1989 SAM Newsletter Index

The enclosed SAM Newsletter Index is a quick reference guide to the SAM 1989 newsletters. It is structured as follows:

I. COMPANIES

Newsletters are organized by company name.

II. EQUIPMENT

Newsletters are arranged in chronological order by end-equipment subject as follows:

Automotive
Communications
Components
Consumer
Data Processing
Forecasts
Industrial
Military

III. INDUSTRY PERSPECTIVES

Newsletters are arranged in chronological order by general industry subject as follows:

Conferences/Shows
Purchasing/Procurement
U.S. Competitiveness

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IV. SEMICONDUCTORS

Newsletters are arranged in chronological order by component product/technology subject as follows:

- Analog
- ASICs
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- DSP
- Equipment
- Inventories
- Memory
- Microcomponents
- Optoelectronics
- Packaging
- Quality
- Standard Logic

The newsletter month and year follow each title listing in the index. Refer to the month tab to locate a specific newsletter.

This index is updated quarterly.

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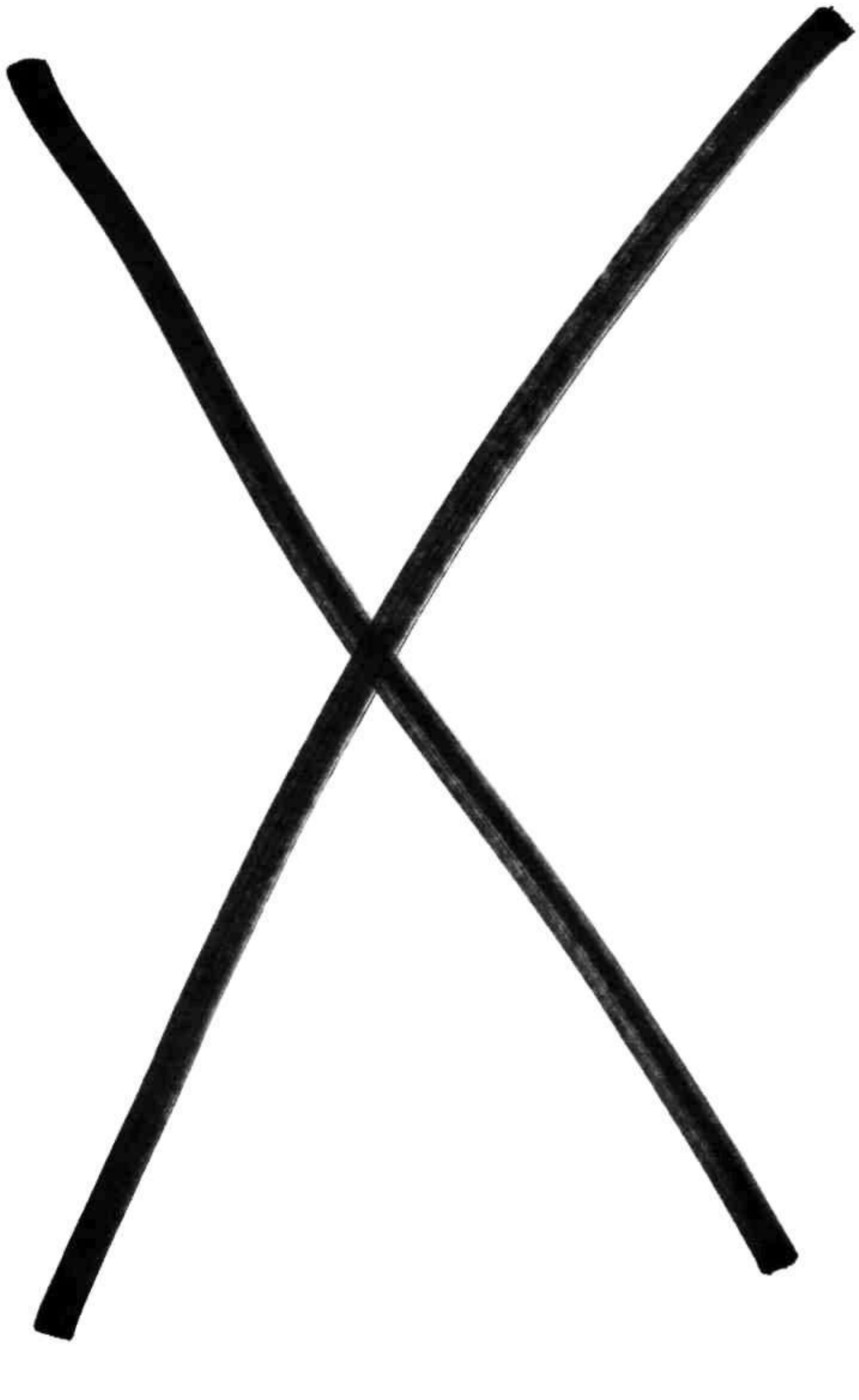

January–March

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

- **High-Definition TV: Is America Finally Waking Up?** (1989-01)—The U.S. Department of Defense (DOD) has announced its intention to finance the development of an advanced, high-resolution video display screen. This bulletin discusses the implications for national security and the challenges of launching high-definition television (HDTV) in the United States. Dataquest concludes that the United States must become involved with the development and manufacturing of HDTV products to preserve its economic and military health.

- **January Procurement Survey: Order Rates Remain Unchanged as Inventory Levels Decline** (1989-02)—Respondents to this month's survey noted that inventory levels were reduced and that targeted levels also declined. This bulletin discusses the current actual versus target semiconductor inventory levels for all OEMs and for computer OEMs. Dataquest concludes that the overall electronics industry is relatively healthy, and the outlook is for a realistically steady growth year in 1989.

- **Northern Telecom: Strategy, Technology, and Semiconductors** (1989-03)—Northern Telecom has become one of the world's largest suppliers of telecommunications equipment. This newsletter focuses on the company's $260 million consumption, $140 million procurement, and $120 million production of semiconductors. Dataquest recommends that Northern Telecom (and the other participants in the industry) continue to tighten the links between design, manufacturing, and marketing to be able to respond as quickly as possible to changing customer needs.

- **Unisys: Successful Merger, Bright Future** (1989-04)—Unisys, formed in 1986 by the merger of Sperry and Burroughs, is a fine example of the power of synergy. This newsletter discusses the company's directions, product line, divisions and subsidiaries, and semiconductor procurement. Dataquest concludes that compatibility, leverage, and cost control are perhaps the best terms to describe the success of the Unisys merger.

- **IBM's 3090-S Series: Market Impact, Future Trends, and Directions** (1989-05)—IBM's recent introduction of the 3090-S systems is a key step in the company's increasing dominance of the mainframe market. This newsletter discusses the following:

  - Why the S series was introduced at this time
  - How the S models and E models compare on price and performance
  - The effect on Amdahl, NAS, and the Japanese suppliers
  - What IBM might do next

January-March

- **February Procurement Survey: Lead Times Fall while Order Rates Stabilize** (1989-06)—Lead times for semiconductors are improving and order rates are steady, yet overall inventory levels have increased since last month's survey. This bulletin discusses the current actual versus target semiconductor inventory levels for all OEMs and for computer OEMs. Dataquest concludes that the easing of lead times and coinciding increases of inventory levels may be an aberration that will smooth out as companies strive to achieve their targeted goals.

- **The Cost Of Quality: Prevention Versus Cure** (1989-07)—The total cost of a semiconductor component can be broken down into three main categories: unit price, inventory cost per unit, and rework costs due to component or system failure. This bulletin discusses the break-even point where the preventative cost of quality and the remedial cost of quality are equal. Dataquest concludes that by analyzing quality costs, one can quantify where improvements are needed and prove the adage that "Quality is free."

- **Chips and Technologies Enters the Mass Storage Controller Business** (1989-08)—Chips and Technologies' newly formed Mass Storage Organization announced its first drive controller chip set, the Micro Channel Fixed Disk Adapter CHIPSet, on February 21. This bulletin analyzes the company's strategy and estimates the hard drive controller market. Dataquest concludes that the entry of a first-rate chip set vendor such as Chips and Technologies into this market will have a catalytic effect, enhancing competition and therefore innovation among all chip set manufacturers.

- **March Procurement Survey: Equipment Sales Up, Orders and Lead Times Down** (1989-09)—This month's respondents continued to see overall lead times fall as system sales climbed relative to February. This bulletin discusses the current actual versus target semiconductor inventory levels for all OEMs and for computer OEMs. Dataquest concludes that as the current business cycle rolls on, the specter of semiconductor supplies overshooting aggregate demand is rearing its disruptive head.

- **Global Competitiveness: The Six-Front War** (1989-10)—Today we find the battle of high-technology competitiveness being fought on six fronts: high performance, quality, lower costs, smaller sizes, standards, and pervasiveness. This newsletter explores these six fronts of competition and their implications for semiconductor users and suppliers. Dataquest concludes that the dedication to understanding customers' needs and providing quality products, service, and solutions to meet them are the most important success factors governing a company's future growth.

- **Storage Industry Update 1988 Perspective—Outlook for 1989** (1989-11)—Most storage industries experienced interesting scenarios in 1988. This newsletter discusses rigid disk, tape, flexible disk, and optical disk drives. Dataquest concludes that 1989 should be a good year.

January–March

- **ISDN: Plans, Potentials, and Pitfalls (Part 1—The Network)** (1989-12)—Integrated Services Digital Network (ISDN) is the next logical step in the digital upgrade of the U.S. telephone network. This newsletter focuses on the ISDN program at the network level as a preview of the implications of ISDN to equipment and semiconductors (to be covered in future newsletters). Dataquest concludes that the United States will experience the beginnings of an all-electronic society in the early 21st century.

- **Hewlett-Packard: Semiconductor Consumer and Manufacturer** (1989-13)—During 1988, Hewlett-Packard (HP) reached two very significant milestones: it turned 50 years old and it posted its first $10 billion year. This newsletter discusses HP's captive versus merchant considerations and solutions, semiconductor technology and manufacturing, and procurement practices. Dataquest concludes that HP's open-minded approach to semiconductor procurement will continue to provide rich and growing opportunities for linear, standard logic, and specialty memory products in the foreseeable future.

- **Intel Introduces First Commercial 64-Bit Microprocessor** (1989-14)—On February 27, Intel Corporation introduced the first 64-bit microprocessor (the i860) that integrates onto a single chip computing capabilities typically associated only with supercomputing systems and three-dimensional graphics workstations. This bulletin discusses the features of the new chip. Dataquest concludes that the modularity of the i860's design suggests that the newly introduced product is only the first in what may become a family of application-specific RISC processors from Intel.

- **Strategic Implications Of Living In A DRAM Technology-Dependent World** (1989-16)*—At Dataquest's recent Semiconductor User and Applications Group Conference, users and suppliers of cutting-edge semiconductors such as DRAMs and ASICs expressed deep concern about industry survival, given the challenge of technology dependence. This newsletter focuses on the serious strategic implications for systems manufacturers and chip suppliers in a technology-dependent world. Dataquest concludes that suppliers should make the necessary capital expenditures and strategic plans so that their companies can profitably survive over the long term by dependably meeting user demand for cutting-edge semiconductors such as DRAMs and ASICs.

*The number 15 (e.g., 1989-15) has been omitted.

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Research Newsletter

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1989–16
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STRATEGIC IMPLICATIONS OF LIVING IN A DRAM TECHNOLOGY–DEPENDENT WORLD

SUMMARY

At Dataquest's recent Semiconductor User and Applications Group Conference, users and suppliers of cutting–edge semiconductors such as DRAMs and ASICs expressed deep concern about industry survival, given the challenge of technology dependence. As shown in Figure 1, long–term demand for DRAMs should remain competitive, with personal computer manufacturers expected to use 56.5 percent of the worldwide DRAM production during 1990. This newsletter focuses on the serious strategic implications for systems manufacturers and chip suppliers in a technology–dependent world.

IMPLICATIONS OF TECHNOLOGY DEPENDENCE FOR SYSTEMS MANUFACTURERS

Technology dependence is defined here as a state of reliance on other suppliers for leading–edge DRAMs, ASICs, and other related product technologies. For semiconductor users, the central issue surrounding technology dependence concerns the number and dependability of suppliers of critical components. Users are concerned about whether there is a single source or multiple sources, whether the source is located locally or overseas, and if a single source, if that source operates multiple worldwide fabs that provide the same advanced manufacturing process and quality standards for a required component. For semiconductor suppliers, the issue of concern is the source of the intellectual property (or technology process) needed to make the chip.

As shown recently, systems manufacturers' technology dependence periodically translates into critical spot shortages of cutting–edge semiconductors as well as higher average selling prices (ASPs) for these devices as compared with worldwide systems competitors. Spot shortages and higher ASPs mean a loss of revenue and profits for systems manufacturers. More precisely, spot shortages cut system unit sales immediately and narrow or kill the window of opportunity for planned new systems. Similarly, higher chip ASPs increase systems' cost of goods sold, reducing profit margins and/or pricing competitiveness.

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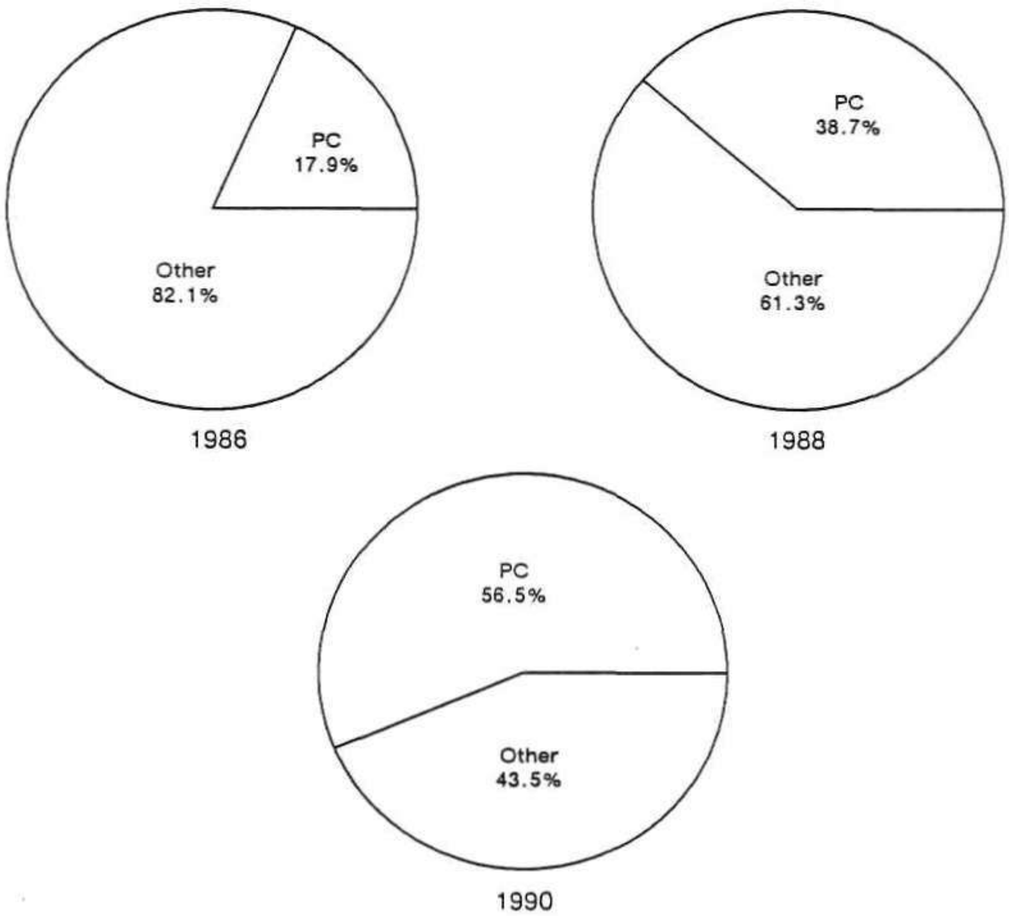
Figure 1

Estimated PC DRAM Consumption as a Percentage of Worldwide DRAM Production



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Source: Dataquest
March 1989

THE LONG-TERM DRAM PROCUREMENT CHALLENGE

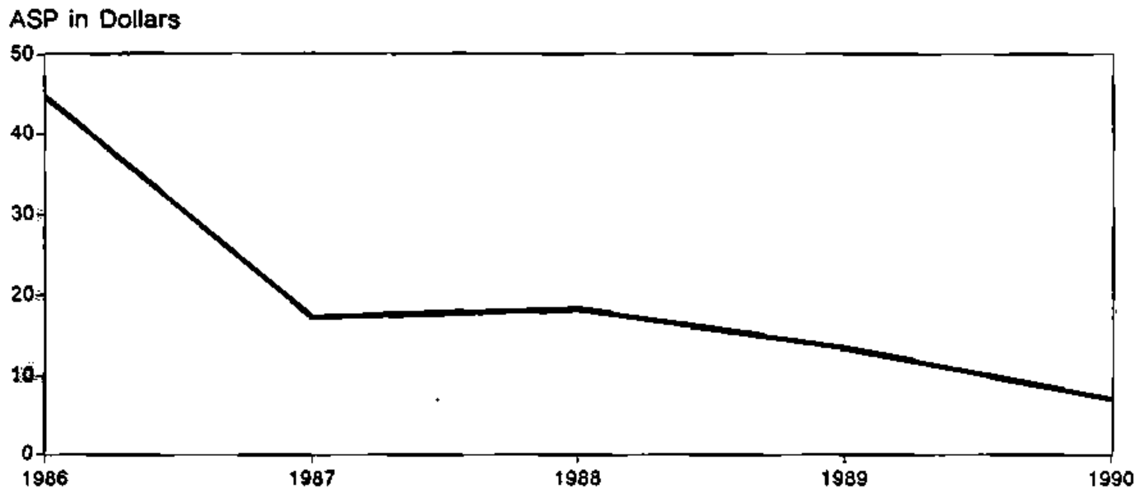
During our conference, users verbally conveyed the message that the procurement of DRAMs (especially specialty DRAMs) ranks as the number one procurement issue of 1989 and beyond.

DRAMs serve as prime examples of technology dependence for worldwide users of semiconductors. North American, European, and Rest of World DRAM users are dependent largely on Japanese suppliers for the DRAM product. During 1988, DRAM technology dependence translated into price disadvantages for North American and European buyers of DRAM vis-à-vis Japanese users.

There is some good news for users of 1Mb DRAMs this year, as shown in Figure 2.

Figure 2

Estimated North American 1Mb DRAM ASPs (100,000 Units)



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Source: Dataquest March 1989

This figure shows a consistent long-term decline in the price for 1Mb DRAMs. The ramp in supply of 1Mb DRAMs should be balanced by demand by early third quarter. Even so, the dynamics of DRAM supply-demand remain quite complicated. In terms of the technology dependence issue, during 1989, North American, European, and Rest of World DRAM users can expect to pay premiums of 18 to 21 percent over Japanese pricing.

In addition, users at the conference consistently expressed dismay that the current ramp in 1Mb DRAM supply misses users' needs and will continue to do so for the foreseeable future.

Unsatisfied DRAM Demand

From these users' perspectives, there will be plenty of 1Mb DRAMs for users at a declining price over the long term—but only regarding the 1Mbx1 device in plastic DIP with an access time of 100ns or greater. For many users, a crying need exists for supply-limited 1Mb DRAMs that operate at 80ns or less, and/or in the 256Kx4 configuration, and/or in a surface-mount SOJ package, as well as specialty products like video RAMs.

For current and prospective DRAM suppliers, production of these devices offers a significant profit opportunity. Premiums for faster speed, surface-mount packaging, and more complex configurations typically run in the range of 10 to 20 percent over the commodity-type counterpart, and as much as 40 to 60 percent during times of spot shortages, as now occurs with the 256Kx4 devices.

The Impact of the DRAM Crunch on the Supply of Other Semiconductors

Life in a DRAM-hungry world also means spot shortages and erratic pricing for other key semiconductor products. The DRAM-related impact on semiconductor supply and pricing is as follows:

- Slow SRAMs—direct and great
- High-speed MPUs—indirect but noticeable
- Fast SRAMs—little and unnoticeable

Users of slow SRAMs (especially the 8Kx8 devices) have experienced a supply crunch for the past year to year-and-a-half. The continuing shortage stems directly from events in the DRAM arena and clearly illustrates the pitfalls of technology dependence of North America and Europe on Japanese technology. From a strategic position, memory suppliers view slow SRAMs as "fab-fillers." During business slowdown periods, these suppliers increase output of slow SRAMs in order to keep their fabs moving, but cut slow SRAM supply (and increase output of DRAMs) when the more lucrative DRAM products are in strong demand. Dataquest expects some relief for users of 8Kx8 and 32Kx8 slow SRAMs by the third quarter of this year; however, the supply of slow SRAMs will remain a long-term function of events in the DRAM world.

For users of high-speed microprocessor components (MPCs), the DRAM supply constraint had an indirect but noticeable impact on their system production and profit targets during 1988. MPCs and DRAMs do not compete for fab space, but shortages of 256K and 1Mb DRAMs (as well as specialty devices now) resulted in system delivery delays, lost unit sales, and higher system prices. The DRAM specter has not disappeared.

MPCs provide another illustration of the disadvantages associated with technology dependence. In this case, Japanese users of high-speed 16- and 32-bit microprocessors pay consistently higher ASPs than North American and European buyers. The explanation is that Japan has traditionally been dependent on North America for microprocessor technology. Even so, Japan is making a determined effort through The Real-time Operating Nucleus (TRON) project to break free from North American technology dependence.

Fast SRAMs provide another example in which North American users (and to a lesser extent, Europeans) enjoy a price advantage over Japanese users. Because the fast SRAM business is a performance-driven marketplace, suppliers of fast SRAMs enjoy many opportunities for product differentiation and thus higher ASPs and profit margins. Because fast SRAMs can be more lucrative than DRAMs, fast SRAM supply is little affected by the DRAM crunch.

In terms of technology dependence and fast SRAM supply/pricing, the many profitable niches in the fast SRAM arena have drawn many suppliers, ranging from start-ups to major North American, Japanese, and European houses, to the North American region. By contrast, Japanese users are largely dependent on large Japan-based suppliers. The competitive fast SRAM environment in North America translates into a price advantage for North American users versus Japanese or European buyers.

TECHNOLOGY DEPENDENCE IN THE FUTURE: ASICs VERSUS DRAMs

For semiconductor manufacturers, memory production has served and continues to serve as the supplier's manufacturing process "technology driver." During the conference speech entitled "ASICs and the Graveyard of Overriding Considerations," Andrew M. Prophet discussed factors that indicate that there may be a parting of the ways in terms of any given semiconductor supplier's process technology into <u>two</u> separate streams—the familiar DRAM stream and the less familiar ASIC stream.

ASIC Technology Dependence

The key point for semiconductor users and suppliers is that a new form of technology dependence—ASIC technology dependence—could emerge. ASIC technology reliance will become an issue in applications that center on lower quantities, faster turnaround, and rapid yield. By contrast, DRAM technology dependence should remain a concern in applications that entail larger volumes, cyclical yield improvements, and cell design optimization.

1989 ASIC Pricing Trends

The long-term scenario of ASIC technology dependence becomes an immediate issue because right now ASIC suppliers, particularly suppliers of 1.5- to 2.0-micron CMOS gate arrays, cell-based ICs (CBICs), and programmable logic devices (PLDs), are waging a fierce pricing battle for ASIC design wins that go into system production during the 1990 to 1992 time frame.

During 1989, all ASIC solutions are declining in price, except for 3.0-micron gate arrays which are being phased out. Most important, gate arrays continue to hold a price advantage over CBICs in terms of price per gate and nonrecurring engineering (NRE) costs, but that edge is narrowing.

For users, total system cost-saving analysis requires users to closely weigh the long-term benefits of using 1.5- to 2.0-micron CMOS CBICs (in larger gate-count applications) versus 1.5- to 2.0-micron CMOS gate arrays. Similarly, CMOS PLDs should be examined for use in systems to be produced in low-unit volumes (approximately 2,000 systems or less) because the avoidance of gate array NRE costs achieved through the use of PLDs typically translates into lower total system cost.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

After careful consideration of this technology-dependent world, we recommend the following to users and suppliers.

For users to minimize the loss of revenue, profits, and overall systems competitiveness associated with technology dependence, systems manufacturers must do the following:

- Seek multiple sources of cutting-edge products like DRAMs, high-speed microprocessors, and ASICs. Ideally, establish both local and overseas sources for these devices.

- Regarding commodity-type products like standard logic, mature 8-bit MPCs, and nonexotic analog ICs, continue to narrow the supplier base. If there is only a sole source to supply your system's critical component, demand that the sole source maintain multiple worldwide fabs for the cutting-edge device, with each fab using an identical technology process, line geometries, and quality standards.

- Given the impending divergence in the semiconductor process technology stream into a DRAM stream and an ASIC stream and in view of your system's total semiconductor needs, search out suppliers on a local and worldwide basis whose fabs can produce both DRAMs and ASICs, including CMOS gate arrays and/or CBICs.

Suppliers should make the necessary capital expenditures and strategic plans so that their firms can profitably survive over the long term by dependably meeting user demand for the cutting-edge semiconductors like DRAMs and ASICs. Profitable opportunities include serving the following:

- North American and European users with DRAMs, especially noncommodity type, and commodity-grade slow SRAMs

- Japanese users with high-speed microprocessors, although the advance of Japan's TRON project will close that window of opportunity to late entrants in the Japanese market and also standard logic, ASICs, and analog ICs.

Ronald Bohn

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Research Bulletin

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0003449

INTEL INTRODUCES FIRST COMMERCIAL 64–BIT MICROPROCESSOR

EXECUTIVE SUMMARY

On February 27, Intel Corporation introduced the first 64–bit microprocessor that integrates onto a single chip computing capabilities typically associated only with supercomputing systems and three–dimensional graphics workstations. The i860 microprocessor contains more than one million transistors and performs up to 80 million calculations per second.

TECHNICAL DETAILS

Features of the new chip include the following:

- 64–bit integer RISC core designed to achieve a performance rate of 86,000 Dhrystones per second at 40 MHz
- Vector floating–point (FP) unit
  - Individual floating–point multiplier and floating–point adder that allow simultaneous FP multiples and adds, resulting in a peak performance rate of 80 mflops at 40 MHz
- 3–D graphics unit that supports high–speed rendering of three–dimensional objects
- Designed to use industry standard DRAMs instead of more costly SRAMs
- On–board 4K instruction cache and 8K data cache
- Manufactured under Intel's patented CHMOS IV, 1–micron double–metal process
  - Die size: 10 x 15mm
  - Package: 168–pin ceramic PGA

- Offered in two speed grades—33 MHz and 40 MHz

  - Samples of the 33-MHz product are available now at $850 each. Production quantities will be available in Q4 of 1989 at $750 in quantities of 1,000.

  - Samples of the 40-MHz product will be available in Q3 of 1989; no pricing was disclosed.

Intel also announced a joint engineering effort under way with AT&T, Convergent Technologies, Olivetti, and Prime to create a multiprocessing version of the UNIX System V release 4.0 operating system for the i860 processor. A beta test version of the software will be available from Intel in Q4 of 1989.

DATAQUEST ANALYSIS

Since sampling of the i860 began last October, customer response has been sufficiently favorable to convince Intel that this product could more than adequately address the high-performance UNIX markets. These markets heretofore have been the bastion of Motorola's 68000 family and, more recently, RISC architectures such as Sun's SPARC, MIP's R3000, and Motorola's 88000. The modularity of the i860's design suggests that the newly introduced product is only the first in what may become a family of application-focused RISC processors from Intel.

Dataquest believes that the i860 was originally designed primarily as a coprocessor for the soon-to-be-announced 80486. This leads to some interesting speculation as to the modularity of the 80486 design, which opens the door for multiple versions of the 80486 as well.

In targeting the i860 toward the high-performance UNIX arena, Intel is abandoning the safety net afforded it by MS-DOS compatibility requirements. To compete in this new arena, the company must display the same aggressive focus and agility that enabled the Intel of old to become the preeminent microprocessor supplier to the PC industry. The establishment of close ties to strategic systems manufacturers in this turbulent market will prove critical.

The announcement of Intel's joint engineering effort with AT&T, Convergent Technologies, Olivetti, and Prime demonstrates Intel's understanding of the importance of such relationships to the success of a new processor. Clearly this represents a step in the right direction, but it remains to be seen whether Intel can generate the momentum required to compensate quickly for its late entry into this market.

The engineering workstation and graphics supercomputer markets are characterized by a growing appetite for processing power. The advent of RISC processors has effectively destroyed preexisting brand loyalties and thrown the market wide open. Although these markets appear open, Intel is entering at a point when competitors have already substantially positioned themselves after 18 months of jockeying for strategic alliances. It will be interesting to watch the world's largest microcomponent vendor play catch-up.

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Kevin Landis
Alice Leeper

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Research Newsletter

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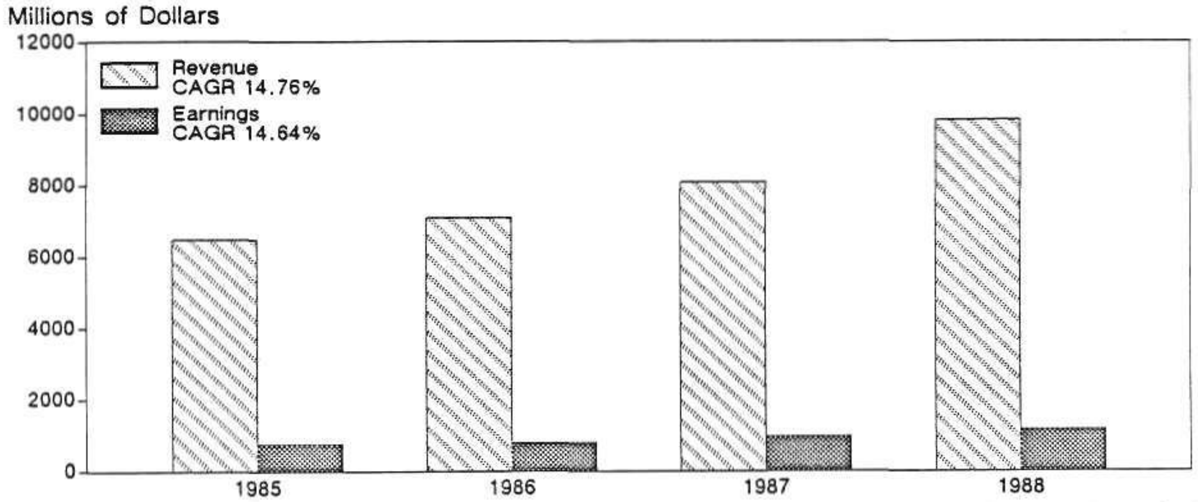
HEWLETT–PACKARD: SEMICONDUCTOR CONSUMER AND MANUFACTURER

INTRODUCTION

During the course of 1988, Hewlett–Packard (HP) reached two very significant milestones; the company turned 50 years old, and it posted its first $10 billion year. The trouble is, HP does not know how to act its age. At 50 years of age and nearly $10 billion in revenue, most firms would be concentrating on maintaining their positions or sustaining moderate growth. All HP has done is to double its revenue over the last five years and grow at an astonishing 21.5 percent from 1987 to 1988. At a time when most firms strive simply to sustain their momentum, HP is accelerating and pushing for leadership in high–growth, highly competitive markets. Figure 1 shows HP's revenue and profit over the past four years.

Figure 1

Hewlett–Packard Financial Summary
(Millions of Dollars)



0003413–1

Source: Hewlett–Packard

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Hewlett-Packard's strategy for sustaining growth has been to maintain a relatively small operating unit size. This has enabled HP to retain the vitality of a start-up, while enjoying the advantages of scale and stability available to a larger, more mature firm. While this strategy has been largely successful in maintaining healthy, steady growth, it does present challenges of coordination.

Semiconductor manufacture is an excellent case in point. In order for captive sourcing to be a viable option, production must be somewhat centralized. Yet to reap the benefits of in-house capability, a close coupling must exist between producing and consuming divisions. Clearly, HP's highly divisionalized corporate structure makes captive sourcing a tricky business.

As a leading-edge manufacturer of a wide array of electronic components and systems for measurement and computation, HP has strived to differentiate itself by offering high-quality, high-performance products. Toward this end, HP has at times elected to manufacture various component parts in an effort to meet customer requirements, push the state of the art, and achieve competitive advantage in its end markets. Based on past success, there is an ongoing and growing appetite for a wide variety of proprietary components within HP.

With no shortage of compelling arguments on either side of the captive sourcing issue, the HP situation and HP's approach to the problems it faces offer an enlightening look into some very thorny issues.

STRATEGIC ISSUES: CAPTIVE VERSUS MERCHANT CONSIDERATIONS

The make-versus-buy decision for semiconductor components is one of the most difficult and complex strategic issues facing equipment manufacturers today. In evaluating the captive sourcing option, the following key issues must be kept in mind:

- Strategic vulnerability
- Competitive advantage in equipment markets
- Objectivity
- Economies of scale

Strategic Vulnerability

As has been made painfully evident by the recent DRAM shortage, equipment manufacturers can be severely impacted by swings in key component markets. For example, an additional 10 percent increase in DRAM prices in 1988 would have reduced HP's net income by approximately 3 percent. Such a high degree of sensitivity to a variable over which the company has literally no control is bad enough, but when considered in conjunction with the cost of lost sales due to limited component availability, the strategic vulnerability of not integrating into the manufacture of key components borders on intolerable.

Competitive Advantage in Equipment Markets

Regardless of HP's success in semiconductor production, the company's prime focus remains firmly on end-equipment markets. It is, therefore, necessary to view the costs and benefits of the captive sourcing issue in terms of their impact on HP's end-equipment business. Having access to a high-capability captive source provides HP's equipment divisions enhanced differentiation as well as the advantage of unique, proprietary capabilities. For example, HP's current family of logic analyzers, introduced last August, features a high-performance, proprietary logic analyzer on a chip that the company believes gives it a substantial competitive advantage over Tektronix, HP's chief competitor in the logic analyzer market.

Objectivity

One of the greatest risks associated with captive sourcing is the loss of objectivity. It is very difficult to view an internal source in the same detached, impartial manner as one would view a merchant supplier. This is particularly true in the case of semiconductors, where the issues of technology transfer, design collaboration, and captive division overhead can obscure other issues, making direct comparison difficult. Additionally, the absence of free market competition not only sacrifices the ability to command the best market price, but more importantly, represents a significant loss of market information. Over time, it is possible for the captive division to unknowingly fall behind the merchant players in terms of manufacturing efficiencies and product technologies.

Economies of Scale

Semiconductor manufacture is perhaps one of the best examples of scale economies in high technology today. As competitive pressures constantly push producers toward state-of-the-art process technologies, overhead, entry, and periodic retooling costs have skyrocketed. This is particularly true of cost-driven products such as mainstream DRAMs and ASICs. In order for captive sourcing of these devices to be an economically viable option for any end-equipment manufacturer, internal demand must be of sufficient volume to justify the substantial overhead involved.

THE HP SOLUTION

HP's decentralized nature makes the task of addressing captive versus merchant issues unworkable at the corporate level. Rather than view this as an obstacle, HP has taken this as a cue to adopting the rather different approach of allowing free competition between merchant and captive suppliers. The beauty of this approach is that it effectively addresses several major issues simultaneously.

The Circuit Technology Group (CTG)

As the sales and marketing arm for HP's captive foundries, CTG calls on divisions within HP as any other vendor would. This allows the chip-consuming divisions within HP to be the ultimate judge of HP's competence and competitiveness as a semiconductor supplier. As an objective and impartial party concerned only with finding the best solution for a given application, the internal consumer tends to buy in-house when looking for a proprietary edge and turns to the merchant market when HP cannot offer a competitive product. In Dataquest's view, the HP approach is both enlightened and pragmatic. By placing the decision in the hands of the consuming division, HP ensures that the correct choice is made.

The arms-length nature of these open market transactions benefits the semiconductor producing divisions as well. By competing with merchant players on an ongoing basis, they are forced to remain competitive and are given constant feedback by the other divisions. In addition, the tapered nature of HP's integration allows it to off-load the risks of demand fluctuation onto the merchant community and to fill surge demand when needed.

If this seems like a lot of trouble to be going through just to maintain a captive capability, it is. But the dangers of strategic vulnerability and the benefits of proprietary equipment capabilities are very real and quite substantial. HP provides an excellent example of the latter, and one need only consider the divergent DRAM positions of IBM and Apple for an example of the former. (In this case, Apple is subject to the considerable costs and exposures of DRAM inventory, while IBM enjoys the luxury of reliable captive DRAM sourcing.)

Corporate Strategy

The really tough issue that firms run up against in trying to retain viable captive capabilities seems to be scale economies. Competitive pressures and trends in manufacturing technologies are successively increasing the minimum size requirements in each of the major chip categories, forcing smaller merchant and captive suppliers out of the business.

In order to directly address this issue, HP seems to have adopted a strategy of maximizing fab utilization through a combination of at-cost ASIC pricing and limited foundry agreements with outside parties. HP's vigorous effort to develop and produce its own RISC processor is probably a better example of seeking a proprietary competitive advantage in the computer market, but an additional benefit will be realized in that IC capacity can be expanded more rapidly to meet this additional demand.

HP seems committed to retaining its ASIC and microprocessor production capabilities, and determined to achieve the production volumes necessary to do so. It remains to be seen, however, whether HP's captive operation can be made to grow fast enough to stay ahead of the ever expanding fab cost spiral. More importantly, it remains to be seen whether HP can continue to capture the lion's share of in-house ASIC requirements and still retain the benefits of genuine competition with the merchant ASIC community.

ELECTRONIC EQUIPMENT MANUFACTURING

As a vertically integrated, worldwide manufacturer of a wide array of products, HP has a far flung, highly decentralized corporate structure. HP has more than 60 divisions worldwide, offering over 5,000 products. Table 1 lists HP's principal component consuming manufacturing operations and its primary end-product descriptions.

Table 1

Hewlett-Packard Manufacturing Divisions

United States

Division Name	Location	Manufactures
Andover Division	Andover, MA	Medical equipment
Avondale Division	Avondale, PA	Electronic instruments
Boise Division	Boise, ID	Printers
Colorado Networks Division	Ft. Collins, CO	Network controllers
Colorado Springs Division	Col. Springs, CO	Electronic test instruments
Colorado Telecom Division	Col. Springs, CO	Telecom test equipment
Computer Manuf. Division	Cupertino, CA	Minicomputers
Corvallis Division	Corvallis, OR	Calculators, workstations
Disk Memory Division	Boise, ID	Disk drives
Ft. Collins Division	Ft. Collins, CO	Workstations
Greeley Hardcopy Division	Greeley, CO	Printers
Greeley Storage Division	Greeley, CO	Tape drives
Lake Stevens Division	Everett, WA	Electronic instruments
Logic Systems Division	Loveland, CO	Logic design systems
McMinnville Division	McMinnville, OR	Medical equipment
Microwave Technology Division	Santa Rosa, CA	Microwave test equipment
Roseville Networks Division	Roseville, CA	Network products
Roseville PC Division	Roseville, CA	Personal computers
San Diego Division	San Diego, CA	Plotters
Santa Clara Division	Santa Clara, CA	Electronic instruments
Scientific Inst. Division	Palo Alto, CA	Test equipment
Signal Analysis Division	Rohnert Park, CA	Test equipment
Stanford Park Division	Palo Alto, CA	Test equipment
Vancouver Division	Vancouver, WA	Printers
Waltham Division	Waltham, MA	Medical equipment

(Continued)

Table 1 (Continued)

Hewlett-Packard Manufacturing Divisions

International

Division Name	Location	Manufactures
Grenoble Networks	Grenoble, France	Networking products
Grenoble P.C.	Grenoble, France	Personal computers
Lyon Manufacturing Systems	Lyon, France	Midrange computers
Boeblingen Computer	Boeblingen, W. Germany	Workstations
Boeblingen Commercial Syst.	Boeblingen, W. Germany	Midrange computers
Boeblingen Instruments	Boeblingen, W. Germany	Analytical instruments
Boeblingen Medical Inst.	Boeblingen, W. Germany	Medical instruments
Walbronn Analytical Inst.	Walbronn, W. Germany	Analytical instruments
Queensferry Telecomm	Queensferry, Scotland	Telecomm test equipment
Queensferry Microwave	Queensferry, Scotland	Microwave test equipment
Barcelona Peripherals	Barcelona, Spain	Printers, drives
Bristol Peripherals	Bristol, England	Disk drives
Yokogawa HP Ltd.	Yokogawa, Japan	Inst., peripherals
Samsung HP	Seoul, South Korea	Inst., peripherals
Panacom Automation	Waterloo, Ontario	Industrial terminals
China HP Ltd.	Beijing, PRC	N/A
HP Mexico	Guadelajara, Mexico	PCs, multiuser systems
HP Puerto Rico	Aguadilla, Puerto Rico	Terminals

N/A = Not Available

Source: Hewlett-Packard

SEMICONDUCTOR TECHNOLOGY AND MANUFACTURING

Consistent with its commitment to remain in the semiconductor manufacturing business, HP strives aggressively to push internal process capabilities. Fab facilities currently under construction in Corvallis, Oregon, and Fort Collins, Colorado, initially will run HP's 0.8-micron BiCMOS process and are planned to switch over to a 0.5-micron BiCMOS process sometime in the early 1990s. Table 2 lists HP's primary semiconductor-related facilities.

Table 2

Hewlett-Packard Chip-Producing Divisions

Location	Technology	Products
Corvallis, OR	CMOS, BiCMOS	ASIC, floating-point uPs
Ft. Collins, CO	CMOS, BiCMOS, Bipolar	ASIC, RISC uP
Loveland , CO	NMOS, CMOS	High-frequency linear
Santa Clara, CA	Bipolar	ASICs
Palo Alto, CA	MOS, Bipolar, GaAs	R&D
San Jose, CA	Bipolar, GaAs	uWave, opto, diode, transistors
Santa Rosa, CA	GaAs	uWave, opto, diode, transistors

Source: Dataquest
March 1989

PROCUREMENT PRACTICES

Semiconductor procurement is coordinated primarily through the Corporate Materials Management Organization (CMM) in Palo Alto, California. Although divisions are free to conduct their own purchasing activities autonomously, CMM strives to act as a centralized procurement hub. By confining its activities to vendor qualification and volume pricing negotiations, CMM hopes to achieve the leverage of a large buyer without compromising division autonomy.

CMM's near-term objectives are assisting divisions in implementing JIT, partnering with suppliers by sharing more information, joint developement of new technology, and eliminating incoming inspection through increased supplier quality. HP takes these objectives quite seriously, and suppliers who are willing to work closely with HP can expect substantial benefits as a result of closer association.

Semiconductor Procurement

The bulk of HP's semiconductor purchases are for memory products, owing to HP's decision not to enter volume production of DRAMs at various times in the early 1980s. HP also purchases large amounts of linear and standard logic devices, for which the merchant market serves them well.

Consistent with the strategy of attaining a proprietary edge at the silicon level wherever possible, HP tends to source internally full custom/exotic components for its instrument products. Workstation and midrange computers are powered by custom in-house RISC processors for the same reason. ASICs seem to be viewed as "strategic silicon" by HP, and are, therefore, sourced internally whenever possible. Finally, microprocessors are sourced externally in those instances where processor differentiation is not deemed desirable, such as within HP's Vectra line of personal computers.

Table 3 presents HP's estimated 1988 equipment revenue and semiconductor content.

Table 3

Hewlett-Packard's Estimated 1988 Equipment Sales and Semiconductor Content (Millions of Dollars)

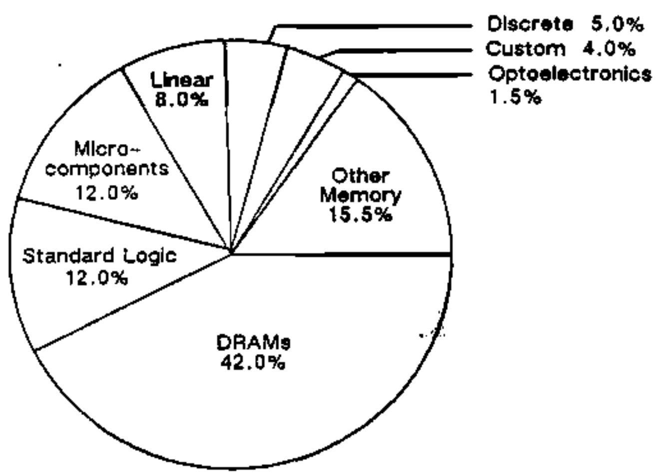
Equipment Type	Revenue	Semiconductor Content
Midrange Computers and File Servers	$2,550	$185
Printers	1,350	235
Personal Computers	650	71
Workstations	645	52
Medical Equipment	545	41
Other Peripherals (Network, Data Storage)	500	34
Analytical Equipment	365	16
Terminals, Alphanumeric	270	20
Hand-Held Calculators	160	20
ATE	105	6
Total	$7,140	$680

Source: Dataquest
March 1989

Figure 2 presents HP's estimated 1988 semiconductor purchases.

