,562	328,482	10	12.9
3	5	8051	130,721	183,011	40	7.2
4	3	TLCS	140,230	153,900	10	6.1
5	4	SM	139,200	149,000	7	5.9
6	7	68HC11	70,054	103,886	48	4.1
7	11	H8	43,200	86,100	99	3.4
8	8	M50XX	66,570	72,960	10	2.9
9	15	PIC16/17	35,477	68,023	92	2.7
10	17	Z8	32,205	60,775	89	2.4
		All Others	706,703	907,523	28	35.7
		Total MCU	2,125,197	2,540,060	20	100.0

Source: Dataquest (June 1995)

Section 3: Microcontroller Unit Shipments—4-Bit Architectures

Table 3-1
Each Company's Shipments of 4-Bit Microcontrollers to the World (Thousands of Units)

1994 Rank	1993 Rank		1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	NEC	300,000	308,000	3	30.8
2	2	Sharp	121,900	128,000	5	12.8
3	3	Toshiba	114,930	114,700	0	11.5
4	5	Mitsubishi	69,110	79,860	16	8.0
5	4	Sanyo	69,240	70,240	1	7.0
6	7	Hitachi	54,380	57,300	5	5.7
7	6	Matsushita	61,200	54,000	-12	5.4
8	8	Fujitsu	39,410	47,170	20	4.7
9	9	Oki Semiconductor	38,442	44,900	17	4.5
10	10	Sony	29,700	30,600	3	3.1
11	11	Samsung	20,677	19,964	-3	2.0
12	13	Holtek	10,000	13,333	33	1.3
13	12	National Semiconductor	16,460	10,150	-38	1.0
14	14	SGS-Thomson	5,600	6,200	11	0.6
15	15	Seiko Epson	5,450	5,700	5	0.6
16	16	Texas Instruments	5,000	4,820	-4	0.5
17	17	LG Semicon	1,500	4,500	200	0.5
18	18	Rockwell	46	0	-100	0
		Others	0	0	0	0
		Total 4-Bit MCU	963,045	999,437	4	100.0

Source: Dataquest (June 1995)

Table 3-2
Top 10 Family Shipments of 4-Bit Microcontrollers to the World (Thousands of Units)

1994 Rank	1993 Rank		1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	uPD	300,000	308,000	3	30.8
2	2	SM	121,900	128,000	5	12.8
3	3	TLCS	114,930	114,700	0	11.5
4	4	M50XX	66,570	72,960	10	7.3
5	6	HMCS	54,380	57,300	5	5.7
6	5	MN1X00	61,200	54,000	-12	5.4
7	7	MB88XXX	39,410	47,170	20	4.7
8	8	OLMS	38,442	44,900	17	4.5
9	9	LC57	38,000	39,000	3	3.9
10	11	SPC500	29,700	30,600	3	3.1
		All Others	98,513	102,807	4	10.3
		Total 4-Bit MCU	963,045	999,437	4	100.0

Source: Dataquest (June 1995)

Section 4: Microcontroller Unit Shipments—8-Bit Architectures

Table 4-1
Each Company's Shipments of 8-Bit Microcontrollers to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Motorola	358,894	421,208	17	30.4
2	3	Mitsubishi	71,674	91,552	28	6.6
3	2	NEC	87,200	89,800	3	6.5
4	5	Philips	60,800	83,000	37	6.0
5	4	Intel	69,306	81,000	17	5.8
6	8	Microchip Technology	35,477	68,023	92	4.9
7	13	Zilog	31,000	60,000	94	4.3
8	7	SGS-Thomson	37,350	56,750	52	4.1
9	11	Matsushita	34,200	56,000	64	4.0
10	6	Hitachi	53,890	51,715	-4	3.7
11	12	Toshiba	31,205	45,150	45	3.3
12	10	National Semiconductor	34,656	38,967	12	2.8
13	14	Texas Instruments	29,725	33,600	13	2.4
14	9	Ricoh	35,000	32,500	-7	2.3
15	20	Fujitsu	14,620	32,000	119	2.3
16	15	Siemens	20,874	23,000	10	1.7
17	16	Sharp	17,505	21,275	22	1.5
18	17	Oki Semiconductor	15,967	21,120	32	1.5
19	18	Sony	15,600	20,500	31	1.5
20	19	TEMIC	15,000	17,386	16	1.3
21	21	Sanyo	12,300	16,300	33	1.2
22	23	Rohm	6,500	14,950	130	1.1
23	22	ITT	8,000	3,840	-52	0.3
24	25	Dallas Semiconductor	1,000	2,500	150	0.2
25	24	Advanced Micro Devices	2,000	2,470	24	0.2
26	29	Atmel	250	625	150	0
27	26	Rockwell	462	331	-28	0
28	28	Seiko Epson	255	305	20	0
29	27	Harris	300	267	-11	0
		All Others	0	0	0	0
		Total 8-Bit	1,101,010	1,386,134	26	100.0

Source: Dataquest (June 1995)

Table 4-2
Top 10 Family Shipments of 8-Bit Microcontrollers to the World (Thousands of Units)

1994 Rank	1993 Rank	Family	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	6805	298,562	328,482	10	23.7
2	2	8051	130,721	183,011	40	13.2
3	5	68HC11	70,054	103,886	48	7.5
4	3	uPD	74,000	89,800	21	6.5
5	7	PIC16/17	35,477	68,023	92	4.9
6	9	Z8	32,205	60,775	89	4.4
7	8	MN18X0	34,200	56,000	64	4.0
8	6	H8	42,200	49,500	17	3.6
9	4	8048	72,827	49,447	-32	3.6
10	11	M37XX	30,500	47,100	54	3.4
		All Others	278,994	350,110	25	25.3
		Total 8-Bit MCU	1,101,010	1,386,134	26	100.0

Source: Dataquest (June 1995)

Section 5: Microcontroller Unit Shipments—16-Bit-and-Up Architectures

Table 5-1
Each Company's Shipments of 16-Bit-and-Up Microcontrollers to the World (Thousands of Units)

1994 Rank	1993 Rank		1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Intel	30,000	41,000	37	26.5
2	7	Hitachi	1,000	36,600	3560	23.7
3	2	NEC	12,310	30,880	151	20.0
4	3	Mitsubishi	9,900	25,200	155	16.3
5	8	Motorola	918	10,451	1038	6.8
6	4	National Semiconductor	2,768	2,858	3	1.8
7	6	Fujitsu	1,030	2,700	162	1.7
8	5	Oki Semiconductor	1,966	2,600	32	1.7
9	9	Siemens	800	1,500	88	1.0
10	11	Matsushita	220	360	64	0.2
11	10	Sony	230	290	26	0.2
12	NM	SGS-Thomson Total	0	50	NM	0
		All Others	0	0	0	0
		Total 16-Bit and Up MCU	61,142	154,489	153	100.0

NM = Not meaningful
Source: Dataquest (June 1995)

Table 5-2
Top 10 Family Shipments of 16-Bit-and-Up Microcontrollers to the World (Thousands of Units)

1994 Rank	1993 Rank	Family	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	8096	30,000	41,000	37	26.5
2	7	H8	1,000	36,600	3,560	23.7
3	2	uPD	10,750	28,600	166	18.5
4	3	M377XX	9,900	25,200	155	16.3
5	NM	68XXX	NM	5,642	NM	3.7
6	8	68HC16	918	4,809	424	3.1
7	4	HPC16	2,768	2,858	3	1.8
8	6	MB907X	1,030	2,700	162	1.7
9	5	OLMS	1,966	2,600	32	1.7
10	10	C16X	800	1,500	88	1.0
		All Others	1,180	2,980	153	1.9
		Total 16-Bit and Up MCU	61,142	154,489	153	100.0

NM = Not meaningful
Source: Dataquest (June 1995)

For More Information...

Sue Kapoor, Market Research Analyst ....(408) 437-8505
Internet address ....skapoor@dataquest.com
Via fax...(408) 437-0292

Dataquest®

a company of The Dun & Bradstreet Corporation

Dataquest®

a company of
The Dun & Bradstreet Corporation

Corporate Headquarters
Dataquest Incorporated
1290 Ridder Park Drive
San Jose, California 95131-2398
United States
Phone: 1-408-437-8000
Facsimile: 1-408-437-0292

Dataquest Incorporated
Nine Technology Drive
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6180

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

European Headquarters
Dataquest Europe Limited
Holmers Farm Way
High Wycombe, Buckinghamshire
HP12 4XH
United Kingdom
Phone: 44-1494-422722
Facsimile: 44-1494-422742

Dataquest GmbH
Kronstadter Strasse 9
81677 München
Germany
Phone: 49-89-930-9090
Facsimile: 49-89-930-3277

Dataquest Europe SA
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: 33-1-41-35-13-00
Facsimile: 33-1-41-35-13-13

Japan Headquarters
Dataquest Japan K.K.
Shinkawa Sanko Building, 6th Floor
1-3-17, Shinkawa, Chuo-ku
Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

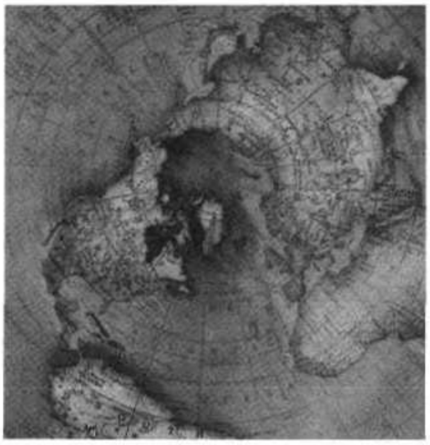
Asia/Pacific Headquarters
7/F China Underwriters Centre
88 Gloucester Road
Wan Chai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei 105
Taiwan, R.O.C.
Phone: 8862-756-0389
Facsimile: 8862-756-2663

Other research offices in Beijing, Singapore, and Thailand

Sales agents in Australia, Belgium, Germany (Kronberg), Israel, Italy, South Africa, and Spain



Dataquest

Final 1994 Microprocessor Market Share and Shipments

Market Statistics

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MS-9501
Publication Date: June 12, 1995
Filing: Market Analysis

Final 1994 Microprocessor Market Share and Shipments

Market Statistics

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MS-9501
Publication Date: June 12, 1995
Filing: Market Analysis

Table of Contents

List of Tables

Note: All tables show estimated data.

List of Tables (Continued)

Note: All tables show estimated data.

List of Tables (Continued)

Note: All tables show estimated data.

Final 1994 Microprocessor Market Share and Shipments

Introduction

This document contains detailed information on Dataquest's view of the microprocessor market. Included in this document are the following:

- 1993-1994 unit shipment and market share estimates
- 1992-1994 revenue and market share estimates

Analyses of market share by company provide insight into high-technology markets and reinforce estimates of consumption, production, and company revenue.

Microprocessor market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. Refer to the section entitled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in other Dataquest documents located in the binder of the same name.

Segmentation

This section outlines the market segments that are specific to this document. Dataquest's objective is to provide data along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients.

For market share purposes, Dataquest defines the microcomponent market according to the following functional segmentation scheme:

Digital Microcomponent IC
- Digital Microprocessor (MPU)
- Digital Microcontroller (MCU)
- Digital Microperipheral (MPR)
- Programmable Digital Signal Processor (pDSP)

Definitions

This section lists the definitions that are used by Dataquest to present the data in this document. Complete definitions for semiconductor devices can be found in the *Dataquest Semiconductor Market Definitions Guide*.

MOS Digital Microcomponent (MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral + MOS Programmable Digital Signal Processor): Defined as a MOS digital IC that contains a data processing unit or serves as an interface to such a unit.

MOS Digital Microprocessor (MPU) (8- and 16-bit CISC MPU + 32-bit and greater CISC MPU + 32-bit and greater RISC MPU): Defined as an IC that includes an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic. It may contain an instruction cache and/or data cache. An MPU's functions are determined by fetching and executing instructions and manipulating data held in external memory or an internal cache. The MPU category includes MPUs incorporating, or originating from, an ASIC design.

Wordwidth: The wordwidth of a microprocessor or microcontroller architecture is determined by the maximum wordwidth of the software that can be run by the architecture. This is defined by the computed accuracy of a single ADD instruction. If an architecture can perform a 32-bit ADD in a single instruction, then it is a 32-bit architecture. This is independent of the I/O bus width or the width of the integer unit. Examples of 32-bit MPUs include: 80386, 80486, and 68000. (Examples of 8-bit MCUs include: 68HC05/6805, 68HC11, 8051, Z8, uPD78xx, and PIC families.)

There are two microprocessors architectures:

- CISC microprocessors are split between embedded applications and compute applications, and include the following primary families: x86 and 68K; and the following low-end families: Z80, 680X, and 6502.
- RISC microprocessors are focused primarily on computing platforms (workstation and PC, among others). A RISC architecture is backed (or implicitly backed) by some form of open systems consortium, which makes it a candidate for mainstream adoption. RISC microprocessor architectures now shipping include the following: SPARC and MIPS (primary families); and PA-RISC, PowerPC, Clipper, and Alpha.

Note that all microprocessor shipments equals CISC microprocessor shipments plus RISC microprocessor shipments.

There are two microprocessor applications. Total microprocessor shipments equals compute-chip shipments plus embedded-chip shipments:

- Compute applications include computing platforms, for example, PCs and workstations. (Includes CISC and RISC architectures)
- Embedded applications are all noncomputing platform applications, such as computer peripherals, electronic printers, and other data processing applications; and the myriad applications in communications, industrial, consumer, military/civil aerospace, and transportation end-equipment markets. (Includes CISC and RISC architectures)

Note that all microprocessor shipments equals compute microprocessor shipments plus embedded microprocessor shipments.

There are five primary microprocessor families:

- x86 family: Defined as all upward-compatible versions of the 8086 microprocessor, regardless of wordwidth, instruction extensions, or level of integration. The following subsegments and versions are broken out to more accurately depict the trends and rivalry within this class:
  - 086 series: Includes the 8086, 8088, 16-bit V-series processors (V20/V40 and V30/V50), 80188, 80186, and new highly integrated versions
  - 286 series: Includes the 80286 alone
  - 386 series: Includes the 386SX, 386DX, 386SL, 376, the 32-bit V-series (for example, the V60/70/80), and future integrated versions
  - 486 series: Includes the 486SX, 486DX, 486DX2, 486SL, 486SLC, and 486DLC, the Pentium-class processors, and future highly integrated versions
- 68K family: Defined as all upward-compatible versions of the 68000 microprocessor, regardless of wordwidth, instruction extensions, or level of integration. The following subsegments and versions are broken out to more accurately depict the trends and rivalry within this class (note that each series, except the 68008/010, includes the 0xx devices and the ECxx devices):
  - 68000 series (32/16-bit device, 000 and EC000 versions)
  - 68008 series (32/8-bit device)
  - 68010 series (32/16-bit device)
  - 68020 series (32/32-bit device, 020 and EC020 versions)
  - 68030 series (32/32-bit device, 030 and EC030 versions)
  - 68040 series (32/32-bit device, 040 and EC040 versions)
  - 683xx series (various application-specific devices)
- SPARC family: Defined as all upward-compatible versions of the SPARC RISC microprocessor. The following subsegments are included:
  - SPARC
  - SPARC1, SPARC2
  - Super SPARC
  - Ultra SPARC
- MIPS family: Defined as all upward-compatible versions of the MIPS RISC microprocessor. The following subsegments are included:
  - R2000
  - R3000
  - R4000

- PowerPC family: Defined as all upward-compatible versions of the PowerPC RISC microprocessor. The following subsegments are included:
  - PPC601
  - PPC603
  - PPC604
  - PPC620

Microprocessors not included in one of the four primary families are included in the family previously known as "Low-End Architecture Family." The low-end architecture class of microprocessors is actually a collection of the first real microprocessors to hit the market and gain widespread use. These processors became the basis for many new products, including the early high-volume PCs such as the Apple II, the Commodore 64, and the Radio Shack TRS-80; the modern instrumentation for such products as function generators, logic analyzers, and medical diagnostic equipment; and the new era for industrial control designs such as modern traffic lights and manufacturing process controls. These low-end processors are also the architectural basis for some of the most successful lines of microcontrollers in use today. Included are the following families:

- Z80 family: Includes the Z80, 8085, and 8080
- 680x family: Includes the 6800/02/08/09, and equivalents
- 6502 family: Includes the 6502, 65SC816, and equivalents

Note that all microprocessor shipments equals shipments of the primary families (x86, 68K, SPARC, MIPS, and PowerPC) plus all other families.

MOS Digital Microcontroller (MCU): Defined as an IC that is similar to an MPU with the primary exception being that it is designed to operate from on-chip program and data memory (not including cache memories). MCU devices must be available with on-chip program and/or data store. As an option, some MCU devices can be purchased without on-chip memory. The MCU category includes MCUs incorporating, or originating from, an ASIC design.

Digital Microperipheral (MPR): Defined as ICs that serve as a logical support function to an MPU in a system. This definition includes MPRs comprising more than one device, such as system core logic chipsets, graphics and imaging controllers, communications controllers, mass storage controllers, audio/other controllers. The MPR category includes MPRs incorporating, or originating from, an ASIC design.

Programmable Digital Signal Processor (pDSP): Defined as an IC that includes a high-speed arithmetic unit (typically a multiply-accumulate unit) used for performing complex mathematical operations, such as Fourier transforms. Like an MPU or MCU, a pDSP is programmable in that it fetches and executes preprogrammed instructions. These instructions are oriented toward signal-processing algorithms. Integrating a pDSP on the same chip as an MPU or MCU does not alter the MPU or MCU categorization of that device.

Merchant versus Captive Consumption: Dataquest includes all revenue, both merchant and captive, for semiconductor suppliers selling to the merchant market. The data excludes completely captive suppliers where devices are manufactured solely for the company's own use. A product that is used internally is valued at market price rather than at transfer or factory price.

The unit tables in this book include the following microprocessors not counted in the revenue tables:

- Digital Equipment Corporation Alpha RISC chip
- Hewlett-Packard PA-RISC chip
- IBM x86 family of microprocessors

The Digital Equipment's Alpha and HP's PA-RISC processors are typically not sold alone in the merchant market, but are integrated into a RISC computer system. As such, chip-only revenue estimates do not exist, and imputed estimates are difficult to interpret. However, microprocessor suppliers do face competition from these chips, even though they are sold integrated into a computer system. IBM only recently has entered the merchant market with products from the x86 family; production previously was strictly for captive consumption.

Worldwide Geographic Region Definitions

North America: Includes Canada, Mexico, and the United States (50 states).

Japan: Japan is the only single-country region.

Europe: Western Europe includes Austria, Belgium, Denmark, Eire (Ireland), Finland, France, Germany (including former East Germany), Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and rest of western Europe (Andorra, Cypress, Gibraltar, Iceland, Liechtenstein, Malta, Monaco, San Marino, Turkey, and Vatican City).

Europe: Eastern Europe includes Albania, Bulgaria, the Czech Republic and Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the republics of the former Yugoslavia, and the republics of the former USSR (including Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan).

Asia/Pacific: Includes Asia/Pacific's newly industrialized economies (NIEs) and the Rest of Asia/Pacific regions. NIEs include Hong Kong, Singapore, Korea, and Taiwan. The Rest of Asia/Pacific region includes Australia, Bangladesh, Brunei, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam.

Rest of World: Includes Africa, Caribbean, Central America, Middle East, Oceania, and South America.

Line Item Definitions

Factory revenue is defined as the money value received by a semiconductor manufacturer for its products. Revenue from the sale of semiconductors sold either as finished goods, die, or wafers to another semiconductor vendor for resale is attributed to the semiconductor vendor that sells the product to a distributor or equipment manufacturer.

Shipment is defined as the number of complete products delivered, whether single chips or chipsets.

Market Share Methodology

Dataquest utilizes both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data utilized by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press
- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other suppliers.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. The following outlines these rates for 1992 through 1994.

Table 1
Exchange Rates

	1992	1993	1994
Japan (Yen/U.S.$)	126.45	111.20	101.81
France (Franc/U.S.$)	5.27	5.67	5.54
Germany (Deutsche Mark/U.S.$)	1.56	1.66	1.62
United Kingdom (U.S.$/Pound Sterling)	1.77	1.50	1.53

Source: Dataquest (May 1995)

Section 1: Final 1994 Microprocessor Revenue Estimates and Rankings

Table 1-1
Each Company's Shipments of All Microprocessors to the World—Embedded and Compute (Thousands of Units)

	1994 Total MPU	Embedded	Compute	Percentage Embedded	Percentage Compute
Total Market	191,392	131,805	59,587	68.9	31.1
North American Companies	146,431	87,243	59,188	59.6	40.4
Advanced Micro Devices	15,316	7,106	8,210	46.4	53.6
California Micro Devices	400	400	0	100.0	0
Chips & Technologies	147	0	147	0	100.0
Cyrix	2,382	0	2,382	0	100.0
Digital Semiconductor	65	0	65	0	100.0
Harris	275	275	0	100.0	0
Hewlett-Packard	175	175	0	100.0	0
Hughes	93	93	0	100.0	0
IBM	3,515	0	3,515	0	100.0
Integrated Device Technology	603	539	64	89.4	10.6
Intel	55,645	17,120	38,525	30.8	69.2
LSI Logic	900	900	0	100.0	0
Motorola	38,080	33,750	4,330	88.6	11.4
National Semiconductor	3,919	3,919	0	100.0	0
Performance Semiconductor	30	30	0	100.0	0
Rockwell	567	567	0	100.0	0
Texas Instruments	2,370	430	1,940	18.1	81.9
VLSI Technology	109	109	0	100.0	0
Weitek	60	50	10	83.3	16.7
Zilog	21,780	21,780	0	100.0	0
Japanese Companies	37,701	37,327	374	99.0	1.0
Fujitsu	463	283	180	61.1	38.9
Hitachi	13,018	13,018	0	100.0	0
Matsushita	340	340	0	100.0	0
Mitsubishi	276	276	0	100.0	0
NEC	11,440	11,320	120	99.0	1.0
OKI	1,400	1,400	0	100.0	0
Ricoh	1,000	1,000	0	100.0	0
Sharp	2,236	2,236	0	100.0	0
Toshiba	7,528	7,454	74	99.0	1.0

(Continued)

Table 1-1 (Continued)
Each Company's Shipments of All Microprocessors to the World—Embedded and Compute (Thousands of Units)

	1994 Total MPU	Embedded	Compute	Percentage Embedded	Percentage Compute
European Companies	6,235	6,235	0	100.0	0
GEC Plessey	550	550	0	100.0	0
SGS-Thomson	5,660	5,660	0	100.0	0
TCS	25	25	0	100.0	0
Asia/Pacific Companies	1,025	1,000	25	97.6	2.4
Goldstar	1,000	1,000	0	100.0	0
UMC	25	0	25	0	100.0

Source: Dataquest (May 1995)

Table 1-2
Each Company's Shipments of All Microprocessors to the World—CISC and RISC (Thousands of Units)

	1994 Total MPU	CISC	RISC	Percentage CISC	Percentage RISC
Total Market	191,392	174,336	17,056	91.1	8.9
North American Companies	146,431	136,778	9,653	93.4	6.6
Advanced Micro Devices	15,316	14,177	1,139	92.6	7.4
California Micro Devices	400	400	0	100.0	0
Chips & Technologies	147	147	0	100.0	0
Cyrix	2,382	2,382	0	100.0	0
Digital Semiconductor	65	0	65	0	100.0
Harris	275	275	0	100.0	0
Hewlett-Packard	175	0	175	0	100.0
Hughes	93	93	0	100.0	0
IBM	3,515	1,515	2,000	43.1	56.9
Integrated Device Technology	603	0	603	0	100.0
Intel	55,645	51,490	4,155	92.5	7.5
LSI Logic	900	0	900	0	100.0
Motorola	38,080	38,048	32	99.9	0.1
National Semiconductor	3,919	3,919	0	100.0	0
Performance Semiconductor	30	15	15	50.0	50.0
Rockwell	567	567	0	100.0	0
Texas Instruments	2,370	1,970	400	83.1	16.9
VLSI Technology	109	0	109	0	100.0
Weitek	60	0	60	0	100.0
Zilog	21,780	21,780	0	100.0	0
Japanese Companies	37,701	30,998	6,703	82.2	17.8
Fujitsu	463	93	370	20.1	79.9
Hitachi	13,018	7,010	6,008	53.8	46.2
Matsushita	340	340	0	100.0	0
Mitsubishi	276	259	17	93.8	6.2
NEC	11,440	11,210	230	98.0	2.0
OKI	1,400	1,400	0	100.0	0
Ricoh	1,000	1,000	0	100.0	0
Sharp	2,236	2,236	0	100.0	0
Toshiba	7,528	7,450	78	99.0	1.0
European Companies	6,235	5,535	700	88.8	11.2
GEC Plessey	550	0	550	0	100.0
SGS-Thomson	5,660	5,510	150	97.3	2.7
TCS	25	25	0	100.0	0
Asia/Pacific Companies	1,025	1,025	0	100.0	0
Goldstar	1,000	1,000	0	100.0	0
UMC	25	25	0	100.0	0

Source: Dataquest (May 1995)

Table 1-3
Each Company's Factory Revenue from Shipments of All Microprocessors to the World (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	8,783	11,436	100.0	100.0
North American Companies	8,408	10,897	95.7	95.3
Advanced Micro Devices	511	985	5.8	8.6
AT&T	2	0	0	0
California Micro Devices	2	2	0	0
Chips & Technologies	6	7	0.1	0.1
Cypress Semiconductor	6	0	0.1	0
Cyrix	95	231	1.1	2.0
Harris	11	12	0.1	0.1
Hughes	3	3	0	0
IBM	88	246	1.0	2.2
Integrated Device Technology	43	51	0.5	0.4
Intel	6,569	8,370	74.8	73.2
LSI Logic	47	51	0.5	0.4
Motorola	705	597	8.0	5.2
National Semiconductor	38	49	0.4	0.4
Performance Semiconductor	16	15	0.2	0.1
Rockwell	5	5	0.1	0
Texas Instruments	200	214	2.3	1.9
VLSI Technology	3	2	0	0
Weitek	19	14	0.2	0.1
Zilog	39	43	0.4	0.4
Japanese Companies	311	461	3.5	4.0
Fujitsu	25	56	0.3	0.5
Hitachi	79	160	0.9	1.4
Matsushita	11	14	0.1	0.1
Mitsubishi	17	9	0.2	0.1
NEC	87	105	1.0	0.9
OKI	9	9	0.1	0.1
Ricoh	4	4	0	0
Sharp	11	12	0.1	0.1
Toshiba	68	92	0.8	0.8
European Companies	61	67	0.7	0.6
GEC Plessey	7	6	0.1	0.1
Philips	1	0	0	0
SGS-Thomson	39	51	0.4	0.4
Siemens	4	0	0	0
TCS	10	10	0.1	0.1

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of All Microprocessors to the World (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Asia/Pacific Companies	3	11	0	0.1
Goldstar	3	1	0	0
United Microelectronics	0	10	0	0.1

Source: Dataquest (May 1995)

Table 1-4
Each Company's Factory Revenue from Shipments of All Microprocessors to North America (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	4,323	5,446	100.0	100.0
North American Companies	4,269	5,351	98.8	98.3
Advanced Micro Devices	187	371	4.3	6.8
AT&T	2	0	0	0
California Micro Devices	1	1	0	0
Chips & Technologies	4	5	0.1	0.1
Cypress Semiconductor	5	0	0.1	0
Cyrix	50	118	1.2	2.2
Harris	5	5	0.1	0.1
Hughes	3	3	0.1	0.1
IBM	44	133	1.0	2.4
Integrated Device Technology	30	33	0.7	0.6
Intel	3,343	4,135	77.3	75.9
LSI Logic	33	11	0.8	0.2
Motorola	337	305	7.8	5.6
National Semiconductor	13	12	0.3	0.2
Performance Semiconductor	15	15	0.3	0.3
Rockwell	3	4	0.1	0.1
Texas Instruments	159	167	3.7	3.1
Weitek	16	12	0.4	0.2
Zilog	19	21	0.4	0.4
Japanese Companies	39	71	0.9	1.3
Fujitsu	4	30	0.1	0.6
Hitachi	8	11	0.2	0.2
Mitsubishi	1	0	0	0
NEC	18	21	0.4	0.4
OKI	3	3	0.1	0.1
Toshiba	5	6	0.1	0.1
European Companies	15	24	0.3	0.4
GEC Plessey	1	1	0	0
SGS-Thomson	9	18	0.2	0.3
TCS	5	5	0.1	0.1

Source: Dataquest (May 1995)

Table 1-5
Each Company's Factory Revenue from Shipments of All Microprocessors to Japan (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	835	1,247	100.0	100.0
North American Companies	651	963	78.0	77.2
Advanced Micro Devices	19	23	2.3	1.8
Cyrix	6	16	0.7	1.3
Harris	2	2	0.2	0.2
Integrated Device Technology	4	5	0.5	0.4
Intel	530	801	63.5	64.2
LSI Logic	0	33	0	2.6
Motorola	68	53	8.1	4.3
National Semiconductor	7	11	0.8	0.9
Performance Semiconductor	1	0	0.1	0
Texas Instruments	9	13	1.1	1.0
VLSI Technology	0	1	0	0.1
Weitek	1	1	0.1	0.1
Zilog	4	4	0.5	0.3
Japanese Companies	178	279	21.3	22.4
Fujitsu	8	9	1.0	0.7
Hitachi	54	129	6.5	10.3
Matsushita	10	13	1.2	1.0
Mitsubishi	11	8	1.3	0.6
NEC	56	70	6.7	5.6
OKI	2	2	0.2	0.2
Ricoh	4	4	0.5	0.3
Sharp	11	12	1.3	1.0
Toshiba	22	32	2.6	2.6
European Companies	6	5	0.7	0.4
GEC Plessey	3	2	0.4	0.2
SGS-Thomson	3	3	0.4	0.2

Source: Dataquest (May 1995)

Table 1-6
Each Company's Factory Revenue from Shipments of All Microprocessors to Europe (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	2,098	2,774	100.0	100.0
North American Companies	2,015	2,677	96.0	96.5
Advanced Micro Devices	109	288	5.2	10.4
Cypress Semiconductor	1	0	0	0
Cyrix	26	62	1.2	2.2
Harris	3	4	0.1	0.1
Integrated Device Technology	9	10	0.4	0.4
Intel	1,673	2,131	79.7	76.8
LSI Logic	14	6	0.7	0.2
Motorola	139	123	6.6	4.4
National Semiconductor	10	17	0.5	0.6
Rockwell	2	1	0.1	0
Texas Instruments	17	25	0.8	0.9
VLSI Technology	3	1	0.1	0
Weitek	2	1	0.1	0
Zilog	7	8	0.3	0.3
Japanese Companies	47	61	2.2	2.2
Fujitsu	8	11	0.4	0.4
Hitachi	6	8	0.3	0.3
Matsushita	1	1	0	0
Mitsubishi	1	0	0	0
NEC	5	6	0.2	0.2
OKI	1	1	0	0
Toshiba	25	34	1.2	1.2
European Companies	36	34	1.7	1.2
GEC Plessey	1	1	0	0
Philips	1	0	0	0
SGS-Thomson	25	28	1.2	1.0
Siemens	4	0	0.2	0
TCS	5	5	0.2	0.2
Asia/Pacific Companies	0	2	0	0.1
United Microelectronics	0	2	0	0.1

Source: Dataquest (May 1995)

Table 1-7
Each Company's Factory Revenue from Shipments of All Microprocessors to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	1,527	1,969	100.0	100.0
North American Companies	1,473	1,906	96.5	96.8
Advanced Micro Devices	196	303	12.8	15.4
California Micro Devices	1	1	0.1	0.1
Chips & Technologies	2	2	0.1	0.1
Cyrix	13	35	0.9	1.8
Harris	1	1	0.1	0.1
IBM	44	113	2.9	5.7
Integrated Device Technology	0	3	0	0.2
Intel	1,023	1,303	67.0	66.2
LSI Logic	0	1	0	0.1
Motorola	161	116	10.5	5.9
National Semiconductor	8	9	0.5	0.5
Texas Instruments	15	9	1.0	0.5
Zilog	9	10	0.6	0.5
Japanese Companies	47	50	3.1	2.5
Fujitsu	5	6	0.3	0.3
Hitachi	11	12	0.7	0.6
Mitsubishi	4	1	0.3	0.1
NEC	8	8	0.5	0.4
OKI	3	3	0.2	0.2
Toshiba	16	20	1.0	1.0
European Companies	4	4	0.3	0.2
GEC Plessey	2	2	0.1	0.1
SGS-Thomson	2	2	0.1	0.1
Asia/Pacific Companies	3	9	0.2	0.5
Goldstar	3	1	0.2	0.1
United Microelectronics	0	8	0	0.4

Source: Dataquest (May 1995)

Table 1-8
Top 20 Companies' Factory Revenue from Shipments of All Microprocessors to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	6,569	8,370	27	73.2
2	3	Advanced Micro Devices	511	985	93	8.6
3	2	Motorola	705	597	-15	5.2
4	6	IBM	88	246	180	2.2
5	5	Cyrix	95	231	143	2.0
6	4	Texas Instruments	200	214	7	1.9
7	8	Hitachi	79	160	103	1.4
8	7	NEC	87	105	21	0.9
9	9	Toshiba	68	92	35	0.8
10	15	Fujitsu	25	56	124	0.5
11	10	LSI Logic	47	51	9	0.4
12	11	Integrated Device Technology	43	51	19	0.4
13	12	SGS-Thomson	39	51	31	0.4
14	14	National Semiconductor	38	49	29	0.4
15	13	Zilog	39	43	10	0.4
16	18	Performance Semiconductor	16	15	-6	0.1
17	16	Weitek	19	14	-26	0.1
18	19	Matsushita	11	14	27	0.1
19	20	Sharp	11	12	9	0.1
20	21	Harris	11	12	9	0.1
		All Others	82	68	-17	0.6
		North American Companies	8,408	10,897	30	95.3
		Japanese Companies	311	461	48	4.0
		European Companies	61	67	10	0.6
		Asia/Pacific Companies	3	11	267	0.1
		Total Market	8,783	11,436	30	100.0

Source: Dataquest (May 1995)

Table 1-9
Top 10 Companies' Factory Revenue from Shipments of All Microprocessors to North America (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	3,343	4,135	24	75.9
2	3	Advanced Micro Devices	187	371	98	6.8
3	2	Motorola	337	305	-9	5.6
4	4	Texas Instruments	159	167	5	3.1
5	6	IBM	44	133	202	2.4
6	5	Cyrix	50	118	136	2.2
7	8	Integrated Device Technology	30	33	10	0.6
8	20	Fujitsu	4	30	650	0.6
9	9	Zilog	19	21	11	0.4
10	10	NEC	18	21	17	0.4
		All Others	132	112	-15	2.1
		North American Companies	4,269	5,351	25	98.3
		Japanese Companies	39	71	82	1.3
		European Companies	15	24	60	0.4
		Asia/Pacific Companies	0	0	NA	0
		Total Market	4,323	5,446	26	100.0

NA = Not available
Source: Dataquest (May 1995)

Table 1-10
Top 10 Companies' Factory Revenue from Shipments of All Microprocessors to Japan (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	530	801	51	64.2
2	4	Hitachi	54	129	139	10.3
3	3	NEC	56	70	25	5.6
4	2	Motorola	68	53	-22	4.3
5	24	LSI Logic	0	33	NA	2.6
6	5	Toshiba	22	32	45	2.6
7	6	Advanced Micro Devices	19	23	21	1.8
8	13	Cyrix	6	16	167	1.3
9	9	Matsushita	10	13	30	1.0
10	10	Texas Instruments	9	13	44	1.0
		All Others	61	64	5	5.1
		North American Companies	651	963	48	77.2
		Japanese Companies	178	279	57	22.4
		European Companies	6	5	-17	0.4
		Asia/Pacific Companies	0	0	NA	0
		Total Market	835	1,247	49	100.0

NA = Not available
Source: Dataquest (May 1995)

Table 1-11
Top 10 Companies' Factory Revenue from Shipments of All Microprocessors to Europe (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	1,673	2,131	27	76.8
2	3	Advanced Micro Devices	109	288	164	10.4
3	2	Motorola	139	123	-12	4.4
4	4	Cyrix	26	62	138	2.2
5	5	Toshiba	25	34	36	1.2
6	6	SGS-Thomson	25	28	12	1.0
7	7	Texas Instruments	17	25	47	0.9
8	9	National Semiconductor	10	17	70	0.6
9	11	Fujitsu	8	11	38	0.4
10	10	Integrated Device Technology	9	10	11	0.4
		All Others	57	45	-21	1.6
		North American Companies	2,015	2,677	33	96.5
		Japanese Companies	47	61	30	2.2
		European Companies	36	34	-6	1.2
		Asia/Pacific Companies	0	2	NA	0.1
		Total Market	2,098	2,774	32	100.0

NA = Not available
Source: Dataquest (May 1995)

Table 1-12
Top 10 Companies' Factory Revenue from Shipments of All Microprocessors to Asia/Pacific-Rest of World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	1,023	1,303	27	66.2
2	2	Advanced Micro Devices	196	303	55	15.4
3	3	Motorola	161	116	-28	5.9
4	4	IBM	44	113	157	5.7
5	7	Cyrix	13	35	169	1.8
6	5	Toshiba	16	20	25	1.0
7	8	Hitachi	11	12	9	0.6
8	9	Zilog	9	10	11	0.5
9	6	Texas Instruments	15	9	-40	0.5
10	10	National Semiconductor	8	9	13	0.5
		All Others	31	39	26	2.0
		North American Companies	1,473	1,906	29	96.8
		Japanese Companies	47	50	6	2.5
		European Companies	4	4	0	0.2
		Asia/Pacific Companies	3	9	200	0.5
		Total Market	1,527	1,969	29	100.0

Source: Dataquest (May 1995)

Section 2: Microprocessor Unit Shipments—Overview

Table 2-1
Ranking of Each Company's Shipments of All Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Intel	46,620	55,645	19.4	29.1
2	2	Motorola	35,536	38,080	7.2	19.9
3	3	Zilog	23,886	21,780	-8.8	11.4
4	4	Advanced Micro Devices	14,885	15,316	2.9	8.0
5	7	Hitachi	7,360	13,018	76.9	6.8
6	5	NEC	10,515	11,440	8.8	6.0
7	6	Toshiba	9,445	7,528	-20.3	3.9
8	8	SGS-Thomson	4,500	5,660	25.8	3.0
9	9	National Semiconductor	2,962	3,919	32.3	2.0
10	16	IBM	947	3,515	271.2	1.8
11	17	Cyrix	900	2,382	164.7	1.2
12	12	Texas Instruments	2,000	2,370	18.5	1.2
13	10	Sharp	2,077	2,236	7.7	1.2
14	13	OKI	1,994	1,400	-29.8	0.7
15	11	Goldstar	2,000	1,000	-50.0	0.5
16	15	Ricoh	1,000	1,000	0	0.5
17	21	LSI Logic	425	900	111.8	0.5
18	22	Integrated Device Technology	329	603	83.3	0.3
19	18	Rockwell	766	567	-26.0	0.3
20	23	GEC Plessey	308	550	78.6	0.3
21	26	Fujitsu	248	463	86.7	0.2
22	19	California Micro Devices	518	400	-22.8	0.2
23	24	Matsushita	304	340	11.8	0.2
24	25	Mitsubishi	262	276	5.3	0.1
25	14	Harris	1,467	275	-81.3	0.1
26	29	Hewlett-Packard	125	175	40.0	0.1
27	28	Chips & Technologies	126	147	16.7	0.1
28	32	VLSI Technology	87	109	24.7	0.1
29	31	Hughes	100	93	-7.0	*
30	35	Digital Semiconductor	30	65	116.7	*
31	30	Weitek	105	60	-42.9	*
32	33	Performance Semiconductor	79	30	-62.0	*
33	37	TCS	25	25	0	*
34	NM	UMC	0	25	NA	*

(Continued)

Table 2-1 (Continued)
Ranking of Each Company's Shipments of All Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
NM	20	Siemens	439	0	-100.0	NA
NM	27	Philips	230	0	-100.0	NA
NM	34	AT&T	30	0	-100.0	NA
NM	36	Cypress Semiconductor	25	0	-100.0	NA
		Total MPU	172,655	191,392	10.9	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 2-2
Ranking of Each Company's Shipments of Embedded Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Motorola	30,092	33,750	12.2	25.6
2	2	Zilog	23,886	21,780	-8.8	16.5
3	3	Intel	18,575	17,120	-7.8	13.0
4	7	Hitachi	7,360	13,018	76.9	9.9
5	4	NEC	10,420	11,320	8.6	8.6
6	5	Toshiba	9,384	7,454	-20.6	5.7
7	6	Advanced Micro Devices	8,095	7,106	-12.2	5.4
8	8	SGS-Thomson	4,500	5,660	25.8	4.3
9	9	National Semiconductor	2,962	3,919	32.3	3.0
10	10	Sharp	2,077	2,236	7.7	1.7
11	12	OKI	1,994	1,400	-29.8	1.1
12	11	Goldstar	2,000	1,000	-50.0	0.8
13	14	Ricoh	1,000	1,000	0	0.8
14	19	LSI Logic	400	900	125.0	0.7
15	15	Rockwell	766	567	-26.0	0.4
16	20	GEC Plessey	308	550	78.6	0.4
17	22	Integrated Device Technology	265	539	103.4	0.4
18	16	Texas Instruments	525	430	-18.1	0.3
19	17	California Micro Devices	518	400	-22.8	0.3
20	21	Matsushita	304	340	11.8	0.3
21	25	Fujitsu	170	283	66.5	0.2
22	23	Mitsubishi	262	276	5.3	0.2
23	13	Harris	1,467	275	-81.3	0.2
24	26	Hewlett-Packard	125	175	40.0	0.1
25	28	VLSI Technology	87	109	24.7	0.1
26	27	Hughes	100	93	-7.0	0.1
27	29	Weitek	75	50	-33.3	*
28	30	Performance Semiconductor	75	30	-60.0	*
29	32	TCS	25	25	0	*
NM	18	Siemens	439	0	-100.0	NA
NM	24	Philips	230	0	-100.0	NA
NM	31	AT&T	30	0	-100.0	NA
		Total MPU	128,516	131,805	2.6	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 2-3
Ranking of Each Company's Shipments of Compute Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Intel	28,045	38,525	37.4	64.7
2	2	Advanced Micro Devices	6,790	8,210	20.9	13.8
3	3	Motorola	5,444	4,330	-20.5	7.3
4	5	IBM	947	3,515	271.2	5.9
5	6	Cyrix	900	2,382	164.7	4.0
6	4	Texas Instruments	1,475	1,940	31.5	3.3
7	9	Fujitsu	78	180	130.8	0.3
8	7	Chips & Technologies	126	147	16.7	0.2
9	8	NEC	95	120	26.3	0.2
10	11	Toshiba	61	74	21.3	0.1
11	12	Digital Semiconductor	30	65	116.7	0.1
12	10	Integrated Device Technology	64	64	0	0.1
13	NM	UMC	0	25	NA	*
14	13	Weitek	30	10	-66.7	NA
NM	14	Cypress Semiconductor	25	0	-100.0	NA
NM	15	LSI Logic	25	0	-100.0	NA
NM	16	Performance Semiconductor	4	0	-100.0	NA
		Total MPU	44,139	59,587	35.0	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Section 3: Microprocessor Unit Shipments by Wordwidth

Table 3-1
Ranking of Each Company's Shipments of All 8-Bit Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Zilog	23,686	21,625	-8.7	45.2
2	2	Toshiba	7,780	6,200	-20.3	13.0
3	3	Hitachi	5,690	5,060	-11.1	10.6
4	4	SGS-Thomson	3,500	4,510	28.9	9.4
5	6	Sharp	2,025	2,180	7.7	4.6
6	5	Motorola	3,003	1,891	-37.0	4.0
7	8	OKI	1,592	1,200	-24.6	2.5
8	7	Goldstar	2,000	1,000	-50.0	2.1
9	10	Ricoh	1,000	1,000	0	2.1
10	9	Intel	1,000	700	-30.0	1.5
11	11	Rockwell	766	567	-26.0	1.2
12	13	NEC	540	540	0	1.1
13	14	California Micro Devices	518	400	-22.8	0.8
14	15	Texas Instruments	300	260	-13.3	0.5
15	17	Mitsubishi	245	255	4.1	0.5
16	16	National Semiconductor	250	219	-12.4	0.5
17	19	Hughes	100	93	-7.0	0.2
18	18	Fujitsu	107	85	-20.6	0.2
19	12	Harris	545	50	-90.8	0.1
NM	20	Siemens	50	0	-100.0	NA
		Total MPU	54,697	47,835	-12.5	100.0

NA = Not available
NM = Not meaningful
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 3-2
Ranking of Each Company's Shipments of All 16-Bit Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	2	NEC	9,770	10,580	8.3	38.6
2	3	Intel	10,375	10,500	1.2	38.3
3	3	Advanced Micro Devices	4,805	4,582	-4.6	16.7
4	6	Hitachi	380	400	5.3	1.5
5	9	SGS-Thomson	275	350	27.3	1.3
6	8	Matsushita	300	340	13.3	1.2
7	4	Harris	922	225	-75.6	0.8
8	5	OKI	402	200	-50.2	0.7
9	10	Zilog	200	155	-22.5	0.6
10	11	Sharp	52	56	7.7	0.2
11	12	Performance Semiconductor	25	15	-40.0	0.1
NM	7	Siemens	372	0	-100.0	NA
NM	13	National Semiconductor	17	0	-100.0	NA
		Total MPU	27,895	27,403	-1.8	100.0

NA = Not available
NM = Not meaningful
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 3-3
Ranking of Each Company's Shipments of All 32-Bit and Greater Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Intel	35,245	44,445	26.1	38.3
2	2	Motorola	32,533	36,189	11.2	31.2
3	3	Advanced Micro Devices	10,080	10,734	6.5	9.2
4	7	Hitachi	1,290	7,558	485.9	6.5
5	4	National Semiconductor	2,695	3,700	37.3	3.2
6	8	IBM	947	3,515	271.2	3.0
7	9	Cyrix	900	2,382	164.7	2.1
8	5	Texas Instruments	1,700	2,110	24.1	1.8
9	6	Toshiba	1,665	1,328	-20.2	1.1
10	11	LSI Logic	425	900	111.8	0.8
11	10	SGS-Thomson	725	800	10.3	0.7
12	12	Integrated Device Technology	329	603	83.3	0.5
13	13	GEC Plessey	308	550	78.6	0.5
14	16	Fujitsu	141	378	168.1	0.3
15	15	NEC	205	320	56.1	0.3
16	18	Hewlett-Packard	125	175	40.0	0.2
17	17	Chips & Technologies	126	147	16.7	0.1
18	20	VLSI Technology	87	109	24.7	0.1
19	23	Digital Semiconductor	30	65	116.7	0.1
20	19	Weitek	105	60	-42.9	0.1
21	25	TCS	25	25	0	*
22	35	UMC	0	25	NA	*
23	26	Mitsubishi	17	21	23.5	*
24	21	Performance Semiconductor	54	15	-72.2	*
NM	14	Philips	230	0	-100.0	NA
NM	22	AT&T	30	0	-100.0	NA
NM	24	Cypress Semiconductor	25	0	-100.0	NA
NM	27	Siemens	17	0	-100.0	NA
NM	28	Matsushita	4	0	-100.0	NA
		Total MPU	90,063	116,154	29.0	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 3-4
Ranking of Each Company's Shipments of 32-Bit and Greater Embedded Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Motorola	27,089	31,859	17.6	56.3
2	6	Hitachi	1,290	7,558	485.9	13.4
3	7	Intel	7,200	5,920	-17.8	10.5
4	4	National Semiconductor	2,695	3,700	37.3	6.5
5	3	Advanced Micro Devices	3,290	2,524	-23.3	4.5
6	5	Toshiba	1,604	1,254	-21.8	2.2
7	8	LSI Logic	400	900	125.0	1.6
8	7	SGS-Thomson	725	800	10.3	1.4
9	9	GEC Plessey	308	550	78.6	1.0
10	10	Integrated Device Technology	265	539	103.4	1.0
11	14	NEC	110	200	81.8	0.4
12	17	Fujitsu	63	198	214.3	0.4
13	13	Hewlett-Packard	125	175	40.0	0.3
14	12	Texas Instruments	225	170	-24.4	0.3
15	15	VLSI Technology	87	109	24.7	0.2
16	16	Weitek	75	50	-33.3	0.1
17	20	TCS	25	25	0	*
18	21	Mitsubishi	17	21	23.5	*
19	18	Performance Semiconductor	50	15	-70.0	*
NM	11	Philips	230	0	-100.0	NA
NM	19	AT&T	30	0	-100.0	NA
NM	22	Siemens	17	0	-100.0	NA
NM	23	Matsushita	4	0	-100.0	NA
		Total MPU	45,924	56,567	23.2	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 3-5
Ranking of Each Company's Shipments of 32-Bit and Greater Compute Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Intel	28,045	38,525	37.4	64.7
2	2	Advanced Micro Devices	6,790	8,210	20.9	13.8
3	3	Motorola	5,444	4,330	-20.5	7.3
4	4	IBM	947	3,515	271.2	5.9
5	5	Cyrix	900	2,382	164.7	4.0
6	6	Texas Instruments	1475	1940	31.5	3.3
7	7	Fujitsu	78	180	130.8	0.3
8	8	Chips & Technologies	126	147	16.7	0.2
9	9	NEC	95	120	26.3	0.2
10	10	Toshiba	61	74	21.3	0.1
11	11	Digital Semiconductor	30	65	116.7	0.1
12	12	Integrated Device Technology	64	64	0	0.1
13	13	Weitek	30	10	-66.7	*
NM	14	Cypress Semiconductor	25	0	-100.0	NA
NM	15	LSI Logic	25	0	-100.0	NA
NM	16	Performance Semiconductor	4	0	-100.0	NA
		Total MPU	44,139	59,562	34.9	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 3-6
Shipments of 32-Bit and Greater Compute Microprocessors by Region to the World (Thousands of Units)

Architectural Word Width	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
32-Bit	43,885	59,264	35.0	99.5
North American Companies	43,807	59,059	34.8	99.1
Japanese Companies	78	180	130.8	0.3
Asia/Pacific Companies	0	25	NA	0
>32-Bit	254	323	27.2	0.5
North American Companies	98	129	31.6	0.2
Japanese Companies	156	194	24.4	0.3
Total MPU	44,139	59,587	35.0	100.0

NA = Not available

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

Source: Dataquest (May 1995)

Table 3-7
Each Company's Factory Revenue from Shipments of All 8- and 16-Bit CISC Microprocessors to the World (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	440	535	100.0	100.0
North American Companies	221	300	50.2	56.1
Advanced Micro Devices	38	81	8.6	15.1
California Micro Devices	2	2	0.5	0.4
Harris	11	12	2.5	2.2
Hughes	3	3	0.7	0.6
Intel	90	115	20.5	21.5
Motorola	0	5	0	0.9
National Semiconductor	4	3	0.9	0.6
Performance Semiconductor	7	11	1.6	2.1
Rockwell	5	5	1.1	0.9
Texas Instruments	22	20	5.0	3.7
Zilog	39	43	8.9	8.0
Japanese Companies	215	234	48.9	43.7
Fujitsu	8	8	1.8	1.5
Hitachi	73	80	16.6	15.0
Matsushita	10	12	2.3	2.2
Mitsubishi	15	9	3.4	1.7
NEC	43	46	9.8	8.6
OKI	9	9	2.0	1.7
Ricoh	4	4	0.9	0.7
Sharp	11	12	2.5	2.2
Toshiba	42	54	9.5	10.1
European Companies	1	0	0.2	0
Philips	1	0	0.2	0
Asia/Pacific Companies	3	1	0.7	0.2
Goldstar	3	1	0.7	0.2

Source: Dataquest (May 1995)

Table 3-8
Top 20 Companies' Factory Revenue from Shipments of All 8- and 16-Bit CISC Microprocessors to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	90	115	28	21.5
2	6	Advanced Micro Devices	38	81	113	15.1
3	2	Hitachi	73	80	10	15.0
4	4	Toshiba	42	54	29	10.1
5	3	NEC	43	46	7	8.6
6	5	Zilog	39	43	10	8.0
7	7	Texas Instruments	22	20	-9	3.7
8	9	Harris	11	12	9	2.2
9	10	Sharp	11	12	9	2.2
10	11	Matsushita	10	12	20	2.2
11	14	Performance Semiconductor	7	11	57	2.1
12	8	Mitsubishi	15	9	-40	1.7
13	12	OKI	9	9	0	1.7
14	13	Fujitsu	8	8	0	1.5
15	15	Rockwell	5	5	0	0.9
16	22	Motorola	0	5	NA	0.9
17	17	Ricoh	4	4	0	0.7
18	16	National Semiconductor	4	3	-25	0.6
19	19	Hughes	3	3	0	0.6
20	20	California Micro Devices	2	2	0	0.4
		All Others	4	1	-75	0.2
		North American Companies	221	300	36	56.1
		Japanese Companies	215	234	9	43.7
		European Companies	1	0	-100	0
		Asia/Pacific Companies	3	1	-67	0.2
		Total Market	440	535	22	100.0

NA = Not available
Source: Dataquest (May 1995)

Table 3-9
Each Company's Factory Revenue from Shipments of All 32-Bit and Greater CISC Microprocessors to the World (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	7,701	9,812	100.0	100.0
North American Companies	7,666	9,763	99.5	99.5
Advanced Micro Devices	440	823	5.7	8.4
Chips & Technologies	6	7	0.1	0.1
Cyrix	95	231	1.2	2.4
IBM	46	0	0.6	0
Intel	6,319	8,050	82.1	82.0
Motorola	685	561	8.9	5.7
National Semiconductor	34	46	0.4	0.5
Performance Semiconductor	9	4	0.1	0
Texas Instruments	32	41	0.4	0.4
Japanese Companies	25	29	0.3	0.3
Fujitsu	1	1	0	0
Hitachi	2	3	0	0
NEC	22	25	0.3	0.3
European Companies	10	10	0.1	0.1
TCS	10	10	0.1	0.1
Asia/Pacific Companies	0	10	0	0.1
United Microelectronics	0	10	0	0.1

Source: Dataquest (May 1995)

Table 3-10
Top 20 Companies' Factory Revenue from Shipments of All 32-Bit and Greater CISC Microprocessors to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	6,319	8,050	27	82.0
2	3	Advanced Micro Devices	440	823	87	8.4
3	2	Motorola	685	561	-18	5.7
4	4	Cyrix	95	231	143	2.4
5	6	National Semiconductor	34	46	35	0.5
6	7	Texas Instruments	32	41	28	0.4
7	8	NEC	22	25	14	0.3
8	9	TCS	10	10	0	0.1
9	27	United Microelectronics	0	10	NA	0.1
10	11	Chips & Technologies	6	7	17	0.1
11	10	Performance Semiconductor	9	4	-56	0
12	12	Hitachi	2	3	50	0
13	13	Fujitsu	1	1	0	0
14	5	IBM	46	0	-100	0
		All Others	0	0	NA	0
		North American Companies	7,666	9,763	27	99.5
		Japanese Companies	25	29	16	0.3
		European Companies	10	10	0	0.1
		Asia/Pacific Companies	0	10	NA	0.1
		Total Market	7,701	9,812	27	100.0

NA = Not available
Source: Dataquest (May 1995)

Table 3-11
Ranking of Each Company's Shipments of All 32-Bit and Greater CISC Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Intel	30,675	40,290	31.3	40.7
2	1	Motorola	32,462	36,157	11.4	36.5
3	3	Advanced Micro Devices	9,425	9,595	1.8	9.7
4	4	National Semiconductor	2,695	3,700	37.3	3.7
5	8	Cyrix	900	2,382	164.7	2.4
6	6	Texas Instruments	1,425	1,710	20.0	1.7
7	7	Hitachi	1,280	1,550	21.1	1.6
8	9	IBM	872	1,515	73.7	1.5
9	5	Toshiba	1,600	1,250	-21.9	1.3
10	10	SGS-Thomson	500	650	30.0	0.7
11	12	Chips & Technologies	126	147	16.7	0.1
12	13	NEC	90	90	0	0.1
13	14	TCS	25	25	0	*
14	20	UMC	0	25	NA	NA
15	16	Fujitsu	8	8	0	NA
16	15	Mitsubishi	16	4	-75.0	NA
NM	11	Philips	230	0	-100.0	NA
		Total MPU	82,329	99,098	20.4	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 3-12
Ranking of Each Company's Shipments of 32-Bit and Greater Embedded CISC Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Motorola	27,089	31,859	17.6	74.9
2	3	National Semiconductor	2,695	3,700	37.3	8.7
3	2	Intel	2,700	1,850	-31.5	4.3
4	6	Hitachi	1,280	1,550	21.1	3.6
5	4	Advanced Micro Devices	2,635	1,385	-47.4	3.3
6	5	Toshiba	1,600	1,250	-21.9	2.9
7	7	SGS-Thomson	500	650	30.0	1.5
8	9	Texas Instruments	225	170	-24.4	0.4
9	10	NEC	90	90	0	0.2
10	11	TCS	25	25	0	0.1
11	13	Fujitsu	8	8	0	*
12	12	Mitsubishi	16	4	-75.0	*
NM	8	Philips	230	0	-100.0	NA
		Total MPU	39,093	42,541	8.8	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 3-13
Ranking of Each Company's Shipments of 32-Bit and Greater Compute CISC Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Intel	27,975	38,440	37.4	68.0
2	2	Advanced Micro Devices	6,790	8,210	20.9	14.5
3	3	Motorola	5,373	4,298	-20.0	7.6
4	5	Cyrix	900	2,382	164.7	4.2
5	4	Texas Instruments	1,200	1,540	28.3	2.7
6	6	IBM	872	1,515	73.7	2.7
7	7	Chips & Technologies	126	147	16.7	0.3
8	NM	UMC	0	25	-100.0	*
		Total MPU	43,236	56,557	30.8	100.0

NM = Not meaningful

*Calculated value of less than 0.1 percent

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

Source: Dataquest (May 1995)

Table 3-14
Each Company's Factory Revenue from Shipments of All 32-Bit and Greater RISC Microprocessors to the World (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	642	1,089	100.0	100.0
North American Companies	521	834	81.2	76.6
Advanced Micro Devices	33	81	5.1	7.4
AT&T	2	0	0.3	0
Cypress Semiconductor	6	0	0.9	0
IBM	42	246	6.5	22.6
Integrated Device Technology	43	51	6.7	4.7
Intel	160	205	24.9	18.8
LSI Logic	47	51	7.3	4.7
Motorola	20	31	3.1	2.8
Texas Instruments	146	153	22.7	14.0
VLSI Technology	3	2	0.5	0.2
Weitek	19	14	3.0	1.3
Japanese Companies	71	198	11.1	18.2
Fujitsu	16	47	2.5	4.3
Hitachi	4	77	0.6	7.1
Matsushita	1	2	0.2	0.2
Mitsubishi	2	0	0.3	0
NEC	22	34	3.4	3.1
Toshiba	26	38	4.0	3.5
European Companies	50	57	7.8	5.2
GEC Plessey	7	6	1.1	0.6
SGS-Thomson	39	51	6.1	4.7
Siemens	4	0	0.6	0

Source: Dataquest (May 1995)

Table 3-15
Top 20 Companies' Factory Revenue from Shipments of All 32-Bit and Greater RISC Microprocessors to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	5	IBM	42	246	486	22.6
2	1	Intel	160	205	28	18.8
3	2	Texas Instruments	146	153	5	14.0
4	7	Advanced Micro Devices	33	81	145	7.4
5	15	Hitachi	4	77	1825	7.1
6	3	LSI Logic	47	51	9	4.7
7	4	Integrated Device Technology	43	51	19	4.7
8	6	SGS-Thomson	39	51	31	4.7
9	12	Fujitsu	16	47	194	4.3
10	8	Toshiba	26	38	46	3.5
11	9	NEC	22	34	55	3.1
12	10	Motorola	20	31	55	2.8
13	11	Weitek	19	14	-26	1.3
14	13	GEC Plessey	7	6	-14	0.6
15	17	VLSI Technology	3	2	-33	0.2
16	20	Matsushita	1	2	100	0.2
17	14	Cypress Semiconductor	6	0	-100	0
18	16	Siemens	4	0	-100	0
19	18	Mitsubishi	2	0	-100	0
20	19	AT&T	2	0	-100	0
		All Others	0	0	NA	0
		North American Companies	521	834	60	76.6
		Japanese Companies	71	198	179	18.2
		European Companies	50	57	14	5.2
		Asia/Pacific Companies	0	0	NA	0
		Total Market	642	1,089	70	100.0

NA = Not available
Source: Dataquest (May 1995)

Table 3-16
Ranking of Each Company's Shipments of All 32-Bit and Greater RISC Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	21	Hitachi	10	6,008	59,980.0	35.2
2	1	Intel	4,570	4,155	-9.1	24.4
3	13	IBM	75	2,000	2,566.7	11.7
4	14	Advanced Micro Devices	655	1,139	73.9	6.7
5	3	LSI Logic	425	900	111.8	5.3
6	4	Integrated Device Technology	329	603	83.3	3.5
7	5	GEC Plessey	308	550	78.6	3.2
8	6	Texas Instruments	275	400	45.5	2.3
9	8	Fujitsu	133	370	178.2	2.2
10	10	NEC	115	230	100.0	1.3
11	9	Hewlett-Packard	125	175	40.0	1.0
12	7	SGS-Thomson	225	150	-33.3	0.9
13	12	VLSI Technology	87	109	24.7	0.6
14	15	Toshiba	65	78	20.0	0.5
15	18	Digital Semiconductor	30	65	116.7	0.4
16	11	Weitek	105	60	-42.9	0.4
17	14	Motorola	71	32	-54.9	0.2
18	23	Mitsubishi	1	17	1,600.0	0.1
19	16	Performance Semiconductor	54	15	-72.2	0.1
NM	17	AT&T	30	0	-100.0	NA
NM	19	Cypress Semiconductor	25	0	-100.0	NA
NM	20	Siemens	17	0	-100.0	NA
NM	22	Matsushita	4	0	-100.0	NA
		Total MPU	7,734	17,056	120.5	100.0

NA = Not available
NM = Not meaningful
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 3-17
Ranking of Each Company's Shipments of 32-Bit and Greater Embedded RISC Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	15	Hitachi	10	6,008	59,980.0	42.8
2	1	Intel	4,500	4,070	-9.6	29.0
3	2	Advanced Micro Devices	655	1,139	73.9	8.1
4	3	LSI Logic	400	900	125.0	6.4
5	4	GEC Plessey	308	550	78.6	3.9
6	5	Integrated Device Technology	265	539	103.4	3.8
7	10	Fujitsu	55	190	245.5	1.4
8	7	Hewlett-Packard	125	175	40.0	1.2
9	6	SGS-Thomson	225	150	-33.3	1.1
10	13	NEC	20	110	450.0	0.8
11	8	VLSI Technology	87	109	24.7	0.8
12	9	Weitek	75	50	-33.3	0.4
13	18	Mitsubishi	1	17	1,600.0	0.1
14	11	Performance Semiconductor	50	15	-70.0	0.1
15	17	Toshiba	4	4	0	*
NM	12	AT&T	30	0	-100.0	NA
NM	14	Siemens	17	0	-100.0	NA
NM	16	Matsushita	4	0	-100.0	NA
		Total MPU	6,831	14,026	105.3	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 3-18
Ranking of Each Company's Shipments of 32-Bit and Greater Compute RISC Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	4	IBM	75	2,000	2,566.7	66.0
2	1	Texas Instruments	275	400	45.5	13.2
3	3	Fujitsu	78	180	130.8	5.9
4	4	NEC	95	120	26.3	4.0
5	6	Intel	70	85	21.4	2.8
6	8	Toshiba	61	74	21.3	2.4
7	9	Digital Semiconductor	30	65	116.7	2.1
8	7	Integrated Device Technology	64	64	0	2.1
9	5	Motorola	71	32	-54.9	1.1
10	10	Weitek	30	10	-66.7	0.3
NM	11	Cypress Semiconductor	25	0	-100.0	NA
NM	12	LSI Logic	25	0	-100.0	NA
NM	13	Performance Semiconductor	4	0	-100.0	NA
		Total MPU	903	3,030	235.5	100.0

NA = Not available
NM = Not meaningful
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Section 4: Microprocessor Unit Shipments—All Processor Families

Table 4-1
Shipments of Each Microprocessor Family to the World (Thousands of Units)

1994 Rank	1993 Rank	Family	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	X86	70,340	81,927	16.5	42.8
2	2	68K	36,072	39,632	9.9	20.7
3	3	MIPS	976	1,732	77.5	0.9
4	4	SPARC	488	780	59.8	0.4
5	5	All other families	64,779	67,321	3.9	35.2
		Total MPU	172,655	191,392	10.9	100.0

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 4-2
Shipments of Each Embedded Microprocessor Family to the World (Thousands of Units)

1994 Rank	1993 Rank	Family	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	2	68K	30,724	35,334	15.0	26.8
2	1	X86	32,477	29,668	-8.6	22.5
3	3	MIPS	752	1,474	96.0	1.1
4	4	SPARC	55	190	245.5	0.1
5	5	All other families	64,508	65,139	1.0	49.4
		Total MPU	128,516	131,805	2.6	100.0

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 4-3
Shipments of Each Compute Microprocessor Family to the World (Thousands of Units)

1994 Rank	1993 Rank	Family	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	X86	37,863	52,259	38.0	87.7
2	2	68K	5,373	4,298	-20.0	7.2
3	3	SPARC	433	590	36.3	1.0
4	4	MIPS	224	258	15.2	0.4
5	5	All other families	246	2,182	787.0	3.7
		Total MPU	44,139	59,587	35.0	100.0

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 4-4
Shipments of CISC Microprocessors by Family to the World (Thousands of Units)

1994 Rank	1993 Rank	Family	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	X86	70,340	81,927	16.5	47.0
2	2	68K	36,097	39,632	9.8	22.7
3	3	All other families	58,484	52,777	-9.8	30.3
		Total MPU	164,921	174,336	5.7	100.0

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 4-5
Shipments of RISC Microprocessors by Family to the World (Thousands of Units)

1994 Rank	1993 Rank	Family	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	3	PowerPC	75	2,000	2,566.7	11.7
2	1	MIPS	976	1,732	77.5	10.2
3	2	SPARC	488	780	59.8	4.6
4	4	All other families	6,195	12,544	102.5	73.5
		Total MPU	7,734	17,056	120.5	100.0

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Section 5: Microprocessor Unit Shipments—x86 Processor Family

Table 5-1
Ranking of Each Company's Shipments of All x86 Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Intel	41,050	50,790	23.7	62.0
2	2	Advanced Micro Devices	14,230	14,177	-0.4	17.3
3	3	NEC	9,860	10,670	8.2	13.0
4	6	Cyrix	900	2,382	164.7	2.9
5	4	Texas Instruments	1,200	1,540	28.3	1.9
6	7	IBM	872	1,515	73.7	1.8
7	8	OKI	756	400	-47.1	0.5
8	5	Harris	922	225	-75.6	0.3
9	10	Chips & Technologies	126	147	16.7	0.2
10	11	Sharp	52	56	7.7	0.1
11	NM	UMC	0	25	NA	*
12	9	Siemens	372	0	-100.0	0
		Total MPU	70,340	81,927	16.5	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 5-2
Shipments of All x86 Microprocessors by Product to the World (Thousands of Units)

Product	Architectural Word Width	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
8086	16	711	253	-64.4	0.3
8088	16	900	360	-60.0	0.4
80186	16	6,560	5,902	-10.0	7.2
80188	16	7,815	8,748	11.9	10.7
80286	16	1,244	444	-64.3	0.5
80386DX	32	5,940	3,580	-39.7	4.4
80386SX/SL	32	5,761	3,287	-42.9	4.0
80486DX/DLC	32	16,875	24,890	47.5	30.4
80486SX/SL/SLC	32	14,297	18,697	30.8	22.8
Pentium	32	325	5,040	1,450.8	6.2
V20/V40	16	4,258	4,258	0	5.2
V30/V50	16	5,564	6,378	14.6	7.8
V60/V70/V80	32	90	90	0	0.1
Total MPU		70,340	81,927	16.5	100.0

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 5-3
Ranking of Each Company's Shipments of All 16-Bit x86 Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	2	NEC	9,770	10,580	8.3	40.5
2	1	Intel	10,375	10,500	1.2	40.2
3	3	Advanced Micro Devices	4,805	4,582	-4.6	17.5
4	4	Harris	922	225	-75.6	0.9
5	5	OKI	402	200	-50.2	0.8
6	7	Sharp	52	56	7.7	0.2
NM	6	Siemens	372	0	-100.0	NA
		Total MPU	26,698	26,143	-2.1	100.0

NA = Not available
NM = Not meaningful
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 5-4
Ranking of Each Company's Shipments of All 32-Bit and Greater x86 Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Intel	30,675	40,290	31.3	72.2
2	2	Advanced Micro Devices	9,425	9,595	1.8	17.2
3	4	Cyrix	900	2,382	164.7	4.3
4	3	Texas Instruments	1,200	1,540	28.3	2.8
5	5	IBM	872	1,515	73.7	2.7
6	6	OKI	354	200	-43.5	0.4
7	7	Chips & Technologies	126	147	16.7	0.3
8	8	NEC	90	90	0	0.2
9	NM	UMC	0	25	NA	*
		Total MPU	43,642	55,784	27.8	100.0

NA = Not available

NM = Not meaningful

*Calculated value is less than 0.1 percent.

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

Source: Dataquest (May 1995)

Table 5-5
Each Company's Factory Revenue from Shipments of All x86 Microprocessors to the World (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	7,133	9,660	100.0	100.0
North American Companies	7,053	9,660	98.9	100.0
Advanced Micro Devices	477	904	6.7	9.4
Chips & Technologies	6	7	0.1	0.1
Cyrix	95	231	1.3	2.4
Harris	8	12	0.1	0.1
IBM	0	300	0	3.1
Intel	6,392	8,165	89.6	84.5
Texas Instruments	75	41	1.1	0.4
Japanese Companies	79	0	1.1	0
NEC	69	0	1.0	0
OKI	7	0	0.1	0
Sharp	3	0	0	0
European Companies	1	0	0	0
Siemens	1	0	0	0

Source: Dataquest (May 1995)

Table 5-6
Top 10 Companies' Factory Revenue from Shipments of All X86 Microprocessors to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	6,392	8,165	28	84.5
2	2	Advanced Micro Devices	477	904	90	9.4
3	17	IBM	0	300	NA	3.1
4	3	Cyrix	95	231	143	2.4
5	4	Texas Instruments	75	41	-45	0.4
6	6	Harris	8	12	50	0.1
7	8	Chips & Technologies	6	7	17	0.1
8	5	NEC	69	0	-100	0
9	7	OKI	7	0	-100	0
10	9	Sharp	3	0	-100	0
		All Others	1	0	-100	0
		North American Companies	7,053	9,660	37	100.0
		Japanese Companies	79	0	-100	0
		European Companies	1	0	-100	0
		Asia/Pacific Companies	0	0	NA	0
		Total Market	7,133	9,660	35	100.0

NA = Not available
Source: Dataquest (May 1995)

Section 6: Microprocessor Unit Shipments—68K Processor Family

Table 6-1
Ranking of Each Company's Shipments of All 68K Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Motorola	32,462	36,157	11.4	91.2
2	3	Hitachi	1,280	1,550	21.1	3.9
3	2	Toshiba	1,600	1,250	-21.9	3.2
4	4	SGS-Thomson	500	650	30.0	1.6
5	6	TCS	25	25	0	0.1
NM	5	Philips	230	0	-100.0	NA
		Total MPU	36,097	39,632	9.8	100.0

NA = Not available
NM = Not meaningful
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 6-2
Ranking of Shipments of All 68K Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Subfamily	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	68000	21,758	20,256	-6.9	51.1
2	3	68020	2,422	3,350	38.3	8.5
3	4	68040	1,934	3,097	60.1	7.8
4	2	68030	3,439	1,200	-65.1	3.0
5	5	68008	500	569	13.8	1.4
6	6	68010	220	185	-15.9	0.5
7	NM	68060	0	1	NA	*
		68300	5,824	10,974	88.4	27.7
		Total MPU	36,097	39,632	9.8	100.0

NA = Not available
NM = Not meaningful
*Calculated value is less than 0.1 percent.
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 6-3
Each Company's Factory Revenue from Shipments of All 68K Microprocessors to the World (Millions of U.S. Dollars)

	Revenue		Market Share (%)	
	1993	1994	1993	1994
Total Market	728	574	100.0	100.0
North American Companies	675	561	92.7	97.8
Motorola	675	561	92.7	97.8
Japanese Companies	39	10	5.4	1.8
Hitachi	25	5	3.4	0.9
Toshiba	14	5	1.9	0.9
European Companies	14	3	1.9	0.4
Philips	1	0	0.1	0
SGS-Thomson	3	3	0.4	0.4
TCS	10	0	1.4	0

Source: Dataquest (May 1995)

Table 6-4
Top 10 Companies' Factory Revenue from Shipments of All 68K Microprocessors to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Motorola	675	561	-17	97.8
2	2	Hitachi	25	5	-80	0.9
3	3	Toshiba	14	5	-64	0.9
4	5	SGS-Thomson	3	3	-17	0.4
5	16	Sharp	0	0	NA	0
6	4	TCS	10	0	-100	0
7	6	Philips	1	0	-100	0
		All Others	0	0	NA	0
		North American Companies	675	561	-17	97.8
		Japanese Companies	39	10	-74	1.8
		European Companies	14	2.5	-82	0.4
		Asia/Pacific Companies	0	0	NA	0
		Total Market	728	574	-21	100.0

NA = Not available
Source: Dataquest (May 1995)

Section 7: Microprocessor Unit Shipments—RISC Processor Families

Table 7-1
Ranking of Each Company's Shipments of All SPARC Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Texas Instruments	275	400	45.5	51.3
2	2	Fujitsu	133	370	178.2	47.4
3	3	Weitek	30	10	-66.7	1.3
NM	4	Cypress Semiconductor	25	0	-100.0	NA
NM	4	LSI Logic	25	0	-100.0	NA
		Total MPU	488	780	59.8	100.0

NA = Not available
NM = Not meaningful
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 7-2
Ranking of Each Company's Shipments of All MIPS Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	LSI Logic	400	900	125.0	52.0
2	2	Integrated Device Technology	329	603	83.3	34.8
3	3	NEC	115	140	21.7	8.1
4	4	Toshiba	61	74	21.3	4.3
5	5	Performance Semiconductor	54	15	-72.2	0.9
NM	6	Siemens	17	0	-100.0	NA
		Total MPU	976	1,732	77.5	100.0

NA = Not available
NM = Not meaningful
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Section 8: Microprocessor Unit Shipments—8- and 16-Bit Embedded Processors

Table 8-1
Ranking of Each Company's Shipments of 8-Bit Embedded Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	Zilog	23,686	21,625	-8.7	45.2
2	2	Toshiba	7,780	6,200	-20.3	13.0
3	3	Hitachi	5,690	5,060	-11.1	10.6
4	4	SGS-Thomson	3,500	4,510	28.9	9.4
5	6	Sharp	2,025	2,180	7.7	4.6
6	5	Motorola	3,003	1,891	-37.0	4.0
7	8	OKI	1,592	1,200	-24.6	2.5
8	7	Goldstar	2,000	1,000	-50.0	2.1
9	9	Ricoh	1,000	1,000	0	2.1
10	10	Intel	1,000	700	-30.0	1.5
11	11	Rockwell	766	567	-26.0	1.2
12	13	NEC	540	540	0	1.1
13	14	California Micro Devices	518	400	-22.8	0.8
14	15	Texas Instruments	300	260	-13.3	0.5
15	17	Mitsubishi	245	255	4.1	0.5
16	16	National Semiconductor	250	219	-12.4	0.5
17	19	Hughes	100	93	-7.0	0.2
18	18	Fujitsu	107	85	-20.6	0.2
19	12	Harris	545	50	-90.8	0.1
NM	20	Siemens	50	0	-100.0	NA
		Total MPU	54,697	47,835	-12.5	100.0

NA = Not available
NM = Not meaningful
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1995)

Table 8-2
Ranking of Each Company's Shipments of 16-Bit Embedded Microprocessors to the World (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Units	1994 Units	Percentage Change	1994 Market Share (%)
1	1	NEC	9,770	10,580	8.3	38.6
2	1	Intel	10,375	10,500	1.2	38.3
3	3	Advanced Micro Devices	4,805	4,582	-4.6	16.7
4	6	Hitachi	380	400	5.3	1.5
5	9	SGS-Thomson	275	350	27.3	1.3
6	8	Matsushita	300	340	13.3	1.2
7	4	Harris	922	225	-75.6	0.8
8	5	OKI	402	200	-50.2	0.7
9	10	Zilog	200	155	-22.5	0.6
10	11	Sharp	52	56	7.7	0.2
11	12	Performance Semiconductor	25	15	-40.0	0.1
NM	7	Siemens	372	0	-100.0	NA
NM	13	National Semiconductor	17	0	-100.0	NA
		Total MPU	27,895	27,403	-1.8	100.0

NA = Not available
NM = Not meaningful
Note: *Columns may not add to totals shown because of rounding.*
Source: Dataquest (May 1995)

For More Information...