Figure 2

Hewlett-Packard 1988 Estimated Semiconductor Purchases



Total = $480 Million

0003413-2

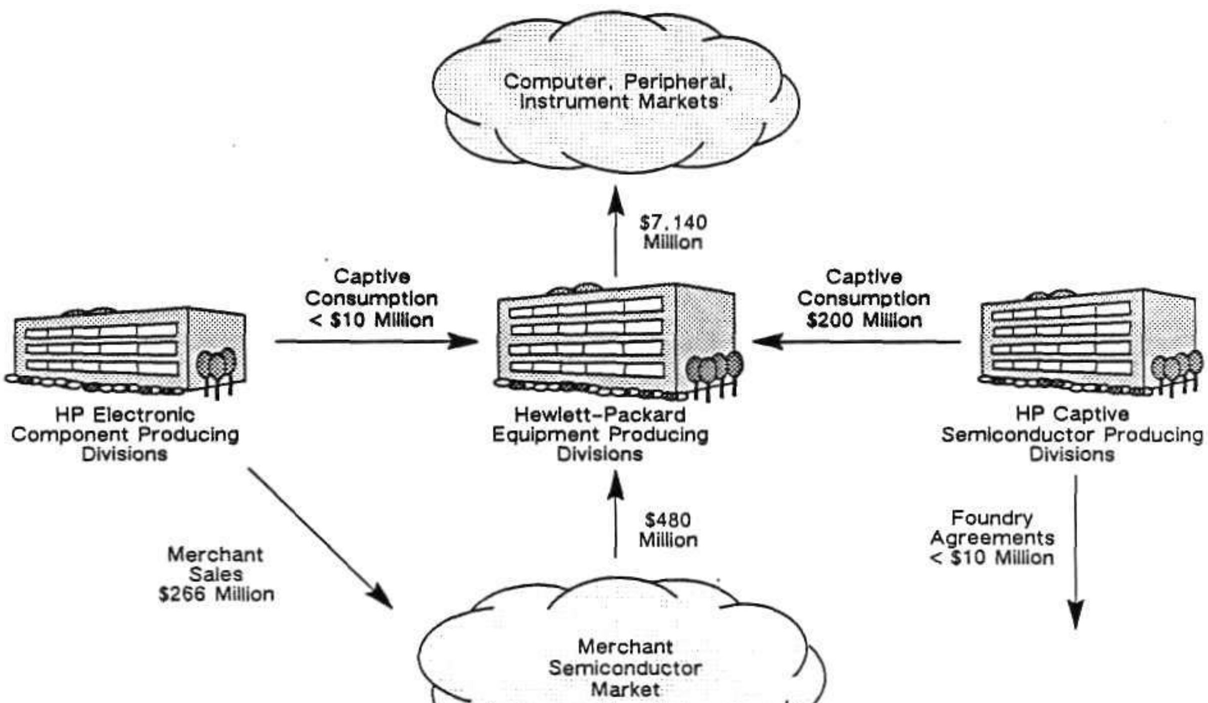
Source: Dataquest
March 1989

DATAQUEST CONCLUSIONS

In trying to maximize captive ASIC production while promoting competition between CTG and the merchant market, HP may be trying to have its cake and eat it too. Furthermore, Dataquest sees a coming shakeout in the ASIC industry in the early 1990s, and it is not altogether clear that HP's internal ASIC requirements, even augmented by outside foundry agreements, will be sufficient to make it a viable ASIC player under the cost structures of the early 1990s. (Figure 3 summarizes HP's semiconductor consumption and production levels.) Nevertheless, HP is to be lauded for aggressively addressing its strategic vulnerability in ASICs in a manner that, at least in the short term, guards against the usual pitfalls of captive sourcing.

Figure 3

Semiconductor Consumption and Production at Hewlett-Packard



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Source: Dataquest
March 1989

For merchant microcomponent suppliers, the message is clear—focus your efforts on those product areas where HP is unlikely to pursue competitive advantage through proprietary captive designs. The message is less clear, however, for ASIC suppliers. HP's interest in maximizing captive custom applications business should relegate the merchant players to addressing only those niche applications for which HP has no ASIC solution. If HP is successful in retaining its captive ASIC capability, it could be a long time before merchant ASIC players see substantial business here.

Memory requirements currently account for over half of HP's semiconductor purchases, and while the expected decline in memory pricing (Dataquest expects the ASPs of 1-Mbit DRAMs to fall another 50 percent within the next 12 to 15 months) should reduce this substantially, it is worth noting that HP's strongest growth products—PCs, workstations, and laser printers—are among the most memory-hungry. Look for HP's demand for memory in bits to continue to surge, even if the dollar value retreats a little this year.

Meanwhile, HP's open-minded approach to semiconductor procurement will continue to provide rich and growing opportunities for linear, standard logic, and specialty memory products for the foreseeable future.

Kevin Landis

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ISDN: PLANS, POTENTIALS, AND PITFALLS (PART 1—THE NETWORK)

SUMMARY

Integrated Services Digital Network (ISDN) is the next logical step in the digital upgrade of the U.S. telephone network. While the digitization of transmission and switching has been under way for the past one to two decades (see Table 1) and is now approximately 60 percent complete, today the local loop remains almost entirely analog. With ISDN, the local loop also will be converted to digital, and an all–digital network will make it easier for computers and other digital machines to use the network.

This newsletter focuses on the ISDN program at the network level as a preview of the implications of ISDN to equipment and semiconductors (to be covered in future newsletters). Both suppliers and users of semiconductors will be affected by the development of ISDN technology for communications.

Table 1

Estimated Penetration of Digital Technology into U.S. Telephone Network Installed Base

	Transmission Portion	Switching Portion	Local Loop Portion
Conversion to Digital	Begun in 1960s	Begun in 1970s	Focus of today's ISDN program
Penetration Estimate			
1984	50%	10%	0
1988	70%	47%	0.04%
1992	80%	78%	0.8%
2000	97%	95%	67%
2010	100%	100%	92%

Source: Dataquest
March 1989

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HISTORICAL PERSPECTIVE

Alexander Graham Bell invented the telephone in the 1870s, and it has benefited from advancements in technology since then. At the component level, the telephone has evolved from relays to vacuum tubes to solid state electronics (e.g., transistors and integrated circuits). For transmission, the technology has expanded from metallic cables to radio waves to geosynchronous satellites to fiber optics.

The actual communications channel in the present telephone network was engineered in the 1930s and was optimized for speech. Since then, there have been innovations such as computers and television. Computers can be made to send data over the present telephone network with the use of modems. The all-digital ISDN, however, will make it easier for computers and other digital machines to access the telephone network. Advanced programs such as broadband ISDN will make it possible to carry television signals to the home over the telephone network.

MIXED TECHNOLOGIES

Telephone service is practically universal in the United States today. An installed base of 238 million telephone units exists in 91 million U.S. households. Upgrading the telephone network usually takes two or more decades, and improvements have to be compatible with existing equipment. A person making a long distance call in 1988, for example, had approximately a 50-50 chance (see Table 1) of having that call routed through an analog switch, a digital transmission link, an analog transmission link, and a digital switch to reach the telephone at the other end. Yet, the caller was probably never aware that so many different technologies were involved just to have a telephone conversation with someone else.

The U.S. telephone network is becoming more digital each year. Although most of the switching equipment (e.g., central office switches and PBXs) and transmission equipment (e.g., multiplexers and microwave radios) shipped in 1988 were digital, this equipment has to work with an installed base accumulated over the last 75 years that is still 15 to 50 percent analog (see Table 2). The older equipment is being removed from service on an accelerated schedule, and Dataquest believes that the U.S. telephone network will be entirely digital early in the twenty-first century.

Besides speech, there is a capability for data communications in the present telephone network. Private digital and packet switching lines are available for this purpose from telephone and packet network companies. (Dataquest estimates that 0.4 percent of the $124 billion communications revenue earned in the United States in 1988 was from packet data services.) These separate voice and data services would be integrated and carried by an all-digital network under ISDN.

Table 2

U.S. Switching and Transmission Equipment Estimates

Equipment	Item	Measurement	Digital Share
Central Office	Lines in Service (1988)	129 million units	49%
	Line Shipments (1988)	14 million units	100%
	Lines in Service (1992)	149 million units	77%
	Line Shipments (1992)	16 million units	100%
PBXs	Lines in Service (1988)	31 million units	84%
	Line Shipments (1988)	5 million units	85%
	Lines in Service (1992)	39 million units	97%
	Line Shipments (1992)	6 million units	100%
Microwave Radios	Shipments (1988)	$480 million	79%
	Shipments (1992)	$527 million	84%
Multiplexers	Shipments (1988)	$975 million	74%
	Shipments (1992)	$932 million	96%

Source: Dataquest
March 1989

ISDN PLAN

The U.S. master plan for ISDN is presented in Table 3. Basic rate access will provide up to three multiplexed digital channels between a telephone company central office and a home or business or between a business PBX and an individual office. Primary rate access will provide up to 24 multiplexed digital channels for PBXs presently connected to a central office with T-1 lines. Dataquest believes that 97 percent of the central office lines will be used for basic rate access, with the remaining 3 percent used for primary rate access.

Both basic and primary rate access will use the existing local loop cabling, which is usually metallic. Broadband ISDN, on the other hand, will require the installation of fiber-optic cables in the local loop for the higher bandwidth needed to carry TV signals. With 91 million U.S. households and a local loop that is typically 2 miles long, more than 175 million miles of optical cable would be needed to implement this version of ISDN. The United States presently requires telephone and cable TV services to be separate in most cases, and the success of broadband ISDN depends on Congress changing that law. Because of these economic and political challenges, Dataquest believes that volume shipments of broadband ISDN equipment will not occur until after the year 2000.

Table 3

The U.S. ISDN Master Plan

ISDN Program	Description
Basic Rate Access	2 64-Kbps channels & 1 16-Kbps channel (2B+D) Voice & data services 144-Kbps combined rate For use in existing twisted-pair local loops
Primary Rate Access	24 64-Kbps channels (23B+D) Voice & data services 1.544-Mbps combined rate For PBXs using T-1 lines in local loop (Europe: 30B+2D, 2.048-Mbps combined rate)
Broadband ISDN (future)	Channels for voice, data, & video services 150-Mbps combined rate (other standards tbd) Requires optical cable in local loop Requires change in Telco/CATV regulations

Source: Dataquest
March 1989

Fiber Optics in Limited Use

Fiber optics is not new to the local loop. Since 1982, optical technology has been used in some feeder lines from the central office to remote terminals, with copper twisted pairs being used between remote terminals and the home. Approximately 100,000 homes are connected to the telephone network using this combined feeder and twisted-pair approach.

Also, 300 of the 1,400 U.S. telephone companies are providing standard cable TV service (which is allowed under very tight restrictions), and optical fiber is planned for a dozen of these systems. About 600 U.S. homes are now connected to an optical cable, and the number is expected to rise to 15,000 homes by the early 1990s.

These initial field installations will provide an indication of how practical fiber optics will be for local loops in the twenty-first century.

ISDN Implementation Time Frames

The projected time frame for implementing ISDN in the United States is presented in Table 4. The 1970s and 1980s saw completion of the proposal phase of ISDN. During the first half of the 1990s, ISDN is expected to be offered to business users in selected areas of the United States. (ISDN field trials currently are being conducted in 15 of the 50 states: Arizona, California, Colorado, Florida, Georgia, Illinois, Massachusetts, Minnesota, Missouri, New Jersey, New York, Oregon, Pennsylvania, Texas, and Virginia.) Each of the seven regional bell operating companies (RBOCs) is conducting ISDN field trials, and AT&T is expected to offer primary rate ISDN services in as many as 70 cities in 1989.

Starting in 1997, Dataquest believes that ISDN will be ready to be offered to the entire United States. Because of the enormous number of local loops and the amount of customer premises equipment affected by ISDN, we expect that this upgrade program will require two or more decades to complete.

Table 4

Projected U.S. ISDN Implementation Plan

Time Frame	Events
1970-1990	ISDN standards defined Field trials completed Public Utilities Commissions approve tariffs
1990-1995	Implementation in selected areas of the United States Lines in service (1995): 6 million units Local loop penetration (1995): 3.6 percent
1995-2015	Implementation across United States Average shipments: 20 million ISDN lines/year Broadband ISDN implementation started

Source: Dataquest
March 1989

Signaling Improvements

Setting up a call from any telephone to any other telephone requires the routing of information through the network to establish the proper series of connections. The systems have continued to evolve from in-band to out-of-band signaling, and the latest version to be adopted for ISDN is CCITT Signaling System #7 (SS7). User benefits of SS7 include better network reliability from improved maintenance and error checking.

DATAQUEST CONCLUSIONS

ISDN is the next step in the evolution of the telephone network. Technology has advanced since the network was last overhauled in the 1930s, and ISDN will thrust telephones forward into the Information Age.

The private sector U.S. telephone system faces political issues because it is regulated by government agencies. Currently, Judge Harold Greene is shaping U.S. telecommunications policy, and he has continued to rule against letting the seven RBOCs engage in manufacturing. Change, however, is perhaps only a heartbeat away, and if the RBOCs (which control approximately 75 percent of the U.S. local loops) ever become vertically integrated manufacturers, merchant suppliers of telecom equipment and semiconductors will face stiff competition from these captive operations. We mention this because the demand for ISDN will be strongly influenced by laws and regulations.

Dataquest believes that ISDN will provide the Unites States with the communications network necessary to promote further progress. There is development and growth in the United States in the areas of desktop publishing, faster and more powerful computers, high-definition TV, high-resolution monitors, laser printers, optical disks, scanners, smart cards, solid-state memory cards, and voice recognition and synthesis. If these developments converge and build on each other, we project that the United States will experience the beginnings of an all-electronic society in the early twenty-first century.

Roger Steciak

Dataquest
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Research Newsletter

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STORAGE INDUSTRY UPDATE
1988 PERSPECTIVE—OUTLOOK FOR 1989

EXECUTIVE OVERVIEW

Most storage industries experienced interesting scenarios in 1988. The rigid disk drive market in 1988 was characterized by severe overcapacity and subsequent price adjustments. Profitability of all market leaders was reduced to a minimum or even to the point of operating losses and inventory writedowns.

The tape drive industry was in hot debate over digital audio tape (DAT), while Exabyte quietly stole the show with 8mm drives, and quarter-inch drives found their home in the robust local area network (LAN) market. We also saw the first real end-user shipments of 3480 plug-compatible tape drives. And, surprisingly, there was actually an increase in demand for half-inch reel products in 1988 as compared with 1987.

The flexible drive industry has become almost a totally Japanese-controlled industry, although new high-capacity devices are being developed in both Japan and the United States.

Optical drives continue on their slow ramp, looking for new applications and markets. During 1988, some major system companies finally introduced subsystems using 12-inch write-once, read many (WORM) drives and automated libraries for archival storage. Digital was first, followed by IBM and then AT&T. Wang Labs also made a heavy commitment to WORM, and Siemens has equipment on order. The announced schedules are such that production volume on these products should pick up during 1989.

We anticipate that 1989 will be a continuation of 1988. Our major concern is the state of the industry and the overcapacity issues. Cautious optimism is in the air as storage companies retrench going into 1989, and we see bright spots in store for the industry in 1989. Each technology segment—rigid disks, tape drives, flexible disks, and optical disks—has its own market characteristics and outlook for 1989. Detailed analyses of each of these technology segments follow.

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RIGID DISK DRIVES

Overview

The rigid disk drive market in 1988 was characterized by severe overcapacity and subsequent price adjustments. Profitability of all market leaders was reduced, with Seagate and Micropolis showing operating losses. As the industry enters 1989, several facts should be noted:

- The retail distribution channels are full of disk drives.
- OEM buyers are rethinking 1989 disk drive purchases.
- Drive prices have stabilized on the low end.
- Price erosion is continuing in the over-200MB market.
- Layoffs by drive makers are accelerating.
- Disk drive component orders have been cut back drastically.
- The cash position of drive makers is dangerously low.

There is little doubt that 1988's turmoil within the rigid drive business will continue in 1989. This section will outline Dataquest's views on the depth of the problems and present a new forecast for 1989.

Industry Capacity Projections

Most of the industry leaders have cut back on production schedules to levels near those of a year ago. Some of the recent production estimates from the leaders are shown in Table 1.

Table 1

Rigid Disk Drives Annual Production
(Thousands of Units)

	Diameter	
Company	3.5-inch	5.25-inch
Seagate	1,800	3,400
Miniscribe	2,000	600
IBM	1,900	500
Micropolis	100	500
Maxtor	100	300
Imprimis	300	1,000
Conner	1,000	N/A
Quantum	500	N/A
Western Digital	1,000	N/A
Estimated Industry Production	8,700	6,300
Dataquest Estimated Market Demand	7,600	6,800

N/A = Not Applicable

Source: Dataquest
March 1989

These figures are supply-side numbers, but generally point to a flat year in production and only a slight increase in sales, reflecting the reduction of existing inventories. Dataquest anticipates actual 3.5-inch production figures for 1989 to be less than the capacity numbers shown. Overall, the supply side indicates a total production estimate for 3.5- and 5.25-inch drives at approximately 15 million units.

What Is the Market in 1989?

Dataquest's personal computer forecasts project that just over 15 million PCs costing more than $1,000 each will be sold. The aftermarket for hard disk devices is slowing dramatically due to saturation over the past three years, so the total small drive market can be estimated to be in the 15 million unit range.

Technical workstations, such as the popular Sun Microsystems machines, are commonly used as diskless computers in corporate or departmental networks. These networks are numbered in the tens of thousands and will not strongly influence the totals of 3.5- and 5.25-inch drive sales.

Dataquest Conclusions

Dataquest had projected sales of 10.3 million units for 3.5-inch drives and 6.1 million units for 5.25-inch drives in 1989. We project that the 3.5-inch devices will reach the 7.6 million mark and the 5.25-inch drives will remain at the 6.8 million record set in 1988. These numbers reflect just under a 2 percent increase in drive sales instead of the 16 percent increase previously anticipated. Dataquest does not expect the 2.5-inch rigid market to develop in 1989, and production volumes of these devices are expected to be only in the tens of thousands.

The high inventories of drive components, manufacturer's finished goods, OEM incoming stores, and retail distribution channels will tend to force a slowdown at all levels of the industry. Further reduction in production rates will damage the industry's profit margins even more; therefore, Dataquest does not expect additional slowing of factories.

The new computer market can absorb the low forecast for production volume. The real elements of risk in this equation lie in the size and nature of current inventories and in the size of the remaining storage aftermarket. Unwieldy inventories or a saturation of the aftermarket could continue the industry's overcapacity problems and amplify the current situation to one of severity.

TAPE DRIVES

Overview

The main question is, "If tape drives typically lag rigid drives by 18 months, can we expect an overcapacity situation or problems in the tape drive segment in 1989 or beyond?" Our answer is one of cautious optimism. We believe that one of the main factors driving the conditions in the rigid market is the change in distribution and integration strategies. In the rigid market, volumes continue to rise, but system integrators are leaving less on the table in terms of business for the third-party add-on vendors. This situation means that large OEM orders become increasingly prevalent and important to the health of any one particular disk drive vendor. We have seen some of this same type of integration activity in the tape drive market, such as the IBM contract with Irwin, but it does not--nor do we expect it to--produce the same results as in the rigid drive market.

Where Has the Tape Drive Market Been and Where Is It Going?

1/4-Inch

Early in 1988, the huge Seagate super-VAR, CMS Enhancements, got into the 1/4-inch tape market with the purchase of North Atlantic Industries' Data Storage Products division. Later in the year, the Japanese audio giant Nakamichi purchased Mountain Computer and firmly entrenched itself in the tape market.

IBM strengthened the presence of 1/4-inch tape by awarding contracts to Tandberg for drives for the AS/400 and to Irwin for the PS/2. These endorsements were good for 1/4-inch drives, but certainly did not forward the QIC standards in the market.

3M is making it possible to have 1GB-plus storage in 1/4-inch form factor by announcing a new generation of tape cartridges. In a separate announcement, 3M was the first to announce an 86MB drive in 3.5-inch minicartridge form factor.

The 1/4-inch market is far from dead in spite of all the DAT hoopla. For the future, we expect moderate growth in the 1/4-inch tape market, for an approximate compound annual growth rate of 20 percent per year over the next four years. We anticipate continued leadership from Archive, Cipher, Irwin, and Wangtek, and growth from Nakamichi-backed Mountain Computer. We will also see production shipments of 320MB 1/4-inch tape drives, 120MB 3.5-inch form factor minicartridge 1/4-inch tape drives, and, perhaps, prototype 1GB 1/4-inch tape drives in 1989.

Helical Scan

Helical hysteria was the focus of industry attention in 1988, and we expect the industry to continue its love affair with DAT in 1989. The main driving force in the market has been the success of Exabyte and the perceived opportunity for some of the large-market participants. DAT gives the tape drive market global status, with activity in Japan, Europe, and the United States.

In competition with HP/Sony, Hitachi announced that it will create its own DAT format. Also, a DAT start-up, Gigatape, was formed, with limited DAT units beginning in November 1988. It also plans to have a proprietary format and will support the data DAT format.

HP/Sony finally agreed to agree and cornered the biggies: AIWA, Archive, Exabyte, LMSI, Mitsumi, WangDAT, and Wangtek now are licensing HP/Sony technology.

Exabyte, the number one supplier of 8mm helical scan devices, at last count had 25 major customers for its product. The market timing was the strongest contribution to the success of the Exabyte product. In 1988, the high end of the LAN server market drove a fair amount of the purchases for the Exabyte drive. Digital add-on systems also created a fair amount of demand for the Exabyte product.

We anticipate that DAT market participants will become more clearly defined in 1989, and that production units for the computer storage market will be available. We do not expect Exabyte to lose any footing with 4mm products coming into production. Although initial volumes will be low, we expect the compound annual growth rate of all helical scan products to reach 77 percent over the next four years, with 4mm products realizing the most growth at almost 500 percent over the same period.

1/2-Inch

Stalled but not dead is the best way to describe the myriad of companies that were trying to move forward in 1988 with 1/2-inch cartridge products. We believe that much of the 1/4-inch success has resulted from the lack of market momentum in the 1/2-inch products in the midrange market. We anticipate much of the same in 1989 as people continue to wait for those low-cost 3480-compatible devices. On the high end of the market, plug compatibles saw a good 1988 with even better volumes anticipated for 1989.

In a move that surprised the industry, StorageTek announced its intent to acquire Aspen Peripherals. Dataquest believes that this move will be a very positive one for StorageTek, while we have a mixed reaction for Aspen Peripherals. While acquisition will not be favorable for some of the affected companies, it will be positive for large-system integrators. For StorageTek, the acquisition creates a much stronger OEM tape drive presence, which is extremely positive for the company. The news for Aspen Peripherals is mixed. It was evident that it needed additional cash to continue operations. Our biggest question for Aspen Peripherals is whether it will continue to be an ongoing business concern. As many as 60 percent of Aspen's employees are former StorageTek personnel, which creates interesting implications in terms of the longevity outlook of existing personnel.

Competitors will watch the transition closely in 1989. If StorageTek is successful with the transition, it will have a lot more muscle in the market than Aspen Peripherals would have had on its own. With StorageTek's resources, OEM contracts for 1/2-inch cartridge devices would appear to be less risky than doing business with a small company such as Aspen. This would enable StorageTek to acquire OEM market share at a much faster rate, leaving less on the table for the up-and-coming, low-cost 3480 compatibles. Large-system integrators should see this acquisition as positive. We would expect that doing business with StorageTek will have a higher comfort level than doing business with Aspen.

On December 21, IBM/Digital announced the long-awaited OEM 3480 contract. It should be no surprise to the industry since it had been a well-known rumor. We are glad they announced the contract before year-end, since that was our original forecast. We are expecting Digital to announce the product to customers with shipments early this year.

FLEXIBLE DISK DRIVES

Overview

The trends that were seen in 1988 will continue and accelerate. It is still a Japanese-controlled industry, but much of the production—especially of 5.25-inch versions—is being moved out of Japan into lower-labor-rate areas. Examples of this production-site migration are as follows:

- Alps—Korea and Garden Grove, California
- Matsushita—Philippines
- Mitsubishi—Thailand
- Mitsumi—Malaysia
- Sony—San Diego (10 percent of 3.5-inch production)
- Y-E Data—Korea and Taiwan

Most 3.5-inch production has been highly automated and kept at home in Japan, since the Japanese correctly perceive that this is the product with the biggest future. During 1988, Japanese production of 3.5-inch drives equaled that of 5.25-inch drives; in 1989, 3.5-inch production will surpass 5.25-inch production on a worldwide basis. The 1989 production of 3.5-inch fixed disk drives (FDD) is expected to be 19 million units, while the 5.25-inch FDDs slip to 14 million units. The 1988 through 1982 outlook for 3.5-inch drives is for a compound annual growth rate of 29 percent per year. This growth in the 3.5-inch segment will be at the expense of 5.25-inch products, which are expected to decline by 14 percent per year. The net industry growth for all types is expected to be 10 percent per year over the five-year period. The growth rate for this segment is anticipated to be below the total system growth rate as more systems ship with a hard disk drive plus a floppy drive instead of the prior configuration of two floppy drives. In addition, Dataquest expects to see more diskless systems as the industry moves toward LANs.

Price Trends

Prices for both types of drives have declined into the $50 range at the factory exit level. There is still a price premium for the 2MB version of the 3.5-inch drive, but it eroded during the past year from about $50 to about $10 extra.

Technical Trends

Despite past failures to market high-capacity (over 2MB) drives, there is a new flurry of activity to develop these products. Development is occurring in both Japan and the United States. The U.S. products announced thus far include a 24MB, 5.25-inch drive from DTC/Qume, a 25MB, 3.5-inch product from Insite Peripherals, and a 50MB, 3.5-inch product from Brier Technology. Only the DTC/Qume product is in production. DTC uses embedded servo tracks to achieve high-track density, barium ferrite media from Toshiba, and a special shuttered hard cartridge. Insite uses a hybrid optical/magnetic approach where alternating tracks are optical servo tracks, and the magnetic areas between them store the data. Brier uses servo information buried below the data to achieve high-track density.

On the Japanese scene, Konica, through its Konica Technology Division in the United States, developed a 5.25-inch FDD that stores 12MB on a conventional diskette after servo tracks are applied. This drive has been in production for about two years. Toshiba is using barium ferrite particles to achieve 4MB via increased bit density in a current 3.5-inch product. Panasonic, Sony, and Toshiba, have 10MB to 16MB 3.5-inch programs using embedded servo. NEC is shipping a 10MB, 3.5-inch drive using metal particle diskettes. Y-E Data is shipping a 4MB product that uses conventional iron oxide 3.5-inch diskettes—the only catch is that the magnetic coating is 23 percent thinner than conventional 2MB diskettes, which are already very difficult to manufacture because of their 0.9-micron coating thickness. The Y-E Data drive is fully upward/downward compatible with previous microfloppy formats and is thus the easiest one of all to integrate into existing systems.

OPTICAL DISK DRIVES

Overview

During 1988, some major system companies finally introduced subsystems using 12-inch WORM drives and automated libraries for archival storage. Digital was first, followed by IBM, and then AT&T. Wang Labs also made a heavy commitment to WORM and Siemens has equipment on order. The announced schedules were such that the production volume on these products should pick up during 1989.

The worldwide production volume of optical disk drives was a tiny 18,000 units in 1988. Even Exabyte, a start-up in the helical scan tape industry, shipped more product in 1988 than this. However, the U.S. government is an increasingly heavy user of optical drives. Together with minicomputer industry endorsement, Dataquest believes that these two end users will cause the shipment rate to go up to 40,000 units in 1989.

The industry has been very slow in getting started, but the potential replacement of paper files, microfilm—and in some cases, magnetic tape—does indeed hold great promise. Dataquest is forecasting a 1988 through 1992 compound annual growth rate of 81 percent for this 12-inch segment, though admittedly from a very small current base. The 12-inch products have a high box cost (approximately $30,000) and media cost (approximately $350) that fit in minicomputer systems; however, they are not likely to be seen to any great extent in PC-based systems.

The 5.25-inch WORM product does make economic sense on high-end, PC-based workstations, but not on home systems at an end-user price of $5,000 or $6,000 and media at around $100. Due to these lower costs as compared with 12-inch products, and applicability to PC platforms, Dataquest expects the number of units to grow more rapidly than the 12-inch segment. The 5.25-inch segment, much newer than the 12-inch segment, shipped about the same number of drives in 1988: 18,000 units. Dataquest expects that the two segments will be equal again in 1989 at 40,000 units, but that the 5.25-inch WORM segment will then grow at a 92 percent compound annual growth rate. The U.S. Federal Government appears as a major market, as there are request for proposals (RFPs) already on the street for an aggregate total of 25,000 drives that will be contracted for during 1989, although deliveries could be scheduled over several years. The advantage of permanent storage on WORM drives for archival purposes finally seems to be recognized.

During 1989, we should finally see the first production shipments of erasable optical drives. Sony appears to have started shipments, and Dataquest has seen an impressive demonstration by Alphatronix of a subsystem using the Sony drive. Canon, Maxtor, Panasonic, Reach/Olympus, Sharp, and Verbatim all appear to be entering this market in 1989. Fujitsu was the first to announce a multiplatter fixed disk optical drive to be ready in 1989. The device uses 8-inch disks and stores 8.9GB. The first interface will be Block MUX.

Dataquest does not expect erasable optical drives to replace Winchester drives in the near term, if ever. The reason is that optical drives are presently much slower and more costly than Winchester drives. Performance of optical disk drives can and will be improved, but Winchester technology advances will also occur. Dataquest believes that the two technologies will coexist, and will often be used together in one system. The hierarchy we perceive is semiconductor cache to Winchester drive to optical drive to automated library (Jukebox). Dataquest also does not expect erasable optical drives to do away with WORM products. Many applications benefit from a permanent audit trail, and WORM products are also less costly than erasable drives.

The CD-ROM market made significant progress in 1988, with about 75,000 drives shipped as additional distribution channels opened up and as more titles became available. Driving the growth are two principal forces. One is publicly available publication titles, of which there are now about 300 in the United States. In fact, the publication activity is so great that McGraw Hill is said to be working on 32 projects simultaneously. The second driving force is internal corporate data distribution. Technical manuals and parts catalogs are already on CD-ROM, and many corporations are preparing to do data distribution this way. This alone will create a large market, but now several large-system builders are planning to distribute software on CD-ROM. Dataquest forecasts 160,000 drives for 1989 and a five-year compound annual growth rate of 91 percent. If the retail price falls below $500 in two years, however, this forecast may be too conservative. It appears to Dataquest that the market has a good deal of price elasticity.

DATAQUEST CONCLUSIONS

Overall, the storage industry faces many challenges in 1989. Each industry segment is distinctly different and has unique challenges:

- Rigid needs to recoup its premier spot in the storage industry.
- Tape must respond to the globalization of the industry, and increase its education of the end user as well as improve its end-user marketing.
- Flexible disk faces the continuation of a more mature market and the need to attract high-capacity interest.
- Optical faces the implementation of standards and the integration into new and existing standards.

Storage? It's an integral part of the computer industry, and 1989 should be a good year.

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Terrance A. Birkholz
Louise Biggs

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Research Newsletter

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1989–10
0003408

GLOBAL COMPETITIVENESS: THE SIX–FRONT WAR

SUMMARY

Today we find the battle of high–technology competitiveness being fought on six fronts: high performance, quality, lower costs, smaller sizes, standards, and pervasiveness. To just stay with the competition, it will require companies' attention in each area. To move ahead of the competition, it will require excellence in each area. In concert with this is the emerging trend of merging technologies and interrelated product markets. In this environment, maximizing the marketable "mileage" of products will require that both semiconductor and systems manufacturers intimately understand the end users' needs. This newsletter will explore the six fronts of competition and their implications for semiconductor users and suppliers.

THE SIX–FRONT WAR

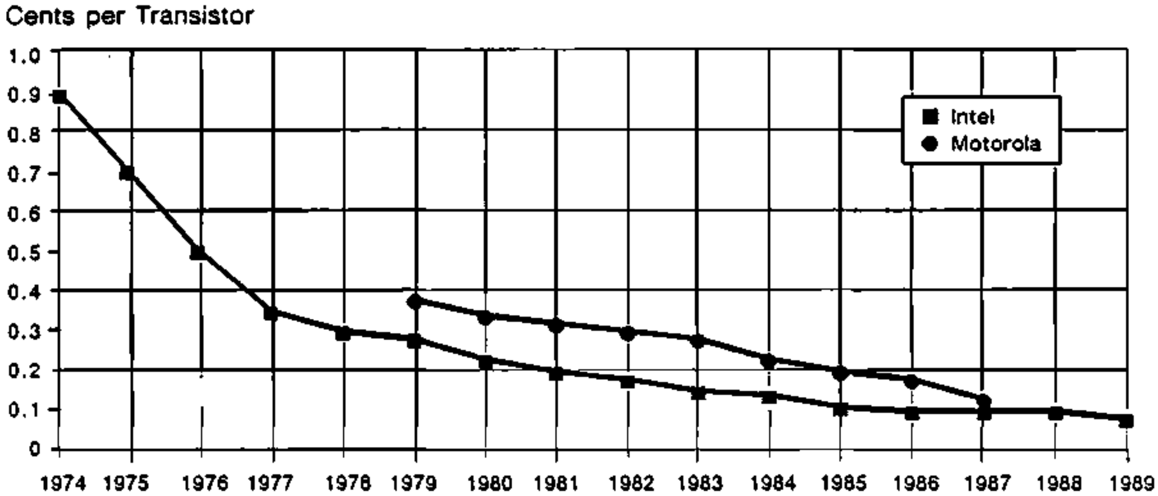
The worst nightmare of any military commander is to face his or her enemy on multiple fronts. A bad dream if you are lucky; yet, this is the reality that the electronics and semiconductor industries face today. When we combine this setting with the volatile relationship between semiconductor consumption and electronic equipment production, the complexity of the competitive battlefield that emerges is enough to make even the most seasoned of campaigners shudder in his or her boots.

HIGHER PERFORMANCE

As Figure 1 illustrates, since the mid–1970s, the price per transistor for some typical mainstream microprocessor chips has tumbled from approximately nine–tenths of a cent to about one–tenth of a cent, representing an incredible 90 percent decrease! It is the same story for memories; per–bit prices have also declined precipitously over the years. Now granted, on the way down the experience curve, prices are sure to be buffeted about by perturbations in availability and other short-term variables. And this fact can make the tasks of economical systems design and component procurement tough. But where performance is at stake—and where isn't it today—over the long haul, it pays to design high performance into today's systems, knowing that these systems will be competitive in tomorrow's environment.

Figure 1

Price per Transistor
(Intel and Motorola MPUs at Introduction)



0003408-1

Source: Intel Corporation
Motorola Inc.

QUALITY

Contrary to popular belief, quality is not grounded in statistics and probabilities. It is not about quality circles or zero-defect programs. Quality is not technical. As business author Tom Peters has repeatedly pointed out, quality is fundamentally an attitude, the wellspring from which quality control devices and programs are used as a means to achieve a desired end. In our businesses, high quality means satisfied customers and return business. The competitive environment we all face today permits no middle ground and no compromise in our attitudes about quality. The battlefield of international competitiveness is scattered with the casualties of those companies that thought "good enough" was just that—good enough.

LOWER COST

The continuing trend in lower costs is as inevitable as day follows night. Table 1 lists some important products, among them workstations, voice-messaging systems, and fax machines, that Dataquest believes will experience the steepest price declines. Contributing to this trend are expanding industry standards (in some cases, raising the number of competitors, by lowering the barriers to entry), expanding chip functionality (the notion of the "system on a chip"), and the pervasiveness of technology. As these trends permeate the industry, it will be critical for semiconductor and systems manufacturers, particularly those involved in these product areas, to work in close union to ensure optimal design and integration, at minimal cost.

Table 1

Average Selling Price
(Thousands of Dollars)

	1988	1989	1992	CAGR 1988-1992
CD-ROM Optical Disk Drives	1.2	0.9	0.3	(29.3%)
Modems	0.5	0.4	0.2	(20.5%)
Optical Disk Drives	3.7	3.7	2.1	(13.2%)
Workstations	21.4	16.6	12.6	(12.4%)
Voice-Messaging Systems	35.4	30.6	22.0	(11.1%)
Fax Machines	2.1	1.9	1.4	(9.6%)
Graphics Terminals	4.3	3.9	3.0	(8.6%)
Nonimpact Page Printers	3.5	3.2	2.5	(8.1%)
Cellular Telephones	0.7	0.7	0.5	(8.1%)
Local Area Networks	0.7	0.7	0.6	(3.8%)

Source: Dataquest
March 1989

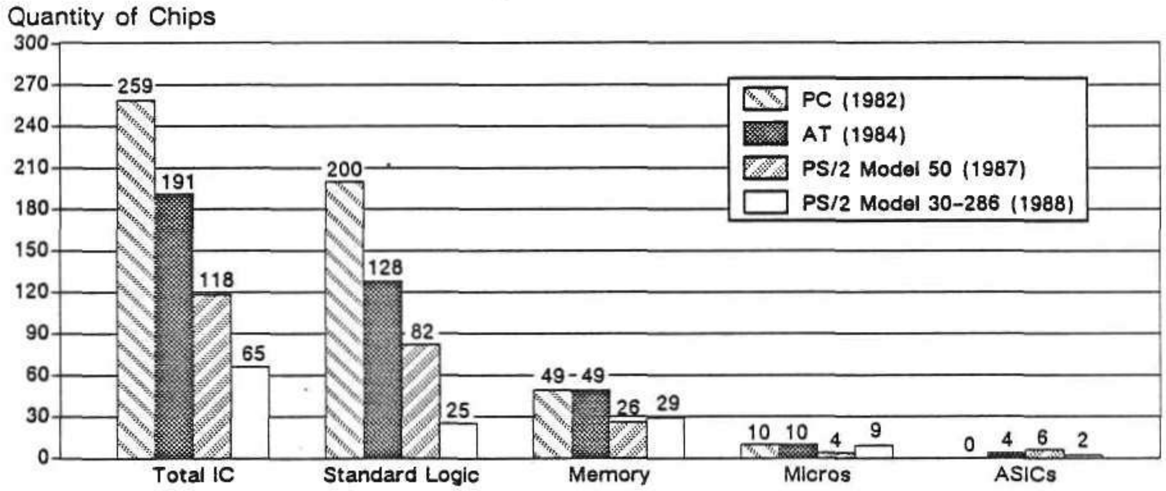
SMALLER SIZES

At the time of its introduction, the original IBM personal computer tipped the scales at approximately 50 pounds. Today, a typical 80386 microprocessor-based portable PC weighs in at 20 pounds, representing a 60 percent reduction. And laptop computers, the fastest growing segment of the PC market today, are pushing the frontiers of size and weight back even further. Chip miniaturization, the rise of chip sets, new screen technologies, and technological advances in flexible and rigid disk drives have contributed significantly to this trend. Today's competitive environment requires that everyone involved knows what the new technologies are, what they do, and what they cost.

While equipment sizes are shrinking, advances in semiconductor technology are permitting fewer chips to be used per system. Figure 2, for example, illustrates that IBM's PS/2 Model 30-286 personal computer, introduced last year, contains a scant 66 integrated circuits, compared with the IBM PC AT that contained 191 ICs. That is 125 fewer chips, representing a 65 percent reduction in chip count. The popularity of chip sets has enabled IBM to manufacture its low-end 30-286 with fewer components, higher performance, and at a lower cost than its high-end AT of a few years ago. Chip set suppliers and users take note: Chip sets will continue to replace proprietary ASIC and standard logic solutions, especially in low-end systems.

Figure 2

IBM Personal Computer System Evolution



0003408-2

Source: Dataquest March 1989

STANDARDS

It was not very long ago that companies could rely on unique proprietary standards as the sole means of differentiating their products. But the proliferation of industry standards is changing the way companies must compete for business. Competitive differentiation in a world of industry standards requires that companies differentiate their products in the following ways:

- Through superior system implementation
- Through extended or enhanced standards
- Through standards that provide systems integration

To win the battle on this front, it will require an unprecedented understanding of end-user needs that translates into solutions to customers' problems. Timely solutions, in turn, will necessitate close working partnerships between systems designers and component engineers.

PERVASIVENESS

The VCR represents the most profound recent example of pervasiveness. In 1983, less than 10 percent of U.S. households owned a VCR. Today, VCRs occupy a place in 62 percent of U.S. households. On the strength of the VCR, the Japanese went from a minority position in the semiconductor market to the world's largest producer of semiconductors, all in the span of four years. The VCR alone accounts for approximately 8 percent of Japan's total semiconductor consumption and 5 percent of the semiconductor output of the world.

Optical compact disc (CD) technology represents another important example of pervasiveness. CD technology has profoundly affected the consumer home-audio equipment market, not to mention the music recording industry. This technology is making inroads in data storage systems and will be the cornerstone of future automotive electronic navigation systems.

Pervasiveness means leverage. To maximize this leverage will require innovative systems and semiconductor manufacturers working closely to capitalize on semiconductor-using opportunities that have yet gone unnoticed.

The implications of pervasiveness are far reaching. The experience of the VCR shows that by pushing the development of a product and a market to their respective limits results in interrelationships of that product and market with other products and markets.

Nowhere is the notion of merging technologies and interrelated markets better illustrated on a grand scale than in the area of high-definition television (HDTV). HDTV promises to be the wellspring of a new round of technological innovation and has important implications for the electronics industry as a whole. This fact has not gone unnoticed by the United States Department of Defense. The Department of Defense has announced its intention to finance the development of an advanced, high-resolution video display screen. The immediate purpose is to make a compact, low-cost unit for military systems (such as helicopters, tanks, planes, ships, and training simulators) that can display detailed images of battlefield conditions. Beyond this, the potential applications include television sets, video games, other military systems, automobile instrumentation, computer monitors, medical scanners, and any system where the display of detailed images would make the systems easier to use.

DATAQUEST CONCLUSIONS

In the fiercely competitive and rapidly evolving electronics and semiconductor business, winning the battle of competitiveness on a few fronts is not enough. Corporate health and viability require that companies win the battle on each front. Different companies may use different strategies to rise ahead of the competition, but the unwavering thread that runs through each is <u>strict attention to customer needs</u>. We at Dataquest have said it before, but it bears repeating: If you are a systems manufacturer, know your customers' needs. If you are a semiconductor manufacturer, know the needs of your customer and the needs of your customer's customer. We urge you to commit yourself to these principles. There is simply no more effective way of bringing better products more quickly to market.

In particular, Dataquest believes that future success makes it incumbent upon systems and semiconductor manufacturers to focus on strategic alliances as a means of accessing technology and strengthening the semiconductor/systems tie. Of course, this is no substitute for companies doing their own homework. Systems companies need to focus on acquiring semiconductor expertise. The emerging trend of interrelated markets suggests benefits to semiconductor companies organizing along vertical markets, not just products. Both users and suppliers should focus on their own company's links between markets, design, and operations.

Finally, to remain a contender in today's international battle of competitiveness, attention to customers' needs must be the central focus of a company's business. Dedication to understanding those needs and providing quality products, service, and solutions to meet them are the most important success factors governing a company's future growth.