Jerry Banks, Director/Principal Analyst....................................(408) 437-8677
Internet address ....jbanks@dataquest.com
Via fax...(408) 437-0292

Dataquest®
a company of
The Dun & Bradstreet Corporation

Dataquest®

a company of
The Dun & Bradstreet Corporation

Corporate Headquarters
Dataquest Incorporated
1290 Ridder Park Drive
San Jose, California 95131-2398
United States
Phone: 1-408-437-8000
Facsimile: 1-408-437-0292

Dataquest Incorporated
Nine Technology Drive
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6180

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

European Headquarters
Dataquest Europe Limited
Holmers Farm Way
High Wycombe, Buckinghamshire
HP12 4XH
United Kingdom
Phone: 44-1494-422722
Facsimile: 44-1494-422742

Dataquest GmbH
Kronstadter Strasse 9
81677 München
Germany
Phone: 49-89-930-9090
Facsimile: 49-89-930-3277

Dataquest Europe SA
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: 33-1-41-35-13-00
Facsimile: 33-1-41-35-13-13

Japan Headquarters
Dataquest Japan K.K.
Shinkawa Sanko Building, 6th Floor
1-3-17, Shinkawa, Chuo-ku
Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

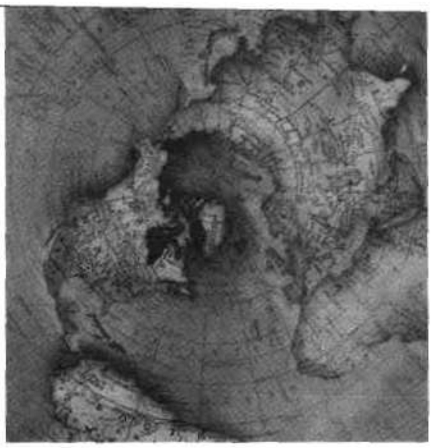
Asia/Pacific Headquarters
7/F China Underwriters Centre
88 Gloucester Road
Wan Chai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei 105
Taiwan, R.O.C.
Phone: 8862-756-0389
Facsimile: 8862-756-2663

Other research offices in Beijing, Singapore, and Thailand

Sales agents in Australia, Belgium, Germany (Kronberg), Israel, Italy, South Africa, and Spain



Dataquest

x86 Market: Detailed Forecast, Assumptions, and Trends

Market Trends

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MT-9501
Publication Date: January 16, 1995
Filing: Market Analysis

x86 Market: Detailed Forecast, Assumptions, and Trends

Market Trends

Program: Microcomponents Worldwide
Product Code: MCRO-WW-MT-9501
Publication Date: January 16, 1995
Filing: Market Analysis

Table of Contents

List of Figures

List of Tables

Chapter 1
Executive Summary/Overview/Introduction

Dataquest provided microprocessor forecasts down to the product family level during 1994. Our basic families consist of the following:

- x86: The x86 family of microprocessors. Members in this family include the 80286, 80386, 80486, and Pentium, among others.
- 68K: The 68000 family of microprocessors. Members in this family include the 68000, 68010, 68020, and 683xx, among others.
- OSR: The open systems RISC family of microprocessors. Included in this category are Alpha, MIPS, PA-RISC, PowerPC, and SPARC.
- ESF: The embedded system-focused microprocessors. This includes such microprocessors families as the i960 from Intel, 29K from Advanced Micro Devices, and 32K from National Semiconductor.
- LEA: The low-end-architecture products consist primarily of 8-bit microprocessors such as the Z80, 6502, 6800, and 8080. Also included are some 16-bit extensions of these families.

Our recently published *Final 1993 Microprocessor Market Share and Shipments* book (MCRO-WW-MS-9403, dated October 17, 1994) published information that delved into greater product level detail within each of these categories.

In this document we are publishing a detailed product forecast together with our set of assumptions for the x86 family of microprocessors. This product family represents more than 80 percent of all microprocessor revenue, as well as more than 80 percent of client requests for detailed microprocessor forecast information.

Key Drivers

The x86 family of microprocessors is growing at a 28 percent rate, in terms of revenue, in 1994 versus a 71 percent growth in 1993. The spectacular revenue growth in 1993 was driven by two interrelated factors. One is the switch from 386 to 486 microprocessors, which automatically increased the average selling price (ASP) of the microprocessors. The other factor is the release of the Windows 3.1 graphical user interface (GUI). The ease of use of Windows drove the personal computer into every facet of business, and the higher processing power required to efficiently run Windows 3.1 drove the need for the 486. The confluence of these two events drove a 48 percent unit shipment increase in 32-bit x86 microprocessors in 1993 and a phenomenal 78 percent growth in revenue for this category of microprocessor, although 1994's growth seems moderate at 16 percent in unit shipments and nearly 30 percent in revenue terms. In real growth, 32-bit x86 units grew by more than 2 million units and by more than $2 billion. This growth occurred without the introduction of a new user interface, such as Windows 3.1, or without the introduction of any one new compelling application to drive the market. The market growth is based upon replacement in the office and the penetration of PCs into the home.

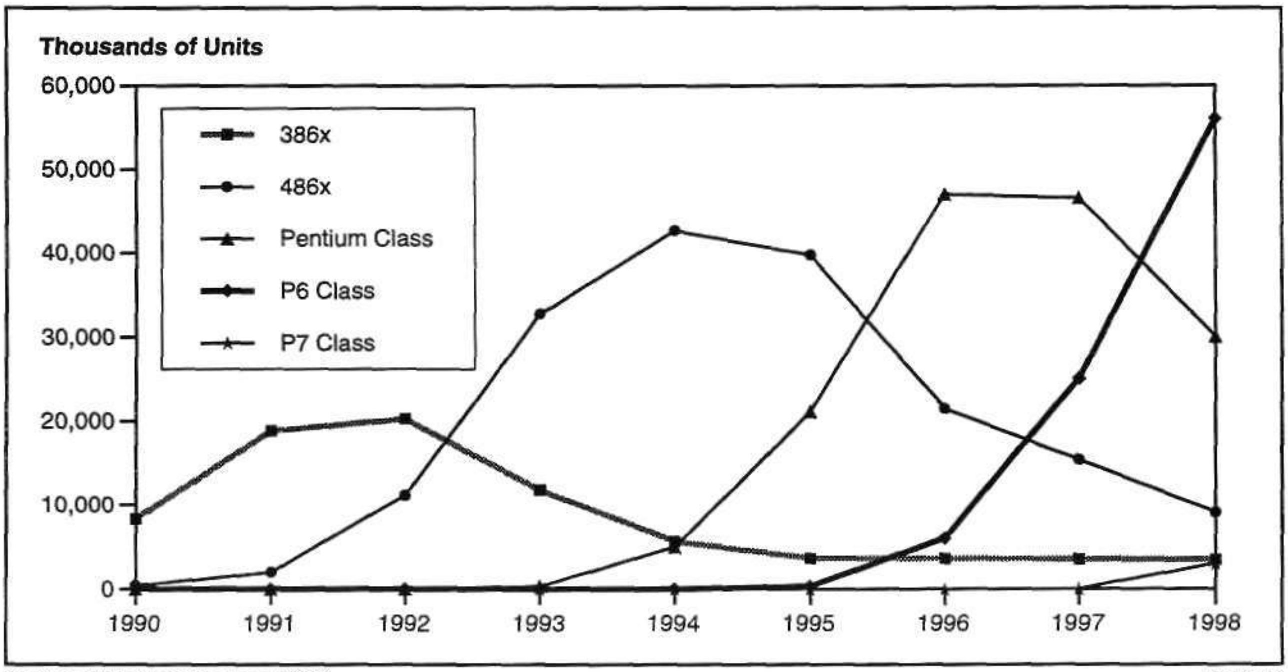
Dataquest sees no fundamental change in the market demand for the PC. The market remains supply constrained. The key component limiting supply is the microprocessor, or more specifically the x86 microprocessor. A shortage of DRAMs continues, but this has resulted in a flattening of the selling price for DRAMs and has limited impact on the demand for PCs. We believe that the microprocessor will remain the key limiting component to the growth of the PC.

Chapter 2
The x86 Forecast

The 486 Peaks and Pentium Takes Off

As is shown in Figure 2-1, 1994 marks the peak production year for the 486 microprocessor. Although we still foresee strong shipments for the 486 in 1995, most of these shipments will be relegated to the low-end PCs and midrange portable PCs. High-end PCs have already made the transition from the 486 to Pentium-based systems. As we move into 1995, we expect the Pentium to become the processor of choice for the mainstream desktop, the home user, and the high-end portable.

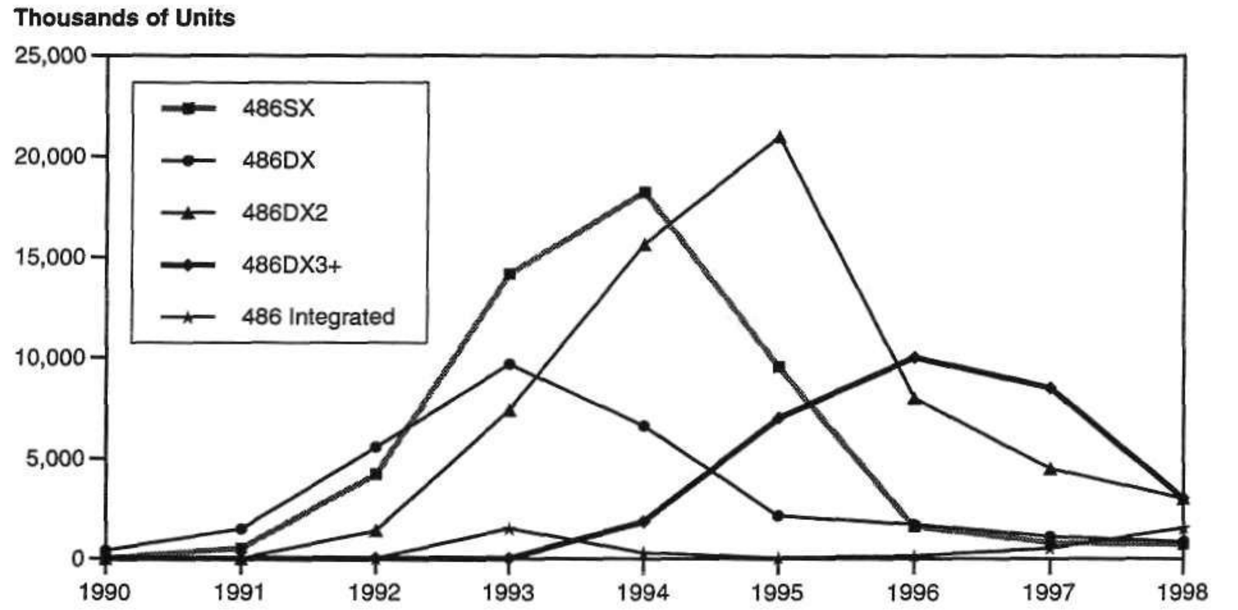
Figure 2-1
x86 Product Forecast



Source: Dataquest (January 1995) G4006962

Figure 2-2 shows the annual product shipments of the various members of the 486 family. At this level of detail it is evident that the single-clock 486DX reached its peak in 1993, while the 486SX is peaking in 1994. The clock-doubled 486DX2 is still a very attractive product in terms of price/performance and is expected to ship about 20 million units in its peak year of 1995. The latest generation of 486 product is clock-tripled, allowing 100-MHz performance with a 33-MHz bus. The life cycle of this product is being truncated by the next-generation x86 MPU, the Pentium-class microprocessor. The clock-tripled 486 will still find its way into low-end and some midrange desktops as well as some midrange portables. We expect the compelling price/performance of this class of product to allow it to continue growing through 1996, but that the rapid growth of the Pentium will force the 486DX3 class of product into entry-level-type products.

Figure 2-2
486 Product Forecast



Source: Dataquest (January 1995)
G4006963

The time from product introduction to high-volume production is shrinking with each successive generation of x86 microprocessor. The Pentium microprocessor reached high-volume production faster than any other microprocessor in history. In addition to this acceleration of the production ramp of the x86 microprocessors, next-generation microprocessors are now being introduced within two-and-a-half years of the prior generation. As a result, we now have an acceleration of the first portion of the life cycle of a microprocessor and a rapid deceleration of the latter portion of the life cycle of a microprocessor. This overall life-cycle shortening will make it very difficult for all but the very rich or very clever to keep up with this continually accelerating technological treadmill.

Is Any Company Able to Keep Pace?

Although both the 386 and 486 both had significant bugs during their respective initial production ramps, the highly publicized "flaw" in the Pentium microprocessor might cause one to wonder whether the current pace of technology can be maintained. The industry seems to be making great strides in architecture, transistor density, performance, packaging, and manufacturing. The one area that seems to be lagging is that of test and emulation. It seems to be a common theme among microprocessor vendors that there is no such thing as a bug-free microprocessor. Until recently, it seemed adequate to emulate and test to a degree of certainty and then go to production. Bugs discovered after this point would either be fixed or documented in the form of errata. Although the user community may not have appreciated such a seemingly laissez-faire attitude, the practice continued without serious repercussion. When the first-generation 486's floating-point problem was discovered, it was of major proportion and was easily encountered by the user. However, at that time the level of sophistication of the typical PC user and the lack of PC penetration into the home market allowed the 486 flaw to quickly fade into history, although the problem itself was much more serious than the now infamous Pentium flaw. Much has changed in the past five years. The user community is now much broader and its level of expectation from its technology providers has risen dramatically.

The Pentium is a dramatic technology step above the prior-generation 486 microprocessor. It contains nearly three times the number of transistors of the 486, including two integer units, versus one, and a completely redesigned floating-point unit. Although it did receive a significant hardware emulation checkout prior to the manufacture of the first prototypes, we now know that at least one flaw did slip through. Although this flaw is much less serious than the start-up problems associated with the 486, today's user community has learned to take certain things for granted. One of those is the absolute accuracy of the microprocessor.

Has the industry's ability to architect and build new generations of microprocessors outpaced its ability to emulate, test, and verify the functions of these ever-more-complex devices? The glamor roles in microprocessor development have historically been identified as those of the architects and designers. Growing in stature is the role manufacturing takes in these large, high-performance, and high-volume products. The role of the test engineer has never been viewed as a glamor role, nor have test engineers been given the same respect as their more glamorous counterparts. Perhaps it is time for things to change. It is evident that test and verification must be given a larger role in the development of the new high-complexity microprocessors. As time goes on, the user community's tolerance for such problems will continue to erode. It is easy to speculate, that, in less than two years' time, if the P6 should happen to exhibit a flaw of the same magnitude that the early Pentium demonstrated, the user community reaction would be much more severe than occurred for the Pentium.

Furthermore, the Pentium was not part of the newly accelerated product introduction cycle that we will see starting with the next-generation x86 microprocessor with the code name P6. Five years ago, a major problem with the 486 was a minor perturbation in its production ramp. Today, a minor, rarely encountered problem is a feature story for nearly every major network and news publication. Tomorrow, such a problem could spell financial disaster to the perpetrator.

Test and Emulation Critical for Follow-On Generations

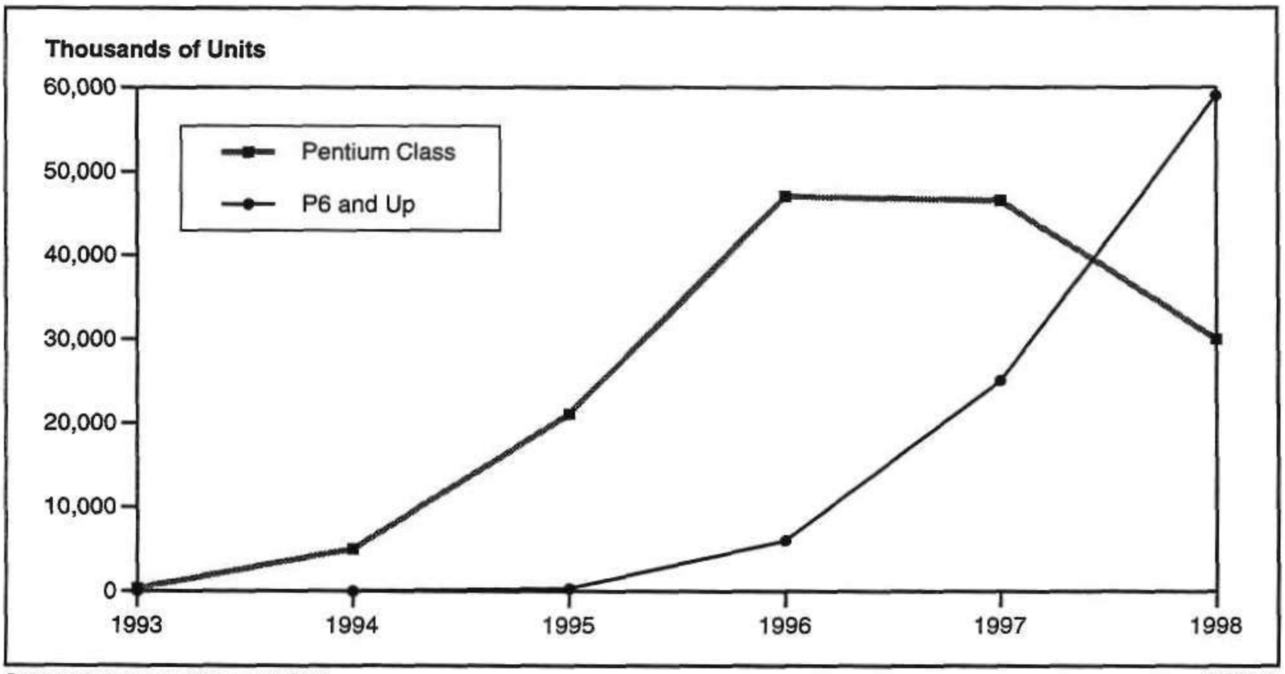
It is not the current Pentium product that is in need of extensive scrutiny. It has already received extensive scrutiny, and for the most part is performing quite well. In fact, we still believe that about 21 million Pentium-class processors will ship in 1995, making it the fastest-growing x86 microprocessor in history. Furthermore, we expect Pentium-based PCs to further accelerate the growth of the home market, which will soon be demanding even-higher-performance PCs. The needs of the home are driving for more sophisticated and easier-to-use user interfaces, and home applications such as multimedia are increasingly demanding more of the MPU. Such a growth rate and such a penetration into the home market will cause the P6 generation of microprocessor to be even more susceptible to criticism should a flaw find its way into production silicon.

It is critical that the P6 be introduced with no functional flaws. We fully expect the P6 to be at least as much of a technological advancement over the Pentium as the Pentium was over the 486. We also expect that the testing and emulation issues for the P6 will increase at least at the same rate and probably at a higher rate. Although at the time of this writing we have no specific knowledge, we are forced to assume that the P6 is being designed in a structured fashion, with as much emphasis being placed on emulation and testability as is placed on performance and manufacturability. Without such an increased emphasis, the increased complexity of the P6 when combined with its accelerated introduction schedule makes the emulation, test, and verification issue even more critical to the success of the product.

Bigger, Faster, and Higher Volume

We believe that the P6 will be receiving much more upper management scrutiny than did the Pentium, and as a result we are slightly revising our estimated P6 first shipment date from mid-1995 to the third quarter. Despite this revision, we still expect the P6 to ship about 300,000 units in its introduction year and, in keeping with historical precedent, will exceed the production ramp of the Pentium (see Figure 2-3).

Figure 2-3
Superscalar x86 Shipment Forecast



Source: Dataquest (January 1995) G4006964

Although Intel has publicly confirmed very few specifics about the P6 microprocessor, it is generally believed that it will come in at more than twice the performance of a 100-MHz Pentium and will have multiple integer units. We also are hearing about a dual-cavity package from multiple sources. Most of the speculation on the need for this package is that at least one version of the P6 will make use of a tightly coupled secondary cache that will exist in one of the cavities in the dual-cavity package. As this would be a very costly solution for the mainstream desktop, one can only surmise that other single-cavity variations of the P6 will also be released coincident with or shortly after the dual-cavity version. It would fit Intel's model to introduce the dual-cavity version first. This product would go into high-performance, leading-edge applications that can afford the initial high selling price of an early release of a next-generation x86 microprocessor. As the product and process begin to stabilize well enough to go into higher-volume production, Intel will release, and presumably price accordingly, versions of the product intended for higher-volume applications.

Appendix A provides detailed x86 forecast tables.

Chapter 3
Computer versus Embedded Applications

Considerable interest has been developing in the embedded microprocessor market. From a non-x86 perspective most of the recent interest in embedded applications has been exhibited by manufacturers of microprocessors that intended to take advantage of the market generated by the Windows NT operating system. Because this market has not materialized and has no short-term prospects of materializing, these vendors are looking for other sockets to fill. Unfortunately, the embedded marketplace is very broad, very application-specific, cost-sensitive, reliant upon third-party development support, and requires a technical sell. There are very few high-volume, highly visible applications from which to choose. Thus far, the No. 1 single application for 32-bit embedded microprocessors has been the laser printer market. Unfortunately, this market can only support very few embedded microprocessor manufacturers.

Embedded Application Defined

In the past we have divided the market into compute and embedded applications. The differentiation between these is that the user can program the microprocessor in a computing application and has no ability to directly alter the program code in an embedded application.

In this report we are making a minor alteration. Embedded applications that use a PC motherboard are being included in the compute split rather than in the embedded category. The reason is that a semiconductor vendor selling into the motherboard marketplace will normally have no idea that the component is being used in an embedded application rather than in a computing application.

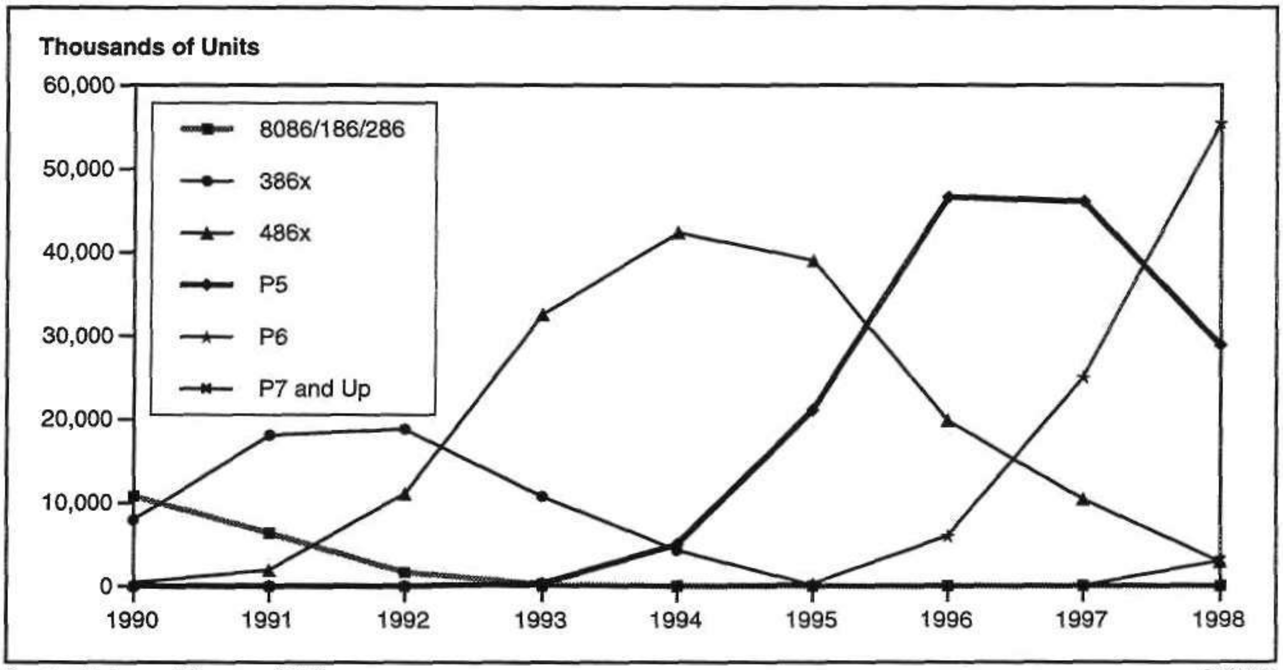
Embedded MPUs: Old Fab Fillers or Strategic Focus Products?

Other than the fact that filling older fabs may be a corporate strategic focus, are embedded MPUs pawns in the fab filling game or do they stand alone as strategic sources of revenue and profit?

As can be seen by contrasting Figures 3-1 and 3-2, the embedded market lags the computing market by several years in terms of market penetration. Successive generations of microprocessors do not begin to penetrate the embedded market until well into the product's life cycle.

Microprocessors that are well suited for the computing market are typically not suited for the embedded market. The embedded market requires higher levels of system integration and has much lower cost requirements than the computing market. As time passes microprocessors originally targeted for the computing market can be reduced in size and cost by moving them to next-generation processes. Such a move makes these processors viable as MPU cores that can be optimized for the embedded market. The advantage with this approach is that an infrastructure of development tools is already in place and a design community familiar with the MPU's basic architecture already exists.

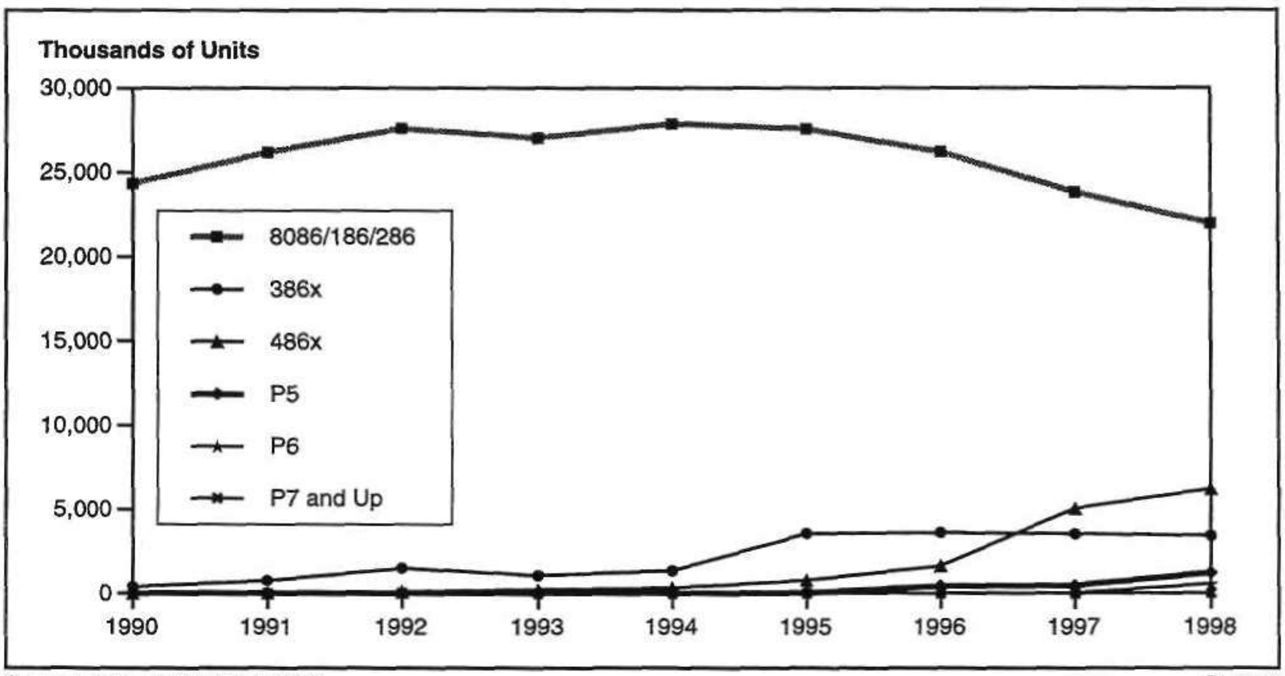
Figure 3-1
x86 Computing Product Forecast



Source: Dataquest (January 1995)

G4006965

Figure 3-2
x86 Embedded Product Forecast



Source: Dataquest (January 1995)

G4006966

The first serious attempts at taking advantage of this issue in the x86 marketplace are occurring now, with Advanced Micro Devices and Intel Corporation both building embedded microprocessors based upon the 80386 microprocessor. Everything seems to be in place to make the 386 a successful embedded MPU core. The key hurdles that may impede the success of the 386 in the embedded marketplace will come from the vendors themselves. Will these embedded products generate enough revenue and profit to make the R&D, marketing, and sales expenditure worthwhile? We have already stated that the embedded market is very broad in terms of applications and customers, each application is relatively low in volume, price is a very important issue, and the effort to sell an embedded microprocessor is much more difficult than selling into a computing application. It will be a very difficult challenge to keep a salesforce focused on selling such a product. It will also be difficult for a team used to the high margins of the computing marketplace to have the patience to continue investing in a market that may take 10 years to develop.

Dataquest Perspective

The x86 market continues on its course of domination. Despite the hoopla generated with the now infamous Pentium flaw, the Pentium appears to be ramping along at an unprecedented rate. Intel's replacement policy, although somewhat belated, has allayed the fears of most Pentium purchasers. Our forecast for Pentium microprocessors in 1995 (see Table A-1) does not include the additional processors that Intel will ship as part of its replacement policy.

We expect aggressively priced 486DX products to greatly extend the life of this product family in both portable and motherboard-based embedded applications. Intel will not have a serious Pentium competitor until late 1995, and competitors' ability to ship volume Pentium clones will not happen until 1996. Until then, we expect clock-doubled and clock-tripled 486 clones to carve out a price/performance niche, making them very attractive in low-end computing applications.

Appendix A
Forecast Tables

Tables A-1 through A-5 detail Dataquest's x86 forecasts.

Table A-1
80x86 Microprocessor Forecast

Processor	1992	1993	1994	1995	1996	1997	1998
8086/88/186/188							
Units (K)	23,636	25,997	27,054	27,043	25,936	23,693	21,961
ASP ($)	9	9	8	7	7	6	5
Revenue (K)	223,637	224,349	210,728	192,822	168,852	140,316	118,130
80286							
Units (K)	5,600	1,244	809	526	263	105	42
ASP ($)	13	13	10	8	7	6	5
Revenue (K)	72,800	16,172	8,409	4,373	1,749	595	214
80386							
Units (K)	20,270	11,790	5,652	3,627	3,599	3,527	3,459
ASP ($)	52	34	26	20	16	13	11
Revenue (K)	1,061,199	406,350	145,456	72,861	59,282	47,233	37,364
80486							
Units (K)	11,150	32,750	42,653	39,731	21,462	15,410	9,100
ASP ($)	271	201	161	87	61	45	35
Revenue (K)	3,017,250	6,575,838	6,845,867	3,450,559	1,313,394	692,218	317,979
Pentium Class							
Units (K)	0	325	5,000	21,077	47,000	46,500	30,000
ASP ($)	0	811	449	349	231	177	126
Revenue (K)	0	263,500	2,243,000	7,350,800	10,880,000	8,242,500	3,780,000
P6 and Up							
Units (K)	0	0	0	300	6,000	25,020	59,000
ASP ($)	0	0	0	825	500	350	282
Revenue (K)	0	0	0	247,500	3,000,000	8,768,000	16,650,000
Total x86							
Units (K)	60,656	72,106	81,167	92,304	104,259	114,255	123,562
ASP ($)	72	104	116	123	148	157	169
Revenue (K)	4,374,886	7,486,209	9,453,461	11,318,916	15,423,277	17,890,862	20,903,688

Source: Dataquest (January 1995)

Table A-2
16-Bit 80x86 Microprocessor Forecast

Processor	1992	1993	1994	1995	1996	1997	1998
8086/88/186/188							
Units (K)	23,636	25,997	27,054	27,043	25,936	23,693	21,961
ASP ($)	9	9	8	7	7	6	5
Revenue (K)	223,637	224,349	210,728	192,822	168,852	140,316	118,130
80286							
Units (K)	5,600	1,244	809	526	263	105	42
ASP ($)	13	13	10	8	7	6	5
Revenue (K)	72,800	16,172	8,409	4,373	1,749	595	214
Total 16-Bit							
Units (K)	29,236	27,241	27,862	27,569	26,198	23,798	22,003
ASP ($)	10	9	8	7	7	6	5
Revenue (K)	296,437	240,521	219,138	197,195	170,601	140,910	118,345

Source: Dataquest (January 1995)

Table A-3
32-Bit 80x86 Microprocessor Forecast

Processor	1992	1993	1994	1995	1996	1997	1998
80386SX							
Units (K)	11,700	5,250	2,200	1,600	1,280	1,024	819
ASP ($)	43	29	18	12	9	7	6
Revenue (K)	503,100	152,250	39,556	18,699	11,967	7,659	4,902
80386 (Integrated)							
Units (K)	1,100	450	400	1,200	1,920	2,304	2,534
ASP ($)	65	38	29	21	17	14	11
Revenue (K)	71,500	17,100	11,400	25,650	32,832	31,519	27,736
80386DX							
Units (K)	7,270	5,850	2,800	600	240	96	38
ASP ($)	63	36	27	23	21	19	18
Revenue (K)	458,010	210,600	75,600	13,770	4,957	1,864	701
80386 (Miscellaneous)							
Units (K)	200	240	252	227	159	103	67
ASP ($)	143	110	75	65	60	60	60
Revenue (K)	28,589	26,400	18,900	14,742	9,526	6,192	4,025
80386 Total							
Units (K)	20,270	11,790	5,652	3,627	3,599	3,527	3,459
ASP ($)	52	34	26	20	16	13	11
Revenue (K)	1,061,199	406,350	145,456	72,861	59,282	47,233	37,364
80486SX							
Units (K)	4,200	14,175	18,233	9,541	1,600	800	720
ASP ($)	111	71	69	42	31	23	19
Revenue (K)	466,200	999,338	1,265,917	397,459	49,990	18,746	13,497

(Continued)

Table A-3 (Continued)
32-Bit 80x86 Microprocessor Forecast

Processor	1992	1993	1994	1995	1996	1997	1998
80486 (Integrated)							
Units (K)	0	1,500	300	50	150	510	1,530
ASP ($)	250	175	147	90	54	35	25
Revenue (K)	0	262,500	44,100	4,500	8,100	17,901	37,592
80486DX							
Units (K)	5,550	9,675	6,625	2,140	1,712	1,100	850
ASP ($)	331	220	200	65	36	30	26
Revenue (K)	1,837,050	2,128,500	1,325,000	139,100	61,204	33,426	21,955
80486DX2							
Units (K)	1,400	7,400	15,652	21,000	8,000	4,500	3,000
ASP ($)	510	395	225	65	36	30	26
Revenue (K)	714,000	2,923,000	3,521,700	1,365,000	286,000	136,744	77,488
80486DX3							
Units (K)	0	0	1,843	7,000	10,000	8,500	3,000
ASP ($)	0	0	350	220	90	55	43
Revenue (K)	0	0	645,050	1,540,000	900,000	467,500	129,855
80486DX Subtotal							
Units (K)	6,950	18,575	24,420	30,190	19,862	14,610	8,380
ASP ($)	367	286	227	101	63	45	32
Revenue (K)	2,551,050	5,314,000	5,535,850	3,048,600	1,255,304	655,571	266,890
80486 Total							
Units (K)	11,150	32,750	42,653	39,731	21,462	15,410	9,100
ASP ($)	271	201	161	87	61	45	35
Revenue (K)	3,017,250	6,575,838	6,845,867	3,450,559	1,313,394	692,218	317,979
Pentium Class							
Units (K)	0	325	5,000	21,077	47,000	46,500	30,000
ASP ($)	0	811	449	349	231	177	126
Revenue (K)	0	263,500	2,243,000	7,350,800	10,880,000	8,242,500	3,780,000
P6 and Beyond							
Units (K)	0	0	0	300	6,000	25,020	59,000
ASP ($)	0	0	0	825	500	350	282
Revenue (K)	0	0	0	247,500	3,000,000	8,768,000	16,650,000
Total 32-Bit and Up							
Units (K)	31,420	44,865	53,305	64,735	78,061	90,457	101,521
ASP ($)	130	161	173	172	195	196	205
Revenue (K)	4,078,449	7,245,688	9,234,323	11,121,720	15,252,676	17,749,952	20,784,642
Total x86							
Units (K)	60,656	72,106	81,167	92,304	104,259	114,255	123,481
ASP ($)	72	104	116	123	148	157	169
Revenue (K)	4,374,886	7,486,209	9,455,458	11,321,239	15,424,842	17,891,580	20,902,773

Source: Dataquest (January 1995)

Table A-4
x86 Product Forecast—Computing Applications (Thousands of Units)

	1992	1993	1994	1995	1996	1997	1998
8086/186/286	1,646	216	0	0	0	0	0
386x	18,790	10,733	4,310	76	0	0	0
486x	11,077	32,539	42,334	38,971	19,827	10,380	2,890
P5	0	325	5,000	21,077	46,570	46,050	28,800
P6	0	0	0	300	6,000	25,000	55,440
P7 and Up	0	0	0	0	0	20	3,000
Total	31,514	43,812	51,644	60,424	72,397	81,450	90,130

Source: Dataquest (January 1995)

Table A-5
80x86 Microprocessor Segment Forecast by Application—Embedded Systems (Thousands of Units)

	1992	1993	1994	1995	1996	1997	1998
8086/186/286	27,590	27,025	27,862	27,569	26,198	23,798	21,961
386x	1,479	1,058	1,342	3,551	3,599	3,527	3,421
486x	73	211	319	760	1,635	5,030	6,210
P5	0	0	0	0	430	450	1,200
P6	0	0	0	0	0	0	560
P7 and Up	0	0	0	0	0	0	0
Total	29,142	28,294	29,523	31,880	31,863	32,805	33,351

Source: Dataquest (January 1995)

For More Information...

Jerry J. Banks, Director/Principal Analyst .... (408) 437-8677
Internet address .... jbanks@dataquest.com
Via fax .... (408) 437-0292

Dataquest
a company of
The Dun & Bradstreet Corporation

Dataquest

a company of
The Dun & Bradstreet Corporation

Corporate Headquarters
Dataquest Incorporated
1290 Ridder Park Drive
San Jose, California 95131-2398
United States
Phone: 1-408-437-8000
Facsimile: 1-408-437-0292

Dataquest Incorporated
550 Cochituate Road
Framingham, Massachusetts 01701-9324
United States
Phone: 1-508-370-5555
Facsimile: 1-508-370-6262

Asian Headquarters
Dataquest Japan K.K.
Shinkawa Sanko Building, 6th Floor
1-3-17, Shinkawa, Chuo-ku
Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

Dataquest Korea
Trade Tower, Suite 3806
159 Samsung-dong
Kangnam-gu, Seoul 135-729
Korea
Phone: 82-2-551-1331
Facsimile: 82-2-551-1330

Dataquest Taiwan
3/F, No. 87 Sung Chiang Road
Taipei
Taiwan, R.O.C.
Phone: 886-2-509-5390
Facsimile: 886-2-509-5660

European Headquarters
Dataquest Europe Limited
Holmers Farm Way
High Wycombe, Buckinghamshire
HP12 4UL
England
Phone: 44-494-422722
Facsimile: 44-494-422742

Dataquest GmbH
Kronstadter Strasse 9
81677 München
Germany
Phone: 49-89-930-9090
Facsimile: 49-89-930-3277

Dataquest Europe SA
Tour Franklin
Cedex 11
92042 Paris-La-Défense
France
Phone: 33-1-41-25-18-00
Facsimile: 33-1-41-25-18-18

Dataquest ICC
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

Representative Agencies in
Bangkok, Hong Kong,
Kronberg, North Sydney,
Singapore, and Tel Aviv

Dataquest

Dataquest

Competitive Dynamics

Microcomponents Worldwide

Product Analysis

An Embedded 486 That Won't Do Windows

Abstract: *National Semiconductor offers an integrated 486-based microprocessor for embedded applications, delivering a lot of performance and features for a very attractive price. With an armful of peripherals and the familiarity of the 486, these parts could get a foothold in their targeted applications for those who want to leave DOS and Windows behind.*
By Tom Starnes

Low-Price, High-Performance Integrated 486 Designed for Embedded Applications

National Semiconductor is bringing to market a 486-based integrated microprocessor that brings most of the performance of a 486SX to the price range of embedded applications. With an aggressive thrust into the broad area of non-PC applications and banking on the popularity and familiarity of the x86 architecture, National introduced its NS486SXF and NS486SXL chips.

The NS486SXF is the first of a series of 486-based embedded microprocessors. This one has a 486-class processor core on-chip with a DMA controller, DRAM controller, PCMCIA controller, UART, LCD controller, parallel port, I^2C serial peripheral interface, clock (and power) control and real time clock, timers, and interrupt controller. Sixteen megabytes of off-chip memory is accessible over a muxed 16-bit data bus. All of this is put into a 160-pin PQFP to run 25 MHz, and it costs only $25 in 10,000-unit quantities. Sampling is now, with production to follow by year-end, and 33-MHz and 3.3V versions are coming. Later, the NS486SXL, an NS486SXF with the more sophisticated peripherals missing, will sell for only $15.

Dataquest

Program: Microcomponents Worldwide
Product Code: MCRO-WW-PA-9501
Publication Date: October 2, 1995
Filing: Competitive Dynamics

But PC and board vendors should stay calm, because this part will not likely be of use to them. The core processor is not a full-fledged 486, but has been gutted with embedded applications in mind. In fact, neither DOS nor Windows (nor applications designed for them) will run on the core processor, because they depend on features that were left on the spec cutting-room floor. National did not have compute applications in mind when it designed this chip, and DOS is not a real-time OS.

A New Small 486 Core

National designers, in a cleanroom environment, designed a 486 microprocessor core specifically to address the embedded market. This processor development is believed to be beyond the reach of royalties or court battles with Intel, though the legal eagles can always surprise us. Instruction execution was speeded up by employing RISC techniques, offsetting potential performance disadvantages stemming from other design compromises. Significant portions of the original 486 were not implemented to streamline the design and minimize the die size.

As an SX, no floating-point unit was designed because its limited use in typical embedded applications wouldn't justify the silicon. Memory addressing was greatly simplified by removing x86 "real mode" and virtual memory support. The resulting flat address space is what many embedded designers prefer, though a Windows environment would be impossible without the memory manager. The processor core was further optimized with a three-stage pipeline rather than a five-stage pipe. The resulting die size of the processor core is just 21mm^2.

On-chip cache is down significantly, from an 8KB unified cache to a 1KB instruction cache on the new chip. Had no cache been provided, instruction execution time would have been severely impacted by having a 32-bit processor fed from the 16-bit data bus, and made worse by slow access to a program ROM. National claims that the NS486SXF processor will run an embedded application on par with the original 486—in spite of the absence of some CPU components—because of enhancements to the implementation of the core.

Peripherals and More

The peripheral circuits are a well-rounded, upper-middle-class collection that would take care of the needs of a fairly sophisticated embedded system. With the attention that has been given to power considerations, IR drivers, LCD displays, and PCMCIA, something that looked like a PDA might be well accommodated. Many of the peripherals are based on standards, not because they may appear in a PC, but because National could pull the modules from its library. The peripherals are compatible with the 8254 timer, 8259 IRQ controller, and the 146818 real-time clock. Interfaces supported include the IEEE 1284 extended capabilities port, PCMCIA 2.0 (ExCA r1.1.50), National's own Microwire and the SPI serial buses, and IrDA and HP-SIR infrared interfaces. The DMA can transfer two bytes per clock cycle.

National will have its knockoff of the NS486SXF available a couple of months after the SFX's debut. The NS486SXL will sell for only $15 and have many of the same subsystems as the SXF, but the DMA is reduced and the PCMCIA, LCD controller, and parallel port are missing.

Development and software support for the new 486SXF appears to be under way, though Dataquest has not yet verified the commitment of third parties. Certainly most x86 assemblers and compilers will get you 90 percent of the way. Emulation support will be provided by Microtek International, which is said to have worked closely with National during chip design. DOS and Windows are way out of their league as the real-time operating systems so critical to embedded control, so it doesn't matter that these do not run on National's 486. Operating systems from Microtek, Wind River, and ISI will run on the chip.

Dataquest Take

National has decided to enter the embedded microprocessor market with a combination of approaches proven by others, perhaps in other markets: Do not reinvent the wheel (maybe redesign it) and use the x86 architecture; use common peripherals; support popular standards; provide a thorough silicon solution; garner development tool support; tie down the right type of operating system; go into a market where there is still some money to be made, even on the side; and sell your silicon at a price that looks like you really are interested in the market.

How successful will National's approach be? Even the best solution isn't guaranteed to be a winner. It appears that on all fronts, National has prudently taken great pains to avoid direct contact with Intel, in courtrooms or with customers. Who really did ever like the architecture of the x86? It's hard to see that it's compelling enough to redirect eyes from the established embedded architectures. The last decade has seen a lot of sex appeal for anything claiming to be RISC, with validity or not, and the x86 is not a RISC, though this implementation has borrowed many RISC techniques.

But for designers beginning an embedded design who are familiar with x86 architecture and for whom the peripheral set provided is an adequate fit, there's a lot of performance in this engine for a very respectable price. The wealth of existing development tools and programmer experience on the x86 should be a big boon for National's parts. As long as the routines do not depend on DOS calls, or can be redirected to a real-time OS, pieces of existing code may be useful to designers. This may allow some applications using a PC platform for convenience to cut costs significantly by redesigning with the National chip, eliminating unneeded PC-specific functions, and reusing a good deal of their software. The incompatibility with Intel's 486 isn't a major problem because embedded applications are so customized anyway that software alterations may not be too big a problem. Plus, with fewer complex operations implemented, National can save precious chip test time compared to a full-blown 486.

The chips reportedly have been designed into customers' applications, though National can't yet reveal them. Those applications must be significant enough for National to be able to ride on their volume and confidently provide the general market a $25-$15 price point. One assumes there are a lot of engineers to pay for designing the core processor.

SEMICONDUCTORS '95: THE BUILDING BLOCKS OF A NEW WORLD ORDER

21st Annual Semiconductor Conference
October 12-14, 1995
Marriott Desert Springs Resort and Spa
Palm Desert, California

They're smaller. Faster. And more powerful than ever. They're in everything from dashboards to sneakers. Today's killer chips are redefining the role of technology in society, with no end in sight. Is your company positioned to get its slice of the pie?

At the heart of today's worldwide digital revolution is the semiconductor. Killer chips are everywhere, enabling products and services ranging from state-of-the-art information systems, wireless communications, and Internet electronic money (e-money) to microcontroller-embedded sneakers, electronic toilets, automobile radar systems, even talking cameras. Reinventing the way our society works and plays, semiconductors are in their third straight year of 30 percent growth. According to Dataquest, the industry will hit $300 billion by the year 2000.

On October 12-14, Dataquest is conducting an event that will help you thrive in the exploding systems and semiconductor industries: Dataquest's Semiconductor Conference 1995! It's being held in Palm Desert, California, near Palm Springs. And it's an event you simply can't afford to miss.

- Prominent executives from major vendors will join Dataquest analysts in providing objective analysis and predictions about dramatic future events in semiconductors and what they'll mean to you – including why Dataquest believes the industry will grow without interruption into the next century.
- We'll explore hot new semiconductor applications, including Internet-based electronic money (e-money), broadband communications, wireless networking, flat panel displays, multimedia, and micromachines.
- An assortment of interactive "fireside" panel discussions will tackle the key short-range and long-range issues facing today's semiconductor manufacturers and buyers. Topics include the infrastructure required to reach $300 billion, the emergence of systems on a chip, and tomorrow's hot new DRAM architectures.

Dataquest also invites you to join the second annual Semiconductor Golf Tournament at the famed Desert Springs Golf Course on Saturday, October 14.

Registration

By phone:	805-298-3262
By fax:	805-298-4388
By e-mail:	Internet: mmakers@ix.netcom.com
By mail:	26524 Golden Valley Road, Suite 401, Santa Clarita, CA 91350

For More Information...

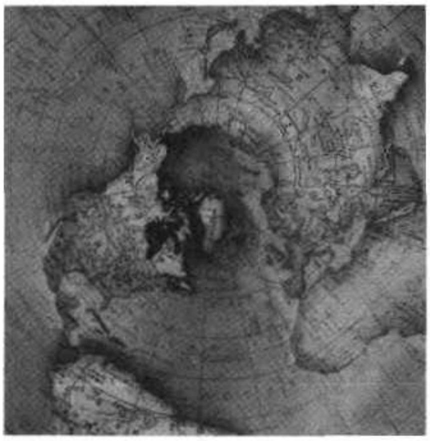
Tom Starnes, Principal Analyst .... (512) 794-7755
Internet address .... tstarnes@dataquest.com
Via fax .... (512) 794-7778

Dataquest

a company of The Dun & Bradstreet Corporation

Focus Studies

Dataquest



Dataquest

PC Graphics Controllers: A Focused Analysis

Focus Report

Program: Microcomponents Worldwide
Product Code: MCRO-WW-FR-9503
Publication Date: August 21, 1995
Filing: Focus Studies

PC Graphics Controllers: A Focused Analysis

Focus Report

Program: Microcomponents Worldwide
Product Code: MCRO-WW-FR-9503
Publication Date: August 21, 1995
Filing: Focus Studies

Table of Contents

List of Figures

List of Tables

Chapter 1
Executive Summary

The graphics controller market for PCs grew 48.5 percent from 1993 to 1994 because of strong PC sales and a trend away from captive graphics solutions. Unit shipments will continue to grow year to year, but the growth rate will follow PC unit growth more closely than it did last year. Revenue will also grow but will not keep pace with unit shipments because of price pressure in this competitive market.

Cirrus Logic remained the largest graphics provider by shipping roughly 26 million units representing 44 percent of the total graphics controller market. S3 showed renewed strength in desktop graphics controllers and moved into the No. 3 slot behind Trident Microsystems. Dataquest expects the 1995 rankings to look a lot like the 1994 rankings, with Cirrus Logic on top because of its overwhelming lead and strong product line. The competition for No. 2 promises to be an exciting race between Trident Microsystems and S3—Trident now leads, but S3 has greater momentum.

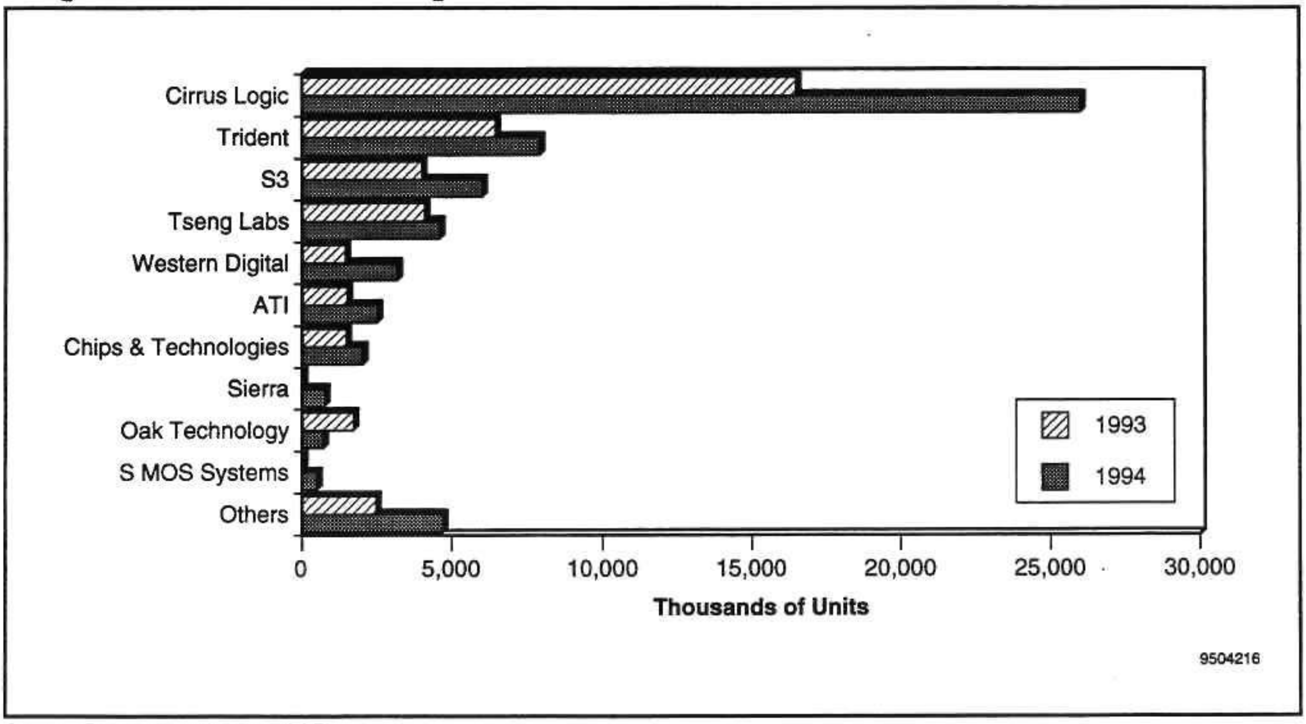
New features will play a larger role in product differentiation in the next few years as motion video acceleration becomes a standard feature and graphics vendors look for new ways to add value. Integrated RAMDACs and power management are more the rule than the exception in 1995, and advanced features such as 3-D graphics, advanced memory interfaces, and motion video acceleration will become standard over the next few years.

Tremendous opportunity exists for graphics companies as PCs fulfill growing requirements for communication and entertainment as well as personal productivity. Those companies who adapt best to this changing role will occupy the top lines of the market share rankings through the year 2000.

Chapter 2
Graphics Controller Market Share Statistics

Cirrus Logic retained the No. 1 spot for 1994 in the PC graphics controller market with a whopping 44 percent of the market, according to a recent Dataquest survey. No other company came close to matching Cirrus' sales volume for either 1993 or 1994. Much of Cirrus Logic's success can be attributed to its high level of integration. Cirrus was the first company to integrate RAMDACs onto graphics controllers, and that feature gave the company a significant edge against its competitors. Dataquest expects Cirrus Logic to remain No. 1 in unit shipments for 1995 also. Look for S3 to challenge Trident Microsystems for the No. 2 spot for 1995 because of S3's renewed strength with some impressive design-wins, including part of the Compaq Presario line. Figure 2-1 and Table 2-1 show worldwide unit shipments of graphics controllers.

Figure 2-1
Graphics Controller Unit Shipments Worldwide



Source: Dataquest (August 1995)

Table 2-1
Graphics Controller Unit Shipments Worldwide (Thousands)

1994 Rank	1993 Rank		1993	1994	Percentage Change	1994 Market Share (%)
1	1	Cirrus Logic	16,500	26,000	57.6	44.2
2	2	Trident Microsystems	6,436	7,903	22.8	13.4
3	4	S3	4,000	6,000	50.0	10.2
4	3	Tseng Labs	4,100	4,600	12.2	7.8
5	8	Western Digital	1,430	3,175	122.0	5.4
6	6	ATI	1,500	2,500	66.7	4.2
7	7	Chips & Technologies	1,461	2,013	37.8	3.4
8	13	Sierra Semiconductor	0	750	NA	1.3
9	5	Oak Technology	1,700	705	-58.5	1.2
10	11	S-MOS Systems	25	500	1,900.0	0.8
		Other	2,465	4,694	90.4	8.0
		Total Market	39,617	58,840	48.5	100.0

NA = Not applicable
Source: Dataquest (August 1995)

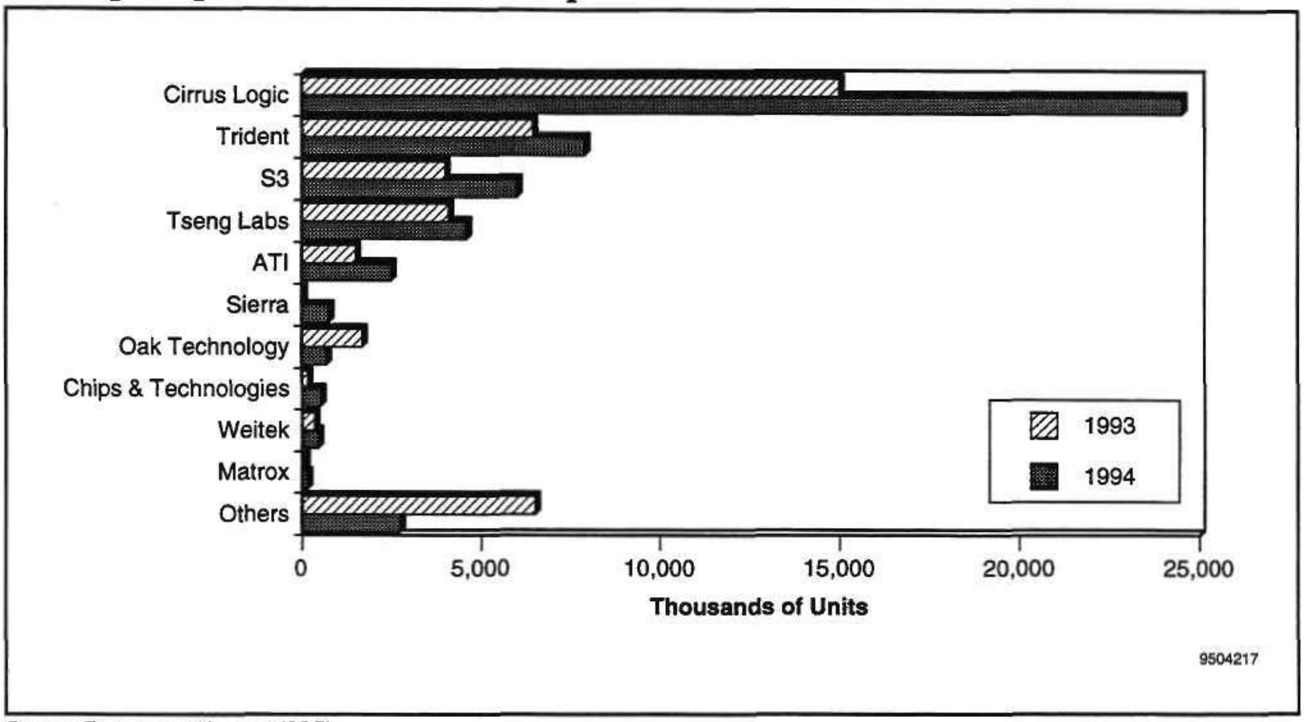
Desktop Players Dominate the Market

The desktop market share rankings look a lot like the total market share rankings. No. 1 Cirrus Logic shipped almost as many graphics controllers into the desktop market as all other suppliers combined. Cirrus' strength in the desktop market is unmatched and should remain unchallenged for 1995. S3's momentum could propel it into second place, ahead of Trident Microsystems next year, with strong sales of S3's Vision and Trio graphics controllers. Chips & Technologies showed spectacular unit growth (219 percent) in desktop graphics controllers, but will need triple-digit growth rates for a couple of consecutive years to play in the top five. Figure 2-2 and Table 2-2 show worldwide unit shipments of desktop graphics controllers.

Mobile Graphics Has a New No. 1

Western Digital displaced Cirrus Logic to claim the No. 1 spot in the mobile PC graphics controller market. Its commanding presence (40 percent) in the mobile graphics arena is similar to Cirrus Logic's share of the desktop graphics controller market. Expect another year of good growth from Western Digital because of its design-wins in current notebook PCs, including the HP Omnibooks. Cirrus suffered flat growth (0 percent) from 1993 to 1994 and is challenged by Chips & Technologies for the No. 2 position. Chips & Technologies has some impressive design-wins in its pocket, including the DEC Hinote Ultra and the Toshiba Satellite Pro. The unit shipments for these two companies are too close to differentiate, but Dataquest has ranked Cirrus as No. 2 because of its former No. 1 status. Expect Chips & Technologies' current momentum to carry it into No. 2 next year. S-MOS was the percentage growth leader for 1994 and should gain market share again in 1995.

Figure 2-2
Desktop Graphics Controller Unit Shipments Worldwide



Source: Dataquest (August 1995)

Table 2-2
Desktop Graphics Controller Unit Shipments Worldwide (Thousands)

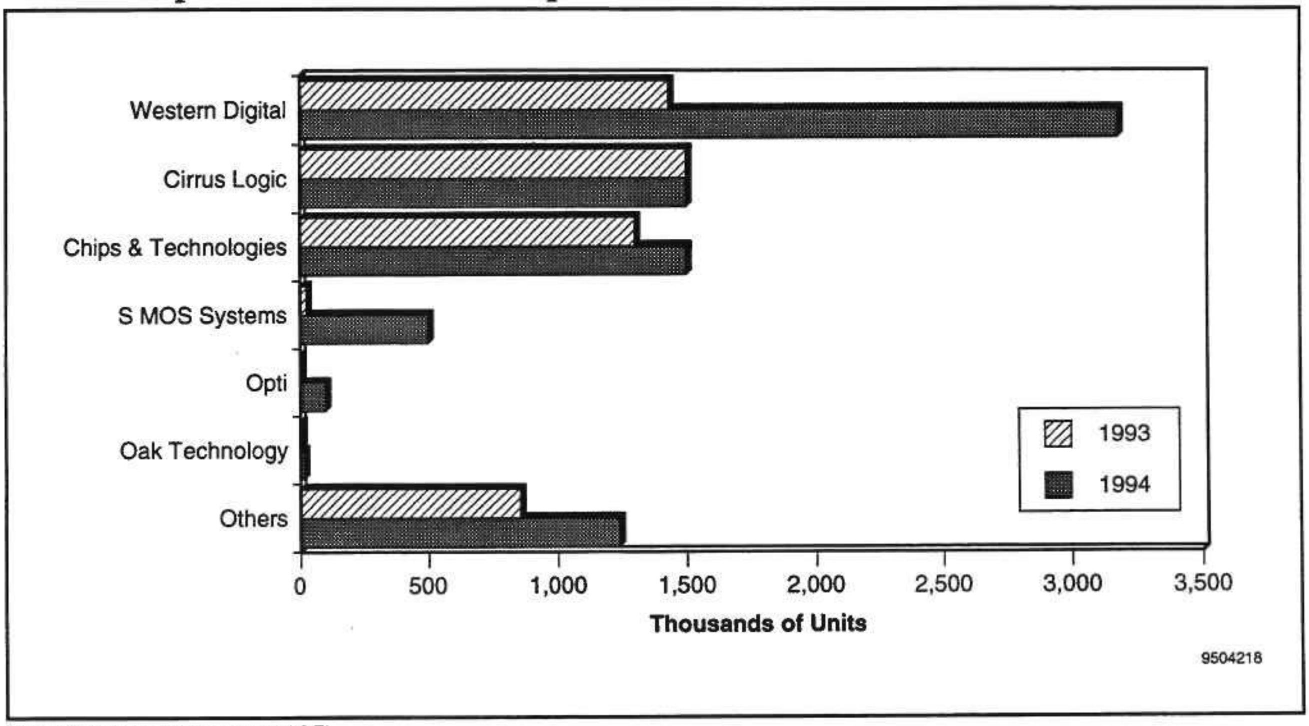
1994 Rank	1993 Rank		1993	1994	Percentage Change	1994 Market Share (%)
1	1	Cirrus Logic	15,000	24,500	63.3	48.2
2	2	Trident	6,436	7,903	22.8	15.6
3	4	S3	4,000	6,000	50.0	11.8
4	3	Tseng Labs	4,100	4,600	12.2	9.1
5	6	ATI	1,500	2,500	66.7	4.9
6	10	Sierra	0	750	NA	1.5
7	5	Oak Technology	1,695	689	-59.4	1.4
8	8	Chips & Technologies	161	513	218.6	1.0
9	7	Weitek	350	452	29.1	0.9
10	9	Matrox	75	150	100.0	0.3
		Others	6,500	2,754	-57.6	5.4
		Total Market	34,505	50,811	47.3	100.0

NA = Not applicable
Source: Dataquest (August 1995)

The roster of mobile PC graphics companies varies significantly from the desktop graphics companies. The total market is much smaller and requires selling directly to the PC OEMs because the third-party, add-in board market does not exist. Graphics controllers in mobile PCs are soldered to the system cards because of space requirements, and any cards purchased for a docking station should be considered part of the desktop PC graphics controller market.

The 57.1 percent unit growth for mobile PC graphics controllers exceeds the unit growth for mobile PC shipments from 1993 to 1994 because of a shift from captive solutions to merchant graphics solutions. Figure 2-3 and Table 2-3 show worldwide unit shipments of mobile graphics controllers.

Figure 2-3
Mobile Graphics Controller Unit Shipments Worldwide



Source: Dataquest (August 1995)

Table 2-3
Mobile Graphics Controller Unit Shipments Worldwide (Thousands)

1994 Rank	1993 Rank		1993	1994	Percentage Change	1994 Market Share (%)
1	2	Western Digital	1,430	3,175	122.0	39.5
2	1	Cirrus Logic	1,500	1,500	0	18.7
3	3	Chips & Technologies	1,300	1,500	15.4	18.7
4	4	S-MOS Systems	25	500	1,900.0	6.2
5	6	Opti	0	100	NA	1.2
6	5	Oak Technology	5	16	220.0	0.2
		Others	852	1,238	45.3	15.4
		Total Market	5,112	8,029	57.1	100.0

NA = Not applicable
Source: Dataquest (August 1995)

Chapter 3
Graphics Controller Market Forecast

The graphics controller market will continue to show strong growth as the boom in PC sales continues. Unit shipments as a percentage (greater the 100 percent) of PC sales will slowly decline as mobile computers command a larger share of PC shipments. Table 3-1 shows the graphics controller unit forecast. Figures 3-1, 3-2, and 3-3 present the data from Table 3-1 graphically. Table 3-2 shows the average selling price (ASP) assumptions. Table 3-3 shows the graphics controller revenue forecast. Figure 3-4 shows graphically the information from Table 3-3.

Assumptions

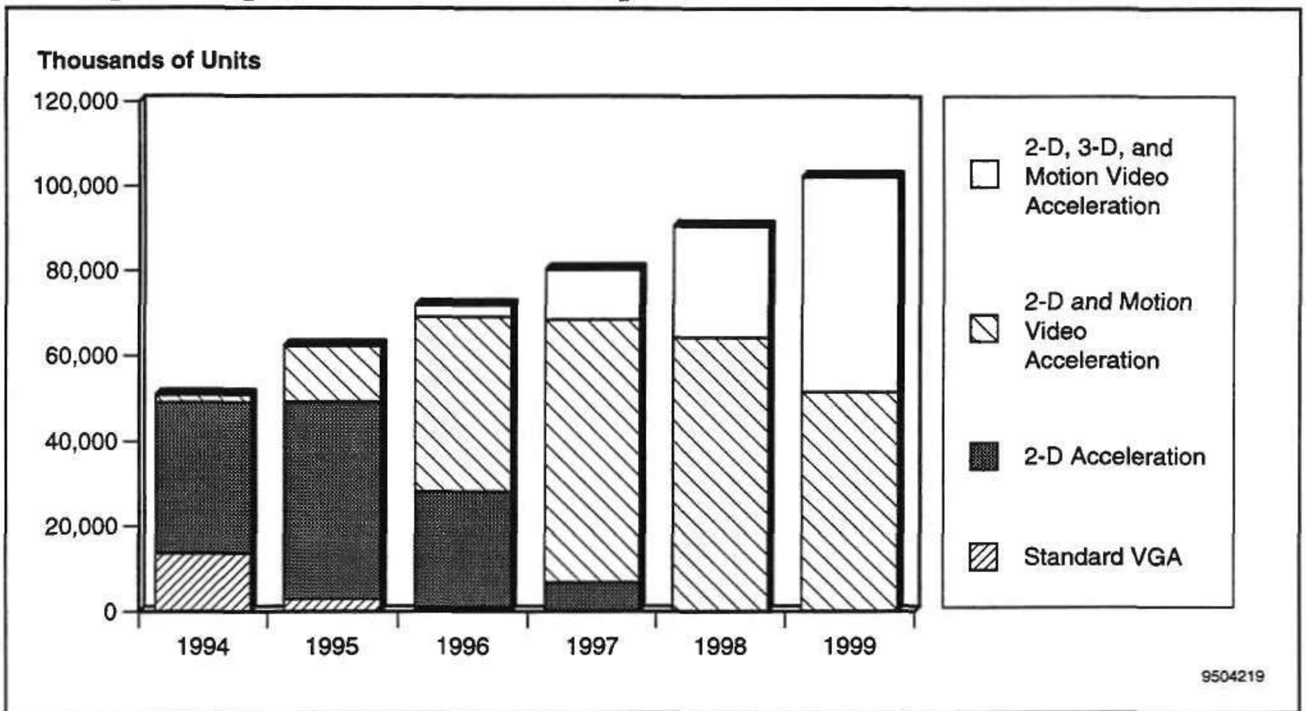
- Unit growth will continue at a strong pace, tied to the expanding PC market.
- Additional unit demand for desktop graphics controllers is created by the retail add-in card market for upgrading existing systems.
- Graphics controllers for mobile computers are not upgradable.
- Graphic controller shipments precede PC shipments by roughly two months.
- ASPs will remain relatively stable through the forecast period because new features and performance increases will offset downward price pressure.
- 3-D graphics acceleration is the next new feature after motion video acceleration that semiconductor vendors will integrate into graphics controllers to add value.

Table 3-1
PC Graphics Controller Unit Shipment Forecast (Thousands)

	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Desktop							
Standard VGA	13,649	3,000	1,000	0	0	0	-100.0
2-D Acceleration	35,512	46,324	27,293	6,863	0	0	-100.0
2-D and Motion Video Acceleration	1,650	13,066	40,940	61,770	64,475	51,636	99.1
2-D, 3-D, and Motion Video Acceleration	0	50	2,750	11,750	26,050	50,697	NA
Total Desktop	50,811	62,390	71,983	80,384	90,525	102,333	15.0
Mobile							
Standard VGA	3,349	250	0	0	0	0	-100.0
2-D Acceleration	4,680	10,662	11,587	6,995	1,890	0	-100.0
2-D and Motion Video Acceleration	0	366	3,069	10,492	17,009	18,220	NA
2-D, 3-D, and Motion Video Acceleration	0	0	0	961	5,125	7,361	NA
Total Mobile	8,029	11,278	14,656	18,448	22,134	25,581	26.1
Total Market	58,840	73,668	86,639	98,832	112,659	127,914	16.8

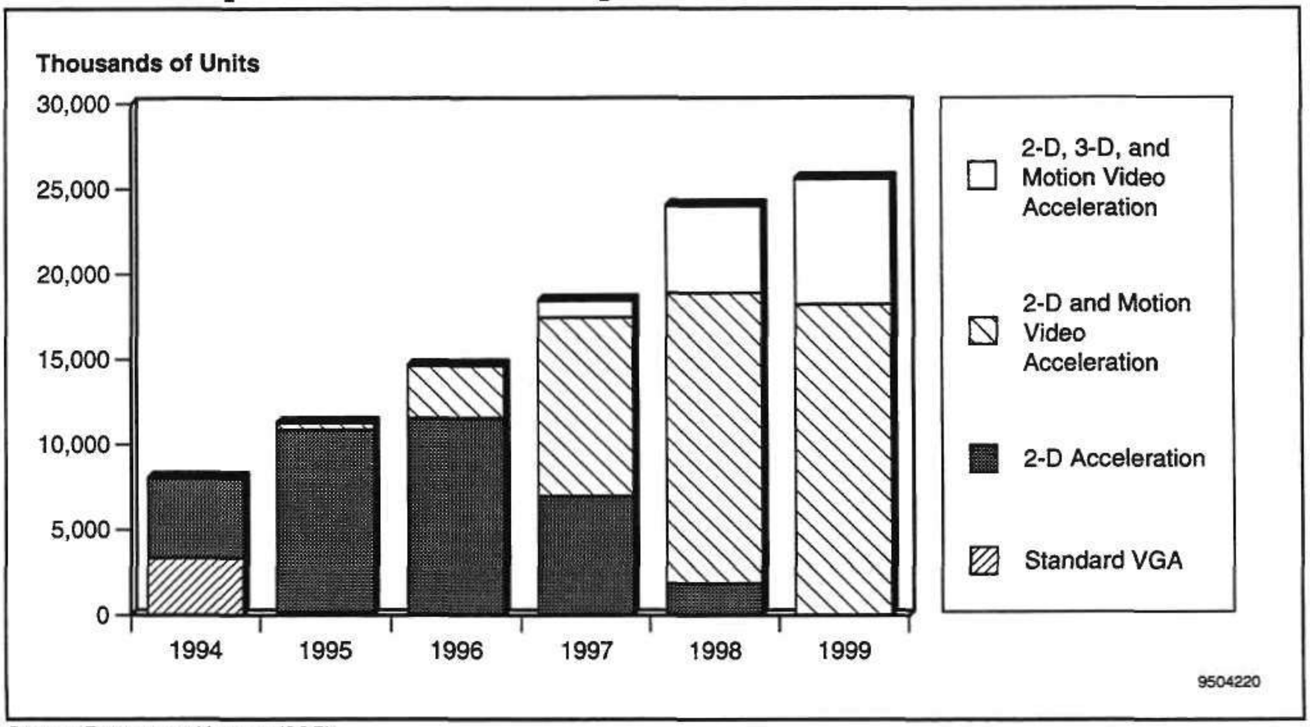
NA = Not applicable
Source: Dataquest (August 1995)

Figure 3-1
Desktop PC Graphics Controller Unit Shipment Forecast



Source: Dataquest (August 1995)

Figure 3-2
Mobile PC Graphics Controller Unit Shipment Forecast



Source: Dataquest (August 1995)

Table 3-2
PC Graphics Controller ASP Forecast (U.S. Dollars)

	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Desktop							
Standard VGA	10.00	9.00	7.00	7.00	7.00	7.00	-6.9
2-D Acceleration	19.50	17.00	15.00	14.50	14.00	12.00	-9.3
2-D and Motion Video Acceleration	30.00	21.00	17.00	15.00	14.00	12.00	-16.7
2-D, 3-D, and Motion Video Acceleration	45.00	45.00	45.00	31.00	25.50	21.00	-14.1
Weighted ASP	17.29	17.49	17.17	17.30	17.31	16.46	-1.0
Mobile							
Standard VGA	23.00	17.00	16.00	15.00	14.00	14.00	-9.5
2-D Acceleration	26.50	22.00	19.00	18.00	17.00	16.00	-9.6
2-D and Motion Video Acceleration	30.00	27.00	24.00	21.00	18.00	17.00	-10.7
2-D, 3-D, and Motion Video Acceleration	50.00	50.00	50.00	40.00	29.00	25.00	-12.9
Weighted ASP	25.04	22.05	20.05	20.85	22.00	19.30	-5.1

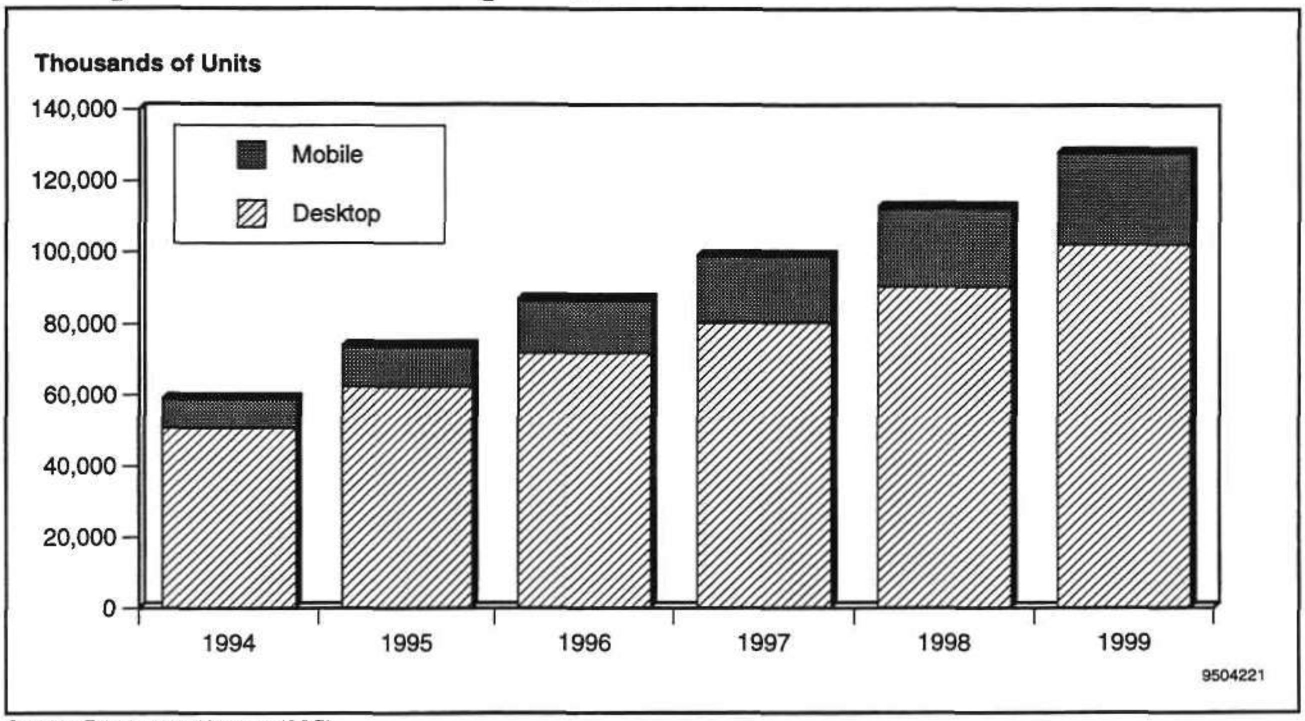
Source: Dataquest (August 1995)