Terrance A. Birkholz

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Research *Bulletin*

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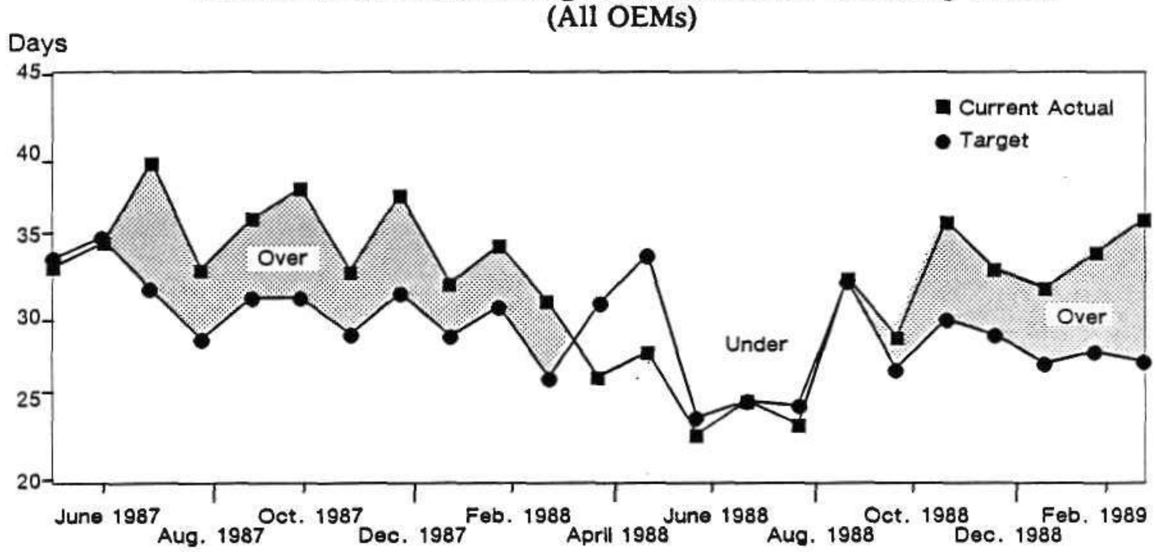
0003287

MARCH PROCUREMENT SURVEY: EQUIPMENT SALES UP, ORDERS AND LEAD TIMES DOWN

This month's respondents continued to see overall lead times fall as system sales climbed relative to last month. Bookings of semiconductors remained constant with last month's input, as reflected in the flat to slightly higher inventory levels seen. Total OEM inventory targets remained flat at 27.4 days, while actual inventories rose to 36.1 days; this was higher than last month's figure of 33.9 days (see Figure 1). Although order levels were lower than last month, actual inventories grew at a faster pace. It is possible that next month's semiconductor order rate may also decline as buyers struggle to meet inventory targets.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



0003287-1

Source: Dataquest March 1989

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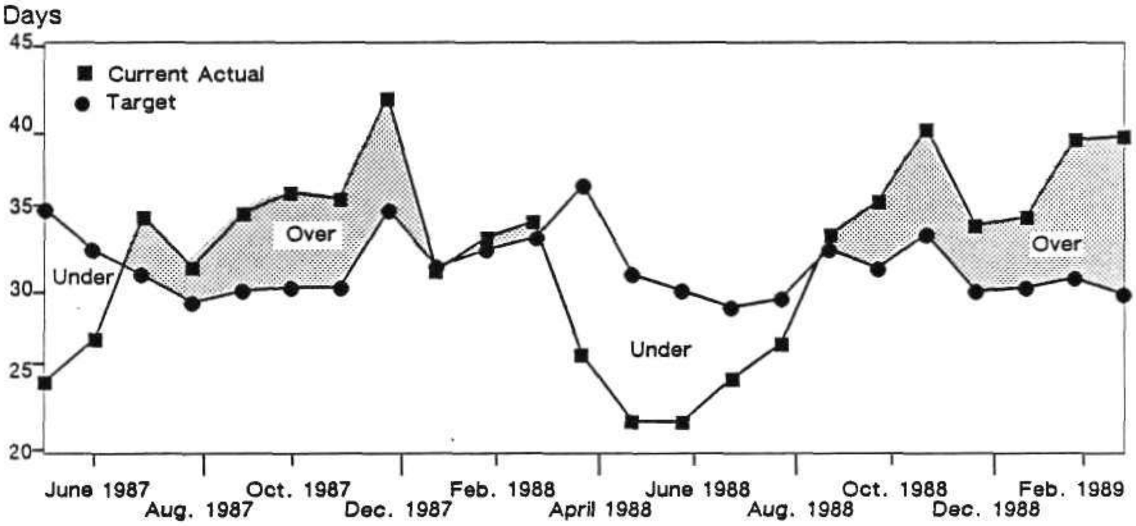
The target inventory level of the computer OEM respondents declined by a day to 29.8 days, while the actual level remained at a flat 39.4 days (see Figure 2). The result is an increase in the difference between actual and targeted inventories. This gap continues to highlight how increased availability of 1Mb DRAMs is affecting the juggling act now going on in semiconductor procurement.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



0003287-2

Source: Dataquest March 1989

Overall pricing continues to decline gradually in the wake of slower bookings and simultaneous increases in supply. Although allocations still exist for video RAMs, some slow SRAMs, 256K DRAMs, and x4-type DRAMs, the overall availability of product (i.e., standard logic, microprocessors in general, nonvolatile memory, and ASICs) is keeping lead times and prices in line. As availability improves, on-time delivery is becoming an issue; surface-mount packaging continues to be a problem for some users.

DATAQUEST ANALYSIS

As the current business cycle rolls on, the specter of semiconductor supplies overshooting aggregate demand is rearing its disruptive head. Accurate forecasting by system buyers combined with close communication between buyers and suppliers can improve the balancing act now under way. Even though system sales continue to grow at a fair clip, once the freight train of semiconductor supply picks up momentum (primarily based on last year's sales rate), the only guide beneficial to both users and suppliers is accuracy in forecasting.

Mark Giudici

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Research *Bulletin*

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0003167

CHIPS AND TECHNOLOGIES ENTERS THE MASS STORAGE CONTROLLER BUSINESS

Chips and Technologies' newly formed Mass Storage Organization announced its first drive controller chip set, the Micro Channel Fixed Disk Adapter CHIPSet, on February 21. Targeted toward OEM suppliers of PS/2–compatible computers, this chip set is capable of supporting ST506/412 (both MFM and RLL versions) and Enhanced Small Device Interface (ESDI) type drives using a single controller.

Consistent with Chips' general product strategy of combining high–level integration with an intelligent, systems–level architectural approach, the Disk Adapter CHIPSet will allow for a significant reduction in chip count, while imposing minimal architectural constraints upon system designers.

In entering this segment of the PC chip set market, Chips will not only be competing against established rivals Cirrus Logic and Western Digital, but also against former ally Adaptec. If successful, Chips is likely to become, by reputation as well as by market presence, a major player in setting future controller interface architectures as well.

Consisting of the 82C780 Micro Channel Hard Disk Controller and the 82C784 Data Separator, this new chip set represents the first step toward a complete line of chip set products aimed at integrating hard and floppy disk drives into AT–, PS/2–, and EISA–compatible personal computers that use AT and ST506/412 interfaces, the Small Computer Systems Interface, and the Enhanced Small Device Interface.

These chip sets will function as host adapters, controllers, and interfaces, not only in systems, but also in the embedded control portion of "smart" disk drives. This capability will expand Chips' current customer base of controller board houses, system houses, and OEMs to include drive manufacturers as well.

DATAQUEST ANALYSIS

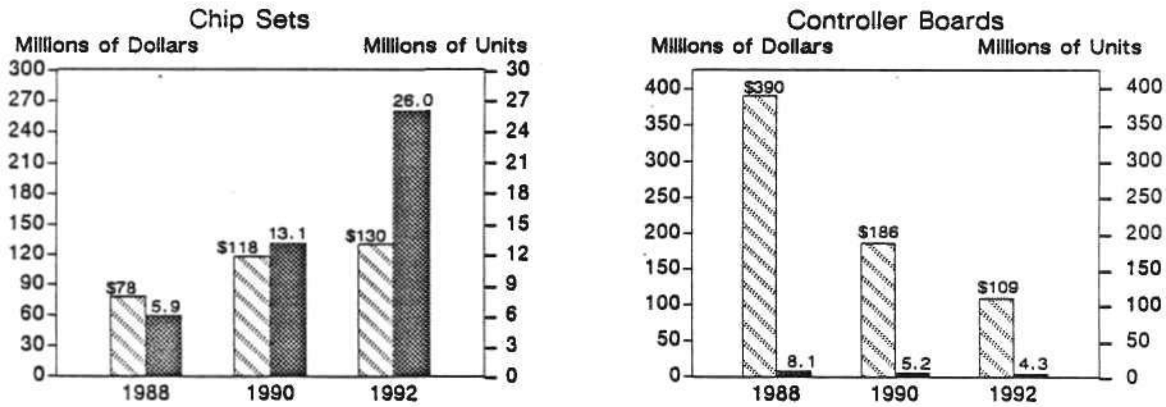
Dataquest views this announcement as a broadening of product and market scope for Chips, rather than a radical departure in corporate strategy. While the move will broaden Chips' customer base within the PC and peripherals industries, the company's fate remains inextricably tied to the health of the PC industry.

As it has in other markets, Chips can be expected to continue applying its strategy of offering system design flexibility through intelligent product architecture while lowering chip count, and therefore total system cost, through high-level integration. This may well serve as a wake-up call to those who still view peripheral control as a board-level industry and expect subsystem-level pricing and revenue.

Dataquest forecasts that by 1992, the percentage of hard drives qualifying as "smart" (i.e., containing embedded controllers and therefore not requiring controller cards) will grow from the present 42 percent to 85 percent. At the same time, we expect that the confusion surrounding the various versions of SCSI (a major roadblock in the transition of controller cards to chip sets) will soon be ironed out, accelerating the trend toward low-cost, standardized, chip set-implemented solutions. Figure 1 shows Dataquest's estimate of the controller chip set market and the controller board market through 1992.

Figure 1

Estimated Hard Drive Controller Markets



Chip sets look promising . . . as controller cards fade

0003167-1

Source: Dataquest February 1989

As a pioneer in the chip set industry, Chips and Technologies has run up an impressive track record by being first out of the gate. By offering unique, systems-level solutions, Chips has enjoyed the luxury of sole-source pricing while offering a reduction in system cost. In this respect, it faces a new set of challenges in playing catch-up with both Cirrus Logic and Western Digital. Many of the advantages that Chips usually enjoys could evaporate in this new market. We look for Chips to establish credibility early and to attempt to establish premium pricing in order to protect the comfortable margins it has enjoyed to date.

While most observers view this card-to-chip-set transition as inevitable and the process of PC consolidation as inexorable, Dataquest believes that the entry of a first-rate chip set vendor like Chips and Technologies into this market will have a catalytic effect, enhancing competition and therefore innovation among all of the chip set players. We expect this heightened competitiveness to accelerate the trend toward intelligent peripherals and subsystems of all kinds, opening the door a little wider for tomorrow's more sophisticated machines and more powerful applications.

Kevin Landis

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Research *Bulletin*

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THE COST OF QUALITY: PREVENTION VERSUS CURE

The total cost of a semiconductor component can be broken down into three main categories: unit price, inventory cost per unit, and rework costs due to component or system failure. There is a break–even point that determines where rework costs can be offset by improvements in incoming quality (i.e., price + quality adder). To determine the break–even point, the following variables need to be identified:

- Unit price
- Inventory cost per unit
- Units per board
- Boards per month
- Incoming inspection cost per unit
- Component burn–in cost per unit
- System burn–in cost
- Average rework cost per board
- Average cost to repair a field failure

Once the above costs are known, it is relatively straightforward to determine the break–even point where a quality price adder at the component level balances with repair costs at the board rework or field repair level. Table 1 shows the cost structure with and without the preventative cost of quality. However, without any of these preventative costs, there are generally remedial costs that far outweigh the up–front expenditures.

Looking at Table 2, the average rework cost per board is $350 and the average field repair cost is $2,000. Assuming that 10 percent of the boards require rework due to a lack of burn–in or incoming QA, and that an additional 5 percent of the boards require field repair, quality costs at the component level become more justifiable. Comparing the bottom lines of Tables 1 and 2 shows that the preventative cost of quality totals less than the remedial cost ($1,092,500 compared with $1,085,000).

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Table 1

Preventative Cost of Quality

Unit Price	$20.00
Inventory Cost/Unit	$0.50
Burn-In Cost/Unit	$0.75
Incoming QA Cost/Unit	$0.45
Units/Board	100
Boards/Month	500

Total Cost with Burn-In & QA:
(($20.00 + $0.50 + $0.75 + $0.45) x 100) x 500 = $1,085,000

Total Cost without Burn-In & QA:
(($20.00 + $0.50) x 100) x 500 = $1,025,000

Source: Dataquest
February 1989

Table 2

Remedial Cost of Quality

Unit Price	$20.00
Inventory Cost/Unit	$0.50
Units/Board	100
Boards/Month	500
10% Board Failure/Month	50 Boards
Rework Cost/Board	$350.00
5% System Failure/Month	25 Systems
Field Repair Cost	$2,000

Total Cost:
(($20.00 + $0.50) x 100) x 500 + ($350 x 50) +
(25 x $2,000) = $1,092,500

Source: Dataquest
February 1989

DATAQUEST CONCLUSIONS

The cost of quality must be looked at closely from both a preventative and a remedial perspective. Customer satisfaction with end products demands that the products work right from the start. The incremental up-front costs of quality more than make up for the ill will and potential lost business earned by poor quality that surfaces after a product is in the field. Fortunately, the preventative costs of quality have declined for users, due mainly to the increased quality levels of semiconductor components. Dataquest's annual procurement survey continues to show that quality is of key importance both in controlling costs and in improving performance. By analyzing quality costs, one can quantify where improvements are needed and prove the adage that "Quality is free."

Mark Giudici

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Research *Bulletin*

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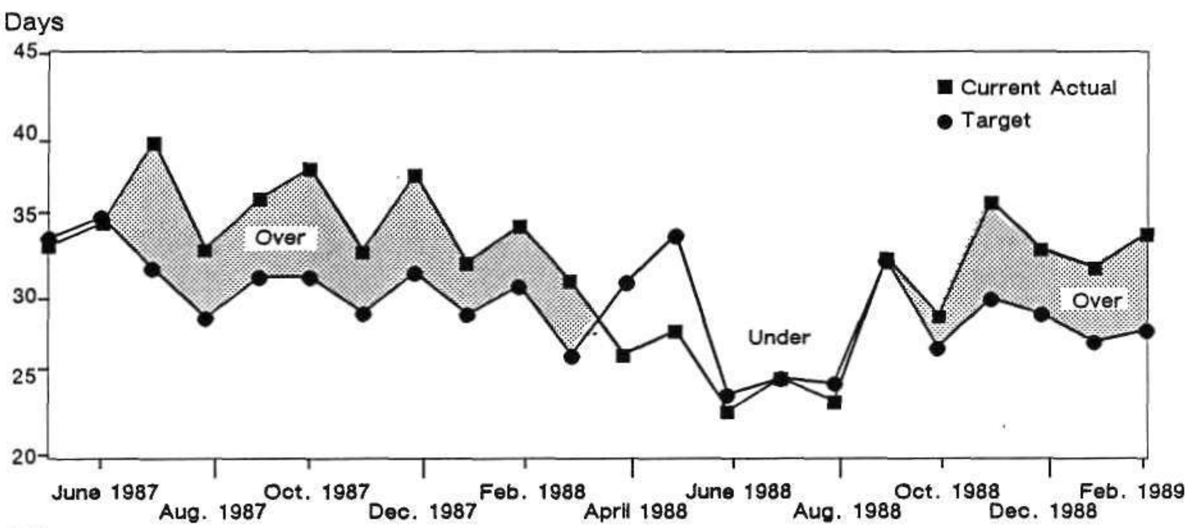
FEBRUARY PROCUREMENT SURVEY: LEAD TIMES FALL WHILE ORDER RATES STABILIZE

Lead times for semiconductors are improving and order rates are steady, yet overall inventory levels have increased since last month's survey. Total OEM inventories, both targeted and actual, rose slightly as users continue to experience fast DRAM and slow, low-density SRAM availability problems. As seen in Figure 1, the inventory target of 27.8 days was exceeded by the current level of 33.9 days. Although this is an incremental increase, these levels still are below targeted and actual inventory levels of a year ago (30.8 and 34.5 days, respectively).

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



0003131-1

Source: Dataquest February 1989

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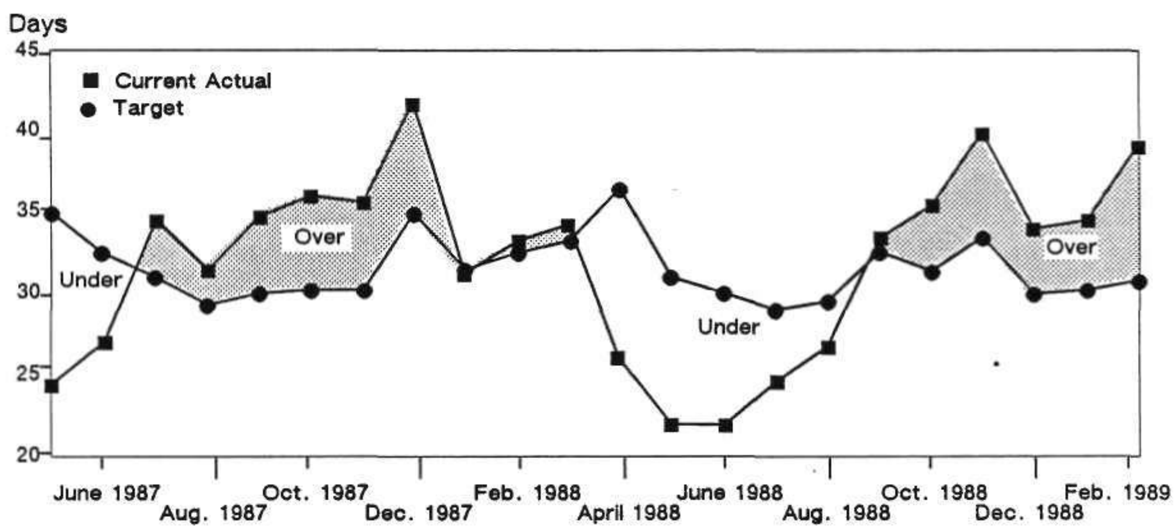
While the average target level hovered at 30.8 days, the actual inventory level of 39.2 days for the computer OEM respondents jumped almost 5 days over last month's level (see Figure 2). This is primarily due to the increasing availability of commodity DRAMs and a relative flattening of end-use demand compared with last year's record growth. Some insurance ordering of DRAMs still is going on by some smaller companies. It is well understood that, as volumes of 1Mb DRAMs increase, it is a matter of time before associated memories will become more available.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



0003131-2

Source: Dataquest February 1989

Overall pricing continues to decline gradually, largely at the hands of improved availability of 1Mb DRAM and some microprocessors. Allocations still exist for some video and x4 configuration memory parts; this will continue, as reported earlier, until the market for the predominant 1Mb part is saturated. Overall pricing, including memories, is slightly lower than in our last survey. Surface-mount packaging continues to be a problem for the minority of users, with problems arising in the ceramic packaged parts.

DATAQUEST ANALYSIS

The easing of lead times and coinciding increases of inventory levels may be an aberration that will smooth out as companies strive to achieve their targeted goals. As the overall availability of semiconductors improves, balancing of inventory needs and system shipment rates will take precedence. As the market approaches supply-demand equilibrium, it is paramount that open communication between users and suppliers continues in order to maintain low inventory levels and constant shipment schedules.

Mark Giudici

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IBM'S 3090-S SERIES: MARKET IMPACT, FUTURE TRENDS, AND DIRECTIONS

INTRODUCTION

IBM's recent introduction of the 3090-S systems is a key step in the company's increasing dominance of the mainframe market. Like most IBM announcements, however, this one raises questions about IBM's future direction at the high end and about the impact the company will have on competitors such as Amdahl, National Advanced Systems (NAS), and Japanese suppliers of 370-compatible mainframes. Overall, Dataquest believes that the 3090-S raises the hurdle for all suppliers of high-end systems—including IBM.

The next generation of IBM systems, called "Summit," will have to be significantly differentiated from the 3090-S and the next expected incremental 3090 system, the 3090-G, to capture the market's imagination.

This newsletter explores IBM's high-end strategy over time and how IBM is competing with the plug-compatible manufacturers (PCMs). It also presents Dataquest's forecasts for future IBM offerings in the 3090 range and above.

IBM's 3090-S SERIES

Some of the key user questions and issues raised by IBM's 3090-S series announcement include the following:

- Why was the S series introduced at this time?
- How do the S models really compare with the E models on a price/performance basis?
- Will Amdahl, NAS, and the Japanese suppliers of 370-compatible mainframes be seriously affected?
- What is next, and does the S series introduction mean that the IBM "Summit" series will be delayed?

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IBM Multiprocessor History

In order to assess the impact of the 3090-S and make some projections about IBM's large-scale system's future trends and directions, we should review past developments to see if a predictable pattern exists.

The first IBM multiprocessor (MP) system was introduced 20 years ago, in 1968, as the 360/65. Since then, MPs have been part of IBM's large-scale system designs for the 370/158 and 168, introduced in 1973; the 3033, introduced in 1978; the 3081, introduced in 1981; and the 3084, introduced in 1982. MPs also have been included in the current 308X/3090 series, which is nearly eight years old. IBM's MP hardware and system software have come a long way over this 20-year period.

Today's 3090 design includes a 33-fold performance range, from the 120-E models to the top-of-the-line 600-S model. The 3090 system design includes up to 512MB of central storage, up to 2GB of expanded storage, up to six main processors (among other specialized processors), one to six vector facilities, 4.5MB channels, fiber-optic channel extenders, and the new Enterprise Systems Architecture (ESA).

Above the hardware and operating system software technology sits the key systems products: TSO, CMS, JES, DB-2, NETVIEW, IMS, RMF, CICS, RACF, etc. The reason for all these layers of systems products is that the applications for the 3090 series cover everything from on-line transaction processing (OLTP) to the office, image processing, numeric-intensive computing, decision support, query processing, and many other cross-industry applications.

IBM's architecture has evolved from MVS to MVS/XA to MVS/ESA. It has also evolved from a complex system, where highly skilled and expensive system staffs were required to tune the system and manage physical storage, to a less complex, system-managed storage, where users now interface at a logical level. By putting more intelligence into the operating system software, IBM has increased user productivity and significantly improved the operational functional value of the system. Dataquest estimates that 85 percent of the current MVS/XA sites will have migrated to ESA by 1990 because the move does not require any significant conversion effort, and the potential benefits are well worth it. Dataquest believes that IBM's Enterprise Systems Architecture (ESA) sets the stage for its future "Summit" series. IBM knows from experience that you do not change architecture, software, and technology at the same time; changing three major systems elements is too risky.

Why Introduce the S Series at this Time?

The S series was introduced to meet the growth requirements of IBM's Fortune 500 customers and to counter the serious competitive challenges from Amdahl, NAS, and the Japanese. IBM claims that DBMS processing is now 60 percent faster, transaction processing is 50 percent greater, and the overall price/performance was increased from 15 percent to 35 percent. The vector facility was improved also by 40 percent for numeric-intensive computing. However, the central electronics complex (CEC)—CPU, memory, and standard basic features—prices were increased by approximately 10.0 to 14.5 percent. New software terms and conditions now reduce effectively the cost of IBM system software for the low-end 3090 sites, while increasing this cost at the high end. IBM's new policy is more evenly balanced because larger, multiprocessor users gain more benefit from the software. By lowering the entry-level price for MVS/ESA and all the system software products, IBM is positioning itself for the "Summit" introduction once again.

How do the S Models and E Models Compare?

Performance Improvements

IBM's new 3990 intelligent DASD controller is now available, and it moves more of the I/O functions and CPU overhead outbound from the CEC. Table 1 summarizes the changes in central and expanded storage, channels, and other features between the 3090-E and the 3090-S models. The performance improvements were accomplished by doing the following:

- Reducing the CPU cycle time from approximately 17.2ns to 15ns
- Using faster 1MB storage chips
- Doubling cache size (models 180-S and up)
- Improving the thermoconduction module to allow denser packaging of chips
- Expanding writable control storage and microcode
- Adding another CPU-to-memory data path
- Improving the MVS/ESA

Table 1

Growth Options for IBM ES/3090-E and ES/3090-S Models

Model	Central Processors	Processor storage (MB) Central	Expanded	Channels	Vector Facilities
120E	1	32	0-128	16-24	0-1
150E	1	32-64	0-128	16-24	0-1
180E	1	32-64	0-256	16-32	0-1
280E	2	64-128	0-512	32-64	0-2
200E	2	64-128	0-1024	32-64	0-2
300E	3	64-128	0-1024	32-64	0-3
400E	4	128-256	0-2048	64-128	0-4
500E	5	128-256	0-2048	64-128	0-5
600E	6	128-256	0-2048	64-128	0-6
120S	1	32-64	0-256	16-32	0-1
150S	1	32-64	0-256	16-32	0-1
170S	1	32-64	0-256	16-32	0-1
180S	1	32-128	0-256	16-32	0-1
280S	2	64-256	0-512	32-64	0-2
200S	2	64-256	0-1024	32-64	0-2
300S	3	64-256	0-1024	32-64	0-3
400S	4	128-512	0-2048	64-128	0-4
500S	5	128-512	0-2048	64-128	0-5
600S	6	128-512	0-2048	64-128	0-6

Note: Bold type indicates Model S enhancements.

Source: IBM Corporation

Internal Throughput Ratios

A closer look at the actual IBM 3090-E to S performance measurements made by IBM shows a 1.2 to 1.5 times greater performance between the same models. (Upgrades from 120-E to 120-S or 150-E to 150-S are not allowed, however.) Our analysis, based on price and performance, using IBM's published internal throughput ratings (ITRs), shows only a 12 to 25 percent performance per price increase—excluding the ESA software and I/O improvements. In other words, the cost per ITR has declined from a range of $397,000 to $409,000 for various E models to a range of $266,000 to $316,000, for S models, depending on actual models upgrade migration patterns.

How will Amdahl, NAS, and the Japanese Be Affected?

Amdahl and NAS customers must pay IBM more for the use of its operating systems and other software on their larger mainframes, which means greater profits for IBM. IBM software charges have increased far more rapidly than the hardware over the past 10 years.

IBM uses a combination of hardware and software to achieve greater performance and productivity, while its competitors are competing on hardware power alone. Table 2 compares some of the 3090-E and 3090-S systems capabilities with Amdahl's new 5990 series and NAS's new AS/EX series.

Actual Price/Performance Differences

Although Table 2 is interesting, it does not present the full story on systems throughput. In order to understand the total systems capabilities, we must also consider the input/output, Enterprise Systems Architecture (ESA) software, and microcode enhancements from IBM, which the PCMs cannot yet deliver. In the I/O area, IBM now has an additional CPU data path and fiber-optic channel extenders, at 4.5 megabytes/second each. IBM claims that MVS/ESA can increase overall system performance by up to 50 percent, depending on the application mix. Moreover, IBM's new ESA-supported version of DB2 can increase on-line transaction processing speeds (TPS) by up to 51 percent. Up to 13 percent of this increase comes from the DB2 relational DBMS; the remaining 38 percent is from the new version of DB2.

Furthermore, unlike IBM's new S Series, Amdahl's earlier 5890 models are not field upgradable to its new 5990 series. (The company does, however, provide an attractive trade-in allowance.) Amdahl had to switch to a closed-loop water-cooling system to dissipate the heat generated by the faster, higher-density circuits. IBM customers who also upgrade their MVS/XA software to MVS/ESA don't have to pay the additional license charges for up to two years. Also, the basic 3090 hardware prices will be increased from 5 to 9 percent by December 1988. Thus, IBM provides "a stick and a carrot" to get its users to migrate upward.

It is interesting to compare the design implementation differences for Amdahl versus IBM. Amdahl achieved higher performance by using a 10ns CPU cycle time and four processors. IBM produced comparable performance (mips) with a slower 15ns CPU cycle but required six processors. Amdahl's 5990s depend on higher-technology processor circuits and memory chips from Fujitsu, its partner. IBM primarily gets its speed from better packaging, i.e., the thermoconduction module (TCM), not from state-of-the-art chip technology. Nevertheless, IBM's six-processor 3090-600S was priced at approximately 5 percent below Amdahl's four-processor mainframe before the recent Amdahl price changes. This means that IBM obviously has a greater economy-of-scale advantage because it sells more products.

Table 2

Competitive Product Comparison

Vendor/Model	CPUs	mips	Base Price (Millions)	Price/mips (Thousands)	Cycle (ns)
NAS AS/XL 100	4	90	$ 9.5	$105	18.0
NAS AS/XL 70	2	39	$ 3.8	$ 97	18.0
Amdahl 5990-700	2	63	$ 7.0	$111	10.0
Amdahl 5990-1400	4	112	$13.1	$117	10.0
Amdahl 5890-600E	4	75	$ 8.5	$113	15.0
IBM 3090-600S	6	108	$12.4	$115	15.0
IBM 3090-600E	6	74	$10.3	$140	17.2

Notes: IBM claimed 135 mips for the 600S; however, Dataquest believes that it is only 108 mips, although internal throughput rates (ITRs) give a better indicator of performance.

The table includes only the basic CEC price for CPU and memory.

NAS claims that its new AS/EX line provides up to 30 percent performance increase over its prior series.

Source: Dataquest
February 1989

Impact on Amdahl

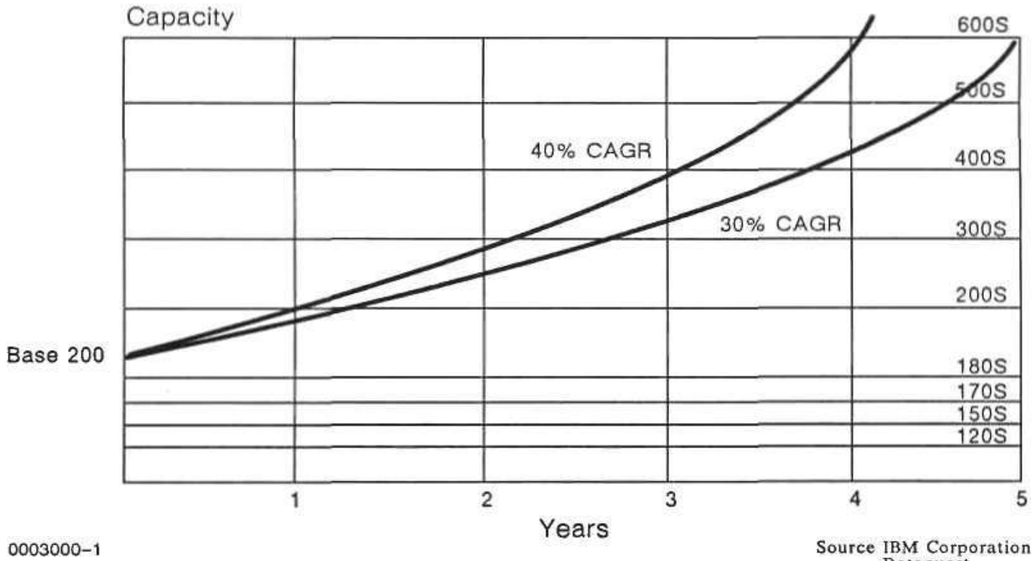
Amdahl's new 5990-700/1400 systems will not be seriously affected, although the company did reduce prices to compensate for the price/performance advantage IBM claims to have with the 3090-S. Equally important is the change in IBM software policy. Six performance-related price groups now have been established for the 3090 series. This means that as PCM customers move up to higher-performance Amdahl 5990s (also NAS and other 370 compatibles), users must pay IBM about 15 percent more to use IBM's MVS/ESA and other key program products on their competitor machines; that is pure profit for IBM. As the cost ratios change over time, more and more revenue will come from software and services and less will come from the hardware. This situation will produce a profit margin squeeze on vendors that primarily supply IBM 370-compatible mainframes and peripherals.

Another impact on Amdahl is the special installation allowance IBM announced to stimulate 3090–E model upgrades by October 1988. For example, 180E to 200E users get a $50,000 allowance, and 200E to 400E customers get $100,000. These allowances are designed to encourage site managers to make a decision to upgrade by the fourth quarter of 1988 in order to increase IBM's year-end revenue and profits. Site managers have 90 days to make a decision to upgrade their IBM 3090–E systems, and later field upgrade to the new S models. Amdahl and NAS sales may experience a temporary shortfall during this decision period if history is any guide. Another IBM product strategy is to recycle the older, less dense, slower thermoconduction modules (TCMs) downward to the low-end 3090 models, while upgrading the high-end 3090–S models with the new, faster TCMs. Amdahl, in contrast, has to recycle the entire mainframe, as users swap out older 5890s for new 5990s—a more costly and disruptive product upgrade for its customers.

IBM's single-system image multiprocessing capability has improved almost fourfold over the past three to four years; however, this growth in architecture, technology, and performance has not kept pace with the users' needs. According to IBM, users' needs are growing by an average of 40 percent per year (see Figure 1.)

Figure 1

User Growth Requirements



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Source: IBM Corporation
Dataquest
February 1989

What Is Next for IBM?

The 3090-S development means that IBM's future "Summit" series must be even better; i.e., the base (target) price/performance has moved up a few notches, which challenges the "Summit" to reach new heights. Table 3 is Dataquest's forecast for the next IBM 3090K series (70 percent probability of introduction by third quarter 1989) and our projections for the "Summit" series.

Table 3

IBM Large-Scale System Trends

	Actual		Forecast	
Attributes	3090-E	3090-S	3090-G	Summit
Announcement	1987	2Q88	3Q89	1Q91
General Availability		1Q89	1Q90	1Q92
CPU Cycle (ns)	17.2	15	12	8-10
Single-CPU mips (model 180 or equivalent)	17.6	22	25	30-40
Internal Throughput Rates (ITRs)	5.1	7.5	8.5	10-12
Number of CPUs (maximum)	6	6	6	8
Cache Capacity (KB)	32	64	64	128
Main Store (maximum MB)	256	512	1,024	2,048
Main Store Technology (Mbits)	1/4	1	4	16
Extended Store (maximum GB)	1.0	2.0	4.0	8.0
I/O Channel Rates (MB/sec)	3.0	4.5	4.5	6.0
Average System Price/ITR	$400,000	$300,000	$250,000	$200,000-$150,000
Fiber-Optic I/O	No	limited	limited	full
Scientific/Engineering Capability	vector	vector	vector	parallel
Single Level Store	No	No	No	Yes
64-Bit Address	No (31)	No (31)	No (31)	Yes
DASD Model/Cap (GB)	3380-D/5	3380-K/7.5	3390/12	3390/18

Source: Dataquest
February 1989

If IBM actually achieved a 15 percent to 35 percent price/performance improvement over the past two years, as IBM management claimed, with the 3090-E to 3090-S model upgrades, the "Summit" series must do much better. Dataquest forecasts up to double the price/performance for "Summit" versus the 3090-S, if the new system is introduced by early 1991. Actual pricing will depend on the competitive forces that exist at the time.

DATAQUEST ANALYSIS

IBM has continued to extend and improve the 3090 series (and its residual values) over the past eight years. Dataquest believes that there is also a 70 percent probability that IBM may boost the 3090-S by another 10 to 15 percent before 1990. This final price/performance increase, near the end of a 10-year product cycle, will indicate that the new technology and architecture of the "Summit" series can be expected by early 1991, and its price/performance will be much better than the 3090-S or K series. A doubling of performance is required if IBM hopes to satisfy the future growth requirements of its Fortune 500 customers. Amdahl and NAS (as well as the Japanese 370-compatible competitors) are moderately affected, but they will continue to match IBM's processor performance, and/or adjust prices, in order to continue to compete. Hardware margins are reduced again by IBM's combination of the following:

- Lower prices for hardware and maintenance
- Higher prices for software
- Greater performance and more field-upgrade options
- Additional functions (such as ESA, 3990 controller, fiber optics)

IBM's major challenge, in our opinion, is how to differentiate "Summit" from the 3090 series. We believe that this was the major weakness of its strategy for the 308X versus 309X transition period—the company failed to differentiate the product lines until recently (eight years after the 308X was first shipped). As a result, many customers bought lower-priced, used 308Xs or PCM machines instead of new 3090s. What will clearly differentiate the "Summit" from the 3090? Significant architectural changes such as a much wider address range, single-level storage, special-purpose processor functions, and faster I/O processors, all supported by a new performance-enhanced release of MVS/ESA will represent the key differences (not just price/performance alone). ESA sets the stage for the "Summit," which will fully exploit the new architectural concepts in hardware, microcode, and software.

Site managers with low-to-moderate (20 to 30 percent) growth requirements should be very cautious about major new hardware acquisitions at this stage. Sites with higher growth needs (larger than 30 percent compound annual growth rates in processor performance and capacity) should consider three- to five-year leases for maximum flexibility.

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UNISYS: SUCCESSFUL MERGER, BRIGHT FUTURE

COMPANY OVERVIEW

Unisys, formed in 1986 by the merger of Sperry and Burroughs, is a fine example of the power of synergy. Unisys' total revenue in 1988 was $9.9 billion, an increase of 3.0 percent from 1987; earnings were $218 million, roughly flat from year to year. The company manufactures computers ranging from networked workstations through mainframes and is a major supplier of defense electronics including embedded computers, radar control, and navigation systems. The compatibility of product lines, organizational skills, and an ongoing focus on cost control have helped this merger to be uniquely successful as it enters its third year. Although the company is not without challenges still from global and focused competition, it already has hurdled many of the financial problems encountered by joined operations.

Cost savings accrued from the structural changes made since the merger are being transformed into opportunities for long-term growth through research and development (R&D), with a budget that increased by 20 percent in 1988. In fiscal year 1987, Unisys ranked fifth among electronics vendors in R&D expenditures, having invested $597 million in R&D.

One of the important reasons behind the company's success at managing its cost structure is an emphasis on cost-effective sourcing of materials—in particular, semiconductors. Total semiconductor use at Unisys in 1988 is estimated at $360 million, with $40 million in commercial grade produced captively (see Figure 1).

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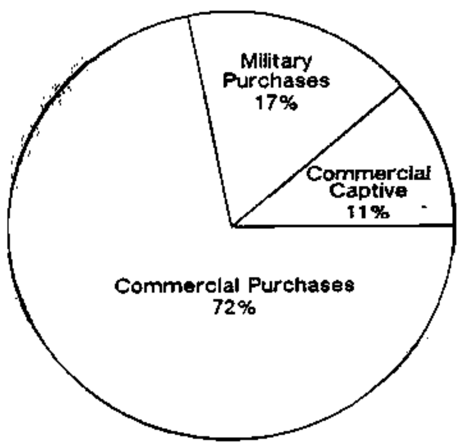
Figure 1

Unisys Semiconductor Use



Source: Dataquest
February 1989

COMPANY DIRECTIONS

Unisys expects to double its revenue to $20 billion by the early 1990s. Internal expansion and acquisitions in selected high-growth areas are paving the way for Unisys' growth. In 1988, Unisys acquired Timeplex and Convergent Inc. and entered into a joint venture with Mitsui & Co. to form Nihon Unisys Ltd. (NUL). Timeplex now forms the core of Unisys Networks, uniting all communications engineering and placing Unisys at the forefront of industry-standard networks that provide whole business solutions. Convergent will provide Unisys with strategically important engineering, development, and marketing expertise and will be an anchor for a $2 billion distributed systems business that includes Unisys' UNIX systems, BTOS workstations, and personal computers. NUL will increase opportunities for Unisys in one of the fastest-growing computer markets in the world; NUL is Japan's fifth-largest computer company.

Unisys plans to be the leader in opening and unifying mixed-system environments, and the company expects to revolutionize the practical use of information technology. A new Unisys "solutions environment" will permit use of software across multiple system families. Drawing on its expertise in fourth-generation languages and artificial intelligence, Unisys intends to streamline the entire process for creating applications software.

After a decade of investment in the development of common module technology, Unisys continues to play its key role of developing modularly designed avionic information-processing systems for the future. Unisys has significantly expanded its role in developing navigation, radar, and communications systems as well as electronic warfare systems by securing significant contracts in 1987.

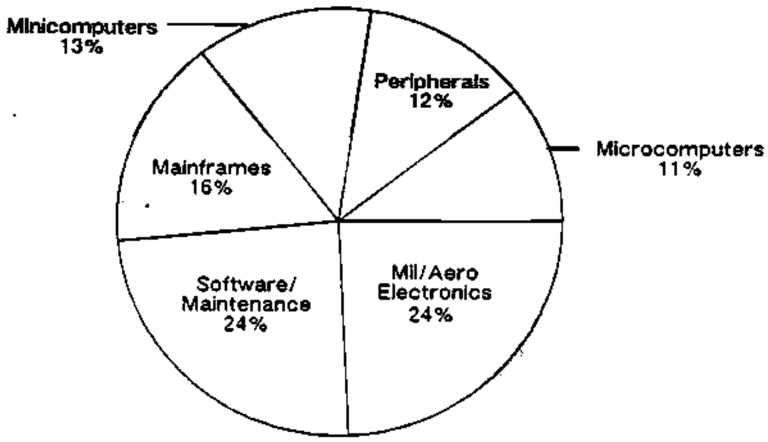
The company is gearing its focus toward entering into larger network projects and improving and upgrading its mainframe and workstation offerings including architectural continuity, connectable open systems, embedded computing systems for military and aerospace, intelligent workstations, and fourth-generation languages.

PRODUCT LINE

Unisys' product portfolio is divided into two main segments: Commercial Information Systems (75 percent of total revenue) and Defense Systems (25 percent of total revenue). Percentage of revenue by product line can be seen in Figure 2.

Figure 2

Unisys Revenue by Product Line



$9.7 Billion

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Source: Dataquest February 1989

Commercial Information Systems

The Commercial Information Systems group focuses on the following five business areas:

- Industrial and Commercial
- Financial
- Public Sector
- Communications and Airlines
- Federal Information Systems

In 1987, Unisys made a significant move toward providing the total business solution. The company expanded its BTOS II family of networked workstations and introduced Cluster Share, through which IBM-compatible PCs can be readily integrated into a BTOS network. The company also introduced the Unisys PW^2 Family, the first Personal Workstation to run all three of the popular industry-standard operating environments: MS-DOS, OS/2, and UNIX.

The company also entered into an important arrangement with AT&T in 1988. This arrangement will allow Unisys to play a strategically valuable role in enhancing the functionality of the UNIX operating system environment for the rapidly growing commercial market.

Unisys reaffirmed its commitment to the mainframe base with a series of significant introductions and announcements in 1988. The company introduced the B38 workstation based on the INTEL 80386. It extended both the high and low ends of the A Series, providing it with one of the widest performance spectrums in the industry. Unisys also extended the 110 and 2200/200 systems and the V Series, and made the first deliveries of the new System 80 Models 10 and 20.

Defense Systems

The Defense Systems group provides defense electronics through these five major lines:

- Shipboard and Ground Systems
- Systems Development
- Communication Systems
- System Support
- Computer Systems

The following paragraphs describe some of Unisys' key military and aerospace programs.

Government Agency Contracts

Unisys is instrumental in the FAA's air traffic control automation and modernization program and supplies all of the FAA's terminal automation systems. Culminating a 10-year cooperative effort by four government agencies, NEXRAD (Next Generation Weather Radar) is now entering production under a $450 million, multiyear contract. By the mid-1990s, 175 NEXRAD systems will be installed for commercial use and in military sites worldwide.

Navy Contracts

The navy accounts for a major percentage of Unisys' defense revenue. In 1988, Unisys won the latest sole-source contract for the AN/AYK-14(V) navy airborne computer. Under this contract, Unisys will provide 65 16-bit computers with options for 365 more units. Unisys is also an alternate supplier for the Aegis combat system. The system will be used aboard more than 50 guided-missile cruisers and destroyers. In April of 1988, a Unisys/Westinghouse team won a $10 million qualification contract leading to becoming second-source producers for the Aegis SPY-1D electronic radar. Unisys, a leading supplier of shipborne computers, is replacing the navy's old, small, general-purpose computers with embedded computer system families—the UYK43 and UYK44. Unisys also has won a $280 million contract to supply microcomputers throughout the U.S. Department of Defense.