Table 3-3
PC Graphics Controller Total Market Forecast (Millions of U.S. Dollars)

	1994	1995	1996	1997	1998	1999	CAGR (%) 1994-1999
Desktop							
Standard VGA	136.5	27.0	7.0	0	0	0	-100.0
2-D Acceleration	692.5	787.5	409.4	99.5	0	0	-100.0
2-D and Motion Video Acceleration	49.5	274.4	696.0	926.6	902.6	619.6	65.8
2-D, 3-D, and Motion Video Acceleration	0	2.3	123.8	364.3	664.3	1,064.6	NA
Total Desktop	878.5	1,091.1	1,236.1	1,390.3	1,566.9	1,684.3	13.9
Mobile							
Standard VGA	77.0	4.3	0	0	0	0	-100.0
2-D Acceleration	124.0	234.6	220.1	125.9	32.1	0	-100.0
2-D and Motion Video Acceleration	0	9.9	73.7	220.3	306.2	309.7	NA
2-D, 3-D, and Motion Video Acceleration	0	0	0	38.4	148.6	184.0	NA
Total Mobile	201.1	248.7	293.8	384.7	486.9	493.8	19.7
Total Market	1,079.5	1,339.8	1,529.9	1,775.0	2,053.8	2,178.0	15.1

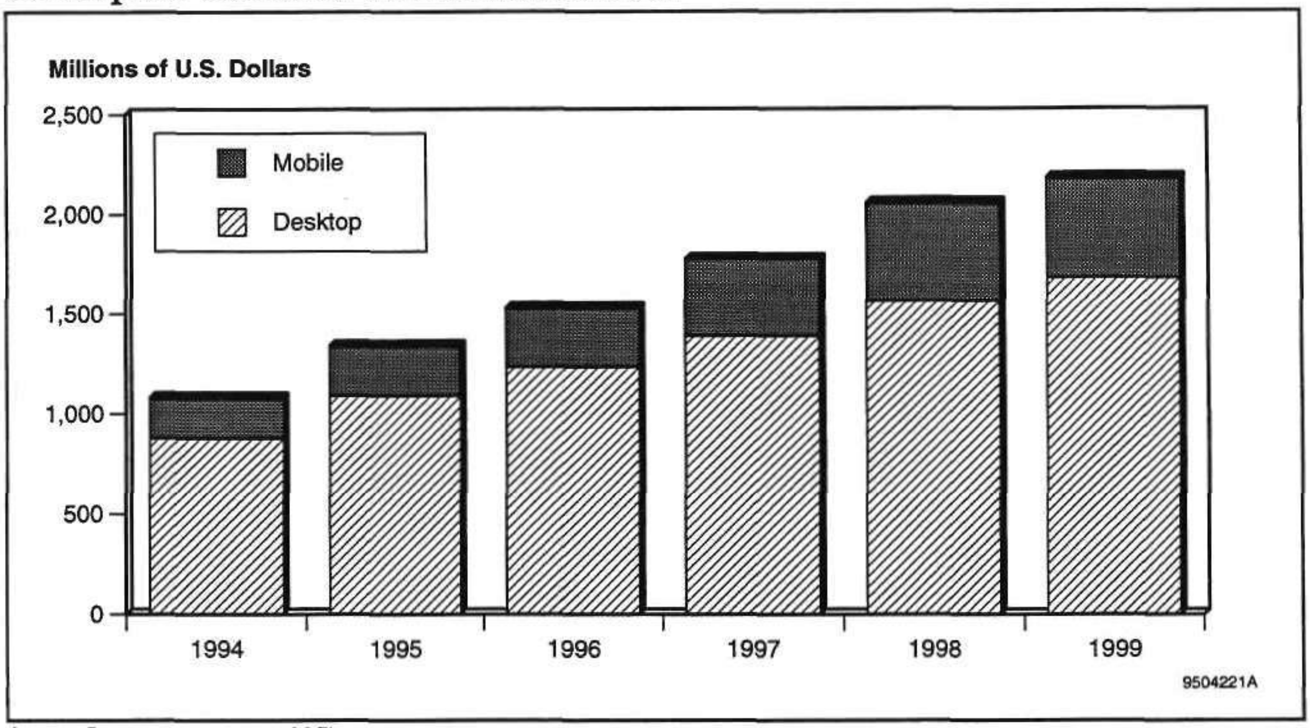
NA = Not applicable
Source: Dataquest (August 1995)

Figure 3-3
PC Graphics Controller Unit Shipment Forecast



Source: Dataquest (August 1995)

Figure 3-4
PC Graphics Controller Total Market Forecast



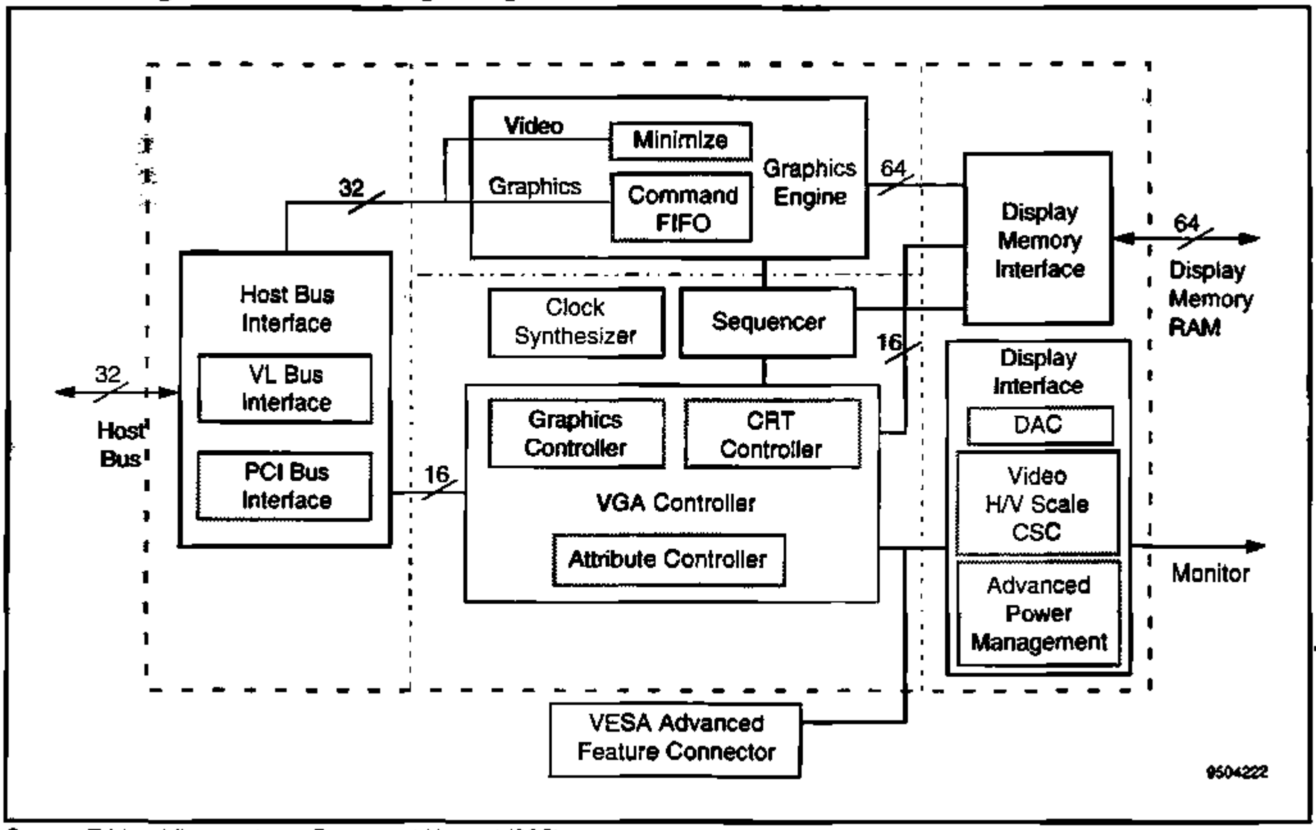
Source: Dataquest (August 1995)

Chapter 4
Feature Trends for Graphics Controllers

Higher Levels of Integration

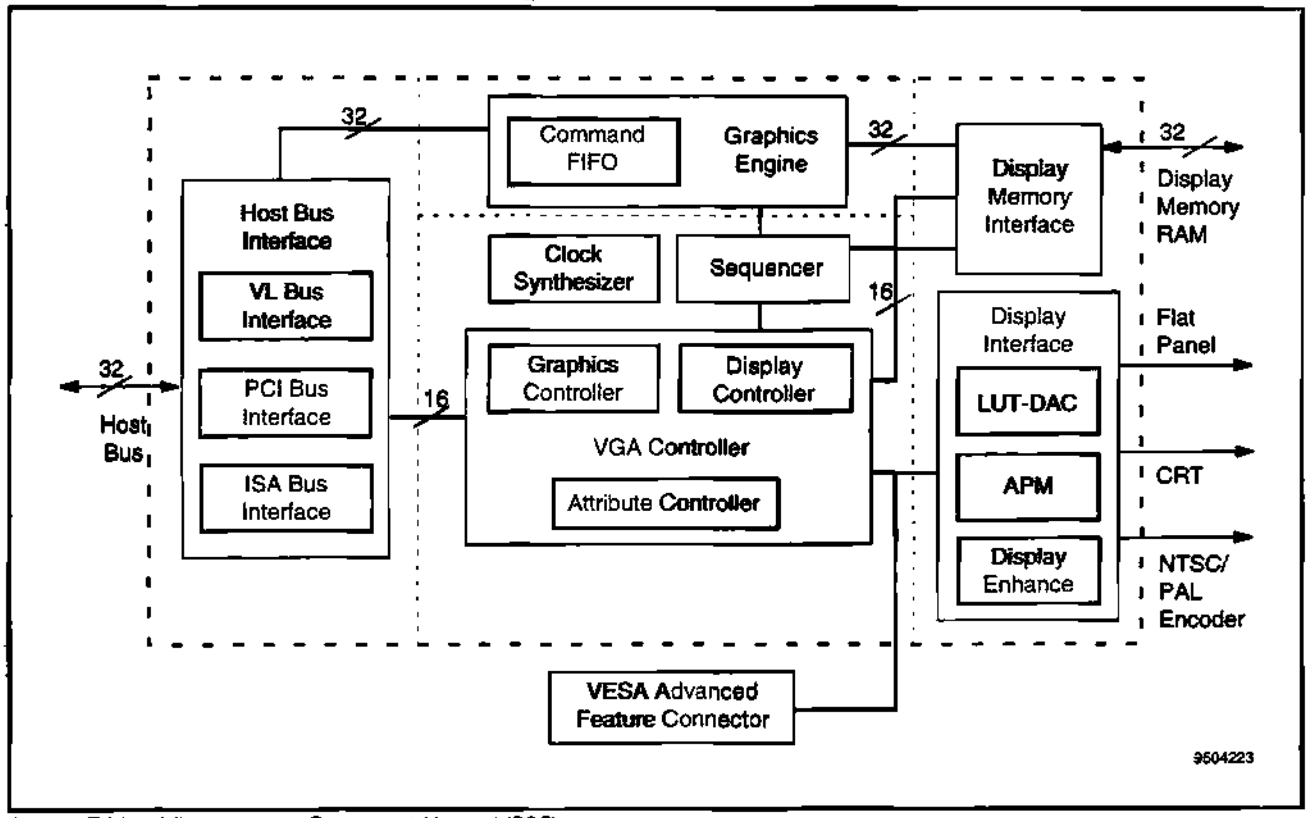
A functional graphics subsystem requires fewer parts today than in previous years. Features such as on-chip RAMDAC, clock synthesizer, glueless bus interface, and glueless memory interface are becoming standard for mainstream PC graphics. This has the effect of eliminating the miscellaneous passive components and standard logic, as well as off-chip RAMDAC, that once were required for a complete solution. A direct quote from Cirrus Logic's Product Overview booklet is "VGA solution with one or more DRAMs," which applies to several of Cirrus' graphics controllers. Other graphics companies offer similar levels of integration. The bottom line here is that fewer parts are required for greater functionality, which means less board space, fewer components to mount, and cost savings for the OEM. Figures 4-1 and 4-2 show block diagrams of graphics controllers for both desktop and mobile applications. These diagrams show the high level of integration already designed into products shipping today.

Figure 4-1
Block Diagram for a Desktop Graphics Controller with Motion Video Acceleration



Source: Trident Microsystems, Dataquest (August 1995)

Figure 4-2
Block Diagram for a Notebook Graphics Controller



Source: Trident Microsystems, Dataquest (August 1995)

Memory Trends

The memory interface is a critical element of the graphics controller, because it has a strong impact on both performance and cost for the graphics subsystem. The two most popular types of memory for use with graphics controllers are standard DRAM and VRAM. VRAM is faster, but costs more than standard DRAM. Over the last few years, DRAM has replaced VRAM in almost all of the mainstream graphics applications because of the price/performance trade-off. Dataquest surveys show that 2 percent of desktop graphics controllers used VRAM in 1994, down from 3 percent in 1993. Mobile PC graphics controllers are 100 percent DRAM-based, according to the same vendor survey. Cost savings from using DRAM instead of VRAM can be as high as $18 to $20 per system, assuming a typical buffer size of 1MB. VRAM is still in demand for high-performance graphics applications, such as CAD and desktop publishing.

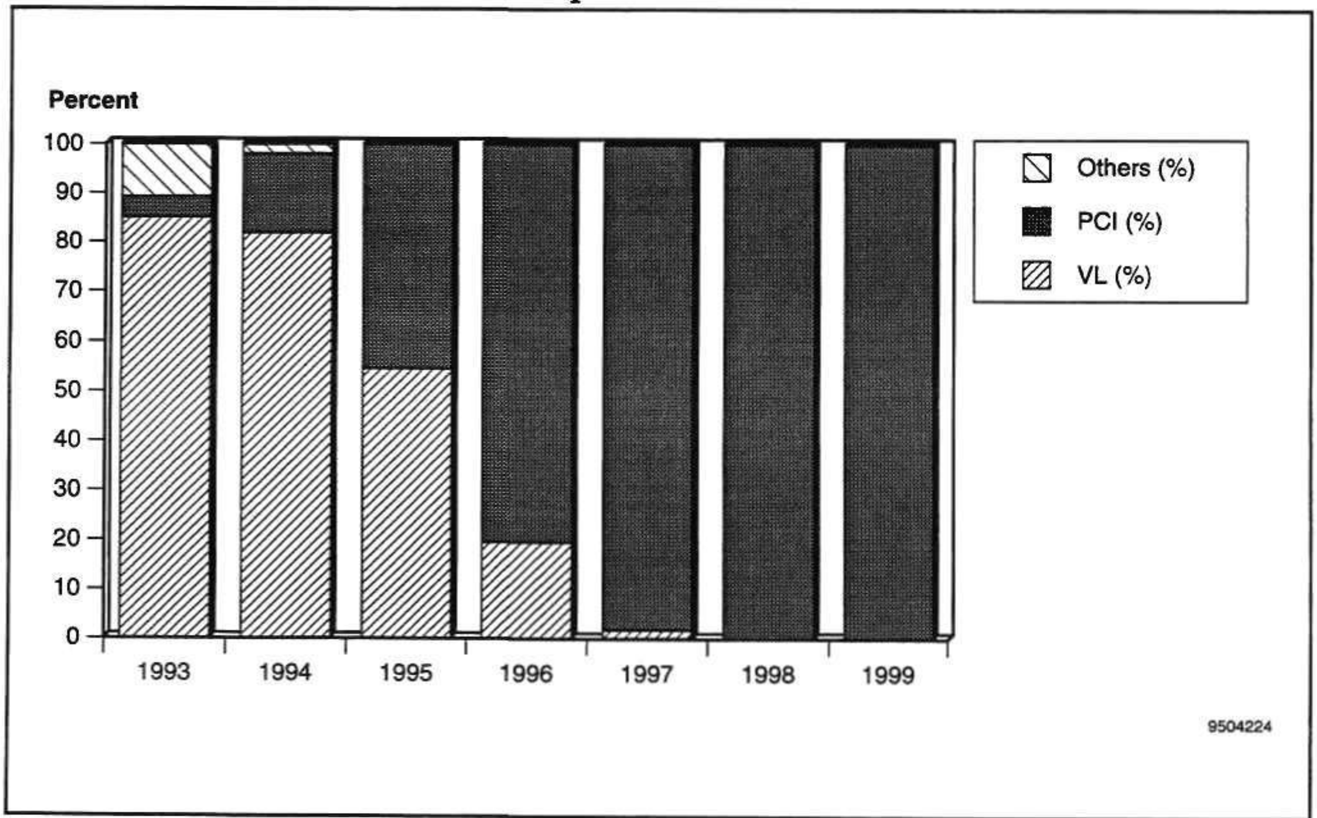
Other types of memory are being considered for frame buffer applications. The goal is better performance than standard DRAM at a lower price than VRAM. Leading candidates are EDO DRAM and Rambus memory (RDRAM). Roughly 1 percent of the desktop graphics controllers sold in 1994 supported EDO DRAM. Look for more variety in 1995 because Cirrus Logic has already announced a graphics controller that uses Rambus memory (RDRAM). RDRAM and synchronous DRAM (SDRAM) have both had design-wins in home video game units, which may lead to greater acceptance in personal computers.

Expansion Bus Interface

PCI made great gains against VL-bus during 1994. Expect this trend to continue for 1995 as Pentium shipments continue to climb. VL-bus graphics controller shipments will follow the 486 MPU shipments because the VL-bus standard was designed for use specifically with 486 microprocessors. 486 MPU unit shipments and VL-based core logic unit shipments are forecast to decline from 1994 to 1995; expect VL-bus graphics controllers to follow that pattern with a chance that some add-in graphics board sales will stretch that peak into 1995.

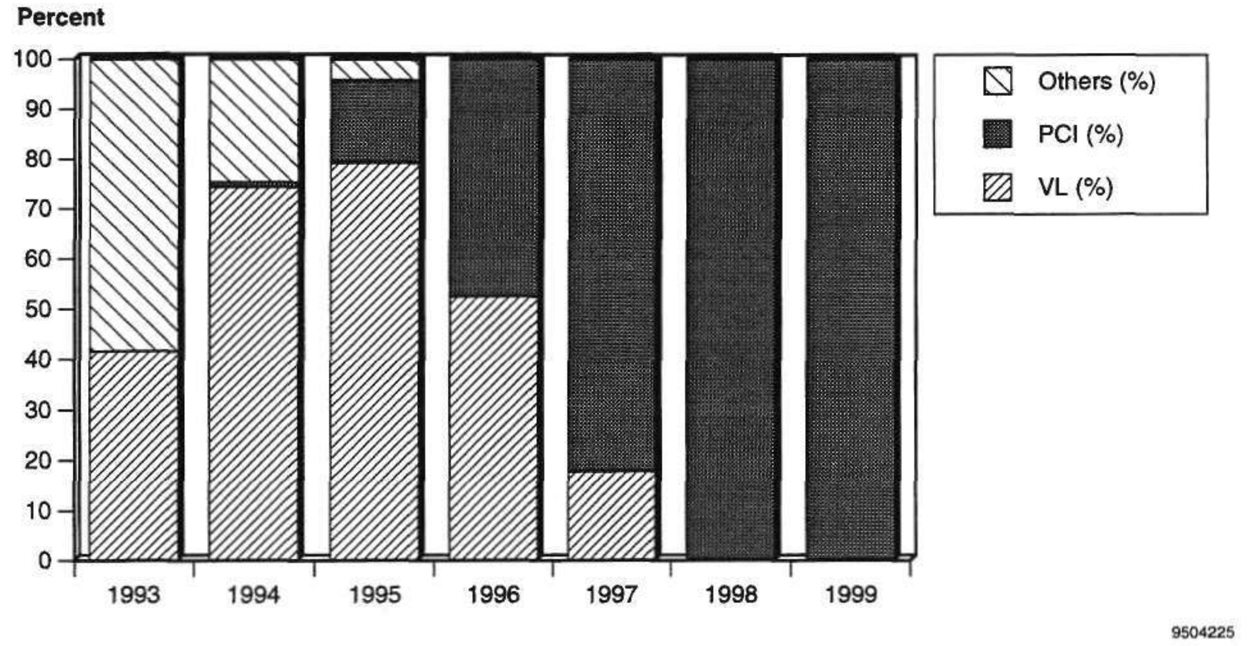
The outlook for PCI graphics is strong because PCI graphics controllers represent a growing share of a growing market. The PCI bus is processor-independent and is being designed into RISC PCs as well as x86 PCs. Where the PCI bus is designed in, PCI graphics controllers will follow. Look for PCI graphics chips in most Pentium PCs as well as in many of the new RISC PCs based upon the PowerPC architecture. The growth opportunities all point to PCI. Figures 4-3 and 4-4 show the bus interface forecast for desktop and mobile graphics controllers.

Figure 4-3
Bus Interface Forecast for Mobile Graphics Controllers



Source: Dataquest (August 1995)

Figure 4-4
Bus Interface Forecast for Mobile Graphics Controllers



Source: Dataquest (August 1995)

Memory Bus Width

Demand for graphics performance is pushing graphics companies to increase the memory bus width for their graphics controllers. A wider memory bus increases memory bandwidth without requiring faster, more expensive DRAM. The transition to 64-bit buses has introduced a new problem, however; the wider bus requires more total memory, which increases the total cost for the graphics subsystem.

The most popular memory bus width today is 32 bits. This is a convenient width because 256Kbx16 DRAM devices are commonly used for graphics memory and two of these devices provide 1MB of total memory with a 32-bit width. A 64-bit memory bus requires 2MB of memory (four devices, each 16 bits wide). If OEMs do not want to increase the graphics memory to 2MB from 1MB (doubling the total cost of graphics memory), then they cannot take advantage of a 64-bit bus. For this reason, many graphics controllers have a flexible bus that tolerates both 32-bit and 64-bit implementations.

The growth in memory bus width has reached its logical end for mainstream applications because of the higher memory requirement. It is unlikely that PC OEMs will increase standard graphics memory configurations from 1MB to 2MB just to improve graphics performance because the $30 cost is too high. Graphics controller companies need to introduce products that support new DRAM architectures before this bottleneck problem can be solved. Synchronous architectures such as Rambus DRAM (RDRAM) and synchronous DRAM (SDRAM) are the most likely long-term solutions for graphics memory. Semiconductor vendors might use the burst characteristics of synchronous memory to emulate a 64-bit (or larger) bus on a narrower, multiplexed bus. This technique would provide much greater bandwidth without requiring larger amounts of memory.

Motion Video Support

Support for motion video is one of the newest features for graphics controllers. About 3 percent of the graphics controllers shipped in 1994 provide some support for motion video, and that number is up from roughly 0.1 percent in 1993. Video features such as color space conversion, image scaling, shared frame buffers, and pixel interpolation are in demand for multimedia PCs. Decompression is also in demand, but hardware decompression will cost an OEM $20 or more to add to a PC. Software codecs (coder/decoder) are more popular because they can be changed easily and use the CPU instead of requiring special hardware. The video features popping up in graphics controllers now complement these soft codecs (as well as hardware codecs) by handling the video stream efficiently after the decompression step. Intel Corporation's Native Signal Processing (NSP) embodies the idea of running software codecs on the CPU instead of on fixed-function hardware for modem, audio, and even motion video codec functions. Also, Windows 95 offers new software interfaces to simplify the use of software codecs. A Pentium-based PC running Windows 95 should have motion video performance acceptable for the mass-market multimedia crowd.

The trade-off between software codecs and hardware codecs focuses on flexibility, performance, and price. Using a software codec running on the CPU allows the users to change standards and avoid the cost of dedicated hardware, but does involve loading the system resources (CPU and PCI bus) much more heavily. Intel and other MPU vendors will provide faster and faster MPUs to handle that data load, but application software vendors have always seized the opportunity to add more features to their own products, leaving fewer spare mips than one could otherwise expect.

Some graphics companies have taken a strong position by introducing hardware codecs for video data. This strategy may conflict with Intel's Native Signal Processing (NSP) at the low- and midrange performance levels. Semiconductor vendors should consider designing their low- to midrange products to complement the use of software codecs. Graphics controllers must handle the graphics windows anyway, so they are a natural location for handling video windows. Color space conversion and scaling are also easily handled by the graphics controller. This strategy leaves the codec functions completely to the CPU. High-end applications will probably require dedicated hardware, so there will continue to be a market for hardware codecs.

One other trend for graphics vendors to consider when planning their graphics strategy is the role of Intel's NSP as a market enabler. NSP may allow users to see good video performance and convince enough of them that a hardware upgrade is worth the price. In that case, the hardware codec market will develop as an aftermarket upgrade rather than a standard feature. Semiconductor vendors are advised to develop modular solutions where the hardware codec could be added in the retail upgrade channel.

3-D Graphics Acceleration

3-D graphics features such as polygon drawing and shading techniques are currently the domain of specialty chips like the GLINT chip by 3D Labs. These features have been designed into the latest generation of home video games, but have not yet penetrated the PC market. Demand for these features will increase when Windows 95 becomes more popular as a computer gaming platform. 3-D games are already popular in the arcades and on home video game systems, so it is likely that these titles will be available on the PC. Semiconductor vendors may want to add 3-D acceleration to their graphics controllers for 1997 to protect against lower ASPs and to add value to differentiate their products.

Power Management

Power management on the desktop has finally made it to the graphics controller. Large monitors can use as much energy as the rest of the computer and offer substantial energy savings if powered down (or off) when not in use. Many graphics controllers are now supporting VESA's display power management signaling (DPMS) as part of the "green" PC wave. Graphics controllers with DPMS actively place the monitor into sleep modes or even turn the electron gun off if the PC is idle. Software utilities allow the end user to change these time-out intervals and even turn this feature off. The ability to turn off the DPMS features is important because DPMS graphics controllers may damage non-DPMS monitors.

DPMS is essentially a software-controlled feature that requires support from the graphics hardware. Some screen savers complicate this issue by making the PC appear to be in use to the power management software. Many software companies are now including DPMS support into their screen savers so the power management features are actually used. As consumers and businesses continue to demand "green" PCs, power management features like DPMS are becoming necessities.

Chapter 5
Players and Groundbreaking Products

Players

Cirrus Logic

- Strong growth for both revenue and unit shipments in the graphics controller market, with an increasing share of a growing market.
- Diverse product offerings including core logic (Pico Power), audio IC's (Crystal Semiconductor), communications ICs, and mass storage ICs.
- Revenue for fiscal 1995, which ended in March 1995, was $889 million, up 60 percent (from $557.3 million) for fiscal 1994.
- Unit shipments for graphics controllers increased 57.6 percent from calendar 1993 to calendar 1994.
- Net income increased 35.2 percent to $61.4 million for fiscal 1995.
- Has a joint manufacturing venture with IBM known as MiCRUS to ensure growing access to manufacturing capacity. Recently accelerated investment in MiCRUS with target of significant production in second half of fiscal year 1996.
- Headquartered in Fremont, California.

Trident

- Very strong earnings growth, with $0.42 per share earnings for the first three quarters of fiscal 1995 versus $0.06 per share for same three quarters in fiscal 1994.
- Class-action lawsuit against company and directors has been settled, subject to court approval. If approved, Trident will pay $1.4 million of the $3.15 million settlement.
- Headquartered in Mountain View, California.

S3

- Revenue and earnings grew faster than unit shipments.
- Second-quarter 1995 revenue of $70.6 million compared to second-quarter 1995 revenue of only $27.5 million.
- Recently acquired Floreat Incorporated, for communications software expertise.
- Added NEC and LG Semicon to foundry list that includes IBM and TSMC.

Tseng Labs

- Faces a challenging time of sharply falling revenue.
- 1994 revenue was $0.49 per share.
- 1995 revenue and shipments will depend greatly on the ET6000 chipset meeting the schedule of sampling in the third quarter and volume shipments in the fourth quarter.
- Headquartered in Newton, Pennsylvania.

Western Digital

- Microcomputer Products Group represents only 7 percent of sales.
- Fourth-quarter fiscal 1995 revenue was $39.5 million for the Microcomputer Products Group, down 18 percent from $48.3 million in the third quarter, but only down 12 percent from the fourth quarter of fiscal 1994.
- 100 percent of units shipped to the mobile PC market.
- Headquartered in Irvine, California.

ATI

- Third-quarter fiscal 1995 revenue was $94.6 million versus 51.6 million for the same quarter last year.
- Sells graphics controllers as well as complete graphics cards.
- Recent design-win in Apple Power Macintosh line with the mach64 product.
- Headquartered in Thornhill, Ontario.

Chips & Technologies

- Fiscal 1995 revenue was $104.7 million, up 42.6 percent from $73.4 million in fiscal 1994.
- Net income was up 246 percent to $9.4 million for fiscal 1995.
- 75 percent of units were shipped to the mobile PC market.
- Headquartered in San Jose, California.

Sierra Semiconductor

- Second-quarter fiscal 1995 revenue was $46.1 million, up 107 percent from the same quarter last year, with a 184 percent increase in earnings per share for the same period.
- Diverse product portfolio with a combination of graphics controllers, audio ICs, and communications ICs.
- Headquartered in San Jose, California.

Oak Technology

- Revenue for the three quarters ending March 31, 1995, was $68.5 million, up 141 percent over the same period last year.
- Diverse product offerings, including IDE/ATAPI interface chips in addition to graphics controllers.
- Completed an IPO in February 1995.
- Headquartered in Sunnyvale, California.

S-MOS Systems

- Privately held, so financial information is not disclosed.
- Estimated to have $150 million annual revenue.
- Diverse product offerings.
- Estimated 230 employees.
- Headquartered in San Jose, California.

Groundbreaking Products

S3 Puts MPEG on the Motherboard

S3 became the first company to introduce an MPEG hardware solution for the mass market when it announced its Cooperative Accelerator Architecture on June 13, 1995. Other companies have MPEG-decoder chips, but S3 designed its chip as part of a three-chip multimedia chipset that includes a graphics controller, MPEG decoder, and audio DAC, all tied together with S3's proprietary Scenic Highway interface. This bold move runs against the current trend, embodied by Intel's Native Signal Processing (NSP), of using software to decode MPEG data.

S3's MPEG strategy appears to have a performance advantage over competing hardware codecs because of the integration with the graphics controller via the Scenic Highway bus. S3 has introduced its MPEG chip at $35 in 10K quantities, almost twice as much as some competing MPEG chips, which trade in the $18 to $20 price range. Dataquest expects the S3 MPEG solution to add $90 to $100 to the retail price of the PC. Compaq has endorsed S3's solution and will include it on some PCs for Christmas 1995. This will be the first big test for MPEG hardware bundled into mainstream PCs. Dataquest believes demand for hardware codecs is very elastic and that the current price is limiting market demand. The challenge for S3 and Compaq is to convince computer buyers that this feature is worth the additional cost when less expensive competing solutions have realized only marginal success.

Cirrus Logic Uses Rambus DRAM

Cirrus Logic raised the bar on graphics memory performance when it announced product support for Rambus DRAM. Other graphics vendors are waiting to see which of the alternative DRAM architectures will prevail, but Cirrus is betting on RDRAM. RDRAM offers a 500MB per second transfer rate with only a 10 percent price premium over standard DRAM, which makes it attractive on a price/performance basis. The looming question is product availability. Several memory manufacturers have announced they will make RDRAM, but mass market acceptance of the architecture is uncertain. The VisualMedia accelerator announced by Cirrus will work only with RDRAM, so there is additional market risk for this product associated with memory availability and pricing. Expect Cirrus' endorsement of RDRAM to boost its legitimacy as a product.

VLSI Ties Graphics to Core Logic

VLSI Technology broke the mold for graphics controllers by providing a special interface to its new Lynx chipset. A special two-wire interface between the Lynx chipset and a select group of VLSI's graphics controllers can boost performance by up to 15 percent. Status-checking information can be sent over this interface instead of the PCI bus, which should improve performance when the PCI bus is heavily loaded by disk or network activity. The graphics controllers will work with other vendors' PCI chipsets, but the extra performance is lost.

The pairing of these chips allows VLSI to jump-start sales of its graphics controllers by leveraging its design-wins for core logic. VLSI has shipped more core logic chipsets than any other vendor for the past two years, according to Dataquest surveys. This tactic is a departure from the trend toward more standard products and fewer custom solutions because there is vendor-specific synergy between the graphics and the core logic. The main interface complies with the PCI specification, but the additional interface is a proprietary standard rather than an open one.

NeoMagic Integrates the Frame Buffer into the Graphics Controller

NeoMagic announced a notebook graphics controller with 1MB of integrated memory for the frame buffer. This one-chip graphics solution breaks ground by combining logic and DRAM on a single chip. DRAM manufacturing processes compromise transistor speed and levels of interconnect in favor of high reliability, so these processes are not optimized for advanced logic functions. NeoMagic claims it has addressed this issue and is making the chip with a process similar to that of 16Mb DRAM and a slightly larger die. The logic speed is slower because of this process, but the level of integration appears to compensate for the difference.

NeoMagic's challenge now is to manufacture the device at a competitive price. OEMs know the benefits of integration and low-power consumption, but may not pay much of a premium over competing solutions. If NeoMagic is successful, look for competing products for the notebook market. Similar products for the desktop are unlikely at least until 64Mb DRAM processes become common. The opportunity at that point will depend mostly upon high performance at a low price, because space and power requirements are less restrictive on desktop systems.

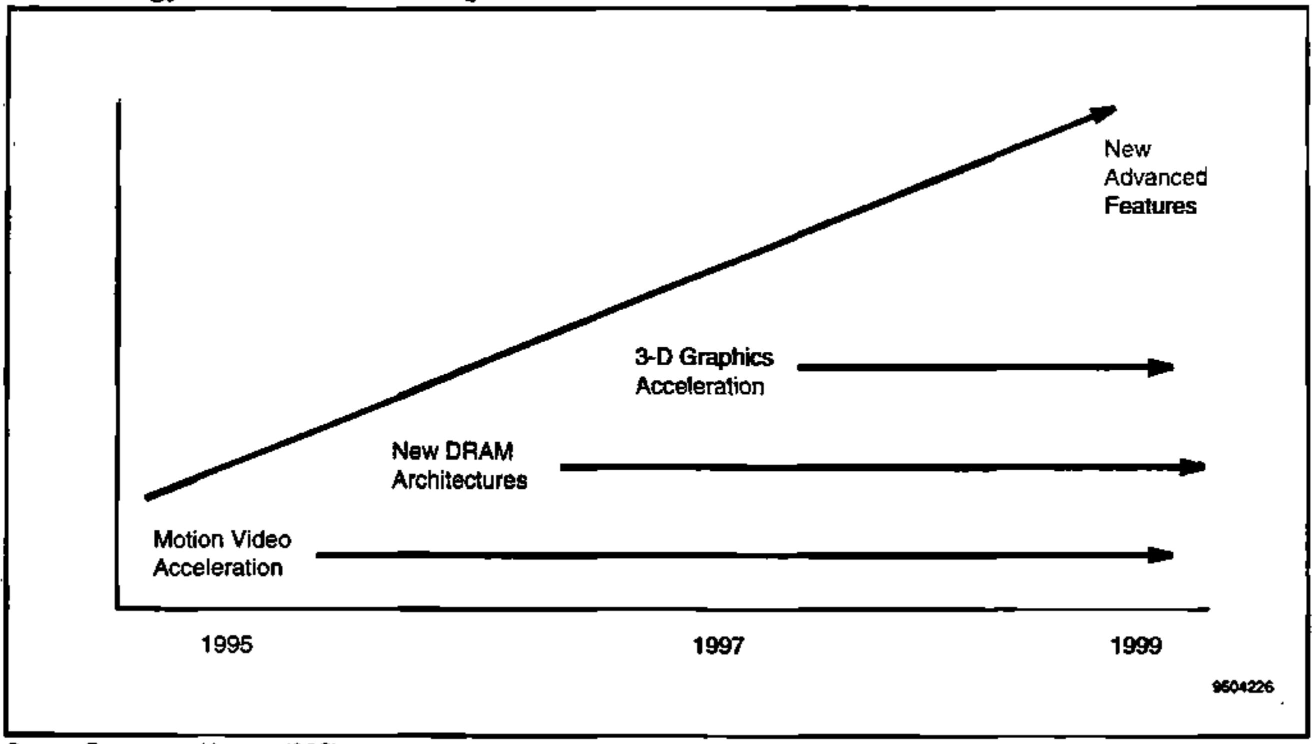
Chapter 6
Dataquest Perspective

The role of graphics controllers is changing just as rapidly as the role of the PC. A higher percentage of PC shipments now goes to the home, where the PC supports personal productivity, communication, and entertainment. Digital video is currently more important for consumer entertainment than business desktop productivity and will most likely continue to be so. The trend for graphics controllers is adding new functionality to address the changing role of the personal computer.

This year, the new feature is motion video acceleration. The next feature to be integrated into the graphics controller will probably be 3-D graphics acceleration. It is unlikely that hardware codecs will be integrated soon because of the additional gate count required and because of the increasing ability of faster MPUs to provide that function. Figure 6-1 depicts this graphically.

Another critical issue for semiconductor vendors is support for alternative DRAM architectures. Graphics performance is currently limited by memory bandwidth issues, and this will not change significantly as long as standard DRAM and VRAM are used for the graphics memory. Semiconductor vendors have an opportunity to differentiate their products by supporting new types of DRAM that solve the memory bandwidth issue without requiring larger frame buffers.

Figure 6-1
Technology Trends for PC Graphics Controllers



Source: Dataquest (August 1995)

One last issue that semiconductor vendors must consider is the large number of competitors in the graphics controller market. It is unlikely that the market can support all the players now on the roster, even with continued growth in PC shipments. PC OEMs and end users are sure to benefit as new entrants to the graphics market cut prices to gain market share and establish their presence in the industry. New features will play a critical role in differentiating products from competing semiconductor vendors. Those same features will also offer the greatest opportunity for semiconductor vendors to charge a relatively stable price for a graphics controller from one year to the next. Without new features, graphics controller companies will be faced with sharply lower ASPs and lost accounts.

For More Information...

Geoff Ballew, Industry Analyst .... (408) 437-8676
Internet address .... gballew@dataquest.com@dataquest.com
Via fax .... (408) 437-0292

Dataquest
a company of
The Dun & Bradstreet Corporation

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
Dataquest Incorporated
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: 1-408-468-8000
Facsimile: 1-408-954-1780

Dataquest Incorporated
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6262

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

Sales Offices:
- Washington, DC (Federal)
- New York, NY (Financial)
- Dallas, TX

LATIN AMERICA

Research Affiliates and Sales Offices:
- Buenos Aires, Argentina
- Sao Paulo, Brazil
- Santiago, Chile
- Mexico City, Mexico

EUROPE

European Headquarters
Dataquest Europe Limited
Holmers Farm Way
High Wycombe, Bucks HP12 4XH
United Kingdom
Phone: +44 1494 422 722
Facsimile: +44 1494 422 742

Dataquest Europe SA
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33 1 41 35 13 00
Facsimile: +33 1 41 35 13 13

Dataquest GmbH
Kronstadter Strasse 9
81677 München
Germany
Phone: +49 89 93 09 09 0
Facsimile: +49 89 93 03 27 7

Sales Offices:
- Brussels, Belgium
- Kfar Saba, Israel
- Milan, Italy
- Randburg, South Africa
- Madrid, Spain

JAPAN

Japan Headquarters
Dataquest Japan K.K.
Shinkawa Sanko Building
6th Floor
1-3-17, Shinkawa
Chuo-ku, Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

ASIA/PACIFIC

Asia/Pacific Headquarters
7/F China Underwriters Centre
88 Gloucester Road
Wan Chai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei
Taiwan, R.O.C.
Phone: 8862-756-0389
Facsimile: 8862-756-2663

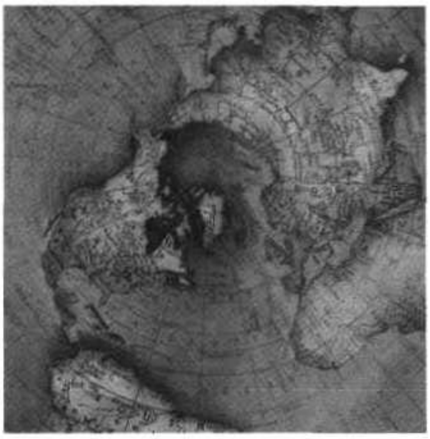
Dataquest Singapore
105 Cecil Street
#06-01/02 The Octagon
Singapore 0106
Phone: 65-227-1213
Facsimile: 65-227-4607

Dataquest Thailand
12/F, Vanissa Building
29 Soi Chidlom
Ploenchit Road
Patumwan, Bangkok 10330
Thailand
Phone: 662-655-0577
Facsimile: 662-655-0576

Research Affiliates and Sales Offices:
- Melbourne, Australia
- Beijing, China

Dataquest

a company of
The Dun & Bradstreet Corporation



Dataquest

PC Core Logic: A Focused Analysis

Focus Report

Program: Microcomponents Worldwide
Product Code: MCRO-WW-FR-9502
Publication Date: June 12, 1995
Filing: Focus Studies

PC Core Logic: A Focused Analysis

Focus Report

Program: Microcomponents Worldwide
Product Code: MCRO-WW-FR-9502
Publication Date: June 12, 1995
Filing: Focus Studies

Table of Contents

List of Figures

List of Tables

Chapter 1
Executive Summary

PC core logic chipsets are as critical to the overall performance of the personal computer as any other component in the system. The PC core logic chips are the interface between the MPU complex (microprocessor and cache memory) and the rest of the PC. These chips manage the system resources that make up the PC. Many of the critical performance bottlenecks, such as the cache algorithms, DRAM refresh, memory management, power management, expansion bus control, local bus control, and DMA control, are handled directly by the PC core logic chips. A poorly designed chipset architecture will severely cripple a PC's performance, completely independent of the microprocessor used in the system.

One key point that will be supported in this report is that traditional users of custom PC core logic chipsets are rapidly moving away from the custom approach to a standard product approach. This transition took a step function change in 1994 when such companies as IBM and Compaq began a rapid move from custom solutions developed in-house to standard solutions. For IBM this involved a move to chipsets manufactured by OPTI, while Compaq made the switch from in-house-developed custom chipsets to standard product chipsets manufactured by VLSI Technology.

Also, the local bus of choice in 1993 and 1994 was the VESA or VL bus, but nearly 100 percent of new development work is focusing on the Peripheral Component Interface (PCI).

Intel is becoming a dominant force in PC core logic chipsets, driven primarily by its position in the Pentium chipset market. We expect Intel to continue its chipset focus in order to facilitate the early adoption of new generations of microprocessors. However, Intel needs to temper its position in PC core logic products. It appears to have modified its original intent of enabling the market to becoming a dominant supplier of PC core logic. Although it certainly has the resources to force this occurrence, following through on this path may create a situation that can hamper the time-to-market plans of its own next-generation microprocessors.

Several non-Intel-compatible microprocessor vendors are trying to enter the market for desktop PCs. Choosing which of these new entrants to support requires all of the market intelligence a company can muster. Advanced Micro Devices (AMD) now is the only truly Intel-compatible provider of a desktop solution for the desktop PC market. Choosing to support any other MPU vendor will require new R&D development. This R&D effort can be minimized, depending on the company in question. After AMD, Cyrix requires minimal modifications to support its data bursting scheme. Nexgen requires still further modifications, and the RISC vendors all require extensive R&D efforts. However, they should be quite helpful to any third-party PC core logic vendor seeking to provide support for its particular architecture.

The following chapters provide a more detailed look at these and other issues.

Chapter 2
The Players

According to a recent Dataquest survey, a familiar name is found at the top of the chart of chipset producers in 1994 (see Table 2-1 and Figure 2-1). VLSI Technology once again is the market leader. VLSI led all challengers vying for the No. 1 position in total PC core logic chips. Although the company's market share fell from 21 percent in 1993 to 17.9 percent in 1994, it was still able to hold off the hard charge of Taiwan-based Silicon Integrated Systems (SIS), which grew at a pace nearly double that of the PC core logic industry and leaped over both United Microelectronics (UMC) and OPTI. At its current pace, SIS should overtake VLSI in 1995. Both UMC and OPTI grew in the 20 percent range and were able to hold off the challenge of Intel, whose meteoric rise may propel it above SIS and VLSI into the No. 1 position before 1995 is finished. The only company to outperform Intel in terms of growth was the Cirrus Logic subsidiary, Pico Power, whose 253 percent growth rate propelled it from the No. 10 position to No. 8.

Growth Adjusted

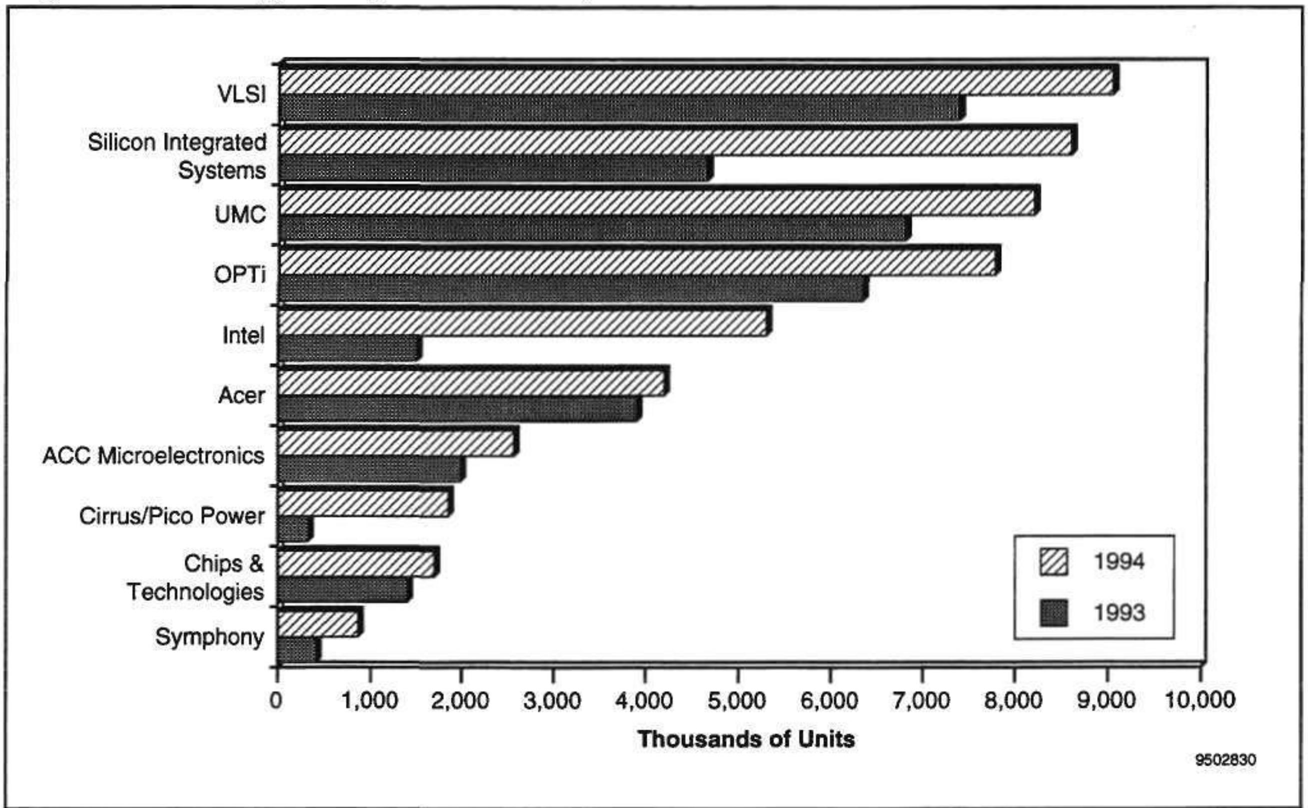
This 43 percent market growth is skewed somewhat by the rapid transition of PC OEMs, such as Compaq and IBM, switching from the use of custom PC core logic to standard off-the-shelf PC core logic. As was estimated in an earlier report from Dataquest's Semiconductor Directions in PCs program, the use of custom PC core logic in desktop PCs fell from 15 percent in 1993 to 9 percent in 1994 and is expected to fall to less than 5 percent in 1995, while the use of custom PC core logic in notebook PCs fell from 65 percent in 1993 to 32 percent in 1994 and is expected to approach 15 percent in 1995. We expect this trend to continue because

Table 2-1
Top 10 Core Logic Chipset Producers, Worldwide (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Total	1994 Total	Percentage Change	Market Share (%)
1	1	VLSI	7,392	9,047	22.4	17.9
2	4	Silicon Integrated Systems	4,652	8,600	84.9	17.0
3	2	UMC	6,800	8,200	20.6	16.2
4	3	OPTI	6,344	7,775	22.6	15.4
5	7	Intel	1,500	5,300	253.3	10.5
6	5	ACER	3,900	4,200	7.7	8.3
7	6	ACC Microelectronics	1,983	2,563	29.2	5.1
8	10	Cirrus/Pico Power	325	1,850	469.2	3.7
9	8	Chips & Technologies	1,400	1,700	21.4	3.4
10	9	Symphony	410	860	109.8	1.7
		Others	800	535	-33.1	1.1
		Total Shipments	35,506	50,630	42.6	

Source: Dataquest (June 1995)

Figure 2-1
Top 1994 Core Logic Chipset Producers, Worldwide



Source: Dataquest (June 1995)

major OEMs are rapidly disbanding, or significantly reducing, internal PC core logic R&D efforts. Because Dataquest does not include the captive PC core logic shipments in its market share calculations, the growth of the overall PC core logic market is overstated by about 6.3 percent for 1994. Adjusting for this, growth for the overall market for PC core logic becomes 37 percent. The 43 percent growth figure reflects the average growth experienced by the merchant market suppliers able to replace the custom products previously used, in addition to the growth of the PC and motherboard upgrade markets.

The Desktop: Still a Rising Star

In the high-volume world of desktop PCs, SIS vaulted from the No. 4 position to the No. 1 position, surpassing last year's desktop leader VLSI as well as the No. 2 and No. 3 players, UMC and OPTI (see Table 2-2 and Figure 2-2). Based on a 1 percent growth, VLSI fell to No. 4 in 1994 and is in danger of falling further in 1995. Intel is well positioned to challenge SIS for supremacy in the desktop category.

Only three companies experienced growth greater than the market average of 34 percent in 1994: SIS, Intel, and Symphony.

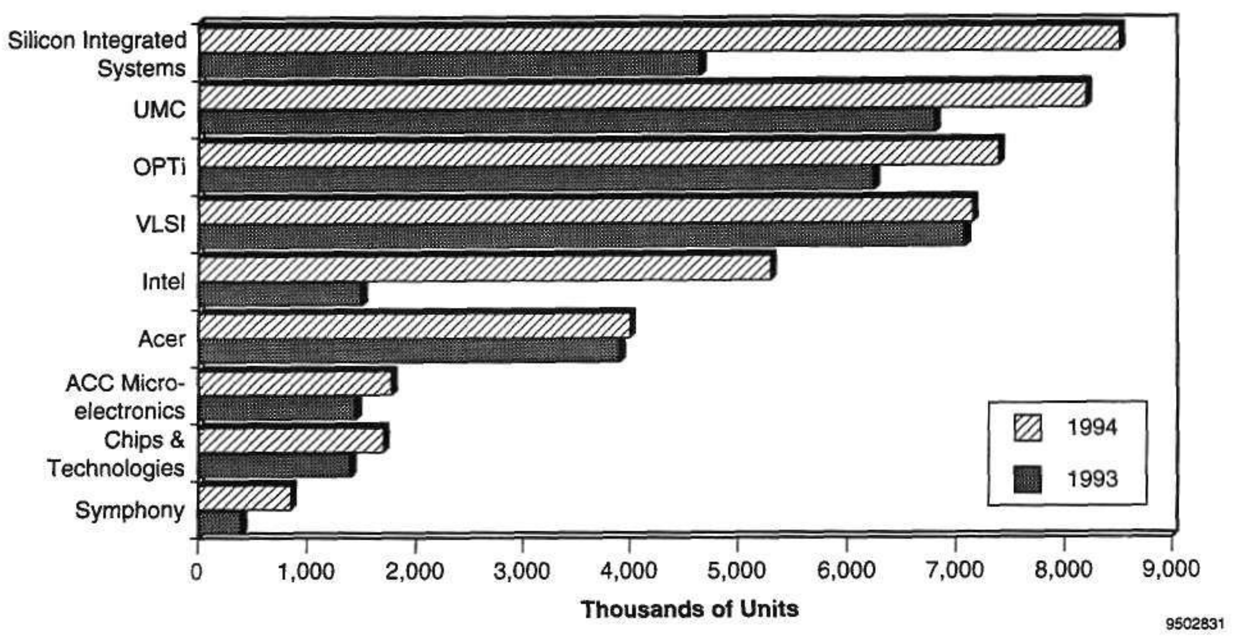
Intel's position in Pentium chipsets and the company's expanding motherboard manufacturing capability are two critical factors leading to our belief that Intel will seriously challenge for the No. 1 position in the

Table 2-2
Top Core Logic Desktop Chipset Producers, Worldwide (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Total	1994 Total	Percentage Change	Market Share (%)
1	4	Silicon Integrated Systems	4,652	8,510	82.9	19.0
2	2	UMC	6,800	8,200	20.6	18.3
3	3	OPTI	6,241	7,396	18.5	16.5
4	1	VLSI	7,080	7,152	1.0	15.9
5	6	Intel	1,500	5,300	253.3	11.8
6	5	ACER	3,900	4,000	2.6	8.9
7	7	ACC Microelectronics	1,446	1,774	22.7	4.0
8	8	Chips & Technologies	1,400	1,700	21.4	3.8
9	9	Symphony	400	850	112.5	1.9
		Others	0	0	0	0
		Total Shipments	33,419	44,882	34.3	

Source: Dataquest (June 1995)

Figure 2-2
Top 1994 Core Logic Desktop Chipset Producers, Worldwide



Source: Dataquest (June 1995)

desktop market. We expect Intel to manufacture about 10 million Pentium-based motherboards. Combining this with Intel's latest-generation Pentium PC core logic chipset, Triton, Intel is well positioned to ship well in excess of 10 million units in 1995.

The 1994 top four vendors—SIS, UMC, OPTI, and VLSI—will be hard-pressed to hold off the Intel challenge. A dark horse challenge may come from Acer Laboratories Incorporated (ALI), which has a significant internal market as well as a selling arm actively marketing its 486 and Pentium PC core logic chipsets. The market dynamics are in place to make 1995 a wild year for market share dominance on the desktop.

Notebooks: Amazing Growth?

The 175 percent growth in PC core logic chipsets shown in Table 2-3 for notebooks applies solely to the growth of standard product chipsets and does not include the rapid decline of the use of custom PC core logic. We expect this trend of switching to standard products to continue through 1995. This trend in notebook PCs has lagged a similar trend in desktop PCs because the notebook feature set is sufficiently different for notebook PCs that the PC core logic developed for the desktop PC market is inadequate for the notebook PC market. Third-party PC core logic suppliers rightly focused their efforts on the much larger desktop market because the desktop market is more mature and the feature sets for this market are much more straightforward. PC core logic suppliers supplying to this market could have had a higher level of confidence that their R&D efforts would bear fruit. The burden of developing PC core logic for the notebook market rested initially on the shoulders of the notebook OEM. Now that the notebook feature set is becoming more predictable and third-party PC core logic vendors are beginning to understand how to implement these features, we are starting to see notebook OEMs begin to disband their internal development efforts in favor of using third-party-developed standard products.

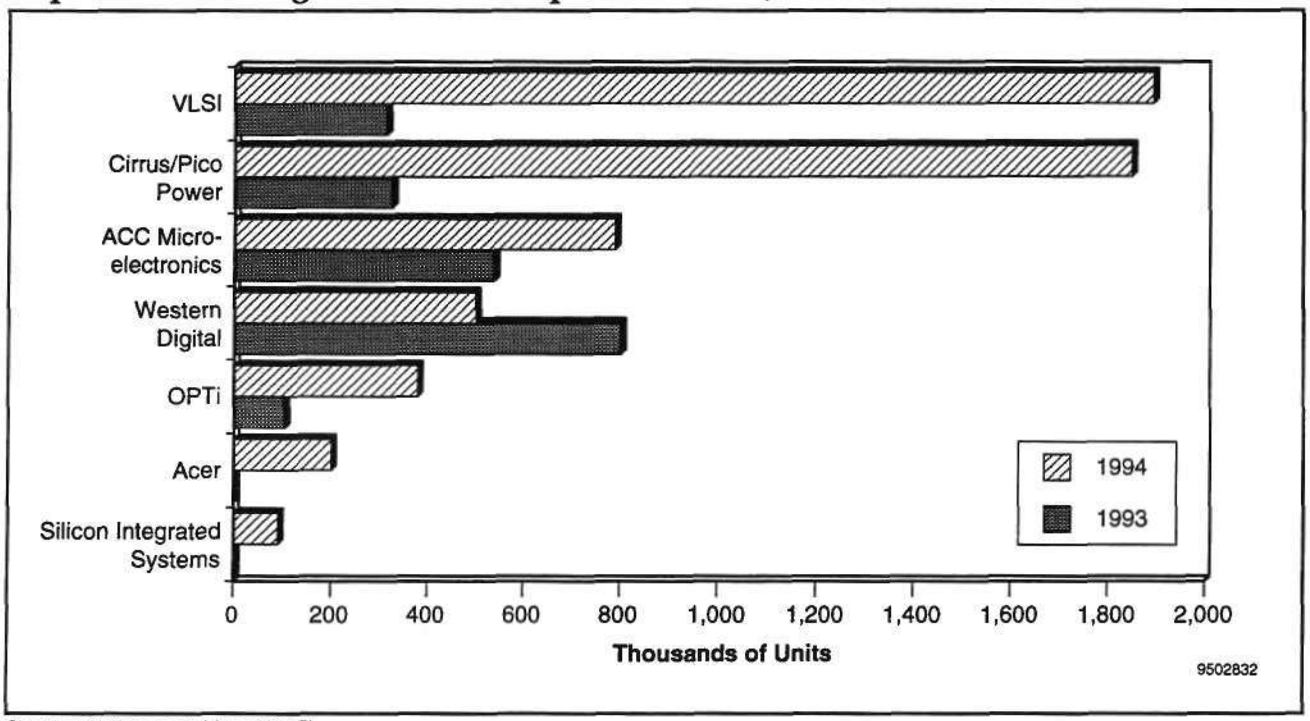
Table 2-3
Top Seven Core Logic Notebook Chipset Producers, Worldwide (Thousands of Units)

1994 Rank	1993 Rank	Company	1993 Total	1994 Total	Percentage Change	Market Share (%)
1	4	VLSI	312	1,895	507.4	33.0
2	3	Cirrus/Pico Power	325	1,850	469.2	32.2
3	2	ACC Microelectronics	537	789	46.9	13.7
4	1	Western Digital	800	500	-37.5	8.7
5	5	OPTI	103	379	268.0	6.6
6	NM	ACER	0	200	NM	3.5
7	NM	Silicon Integrated Systems	0	90	NM	1.6
		Others	10	45	350.0	0.8
		Total Shipments	2,087	5,748	175.0	

NM = Not meaningful
Source: Dataquest (June 1995)

Somewhat surprisingly, VLSI attained the No. 1 position in this fast-growth category (see Figure 2-3) because of a key design-win in one of Compaq's portable products, which is not a true indicator of VLSI's present position in the notebook market for PC core logic chips. However, a version of the company's new Eagle chipset is targeted at the Pentium notebook market. Cirrus Logic, via its acquisition of Pico Power, has jumped into the No. 2 position in this category. Cirrus' position is based upon a much broader portfolio of notebook OEM design-wins than that of VLSI, and we expect Cirrus to vault into the No. 1 position in 1995 as its design-wins evolve into high-volume production. ACC Microelectronics finds itself in the No. 3 position, but with less than half the market share of either VLSI or Cirrus. It is running at a tenth of these companies' growth rates, and we do not expect ACC to threaten for the No. 1 position in 1995. The leader in 1993, Western Digital, has begun pulling out of this market; it is not surprising to see it fall to the No. 4 position. Because we expect no change in its focus on this market, we believe that it will fall into the "others" category in 1995. Western Digital will continue to focus in product areas where it believes it has a stronger competitive position. OPTI is beginning to make a move in the portable arena and, along with Acer and SIS, should improve its market share position in 1995.

Figure 2-3
Top Seven Core Logic Notebook Chipset Producers, Worldwide



Source: Dataquest (June 1995)

Chapter 3
Where the Industry Has Been and Where It Is Going

The rate of change in the realm of PC core logic is on an accelerating path. Ten years ago, the industry was making the transition from the 286 microprocessor to the 386, with the only technical challenge being how to cope with the 32-bit-wide I/O bus of the 386DX microprocessor. Today we still have some lingering 386 designs, a vast array of 486 product offerings, the Pentium microprocessor with its 66-MHz, 64-bit I/O bus, Nexgen's 586-class processor, the soon-to-be-released clones from AMD and Cyrix, and Intel about to release its next-generation x86 microprocessor still known as the P6. The challenges for the PC core logic vendors have increased with each successive generation of x86 microprocessor.

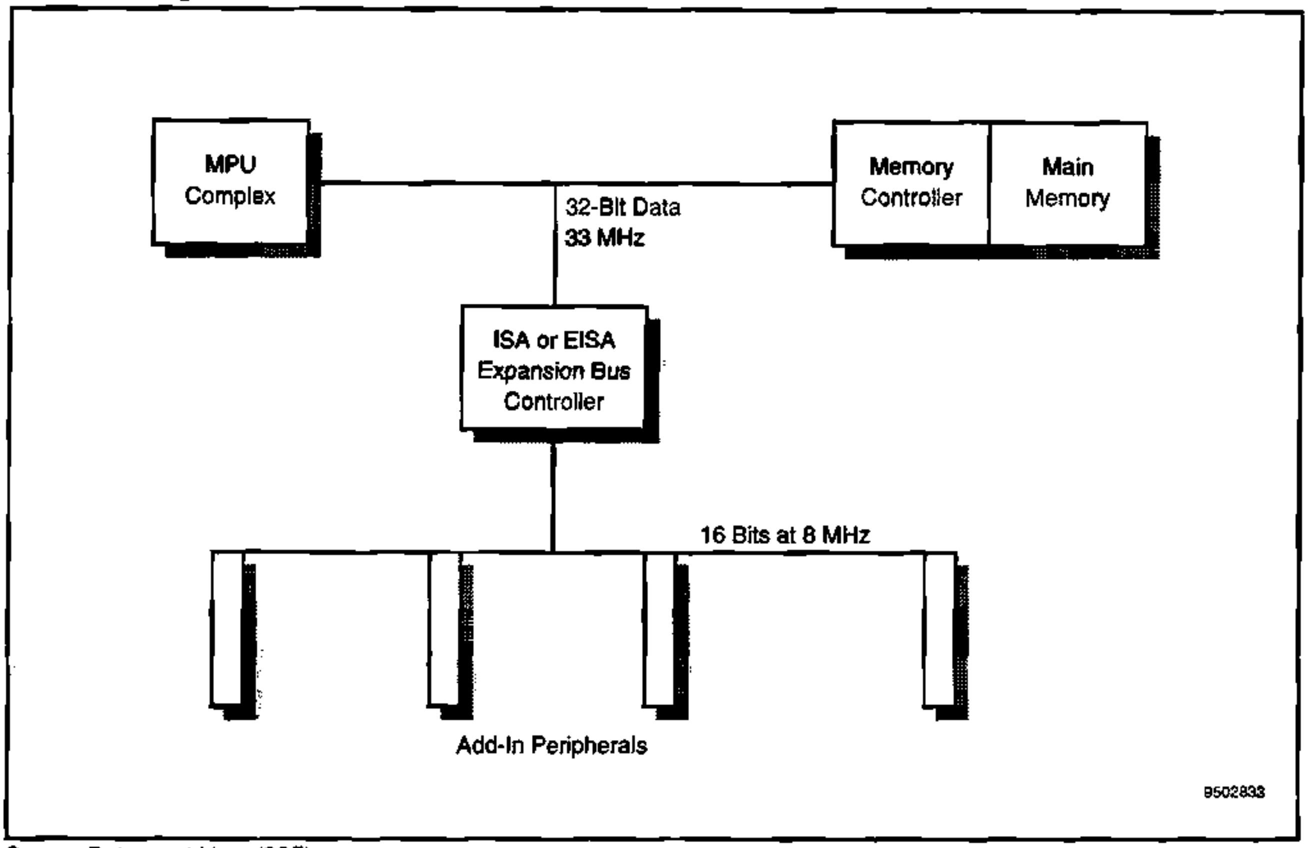
Cache Is King

The transition from the 286 to 386 involved moving from a 16-bit to a 32-bit bus I/O. Moving from the 386 to the 486 required the addition of a secondary cache controller because PC performance was becoming increasingly important. This feature made the secondary cache controller a key product differentiator. An efficient cache controller could greatly improve the performance of a given PC. Inefficient controllers would often decrease performance because of a very low "hit rate" in cache. This lack of understanding by the PC core logic industry forced many PC OEMs to design their own PC core logic rather than purchase standard product. By the end of the 486 life cycle, everyone in the PC core logic industry seemed to have a good understanding of cache controller algorithms.

The Expansion Bus Wars

The only expansion bus 10 years ago was the Industry Standard Architecture (ISA) bus. Today we still have ISA, some remnants of the Extended Industry Standard Architecture (EISA) bus, the VESA local (VL) bus, and now the PCI bus. During the life cycle of the 386, the PC industry made a few attempts at replacing the incredibly slow ISA bus. The ISA bus, with its 16-bit width and 8-MHz clock rate, was a major performance bottleneck for the PC (see Figure 3-1). The first attempt at replacing this industry standard came from IBM with its Micro Channel Architecture (MCA) bus. IBM's own arrogance during the development and marketing of this bus doomed its chance of success at the outset. The industry had rapidly grown beyond a group of small companies that would happily follow IBM's lead to a group of very successful and fast-growing companies that believed they had a better handle of what the industry needed than did IBM. IBM's launch of the MCA architecture caused the leading companies in the PC industry to come together and develop the alternative expansion bus known as the Extended Industry Standard Architecture (EISA) bus. Although the EISA bus did have a broad number of backers, it had extremely limited success because of a number of factors, including its high cost, very limited add-in card support, and the fact that virtually none of the PC core logic vendors believed the return on investment warranted a new product design. As a result, the industry is still limping along with the ISA bus as the primary expansion bus in today's desktop PCs.

Figure 3-1
ISA Bus Implementation

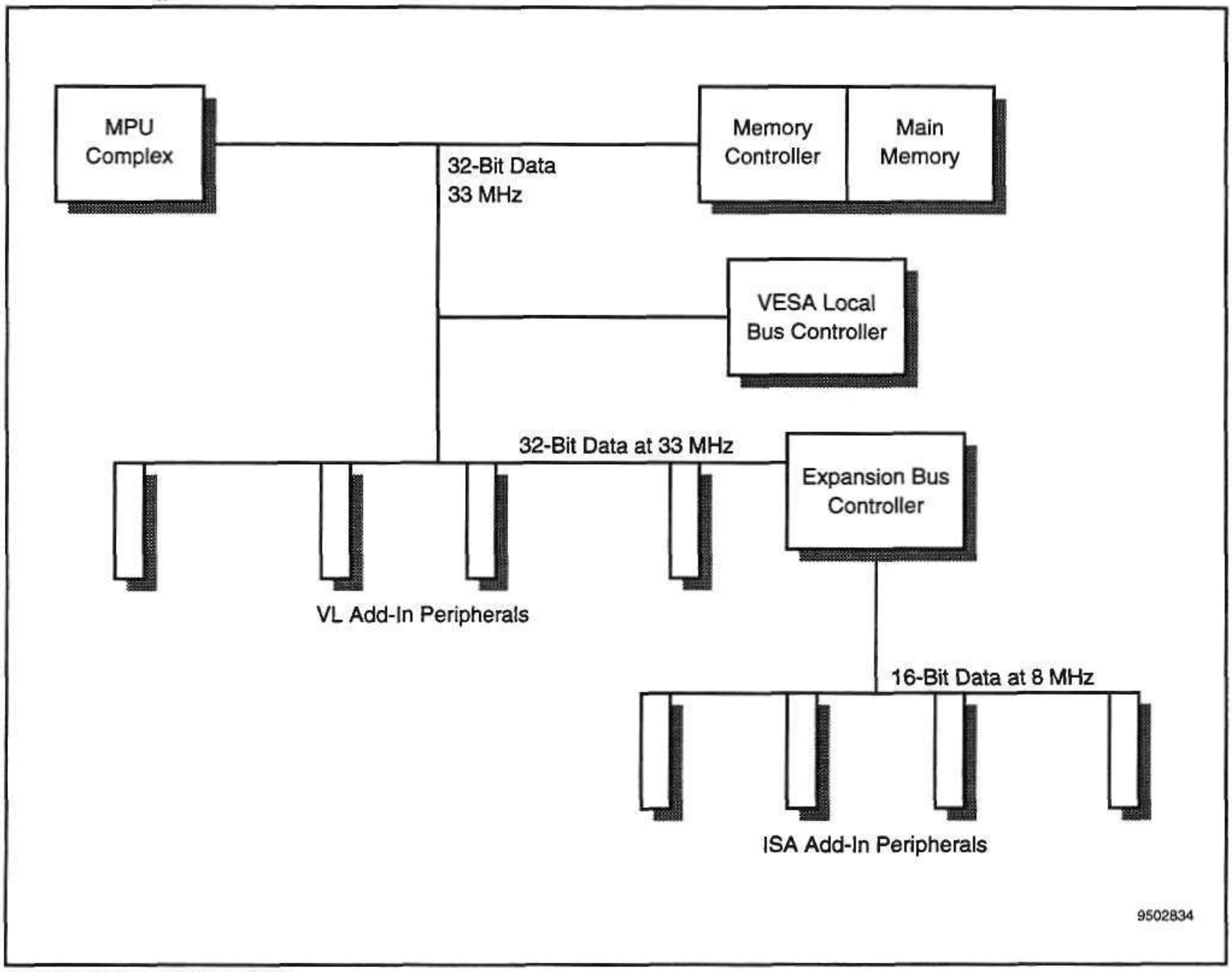


Source: Dataquest (June 1995)

Local Bus to the Rescue

The PC performance bottleneck was so severe that the industry kept working on alternative solutions that would prove acceptable to the industry and provide an adequate road map for future generations of PCs. This effort gave birth to another potential functional differentiator known as the local bus. The first industry-standard local bus to become implemented is the VESA local bus, or more commonly, the VL bus. Another local bus, the PCI, was in a standards committee when the VL concept was first launched, but because the PCI committee was attempting to develop a specification for a local bus that would easily extend into other microprocessor and/or PC architectures, the PCI standard would be years in the making. The VESA committee set its sights on a local bus that would be used in IBM PCs only, and version 1 was targeted specifically at the 486 microprocessor (see Figure 3-2). This less-aggressive specification allowed the VL bus to capture an early market share advantage over the PCI bus that peaked in 1994 with shipments of 33.9 million units giving it two-thirds of the market (see Table 3-1 and Figure 3-3).

Figure 3-2
VL Bus Implementation



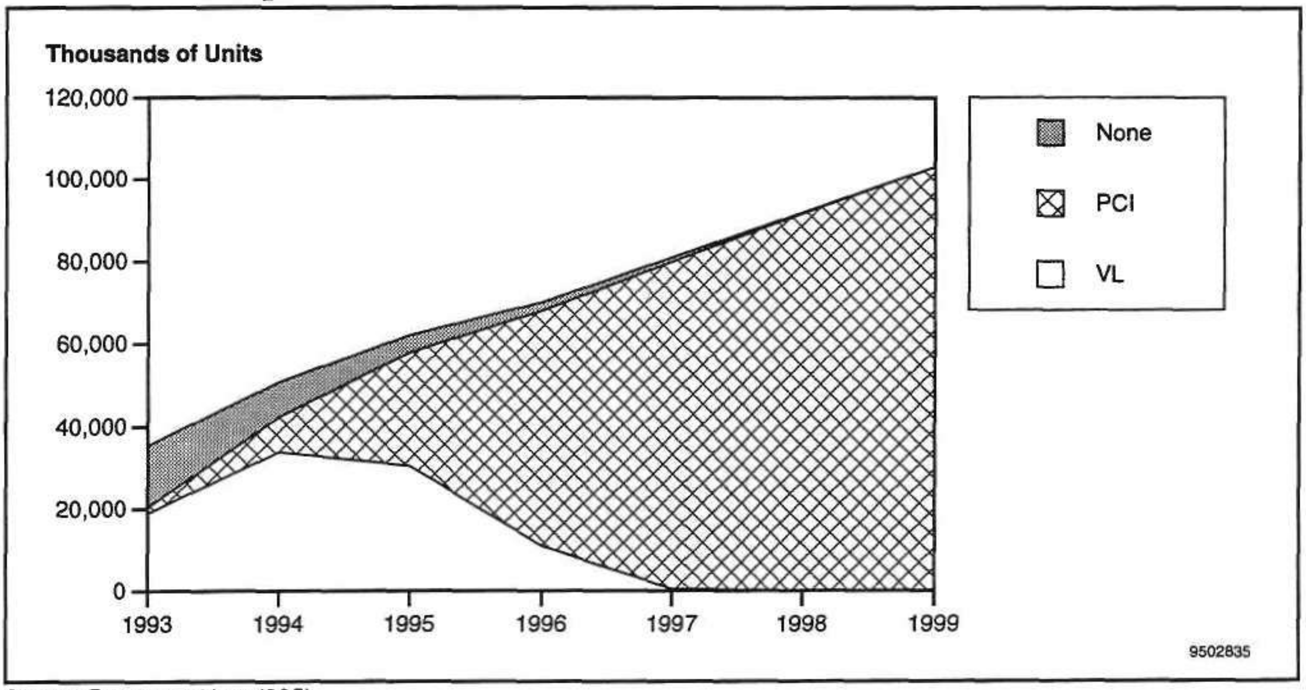
Source: Dataquest (June 1995)

Table 3-1
PC Local Bus Chipset Forecast (Thousands of Units)

	1993	1994	1995	1996	1997	1998	1999
VL	18,844	33,869	30,500	10,900	450	0	0
PCI	1,490	8,385	27,300	57,000	79,500	91,750	103,000
None	15,172	8,377	4,200	2,100	1,050	250	0

Source: Dataquest (June 1995)

Figure 3-3
PC Local Bus Chipset Forecast



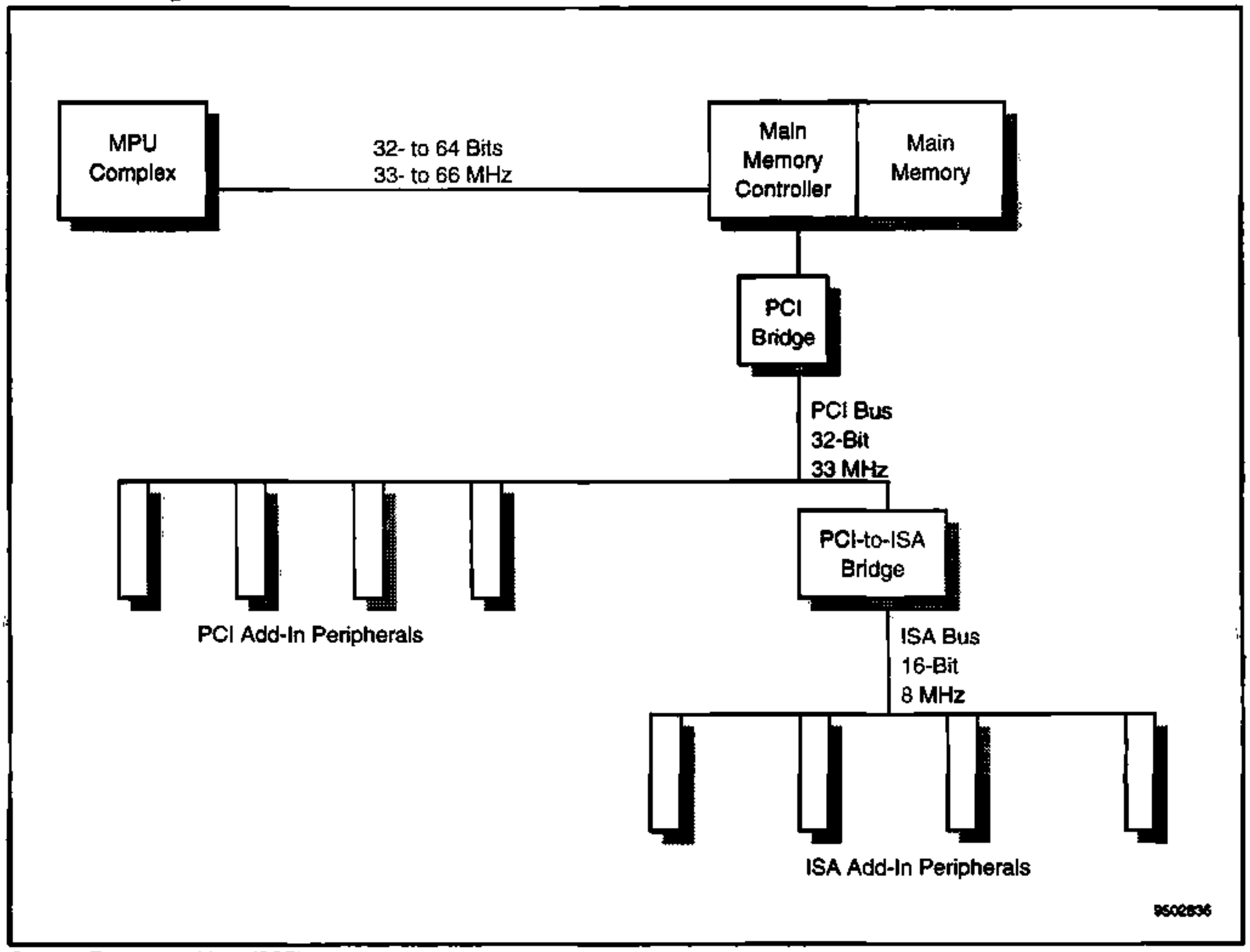
Source: Dataquest (June 1995)

The PCI bus has many advantages over the VL local bus:

- It is buffered from the microprocessor memory bus interface (see Figure 3-4), which allows the microprocessor to operate concurrently while the PCI bus is in use.
- It allows for bus mastering. An example of this would be a bus master IDE controller that could transfer data from a mass storage device directly to main memory with minimal microprocessor intervention.
- It is extensible to 64 bits using the same connector.
- It has a smaller form factor than VL (VL uses 80 pins and also requires use of the ISA bus slot; PCI requires a single 50-pin connector).
- It has much higher bandwidth at 132 MB/sec. This increases to 264 MB/sec at 64 bits and 528 MB/sec with the coming 66-MHz revision. Such high bandwidth is essential in multimedia and multitasking environments.
- It has broad industry backing.