Other major navy contracts awarded in 1988 include a $509 million contract in March for the initial production of navigation systems for D-5 Trident II missile-firing submarines and a $101 million award to provide MK 99 fire-control systems for which Unisys is a second-source supplier. In 1988, installation of the first navigation system on the Trident submarine, the USS Tennessee, was completed and integration tests started.

Air Force Contracts

Unisys is also a contractor on major air force programs. Selected to develop the YF-23 advanced tactical fighter (ATF) avionics processor, Unisys is at the leading edge of new technologies for the future generation of military aircraft. The company has expanded its role in advanced modular avionics and very high speed integrated circuit (VHSIC) central computers for U.S. combat aircraft during the last year. The Unisys Common Module family that includes various standard modules currently consists of 16-bit 1750 MPU modules; 32-bit MPU modules planned; communication modules (1553B, high-speed, dual-speed); and memory (EEPROM, CMOS) and power modules.

The air force also selected Unisys to be one of two major suppliers to the air force's rapid-deployment, high-capacity voice communications project: the AN/TRC-170 Troposcatter Digital Microwave Communication System.

Unisys is developing a third-generation airborne battlefield command and control center (ABCCC3) in a capsule for specially modified Air Force EC-130s to provide contingency command control for forward areas of the battlefield. The center serves as an airborne extension of several ground-based control agencies.

Foreign Government Contracts

Unisys is working on several contracts for foreign governments. At the end of 1987, the Royal Thai Air Defense System (RTADS) which Unisys is designing, integrating and installing, was more than half complete. Unisys is also working on a nearly $1.1 billion contract covering electronic combat systems for six Canadian frigates assigned to Unisys Canadian subsidiary-Paramax Electronics Inc.; the initial contract was extended by $1 billion to supply systems for six more frigates.

DIVISIONS/SUBSIDIARIES

Table 1 presents a summary of Unisys' commercial and defense divisions and subsidiaries. This list represents a combination of Sperry and Burroughs units minus the divisions sold to Honeywell.

Table 1

Unisys Divisions and Subsidiaries

Location	Equipment
Unisys Corporation Detroit, MI (Parent Company)	
Commercial Systems Group	
Foundation Computer Systems Cary, NC	Utility software
GRAFTEK, Inc. Boulder, CO	Peripherals, computer services, engineering/ technical software
Memorex Santa Clara, CA	Peripherals, accessories, components
Pasadena Plant Pasadena, CA	Computers
Sperry Corp. Saint Paul, MN	Electronics services, computers, peripherals, AI software
Timeplex, Inc. Woodcliff Lake, NJ	Utility software, data communications equipment
Unisys Knowledge Systems Organization Paoli, PA	Artificial intelligence
Defense Systems Group	
Communication Systems Group Salt Lake City, UT	Telecommunications, intelligence, data communications, computers
Computer Systems Division Eagan, MN	Information processing systems, militarized computer products and displays
Shipboard & Ground Systems Group Great Neck, NY	Sonar equipment, EW communication systems, sonar countermeasures equipment, ground defense radar systems, shipboard navigation equipment, shipboard radar equipment
System Development Group Camarillo, CA	Command and control, custom services microcomputers
System Support Group McLean, VA	Technical services, facilities management, integrated systems
Semiconductor Facilities	
Unisys Components Group Rancho Bernardo, CA	ASICs

Source: Various Industrial Sources

SEMICONDUCTOR PROCUREMENT

The impact of Unisys' new leverage after the merger was felt directly in purchasing. Greater volume allowed Unisys to renegotiate supplier contracts, significantly reducing procurement costs. It also created a critical mass to successfully execute vendor quality-improvement programs. In 1987, Unisys cut 21 percent off its purchasing bill. Suppliers' rosters were dramatically cut also; for instance, the number of connector suppliers was reduced from 88 to 20.

The purchasing operation is done through central procurement units as well as through the divisions themselves. The Materials Management Center (MMC) in Pueblo, Colorado, is in charge of semiconductor procurement for the Computer Systems Division units in Pueblo and in Saint Paul, Minnesota, as well as for the Shipboard and Ground Systems Group in Clearwater, Florida. The Communication Systems Division in Salt Lake City, Utah, and the Shipboard and Ground Systems Group in Great Neck, New York, do their own purchasing. Central procurement for commercial semiconductors is done by the Component Engineering and Procurement Organization (CEPO) in San Diego, California. CEPO is responsible for supplier qualification, component engineering, quality verification, contracts, and executing procurement.

Figure 3 shows a percentage breakout of semiconductor purchases. In-house capabilities, recently consolidated into the Rancho Bernardo, California, facility, supply an estimated 11 percent of commercial semiconductor use. This facility produces primarily gate arrays and cell-based ICs. These products are manufactured both on bipolar process technology as supplied by Motorola and on CMOS from Intel. Along with internal CAD and packaging technology, the purpose of this captive capability is to produce volume proprietary logic ICs as well as quick-turn engineering prototypes. Standard products are almost entirely purchased directly from outside vendors.

Military semiconductor purchases accounted for approximately 19 percent or $60 million of total external purchases. All of the military semiconductor sourcing is done externally, both directly and with distributors.

After the merger, Unisys reorganized its purchasing operations, creating the following seven procurement task forces:

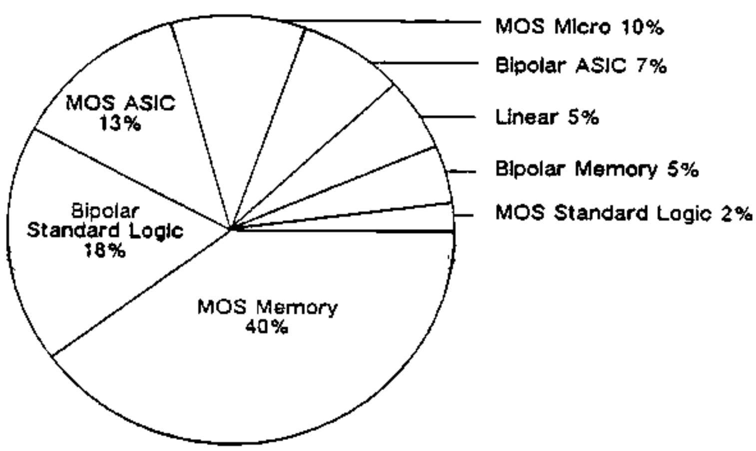
- Electronics
- OEM
- Foreign
- Mechanical
- Semiconductor
- MRO
- Government

These task forces are responsible for determining corporate needs, setting price targets, and conducting negotiations. Four of the task forces deal primarily with electronics. The semiconductor group coordinates contracts for both defense and commercial divisions; the OEM group coordinates personal computers and small systems; the electronic group coordinates all passive devices, connectors, electromechanicals, and printed circuit boards; and the international procurement group executes purchases with offshore suppliers mostly in the Far East. Offshore suppliers, account for roughly $350 million annually—mostly for systems, peripherals, and components. The role these offshore suppliers play is increasing as they represent a growing portion of Unisys' purchases.

Strategic programs that facilitate and improve operations efficiency are also being set in place. Currently Unisys has certification, just-in-time (JIT), and electronic data interchange (EDI) programs with selected component vendors.

Figure 3

Unisys Semiconductor Purchases
1988



$360 Million

0003038-3

Source: Dataquest February 1989

DATAQUEST CONCLUSIONS

Compatibility, leverage, and cost control are perhaps the best terms to describe the success of the Unisys merger. Similar yet somewhat complementary product lines and corporate organizations have helped Unisys in achieving leverage in both the markets it serves and the purchases it makes. Although 1988 was a relatively flat year for revenue and earnings growth, the company is faring much better than most mergers and probably much better than either Burroughs or Sperry could have alone.

Unisys has been able to maintain a high level of R&D investment principally because of aggressive cost control and economies of scale achieved during the past two years. By applying the principle of centralized leveraged contracting and working closely together with its suppliers and internal engineering organizations, the component procurement groups at Unisys have contributed greatly toward maintaining cost control.

Unisys' ability to increase R&D efforts because of reduced overall costs is a key competitive advantage, putting the company in an enviable position of decoupling its new product-development funding from moderate swings in revenue. This could prove to be an advantage in both the commercial computer market, where many economists are predicting a downturn in 1990, and in the defense electronics market, where funding is flat and efficiencies will be mandated.

Greg Sheppard
Najoo Wadia

Dataquest
a company of The Dun & Bradstreet Corporation

Research *Newsletter*

SAM Code: 1989–1990 Newsletters: January–March
1989–3
0002933

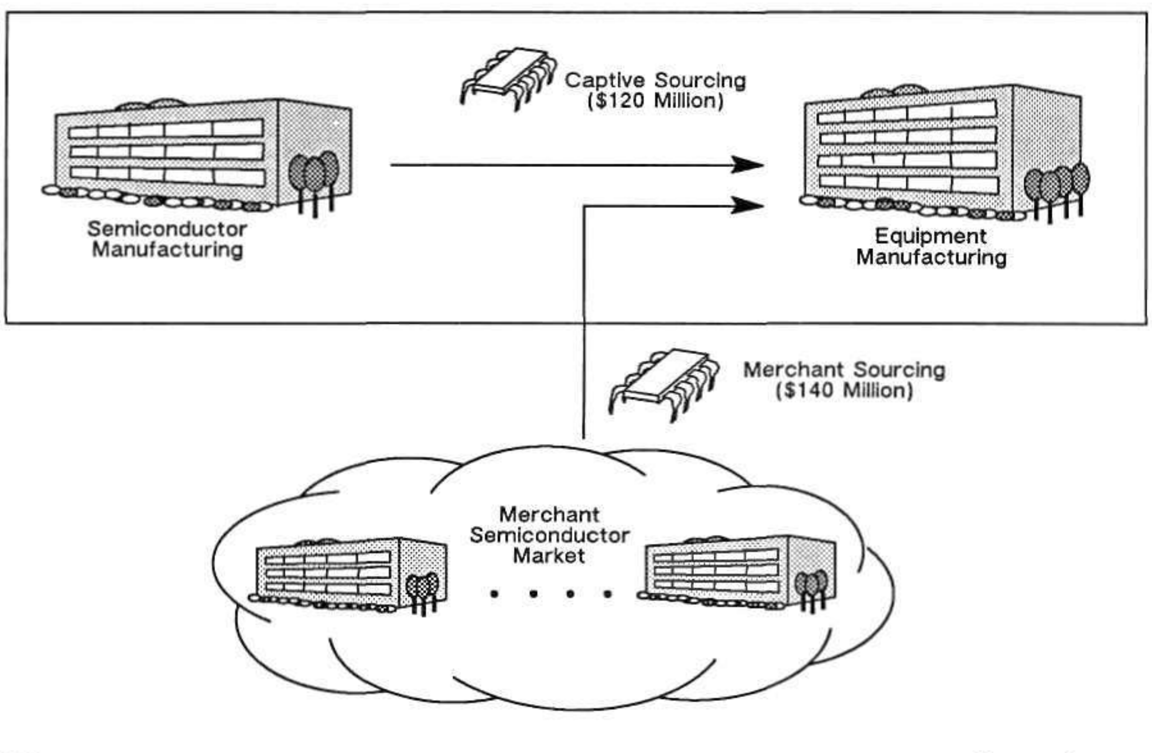
NORTHERN TELECOM: STRATEGY, TECHNOLOGY, AND SEMICONDUCTORS

SUMMARY

Northern Telecom has become one of the world's largest suppliers of telecommunications equipment. The company also has an integrated strategy of manufacturing 40 to 50 percent of the semiconductor components it needs, as illustrated in Figure 1. This newsletter focuses on Northern's $260 million consumption, $140 million procurement, and $120 million production of semiconductors.

Figure 1

Semiconductor Consumption and Production at Northern Telecom



0002933-1

Source: Dataquest
February 1989

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

COMPANY PROFILE

Northern Telecom had sales of $4.9 billion in 1987, as presented in Table 1. The company's revenue grew at a compound annual growth rate (CAGR) of 12.9 percent between 1984 and 1987, or 50 percent faster than the estimated CAGR of 8.2 percent of the overall telecommunications market during the same period.

Table 1

Northern Telecom's Performance Results

	1984	1985	1986	1987	CAGR 1984-1987
Revenue ($M)	$3,374	$4,263	$4,384	$4,854	12.9%
Income ($M)	$ 256	$ 299	$ 313	$ 347	10.7%
Employees	47,000	47,000	46,000	49,000	1.4%

Source: Northern Telecom
Dataquest
February 1989

Northern's manufacturing facilities in North America are listed in Table 2. The company's research and development activities are conducted by Bell-Northern Research, a subsidiary of Northern (70 percent ownership). Northern Telecom spent $588 million on research and development in 1987; this amount represents 12 percent of the company's revenue.

Table 2

Northern Telecom's Manufacturing Facilities in North America

Location	Products
Canada	
Aylmer, Quebec	Transmission equipment
Belleville, Ontario	Business telephones
Brampton, Ontario	Central office switches
Calgary, Alberta	Key telephones
London, Ontario	Residential telephones
Montreal, Quebec	Wire and cable
Ottawa, Ontario	Semiconductors
Saskatoon, Saskatchewan	Optical fibers
Winnipeg, Manitoba	Transmission equipment

(Continued)

Table 2 (Continued)

Northern Telecom's Manufacturing Facilities in North America

Location	Products
United States	
San Diego, CA	Semiconductors
Santa Clara, CA	Private branch exchanges
W. Palm Beach, FL	Datacom equipment & phones
Atlanta, GA	Transmission equipment
Morton Grove, IL	Datacom equipment
Ann Arbor, MI	Private branch exchanges
Minneapolis, MN	Datacom equipment
Minnetonka, MN	Business systems
Marlton, NJ	Datacom equipment & phones
Moorestown, NJ	Network monitoring equipment
Concord, NH	Network monitoring equipment
Raleigh-Durham, NC	Central office switches
Nashville, TN	Telephones
Dallas, TX	Private branch exchanges

Source: Northern Telecom
Dataquest
February 1989

In 1987, Northern earned 65 percent of its revenue from sales made in the United States, 30 percent from sales made in Canada, and 5 percent from sales made outside North America. In the United States, the company manufactures most of the products that it markets there. Northern's stated goal is to expand its business in Europe and Japan.

Semiconductor Consumption

Dataquest's estimate of Northern Telecom's 1987 semiconductor consumption is presented in Table 3. The company earned 63 percent of its revenue from the sale of public network equipment; 29 percent from the sale of customer premises equipment; and the remaining 8 percent from the sale of cable, outside plant, and R&D services. In addition, Dataquest estimates that 39 percent of Northern's 1987 semiconductor consumption of $260 million was for logic products, 34 percent was for memories and microcomponents, 19 percent was for linear, and 8 percent was for discretes and optoelectronics.

Table 3

Northern Telecom's Estimated 1987 Equipment Sales
and Semiconductor Content
(Millions of Dollars)

Equipment Type	Market Share	Revenue	Semiconductor Content
U.S. Totals	N/A	$2,894	$169
Central Office Switches	34%	936	60
Private Branch Exchanges	19%	599	39
Carrier Systems	6%	65	4
Microwave Radio	9%	43	2
Automatic Call Distributors	29%	36	2
Multiplexers	4%	30	2
Network Diagnostics	33%	25	1
Packet Switches	9%	24	1
Integrated Voice/Data Workstations	33%	22	1
Other	N/A	1,114	57
Canadian Totals	N/A	$1,335	$ 79
International Totals	N/A	$ 222	$ 12
Cable, Outside Plant, R&D	N/A	$ 403	N/A
Worldwide Totals	N/A	$4,854	$260

N/A = Not Applicable

Source: Dataquest
February 1989

Semiconductor Procurement

Northern's component and manufacturing technologies are key to its overall competitive strategy. Semiconductor procurement is a function of the corporate operations staff and includes both tactical and strategic elements. Northern also has an external business group to manage foundry and semiconductor technology agreements. Vice presidents head these procurement and external business groups.

The company's component purchasing organization is headed by a purchasing operations director at the company's U.S. headquarters in Nashville, Tennessee. Northern negotiates annual contracts with its key semiconductor suppliers from this central location every fall. The actual purchases of semiconductors, however, are made throughout the year by the purchasing managers at each manufacturing location. Dataquest estimates that 55 percent of Northern's 1987 merchant semiconductor purchases of $140 million was for memories and microcomponents, 22 percent for logic, 15 percent for discretes and optoelectronics, and 8 percent for linear. The company has standardized on Motorola's microprocessor architectures.

Northern Telecom establishes the strategic relationships it needs with suppliers for ISDN and advanced semiconductor technology from both Nashville, Tennessee, in the United States and Ottawa, Ontario, in Canada. The company has been reducing its supplier base in recent years to just a few companies. (Dataquest believes that Northern's major suppliers include Intel, LSI Logic, Mitsubishi, Motorola, National, and Texas Instruments.) Northern works very closely with its partners to establish realistic requirements regarding pricing, delivery, quality, reliability, and technology. For example, the company is investigating a just-in-time delivery system for raw materials, and this will require very close relationships with Northern's suppliers in order for it to be practical. These long-term programs are headed by a strategic procurement practices director.

Semiconductor Production

Northern Telecom has CMOS fab facilities located in Ottawa, Ontario and in San Diego, California, to make custom digital and mixed analog/digital semiconductors for its telecommunications equipment. Dataquest estimates that Northern's 1987 semiconductor production was $120 million. None of Northern's semiconductor production is available on the merchant market.

Northern has just installed a $100 million submicron fab in its Ottawa plant, and one of the company's greatest concerns is the capital investment required to keep its production facilities current in the future. Based on historical trends, Dataquest estimates that the cost of a new fab doubles every 4 years. (Thus, a fab that costs $100 million in 1988 can be expected to cost $200 million in 1992 and $400 million in 1996.) The company is participating in the Captive Manufacturers Subgroup of the Semiconductor Industry Association to share its concerns with other organizations in similar situations.

DATAQUEST CONCLUSIONS

Competition

Competition in the telecommunications equipment market is becoming global and is increasing in intensity. One of Northern's competitors (i.e., AT&T) recently complained that companies in Japan, South Korea, and Taiwan are selling some of their equipment in the United States at unfair prices. Regardless of the final legal decision regarding pricing, however, Dataquest believes that Northern (and AT&T and all other suppliers to North America) will experience severe downward pricing pressures in this crowded market.

Strategy

Northern Telecom originally established its captive component operations to obtain the efficient use of silicon that comes from custom circuits. This strategy allowed the company to sell equipment with higher performance and more features at prices that were still competitive. A side benefit of this approach was the creation of entry barriers because the relatively high cost of a custom circuit design discouraged competitors from participating in the market. Today, however, application-specific IC (ASIC) technology makes customized silicon available to all equipment manufacturers as a result of the lower costs required to design a circuit. Dataquest believes that Northern must consider new ways to differentiate its equipment in the marketplace now that clonemakers have these tools at their disposal.

Leadership

Northern was one of the first companies to develop and market a digital central office switch, and this innovation has become the practice of the industry today. As competition in the telecommunications equipment industry increases and ASICs give all suppliers a common capability in semiconductor technology, Dataquest believes that the next strategic battleground in this market will be the accelerated time to market with new generations of products. Dataquest recommends that Northern Telecom (and the other participants in the industry) continue to tighten the links between design, manufacturing, and marketing to be able to respond as quickly as possible to changing customer needs.

Roger Steciak

Dataquest
a company of The Dun & Bradstreet Corporation

Research *Bulletin*

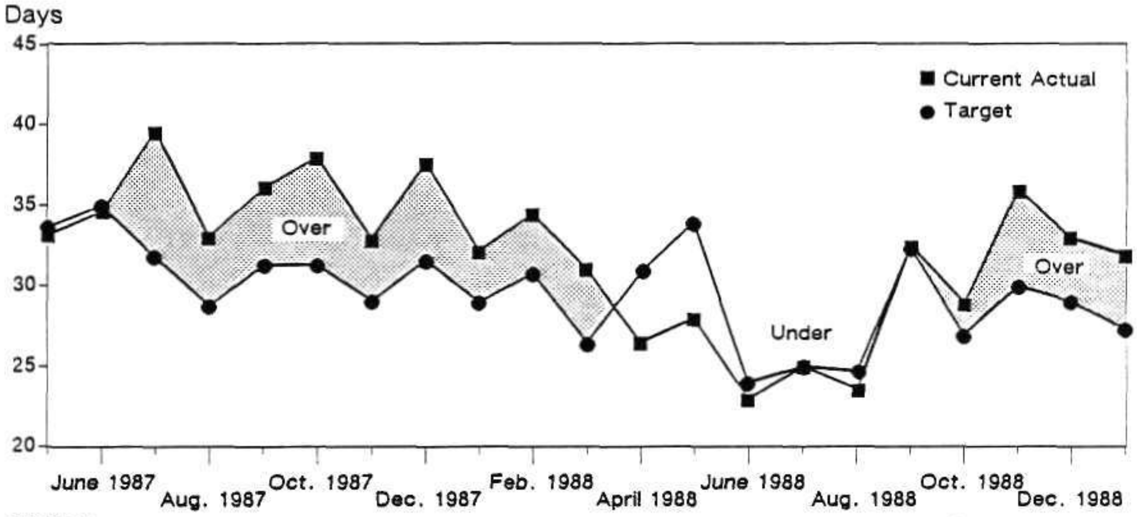
SAM Code: 1988–1989 Newsletters: January–March
1989–2
0002682

JANUARY PROCUREMENT SURVEY: ORDER RATES REMAIN UNCHANGED AS INVENTORY LEVELS DECLINE

Respondents to this month's survey noted that overall inventory levels were reduced and that the targeted levels also declined. Now that the holidays are past, order rates are expected to remain firm in relation to last month's slight decline, adding another stabilizing factor to the inventory situation. For the year, overall system sales ranged from 2 to 40 percent higher than last year's levels. During this time, inventory levels fluctuated by approximately 6.5 days around the 1988 mean of 29.5 actual inventory days, as seen in Figure 1. The January targeted and actual inventory levels of 27.3 and 31.9 days, respectively, continue to reflect the close inventory controls that have hallmarked the past two years.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



0002682-1

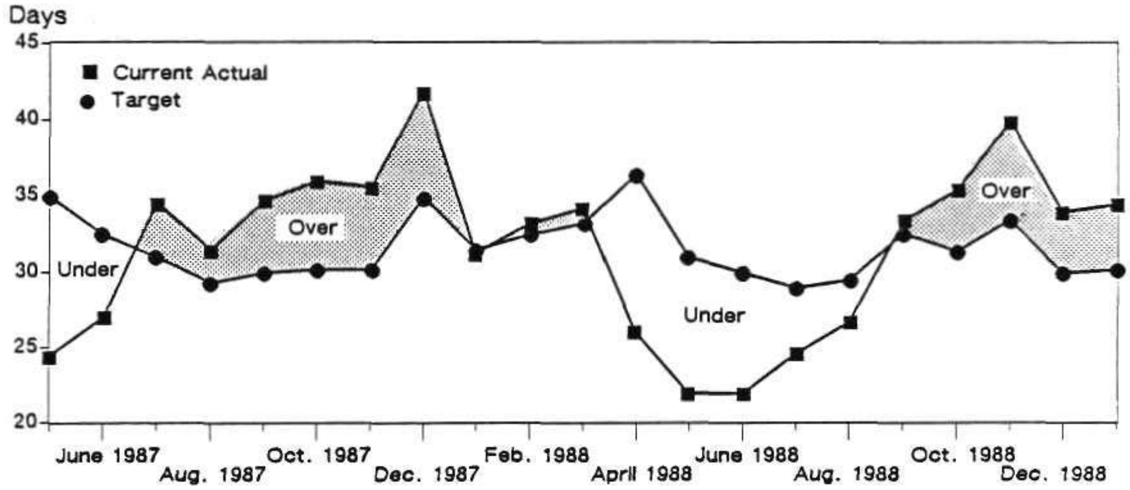
Source: Dataquest January 1989

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398, (408) 437-8000, Telex 171973, Fax (408) 437-0292

Inventory levels for computer OEMs have remained remarkably constant since our last survey, holding at 30.3 targeted days and 34.5 actual inventory days. Although the gap between the actual and targeted inventories (see Figure 2) still remains at slightly more than four (4.2) days, order rates for semiconductors have stayed at the same level if not slightly higher. The continued improved availability of 1Mb DRAMs has kept average actual inventory levels slightly higher as buyers continue to order memory to meet past demand.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



0002682-2

Source: Dataquest January 1989

Overall, pricing of semiconductors has declined, largely in part due to the increased availability of 1Mb DRAMs and the softening of some logic and microprocessor prices. SRAM and 256K DRAM pricing remains firm and is expected to continue so through the next six months. Lead times have increased slightly up to 12 weeks as the mix of SRAM and lower-density DRAM shipments keeps lead times relatively high. Surface-mount package availability is becoming a critical problem for one-half of the respondents who use these parts.

DATAQUEST ANALYSIS

Inventory levels continue to decline as key components become more available and begin to catch up with order rates. As mentioned in earlier surveys, this inventory correction is expected and should continue through the next few months. Pricing should also continue its downward trend, with some exceptions in video RAMs and SRAMs. The overall electronics industry is relatively healthy, and the outlook is for a realistically steady growth year in 1989.

Mark Giudici

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Research Bulletin

SAM Code: 1989–1990 Newsletters: January–March
1989–1
0002616

HIGH–DEFINITION TV: IS AMERICA FINALLY WAKING UP?

The United States Department of Defense (DOD) has announced its intention to finance the development of an advanced, high–resolution video display screen. The immediate purpose is to make a compact, low–cost unit for military systems (such as helicopters, tanks, planes, ships, and training simulators) that can display detailed images of battlefield conditions. In the coming months, the Defense Advanced Research Projects Agency (DARPA) is expected to provide further details of the specific projects to be funded. Dataquest believes that this action is an attempt by the United States to reclaim the high ground lost to foreign competition as the international economic landscape has shifted over the past two decades.

NATIONAL SECURITY

We believe that the broader purpose of this project is to restore vitality to the U.S. consumer electronics industry, while at the same time, bolster the country's national security. This twofold intent is an example of the interrelationship of today's end–use markets; for example, the focusing system of the 35mm camera has become the focusing system of the VCR, and the automatic electronic system of the VCR has become the automatic electronic system of the 35mm camera. Thus, the technology for one product can improve the performance or convenience of other products. A high–resolution display screen is an example of a strategic technology with potential applications in television sets, video games, military systems, automobile dashboards, computer monitors, medical scanners, and any systems where the display of detailed images would make the systems easier to use. We believe that a nation that ignores these types of end–use market interrelationships and the corresponding leverageability of these strategic technologies can put itself in danger on both economic and military fronts.

The mass production of equipment for the home creates demand for semiconductor components and helps to reduce the cost of the technology used by achieving scale economies. Without domestic production of consumer electronics equipment, technology costs will remain high for other domestic equipment industries. Although the United States pioneered almost all of the consumer electronics equipment in use today, Dataquest estimates that imported products have taken about half of the U.S. consumer electronics equipment market in the last 10 years. In addition, Dataquest estimates that products exported from the United States have only about a 10 percent share of the worldwide consumer electronics equipment market. VCRs, for example, are estimated to use almost 5 percent of the world semiconductor output, yet more than 98 percent of the world market is served by non-U.S. producers. As another example, there is now only one remaining U.S. TV set producer. By not participating in such key industries, we foresee that the United States is in danger in the long run of losing its leadership position in technology.

LAUNCHING HDTV IN THE UNITED STATES

Dataquest notes that estimates of the U.S. market potential of HDTV vary because this is an emerging industry with hundreds of variables between the initial idea and ultimate commercial success. We do believe, however, that an annual potential of 5 million HDTV sets at an average price of $750 in the year 2000 is a good estimate. With the installed base of conventional TV sets in the U.S. currently at about 160 million units, the potential for sales of HDTV sets over the next two to three decades is very large indeed as consumers eventually upgrade to the newer models.

However, HDTV is too expensive for any one company to develop alone. Dataquest sees as positive moves for the domestic HDTV industry the Defense Department's announcement to sponsor development of a high-definition display and an announcement earlier last year by the United States Federal Communications Commission requiring any HDTV standard to be backwards-compatible with conventional TV sets. It will require many years for HDTV sets to penetrate the market even under the best conditions because Dataquest believes that most consumers will not obsolete their conventional TV sets for HDTV until there is an ample supply of HDTV programs to watch. But Dataquest notes that investors might be more willing to fund HDTV programming ventures during the start-up years of the HDTV industry when they know that these programs can also be received on conventional TV sets.

DATAQUEST CONCLUSIONS

The world of the 1990s will be different from the past; as we approach the new decade, the United States no longer has a monopoly on high technology, and the competition is now both global and brutal. To survive, we believe that the United States must make changes in the way it does business in the world economy. Dataquest sees these HDTV announcements as the beginnings of a U.S. version of the industry-government consortiums that are common in both Europe and Japan to coordinate economic activity. It remains to be seen whether the result will be a wall of protectionism leading to another worldwide Great Depression or an environment where the U.S. economy can flourish as part of the larger world economy.

The standards for HDTV must still be defined before any HDTV products can be developed. Dataquest believes that with the recent announcements by U.S. government agencies regarding HDTV, the U.S. industry will move ahead, and potential suppliers of both equipment and semiconductors will be more willing to make the necessary investments in products for the HDTV application. End-use markets today are interrelated, and with the United States already losing ground to imports in the consumer electronics segment, there is the possibility that it could also begin to lose ground in other segments (such as military electronics). Dataquest concludes that the United States must become involved with the development and manufacturing of HDTV products to preserve its economic and military health.

Roger Steciak

April–June

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

- **April Procurement Survey: Order Rates Steady, Overall Availability Drought Over!** (1989–17)

  The semiconductor availability bubble has burst, according to this month's procurement survey respondents. This bulletin discusses the current actual versus target semiconductor inventory levels for all OEMs and for computer OEMs. Dataquest recommends that users should write into their contracts (if they have not done so already) clauses that allow for quarterly price reviews.

- **Will the Japanese Own the 3.5-Inch Rigid Market?** (1989–18)

  As of the end of 1988, no Japanese companies were credited with as much as 10 percent of the world's 3.5-inch rigid disk drive sales. This newsletter examines the reasons behind the slowness of the Japanese in capturing this lucrative market. Dataquest concludes that we are approaching a period when U.S. leaders such as Miniscribe, Western Digital, Conner, Quantum, and Seagate will expand their facilities to meet the intramural competition, showing little regard for the sleeping giant that is about to absorb the 3.5-inch RDD industry.

- **The ASIC Package Proliferation** (1989–19)

  Surface-mount technology now is mainstream. This newsletter discusses the packages currently being used or under development for ASICs, and it also reviews the issues and choices pertaining to standards involved in ASIC packaging. Dataquest believes that package proliferation will continue as the ASIC market develops.

- **80486/68040: A RISC-Less Approach** (1989–20)

  On April 10, Intel announced the widely anticipated 80486 microprocessor, which came two weeks after the unveiling of Motorola's 68040. This newsletter examines the ties to the past, feature comparison, RISC versus CISC, availability, and the bridge to the future. Dataquest predicts that Intel's 80386/486 and Motorola's 68020/030 product lines will continue to dominate the general-purpose 32-bit microprocessor market in the foreseeable future.

- **ISDN: Plans, Potentials, and Pitfalls (Part 2—The Equipment)** (1989–21)

  Integrated Services Digital Network (ISDN) will affect all 500 million items of communications equipment currently in service in the United States. This newsletter discusses market potential, interface standards, and the reason to integrate. Dataquest recommends that all semiconductor suppliers participating in this market work very closely with customers to keep up with current developments.

April–June

- **Fourth Annual Procurement Survey: Old Issues Remain Hot; Accurate Forecasting is the Key** (1989–22)

  The fourth annual Dataquest procurement survey results were announced at the Semiconductor User and Applications Conference that was held in San Francisco, California, in late February. This newsletter discusses the survey structure and findings. Dataquest concludes that the underlying thread running through this year's survey was that the availability of key components pervaded all areas of procurement.

- **Comdex/Spring: What's Missing?** (1989–23)

  As the mercury fell in Chicago, so did the level of excitement surrounding Comdex. This newsletter discusses the i486, file servers, MACDEX, EISA, and the debuts and no-shows. Dataquest concludes that the event would have felt much more complete if the Apples, the NeXTs, and the Suns of the world had been enticed into attending.

- **May Procurement Pulse: Industry Levels Improve, DRAM Market Amiss** (1989–24)

  The Procurement Pulse is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin presents the results of the survey and analyzes what this information means to both semiconductor users and manufacturers. Dataquest concludes that accurate forecasting and inventory control by both users and vendors will be critical in preventing any slowdown from becoming a recession.

- **Second Quarter Electronics Equipment Forecast** (1989–25)

  In keeping with Dataquest's outlook for slower economic growth this year, we forecast that North American electronic equipment production will grow only 6.5 percent in 1989 (down from 8.8 percent growth in 1988) and will accelerate only slightly in 1990, to 6.7 percent. This newsletter presents an overview of recent business activity in the North American electronics industry and gives Dataquest's short-term outlook for the industry. Dataquest believes that the strengthening tie between electronics industry activity and overall economic activity is an important characteristic of the climate in which business will be conducted in the future.

April–June

- **ISDN: Plans, Potentials, and Pitfalls (Part 3—The Semiconductors)** (1989–26)

  Integrated Services Digital Network (ISDN) is an opportunity with high rewards and high risks for the semiconductor industry. This newsletter discusses the purpose behind ISDN, circuits and applications, and suppliers and demand. Dataquest concludes that ISDN represents an opportunity disguised as a challenge.

- **OEM Monthly (May)** (1989–27)

  OEM Monthly has been designed to give our semiconductor industry clients a deeper insight into the production of PCs and other end equipment in North America. This bulletin discusses PC shipments, OEM profits, equipment markets, and semiconductor consumption by region. Dataquest concludes that standard desktop PCs have become a low–cost commodity, with marketing issues replacing technology as the driver.

- **Server: What's In a Name?** (1989–28)

  Every year, a marketing buzzword becomes popular in the marketplace; this year, the buzzword is "server." This newsletter discusses definition, server uses, types of computers, and the size of the server market. Dataquest believes that servers bring the industry closer to being focused on service and added value rather than being product specific.

- **LANs: Changes, Choices, and Challenges** (1989–29)

  Local area networks (LANs) are used for sharing data among machines such as personal computers, workstations, minicomputers, mainframes, and supercomputers. This newsletter discusses the historical background, connection potential, LAN suppliers, semiconductor components, and PC LANs. Dataquest recommends that semiconductor suppliers work with both LAN and PC OEMs as a way to seize every available opportunity in this area.

- **Desktop Connectivity: Present and Future Directions** (1989–30)

  In the late 1970s and early 1980s, a new phenomenon was taking place in the office environment: office automation or the building of the office of the future. This newsletter explores the issues and technology that affect the battle for connectivity of desktop devices within the office environment. Dataquest concludes that as we enter the 1990s, desktop connectivity options will continue to be the focal point and/or solution to improving work group and company productivity issues.

April–June

- **Where Will All Those DAT Drives Go?** (1989–31)

  Catchy headlines in industry tabloids have hyped digital audio tape (DAT) recently. This newsletter addresses the issues pertaining to the DAT market and Dataquest's predictions for the future. Dataquest believes that DAT will live up to users' expectations, and once marketed at moderate prices, DAT will take off as an alternative to other secondary storage products.

- **High–Definition Video—"A New Frontier"** (1989–32)

  High–definition video technology (HDVT) will serve as the rallying cry for the United States in the 1990s as did the race to the moon in the 1960s. This bulletin discusses the consumer, the industry, the technology, and the spinoffs. Dataquest recommends patience for semiconductor companies that want to pursue opportunities in HDVT because large orders will come very slowly.

- **CES Highlights** (1989–33)

  The Consumer Electronics Show (CES) is held every June in Chicago to bring together industry participants ranging from manufacturing to retailing. This bulletin presents the overall impressions and strategic currents of the show. Dataquest recommends that semiconductor suppliers take a systematic approach to their businesses' growth, with consumer electronics items that are expected to be hot in the next century being good places to start today.

- **OEM Monthly (June)** (1989–34)

  OEM Monthly has been designed to give our semiconductor industry clients a deeper insight into the production of printers and other end equipment in North America. This bulletin discusses printer market growth, average selling price, and unit market share by printer type. Dataquest predicts that there will be a strong growth in memory and application–specific processor applications in both laser and ink jet printers in the foreseeable future.

Research *Bulletin*

SAM Code: Newsletters 1989: April–June
1989–34
0004281

OEM MONTHLY

OEM Monthly has been designed to give our semiconductor industry clients a deeper insight into the production of printers and other end equipment in North America. Figures 1 through 3 below will be discussed in detail in the paragraphs that follow.

Figure 1
North American
Printer Market Growth

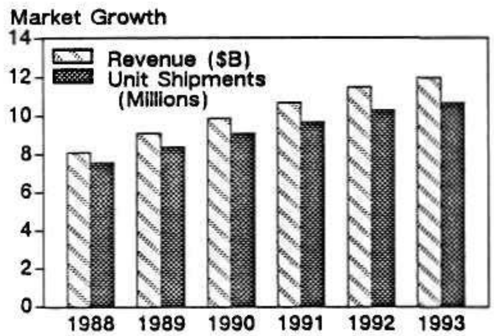


Figure 2
Average Selling Price
of Selected Printer Types

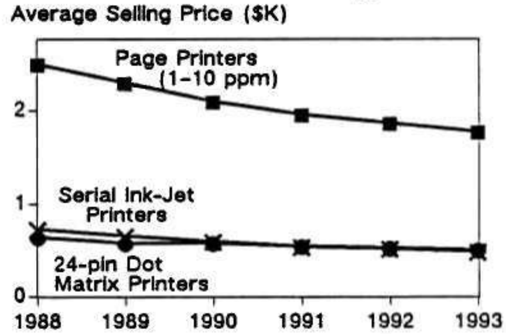
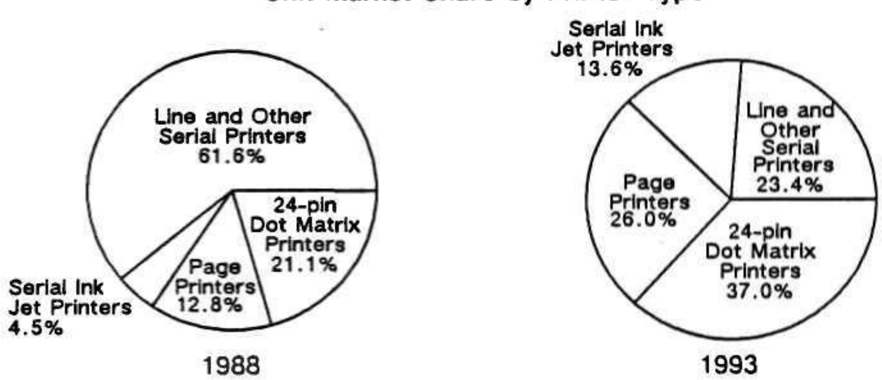


Figure 3
Unit Market Share by Printer Type



0004281-1

Source: Dataquest
June 1989

At first glance, the North American printer market appears healthy but unexciting, with a 6.9 percent growth rate predicted over the next five years. This top-level view can be deceiving, however, as it masks the explosive growth expected from three important segments: high-quality (24-pin) dot matrix, ink jet, and page printers. Combined, these segments are expected to realize compound annual growth rates (CAGRs) of more than 20 percent in unit shipments and 15 percent revenue growth through 1993.

GROWTH SEGMENTS

Of these growth segments, high-end dot matrix printers represent the most mature product group. Greatly improved print quality afforded by the 24-pin head, and the low cost of manufacture resulting from high production volumes have enabled dot matrix printer manufacturers to capture a large and growing portion of the personal printer market. Manufacturers can now offer competitive quality at a low price, while minimizing speed, noise, and print quality trade-offs.

The page printer or laser printer segment is clearly the most explosive of all printer segments. With its ability to interpret and implement a page description language (PDL), the page printer offers users a quantum leap in printing quality and flexibility.

But growth in unit volume does not tell the whole story. Because page printers are fundamentally different from prior printing technologies (page printers are "smart" peripherals, which implement higher-level instructions and then act as controllers to print engines), their semiconductor content is much richer. Dataquest foresees expanding opportunities in memory and specialized processing products within the controller portion of page printers.

Still small in relation to the other segments, the newly emerging ink jet segment is coming up fast. Serial ink jet printers are making substantial inroads at the expense of dot matrix and other impact technologies. But the really explosive potential for this technology is in the middle ground between the performance- and feature-limited dot matrix and the still-pricey laser printer. "Laser quality" products, such as Hewlett-Packard's DeskJet series, which implement a PDL and offer many of the features and capabilities associated with laser printers, have given rise to the phrase "poor man's laser printer" in reference to this very promising market segment.

CONTENT TRENDS

Market acceptance of controller-based printers has been enthusiastic. The fundamental difference in semiconductor content caused by the controller board leads us to predict strong growth in memory and application-specific processing applications in both laser and ink jet printers for the foreseeable future.

Kevin Landis

Dataquest
a company of The Dun & Bradstreet Corporation

Research Bulletin

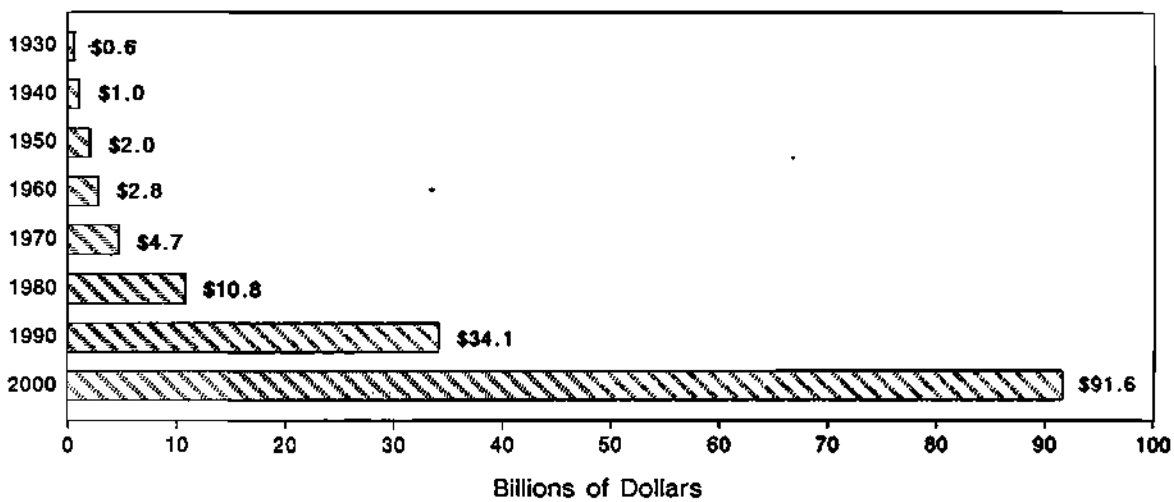
SAM Code: Newsletters 1989: April-June
1989-33
0004248

CES Highlights

The Consumer Electronics Show (CES) is held every June in Chicago to bring together industry participants, from manufacturing to retailing. Sales of consumer electronics have been growing at a 10.4 percent compound annual growth rate (CAGR) for the past 20 years and are expected to reach $34.1 billion in 1990 and $91.6 billion by the year 2000 (see Figure 1).

Figure 1

Estimated U.S. Sales of Consumer Electronics



0004248-1

Source: EIA
Dataquest
June 1989

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OVERALL IMPRESSIONS

No blockbuster products appeared at CES this year. Instead, there was a slight improvement in performance and features of existing products. For example, some language translators and electronic dictionaries now provide audio to help students and travelers. Also, the premium audio and video equipment on display was aimed at audiophiles and videophiles, rather than at the typical budget-conscious consumer.

STRATEGIC CURRENTS

Audio, video, and personal electronics will continue as the bread-and-butter business for the industry well past the year 2000. During the next decade, however, two areas will emerge as the drivers for the 21st century.

High-Definition TV (HDTV)

Interest in HDTV has skyrocketed because this potential product is perceived as a way to restore U.S. competitiveness. Congress began hearings this year to establish a U.S. HDTV policy, and several bills were introduced. Government support for HDTV will be more in the form of cheers than dollars, however, because of the huge budget deficit.