The PCI local bus is rapidly gathering momentum, driven by the industry switch from the 486 to the Pentium microprocessor. The PCI specification was spearheaded by Intel, and it is Intel that is leading the transition from the VL bus to PCI. Intel is the No. 1 supplier of Pentiums, PC core logic supporting the Pentium, and Pentium-based PC motherboards. It should be no surprise that a company in such a position can cause such a rapid transition from one standard to another. Our analysis indicates that the PCI local bus that had only a 4 percent market share in 1993 will become the dominant local bus in 1996, achieving shipments of 57 million units, which translates into market share of 81 percent (see Table 3-1 and Figure 3-3).

Figure 3-4
PCI Bus Implementation



Source: Dataquest (June 1995)

NSP Takes a Ride on PCI

Another initiative being spearheaded by Intel is the Native Signal Processing (NSP) initiative. When NSP was first introduced at COMDEX/Fall in 1994, the message received by the world was that NSP would replace the function of multiple specialty chips that were trying to find a place in the PC. Since that first introduction, Intel has gone to great pains to tell the world that the message had been misinterpreted. At the WINHEC conference held in San Francisco in 1995, Intel began its re-education process in earnest. The message it is now clearly telling us is that NSP is an enabling platform for multimedia. It is trying to get the industry to agree upon a standard for implementing multimedia in the PC. Today there is a hodgepodge, with every card manufacturer developing its own unique feature set to implement some portion of multimedia in the PC. This approach often is wasteful because it can duplicate circuitry that already exists in the PC and quite often it is difficult to integrate these functions into today's PC. The NSP approach provides a baseline target or standard at which everyone can take aim with their particular solution. This should allow companies to focus their efforts on specific areas of competence and expertise and have the assurance that, if they follow the standard, their product will operate in an NSP-ready system.

Central to the operation of a multimedia PC is the need to transfer lots of data at very high rates to and from the PC, totally transparent to the user of the PC. For example, while a user is watching a training video on how to use a spreadsheet and simultaneously operating the spreadsheet and printing a document, the user should be able to receive a fax or other communication completely in the background without interrupting or noticeably impacting the session in progress. Such an example requires bandwidth and parallel operation not possible with either the ISA or VL bus architectures.

Power Management and the "Green PC"

Power management began with the need to extend the useful life of a battery in notebook computers. Notebooks could operate for only 1 to 2 hours, and this was viewed as unacceptable by the purchasing public and was a key element that slowed the acceptance of notebooks into the market. Battery technology moves at a relatively slow pace, so it became the task of the IC community to come up with a solution. The first and most obvious solution was to switch everything from 5V to 3.3V. This task was not as straightforward as at first thought, and the power savings, while significant, was not adequate. The task of finding a long-term solution was left primarily on the shoulders of the PC core logic vendors.

After a government study of the power consumed by personal electronics revealed that PCs were fast becoming the largest consumer of the world's electrical power plants, the U.S. Department of Energy developed a standard known as Energy Star. This environmentally safe standard soon was given the unofficial moniker of the "Green PC." The need for power management had now grown beyond the need of portable computers and was rapidly becoming a required feature in desktops as well.

The first versions of power management simply monitored which peripherals were not being used and shut them down. Although this technique does provide some benefit, it also created some problems. Some of the peripherals, once shut down, took time to power back up. A notable case is the hard disk drive, which can take up to tens of seconds to get back up to speed.

Later attempts involved a finer layer of granularity of shutdown. These varied from standby, to doze, to sleep, to off. This flexibility gave a better trade-off of power for performance, but the power savings was still not of breakthrough proportions.

More recently we have seen more sophisticated power management solutions that take a more proactive stance regarding power management. Foremost of these is the Cirrus Logic subsidiary Pico Power, which uses an active power management approach. Basically the PC core logic starts out in a standby or low power state and only allocates power as the need arises. This is the reverse of most power management approaches that start out at full power and only power down components or peripherals if they remain dormant for a set period. This active power management approach, although more complex to implement, in theory should be more efficient and effective than the traditional passive approach to power management. The passive approach is waiting for a reason to reduce power, while the active approach is waiting for a reason to apply power.

A new feature in PCs that is a direct fallout of the power management issue is referred to as "Instant On." This feature will allow a PC to be turned on and left on. In theory, a PC can be placed in a deep sleep, consuming less than 10W, and then be awakened at a keystroke or telephone ring. This would eliminate the need to physically turn a machine off and then reboot when the PC was needed at some later time. Of course, this will not yet completely eliminate the need to reboot. We still need to eliminate software crashes, and such hardware issues as internal modems that cannot be initialized will still require the system to be powered on and off. But once these bugs are fixed, Instant On will virtually eliminate the need to have easy access to the on/off power switch.

The whole area of power management is one that will be undergoing constant evolution and will involve close cooperation between IC companies and software developers, as well as peripherals vendors. Power management will continue to be a major challenge through the end of the decade and will be a key selling feature in all notebook computers and most desktop PCs.

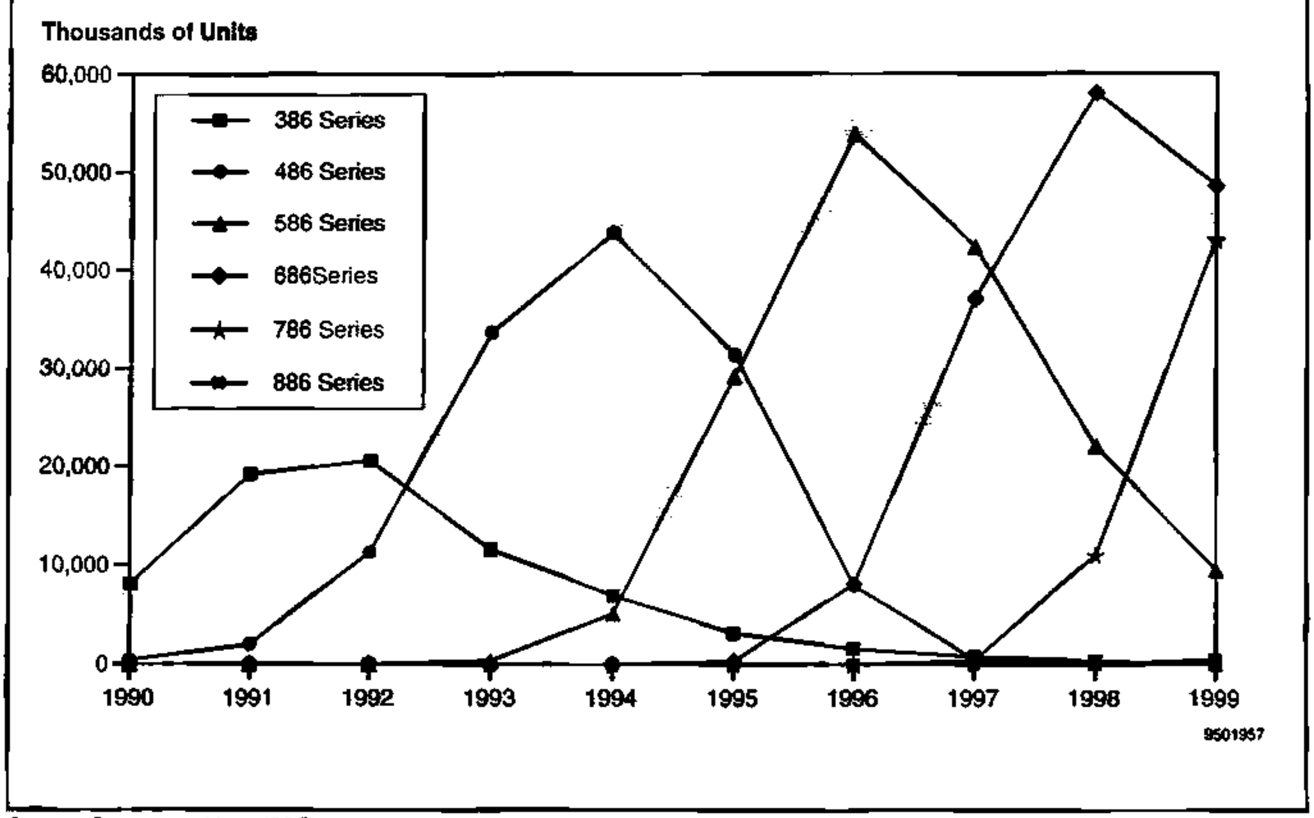
Chapter 4
Time to Volume

Ten years ago, an x86 microprocessor took several years to reach volume production after the product was released. Today, the time to high-volume production (a 10 million-unit-per-year run rate) takes less than two years; it will take less than 18 months for the P6, and less than that for the P7 (see Figure 4-1).

Too Much Paranoia Can Hurt

As the time to volume for new microprocessors continues to accelerate, the pressure on the PC core logic vendors increases. When major microprocessor vendors announce a new generation of processor, the PC core logic vendors must race to develop new chipsets to support this new architecture. If they are late, they risk losing the entire market window. A prime example of this involves Intel's recent announcement of the P6 microprocessor. The P6 was first discussed with the public in February 1995. Conversations with Intel indicate that third-party suppliers of PC core logic did not receive their first look at the new architecture and the specifications they will need to support it until about the February time frame. Because the P6 uses a new bus, the PC core logic vendors must do a lot of ground-up engineering to support the product.

Figure 4-1
x86 Product Life Cycles



Source: Dataquest (June 1995)

To further place pressure on the third-party suppliers, Intel's own PC core logic group had seen the new bus requirements long before the public disclosure and had been given a tremendous jump-start in the race for market share. Also, with Intel manufacturing more than 10 million motherboards per year, the third-party PC core logic suppliers will have to develop a technologically superior product to the Intel chipset if they are to have a chance of capturing some of the high-volume business from Intel's motherboard business. If they develop a comparable product, they will probably be forced to eliminate 10 million units from their served available market.

Relying solely upon internal talent to develop such a critical set of components as the PC core logic chipset is not the most efficient way of getting the best product to market in a timely fashion. It may in fact delay the time to volume of a microprocessor if the internally developed PC core logic chipset design contains some undiscovered bugs or is missing a key feature that was overlooked or, for some unforeseen reason, is deemed unacceptable by the PC industry OEMs at large. Any of the aforementioned occurrences may slow the acceptance of high-margin microprocessors into the market.

A Better Solution

Intel and other microprocessor vendors must find a way to get third-party chipset suppliers into the architecture loop much sooner than happened on the P6. This may involve creative programs with third-party vendors that guarantee the safety of the microprocessor vendor's intellectual property. But, over the long run, this will be beneficial to all parties. The third-party PC core logic suppliers will have more opportunity to develop a good solution in a timely manner and the microprocessor vendor will have more, and possibly better, PC core logic chipset support when the microprocessor is ready to ship, thus eliminating a potential bottleneck in the critical "time to volume" issue.

Chapter 5
Whom to Support?

Ten years ago, the PC industry needed only to deal with an x86 microprocessor running DOS. Today, multiple processor architectures are vying for the desktop based upon new cross-architecture operating systems:

- x86
  - Intel
  - AMD
  - Cyrix
  - Nexgen
  - Texas Instruments
  - UMC
- RISC
  - IBM
  - Motorola
  - Digital Equipment
  - Sun Microsystems
  - Hewlett-Packard
  - MIPS

Today there is only one given for PC core logic chipset vendors: support Intel's implementation of the x86 architecture. Up through today, supporting Intel also meant supporting AMD, and this will probably continue down the road. Because AMD has been cleared to use Intel intellectual property, one could presume it will continue to capitalize on the installed infrastructure that supports the Intel architecture. It probably will benefit AMD to chart its own course if it wants to become truly positioned as an innovator in the microprocessor market, although this is further down the road. From this point on decisions on whom to support have to be well-thought-out. The others in the x86 camp are vying for the No. 3 slot. Of these, Cyrix and Nexgen are forging off into 586-class product, while Texas Instruments and UMC seem content to remain low-cost suppliers of 486 technology.

Nexgen is the only alternative source to Intel for a 586-class product. Its product uses a unique architecture to implement the 586 instruction set and requires a unique chipset to support it in a PC. Nexgen and VLSI technology have reached an agreement whereby VLSI will produce and market a chipset being designed primarily by Nexgen. Combining this third-party support with the announcement by Compaq to manufacture a computer based on the Nexgen product gives Nexgen a considerable boost in status. This boost may be enough to cause other first- and second-tier PC OEMs to consider using the Nexgen product. Additional third-party support for the Nexgen product has not yet been announced but may be a way for third-party PC core logic vendors to leverage themselves into Compaq.

Mixed Signals

Cyrix and IBM seem to be sending different signals on the production status of Cyrix's 586-class product, known as the M1. When Cyrix first introduced the product, it was more of a proof of concept than a real attempt to develop a manufacturable microprocessor. It had a prohibitively large die size of about 400 sq. mm. Cyrix is performing an optical shrink to get the die size down and expects to ship this product in the third quarter of 1995. IBM, on the other hand, is waiting for a complete redesign and relayout based upon its 0.5-micron CMOS process before taking the product to market. This is not expected to occur until the first quarter of 1996. On the compatibility front, the Cyrix product does target the Pentium pinout but, because of intellectual property reasons, it is forced to use a different data bursting scheme than does the Pentium. This unique bursting scheme will require specific support from PC core logic vendors. Assuming the M1 does not reach high-volume production status until the redesigned product is available in the first quarter of 1996, the 586 class will still have two years of good volume. And, as Intel begins to exit the 586 market in late 1996 or early 1997, opportunity exists for Cyrix and the other 586 vendors to ship millions of units.

The Super 486

In the shorter term, it appears that the M1-SC from Cyrix will have a more immediate impact on the PC market. This product is not a superscalar microprocessor like its big brother M1. The M1-SC, or scalar M1, is meant to provide 75-MHz Pentium performance in a 486DX4 socket. This product, and some of the higher-performance 486 products that operate in the 100-MHz and up range, will provide very attractive price/performance points that may compel some notebook OEMs to perform an upgrade of their existing 486 notebook products.

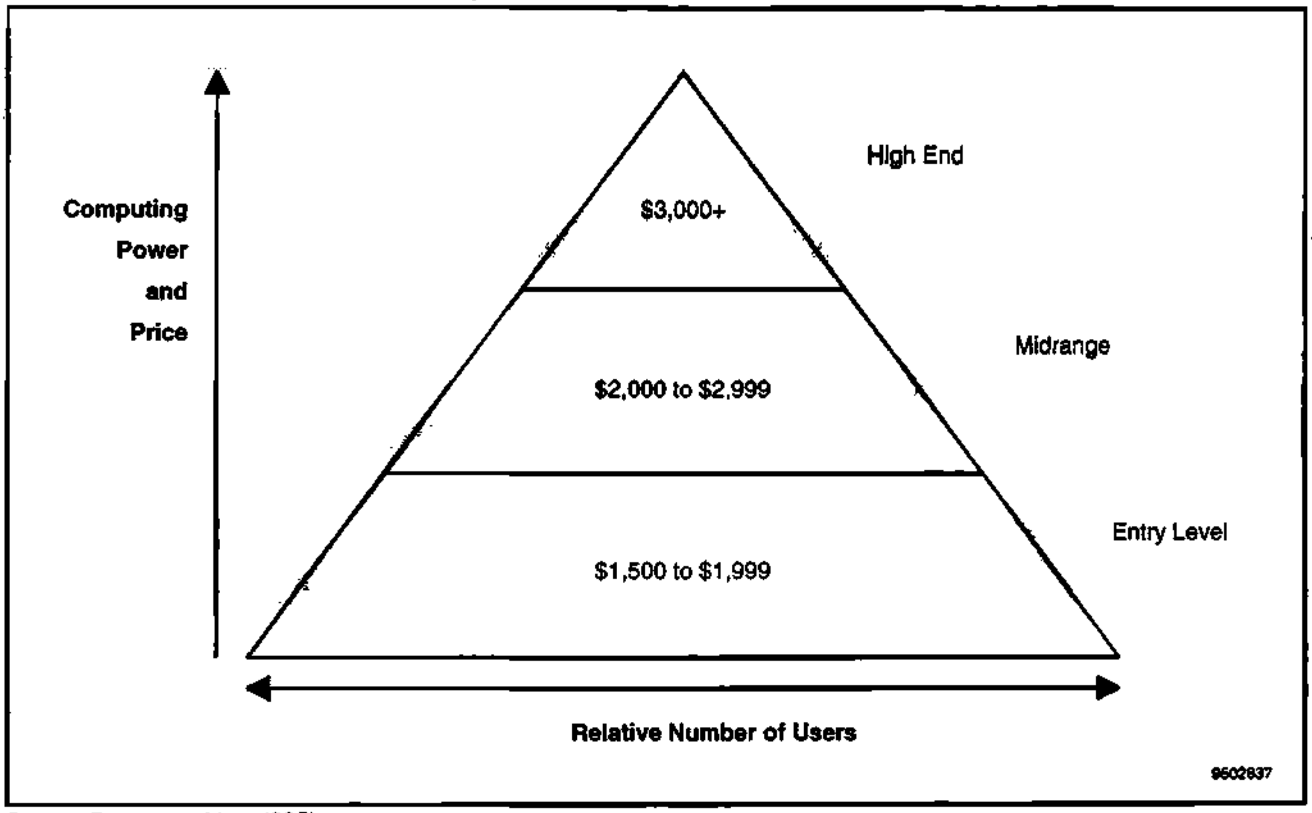
The Grand Experiment

At the low end is the grand experiment: the attempt to tap into the blue collar homes and greatly expand the PC base. For years we have been subjected to various versions of the pyramid shown in Figure 5-1.

The top of the pyramid represents the early adopters and power users, the middle represents the mainstream, and the bottom layer represents the entry level. The width of each segment is meant to indicate the relative size of each market. There has been much discussion recently about what a lower price point with the right feature set might mean in terms of volume. The basic thought, as represented in Figure 5-2, is that a multimedia-capable machine that is as easy to install as a home appliance with the complexity of a toaster, and sells for $795 to $1,000, will be that solution.

Maybe, just maybe, that time is approaching. However, there is an extreme difference between a $795 price point and a $1,000 price point in the mass merchant channel. If the industry is ready to make this grand experiment, it had better be prepared to offer this new box at the right price point. To that end, we are beginning to see some semiconductor manufacturers address this issue. Texas Instruments, which knows a thing or two about the mass merchant electronics market, is touting a 486SX2-66 for $33, and Pico Power has introduced a PC core logic chipset targeted to provide this market the multimedia features it needs while simultaneously facilitating a lower cost point. This will be an interesting

Figure 5-1
Traditional PC Installed Base Pyramid



Source: Dataquest (June 1995)

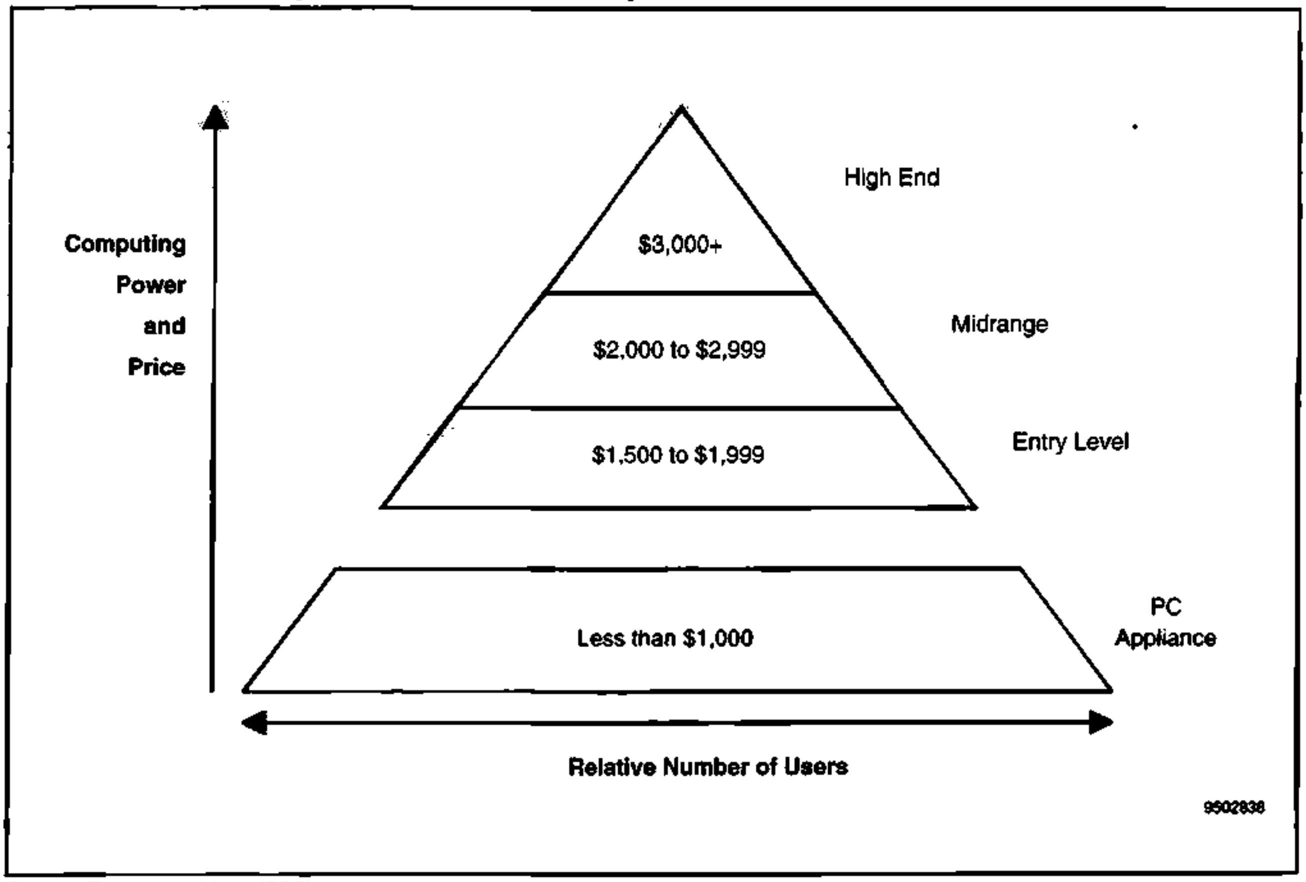
experiment and, if well-thought-out, could greatly expand the total available market for PCs.

UMC's position in the 486 market seems a little tenuous, as UMC's own 486 advertisements in the international airport in Taipei, Taiwan, state clearly that its 486 is "not for export."

To RISC or Not to RISC

The vendors of the various RISC microprocessors are as fragmented in their individual approaches to gaining market share as is the open UNIX platform. (The "open UNIX platform" has at least as many versions as there are computers supporting the "standard".) Sun Microsystems' approach with the SPARC architecture appears to be to push a UNIX box into the mainstream PC desktop with "lower" prices. Hewlett-Packard is making no overt rush to the desktop with its PA-RISC architecture, but the relationship with Intel has not yet borne its fruit. MIPS et al. (referring to the various silicon partners) is still counting on Windows NT to carry it into the desktop. Digital Equipment is following a similar strategy with the Alpha microprocessor. Digital's difference is that it seems to have an architecture built for speed and has consistently demonstrated that it can lead the market in this area. We are not suggesting that the other RISC architectures are not high-performance, but recent history suggests that the Alpha is just faster. Over time, this speed advantage may come into play as a cross-platform operating system such as Windows NT or a derivative becomes mainstream.

Figure 5-2
PC Installed Base Pyramid with New Entry Point



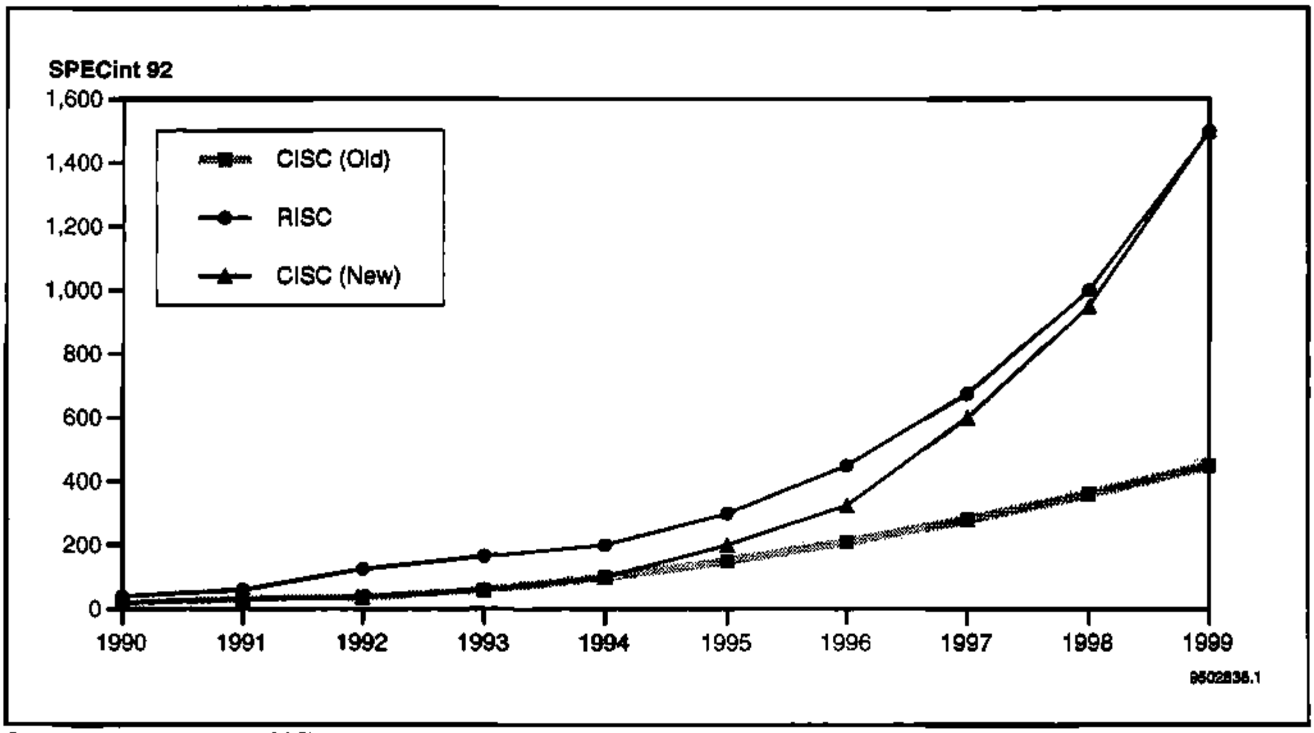
Source: Dataquest (June 1995)

Last but not least in the RISC processor camp is the PowerPC. The alliance of IBM, Apple, and Motorola cannot be ignored. Each of these companies brings formidable skills to the alliance. To name but a few: IBM's technology, Apple's experience and knowledge in developing user-friendly systems, and Motorola's highly reliable manufacturing muscle. Each of these companies also has other strengths, but we believe the point is proven that this alliance is potentially formidable. Unfortunately there exist some sizable negatives that have slowed the acceptance of the PowerPC into the market. Although Apple is making a massive shift to the PowerPC, it remains the only company to use the PowerPC in volume. The attempts to make the Macintosh an open standard have yet to yield any tangible results. Further confusing the issue is the operating system focus, or what appears to be a lack of focus. At this point it would seem that the only real chance for the PowerPC to compete head-on with the x86 architecture for a dominant position in the PC market is to attempt to expedite the acceptance of Windows NT on the desktop.

Windows NT's current lack of support for legacy 16-bit software and its larger system resource requirements has relegated it to file servers and other high-end applications. The upcoming release of Windows 95 will also serve to delay the need to shift to an NT-like operating system. As microprocessors continue on their high-performance migration path and as Windows 95 is perceived to be running out of steam, the industry will finally be ready to move to an NT-like operating system. Unfortunately for the RISC vendors, such an event is not likely in the short term and will probably not occur until the end of the decade. At that point it is quite likely that the x86 vendors will be at, or very near, the performance of mainstream RISC microprocessors (see Figure 5-3). There is little argument that, with a given transistor budget, a RISC architecture will give more performance than a CISC architecture. However, if the CISC architecture is able to pay a transistor penalty, there is no reason why a CISC architecture cannot match the performance of a mainstream RISC architecture.

In Figure 5-3, the RISC and CISC (Old) lines represent historical views of the performance paths of the two basic architectural types. Of course, this assumption assumed that architectural techniques such as branch prediction, speculative execution, out-of-order execution, superpipelining, and superscalar architectures are the domain of RISC microprocessors only. However, it has recently been demonstrated by a number of people that these same techniques also can be applied to CISC microprocessors. In fact, the CISC microprocessors began to deviate from the traditional performance forecast with the Pentium that included two execution units. Announcements by AMD, Cyrix, Intel, and Nexgen indicate that the CISC vendors have every intention of making use of these same time-proven architectural techniques. The line labeled CISC (New) works under the assumption that the CISC suppliers can afford the transistor penalty to attain performance parity with their RISC competitors and that this will occur by the end of the decade.

Figure 5-3
SPECint92 Performance Forecast



Source: Dataquest (June 1995)

If the x86 industry infrastructure is still in place when the move to an NT-like operating system occurs, if the x86 microprocessors have reached performance parity with mainstream RISC, if the various RISC vendors are unable to match the x86 industry's ability to ramp to volume (see Figure 3-1), what will motivate the requisite PC support infrastructure to develop the ability to support another microprocessor architecture (let alone several)? There are a lot of "ifs" in this scenario, but none of them is beyond the realm of reason. It will be an interesting story as it unfolds. Dataquest will be there to advise on its progress.

Chapter 6
Dataquest Perspective

A trend seems to be developing in the PC core logic market that is not good for the PC industry at large. Intel appears to be relying more heavily upon its own resources to develop and manufacture PC core logic chipsets. Now the world has been shown that Intel has no peer at developing high-performance microprocessors in high volume. Intel has reaped substantial financial rewards for developing this capability and for properly maintaining focus on this objective. However, is it possible that it is beginning to defocus its attention just a bit? Intel has a history of developing new technology and standards to enable the PC industry to build better, faster, and cheaper computers. The leadership provided by the Intel Architecture Labs has provided the entire industry. Of course, it is no coincidence that this direction also has been financially beneficial to Intel.

As of late, however, Intel's positioning in the PC core logic arena has taken on more of a role of a company trying to gain dominant market share rather than a company trying to lead the industry in a specific direction. Maintaining a PC core logic development effort certainly seems to be a critical program for Intel. One need not look back very far in history to see the importance of this program for Intel. During the ISA, MCA, and EISA bus wars, Intel was one of the few companies that developed an EISA chipset that was critical in selling high-end x86 microprocessors into server applications. Although this market never developed into significant volume, Intel's leadership caused other core logic vendors to develop EISA bus PC core logic. When the third-party PC core logic vendors were busy making money selling core logic based on the VESA local bus, Intel developed its own support for the PCI bus that it believed to be a better bus for the future. As the PCI standard solidified, the advantages of PCI over the VESA local bus were compelling. Now that the industry is switching to new motherboards based on the Pentium microprocessor, it is a natural time to switch from the VESA local bus to PCI. This general support of PCI is directly benefiting Intel because the PCI bus allows the power of the Pentium and next-generation x86 microprocessors to be more efficiently used.

The third-party PC core logic vendors are positioned with some very solid products to compete in this market that implement the PCI function and bring into play additional value-add that they have developed, such as a wider variety of main memory support, higher levels of integration, and better power management techniques, to mention but a few. However, Intel seems to be in an "I can do it better" mentality rather than a "here's how I would do it" mentality. The latter approach builds on the various levels of expertise developed by the third-party PC core logic suppliers and results in a product that implements the concepts Intel would like to see as well as the new innovations and value-add that the third-party suppliers can supply. The former approach seems a little risky and uncharacteristically shortsighted for Intel.

Today's leaders in developing PC core logic chipsets have come a long way in developing the requisite skills to support this critical portion of the PC market. Evidence of their growing skills is the fact that major PC OEMs such as Compaq and IBM have almost entirely retreated from the development of custom solutions and are now purchasing standard products for the bulk of their requirements. Only a few systems still rely upon custom PC core logic, and we expect these to disappear in short order.

Given the tremendous strides that the PC core logic community has made in the development and design of PC core logic chipsets, it seems quite clear from a third-party observer's perspective that Intel would be well-served to bring the PC core logic vendors into the disclosure loop of the chipset requirements of a next-generation microprocessor much sooner than occurred on the P6. The PC core logic industry only received the necessary specifications to begin such a design nearly simultaneous with the announcement of the product itself. This allows just a few short months to develop P6-capable product. Such a time constraint serves no one's interests because many vendors will be fortunate to develop a bare-bones chipset in time, let alone develop one that will help Intel's ambitious goal of shipping several hundred thousand P6 microprocessors in 1995 and several million in 1996 (8 million, according to Dataquest's estimates).

The industry is growing at a rapid rate, and the time-to-volume pressures Intel has placed on itself do not allow for any stumbles along the way. Intel should be wary of becoming too enamored with its own development capabilities. The company would be better served enabling the industry rather than relying solely on its own resources to develop the support products for its highly lucrative microprocessor line. Such an enablement would better ensure that the right products were available at the right time and at the right price in order for Intel to achieve its ambitious goals of getting newer generations of microprocessors to market faster than prior generations.

For More Information...