It will be difficult to form a national consensus regarding establishing the U.S. HDTV policy, because of the many groups that are voicing opinions. For example, consumer advocates ask whether it is fair to have consumers subsidize the development of a technology that also has major military uses. Expect the HDTV program to take shape slowly.

Home Automation

Consumers may wonder why their kitchen appliances would ever want to talk to each other on a local area network. One reason is conservation. Energy consumption management in the home is becoming increasingly important, because energy is expected to become even more costly and scarce in the next century.

Another force driving home automation is convenience. The integration of energy, security, and entertainment controls will let consumers link different makes of equipment together for common operation. Even voice recognition is expected after the year 2000.

DATAQUEST CONCLUSIONS

Standards still must be developed for HDTV and home automation. Thus, an opportunity exists for semiconductor suppliers to participate in the creation of their future. Application-specific ICs will be needed to reduce the cost of this equipment; committee involvement will let chipmakers jump in at the beginning. However, these future products do not present fast-buck opportunities. We recommend that semiconductor suppliers take a systematic approach to their businesses' growth. The consumer electronics items that are expected to be hot in the next century are good places to start today.

Roger Steciak

Dataquest
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Research *Bulletin*

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HIGH–DEFINITION VIDEO—"A NEW FRONTIER"

High–definition video technology (HDVT) will serve as the rallying cry for the United States in the 1990s as did the race to the moon in the 1960s.

U.S. residents perceived the country as lagging in technology in the 1950s; efforts to gain new technologies were intensified, and the result was the ambitious program to go to the moon. Technologies that benefited from this effort included microelectronics, systems management, materials science, and precision equipment.

Many U.S. residents today perceive the country as slipping in electronics technology, and HDVT could be the candidate to reunite its crumbling industries into a new competitive force. Technologies benefiting from HDVT applications include high–resolution displays, image computing (for education, entertainment, and military uses), semiconductors, and manufacturing.

Getting to the moon was not easy, however, and neither will be perfecting HDVT technology.

THE CONSUMER

HDVT is perceived by the electronics industry as the next step in television's evolution, because high–definition displays would have four times as many pixels per screen than today's televisions. The consumer, on the other hand, perceives the television set as the box in the living room that delivers entertainment cheaply. If a set costs too much or delivers anything besides leisure, the consumer will buy something else for relaxation.

We believe that high–definition television will take at least a decade to become established in the United States because the only advantage it offers so far is a better picture. However, Sony and other Japanese video makers already are introducing high–definition VCRs and negotiating deals with both Hollywood and independent producers to shoot high–definition movies. We believe that HD–VCRs and cable TV will be the entry points for consumer HDVT.

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THE INDUSTRY

TV sets represent a high-volume global business with thin profit margins; entrants to this market face a struggle. For example, Sony now has a 7.3 percent share of the U.S. market after 20 years of effort. Thomson (RCA/GE), on the other hand, has a U.S. market share of 23.4 percent.

Consumers know when uncertainties exist and avoid bad deals by refusing to purchase bad products. Quadraphonic sound, 8-track tape, Beta video standard, and AM stereo all failed when the high sales volumes needed for success never happened. We note that any of the following groups have veto power over any high-definition television plan:

- 25 programming studios
- 1,400 broadcasting stations
- 7,000 cable operators
- 10,000 video cassette rental stores
- 50,000 consumer electronics retailers
- Manufacturers of more than 50 brands and hundreds of TV and VCR models

THE TECHNOLOGY

Television is broadcast as analog signals, and most TV sets today process these signals with analog techniques. The HDVT debate, however, opens the door to alternative technologies such as digital transmission over the air, satellite or optical cables for signal delivery, and digital processing techniques inside the set. We believe that these alternative technologies are too risky to be practical at this time.

THE SPIN-OFFS

The real benefits of HDVT to the United States will be in the spin-offs. For example, high-resolution displays are needed for desktop publishing, battlefield graphics, medical imagers, flight simulators, and video games. Image manipulation algorithms for videocomputed graphics also are needed in education, entertainment, industrial design, personnel training, and military systems. We believe that technologies such as these will be necessary for industrial leadership in the 21st century.

DATAQUEST CONCLUSIONS

HDVT is an important program for the United States and should be a national priority. Dataquest believes that U.S. government policy should be to encourage companies to invest in advanced video technology for use in consumer, industrial, and military electronics. We recommend patience for semiconductor companies that want to pursue opportunities in HDVT, because large orders will come very slowly. We also note that the long-term nature of HDVT requires executives to look beyond the next quarter and politicians the next election.

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Research Newsletter

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WHERE WILL ALL THOSE DAT DRIVES GO?

OVERVIEW

Catchy headlines in industry tabloids have hyped digital audio tape (DAT) recently. Exposés of product wars being waged, of personnel stealing, of technology snafus, and of enormous amounts of money to be made with DAT are common. One would think DAT was the newest illegal high-technology "drug" being smuggled in from Japan.

Industrywide forecasts for DAT drives range from 120,000 units to between 600,000 and 700,000 units in 1992. As a comparison, Dataquest forecasts that the total 1/4-inch market will reach 2.1 million units in 1992. Dataquest estimates that a total of 911,000 1/4-inch units were shipped in 1988. Admittedly, it is hard to believe that the DAT market will approach the size of the 1/4-inch market in just three years, especially when there are no products shipping in quantities greater than 200 units.

This newsletter addresses the issues pertaining to the DAT market and Dataquest's predictions for the future.

THE ISSUES

In Dataquest's opinion, there are several issues that will affect the success of DAT products. These issues are as follows:

- Will interest in data-oriented DAT products help drive the consumer market, thereby providing an eventual economy of scale?
- Are American manufacturers selling their livelihood to the Japanese?
- Is the market going to be big enough to support all those who wish to compete?
- Will tape and head wear issues thwart success?
- Is DAT a product in search of a market?
- Are the current operating and storage conditions adequate?

Economies of Scale

First of all, DAT has been hyped as the cure-all for inexpensive, high-capacity secondary storage. Features such as fast search, random read, and 1.2 gigabytes of storage capacity have helped fuel the hype. Nevertheless, rumors of $400 OEM pricing for a DAT deck by 1992 seem a little farfetched. At best estimate, current prices for OEM quantities for DAT products are between $1,800 and $2,000. If one figures a minimum markup of 50 percent, by 1992, DAT units will have to be produced for less than $250 each to hit the $400 price mark. To draw a comparison, the approximate standard cost (burdened) for a 60MB, 5.25-inch, rigid disk drive is between $200 and $300. Dataquest forecasts that rigid disk drives in the 31-to-100MB category will exceed 2 million units in 1989. The sheer mass of the rigid market drives prices down. Even at the upper end of the DAT forecast scale, the numbers do not approach 2 million. Thus, how can DAT manufacturers expect to produce a deck for less than $250?

This brings us to our next issue, economies of scale from the consumer market. Best estimates for consumer DAT units are as follows:

1989	1990	1991	1992
7,500	30,000	60,000	120,000

This forecast doesn't look much different than the data DAT products. According to Dataquest research, the Japanese are expected to slowly increase sales of DAT players in the United States over time. This slow selling strategy is intended to cool U.S. legislative bodies from charging the Japanese with trade sanctions. This slow selling strategy is not going to help the data DAT market at all.

Increased sales in the audio market benefit the Japanese manufacturers much more than others. Manufacturers such as Sony, Hitachi, and JVC have lower production costs for DAT drives than manufacturers such as WangDAT, Archive, and Cipher Data. The Japanese manufacturers do not have to purchase DAT decks from third parties, they are internal customers, and they assuredly will benefit from economies of scale greater than their American counterparts.

American Manufacturing Issues

Does this mean that American manufacturers are selling their livelihood to the Japanese? This is not a small issue to many American manufacturers. Currently, only the Japanese are manufacturing DAT decks. Thus, American or other manufacturers that wish to participate in this market have no choice but to purchase products from the Japanese. Some manufacturers that Dataquest interviewed said that the Japanese are difficult to work with, and that they perceive their Japanese business partners as noncommunicative, uninventive and, in certain instances, less than helpful. Some American manufacturers that Dataquest spoke with felt that they were "giving away" technical improvements and strategies to the Japanese, and getting little in return. In essence, anti-Japanese sentiments amongst U.S. manufacturers continue to reign, creating frustration and discontent. However, one should remember that Sony perfected the audio DAT player.

Room for All

Another issue that Dataquest raises is whether or not the market is big enough to support all the manufacturers that intend to manufacture DAT products. There are approximately 50 manufacturers that will participate in the data side of the DAT market. If spread equally among all manufacturers, each manufacturer would produce 2,400 units in 1992 on the low side; on the high side, each would produce 14,000 units in 1992. These quantities are more reminiscent of a high-priced specialty product, not a low-priced, high-volume product. Dataquest anticipates that the market will support a maximum of five dominant players, with approximately 10 or 15 minor players. The five dominant players, let alone the minor players, will have a hard enough time making money.

Head and Tape

Head and tape wear issues have been raised since the conception of DAT as a computer product. The Digital Data Storage (DDS) committee has stated in its product literature that it will attempt to achieve more than 2,000 passes on media. Data specification sheets for DAT products that Dataquest has seen quote more than 1,000 passes. In comparison, a typical 1/4-inch tape product is certified for 5,000 passes. While the DAT media seems to have less of a life than that of 1/4-inch tapes, this can be offset, perhaps, by the fact that one can purchase three or four DAT tapes for the price of one 1/4-inch tape.

With regard to head wear, Dataquest conducted research with industry engineers. DAT head wear is anticipated to be equivalent to that of 1/4-inch products, somewhere in the range of 1,500 hours of tape motion. However, all tape heads need to be cleaned regularly. In many instances, tape drive manufacturers will void warranties if mechanical failure is due to the heads not being cleaned. Tape drive companies often offer incentives such as free cleaning kits to encourage users to clean tape heads. Consumer stereo tape products are being introduced with alarms to warn the consumer when to clean the heads—an idea for computer tape drive manufacturers? Whatever the product, tape heads need to be cleaned in order to prevent excessive wear.

The DAT Market

Is DAT a product in search of a market? Succinctly, no. While we do not anticipate that DAT drives will be used in previously developed products, we do anticipate that computer manufacturers, workstation manufacturers, and file server manufacturers will develop their next-generation products with DAT storage in mind. The problem with older-generation products is backward compatibility. DAT provides no backward compatibility, so to get users to convert to DAT is a difficult sell. DAT provides inherent advantages over other storage products in media costs, capacity, size, and ease of use. Applications for DAT include telephony products (voice and data), seismic applications, medical technology (X-ray storage), graphics imagery (computerized animation and special effects and desktop publishing), and data transportation, as well as high-capacity archival storage and backup.

Operating and Storage Conditions

Environmental issues also have been raised. It has been stated that the current operating and storage temperatures for DAT media are too low for data storage purposes. The standard operating temperature for peripheral devices is upwards of 45 degrees Celsius, and DAT media complies with this standard. For shelf life (archival storage), the American National Standards Institute's (ANSI) working document quotes 5 degrees Celsius to 32 degrees Celsius, and 50 percent (plus or minus 10 percent) noncondensing humidity. For transportation purposes, the ANSI document quotes negative 40 degrees Celsius to 45 degrees Celsius and 5 percent to 80 percent noncondensing humidity. Both of these standards seem quite reasonable, and alarm is not warranted.

THE FUTURE OF DAT

It seems that it is difficult for all of us to accept and adopt new things and new ways of doing things. If the old way has worked in the past, won't it carry us into the future? The adage of, "if it's not broken, don't fix it," seems to apply. On the other hand, without new ways of doing things, the world would have missed opportunities like the telephone, the personal computer, the terminal that this newsletter was written on, and perhaps a high-capacity storage product known as digital audio tape. DAT is a product not to be missed. Although Dataquest does not believe that DAT will take the world by storm, clearly there is a market for this product. DAT fills the niche where 1/4-inch leaves off, where erasable optical is too expensive, and where 8mm helical scan is too large.

Dataquest anticipates that the DAT market leaders will include Alps Electric, Hewlett-Packard, Hitachi, and Sony. Strong competition also will come from Archive, Wangtek, and the DAT start-up, WangDAT. In the issues segment of this newsletter, we purposefully ignored the format controversy. Dataquest does not believe that there really is a controversy in this area. The DDS group seems to have money and momentum on its side. However, the Data DAT format does address some features that are application-sensitive. If large archival backup and storage are the only applications, then the DDS format is perfect. For applications such as computerized animation, Data DAT may have a slight edge. Over time, Dataquest anticipates a merging of the two formats: DDS will pick up some features of Data DAT, and Data DAT will pick up some of the features of DDS. Certainly, a large-system player such as IBM, Apple, or Compaq could drive the market one way or the other. However, the market is relatively small, so it is not very sensible to have competing formats that lack compatibility.

For the future, Dataquest believes that, if DAT is going to make it in the computer industry, it is going to have to go it alone, without the support of the audio industry. Manufacturers should not count on economies of scale, the resolution of trade issues, or people's willingness to accept what is now an expensive, new audio product. Manufacturers need to make their own economies of scale through design and packaging, to make their own marketing channels through system and application integration, and to use pull-through advertising to get end users excited about DAT products.

DATAQUEST CONCLUSIONS

Clearly, digital audio tape has not warranted the hype it has received. In fact, the hype may have hurt its acceptance. End users have been waiting for DAT for the last several years, and once again, it was a product that was announced and not delivered on time. A report by Magnetic Media Information Services, published in 1986, states that, "...in high volume (R-DAT) can ultimately be built to retail for as little as $100...." Perhaps it can, but it is not likely in the near future. Pricing is going to be the big disappointment for end users, as it is clear that prices will be higher than previously anticipated. But aside from price, Dataquest believes that DAT will live up to users' expectations, and once marketed at moderate prices, DAT will take off as an alternative to other secondary storage products.

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Research Newsletter

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DESKTOP CONNECTIVITY: PRESENT AND FUTURE DIRECTIONS

INTRODUCTION

In the late 1970s and early 1980s, a new phenomenon was taking place in the office environment: office automation or the building of the office of the future. Office automation refers to the new breed of desktop devices that were entering the business office, including dedicated word processors, intelligent printers, personal computers, electronic typewriters, scanners, and facsimile machines.

The original purpose of these new office automation devices was to increase the productivity of the average office worker. In the early 1980s, the new desktop devices often lived up to, and exceeded, their designed expectations. However, toward the mid-1980s, productivity growth slowed in the business environment. It became evident that the communication capabilities between the new desktop devices and existing data processing equipment was a problem. To continue the strong growth in worker productivity as seen in the late 1970s and early 1980s, integration of desktop devices was now needed.

In order to meet the office productivity demands of the late 1980s, the concept of office automation was redefined and a new term was coined, work group computing. Loosely defined, work group computing means the integration of office desktop devices and the users of those devices. Work group computing focuses on the information needs by all members of the work group and the transparent communication of information between work group members. Work group computing is a key concept and technology for desktop connectivity in the late 1980s and early 1990s. Further, work group computing addresses three constants that have existed in the business environment for the past 10 years. Those constants are as follows:

- The rapid introduction of new information devices has remained constant.
- The home of new information devices is the desktop.
- Isolated "islands" of information in the business environment have limited utility.

EXECUTIVE SUMMARY

This newsletter explores the issues and technology that affect the battle for connectivity of desktop devices within the office environment. Isolated islands of information that reside in piles of paper and standalone PCs on the desktop are targeted for transformation into a more productive, shared-information environment. The 3 x 5-foot piece of desktop "real estate" is the battle zone for competing technologies. Wide and local area connectivity options will connect the competing desktop information devices. Dataquest estimates that the installed base of desktop devices at the end of 1988 was approximately 40.2 million. Furthermore, Dataquest forecasts that, by 1992, the number of desktop devices will grow to nearly 61 million units.

Several key technologies are driving the connection of desktop devices. The combination of powerful new PCs, multitasking operating system software, and application software are driving typewriters and word processors out of the office. The placement of desktop-character-based display terminals also is slowing as graphics terminals, processing terminals, powerful PCs, and technical workstations quickly are becoming the information workers' preferred option.

PC local area network (LAN) technology is set to reach a new, higher level of sophistication in 1989. PC LAN-to-mainframe connectivity is much more robust than just a year ago. Popular PC LAN software, such as that available from IBM, Novel, and 3Com, will be supporting ISO communication protocols as well as de facto standards such as IBM LU6.2. SQL data bases, data base servers, and electronic mail technology such as that offered by Oracle will be among the first applications to connect most desktop devices in a heterogeneous network.

This newsletter graphically presents most of the information as it:

- Defines the categories of desktop information devices and presents the forecast for these devices in the United States
  - Display terminals
  - Personal computers
  - Electronic typewriters
  - Dedicated word processors
  - Integrated voice/data workstations
  - Technical workstations
- Identifies five types of connection technologies for the information devices listed above
  - Local area networks
  - Integrated voice/data PBXs
  - Data PBXs

- Remote (modems, X.25 PADs, multiplexers)
- Hardwire direct connection

- Considers the total available market for these connection technologies and the way in which the desktop devices will be connected (see Table 1)
  - How the desktop information devices were connected in 1987
  - How the desktop information devices are connected today
  - How the desktop devices will be connected in 1992

Table 1

Estimated Percentage of U.S. Connections

1987

	Installed Base (K)	Local Area Networks	PBX	Data PBX	Hardwire Connection	Remote Connection	Not Connected	Total Connections
PCs	15,700.00	11.60%	0.30%	3.50%	12.00%	16.00%	56.60%	43.40%
Technical Workstations	179.70	96.30%	0	0	0.20%	0.50%	3.00%	97.00%
Character Terminals	11,900.00	12.50%	1.30%	12.40%	48.10%	25.70%	0	100.00%
Graphics Terminals	506.80	N/A	N/A	N/A	N/A	N/A	0	100.00%
Electronic Typewriters	5,100.00	0.10%	0.30%	0	1.00%	2.10%	96.50%	3.50%
Integ. Voice/Data Workstations	235.20	3.00%	70.00%	0	5.00%	14.30%	7.70%	92.30%
Total	33,621.70	10.39%	1.14%	6.02%	22.82%	16.99%	41.14%	58.86%

1988

	Installed Base (K)	Local Area Networks	PBX	Data PBX	Hardwire Connection	Remote Connection	Not Connected	Total Connections
PCs	19,200.00	18.70%	0.40%	3.50%	12.00%	16.00%	49.40%	50.60%
Technical Workstations	189.97	96.00%	0	0	0.50%	0.50%	3.00%	97.00%
Character Terminals	13,200.00	14.00%	1.30%	12.70%	48.00%	24.00%	0	100.00%
Graphics Terminals	643.80	15.00%	0	5.00%	70.00%	10.00%	0	100.00%
Word Processors	832.40	12.50%	1.50%	3.20%	30.00%	11.00%	41.80%	58.20%
Electronic Typewriters	5,900.00	0.10%	0.30%	0	1.00%	2.10%	96.50%	3.50%
Integ. Voice/Data Workstations	254.30	4.30%	71.00%	0	4.50%	13.20%	7.00%	93.00%
Total	40,220.47	14.52%	1.14%	5.99%	23.40%	16.30%	38.66%	61.34%

N/A = Not Available

(Continued)

Table 1 (Continued)

Estimated Percentage of U.S. Connections

	1992							
	Installed Base (K)	Local Area Networks	PBX	Data PBX	Hardwire Connection	Remote Connection	Not Connected	Total Connections
PCs	32,391.60	65.70%	1.00%	3.50%	9.50%	13.50%	6.80%	93.20%
Technical Workstations	1,199.63	97.00%	0	0	0.50%	0.50%	2.00%	98.00%
Character Terminals	19,400.00	22.00%	5.50%	15.00%	33.50%	24.00%	0	100.00%
Graphics Terminals	1,225.10	50.00%	0	5.00%	30.00%	15.00%	0	100.00%
Word Processors	462.50	13.50%	2.00%	3.50%	30.00%	13.00%	38.00%	62.00%
Electronic Typewriters	6,000.00	1.00%	0.50%	0	2.50%	3.50%	92.50%	7.50%
Integ. Voice/Data Workstations	284.50	9.50%	75.00%	0	3.00%	10.00%	2.50%	97.50%
Total	60,963.33	45.07%	2.70%	6.76%	16.81%	15.61%	13.06%	86.94%

N/A = Not Available

Source: Dataquest
June 1989

WHAT ARE THE STAKES?

The stakes in this market are high. Dataquest estimates that approximately 59 percent of all desktop information devices currently are connected by one of the five technologies previously mentioned. By 1992, the connectivity rate will jump to approximately 87 percent for all information devices on the desktop. Thus, an expected additional 26.37 million desktop devices will be connected by 1992. Using an average connection cost of $400 per desktop device, this represents a total market opportunity of $10.5 billion.

HOW MANY WORKERS ARE THERE?

According to the U.S Department of Labor, Bureau of Labor Statistics, the overall U.S. work force population increased from 109.6 million in 1986 to 112.4 million in 1987. Dataquest estimates that the total employed population will reach nearly 130 million by the year 2000. Workers in occupations traditionally classified as white-collar jobs make up more than one-half of the entire employed work force population today.

HOW MANY DESKTOPS AND INFORMATION WORKERS ARE THERE?

In an effort to determine the available market opportunity for desktop device connectivity, Dataquest began to research this area in 1984. In part, this ongoing research tries to determine:

- The total number of desktops
- The total number of information workers

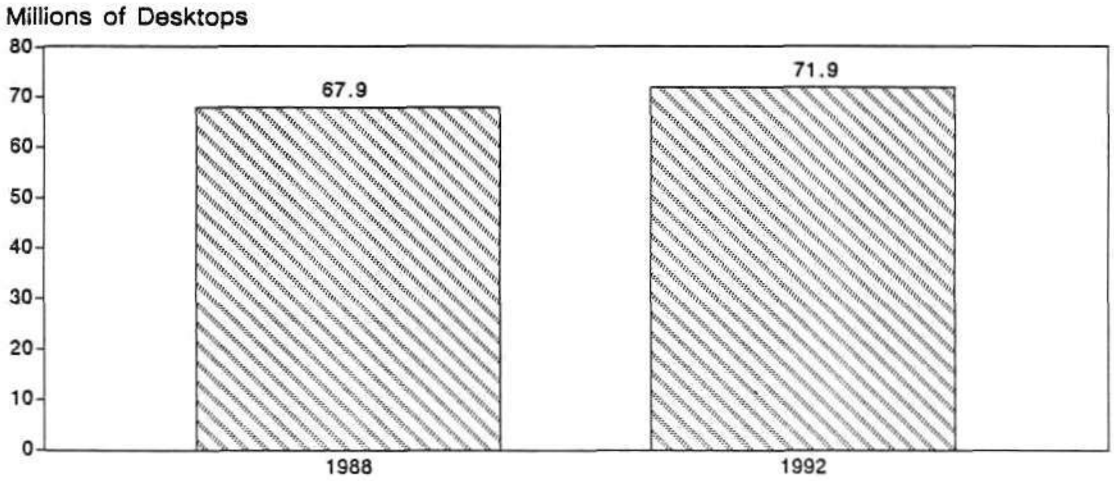
Desktop, as defined in this Dataquest analysis, refers to a potential location for a desktop information device. An information worker is an individual who uses an automated desktop information device. Information workers are found in all industries and occupations. This segment includes the traditional white-collar workers as well as a portion of the blue-collar workers.

Dataquest estimates that, in 1988, 67.9 million desks were potential locations for desktop information devices. As shown in Figure 1, the potential number of desktop information device locations will grow to 71.9 million in 1992. Figure 2 shows that, in 1988, Dataquest estimated the information worker labor force population as approximately 67 million. Dataquest forecasts that the estimated number of information workers will grow to 68.8 million by 1992.

Using Dataquest estimates for potential desktop device locations in conjunction with current estimates for the installed base of desktop information devices, we can calculate the estimated penetration of desktop information devices. From Figure 3 we see that a 59.3 percent penetration of the total available desktop market existed in 1988. Figure 3 also indicates that desktop penetration should reach approximately 87.0 percent by 1992.

Figure 1

Potential Location for a Desktop Information Device (Millions)



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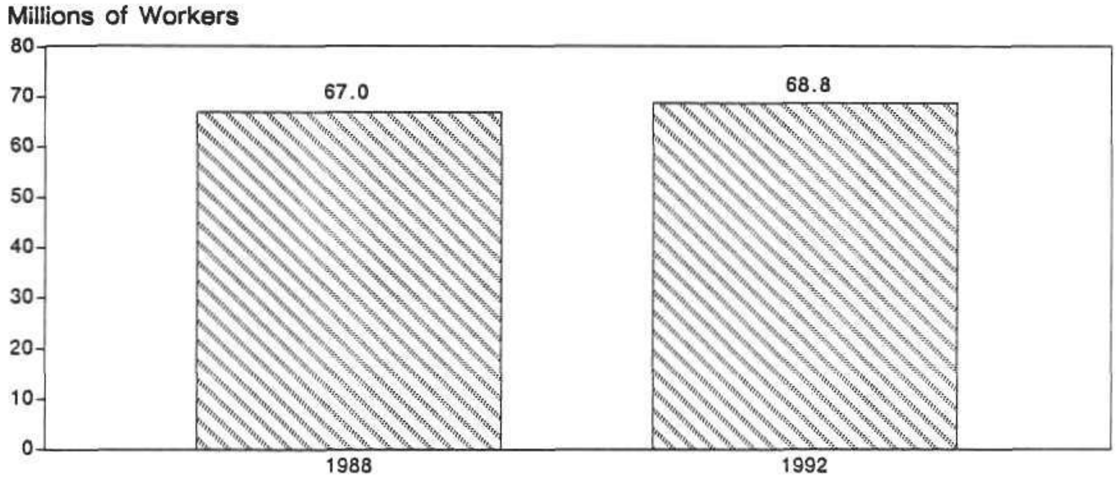
Source: Dataquest June 1989

Figure 2

Estimated Number of Information Worker Labor Force (Millions)



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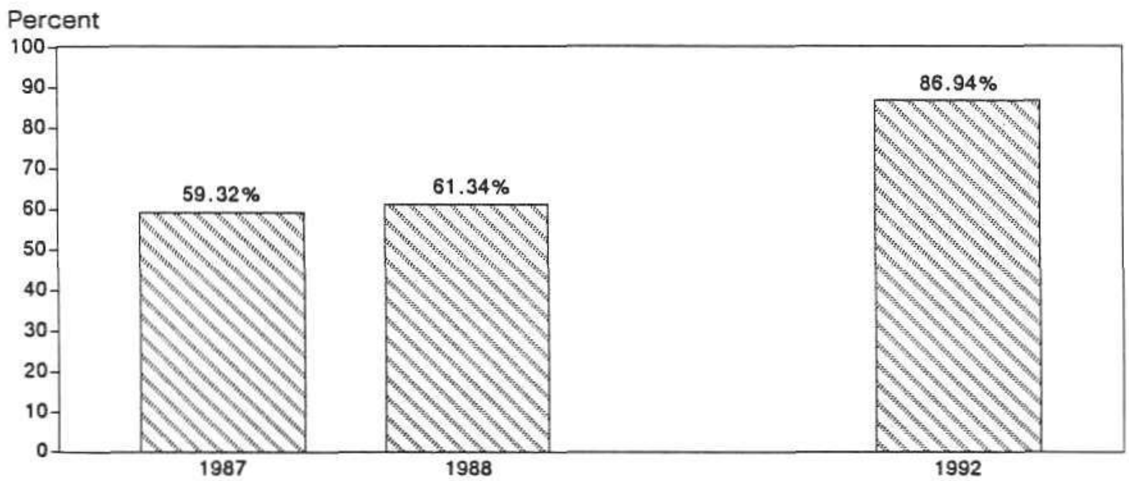
Source: Dataquest June 1989

Figure 3

Estimated Penetration of Desktop Information Devices



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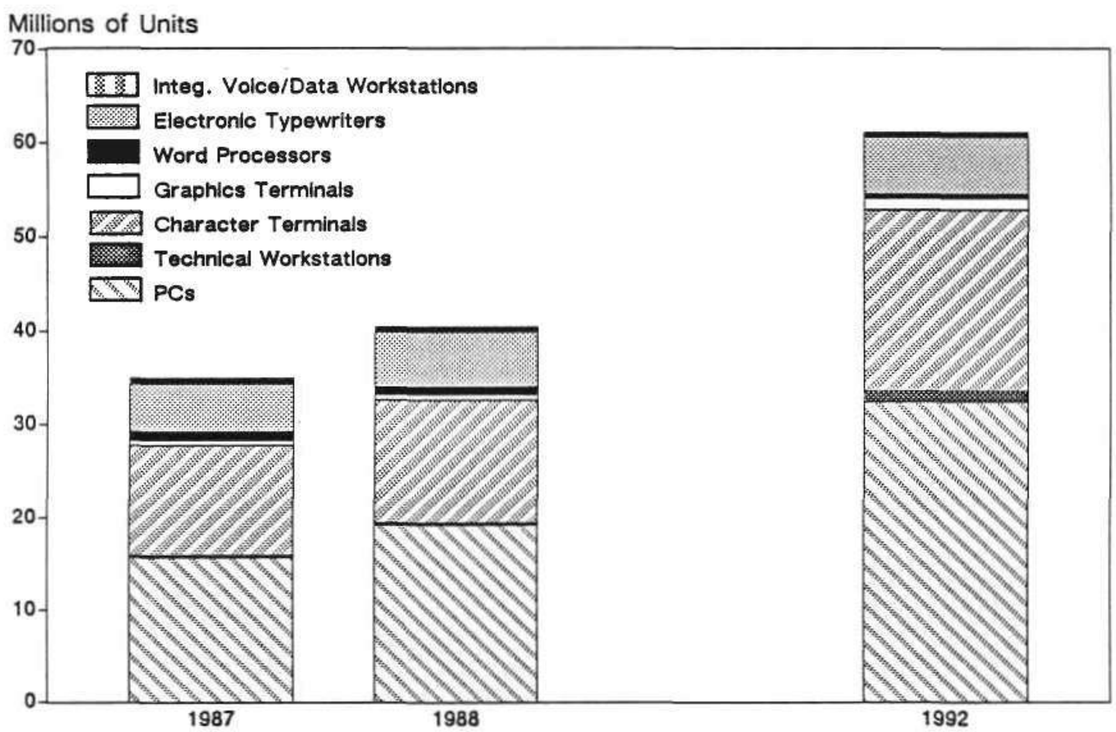
Source: Dataquest June 1989

DESKTOP DEVICE POPULATION MIX

The estimated breakdown of desktop information devices by type installed is shown in Figure 4. Personal computers and display terminals make up approximately 80 percent of the installed base through the forecast period. Figure 4 also shows that, while the installed base of PCs and technical workstations will experience high rates of growth, most other desktop devices will show only moderate growth. The only device to show a decline during the forecast period is dedicated word processors.

Figure 4

Estimated U.S. Population of Desktop Devices (Millions)



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Source: Dataquest June 1989

CONNECTION TECHNOLOGIES

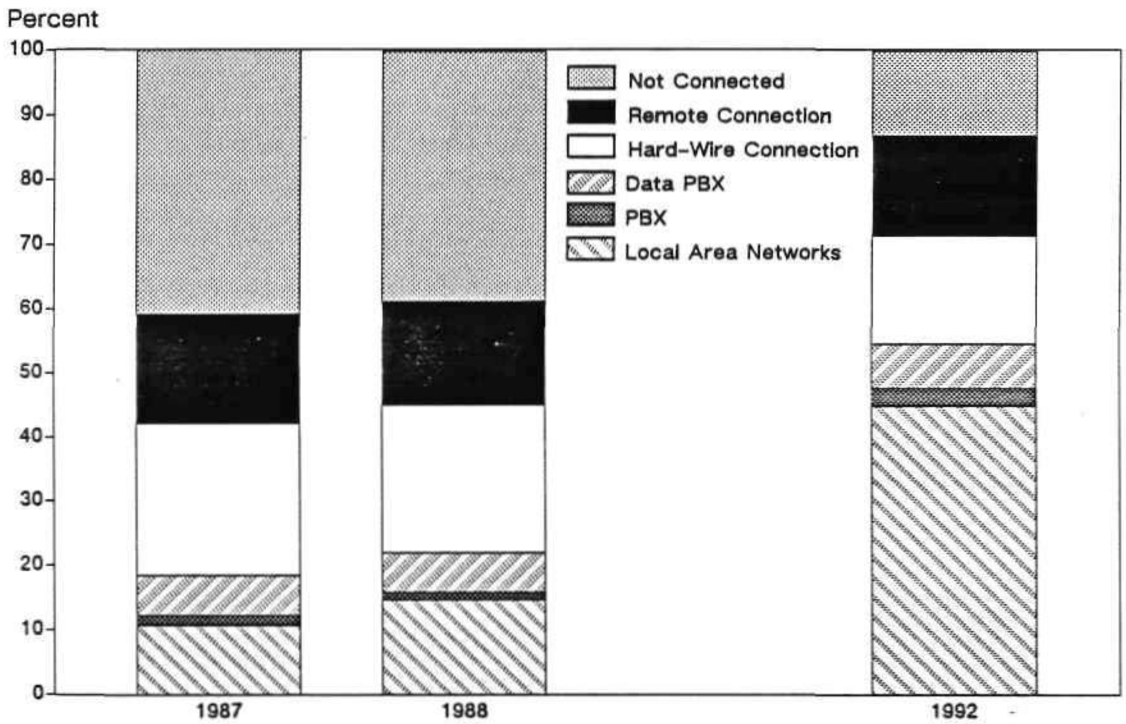
It is important to note that this analysis looks at the technology to which a device is connected, not at the ultimate destination of the data. For example, consider a PC sending data through a modem. The modem then sends the data through an analog signal through a PBX, which connects to a public data network. At the receiving end, the data moves through an X.25 interface to a LAN, which routes the information to the final destination, a PC on the LAN. For the purpose of this analysis, the PC is considered to be remotely connected, since the PC is connected first to a modem.

Figures 5 and 6 illustrate the estimated U.S. connection technology trends for all desktop devices. Figure 5 presents the information by percentage of connections and Figure 6 by number of connections.

In 1987, approximately 41 percent of all desktop information devices were not communicating, due to the large percentage of PCs and electronic typewriters that were not connected. Dataquest estimates that, in 1992, the number of devices that will not be communicating will be just over 13 percent.

Figure 5

Estimated U.S. Connection Technology Trends for All Desktop Devices (Percent of Connections)

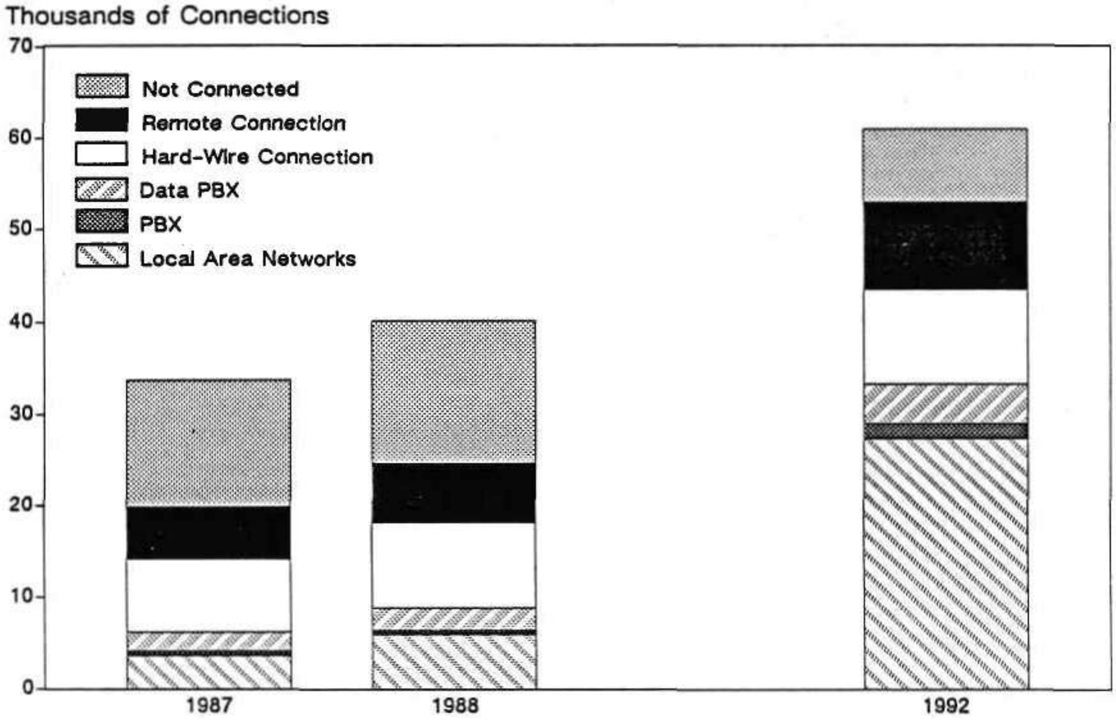


0004087-5

Source: Dataquest June 1989

Figure 6

Estimated U.S. Connection Technology Trends for All Desktop Devices (Thousands)



0004087-6

Source: Dataquest June 1989

LAN Connection Technology

In the period from 1988 to 1992, Dataquest estimates that LANs will show the most significant growth as a connection technology. From 1988 to 1992, the percent of total connections for LANs will rise from 14.52 percent to 45.07 percent. This growth will be fueled by many reasons; however, some of the major reasons are as follows:

- New, powerful LAN operating system software
- Enhanced communication capabilities to host computers
- LAN data base and communication server engines, i.e., SQL Server
- Proliferation of PCs on the desktop

- Declines in wiring costs and price per connection
- Focus on work group computing

Hardwire Connections

Traditionally, hardwire connections have been the most popular connection technology. However, Dataquest expects a decline in this type of connection from 23.05 percent in 1988 to 16.88 percent in 1992. The decline in hardwire connection technology is due primarily to the following:

- More flexibility offered by other technologies
- Proliferation of PCs on the desktop
- Information workers' requirement for graphics support, i.e., the ability to produce charts, graphs, and graphics presentations

Remote Connections

Dataquest believes that the remote communications segment will remain strong during the forecast period. This strong growth will result from the variety of connectivity options that will be available to the user through modems, X.25 lines, and digital communications lines.

PBXs

Data PBXs will show limited growth during the forecast period, due to LANs and the overall maturity of the PBX market. The least important connection technology for desktop devices is expected to be integrated voice/data PBXs. Despite the fact that PBX companies have invested large amounts of resources in integrated voice/data technology, pricing and real-time limitations have discouraged most potential buyers.

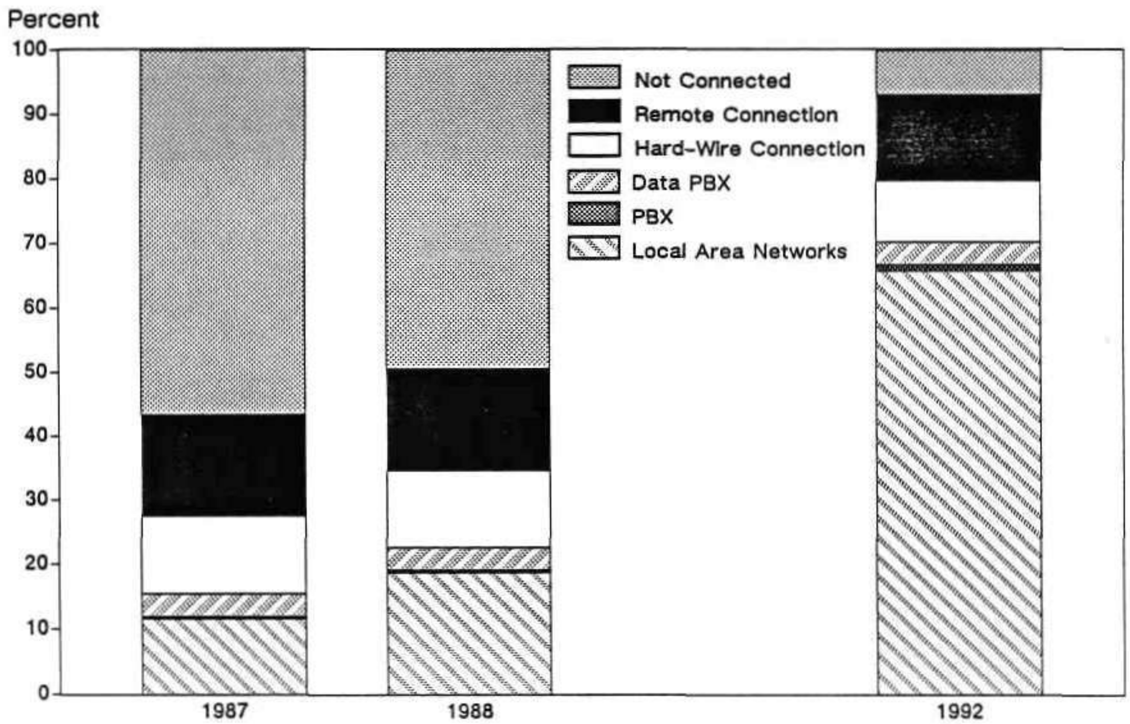
CONNECTION TECHNOLOGY TRENDS

Personal Computers

The ways in which PCs are connected is the focus of Figure 7. Just as PCs have proliferated throughout all industries in the mid to late 1980s, Dataquest predicts that the PC will be the information workers' preferred desktop device in the 1990s. The combination of powerful operating systems, application software, network interface cards, and modems will give the information worker transparent access to all internal and external resources. Current Dataquest estimates indicate that only 50.6 percent of all PCs on the desktop in 1988 were connected and communicating via one of the connection technologies listed in this analysis. By 1992, the estimated number of connected PCs should rise to 93 percent.

Figure 7

Estimated U.S. Connection Technology Trends for PCs (Percent of Connections)



0004087-7

Source: Dataquest June 1989

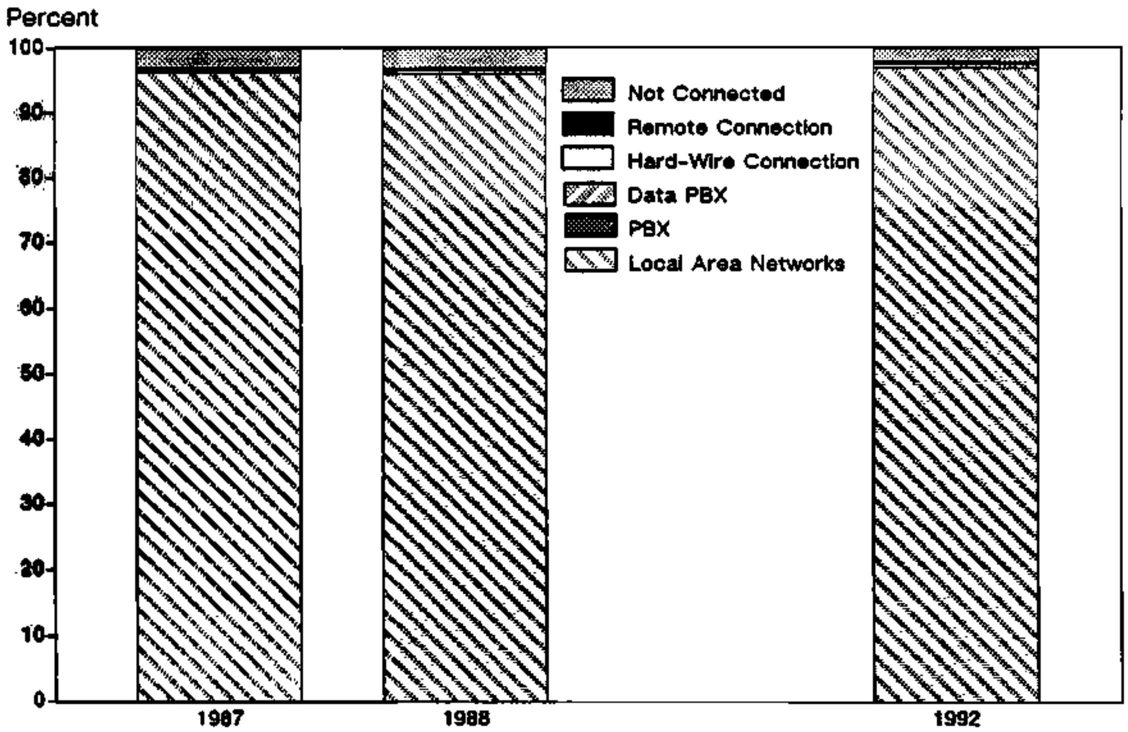
Technical Workstations

Figure 8 illustrates the connection trends from 1987 to 1992 for technical workstations. By Dataquest's definition, all technical workstations have a connection device built into them, i.e., Ethernet. This fact helps explain technical workstations' high 1988 and 1992 connection rates, and the ease with which these devices can be connected.