Jerry J. Banks, Director/Principal Analyst .... (408) 437-8677
Internet address .... jbanks@dataquest.com
Via fax .... (408) 437-0292

Dataquest
a company of
The Dun & Bradstreet Corporation

Dataquest

a company of
The Dun & Bradstreet Corporation

Corporate Headquarters
Dataquest Incorporated
1290 Ridder Park Drive
San Jose, California 95131-2398
United States
Phone: 1-408-437-8000
Facsimile: 1-408-437-0292

Dataquest Incorporated
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6180

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

European Headquarters
Dataquest Europe Limited
Holmers Farm Way
High Wycombe, Buckinghamshire
HP12 4XH
United Kingdom
Phone: 44-1494-422722
Facsimile: 44-1494-422742

Dataquest GmbH
Kronstadter Strasse 9
81677 München
Germany
Phone: 49-89-930-9090
Facsimile: 49-89-930-3277

Dataquest Europe SA
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: 33-1-41-35-13-00
Facsimile: 33-1-41-35-13-13

Japan Headquarters
Dataquest Japan K.K.
Shinkawa Sanko Building, 6th Floor
1-3-17, Shinkawa, Chuo-ku
Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

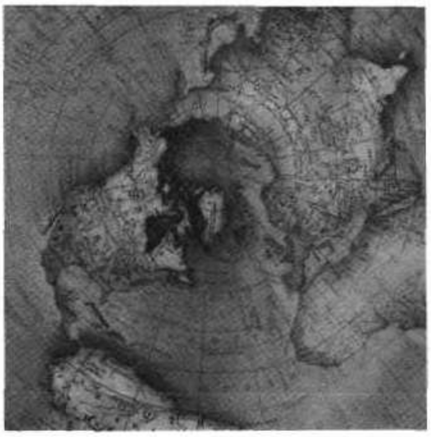
Asia/Pacific Headquarters
7/F China Underwriters Centre
88 Gloucester Road
Wan Chai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei, 105
Taiwan, R.O.C.
Phone: 8862-756-0389
Facsimile: 8862-756-2663

Other research offices in Beijing, Singapore, and Thailand

Sales agents in Australia, Belgium, Germany (Kronberg), Israel, Italy, South Africa, and Spain



Dataquest

Advanced Microprocessor Update: Life Cycles of the Rich and Famous

Focus Report

Program: Microcomponents Worldwide
Product Code: MCRO-WW-FR-9501
Publication Date: January 16, 1995
Filing: Focus Studies

Advanced Microprocessor Update: Life Cycles of the Rich and Famous

Focus Report

Program: Microcomponents Worldwide
Product Code: MCRO-WW-FR-9501
Publication Date: January 16, 1995
Filing: Focus Studies

Table of Contents

List of Figures

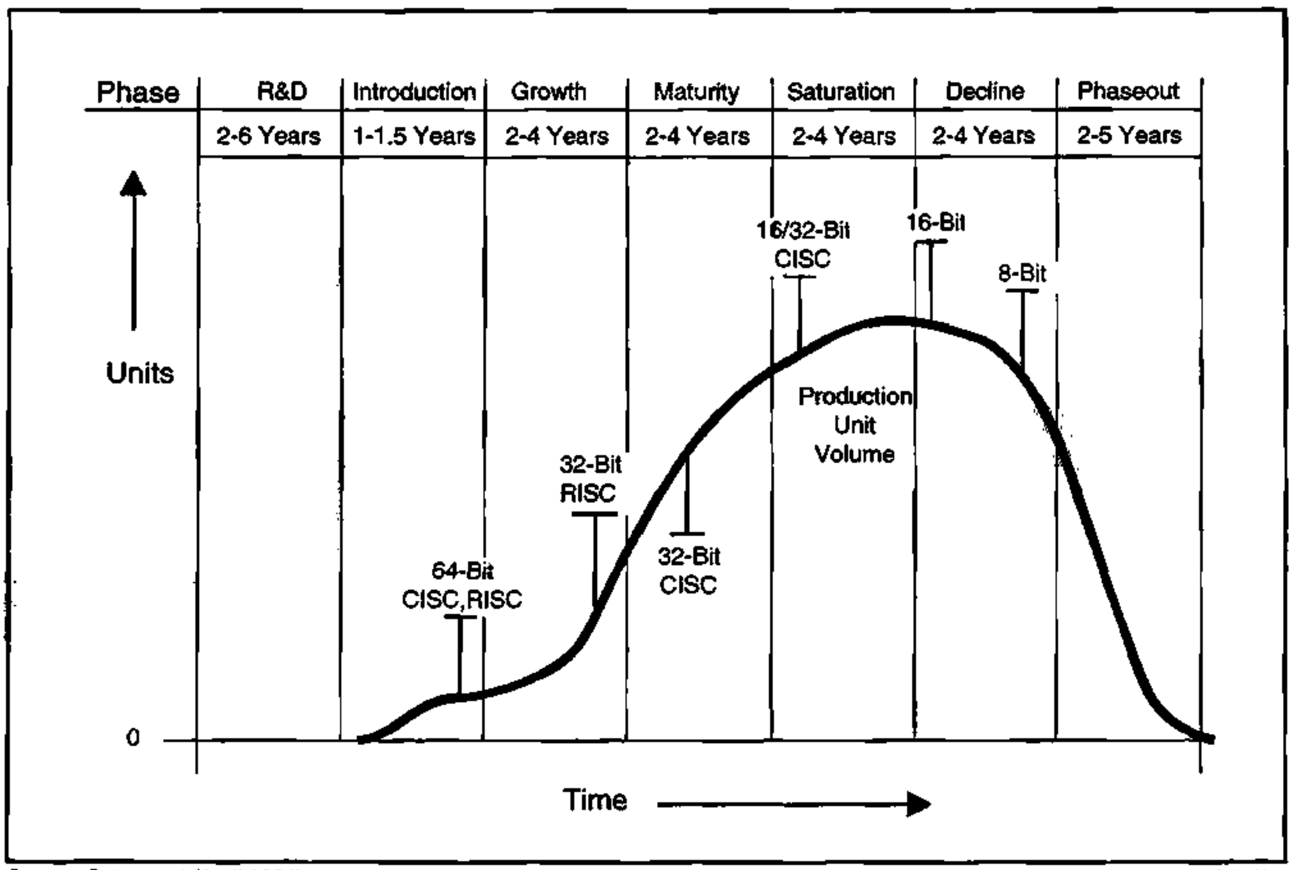
Chapter 1
MOS Microprocessor Product Life Cycles

The Changing Life Cycles for MPU Products

Figure 1-1 represents a historical view of the complete life cycle for a microprocessor family. The typical life cycle ranges from 13 to 28 years from the initial R&D phase through obsolescence (phaseout). The typical MPU life cycle that involves production volumes (growth through decline) exceeds 10 years.

The lengthy R&D phase shown in Figure 1-1 provided users a valuable opportunity to monitor a supplier's (or prospective supplier's) pace of technical achievement and legal standing where applicable, as well as the supplier's timetable for bringing new, state-of-the-art devices to market. However, we are now seeing manufacturers search for ways to effectively shorten all phases of the microprocessors' path to high-volume production. To this end, Intel, the world's dominant microprocessor vendor, has established two separate microprocessor design teams that work on alternate generations of the x86 architecture. This allows Intel to perform significant work in parallel rather than in the serial fashion it had employed

Figure 1-1
Microprocessor Product Life Cycle as of April 1994



Source: Dataquest (April 1994)

G4006958

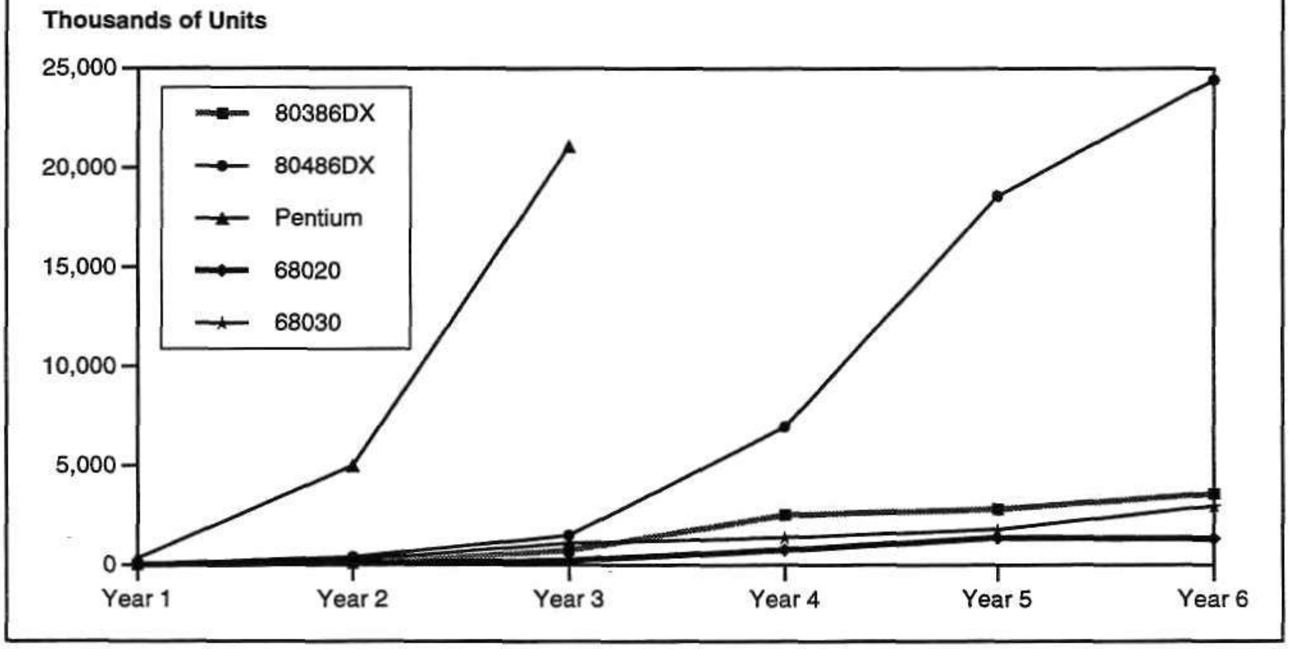
in the past. This decision alone has the effect of cutting the design time in half when viewed from outside the company. Although the internal R&D portion of the cycle was not actually cut in half, the world outside of Intel is seeing a new generation of microprocessors ready for announcement in half the time set by historical precedent. We are now in the first iteration of this relative halving of the R&D phase with the upcoming P6 microprocessor, which Intel is expected to start shipping in the third quarter of 1995. This initial shipment date will occur only two-and-a-half years from the initial shipment date of the Pentium. Contrast this with a four-year time span between the 486 and the Pentium.

Dataquest received many inquiries about leading-edge microprocessors such as the Pentium, R4000, 21064 (Alpha), and the PowerPC during the past 12 months, which reflects this interest in emerging microprocessors. The increasingly competitive x86 market continues to cause price and availability relief as Advanced Micro Devices (AMD), Cyrix, Texas Instruments (TI), IBM, and NexGen legally compete in this area. The 8-bit processor market remains solely with embedded applications, and the 16-bit arena is also quickly ramping up into the embedded areas and in some handheld products. The 32-bit market remains fragmented. A number of competitors vie for a piece of the Intel money pie, Motorola continues to support the aging 68020/030 products, and the 68040 falls victim to the PowerPC. The emerging Pentium and other 32-bit-plus RISC products are on the high end of the price/performance curve, but will gradually come down the learning curve during the next two to three years.

Figure 1-2 highlights the early product life cycle for selected CISC 32-bit MPUs, including 1994 estimates for the 486 and 1994 and 1995 estimates for the Pentium. As is shown, each successive generation of a microprocessor exhibits a faster production ramp than the prior generation. This holds true for both 68K and x86 families of microprocessors, although it is much more exaggerated in the case of the x86 family. Figure 1-2 is also an indication as to why the now infamous Pentium "flaw" caused as much flap as it did. When the 486 floating-point bug (differentiated from a "flaw" in that it was a much more serious problem) was discovered, only a few hundreds of thousands of devices had been shipped. By the time the Pentium "flaw" was made public, several million Pentiums had shipped. We have every expectation that the P6 will exhibit a production ramp that exceeds that of the Pentium.

The mature Motorola 68020 products continued to decline in unit volume. Also, the introduction of the PowerPC version of the Macintosh by Apple Computer has seriously curtailed the growth of both the 68030 and the 68040. Growth for these products will depend on the embedded marketplace. It is doubtful that they will see significant growth as standalone microprocessors, but as process technology moves forward, as driven by the PowerPC, these products will be scaled down to the point that they will be used as core processors in Motorola's 683xx family of embedded processors.

Figure 1-2
Production Ramp Comparison



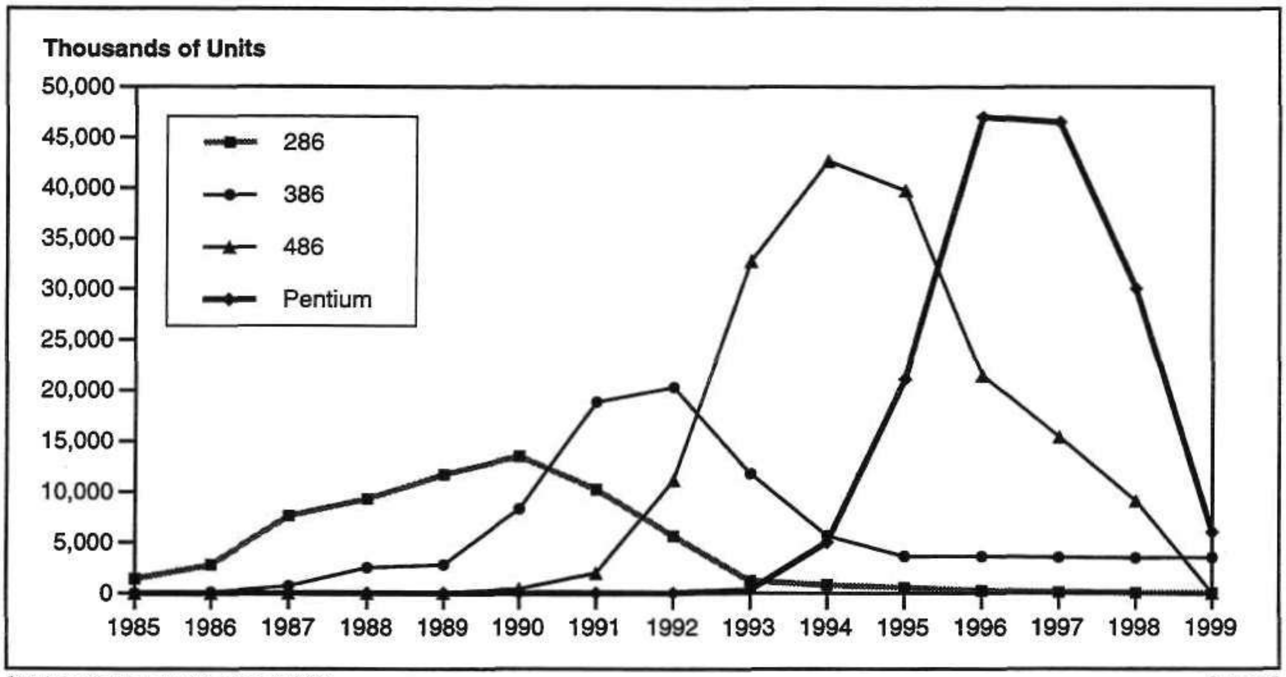
Source: Dataquest (January 1995) G4006959

Figure 1-3 shows the acceleration of the x86 family's shorter product introduction cycle and its faster ramp-up to volume production. Figure 1-4 uses the same data as Figure 1-3, but each x86 category is normalized against the peak production year for each of these individual product categories. The peak year of production for each x86 product category is represented as 100 percent; every other year is represented as a percentage of the peak production year. It is clear that the projected growth for the Pentium is not without precedent. In fact, within a small measurement error, the Pentium exactly matches the relative market penetration rates of both the 386 and 486 microprocessors.

Given the expected run rates of successive generations of microprocessors, and given that each new generation is being introduced in half the time, starting with the P6, we might expect the overall life cycle of the x86 microprocessor to start shrinking. What this means to all suppliers to the PC market is that everyone will have less time to develop new products for the next-generation computers. Because the PC life cycle will also be drastically shortened by this event, there will be less time to recoup R&D costs. In short, the technology treadmill has just doubled its pace.

Now things get really interesting. With everyone running harder to keep pace, the chances of making a mistake are that much greater. Product development teams must hit the right feature set the first time, designers must get the design right, and the products cannot be misprocessed in fab. Any slip in the schedule can cause a company to miss a market window. For some, such slips can be tolerated. For others, with a narrow product line in a highly competitive market, such slips can be devastating.

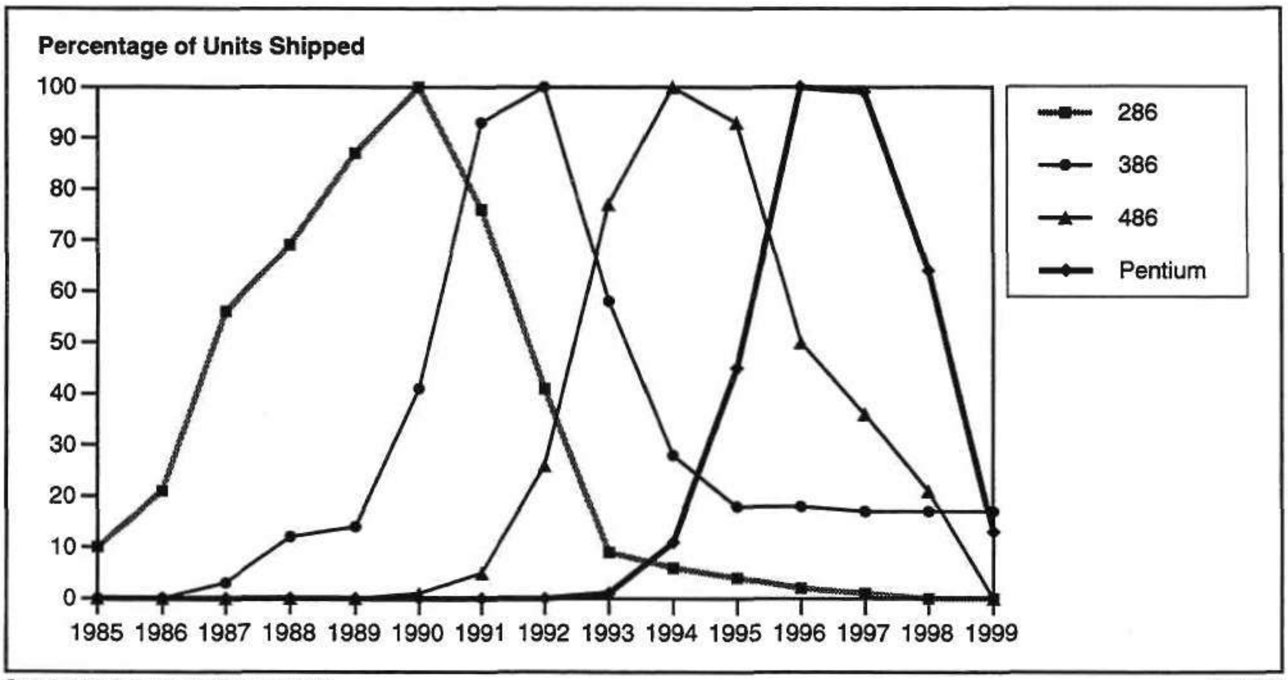
Figure 1-3
x86 Life-Cycle Dynamics



Source: Dataquest (January 1995)

G4006960

Figure 1-4
x86 Life-Cycle Dynamics Normalized



Source: Dataquest (January 1995)

G4006961

This new scenario spells trouble for second-tier players. We will probably see more "shooting star" companies—companies that have no position in the marketplace and can afford to look ahead and put all resources into developing a new technology, capability, or product feature set. Once these products are launched, the company's revenue will soar. Unfortunately, such quick success usually causes the start-up to lose the focus that made it a success, the result being a very hard fall when the new product's life cycle is over. This also means that PC OEMs will have to closely and quickly evaluate some of these new start-ups. Although the chances of their life as successful long-term companies are small, these types of companies will typically be able to provide a value-added product that may mean the difference in a PC's overall feature set.

We expect the traditional desktop computer to continue to rapidly evolve to the next generation's microprocessors, and these will still be the prime focus for OEMs because of the sheer volumes and revenue involved. However, we do believe that the clock-doubled and -tripled 486 microprocessors have sufficient performance to carve out a new niche of low-end computers. We believe that the 486s will have to be priced in the $50 range in 1995 to drive these new applications, and that they will have to continue downward. The cost of other components will have to be similarly reduced. If this occurs, the tail end of production for the 486 will not be truncated by the rapid growth of the Pentium. Instead, it might be extended out further than normal because the price/performance ratio should accelerate the market for low-end desktops and portable devices that have the power to do real work and play some pretty sophisticated games at a relatively low price. We have seen the beginnings of this with the announcement from Apple regarding a sub-$500 computer/game machine called "Pippin," which is based on the PowerPC603. We estimate that the price of this processor will have to fall at about $50 to be cost-effective for Pippin.

Chapter 2
Microprocessor Supplier Analysis

This chapter analyzes the product and market strategies of the leading suppliers of advanced microprocessors and focuses on the top three microprocessor manufacturers: Intel, Motorola, and AMD. Intel increased its lead as the top semiconductor company in 1993 by owning nearly three-fourths (74.1 percent) of the microprocessor market. Suppliers exceeding the average market growth rate of 61 percent in 1993 were Intel (73 percent), Motorola (65 percent), TI (213 percent), and Cyrix (252 percent). Although the growth rates for TI and Cyrix are high, they started from a very small base in 1992. Although 1994 is not exhibiting the growth rates of 1994, it is still coming in at a respectable rate in the range of 25 to 30 percent. This growth over the banner year of 1993 is nothing to be ashamed of. The year 1994 was one of some competition for Intel's 486, albeit limited to the low end. Competitors shipping product in 1994 included AMD, Cyrix, TI, NexGen, and UMC (although UMC is shipping only into Asia/Pacific countries). This competition put severe pricing pressures on the low end of the market. The year 1995 is expected to be very strong because of a relative lack of volume competition from Pentium-class microprocessor vendors.

Intel

Intel remained the No. 1 microprocessor (and semiconductor) supplier in the world in 1993 and 1994 primarily because of the high growth of the 80486 product line. In 1993, Intel ceded the low-margin highly competitive 386 market as an engine for computers; in 1994, it followed the same course with the low-end 486 market. This allowed the company to focus on its mainstay 486 offerings and the quickly growing Pentium products. In 1993, the legal battle over microcode always hindered AMD's efforts to make strong inroads into the 486 market. In 1994, this obstacle was completely removed, but AMD was not positioned with sufficient fab capacity for its highly competitive line of 486s to significantly alter Intel's pricing strategies.

Intel Strategy Remains the Same: Take the High Road

Keeping true to form, Intel flawlessly executed on its higher-technology, higher-priced formula in 1993 and for most of 1994. At the end of 1994, Intel did stumble with the manner in which it initially handled the Pentium flaw fiasco. As we stated in a *Dataquest Alert* in early December 1994, Intel was finally compelled by customer pressure to issue a no-hassle return policy for all "flawed" Pentium processors. We believe that this latest action has allowed Intel to dodge a bullet and may in fact turn into a win for the company. Although the cost of replacing the Pentiums in the field may at first appear to be significant (we estimate it could run from $200 million to $800 million), Intel will gain significant goodwill with millions of early adopters (Intel's favorite kind of customer). Also, with the relative lack of competition for a Pentium-class processor, the company will not be compelled to reduce the selling price of the Pentium as rapidly as it may have earlier estimated.

Although Intel's 1994 growth did not match that of the market (for this Intel can blame DRAMs, which grew in excess of 60 percent), it still exhibited record revenue and profits. The company is extremely well positioned for growth in 1995. It is rapidly making the transition from the 486 to the Pentium, where it has virtually no competition. If history repeats itself, Intel will be relieved of the burden of shipping low-margin 486s by the numerous competitors that are all fighting for market share. This will allow Intel to remain focused on the Pentium conversion because it is not burdened with the necessity of servicing customers that still want the lower-margin product.

Motorola

The rise of Motorola as the No. 2 microprocessor supplier in 1993 was largely because of the increasing acceptance of the 68xxx as a premium embedded microprocessor family, and of the increased competition in the 386 market, which hurt AMD. Besides being the leading volume 32-bit embedded microprocessor to date, the 68000 series ensured continued growth in the near future as the processor of choice for the advanced Sega-Genesis game. In 1994, Motorola suffered a market share setback as Apple began its wholesale move from the 68K family of microprocessors to the PowerPC. Where Motorola was in a sole-source position with the 68K, it found itself on the outside looking in when it came to shipping the PowerPC to Apple. Although Motorola is one of the three members of the PowerPC alliance, the other semiconductor supplying member of the alliance, IBM, was a nearly sole-source supplier of the PowerPC to Apple. We expect Motorola and IBM to start to share this lucrative part of the business as Apple moves on to newer generations of the PowerPC. However, the rewards will not be as high as one might expect because Apple is the third member of the PowerPC alliance and as such will command very good bargaining leverage when negotiating price.

The 68020/030 series now focuses on low-end Apple Macintosh and Powerbook shipments, laser printers, and other embedded applications. Motorola recently announced a new product architecture with the code name "Coldfire" that is compatible with the instruction set architecture of the 68K. This will allow the company to compete at the high end of the embedded market and still capitalize on the venerable 68K family legacy.

Although Motorola is shifting its energy to the fast-growing PowerPC, it finds that the market is not yet developing as planned. The company has been in steady negotiations with IBM and Apple to come up with a specification for an alternate computer to the x86/Microsoft system that dominates the PC market. Most of this specification was finally agreed upon in late 1994, although a few bugs still need to be worked out. Although Apple seems to have agreed in principle to license its operating system to manufacturers of this new platform, the company still seems unsure as to how this will be implemented.

We expect overall unit shipments of the 68K family to grow in the long term because of Motorola's strength in winning high-volume embedded designs outside the computer systems market. Its position in the computing marketplace is totally dependent upon the success of the new PowerPC-based platform specification. Only time will tell if this will truly grow into a competitor for the x86/Microsoft platform, but for now it is getting off to a rocky start. The most recent announcement by Microsoft delaying the shipments of Windows 95 does give the PowerPC contingent a little more time. If Windows 95 running on a Pentium or higher is allowed to gain a foothold in the computer market, then the PowerPC-based platforms running the Macintosh operating system will face a nearly impossible task in the market share battle.

AMD

What a difference a year makes. AMD's short-term focus on the 386 market in 1993 allowed it to gain some breathing room while it got its cleanroom Am486 into production. The Am486 shipped in 1993, but in rather low volume because of fab constraints. As the market quickly migrated to the 486 family, AMD's short-term focus on the very low priced 386 hindered the development of its 486 products and resulted in lower than anticipated revenue. The company's "vindication" in the courts that effectively allows it to use Intel microcode (at least until the end of 1995) set the stage to improve its reputation and revenue stream in 1994. However, fab constraints continued to limit AMD from having the impact on the market it would have liked. The company is taking strides to beef up this capacity limitation. So far, this is a two-prong approach. The first thrust is to build AMD's own state-of-the-art IC fabrication facility in Austin, Texas. This facility, known as Fab 25, is expected to come online in mid-1995. AMD also is negotiating for foundry services and has reached agreements with Digital Equipment Corporation and Taiwan Semiconductor Manufacturing Corporation (TSMC). Digital is expected to produce about 2 million 486 equivalents in 1995, while it is estimated that TSMC will produce 10 million. If this additional capacity comes on as planned, AMD should be in a position to show substantial growth.

AMD is expected to ship its Pentium-class processor in mid-1995. This product looks very competitive on paper and should go a long way toward improving the company's reputation as an innovator rather than as a follower (albeit a rather successful follower). As was the case for the 486, the company will be capacity-constrained with the K5. Fab 25 is not expected to be running at full capacity until the end of 1996. Unless AMD can pull this date in and begin a rapid expansion, it will cede much ground to Intel. Because AMD seems motivated to pull up to Intel as a real threat, we would expect to see more moves to significantly improve capacity in the coming year.

Chapter 3
Advanced Microprocessor Supply Base Analysis

This chapter uses information on MPU product life cycles and suppliers to present a product family evaluation of the supply base over the long term for CISC 32-bit and RISC 32-bit MPUs. This chapter also includes information on the global MPU fab network of key suppliers.

The advanced microprocessor market in many ways became more competitive in 1994, while also remaining monopolistic at the very high end of the technology spectrum. The result is an increased challenge for procurement managers, component engineers, and system designers of system companies concerning the choice of product, let alone supplier. This chapter combines product life-cycle and key supplier analysis to summarize the anticipated MPU supply/supplier base from a user's perspective. The summary addresses whether the user faces a favorable or critical supply base for each family/device. This chapter builds on prior sections and discusses factors affecting the supply base such as supplier strategies and strategic alliances.

Supply Base for 32-Bit MPUs

x86 Market Keeps Going and Going and Going... (with Intel in the Driver's Seat)

The growth of the x86 market in 1994 highlighted that the future of this product family lies with the 486 and Pentium-class series of processors. The addition of competition further strengthens an already strong market position for this family, resulting in a solid supply base of more competitively priced products for the future. AMD in 1993 became the big fish in the shrinking 80386 pond (80386 share of 32-bit shipments dropped from 23.5 percent in 1992 to 10.0 percent in 1993), with more than 90 percent of all shipments of this product. For the time being, the legal cloud surrounding AMD's role in the 486 market has evaporated. This will result in a more secure supply base of this important processor family when AMD lines up more fab capacity for 1995 and beyond. The current focus on the 486 market by the group of competitors now numbering six (Intel, AMD, Cyrix, TI, United Microelectronics Corporation, and IBM) promises to provide users with continued variety and price improvements, at least at the low end.

68K Market in the PowerPC Era

Motorola Continues to Embed 68xxx Processors while Focusing on PowerPC Gold

Now that the PowerPC is taking over the computer sockets from the 68K family, the fastest-growing segment of Motorola embedded processors is the 683xx series. Within this series there are three categories: the low-end 000 core, the midrange 020/030 cores, and the high-performance LC040 core. Motorola will continue to support existing customers of its 68020/30/40 products and has an upward migration path for them either with the 68060 or the recently announced Coldfire architecture that is targeting a higher performance point while still providing some level of compatibility with existing 68K source code. The continued emphasis on embedded

MPU applications will continue to keep the fabs full, but at a lower price than that enjoyed by the computer MPUs.

Motorola realizes that, as the shift to the PowerPC evolves, there will be a commensurate near-term revenue loss from the shift of existing Motorola-supplied 68030 and 68040 microprocessors for the Macintosh to IBM-supplied PowerPCs—thus the accelerated focus on embedded designs.

Open System RISC Processors

Dataquest segments the open system RISC (OSR) market to include the following processor families: Alpha, MIPS, PA-RISC, PowerPC, and SPARC. This class of RISC-based microprocessors is focused primarily on computing platforms, with a secondary focus on embedded applications.

Alpha Family

- Digital Equipment Corporation has put much effort into carefully crafting the Alpha microprocessor into a high-performance core of its own PC and other computer businesses while simultaneously working to make the family a standard RISC architecture used by others. As an early adapter of Windows NT, Digital's market position and aggressive independent software suppliers, plus direct PC distribution channels, give it a good head start on other RISC-based Windows NT PC companies. The major downside is the lack of alternate sources for the part other than Mitsubishi, which has no experience in the development or marketing of microprocessors. Digital continued to announce faster versions of the Alpha in 1994. Also, Digital in October 1994 announced its latest product, which contains more than 9 million transistors. A large portion of these transistors is used in the company's extremely large on-chip cache. This latest Alpha contains 104KB of on-chip cache.

Although Digital is going full tilt to promote the Alpha, the slow ramp of Windows NT as a mainstream desktop operating system is hindering its efforts. It has correctly focused on computer applications, and what it needs now is another processor supplier and a creative method of better marketing this advanced product family.

MIPS Family

- Unit shipment of MIPS processors grew a meteoric 206 percent in 1993 and is seeing strong growth in 1994. This growth is fueled by large shipments of chips from the top three suppliers—LSI Logic, IDT, and NEC. Besides shipments to Silicon Graphics (the lone computer user), 1993 saw large MIPS product growth in embedded applications such as laser printers and X terminals. Some of the more significant events that affected the MIPS world are as follows:

- LSI Logic announced in June its LR33120 GraphX processor, based on the R3000, claiming to be the fastest X terminal solution.

- Nintendo and SGI announced an agreement to develop a 3D Nintendo machine for home use, based on a version of the MIPS Multimedia Engine (a 64-bit MIPS RISC MPU chipset).

- Sony Corporation previewed the use of the R3000 as a basis for an advanced multimedia audio processor, aimed at entertainment equipment, called the Playstation.

Unless vendors such as NEC and Acer start a full-court press to establish a position for MIPS PCs, the prospects for this family in the PC market look dim. On the other side of the coin, strong growth in embedded applications will allow for continued growth of the product line, however, at the cost of fewer suppliers.

PA-RISC Family

The PA-RISC processor family made some significant moves in 1993 that were targeted to renew market momentum for this high-performance product line. After a six-year nascent period (the PA-RISC was first developed in 1987), this processing platform went after alternate sourcing support to help establish the architecture as an industry standard. Thus far, these agreements have had little impact on the market.

Part of the reason for the architecture's lack of industrywide acceptance is that HP's production model for the PA-RISC platform is systems-profitability-based, while the new alliance suppliers are using a device-profitability model. For PA-RISC to gain broad market acceptance, Hewlett-Packard as a leading computer supplier needs to enter the RISC PC market and be the architecture standard-bearer. Additionally, if HP wants its semiconductor-oriented partners to succeed in proliferating the architecture, HP must look at PA-RISC profitability from the same perspective as does its partners. Without such a common viewpoint, it is unlikely that the PA-RISC architecture will succeed in becoming an industrywide standard. Except for a few captive embedded designs, other embedded applications for this processor will grow slowly.

PowerPC

This processor family, which was jointly developed with IBM and Apple Computer, became the largest-selling RISC product in its first year of production, overtaking the MIPS microprocessor family. Applications run the gamut from PCs to workstations and then on to using the PowerPC as a high-performance future platform for embedded applications. Although both Apple and Motorola have hitched their stars to the PowerPC wagon, the third horse in the team, IBM, has not been as clear with its PowerPC plans. Although IBM was the chief beneficiary of Apple's switch to the PowerPC (IBM Microelectronics shipped nearly all of the 2 million units that shipped in 1994), it is having problems releasing a PowerPC-based system of its own. While acknowledging that changing horses midstream is difficult (especially if the Intel horse is not dead yet), IBM and its PC Company continue to send mixed signals regarding processor support. The quick adoption of the PowerPC as a standard processing platform could be at stake—the emphasis being on "quick." The recently announced agreement regarding a specification for a PowerPC-based platform that will run the Apple operating system is not scheduled to result in hardware platforms until mid- to late 1996. Such a late entry will make the x86/ Microsoft combination very difficult to overtake.

SPARC Family

The year 1994 is when the SPARC family of processors stepped down as the leading RISC microprocessor for computer applications, overtaken by the PowerPC for this high-profile position. In 1993, the SPARC processor group, dominated by Sun Microsystems, moved to disassociate itself from its largest benefactor and hindrance (Sun) by providing a technology road map targeting three design series. The low-end MicroSPARC targets embedded applications, the midrange SuperSPARC aims at the PC business, and the high-end UltraSPARC (with more than 200 SPECint performance) shoots for advanced workstation designs. Some of the key events that impacted this market in 1993 were as follows:

- The SPARC vendor base was reduced by one when Fujitsu bought the ailing Ross Technology Division from Cypress.
- Sun announced the SPARC Technology Sun Business (STB), whose charter is to market Sun-developed SPARC processors, system product designs, and software. As part of STB, Sun entered the merchant semiconductor market by offering SPARC processors and support ASIC chipsets.
- Sun and Fujitsu formed a partnership to design and produce the next-generation MicroSPARC II, which began shipping in October.
- TI released 50- and 60-MHz versions of the SuperSPARC and extended its partnership with Sun to incorporate the development and production of the first UltraSPARC I product, a 64-bit processor designed to reach more than 200 SPECint performance.

Although the SPARC family was the largest computer volume OSR family, it continues to mirror the loss of market momentum suffered by its largest computer user, Sun. Despite the good efforts of the STB and recent design wins by Fujitsu and LSI Logic, the overall outlook for large embedded shipments in the near term is dim. The only product seeing success is the product used by Sun, and that is the SuperSPARC. As the UltraSPARC becomes available, it will supplant the SuperSPARC as the dominant SPARC product.

Dataquest Perspective

The advanced microprocessor market continues to change, and 1994 was no exception. The x86 arena is unfettered by legal intrusions, and the RISC segment appears to have a new volume leader in the making with the PowerPC. Transferable advanced software (such as Windows NT) appears to be the common denominator determining market acceptance for new processors, confirming that both hardware and software are now key factors in users' decisions regarding high-performance systems. Each RISC architecture has an organization promoting the openness of each processor's architecture. This effort is an attempt to gain broad software support from third-party ISVs, as well as advanced operating system support.

The x86 market continues to grow at very strong rates, all the while with Intel firmly in control of this technology-driven moneymaking machine. By playing technology leapfrog with its increasing number of competitors, Intel continues to control the lucrative high end of the market and simultaneously sows the seeds for additional x86 sales by ceding the low end to competition where price is the main decision factor. AMD's past focus on the Am386 without a cleanroom Am486 as an encore allowed Motorola to regain the No. 2 MPU supplier position in 1993. However, this win by Motorola was short-lived because the PowerPC transition caused 68K family revenue to shrink in 1994. Although the legal hurdles of 1993 have been passed, AMD still released a cleanroom 486 this year. When the company releases its forward-engineered K5 product in the middle of next year, it will take a giant step in gaining control of its own destiny in the microprocessor computing marketplace. Motorola's balanced mix of embedded products and now a multisourced RISC core will continue to provide users with a wide selection of price/performance options rivaled only by Intel. IBM's Blue Lightning product (board-level clock-tripled licensed 80386) has received technological approval but in many cases has been upstaged by Intel's 486DX4 marketing machine. Both Cyrix and TI gained ground in the 1993 MPU price war despite the two companies' falling out regarding foundry access. Now that Cyrix has captured both SGS and IBM as foundry and second-source partners, it hopes that its foundry woes are far behind it. Cyrix has run into some trouble with its Pentium-class processor with the code name "M1." The die size of the M1 was recently announced at 20.3 x 19.4 mm^2. That is not a manufacturable die size. Cyrix will have to relayout the M1 and optimize it for an advanced process. Such a large die in this world of high volume is not a practical product position. Until the company can get its higher-performance products to market quickly, it will be forced to fight it out in the very competitive low end of the 486 market.

The OSR market continues to rightly focus on price/performance advances over CISC alternatives, and many suppliers have put the infrastructure in place, which is needed by mainstream system users (common advanced operating systems and second sourcing, among others) to better facilitate market acceptance. Operating systems and software applications continue as critical elements of success in the conservative CISC-versus-RISC architecture selection process. The bottom line remains as follows: If an end user can purchase a hardware platform that can competitively run a wide variety of software applications, the user will opt for the software-flexible hardware. However, Windows NT, once considered the main vehicle to slow down Intel, has had little impact on the mainstream market. Now that Microsoft is readying Windows 95 for release in the second half of 1995, it appears that the x86 architecture will become even more firmly entrenched. Windows 95 is written for the x86 architecture and will form a considerable barrier to alternate microprocessor architectures and operating systems.

(Note: This report was prepared with the assistance of Mark Giudici of Dataquest's Semiconductor Procurement Worldwide service.)

For More Information...

Jerry J. Banks, Director/Principal Analyst .... (408) 437-8677
Internet address .... jbanks@dataquest.com
Via fax .... (408) 437-0292

Dataquest
a company of The Dun & Bradstreet Corporation

Dataquest

a company of
The Dun & Bradstreet Corporation

Corporate Headquarters
Dataquest Incorporated
1290 Ridder Park Drive
San Jose, California 95131-2398
United States
Phone: 1-408-437-8000
Facsimile: 1-408-437-0292

Dataquest Incorporated
550 Cochituate Road
Framingham, Massachusetts 01701-9324
United States
Phone: 1-508-370-5555
Facsimile: 1-508-370-6262

Asian Headquarters
Dataquest Japan K.K.
Shinkawa Sanko Building, 6th Floor
1-3-17, Shinkawa, Chuo-ku
Tokyo 104
Japan
Phone: 81-3-5566-0411
Facsimile: 81-3-5566-0425

Dataquest Korea
Trade Tower, Suite 3806
159 Samsung-dong
Kangnam-gu, Seoul 135-729
Korea
Phone: 82-2-551-1331
Facsimile: 82-2-551-1330

Dataquest Taiwan
3/F, No. 87 Sung Chiang Road
Taipei
Taiwan, R.O.C.
Phone: 886-2-509-5390
Facsimile: 886-2-509-5660

European Headquarters
Dataquest Europe Limited
Holmers Farm Way
High Wycombe, Buckinghamshire
HP12 4XH
United Kingdom
Phone: 44-1494-422722
Facsimile: 44-1494-422742

Dataquest GmbH
Kronstadter Strasse 9
81677 München
Germany
Phone: 49-89-930-9090
Facsimile: 49-89-930-3277

Dataquest Europe SA
Tour Franklin
Cedex 11
92042 Paris-La-Défense
France
Phone: 33-1-41-25-18-00
Facsimile: 33-1-41-25-18-18

Dataquest ICC
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

Representative Agencies in
Bangkok, Hong Kong,
Kronberg, North Sydney,
Singapore, and Tel Aviv

Dataquest