Today, most technical workstation vendors have adopted UNIX as the preferred operating system, as well as encouraged independent software vendors to provide popular PC applications for the UNIX environment. Concurrently, the prices of technical workstations have been coming down, while the price of high-end PCs have been rising. The convergence of high-end PC technology and low-end technical workstation technology was inevitable. Overall, the PC will remain the most popular desktop device in the early 1990s. However, using UNIX-based technical workstations as a LAN server and workstation will be a popular alternative to high-end OS/2 LAN servers and PCs.

Figure 8

Estimated U.S. Connection Technology Trends for Technical Workstations (Percent of Connections)



0004087-8

Source: Dataquest June 1989

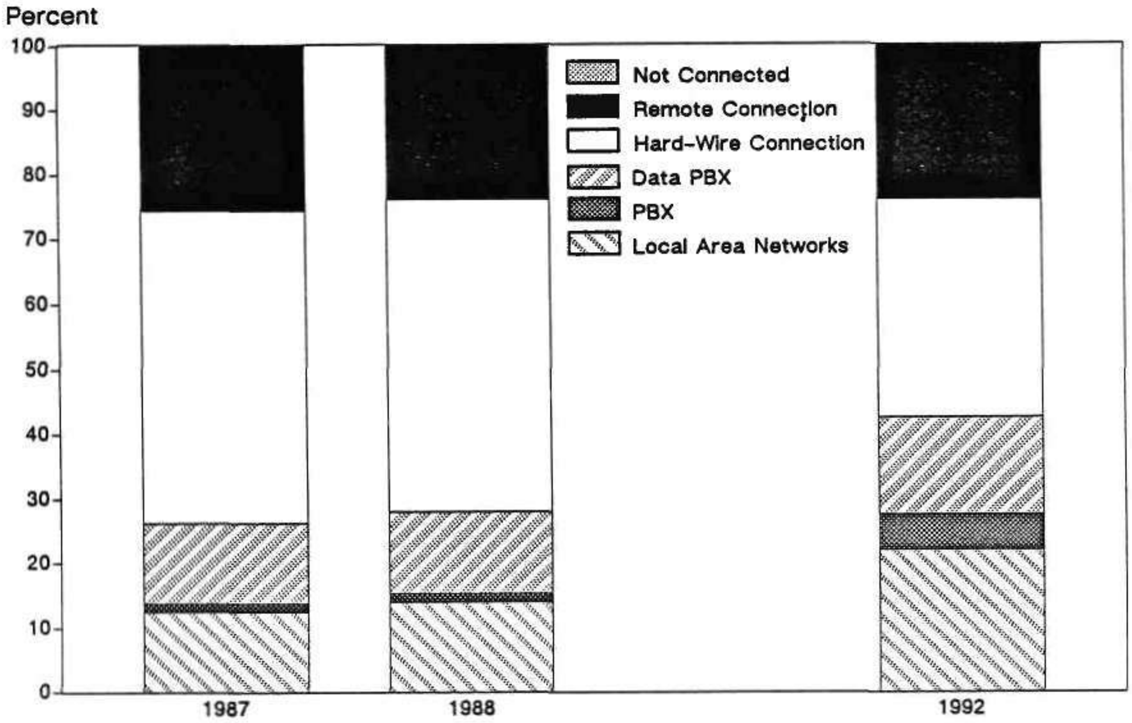
Character-Display Terminals

Figure 9 illustrates the connection forecast for character-display terminals. By definition, a character-display terminal must communicate with a host to perform its primary function; therefore, terminals are always 100 percent connected. As expected, most character-display terminals in 1988 were connected to the host by a hardwire connection. This connection may be through a nonintelligent, nonswitching, intermediate communications product, such as a wiring closet, a multiplexer, or a communications controller. The percent of hardwire connections is expected to decrease through 1992, and LANs are expected to be the beneficiary.

The overall forecast for character-based terminals looks strong through the early 1990s. However, the information worker will need more powerful graphics terminals to create graphics presentations and representations of available data. Graphics terminals also will be required when working in graphics windowing environments such AT&T Open Look, DECwindows, or HP NewWave, because ASCII character terminals offer only limited functionality.

Figure 9

Estimated U.S. Connection Technology Trends for Character Display Terminals (Percent of Connections)



0004087-9

Source: Dataquest June 1989

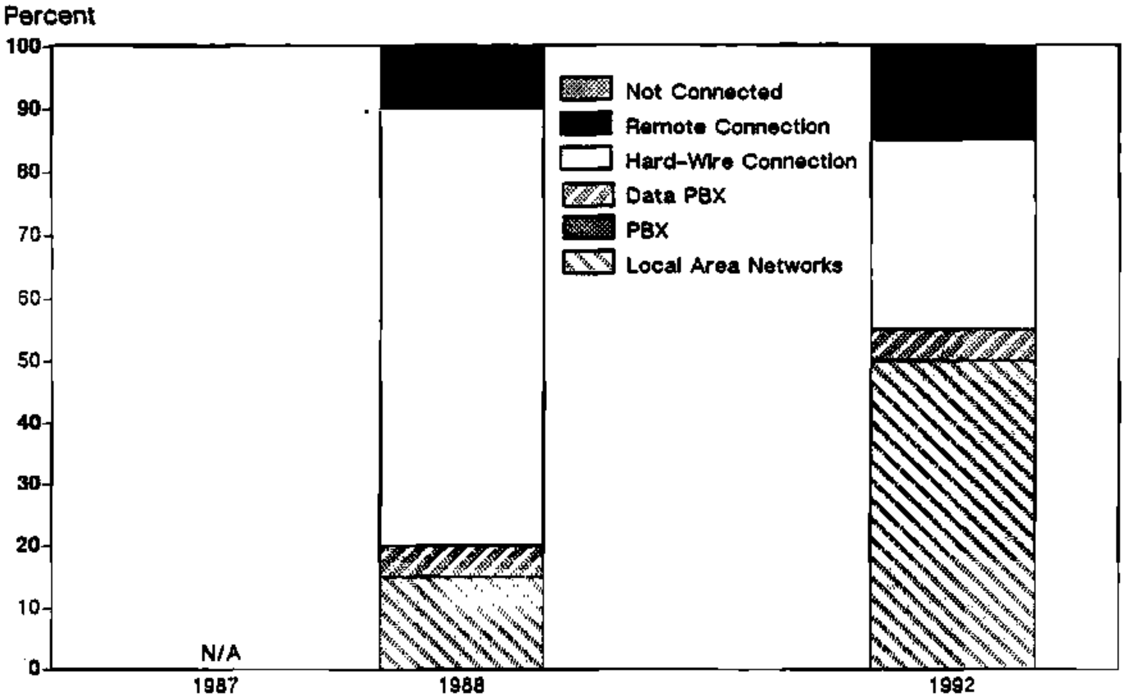
Graphics Display Terminals

Figure 10 illustrates Dataquest's connection forecast for graphics display terminals. Like character-display terminals, most graphics display terminals are hardwire connected to the host. Connection technology used for graphics display terminals also is very similar to character display terminals. The differences between the two forecasts can be attributed to the fact that graphics display terminals handle many more bits of information than character display terminals. LANs and direct connections provide the power to handle large quantities of data, whereas current modem technology greatly hinders speed when transferring large quantities of graphics data.

As mentioned previously, many information workers will require power to display graphics and work in a graphics windowing environment. Character display terminals are not capable of presenting data in a windowing environment or of producing on-screen graphics from data.

Figure 10

Estimated U.S. Connection Technology Trends for Graphics Display Terminals (Percent of Connections)



N/A=Not Available

0004087-10

Source: Dataquest June 1989

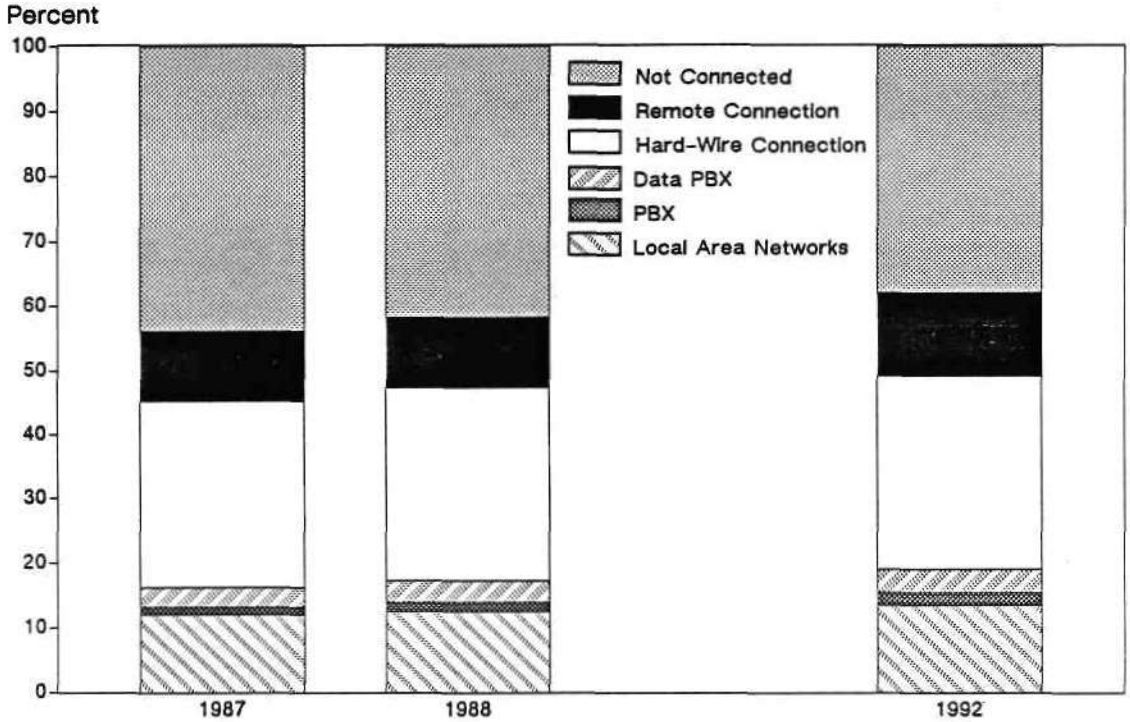
Word Processors

Figure 11 shows that the connection rate for word processors will remain relatively flat through 1992. Of the connected word processors, most are connected via hard wire to a shared logical unit.

Word processors were one of the key building blocks of office automation in the late 1970s and early 1980s. However, in the mid-1980s, the information worker required more power than was available in word processing equipment, and the PC was the logical alternative. Sales of word processors have declined sharply during the past four years, and Dataquest is not projecting any unit shipments of dedicated word processors by 1990. This will be the last year that Dataquest will track the dedicated word processing market as the product is quickly becoming obsolete.

Figure 11

Estimated U.S. Connection Technology Trends for Word Processors (Percent of Connections)



0004087-11

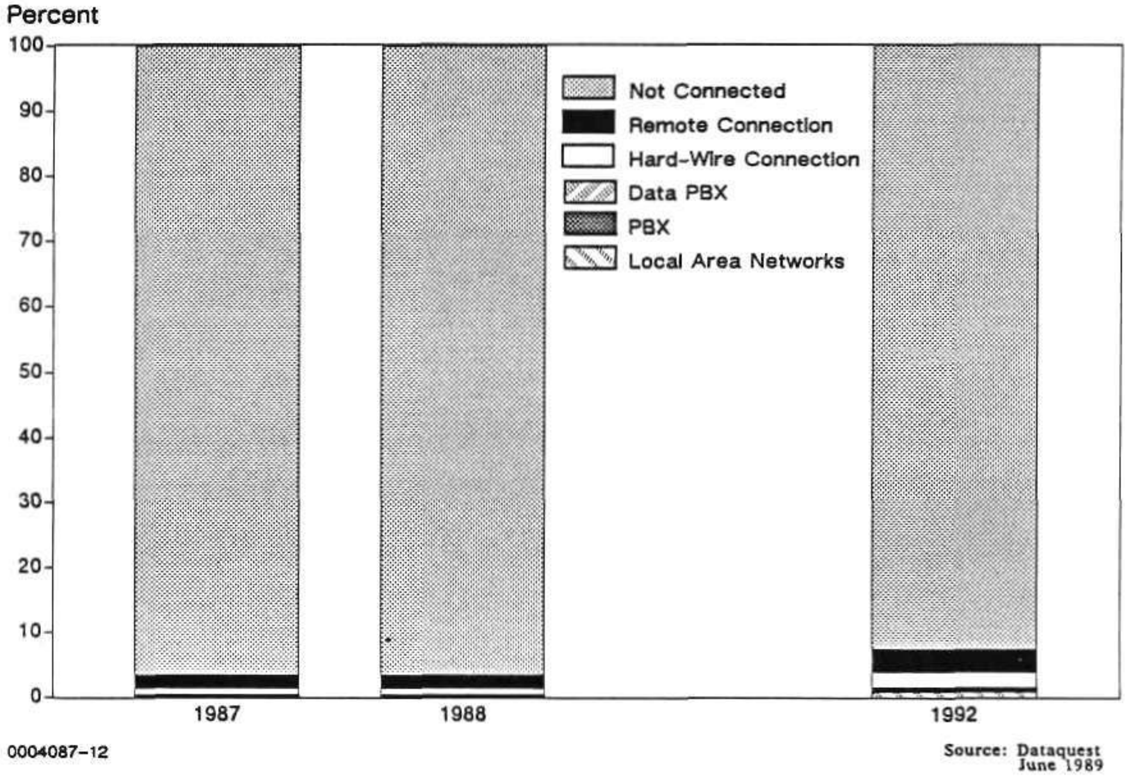
Source: Dataquest June 1989

Electronic Typewriters

Figure 12 shows Dataquest's projection of connection trends for electronic typewriters. We expect only 7.5 percent of all installed high-end electronic typewriters to be communicating by 1992. Like dedicated word processors, high-end electronic typewriters have lost market share due to the proliferation of the PC. However, the life span for electronic typewriters will continue to be strong through the mid-1990s.

Figure 12

Estimated U.S. Connection Technology Trends
for Electronic Typewriters
(Percent of Connections)



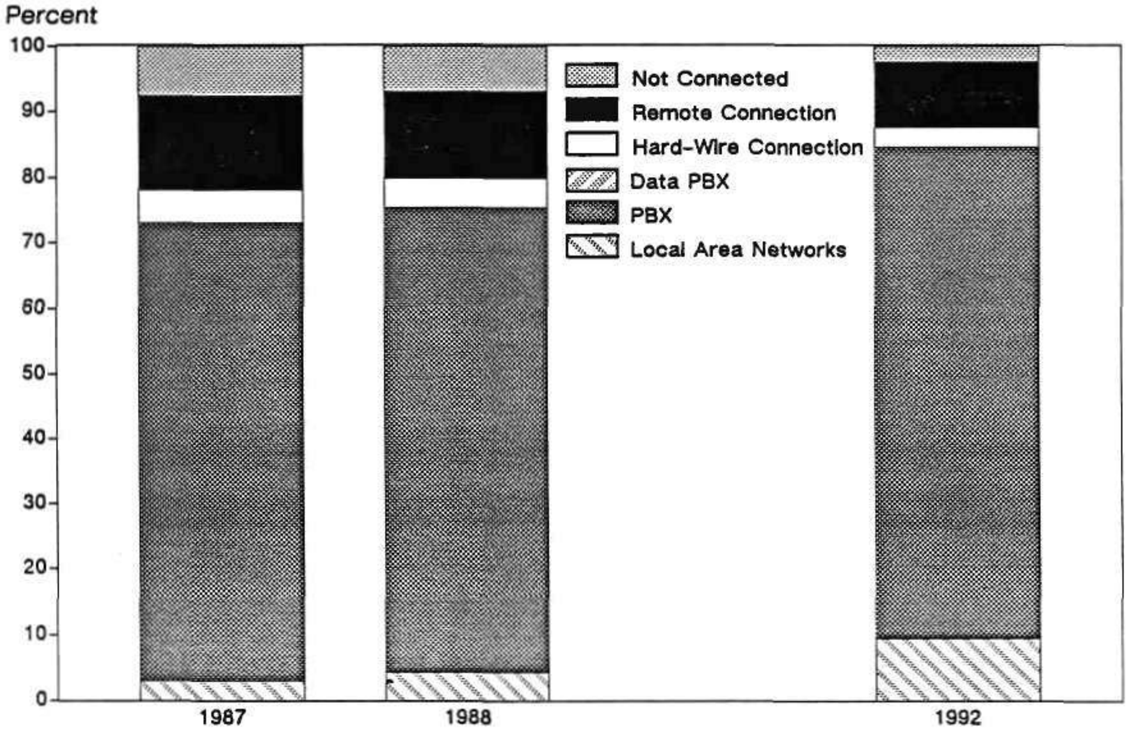
Integrated Voice/Data Workstations

Connection trends for integrated voice/data workstations (IVDWs) are shown in Figure 13. The IVDW category comprises integrated voice/data terminals, PCs, and integrated service digital network (ISDN) terminal adaptors. An adaptor converts a PC into an integrated voice/data communications device through a switching or transport mechanism equipped with ISDN interfaces. Dataquest believes that the majority of IVDWs are, and will continue to be, connected to PBXs.

Integrated voice/data workstation vendors share a fate not unlike that of dedicated word processing vendors. Dataquest forecasts a slowdown in this market because the ISDN will make IVDW technology obsolete. Changes in the percent of IVDWs are expected to be minimal, as most IVDWs use their data communication capabilities. IVDWs not connected include integrated voice/data PCs that operate on the data side as a standalone PC, although the telephone line is connected for voice communications.

Figure 13

Estimated U.S. Connection Technology Trends for Integrated Voice/Data Workstations (Percent of Connections)



0004087-13

Source: Dataquest June 1989

DATAQUEST CONCLUSIONS

In the late 1970s and early 1980s, desktop devices were designed to improve individual productivity. However, as productivity growth slowed in the mid-1980s, work group computing became the major focus, and isolated islands of information were targeted for transformation into a more productive, shared-information environment. As we enter the 1990s, desktop connectivity options will continue to be the focal point and/or solution to improving work group and company productivity issues.

Dataquest estimates that, by the end of 1992, the number of available desktops will grow to 71.9 million, of which 60.96 million—or 84.8 percent—will be equipped with an information device. This growth represents a $10.5 billion opportunity for vendors suppling replacements as well as new installations of connectivity solutions. Throughout the forecast period, successful vendors should look forward to supplying both the replacement market and the new customer market.

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Roger Steciak
Dave Perro

Dataquest
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Research Newsletter

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LANs: CHANGES, CHOICES, AND CHALLENGES

SUMMARY

Local area networks (LANs) are used for sharing data among machines such as personal computers, workstations, minicomputers, mainframes, and supercomputers. The speed of the LAN and the cabling required depends on the use for the LAN (see Table 1).

Semiconductors used in LANs include application-specific circuits that are mass produced as standard products. Integration trends in the industry, however, suggest that many of these circuits may become standard cells in other ICs by 1995.

Table 1

LAN Application Segments

Connection Use	Bandwidth Range	Transmission Media
Supercomputers and Mainframes	100-2,500 Mbps	Optical cable
Minicomputers and Workstations	10-250 Mbps	Optical and coaxial cables
Personal Computers	1-25 Mbps	Coaxial cable and twisted pair

Source: Dataquest
June 1989

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HISTORICAL BACKGROUND

LANs originally were developed in the 1970s by office equipment suppliers. Their purpose was to link word processors with data processing equipment, so that files could be shared electronically. During these pioneering days, each LAN supplier had a unique protocol for the transfer of information.

Connection Standards

Standards were needed because users wanted to be able to buy office equipment from more than one supplier. The resulting standards (e.g., Ethernet, MAP, Token-ring) that were developed in the 1980s made multisourcing possible.

Office automation accelerated in the 1980s with the introduction of PCs to the workplace. Computing power became distributed, and the need to share files electronically intensified.

Performance Diversity

LANs traditionally have used coaxial cables for a transmission medium, with data rates typically in the 1- to 50-Mbps range. Standards now are being defined for the less expensive unshielded twisted-pair transmission medium (e.g., telephone wire).

High-end machines, from technical workstations to supercomputers, need high-speed communications channels. The fiber distribution data interface (FDDI) is a new 100-Mbps standard that uses optical cables for transmission. Proprietary LANs that are capable of data rates in excess of 1,000 Mbps using optical cables for transmission were also introduced in 1988.

CONNECTION POTENTIAL

Dataquest estimates that there were potential locations for 68 million desktop information devices in 1988, and that this potential will increase to 72 million in 1992. Examples of these devices include PCs, terminals, and workstations. We estimate that the percentage of the installed base connected to a LAN will increase from 15 percent in 1988 to 45 percent in 1992 (see Table 2).

Standard LANs now are more popular than proprietary LANs. Only one-third of the 1988 U.S. LAN installed base was proprietary (see Table 3). Standard LANs include Ethernet, FDDI, MAP, and Token-ring. Ethernet and Token-ring are used primarily to connect desktop devices; MAP is used primarily in factories; and FDDI will be used primarily as a high-speed backbone LAN in the office environment.

Table 2

U.S. Desktop Connectivity Forecast
(Thousands of Units)

	1988			1992		
Desktop Device	I/Base	LAN Connects	Percent Connected	I/Base	LAN Connects	Percent Connected
PCs	19,200	3,590	19%	32,392	21,282	66%
Character Terminals	13,200	1,848	14%	19,400	4,268	22%
Electronic Typewriters	5,900	6	0	6,000	60	1%
Word Processors	832	104	13%	463	62	14%
Graphics Terminals	644	97	15%	1,225	613	50%
IVD Workstations	254	11	4%	285	27	10%
Technical Workstations	190	182	96%	1,200	1,164	97%
Totals	40,220	5,838	15%	60,963	27,476	45%

Source: Dataquest
June 1989

Table 3

U.S. LAN Installed Base and Shipments Forecast
(Thousands of Units)

	1988 Installed	Annual Shipments					CAGR
LAN	Base	1989	1990	1991	1992	1993	1989-1993
Ethernet	4,500	2,925	3,563	4,094	4,590	5,600	17.9%
Proprietary	2,508	770	858	866	918	982	6.3%
Token-ring	900	1,437	2,179	2,913	3,672	4,500	33.9%
MAP	3	4	7	13	31	56	93.4%
FDDI	0	10	63	155	257	358	144.6%
Total	7,911	5,146	6,670	8,041	9,468	11,496	22.3%

Source: Dataquest
June 1989

LAN SUPPLIERS

More than 100 OEMs are supplying LAN equipment to the U.S. market. The supply base, however, is concentrated with the top three suppliers to a segment having a combined share that exceeds 40 percent (see Table 4).

Table 4

U.S. LAN OEM Market Shares

LAN	First-Ranked Supplier	Share	Second-Ranked Supplier	Share	Third-Ranked Supplier	Share
Ethernet	Digital	35%	3Com	22%	U/B	13%
MAP	Digital	56%	U/B	19%	Concord	13%
Proprietary	Apple	25%	Standard Micro	12%	Sytek	6%
Token-ring	IBM	77%	Proteon	6%	3Com	6%

Source: Dataquest
June 1989

SEMICONDUCTOR COMPONENTS

Ethernet is the most widely sourced LAN chip set (see Table 5), with three different categories of circuits: Ethernet and Cheapernet (for coaxial cable) and Starlan 10 (for telephone wire).

Table 5

LAN Semiconductor Suppliers

LAN	Suppliers
Ethernet	AMD, AT&T, Fujitsu, Intel, National, SEEQ, SGS-Thomson, Standard Micro, SynOptics, Western Digital
FDDI	AMD, National
MAP	Motorola
Proprietary	Arcnet: NCR, Standard Micro Starlan 1: AT&T, Chips and Technologies, Intel, Western Digital
Token-ring	IBM (captive), Texas Instruments

Source: Dataquest
June 1989

PC LANS

PC LANs today are offered as add-on cards for the expansion slots. We believe, however, that user demands and technology advances expected during the next few years will alter this approach (see Table 6).

Table 6

PC LAN Migration Scenario

Time Frame	Expected Events
1991	• More than 50 percent business PC base connected to LANs
	• OEMs implement LAN functions on PC motherboards
1993	• Users demand both LAN and WAN communications capabilities
	• Universal telecom coprocessors replace LAN circuits
1995	• MPUs announced, having 10 million transistors
	• Telecom functions implemented as standard MPU cells

Source: Dataquest
June 1989

OEMs offer certain features as standard when the majority of users want them. We expect LANs to become a necessity for more than half of the business PC users by the early 1990s; by then, the LAN circuits will be placed on the motherboard. We note that Ethernet ports are standard now on most technical workstations.

Technology Drivers

Several communications standards are emerging for PCs, and they are likely to coexist. For example, Ethernet and Token-ring are standards for PC LANs, and ISDN is the standard for PC wide area networks (WANs). We predict that a controller capable of all three standards will be used as a telecom coprocessor. We see the recent Zilog announcement of the Z16C30 Universal Serial Controller as evidence of this trend.

The number of transistors in a microprocessor is increasing with each new generation. For example, the Intel 80286 has 100,000 transistors, the 80386 has 275,000 transistors, and the 80486 has 1.2 million transistors. By 1995, we expect microprocessors to have 10 million transistors, and enough room will exist to incorporate the telecom coprocessor on board as a standard cell.

DATAQUEST CONCLUSIONS

The connection of machines to an electronic network for information sharing is becoming more important as our society automates. Standards allow equipment made by different OEMs to be linked together.

Silicon Chassis

The size of electronic circuits is shrinking. Functions that required a cabinet or card for implementation a decade or two ago now fit on a chip or cell. This trend shows every indication of continuing. We believe that as LAN circuits become part of every PC manufactured, the LAN circuit functions will be integrated with other PC circuit functions to reduce the chip count.

Industry Restructure

User demands and technology advances will interact to change the structure of downstream markets. An option becomes a standard when enough users want the feature, and its source of supply changes from the aftermarket to the OEM. We expect to see a migration of PC LAN production from LAN OEMs to PC OEMs to semiconductor suppliers.

Structural change is never smooth, however, because few companies will surrender market share without a struggle. Dataquest recommends that semiconductor suppliers work with both LAN and PC OEMs as a way to seize every available opportunity in this area.

Roger Steciak

Dataquest
a company of
The Dun & Bradstreet Corporation

Research *Newsletter*

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0003978

SERVER: WHAT'S IN A NAME?

SUMMARY

Every year, a marketing buzzword becomes popular in the marketplace. This year, the buzzword is "server." Since the term is used in so many different contexts, the question that continues to be asked is, "What is a server?" This newsletter answers the following questions:

- How does Dataquest define a server processor?
- What are the uses of a server?
- What kind of computer is used as a server?
- How big is the server market now?
- What effect do servers have on the computing environment?

This newsletter is based on information from a Dataquest research report, which is being prepared by Dataquest's UNIX Systems Software Service. The report will be available in late spring.

DEFINITION

Dataquest defines a server processor as a computer that is designed or configured to provide a specific limited set of services and is accessed from workstations or other computers via a local area network (LAN). There are two major classes of server processors: general-purpose computers as server processors and custom server processors.

A general-purpose server processor is a general-purpose computer that has a software product added to enable it to function as a server processor. Examples of this class of server processor are the IBM PC type 80286 and 80386 machines that are used as file servers on LANs. Other systems used in this manner are mainframes, minicomputers, and multiuser microcomputers. Sometimes, additional hardware is added to the systems (for example, a special type of board, which allows the systems to function as server processors).

A custom server processor is a specially packaged and labeled system that is assembled completely with all of the components necessary for server processor capability. An example of this class of server processor is a workstation that is configured to be easy to install and use as a server processor—a "plug and play" system.

SERVER USES

Vendors have their own definitions of a server environment. Terms used to define the server's functionality include project system, shared resource environment, and departmental computing system. The term server has generally referred to systems used as file servers, but there are many types of server processors, with varying markets, as illustrated in Table 1. Traditionally, the custom servers with any measurable market share have been file servers.

Table 1

Types of Server Processors

Server Processor Type	Specific Use
Application Server	Computes a specific application or program (i.e., logic simulation, ADA, or AI program development).
Communications Server	Processes protocols for access to larger computers and networks.
Compute Server	Decreases time of computationally intense applications and maintains user interactivity and productivity.
Data Base Server	Provides high-performance data base access across a network.
File Server	Provides mass storage, common access to files, and secure tape backup.
Print Server	Provides a network connection for large printers or plotters.
Terminal Server	Provides a connection point for other terminals.

Source: Dataquest
June 1989

Table 1 lists the major examples of how servers are currently used. However, interactive computing is an area that is rapidly growing in the technical and commercial markets. Dataquest projects that today's general-purpose server will be tomorrow's custom server, as the types of uses for server processors are expected to increase to the point at which each system becomes specialized.

TYPES OF COMPUTERS

What kind of computer can be used as a server? Any kind from a personal computer to a supercomputer is possible, depending on the user's needs. Table 2 lists, by category, how general-purpose systems, excluding the low-end systems, are used as multitasking or multiuser servers.

As networking resources evolve, more types of general-purpose systems will be connected transparently, and the systems will share responsibilities so that the type of server use per product segment will become less defined.

Table 2

General-Purpose Systems as Servers

Product Segment	Uses
Microcomputer	Could be used as a file server with a limited number of users on a LAN.
Superminicomputer	Historically used as a compute server, although it is not very effective as such. Could also be used as a data base or file server.
Minisupercomputer	Used as a compute server. Is very effective because of architectural strength in computationally intensive applications. Also useful as an applications server.
Mainframe	Is a good file server because of low cost per megabyte of storage achieved through the use of larger disks. The availability of new software packages running on these systems is a problem, however.
Supercomputer	Is excellent for use as a compute server, but is not the most cost-efficient approach for some companies.

Source: Dataquest
June 1989

SIZE OF THE SERVER MARKET

Dataquest's estimate of the size of the server processor market is based on custom servers, because, theoretically, the number of general-purpose servers in the market can be estimated to be the number of general-purpose computers in the market. We forecast the market for file and data base servers to be $1.6 billion in 1991, with workstation file servers estimated to be $451.0 million. Established vendors are expected to dominate the distribution channels in this portion of the market. (The file server market will be covered in more depth in an upcoming Dataquest newsletter.)

DATAQUEST ANALYSIS

Dataquest believes that the concept of the server changes the way the industry approaches computing as a whole. Servers and networks reflect the fact that all of the individual pieces of the computing puzzle, no matter how powerful, need to communicate and share resources. Vendors will remarket the individual system's performance to customers by emphasizing how the system can enhance the entire network and how quickly it will help the users to achieve the total solution. We project that departmental computing will change to resource computing, whereby the network will be transparent to the user to the point at which the user is unaware of its existence. As open systems and standards evolve to mainstream use, integration among computers will make applications available to systems that never before have been considered for those applications. In our opinion, servers bring the industry closer to being focused on service and added value rather than being product specific.

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Dataquest
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Research *Bulletin*

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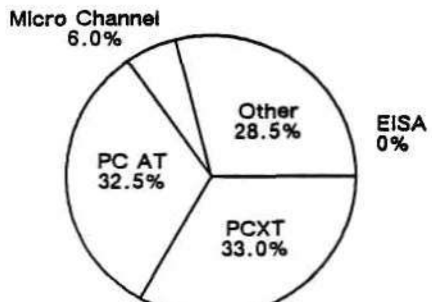
OEM MONTHLY

OEM Monthly has been designed to give our semiconductor industry clients a deeper insight into the production of PCs and other end equipment in North America. Figures 1 through 4 below will be discussed in detail in the paragraphs that follow.

Figure 1
Worldwide PC Shipments by Bus Type



Total Worldwide Shipments = 19 Million

Figure 2
OEM Net Earnings as a Percent of Revenue

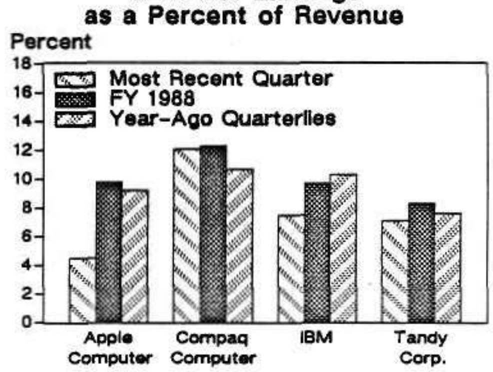
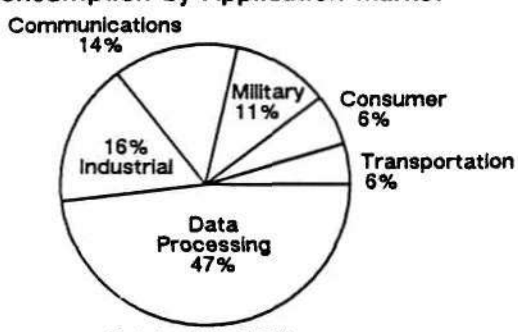
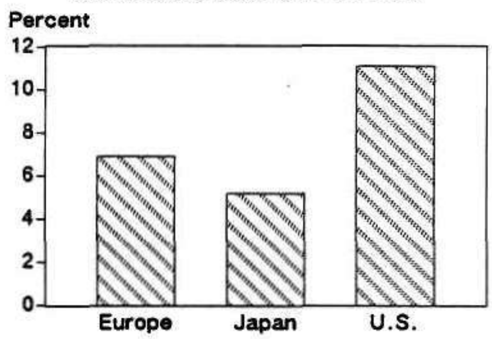


Figure 3
Estimated 1988 U.S. Semiconductor Consumption by Application Market



Total = $15.7 Billion

Figure 4
Estimated 1988 Semiconductor Use in PCs



0003921-1

Source: Dataquest
May 1989

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SHIPMENTS

Old designs are sometimes the ones that sell the best. For example, XT and AT systems had the largest worldwide market share (see Figure 1). The AT enjoyed the fastest unit growth rate (61 percent) last year.

A lack of differentiating software, combined with the absence of a low-cost systems vendor, continues to slow market penetration and acceptance of IBM's Micro Channel Architecture (MCA). While Dataquest sees several new MCA vendors entering the market this year, and notes that Presentation Manager continues to gather momentum, we nevertheless expect AT sales to outpace MCA by at least a 4-to-1 margin through 1993.

OEM PROFITS

Reflecting the slowing growth and general product maturation within the PC industry, most vendors reported a decline in operating and net profit levels for their most recent quarters. The four OEMs listed in Figure 2 had a combined worldwide market share of 33 percent, and three of them felt the squeeze.

Dataquest expects PC OEMs to lower inventory levels and seek lower ASPs in an effort to improve sagging margins.

EQUIPMENT MARKETS

Data processing equipment continued to be the largest North American semiconductor application market in 1988 (see Figure 3), and at 14.5 percent, was also one of the fastest growing. Dataquest expects data processing equipment production in North America to grow by 10.7 percent in 1989.

CONSUMPTION BY REGION

Certain equipment production categories represent especially significant demands for components. For example, PCs consumed 11.1 percent of U.S. semiconductor sales last year (see Figure 4), and VCRs consumed 11.3 percent of last year's semiconductor sales in Japan.

Dataquest expects the worldwide PC market to experience 10 percent unit growth and 24 percent revenue growth in 1989, due in large part to growth in the laptop segment.

DATAQUEST ANALYSIS

Standard desktop PCs have become a low-cost commodity, with marketing issues replacing technology as the driver. U.S. OEMs are feeling the pressure on profits. We believe that semiconductor suppliers will also feel pressure to help OEMs reduce their costs.

Data processing equipment production consumes the largest percentage of semiconductors in North America and therefore serves as an indicator of the health of the electronics industry. PC sales are expected to do well in 1989, and despite strong anticipated ASP pressure, we expect semiconductor sales to do well also.

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Roger Steciak

Dataquest
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Research Newsletter

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ISDN: PLANS, POTENTIALS, AND PITFALLS (PART 3—THE SEMICONDUCTORS)

SUMMARY

Integrated Services Digital Network (ISDN) is an opportunity with high rewards and high risks for the semiconductor industry. As a result, technology alliances are being formed by semiconductor suppliers to reduce the costs of developing microelectronic components for ISDN (see Table 1).

ISDN semiconductors are highly integrated application-specific circuit functions that are used only in voice and data communications equipment. Sales of these chips depend on the rate at which a telephone network is converted over to ISDN.

Table 1

ISDN Technology Alliances

Announcement Date	Partners
June 1988	AMD, Siemens
July 1988	Level One, Mitel
October 1988	National, SGS-Thomson
February 1989	AT&T, Intel
March 1989	IMP, Mitel

Source: Dataquest
May 1989

WHY ISDN?

ISDN is an open system. Interfaces between terminal equipment and the network are standard and invariant. However, technologies and services will change dramatically over the next several decades because of advances in science and new demands from users.

ISDN is intended to be a timeless architecture that would allow any new terminal or service to be connected to the network without reengineering the entire system each time.

Technology Evolution

Each new generation of semiconductor has more functions, while the price remains the same. For example, the industry average price of an integrated circuit (IC) has stayed between $0.90 and $1.10 since the early 1970s. However, the five dollars that would buy a single transistor in 1960 would buy an IC with the equivalent of 500,000 transistors in 1985.

These advancements are expected to continue. For example, discoveries that are still in the laboratory stage (e.g., bipolar quantum resonant tunneling) promise that semiconductors will be 100 times smaller and 1,000 times faster by the year 2000. ISDN is designed to allow the telephone network to adapt to this ever-increasing electronics capability.

Services Evolution

Telephone companies have always taken advantage of new technology to offer new communications services to users. Examples of past service innovations include direct dialing, touch-tone dialing, speed dialing, call blocking, call forwarding, and call waiting. These services were made possible by the declining cost of electronic components.

As electronic components continue to decline in cost, new services become more practical. Two examples include caller identification and central office voice mail. ISDN is designed to support the easy implementation of these and many other new services that users may demand in the future.

CIRCUITS AND APPLICATIONS

The sales potential for electronic circuits used with telephone lines is large (i.e., an estimated 19 million lines were shipped in the United States last year). Semiconductor suppliers can profitably build chips that are customized for this telecom application.

Some telecom ICs designed for pre-ISDN equipment are also needed for ISDN equipment, while other telecom ICs will be new. Table 2 compares the function content of pre-ISDN and ISDN equipment.

Table 2

Function Content of Telecom Equipment

Equipment	Pre-ISDN Content	ISDN Content
Central office switch line card	Codec, combo, or SLAC SLIC	N/A (in telephone) U-interface and basic rate access control
PBX line card	Codec, combo, or SLAC SLIC and SCC or UART	N/A (in telephone) S-interface and basic rate access control
Personal computer serial port	Modem and SCC or UART	S-interface and basic rate access control
Telephone	Dialer (tone, pulse)	S-interface and basic rate access control
	N/A (in switch)	Codec, combo, or SLAC

N/A = Not Applicable

Source: Dataquest
May 1989

Voice Equipment

Codecs, combos, and SLACs are ICs that convert analog speech into a digital waveform. These circuits, used on pre-ISDN line cards of central office switches and PBXs, will be located in ISDN telephones.

Dialers are ICs that generate either the pulses (rotary dial) or the tones (touch-tone dialing) needed to set up a telephone call. With ISDN, dialing (and other) information needed for a call will be placed directly on the basic access "D" channel at the telephone.

Data Equipment

SCCs and UARTs are ICs used for data communication within a system. These chips often are used in PBXs to send control signals between telephones and line cards. With ISDN, this communications function will be performed by the basic access "D" channel.

SCCs and UARTs also are in PCs to control the flow of data between memory and the serial port used by a modem. The S-interface will replace the modem, and it is capable of handling data rates up to 64 Kbps.

Circuit Implementations

The equipment-level standards for ISDN are coordinated by the Consultative Committee on International Telephony and Telegraphy (CCITT) and finally are solidifying after many years of discussion. The ISDN standards at the chip level are defined by the industry, however, and the debate is just beginning. The proposed interchip connection standards are as follows:

- Concentration Highway (K2)
- General Component Interface (GCI, IOM-2, V*)
- Interchip Digital Link (IDL)
- Serial MPU Bus
- ST Bus (ST)
- Subscriber Line Datalink (SLD)

Another important item at the component level is software. An ISDN interface circuit requires both hardware and software to implement the CCITT standards. Most original equipment manufacturers (OEMs) require that ISDN software be certified before ISDN semiconductors can be used in their equipment.

SUPPLIERS AND DEMAND

Several companies either are or will be supplying semiconductors for ISDN equipment (see Table 3). Many of these companies have been shipping telecom ICs for pre-ISDN equipment. For these suppliers, ISDN ICs represent extensions of their existing product lines. For example, the design of the circuit functions needed in both pre-ISDN and ISDN equipment are determined by the requirements of the telecom application. In addition, the customer base is the same because the same OEMs are building both pre-ISDN and ISDN equipment.

Table 3

ISDN Semiconductor Suppliers

AMD	Gold Star	Motorola	SGS-Thomson
AT&T	Gould	National	Siemens
Cal Micro	Hitachi	NEC	Sierra
Cirrus	Harris	OKI	Siliconix
Crystal	IMP	Philips/Signetics	Silicon Systems
Dallas	Intel	Plessey	TI
Ericcson	Level One	PMI	Western Digital
Exar	Mitel	Rockwell	Zilog
Fujitsu	Mitsubishi	Samsung	

Source: Dataquest
May 1989

Demand Forecast

Dataquest estimates that ISDN semiconductor sales in the United States will be approximately $70 million in 1989 and approximately $700 million in 1995 (see Table 4).

Table 4

U.S. ISDN Semiconductor Forecast
(Thousands of Units, Millions of Dollars of Sales)

Function	Item	1989	1992	1995	CAGR 1989-1995
Basic Access Control Function	Units	725.0	3,400.0	19,000.0	72.4%
	ASP	$15.0	$ 8.0	$ 6.0	(14.2%)
	Sales	$10.9	$ 27.2	$114.0	48.9%
S-interface	Units	710.0	3,050.0	17,000.0	70.0%
	ASP	$18.0	$ 10.0	$ 7.0	(14.6%)
	Sales	$12.8	$ 30.5	$119.0	45.0%
U-interface	Units	540.0	2,400.0	15,000.0	74.0%
	ASP	$95.0	$ 45.0	$ 30.0	(17.5%)
	Sales	$51.3	$108.0	$450.0	43.6%
Total Sales		$75.0	$165.7	$683.0	44.5%

Source: Dataquest
May 1989

DATAQUEST CONCLUSIONS

ISDN represents an opportunity disguised as a challenge. Semiconductor companies have traditionally relied on learning curves for success (i.e., lower the price, increase unit production, reduce unit cost, and make a profit).

This scale-economies strategy worked for the consumer electronics revolution in the 1970s and the PC revolution in the 1980s. Growth of the telephone business, however, is related to growth of the population and is more inelastic in price than other semiconductor markets.

Semiconductors Are Now Subsystems

The semiconductor industry also may have become a victim of its own success. Integration has meant that more circuit functions have moved onto the chip, so that a chip now has become a subsystem.

An equipment manufacturer has to be able to specify the functions inside these VLSI chips, because the equipment in which the chips are to be used has to be differentiated from competing brands. Since each equipment model is slightly different, the semiconductor manufacturer has to make it easy for each chip to be slightly different.

OEMs also want integrated components for the design of the electronic circuits inside the equipment. This sometimes means having both analog and digital functions on the same chip.

Timeliness and Added-Value Command A Price

The new element of success for semiconductor suppliers may well be aiming for and hitting market windows of opportunity. Having a chip with the right functions when new equipment is being designed is becoming more important than creating a chip with a minimum size well after the design of the equipment is completed.

Dataquest recommends that semiconductor suppliers do the following:

- Partition designs into organized floorplans so that change of part of the design (e.g., interface block) does not require relayout of the whole chip.
- Use computer-based design tools so that a design change can be turned into working prototypes in less than six months.
- Develop the capability to mix analog and digital functions on the same chip so that OEMs can buy the integrated components needed for their equipment.
- Participate on standards committees to understand the concerns of OEMs and to explain the capabilities of semiconductors.

Roger Steciak

Dataquest
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Research Newsletter

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SECOND QUARTER ELECTRONIC EQUIPMENT UPDATE

SUMMARY

In keeping with Dataquest's outlook for slower economic growth this year, we forecast that North American electronic equipment production will grow only 6.5 percent in 1989 (down from 8.8 percent growth in 1988) and will accelerate only slightly in 1990, to 6.7 percent. Figure 1 illustrates the expected short-term market revenue and revenue growth for each of the six equipment markets.

In general, growth in business' equipment investment is expected to decline by approximately one-half this year, from 13.4 percent growth in 1988, to 6.5 percent growth in 1989, in response to higher interest rates. Accordingly, the production growth of data processing, communications, and industrial electronic equipment also is expected to decelerate. In contrast—for reasons unrelated to the macroeconomic outlook—production growth in consumer, military, and transportation equipment is expected to accelerate slightly in the short term.

This newsletter presents an overview of recent business activity in the North American electronics industry and gives Dataquest's short-term outlook for the industry.

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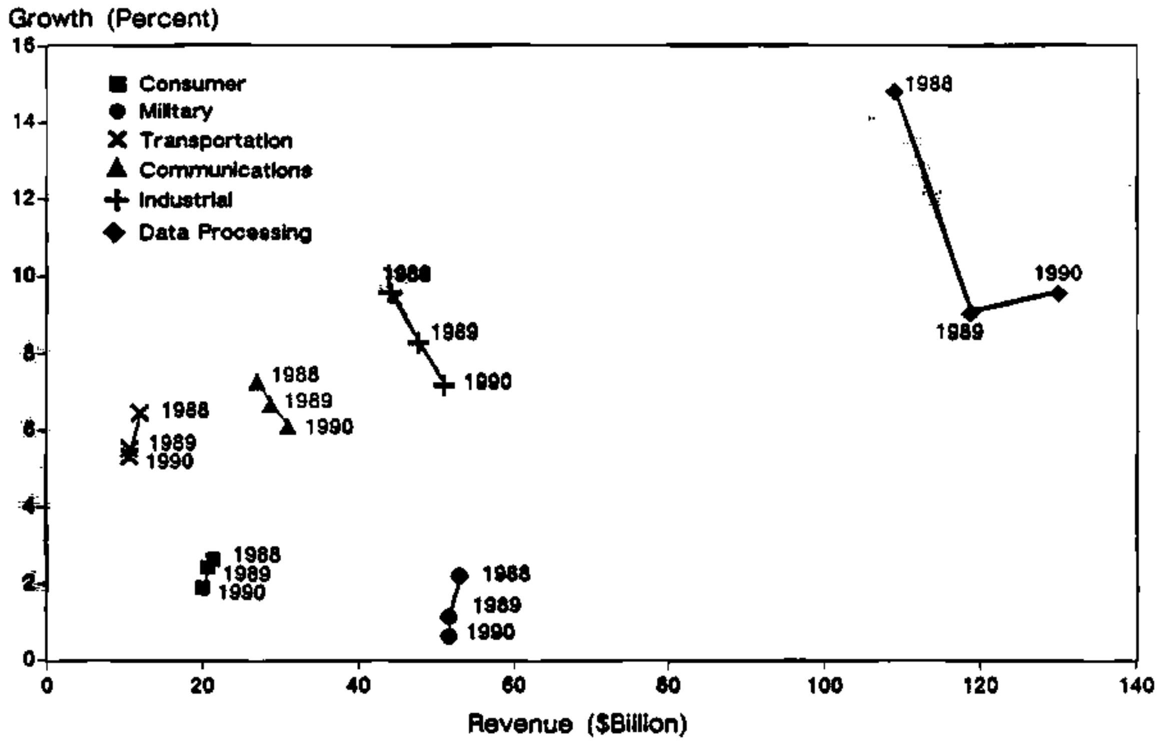
Figure 1

North American Electronic Production Outlook



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Source: Dataquest May 1989

OUTLOOK FOR EQUIPMENT MAREKTS

Table 1 shows Dataquest's most recent North American electronic equipment forecast. We expect the electronic equipment industry to grow 6.5 percent in 1989, to $279.8 billion. This increase actually represents a slight deceleration when compared with 1987, when the industry grew 8.8 percent. The data processing equipment market, fueled by heady workstation production and strong disk drive manufacturing, is expected to lead the pace with 9.1 percent growth in 1989 and a compound annual growth rate (CAGR) of 8.6 percent from 1988 through 1993.

Table 1

North American Electronic Equipment Forecast (Millions of Dollars)

	1988	1989	1990	1991	1992	1993	CAGR 1988-1993
Data Processing	$108,710	$118,615	$129,950	$141,128	$152,559	$164,567	8.6
Communications	27,004	28,823	30,605	32,471	34,743	37,050	6.5
Industrial	44,297	47,992	51,498	56,438	61,414	65,649	8.2
Consumer	20,118	20,607	21,138	21,752	22,395	22,947	2.7
Military	51,839	52,420	53,399	55,267	57,251	59,600	2.8
Transportation	10,744	11,331	12,030	13,511	14,615	15,498	7.6
Total	$262,712	$279,788	$298,620	$320,567	$342,977	$365,311	6.8

Source: Dataquest
May 1989

Data Processing

Dataquest expects North American data processing equipment production to grow 9.1 percent this year, down from 15.0 percent in 1988. Slower production growth is expected across the board, including computers, disk storage subsystems, and input/output systems.

North American personal computer production is expected to slow from the 20.3 percent breakneck pace that it set in 1988. Slower unit growth should combine with relatively stable prices, yielding 7.8 percent growth in 1989.

In contrast, growth of North American production of single-user, enhanced technical workstations (≤ $75,000), is expected to pick up a bit this year, to 38.4 percent from 36.8 percent in 1988. In light of the strong price pressures that workstations are currently weathering, this growth path is all the more amazing.

The PC and workstation businesses have seemed to be in a perpetual state of flux, and this year is no different. PC makers are bringing out high-end machines aimed at the workstation market, while workstation companies have begun to introduce low-end machines at power and pricing that have, until recently, been the domain of PCs. Meanwhile, the 80286-based PC market is coming under increasing pressure from the clone manufacturers, and from price cutting in the 80386-based market. Competition is tough for all concerned, but top-tier PC manufacturers that have more differentiation in their products are in a relatively more secure position to weather the storm ahead than, say, the lower-tier manufacturers that rely solely on price competition.

High inventories and overcapacity notwithstanding, North American disk storage subsystem production is expected to grow 16.4 percent this year, down from 19.4 percent in 1988. In 1989, growth of 3.5-inch disk drives will dominate as this form factor overtakes the 5.25-inch growth. Manufacturers' profit margins remain paper-thin, providing incentive for them to maintain production rates.

Communications

The short-term outlook for North American communications equipment production represents a real mixed bag, with local area networks (LANs) leading the pace, public telecommunications equipment essentially flat, and the modem market in decline. Overall, Dataquest estimates that North American communications systems shipments will be up 6.7 percent in 1989.

The trend toward distributed processing and interconnectivity continues to provide the impetus for LAN growth. Dataquest expects the value of North American LAN production to grow 40.3 percent in 1989 to $3.6 billion, down slightly from the 58.3 percent growth pace set last year.

In the middle is public telecommunications equipment. Sluggish capital investment in switching and transmission equipment is likely to restrain growth again this year to about 1.8 percent. Once ISDN takes hold, production in this segment will likely take off; however, do not expect this to occur until the mid-1990s.

The proliferation of chip sets continues to make the modem market a tough place in which to compete. Dataquest expects that the value of production will fall 2.4 percent this year, the same as in 1989. The 300-/1200-bps and 4800-bps modem segments are expected to be hit the hardest this year, shrinking 16.6 percent and 14.6 percent, respectively; the 9600-bps modem segment is forecast to shrink by 4.1 percent. Unit growth remains positive, but the industry is experiencing unprecedented competition, which is putting downward pressure on prices and resulting in constrained revenue growth.

Industrial

Growth and activity in the industrial electronics market are more closely tied to overall capital equipment spending in the economy than the other electronics markets. So, as last year's capital spending boom subsides, Dataquest expects a slowing trend in the industrial electronics market. We forecast North American industrial electronic equipment production to grow 8.3 percent in 1989, down from 9.7 percent in 1988, and slowing to 7.3 percent in 1990. The slowing trend is expected to broadly affect the entire North American industrial electronics market.

Manufacturing systems, which represents 36.5 percent of industrial electronics production, is expected to grow 7.3 percent this year, down from 14.6 percent in 1988. Instrumentation is forecast to grow 7.1 percent in 1989, down from 8.3 percent in 1988.

Consumer

No significant change in North American consumer equipment production is expected in the near term. Overall, North American consumer electronic equipment production is forecast to grow 2.4 percent in 1989, up from 1.6 percent in 1988, and to accelerate slightly to 2.6 percent growth in 1990. This expected growth stems not so much from production expansion by domestic manufacturers, but more from foreign manufacturers moving production to North America. The trade environment continues to be tense, and foreign consumer products producers are setting up shop offshore in hopes of keeping their export channels to the North American market open.

Military

Military electronic equipment production is forecast to grow a meager 1.1 percent this year and only 1.9 percent in 1990. Through 1993, the compound annual growth rate is forecast at 2.8 percent. Slow growth is being brought on by the Bush administration's downward revision of Ronald Reagan's 1990–1994 defense budget proposals. Instead of the previous administration's 2 percent annual real growth, President Bush has proposed to freeze the defense budget in real terms in fiscal 1990. In 1991 and 1992, the proposals call for 1 percent real growth per year and 2 percent growth in 1993 and beyond.

Instead of eliminating programs because of budget cuts, Congress is more likely to slow funding of research and procurement. For example, the Strategic Defense Initiative, the National Aerospace Plane, and the B-2 bomber seem likely candidates for spending reductions.

Slowdowns in military spending could well be the order of the day for some years to come, making life tough for equipment manufacturers and semiconductor manufacturers that likely will be faced with more extended, lower-level production than in years past.

However, opportunities do exist. For example, upgrades for F-14, F-15, and F-16 aircraft and the M-1 tank should be relatively safe from the budgetary ax. New aircraft programs, such as the Advanced Tactical Fighter (ATF), the Advanced Tactical Aircraft (ATA), and the European Fighter Aircraft (EFA), should provide some relief, as should the long-term space programs.

Transportation

Transportation electronic equipment production is expected to grow 5.5 percent this year and 6.2 percent in 1990. Despite sluggish automobile production brought on by the slowing economy, continued automotive electronics systems pervasiveness—particularly with respect to antilock braking and transmission control—should translate into positive automotive electronics systems growth.

DATAQUEST CONCLUSIONS

As the economy heads toward its seventh year of expansion, it is beginning to show signs of slowing. At one time, the electronics industry was thought to be immune from the basic macroeconomic forces that governed other, more mature, industries. The rapid rate of technological change was a major force driving industry growth. But as the electronics industry becomes a greater part of the economic pie, the industry's performance is likely to become more closely tied with the economy's overall performance.

Dataquest believes that as the economy's expansion slows, firms will curtail their capital spending plans. Slower capital spending will in turn translate into slower electronic equipment purchases. Dataquest forecasts slower production growth across the board for the entire North American electronics industry. We believe that the strengthening tie between electronics industry activity and overall economic activity is an important characteristic of the climate in which business will be conducted in the future.

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Research *Bulletin*

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MAY PROCUREMENT PULSE: INVENTORY LEVELS IMPROVE, DRAM MARKET AMISS

The Procurement Pulse is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin will present the results of the monthly survey and analyze what this information means to both semiconductor users and manufacturers.

Figure 1
Averaged Monthly Semiconductor Orders

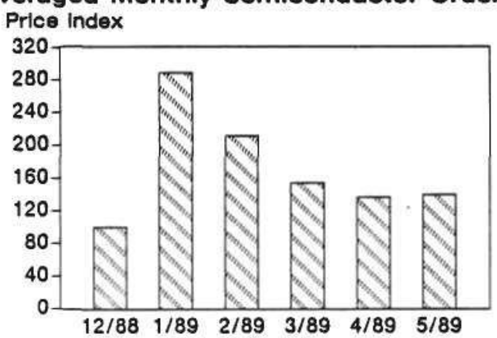


Figure 2
Averaged Semiconductor Lead Times

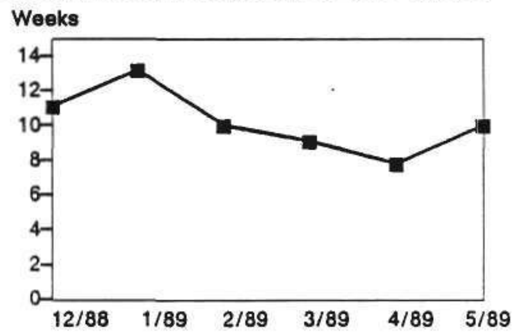


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

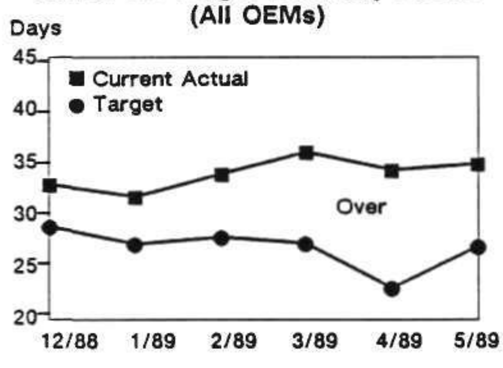
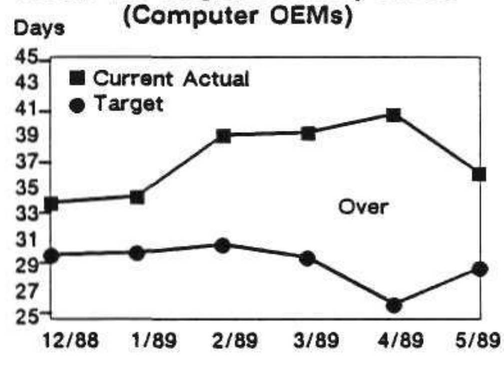


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



0003872–1

Source: Dataquest
May 1989

SEMICONDUCTOR ORDER RATE STABILIZES; DITTO SYSTEM SALES OUTLOOK

The large increase in semiconductor orders in January and February is now hitting semiconductor suppliers' books as billings (Figure 1). The rosy situation that led to strong Q1 book-to-bill ratios will not last. Threatening to dampen the Q1 rally of suppliers, semiconductor order rates for the past three months dipped to just above Q4 1988 levels. Now that overall semiconductor availability is just a concern, not a crisis, procurement managers are trying to balance order rates with overall system sales, which are expected to grow 4 percent to 15 percent during the next six months.

OVERALL SEMICONDUCTOR LEAD TIMES ARE MANAGEABLE

Except for DRAM-process-related semiconductors, the overall availability of devices continues to improve compared with earlier this year (10.1 weeks in May versus 13.3 weeks in January). The rebound in lead times this month (Figure 2) is due to SRAM and DRAM products refusing to become more available despite increased capacity levels. Korean memory products are the exception, being lower than average in price and lead time. Users of DRAMs and SRAMs should expect slower price declines this year relative to past supply/demand cycles, resulting from a seemingly concerted supplier strategy.

INVENTORY LEVELS DECLINE; TARGET LEVELS AGAIN IN SIGHT

Overall target inventory levels rose this month to 27.1 days over last month's low level of 23.1 days (Figure 3). With memories relatively more available now, inventory target levels have risen; this reflects increased confidence that order rates can be balanced with system sales. The relative stability of actual inventory levels (35.0 over 34.4 days) also correlates with the flattened order rate, which the industry hopes will keep pace with system shipments. Without work in process (WIP) or DRAM constraints, overall actual levels were less than 4 days over target levels (25.4 and 21.6 days, respectively). While computer sales rolled on, eating inventory, specific semiconductor order reductions had their intended effect (Figure 4). Current target and actual levels of 29.0 and 36.3 days are a large improvement over the respective levels of 26.2 and 40.8 days seen last month. Without WIP and DRAM inventory noise, computer semiconductor inventories were less than 2 days over target (22.0 days actual, 20.7 days target)! Inventory controls in this volatile segment improve as memory supplies increase, lessening the need for insurance stock.

DATAQUEST ANALYSIS

Improved availability of components for users is indicated by the following:

- Reduced semiconductor order levels
- Lead-time and price reductions (except for DRAMs/SRAMs)
- Historically low inventory levels
- A steady electronics market

Dataquest recommends that users closely match long-term contract levels to system sales rates. Semiconductor suppliers should not expect monthly billing levels to be the same in Q3 as in the first half of 1989. Suppliers should anticipate Q2 1989 booking levels comparable with those of Q3 1988. Accurate forecasting and inventory control by both users and vendors will be critical in preventing any slowdown from becoming a recession.

Mark Giudici

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Research *Newsletter*

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Comdex/Spring: What's Missing?

INTRODUCTION

As the mercury fell in Chicago, so did the level of excitement surrounding Comdex. With attendance down (estimated at 60,000), many key players noticeably absent, and surprisingly few exciting new product announcements, the real news at Comdex/Spring seemed to be what did not happen there and what did happen elsewhere.

For our readers who missed it, here is a brief run–down of what attendees saw and what was noticeably missing.

THE i486

Intel announced its new i486 product with a bang. The presentation featured endorsements from such industry heavyweights as Rod Canion of Compaq; Microsoft's Bill Gates; Jim Cannavino, president of IBM's Entry Systems Division; Philippe Kahn of Borland; Vittorio Cassoni of Olivetti; and John Frank of Zenith Data Systems. Although the 80486 was widely anticipated, the formal announcement nevertheless made quite a splash. (For more on the i486, see our SAM newsletter number 1989–20 entitled "80486/68040: A RISC–Less Approach.")

But the other shoe failed to drop. The timing of Intel's 486 development was such that although Intel was ready for Comdex, the PC community appears to be months away from announcing the first 486–based machine.

This left those of us watching high–end PC developments to wander the floor counting 33–MHz machines. Among those showing such systems were Acer, AST, Everex, Tandon, Zenith, and a host of clone vendors. Although these represent a powerful extension of the companies' product lines, their only differentiating feature is a 30 percent increase in power.

Worse yet, the show lacked the exciting software breakthroughs that many of us were hoping for (the kind that would give an added incentive to buy one of those 33–MHz systems). Deskview 386, with its ability to pull almost any software into a multitasking environment, did raise some eyebrows, though.

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FILE SERVERS

To present a full product line, many PC exhibitors labeled their high-end products "workstations" and also showed models that were configured as file servers. Although these systems typically were stripped of their monitors and keyboards and were running the appropriate I/O software, most were simply that—PCs functioning as file servers. Attendees did not see any new hardware optimized for the file server function (fast I/O, high-capacity, fast-access hard disk, etc.).

MACDEX

People looking for big news at MACDEX came away empty-handed. MACDEX virtually failed to show up. The real question here was why such a small show was made to stand on its own in the first place. The number of exhibitors and attendees was so small that MACDEX started to make the cruel joke circuit (the guards were there to keep people in, etc.). As further punishment, MACDEX was literally made to stand in the corner. By the end of the second day, it was opened up to all Comdex attendees. The really interesting Apple-related booths were a couple of MAClones, downstairs at Comdex.

EISA

The people at Zenith data systems were sporting provocative "EISA!" buttons on their lapels. As buttons go, these were nice ones, but many attendees were looking for actual EISA systems, or failing that, some hard EISA news. Neither was to be found.

DEBUTS AND NO-SHOWS

This was Olivetti's first Comdex appearance, and the company showcased its various PC lines, including its new MCA machines, impressively.

With no 486-based or EISA products to debut, Compaq opted to limit its presence to a nearby suite. Although this low-profile strategy allowed Compaq to woo selected VIPs, the buying public was given no new information concerning the company or its product line. NEC adopted a similar low profile, behind-the-scenes approach.

Attendees might have noticed Panasonic's new machines, noteworthy not for what they are (standard PCs), but for who manufactures them (Tandy). This was interesting in that it confirms Tandy's recent strategy of increasing business through an aggressive OEM campaign. Tandy already has a similar agreement with Digital Equipment and currently manufactures the desktop machines sold by its GRiD subsidiary. This suggests that Tandy might feel limited by its distribution channel. In fact, Tandy products occupied more floor space in other companies' booths than they did in its own booth.

Finally, attendees would have seen a few intriguing technology teasers, such as color LCD displays by such laptop vendors as Hitachi, Mitsubishi, Sharp, Toshiba, and Zenith. But most of these displays featured a prominent disclaimer stating that these were not yet released products, so they were truly "teasers." When pressed, several vendors estimated that these will be brought to market sometime in the fourth quarter of this year, or the first quarter of 1990 (yes, after Comdex/Fall).

CONCLUDING REMARKS

What is really interesting about this Comdex/Spring is not only what did not happen there, but what did happen elsewhere. Comdex has never been a workstation-oriented show; however, the gradual merging of the PC and workstation markets left pedestrians at the show with an incomplete picture—here is Zenith, where is Sun? Here is IBM, where are Digital and NeXT?

While they were not attending the show, some no-shows certainly were not idle. On the flight home, many attendees learned that Apollo had been acquired by HP, and that on April 12, Sun made a major new product announcement, the low end of which is to be priced significantly below many of the "PC-workstations" that were on display at the show.

Although it is true that Comdex/Fall traditionally has been the bigger event, the timing of these events underscores the fact that as attendees, we really did not get the feeling that we "saw it all under one roof." Perhaps because Comdex traditionally has been aimed at the distributor channel, the workstation segment (which tends to sell through other channels) has not been well represented there. In any case, things would have felt much more complete if the Apples, the NeXTs, and the Suns of the world had been enticed into attending.

Kevin Landis
Joan Holewinski

Dataquest
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Research Newsletter

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FOURTH ANNUAL PROCUREMENT SURVEY: OLD ISSUES REMAIN HOT; ACCURATE FORECASTING IS THE KEY

SUMMARY

The fourth annual Dataquest procurement survey results were announced at the Semiconductor User and Applications Conference that was held in San Francisco, California, in late February. The top three issues of availability, pricing, and on-time delivery remained unchanged from last year's survey because of 1988's severe memory shortage. As a direct result of this memory shortage, U.S. semiconductor suppliers lost 20 percent of the business of respondent companies to the hands of Japanese suppliers.

Supplier of the Year

The procurement survey was used as a vehicle to allow users to vote for the Semiconductor Supplier of the Year. Suppliers were rated on the following five criteria:

- Quality
- On-time delivery
- Price
- Technical support
- Overall customer service

Based on input from 300 purchasing managers, Motorola Inc. was presented with the First Annual Semiconductor Supplier of the Year Award at the conference dinner.

Offshore Production

Offshore production by system companies has peaked since most of all planned offshore production facilities have now been completed. Eighty-eight percent of those that have offshore production do not plan on bringing their offshore production back home. A regionally balanced production base now appears to be in place.

Purchasing Growth

Semiconductor users have been conservative regarding semiconductor purchasing growth for the past two years. In our last survey, users projected growth for the year at 13.3 percent; the actual growth totaled 24.7 percent. This year, the users project semiconductor purchasing growth to be 17.8 percent. Users are being fairly aggressive with their projections; this is in part due to last year's memory shortage that left many in the lurch combined with some pent-up system demand carryover. Dataquest forecasts that North American semiconductor consumption will grow by 8.4 percent this year due to an anticipated second-half slowdown in electronics semiconductor demand.

SURVEY STRUCTURE

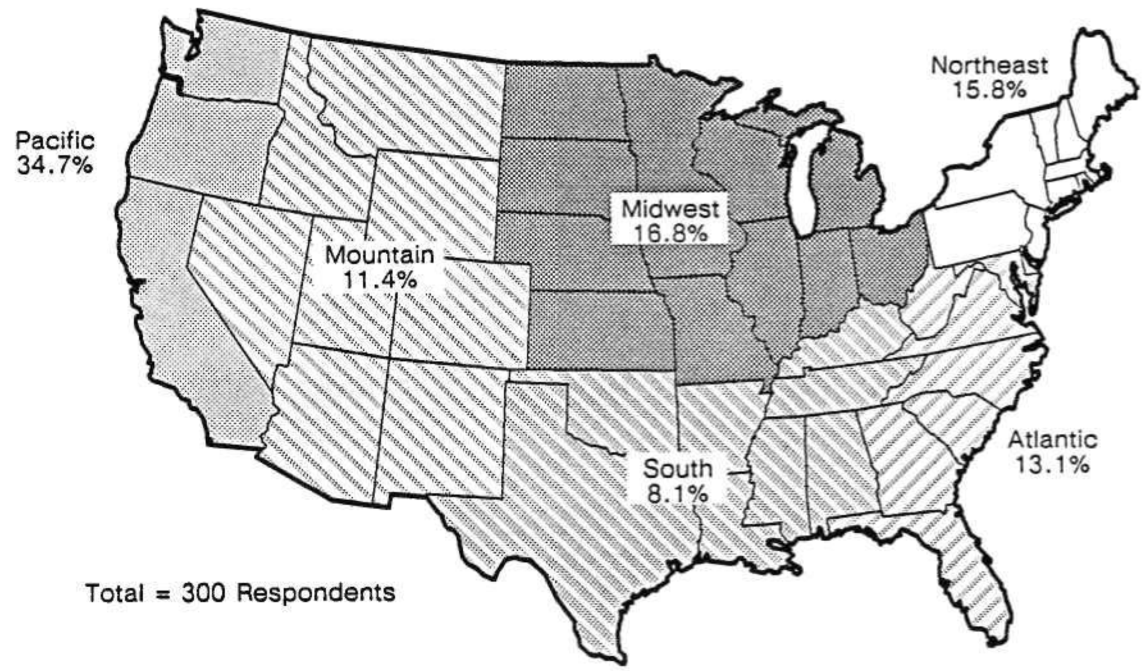
As we have done for the past three years, Dataquest's Semiconductor User and Applications Group gathers procurement information regarding major customers and markets for semiconductor manufacturers and users. Semiconductor users utilize this information to check their status against the market, and semiconductor manufacturers glean information about their customer base.

The respondents to this year's survey came from the Electronic Business 200 (EB 200). The overall response rate of 36 percent of the 841 purchasing sites (48 percent response of the top 400 sites) indicates that buyers expect to increase their 1989 semiconductor purchases by close to 18 percent.

In order to ensure that the companies we questioned used semiconductors, we selected from the original 200 companies system companies that were not component, software, or component distribution firms. This resulted in a sample of 168 companies (EB 168). We then surveyed by telephone each of the 841 procurement sites of these 168 companies. The interviews were conducted with buyers, purchasing managers, or those involved with material or corporate contract management. The EB 200 represents $299 billion in electronics revenue. Our sample, the EB 168, represents 63 percent of North American semiconductor consumption. Figure 1 illustrates the geographic locations of these major customers.

Figure 1

Procurement Survey Respondents' Geographic Locations



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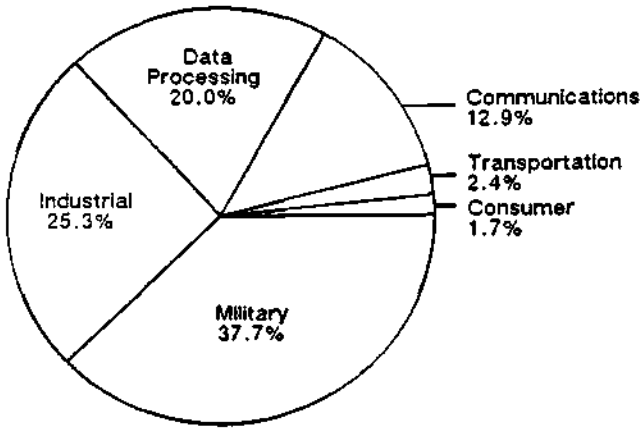
Source: Dataquest April 1989

The respondents to the survey closely match the overall industry distribution of the EB 168, as seen in Figure 2. All but two industry segments were within 2 percent of the overall EB 168 distribution (industrial, a negative 8.1 percent and military, 6.1 percent). The higher-than-actual military response minimally affected the survey, with the exception of inventories and ASIC nonuser responses, which were slightly higher as a result.

Figure 2

Survey Respondents by Major Line of Business



Total = 300 Respondents

0003732-2

Source: Dataquest April 1989

SURVEY FINDINGS

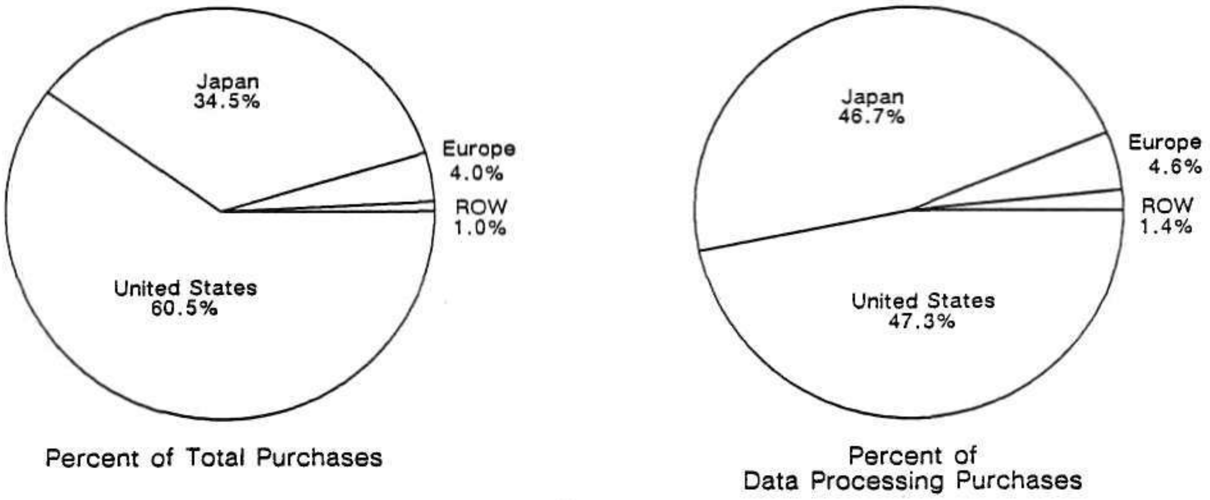
Regional Sourcing Trends

This year's respondents purchased 20.0 percent fewer semiconductors from U.S. suppliers (60.5 percent, down from 80.5 percent), while the Japanese doubled their market share (34.5 percent, up from 17.1 percent). Regional sourcing was the telltale response that clearly illustrated what last year's memory shortage did to the electronics industry. (We defined the regional base of semiconductors as the semiconductor company's country of origin.) This type of large loss of market share by one group of suppliers (in this case, U.S. suppliers) points out the dangers of having a regionally unbalanced supply of key components.

As an example of this imbalance, the data processing respondents who use a higher percentage of memory now buy nearly equal amounts of their semiconductors from U.S. and Japanese suppliers, as shown by Figure 3. This situation represents a drop for U.S. suppliers from 63.0 percent of the market to 47.3 percent and a corresponding rise for Japanese suppliers from 34.5 percent to 46.7 percent. Within the United States, distributors gained market share last year (14.6 percent versus 12.2 percent) as a result of the pervasive memory shortage that forced many buyers to source from distribution once their OEM contracts were exhausted. An interesting point is that European suppliers gained market share, rising from 1.1 percent to 4.6 percent, while Pacific Rim vendors maintained a 1.4 percent share.

Figure 3

Regional Supplier Base



0003732-3

Source: Dataquest
April 1989

ASIC Usage Trends

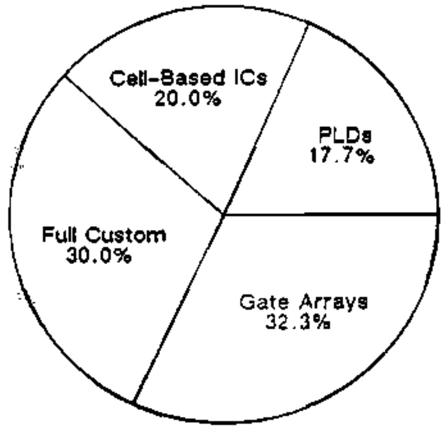
ASICs continue to be used as a design solution, while component counts per system and power consumption decline. More than one-half (56 percent) of the respondents now use ASICs. Of the 44 percent not now using ASICs, 23 percent plan to use them this year, 40 percent will not use ASICs, and 37 percent do not know their ASIC plans. The types of ASICs that will be bought by those that use or plan to use ASICs in 1989 are shown in Figure 4. The 37 percent of nonusers that are undecided about this technology present both an opportunity and a potential stumbling block as ASICs vendors try to remove the mystique that continues to surround this technology for some users.

The industry breakdown of the 44 percent of ASIC nonusers is shown in Table 1. The higher-than-average military segment and lower-than-average industrial responses have affected this breakdown somewhat. Another reason that the military use of ASICs is low is the long life cycles of typical military systems and the relatively short life cycle of an ASIC technology. With ASICs, the typical 10 to 20 year life cycle of a military system could go through as many as three costly technology/redesign iterations.

The trend to shift production offshore has peaked (see Table 2). For 1989, 80.0 percent of the respondents say that they do not plan to move production offshore at all. Of those that have offshore facilities, 87.7 percent do not plan to bring production back to the United States. The reason given for not changing the status quo is that all plans for offshore production are now completed. Because the major proportion of production cost is no longer labor but material, it appears that the worldwide regional production base is now becoming balanced.

Figure 4

Type of ASICs Planned for in 1989



0003732-4

Source: Dataquest
April 1989

Table 1

Profiles of ASIC Nonusers
Percent of Total

	1986	1987	1988
Data Processing	18%	13%	13%
Communications	11	15	11
Industrial	49	55	35
Consumer	6	2	2
Military	14	15	35
Transportation	2	0	4
Total	100%	100%	100%

Source: Dataquest
April 1989

Table 2

Anticipated Shift to Offshore Production

	1986	1987	1988	1989
A Great Deal	8.4%	10.1%	3.3%	2.7%
Some	35.9%	33.2%	34.0%	17.3%
Not at All	55.7%	56.7%	62.7%	80.0%

Source: Dataquest
April 1989

Offshore purchasing of semiconductors has also peaked with 14.9 percent of all respondents' buying coming from offshore sites compared with 14.2 percent from last year's survey. This response correlates with the production plans of companies that have now expanded operations offshore and are also increasing their purchases of foreign parts onshore.

Inventory Trends

The ongoing trend to reduce inventories is growing as semiconductor users strive to cut overhead costs and improve quality. The vendor reduction programs that have been put in place over the past years are now bearing fruit as inventory levels continue to decline. The average inventory level from the respondents for 1988 was 36.5 days. Only 37.0 percent of the respondents were at targeted inventory levels, 46.0 percent surveyed were over the target levels by an average of 22.5 percent, and 17.0 percent were under target by an average of 16.0 percent. The fact that 63.0 percent of the respondents were missing their inventory goals points out the need for improved forecasting and communications between buyers and sellers. Improvement in inventory control is being planned by 45.0 percent of the respondents who plan on reducing their inventory levels. This is the highest percentage recorded for those planning to lower inventories since we started taking this survey. The improved buyer-supplier communications environment was cited as the main reason buyers felt comfortable with lowering their inventory levels.

Major Issues

Every year we ask users what the most vexing problems are that they expect to face in the coming year. Table 3 shows the historical and future issues that procurement managers have faced and expect to face. Pricing, quality, on-time delivery, and availability changed positions but remained the top four issues in 1986 and 1987, while availability, pricing, and on-time delivery remain unchanged in the top three positions for 1988 and 1989. The scramble to acquire DRAMs and SRAMs last year kept availability, in large part, the key issue foreseen in 1989. Pricing and delivery remain key issues even in the current seller's market.

Table 3

Major Procurement Issues

1987		1986
1	Pricing	1
2	Availability/Lead Times	
3	Quality/Reliability	2
4	On-Time Delivery	3
5	FMVs/Trade Agreement	-
6	Cost Control	-
7	JIT/Inventory Control	5
8	Surface Mount	-
9	New Products/Obsolescence	-
10	ASICs	-
11	Offshore Manufacturing and Procurement	-
-	Reducing Vendor Base	6
-	Product Obsolescence	7
-	Second-Sourcing	8
-	Forecasting	9
-	Supply/Availability/Shortages	4

1989		1988
1	Availability	1
2	Pricing	2
3	On-Time Delivery	3
4	Quality/Reliability	6
5	Memories	5
6	JIT/Inventory Control	9
7	Cost Control	4
8	New Products/Obsolescence	8
9	Surface-Mount Technology	-
10	Second-Sourcing	-
-	Reducing Vendor Base	7
-	Fluctuating Yen/Currency Exchange	10

Source: Dataquest
April 1989

What has changed is the higher focus on quality as buyers are passing on to their suppliers the market's demand for ever higher quality. The higher ranking of quality reflects this emphasis to meet customer demand, and also indicates some dissatisfaction with suppliers that fail to keep pace wit'. quality improvement. Inventory control/JIT also has risen as a concern as companies continue to work at squeezing out all excess costs. Two new issues reemerging into the top ten are surface-mount technology (SMT) and second-sourcing. The prevalence and increased technical support needed by SMT has made this package technology again an issue. Second-sourcing again is an issue again primarily because of the memory shortages experienced last year that left many buyers high and dry, searching for parts.

DATAQUEST CONCLUSIONS

The underlying thread that ran through this year's survey was that the availability of key components pervaded all areas of procurement. The following were all affected by last year's shortages:

- Pricing
- Delivery
- Forecasting
- Second-sourcing

Companies that coped best through last year's supply difficulties were those that had in place good working relationships with their suppliers and informed the suppliers as soon as possible of any foreseen change in component need. Although not the whole solution, close communication between buyer and seller is much better than little or no communication.

Many of today's leading-edge technology companies are continuing to integrate the following:

- Design
- Purchasing
- Manufacturing

Good internal communications are a prerequisite to good external communications. The strong outlook in semiconductor purchases foreseen by this year's respondents may be an instinctive reaction to prevent last year's memory scramble. The combination of expected availability problems and high purchase rates points out the need for an improvement in forecasting that can only come from improved communication.

The current three key issues of availability, price, and on-time delivery all focus on how well a company copes with the uncertainties of the volatile electronics market. Accurate forecasting of both increases and decreases is the key that top companies use to remain competitive and maintain leadership in their fields.

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Mark Giudici

Dataquest
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Research Newsletter

SAM Code: Newsletters 1989: April-June
1989-21
0003731

ISDN: PLANS, POTENTIALS, AND PITFALLS
PART 2—THE EQUIPMENT

SUMMARY

Integrated Services Digital Network (ISDN) will affect all 500 million items of communications equipment currently in service in the United States. This impact will extend to both voice and data equipment located at business, residential, and telephone company locations (see Table 1). For suppliers of semiconductors, ISDN is an opportunity with a large potential.

Table 1

Types of Equipment to Be Affected by ISDN

Location	Voice Communications Use	Data Communications Use
Business	Answering machines	Data PBXs
	Call distributors	DSUs/CSUs
	IVD workstations	Fax machines
	PBXs	IVD workstations
	Telephones	Modems
	Video conferencing	Packet data networks
	Voice mail systems	Statistical multiplexers
Residential	Answering machines	Fax machines
	Telephones	Modems
Telephone Company	Central office switches	Central office switches
	Transmission systems	Transmission systems

Source: Dataquest
April 1989

WHY INTEGRATE?

For the user, ISDN will mean a broader choice of services. For the telephone company, ISDN will mean lower costs from equipment commonality. For both, network reliability will improve because maintenance testing will be done as a regular part of signal transmission.

Greater Versatility

Communication services today require an assortment of equipment in the telephone network. For example, voice traffic and some data traffic are carried on analog circuit-switched channels. Other data traffic is carried either on digital private lines or on packet-switched channels. ISDN will provide each of these different services with the same network equipment.

More Channels per Line

Each analog line in the local loop between the customer premises and central office can carry only one channel of communications. The need for additional communications capacity requires the installation of additional lines. With ISDN, up to three channels can be carried on a single line.

Faster Transmission

The telephone network today has analog lines that were originally designed for speech only. A PC can send data over this type of line using a modem at a maximum rate of 9.6 Kbps. With ISDN, the maximum rate is more than six times faster at 64 Kbps.

Faster transmission means messages are sent more quickly. A Group III fax machine (pre-ISDN), for example, can transmit one page of a document in about 30 seconds. A Group IV fax machine (ISDN compatible) is expected to transmit this same page in less than five seconds.

MARKET POTENTIAL

ISDN will require the redesign of all telephone equipment used for voice or data communications. Dataquest estimates that these types of equipment had a 1988 U.S. installed base of 500 million units and 1988 U.S. shipments of 65 million units (see Table 2). At the present compound annual growth rate (CAGR) of 5.4 percent, U.S. shipments will reach 120 million units per year by the year 2000.

Modems connect digital computers with analog telephones. In Table 2, however, Dataquest interprets modems in the broader sense as a measure of the connections of personal and other computers to the telephone network. We expect that connection growth will accelerate because ISDN makes it much easier for computers to use the network for data transmission.

Table 2

Estimated U.S. Equipment Consumption (Millions of Units)

Equipment	Installed Base 1988	Installed Base 1992	Installed Base CAGR	Annual Shipments 1988	Annual Shipments 1992	Annual Shipments CAGR
Telephones	314.00	398.00	6.1%	35.00	43.00	5.4%
Central Office Lines	129.00	149.00	3.6%	14.00	16.00	2.6%
PBX Station Lines	30.00	39.00	6.2%	5.00	6.00	3.2%
Answering Machines	22.00	42.00	17.6%	6.00	7.00	3.3%
Modems	10.00	22.00	22.2%	2.00	4.00	12.0%
Data PBX Lines	1.50	2.90	9.5%	0.20	0.20	3.0%
Fax Machines	1.50	5.80	40.2%	0.90	2.30	27.5%
Call Distributors	0.60	1.10	16.9%	0.10	0.20	15.8%
Statistical Muxes	0.50	0.70	18.9%	0.07	0.09	5.4%
DSUs	0.50	1.10	21.7%	0.10	0.20	16.2%
IVD Workstations	0.30	0.30	2.8%	0.03	0.03	(4.7%)
Voice Mail Ports	0.20	0.90	50.0%	0.10	0.30	33.3%
Packet Switches	0.20	0.30	10.7%	0.02	0.04	11.7%
CSUs	0.10	0.40	34.1%	0.04	0.09	27.0%
PADs	0.05	0.10	21.6%	0.01	0.02	8.1%
Video Conferencing	0.02	0.10	49.7%	0.01	0.02	17.8%
Totals	510.00	664.00	6.8%	64.00	79.00	5.4%

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

Source: Dataquest
April 1989

The telephone equipment supply base is highly concentrated. Dataquest estimates that the combined market share of the top three suppliers in most segments ranges from 40 to 80 percent (see Table 3). These suppliers of pre-ISDN equipment are redesigning their products for ISDN and represent the major customer base for suppliers of ISDN semiconductors.

Dataquest estimates that 1988 shipments of ISDN equipment were 302,000 units with a four-year CAGR of 78.4 percent (see Table 4). Installations are done in central offices first, followed by Centrex and single business lines. Basic access allows up to three channels on a line, with primary access replacing the T-1 connections between PBXs and central offices. Terminal adapters connect non-ISDN equipment to the network.

Table 3

Estimated U.S. Market Shares

Equipment	First Ranked (Suppliers)	Market Share	Second Ranked	Market Share	Third Ranked	Market Share
Call Distributors	NTI	25%	AT&T	13%	Rockwell	12%
CO Switches	AT&T	47%	NTI	39%	GTE	8%
CSUs	Verilink	51%	Larse	21%	Kentrox	15%
Data PBXs	Micom	41%	Gandalf	22%	Equinox	14%
DSUs	AT&T	39%	TPP	20%	GDC	17%
Fax Machines	Sharp	19%	Ricoh	16%	Canon	11%
IVD Workstations	NTI	41%	Siemens/ ROLM	37%	Davox	14%
Modems	Codex	19%	AT&T	17%	Racal/ Milgo	11%
Packet Switches	BBN	33%	Tymnet	13%	Telenet	9%
PADs	Dynatech	19%	BBN	13%	Memotec	13%
PBXs	AT&T	22%	Siemens/ ROLM	18%	NTI	17%
Statistical Multiplexers	Micom	15%	Codex	15%	Timeplex	8%
Telephones (key)	AT&T	28%	TIE	18%	Toshiba	9%
Telephones (std)	AT&T	15%	Panasonic	10%	Tandy	10%
Video Conferencing	Mitsubishi	61%	Image Data	20%	CLI	5%
Voice Messaging	Siemens/ ROLM	15%	Octel	11%	OPCOM	10%

Table 4

U.S. ISDN Shipments Forecast
(Thousands of Units)

Equipment	1988	1989	1990	1991	1992	CAGR
Basic Access Lines	165	288	600	1,000	1,550	75.1%
Centrex	158	250	500	700	1,000	58.6%
Single	5	20	50	150	200	151.5%
PBX	2	18	50	150	350	263.7%
Primary Access Lines	1	3	5	7	8	68.2%
Terminal Equipment	136	420	660	920	1,500	82.2%
ISDN Terminals	55	170	260	410	740	91.5%
Terminal Adapters	81	250	400	510	760	75.0%
Total	302	711	1,265	1,927	3,058	78.4%

Source: Dataquest
April 1989

INTERFACE STANDARDS

Standard interface circuits will have to be built into each piece of ISDN equipment so that connection to the telephone network can be made. The large sales potential for this type of standard element encourages component companies to supply semiconductors designed specifically for this use. The equipment manufacturer is able to buy low-priced chip sets that are optimized for ISDN.

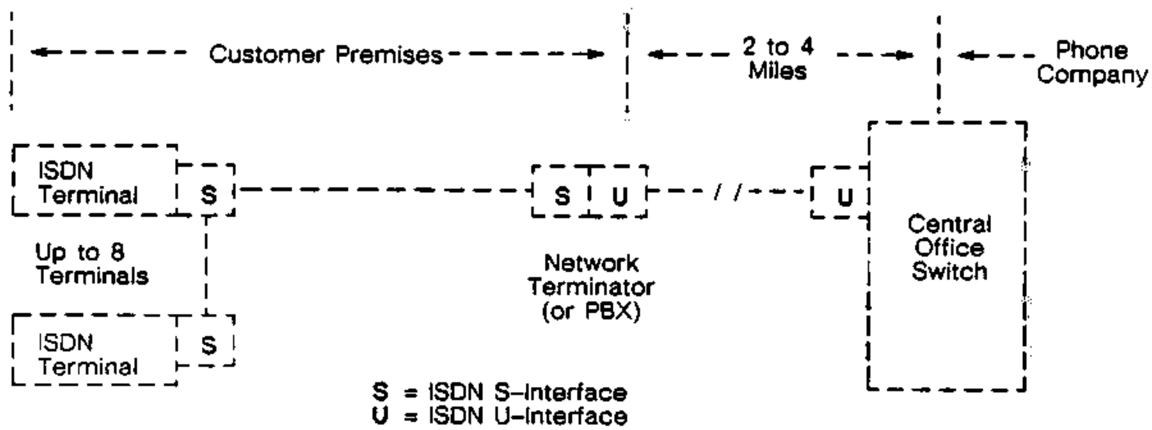
Basic Access

The major elements of the local loop for basic ISDN access include the U-interface, network terminator, S-interface, and ISDN terminals (see Figure 1). The U-interface controls the signal transmission between the customer premises and central office.

ISDN terminals include telephones, PCs, fax machines, statistical multiplexers, packet switching ports, and other equipment used for voice and data communication. The S-interface links up to eight ISDN terminals with the network terminator.

Figure 1

The Basic Access Local Loop



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Source: Dataquest April 1989

DATAQUEST CONCLUSIONS

ISDN represents a fundamental change in the telephone network. Full digitization means that telephones are finally entering the "Information Age," and computers will have an easier time using them to send data. At the same time, every item of communications equipment in the installed base will become obsolete and will have to be replaced. Equipment opportunities are also semiconductor opportunities; the estimated consumption of ISDN equipment in the United States is forecast to be 120 million units per year by the year 2000.

Applications Knowledge Is the Key to Success

The telecommunications market is very applications intensive. All equipment must meet complicated industry standards that require many years to learn. This in turn requires the semiconductor supplier to have much more specialized knowledge about this market than is usually required to service most other markets.

ISDN presents an even greater challenge. The industry standards are just now starting to solidify after a 15-year debate. For example, the U-interface standard for the United States was finalized in 1988. Other standards (such as the contention protocol used when up to eight ISDN terminals are connected to the same line) still must be determined.

The details of the ISDN application are the snakes in the grass that will bite the unwary. Dataquest recommends that all semiconductor suppliers participating in this market work very closely with customers to keep up with current developments.

Roger Steciak

Dataquest

Conference Schedule

1989

Semiconductor User/ Semiconductor Application Markets	February 27-28	Le Meridien Hotel San Francisco, California
Japanese Components	April 20-21	Tokyo Bay Hilton International Tokyo, Japan
Computer Storage	April 26-28	The Doubletree Hotel Santa Clara, California
Document Processing	May 16-18	Monterey Sheraton Hotel Monterey, California
Copiers	May 16-17	
Printers	May 16-17	
Electronic Publishing	May 18	
Imaging Supplies	May 18	
Color	May 18	
SEMICON/West Seminar	May 24	The Dunfey Hotel San Mateo, California
Telecommunications	June 5-7	Silverado Country Club Napa, California
European Components	June 7-9	Park Hilton Munich, West Germany
Asian Semiconductor and Electronics Technology Seminar	June 28	Radisson Hotel San Jose, California
Financial Services	August 22-23	The Doubletree Hotel Santa Clara, California
Technical Computing and Applications	September 11-13	The Doubletree Hotel Santa Clara, California
European Copying and Duplicating	September 18-19	Majestic Hotel Cannes, France
Western European Printer	September 20-22	Majestic Hotel Cannes, France
Taiwan Conference	September 25-26	Grand Hotel Taipei, Taiwan
Distributed Processing	September 26-28	The Doubletree Hotel Santa Clara, California
SIA/Dataquest Joint Conference	September 27	Santa Clara Marriott Santa Clara, California
Information Systems	October 2-6	Tokyo American Club Tokyo, Japan
Semiconductor	October 16-18	Monterey Sheraton Hotel Monterey, California
Asian Semiconductor and Electronics Technology	November 2-3	Kunlun Hotel Beijing, China
European Telecommunications	November 8-10	Grand Hotel Paris, France
European Personal Computer	December 6-8	Athens, Greece

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Research Newsletter

SAM Code: Newsletters 1989: April–June
1989–20
0003734

80486/68040: A RISC–LESS APPROACH

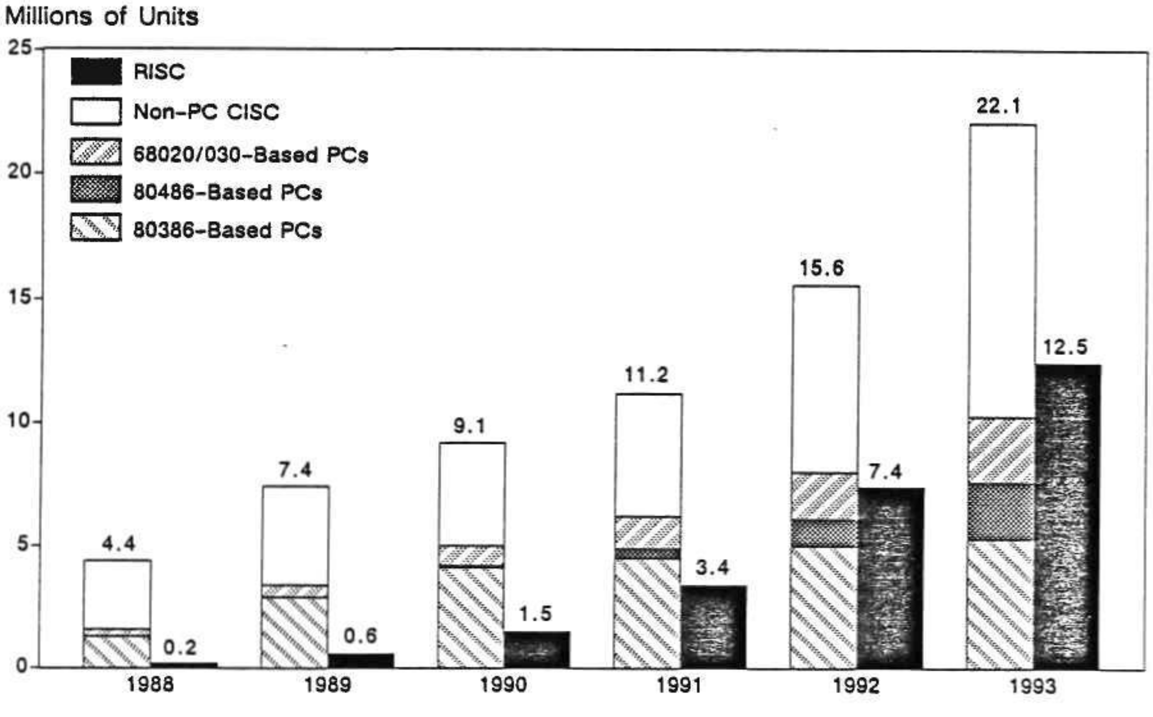
SUMMARY

On April 10, Intel announced the widely anticipated 80486 microprocessor. This announcement came less than two weeks after the unveiling of Motorola's 68040. The striking market and technology parallels between these two processors offers an interesting insight into the strategic choices facing Intel, Motorola, and their customers.

Despite the constant barrage of media hype about mips, mflops, embedded control, and RISC versus CISC, the 32-bit microprocessor market still belongs to Intel and Motorola. Figure 1 highlights Dataquest's PC forecast by microprocessor family as a function of total 32-bit microprocessor consumption. Based on the PC forecast alone, we are predicting that Intel's 80386/486 and Motorola's 68020/030 product lines will continue to dominate the general-purpose 32-bit microprocessor market for the foreseeable future.

Figure 1

Worldwide 32-Bit Microprocessor Unit Shipment Forecast



0003734-1

Source: Dataquest April 1989

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

TIES TO THE PAST

Intel and Motorola are undeniably the microprocessor industry leaders, each enjoying the luxury of a large, lucrative, and so far, loyal customer base. However, customer loyalty in the microprocessor business is born strictly of necessity and driven by the relentless competitive pressures facing the computer industry. With each succeeding product iteration, system designers must choose between the upgrade and the redesign paths, balancing system performance requirements against software compatibility considerations. It is toward these critical choices that each of these microprocessors is aimed.

Switching Costs: An Overriding Consideration

Nowhere are switching costs more undeniably overriding than in the selection of the microprocessor for succeeding generations of computer products. In jumping to a new processor, a computer vendor faces the prospect of obsoleting an entire software applications base. This imposes substantial switching costs not only on the computer vendor, but on the end user. More importantly, because "replatforming" is essentially a fresh start, the field is thrown open to all competitors, jeopardizing the customer bases of both the microprocessor vendor and the system designer. Clearly, software considerations provide all parties with a compelling reason for maintaining and extending their existing platforms.

Keeping the Platform Alive

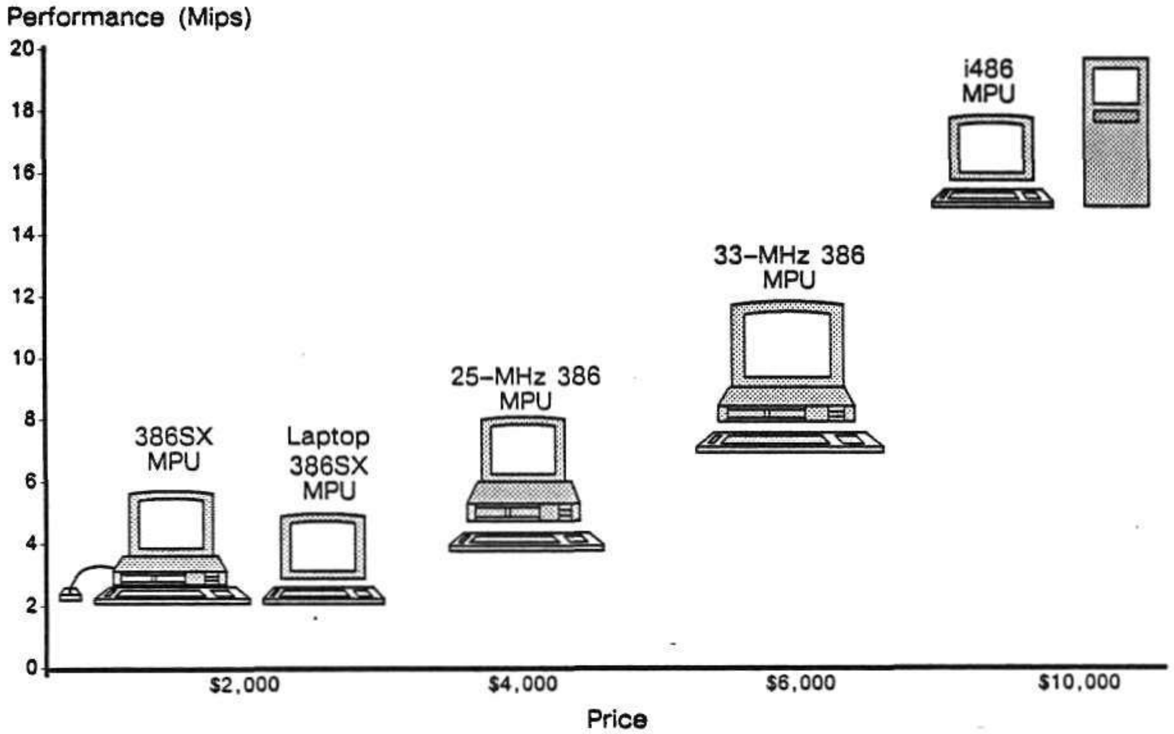
Dataquest believes that as long as these microprocessor family extensions offer system designers a competitive level of performance, software considerations will provide sufficient reason for their existing customer base to stay within the fold.

How long can Intel and Motorola keep offering competitive performance levels on updates to these aging platforms? Historians might point to the fact that each of these is essentially a late '70s design and argue for the inevitability of stagnation under such a restrictive and cumbersome set of constraints. So far, however, both firms have displayed an annoying tendency to make their innovative new ideas work within the constraints they have given themselves. To date there has been little indication of the expected trade-off between innovation and backward compatibility.

But these companies did not reach the commanding positions they now enjoy by being naive. Far from it—the longevity of the 68000 and the 8086 architectures is testament to each firm's visionary design philosophies. Intel's vision of a sole-sourced 80386/486 system-level price/performance spectrum is shown in Figure 2. Motorola's 68040 is intended to similarly extend the 68000 product line, allowing its customers to offer compatible systems at multiple price/performance points.

Figure 2

32-Bit Performance for Everyone



0003734-2

Source: Intel Corporation

FEATURE COMPARISON

Because of the limited information available on the 68040, it is difficult to accurately compare these two products. However, based on features described in Motorola's March 28 press release, the chips appear strikingly similar.

RISC/CISC: How Valid a Distinction?

As expected, both companies seem to have taken a page from the RISC book, optimizing performance by minimizing the number of clock cycles required for the execution of key instructions. Like their RISC counterparts, these devices have an optimized subset of frequently used commands. Unlike their RISC counterparts, the 68040 and the 80486 have retained the balance of their instruction sets in order to maintain compatibility with prior generations. Figure 3 shows the reduction in clock cycles required for certain key instructions in the 80486. Motorola's 68040 is expected to reflect a similar reduction in cycles per instruction, bringing both CISC processors closer to RISC processor performance.

Figure 3

RISC Design Techniques Reduce Clocks per Instruction

Instruction Type	Clock Counts 386 CPU	i486 CPU	SPARC	88000
Load	4	1	2	1-3
Store	2	1	3	1
Reg/Reg	2	1	1	1
Jump (Taken/Not Taken)	9/3	3/1	1/2	1
Call	9	3	3	1

0003734-3

Source: Intel Corporation

Integer Unit

The 80486 boasts six new instructions aimed at facilitating cache management and future multiprocessor applications. One of these is a byte swap instruction that will allow the 80486 to accept both big endian (68000 style) and little endian (80386 style) data, obviously opening access to non-X86 data bases. There is no indication at this time whether the 68040 will also accept both types of data; however, Motorola's 88000 supports both.

More important, perhaps, is the change from a 2X clock-in to a 1X clock-in on the 80486. This will become more significant as clock speeds approach 50 MHz. The 68040 is believed to still require a 2X clock-in. Both products will initially be offered at 25 MHz, although the 80486 may be available at 33 MHz before the 68040 comes to market.

Floating-Point Unit

Both the 80486 and the 68040 have migrated the floating-point unit (FPU) on-board. Both new FPUs are compatible with their predecessors, the 80387 and the 68882, as well as with IEEE standard 754.

Memory Management Unit

Again, both the 68040 and the 80486 have on-chip memory management units (MMU), as do the earlier 68030 and 80386. Both new MMUs will support paged mode operation and will undoubtedly be compatible with their predecessors.

Cache

The 80486 and the 68040 both feature 8K bytes of on-chip cache memory with full bus snooping capabilities. In the case of the 80486, the cache is a unified code/data cache that can be configured by the user. The 68040 will have separate data and instruction caches, each with 4K bytes.

Dataquest views this on-chip migration of the FPU and caches as a natural adjustment, given the need for increased system speed and the availability of die area afforded by finer-line geometries.

AVAILABILITY

Intel already has first silicon on the 80486, with production quantities scheduled to ship in approximately six months. Motorola, on the other hand, is still five to six months away from first silicon. This would imply that the 68040 will not begin shipping in volume for as much as a year from now. In order to address this window of vulnerability, and in an effort to placate its customer base, Motorola last week announced a 50-MHz version of the 68030, capable of delivering up to 12 mips. This product will begin sampling in May, with volume production expected in the third quarter of this year.

BRIDGE TO THE FUTURE

It is tempting to conclude that because of software-imposed brand loyalty, processors do not compete with one another. But that would be rather simplistic, since processors compete daily not only for new system designs, but secondarily as computer vendors compete with one another for consumer dollars.

Recognizing perhaps the ultimate mortality of these product families, Intel and Motorola have taken up competitive positions away from the security of their old platforms. If the 80486 and the 68040 represent these companies' present, with a nod to a distinguished lineage, then Intel's 80860 and Motorola's 88000 represent their future. These processors allow each to pursue new high-performance applications that are not limited by the old compatibility constraints.

However, the fundamental similarities between the 80860 and the 80486 (such as compatible register sets) suggest that Intel designed the 80860 with an eye toward providing a bridge between the huge 80X86 applications base and new end-user markets.

Dataquest believes that we will soon see an 80486-based system, possibly with an 80860 applications accelerator option. It would likely be made by a "PC" company, competing head-to-head with Sun, Digital, HP/Apollo, et al, driving yet another nail in the coffin of the increasingly arbitrary and outdated PC/workstation distinction.

Because first silicon on the 68040 is still some months away, it is not yet known whether Motorola will implement the necessary hardware compatibilities to accomplish an easy bridge to the 88000, or if it is even necessary.

A WORD ABOUT THE FORECAST

The 32-bit microprocessor unit shipment forecast presented in Figure 1 represents a significant strengthening over Dataquest's previous forecast, in large part because of a strengthening of the 32-bit single-user personal computer market. In order to relate PCs sold in a given year to microprocessors shipped for the same year, the PC numbers were increased approximately 17 percent allowing for a 60-day WIP/dealer inventory. Remember also that Dataquest's PC forecast does not consider the impact of multiuser systems such as NCR's tower products or of add-in accelerator cards.

Dataquest considers the following products to be RISC processors: SPARC, MIPS' RXXXX, Motorola's 88000, Intel's 80860/80960, Clipper, Transputer, Acorn, and AMD's 29000. Included in the CISC segment are Intel's 80386/80486, Motorola's 68020/030/040, National's 32X32, NEC's V60/70, and the TRON MPUs. The forecast presented in Figure 1 does not address Intel's 80386SX or Motorola's 68000/10.

DATAQUEST CONCLUSIONS

Dataquest sees the following issues as key to future market development:

- Greater emphasis on multitasking operating systems
- Increased connectivity among single-user systems via file servers
- Adoption of multiuser systems for departmental computing
- Development of multiprocessor systems for high-end computing applications

Dataquest views these issues below as transitory, and therefore of limited importance:

- The distinction between RISC and CISC
- The distinction between personal computers and single-user workstations

By adopting their two-pronged strategies, Intel and Motorola are effectively addressing these issues without passing up the opportunity to exploit the tremendous advantages afforded by their past successes. It is our view that the much anticipated migration toward the RISC camp will be slower and less widespread than anticipated. This assessment is based largely upon the consideration of established customer bases, switching costs, and the merging of RISC innovations onto CISC architectures.

It can be argued that design win opportunities within the embedded segment far exceed those more visible reprogramming applications, therefore offering abundant opportunities for the new RISC architectures. But, it is also important to recognize the massive installed base of embedded designs already committed to Intel's and Motorola's architectures and the latent effect of architectural familiarity on new designs.

If Intel and Motorola are successful in protecting the bulk of their customer bases from the onslaught of these new RISC architectures, competition from other sources may develop. The prospect of two very large user groups being served by sole-source suppliers may prove too enticing to pass up. Reports of 80386 look-alikes already exist.

Dataquest believes that in the long run, the computing community can support only a few platforms (perhaps three or four). This leaves us with a surplus of solutions, suggesting a shakeout to come. Be that as it may, one thing is for certain—Intel and Motorola have the home-field advantage.

Kevin M. Landis
Alice K. Leeper

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THE ASIC PACKAGE PROLIFERATION

SUMMARY

Surface–mount technology is now mainstream. Dataquest believes that surface–mount devices (SMDs) will continue to grow at a pace that exceeds traditional packaging and assembly techniques. As ASICs continue to grow in usage, many new surface–mount package families will be developed. This will cause multiple package choices for the same IC, resulting in difficulties for design engineers, assembly engineers, and purchasing agents (i.e., nonstandard packages for second–sourcing). It could make it more costly for semiconductor manufacturers to compete.

This newsletter will discuss the packages currently being used or under development for ASICs. It will also review the issues and choices pertaining to standards involved in ASIC packaging.

INDUSTRY ANALYSIS

Dataquest expects the worldwide integrated circuit package market to grow at a 10 percent compound annual growth rate (CAGR) from 1987 to 1992. We expect surface–mount devices to continue to show the greatest gain. They are expected to grow from the current level of 20 percent (year–end 1988) to almost one–half of all IC packages (48.4 percent) by 1992. These statistics are shown in Tables 1a and 1b.

The forecast shows the fastest growth area to be the quad flat package (76.3 percent CAGR). This is directly related to the worldwide increase in ASIC production.

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Table 1a

Estimated Worldwide Shipments by Package Type
(Millions of Units)

Package	1987	1988	1989	1990	1991	1992	CAGR 1987-1992
Plastic DIP	23,194	26,282	25,292	21,741	21,103	20,625	(2.4%)
CERDIP	3,346	3,738	3,274	2,778	2,783	2,727	(4.2%)
Ceramic DIP	270	277	250	231	225	203	(5.9%)
Quad/Ceramic and Plastic	284	805	1,357	1,640	2,785	4,833	76.3%
Ceramic Chip Carrier	207	315	374	383	430	562	22.1%
Plastic Chip Carrier	508	1,024	1,412	1,513	1,987	2,792	40.6%
SO	3,092	4,954	6,202	7,167	9,396	12,881	33.0%
PGA/Ceramic and Plastic	234	614	983	1,118	1,583	2,339	58.5%
Other (TAB/COB/ FCHIP)	470	860	1,224	1,480	2,249	3,817	52.0%
Others	479	657	684	596	612	608	4.9%
Total	32,084	39,526	41,051	38,647	43,153	51,386	9.9%
Total of SMT	4,561	7,958	10,569	12,183	16,847	24,885	40.4%
Percent of SMT	14.2%	20.1%	25.7%	31.5%	39.0%	48.4%	

Table 1b

Estimated Worldwide Shipments by Package Type
(Percent)

Package	1987	1988	1989	1990	1991	1992
Plastic DIP	72.3%	66.5%	61.6%	56.3%	48.9%	40.1%
CERDIP	10.4	9.5	8.0	7.2	6.5	5.3
Ceramic DIP	0.8	0.7	0.6	0.6	0.5	0.4
Quad/Ceramic and Plastic	0.8	2.0	3.3	4.2	6.5	9.4
Ceramic Chip Carrier	0.7	0.8	0.9	1.0	1.0	1.1
Plastic Chip Carrier	1.6	2.6	3.4	3.9	4.6	5.4
SO	9.6	12.5	15.1	18.6	21.8	25.1
PGA/Ceramic and Plastic	0.7	1.6	2.4	2.9	3.7	4.6
Other (TAB/COB/ FCHIP)	1.4	2.2	3.0	3.8	5.2	7.4
Others	1.4	1.6	1.7	1.5	1.4	1.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Percentages may not add to 100.0% because of rounding.

Source: Dataquest
May 1989

PACKAGE TYPES

Quad Flat Packs—Old and New

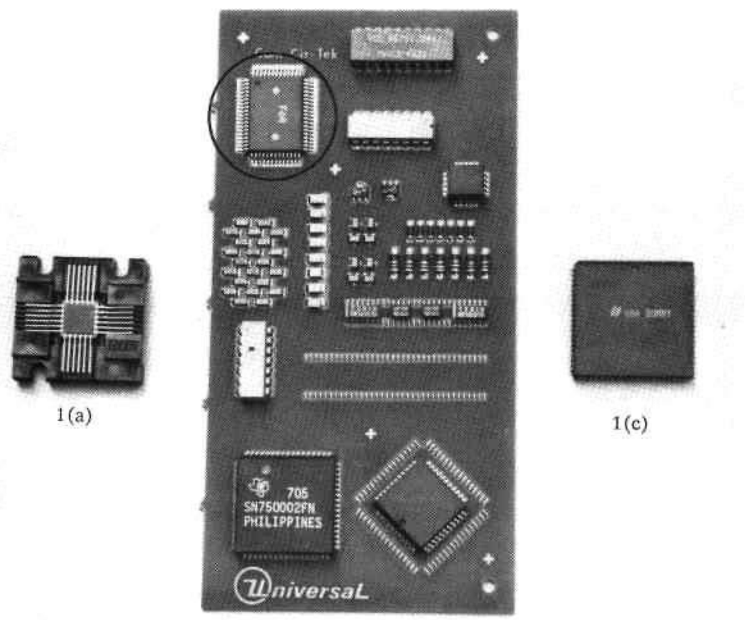
The true, original flat package is not new. Based on 50-mil lead spacing and ceramic technology, it has been and still is used primarily in military applications. The quads are mostly flat, retangular packages with bodies constructed of alumina or beryllia, with glass-to-metal seals. The long leads are splayed out away from the package body on all sides, in a gull-wing-style lead form. Lead counts generally range from 12 to 28 leads. Figure 1(a) shows a photograph of a ceramic quad flat package.

As commercial development of surface mount became prevalent in the early 1980s, the Electronic Industries Association of Japan (EIAJ) began to develop its own plastic versions of the quad flat package. These packages were based on the premise of keeping package body sizes the same and varying the lead pitch, thus increasing lead count density. Pitches of 1.0mm (39.4 mils), 0.8mm (31.5 mils), and 0.65mm (25.6 mils) form standards that define packages from 20 to 240 leads, depending upon body size. This package is also called the quad flat pack (QFP, as seen in Figure 1(b).

Expanding on this, the U.S. manufacturers agreed that placing leads on all four sides of a package was beneficial. But bending the leads underneath the package would increase density even further, and it also could be compatible with the ceramic leadless chip carrier board footprint. Thus the J-bend plastic leaded chip carrier (PLCC) was developed, with lead counts ranging from 18 to 100 leads on 50-mil center lead spacing (see Figure 1(c)).

Figure 1

Ceramic Quad Flat Package



1(a) 1(c)

1(b)

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Source: Dataquest May 1989

However, the PLCC on 50-mil spacing did not address the increasing demand of ASIC products for higher lead counts (more than 100 pins). So, the United States through the Joint Electronics Device Engineering Council (JEDEC) developed the plastic quad flat package (PQFP) for this requirement. It uses the same plastic body sizes as the PLCC, but has leads on 25-mil centers and a molded "bumper" protruding from each corner for lead protection during handling. Lead counts for this package family range from 44 to 244 leads, and the gull wing is the preferred lead form (See Figure 2).

Figure 2

Plastic Quad Flat Package

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Source: Dataquest May 1989

Finer Pitch Packages

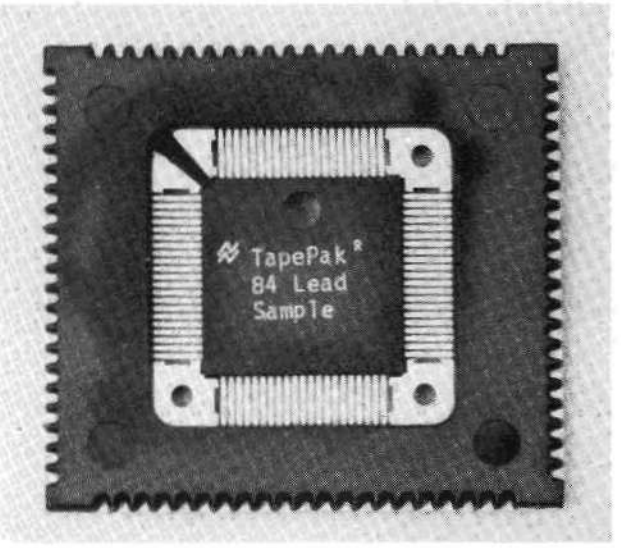
With the consumer market driving for smaller, less costly electronic gadgets and the ASIC market needing higher lead count packages, the Japanese have developed yet another package family: The shrink quad flat package (sometimes called the very small quad flat package (VQFP)). In some ways, this family is an extension of the EIAJ quad flat package (QFP). It also uses standard body sizes, but the package is one-half the thickness, and the lead pitches are reduced to 0.5mm (19.7 mils), 0.4mm (15.7 mils), and 0.3mm (11.8 mils). Lead counts range from 32 to 520 leads.

Besides those mentioned, two more surface-mount package families have recently been introduced into the market for ASIC packaging. One is TapePak developed by National Semiconductor; the other is the TQFP, a TAB quad flat pack developed by LSI Logic.

TapePak uses TAB (tape automated bonding) tape as the lead frame that is attached directly to the die. No wire bonding is used. This die-on-tape combination is then molded in plastic so that an outside ring is formed apart from the inside encapsulated die. This outside ring provides for lead protection and test capabilities. The package body is excised from the carrier ring by the pick-and-place machine and is subsequently attached to the printed circuit board. Like the Japanese quad flat pack, the TapePak family uses standard body sizes with lead counts from 40 to more than 460 leads on 20-, 15-, and 10-mil pitch. This package is shown in Figure 3.

Figure 3

TapePak



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Source: Dataquest May 1989

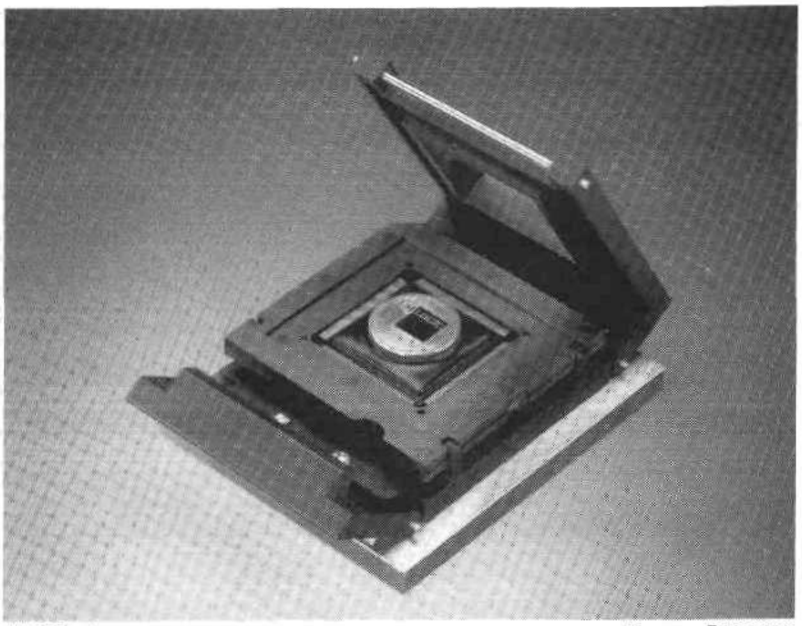
The TQFP is similar to TapePak, except for the following:

- It uses wire bonding for lead counts up to 300 and TAB from 300 to 524 leads.
- The die is encapsulated, using a liquid epoxy "blob."
- A two-piece plastic disposable slide carrier is used for lead protection and test.
- Pin counts range from 164 to 524 leads.

A picture of the TQFP is shown in Figure 4.

Figure 4

TAB Quad Flat Pack



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Source: Dataquest May 1989

Higher Lead Counts and the No-Package Package

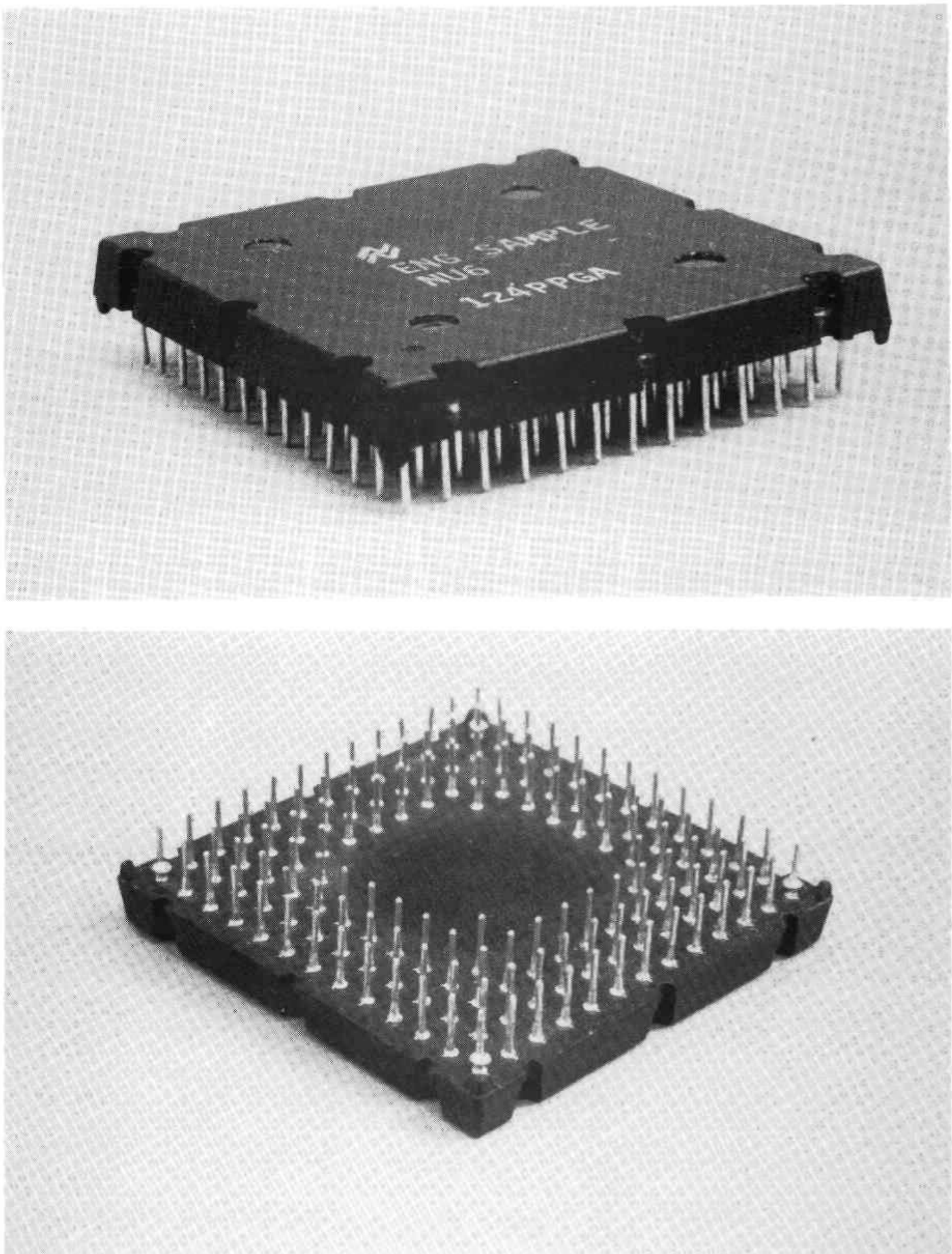
Another packaging solution to ASICs is the pin grid array. Although not assembled to the board using surface-mount technology, it does provide high-density capability to 1,000 leads and beyond. Rows of pins on 100-mil spacing (and more recently 50 mil) are arranged in a grid format to form the PGA (see Figure 5). It is available in both ceramic and plastic and is capable of dissipating more heat than most surface-mount packages.

There is one more approach to ASIC packaging that does not really use a package in the traditional sense. Chip-on-board (COB) technology enables the bare die to be attached directly to the printed circuit board. The die is attached to the board via an adhesive (usually epoxy) and wire-bonded directly to the pads or traces on the PCB. After bonding, the die is usually coated with a blob of plastic material to provide for mechanical and environmental protection.

Variations of the COB approach include TAB-on-board (TOB). Component leads are etched on single-layer or multilayer copper/copper-polyimide tape. The tape is etched to form patterns that correspond to the die pad layout. These patterned leads then make the connection between the die and the printed circuit board. Whereas wire-bonded COB is done on a chip-by-chip basis, TOB can be done via an automated, reel-to-reel process. The die-on-tape can then be attached to the board and encapsulated, as in the COB process. An example of TOB is Siemens' Micropak. A basic flow of the TOB process is shown in Figure 6.

Figure 5

Rows of Pins Forming the PGA



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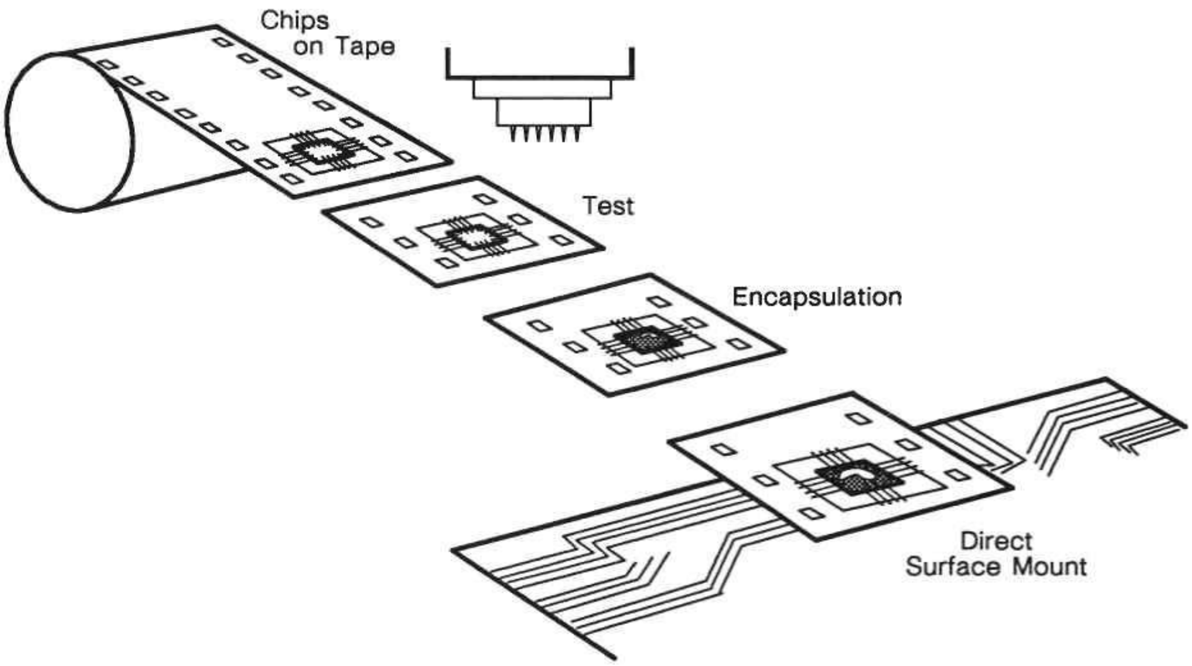
Source: Dataquest May 1989

Figure 6

TOB Process (Basic Flow)



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Source: MESA Technology

Finally, flip chip is one other assembly process that can be used in ASIC packaging. This process was developed by IBM in the late 1960s and is known as C-4, for controlled-collapse chip connection. It is basically a process in which the chip is designed for facedown reflow soldering. The bond pads are bumped with solder while in wafer form. Passivation (silicon nitride) is added, and the wafer is tested via the solder bumps. After testing, the dice are placed facedown, or flipped, on the ceramic substrate, and the assembly is heated in a furnace to reflow the solder. The surface tension of the solder aligns the dice properly to the substrate. This is the maximum use of interconnect density, as no lead frame, wires, or tape are used.

A DESIGNER'S NIGHTMARE

What package should an ASIC design engineer choose? Assuming that it is an ASIC requiring 68 leads, the following choices can be made if a plastic package is desired:

- 68-lead PLCC (JEDEC)
- 68-lead PQFP (JEDEC)
- 68-lead QFP (EIAJ)
- 68-lead VQFP (EIAJ)
- 68-lead TapePak (JEDEC)
- 68-lead PPGA (JEDEC)
- 68-lead COB (No standard)
- 68-lead TOB (EIA/IPC/ASTM)
- 68-lead Micropak (Europe/DIN)

The following section discusses the above listing in more detail. Table 2 lists some common specifications for each package.

Table 2

68-Lead Package Options*

	Lead Pitch	Lead Width	Package Size	Package Height
PLCC	0.050"	0.028"	0.950" sq.	0.180"
PQFP	0.025"	0.012"	0.550" sq.	0.102"
QFP	0.0256"	0.0118"	0.394" x 0.551"	0.100"
VQFP	0.0118"	0.004"	0.197" x 0.276"	0.050"
TapePak	0.020"	0.010"	0.505" sq.	0.072"
PPGA	0.100"	0.018"	1.14" sq.	0.180"
COB	0.008"	0.0014"	0.378" sq.	0.032"
TOB	0.020"	0.010"	0.378" sq.	0.032"
Micropak	0.0197"	0.009"	0.386" sq.	0.025"

*See Appendix A attached to this newsletter.

Source: Dataquest
May 1989

One can readily see that little, if any, compatibility exists among the various packaging styles, except possibly COB versus TOB. This means that designing with an ASIC from supplier A in PQFP (JEDEC) may not be compatible with the ASIC from supplier B in QFP (EIAJ), even if the silicon function is the same. The possible result is a sole-source supplier based primarily on package offering, not silicon.

STANDARDS ACTIVITY

There has been criticism of industry organizations for their lack of leadership in setting surface-mount standards. Some is justified, as it is difficult to get everyone to agree on one of anything, whether it be process, part, or package. There are major differences between the U.S. and Japanese styles of packages. Work needs to continue to bring commonality to this area.

Package standardization is proceeding within the United States at a faster rate as surface mount becomes a proven technology. To address industry awareness and the need for areas of standardization in surface-mount technology, representatives from EIA, IPC, JEDEC, and ASTM have joined together to form the Surface Mount Council. In January 1989, they issued a document entitled "Survey Report: Surface-Mount Standards, Requirements, and Issues."

This report surveyed responses regarding the awareness and usage of 14 typical standards currently available to the industry. In the case of integrated circuit components, the survey found that only 61 percent of the respondents used all or part of the EIA JEP-95 specification (JEDEC Registered and Standard Outlines for Semiconductor Devices). Eighteen percent were aware of this standard but did not choose to use it, and 16 percent were not aware of the standard. Highlights from this report related to component standards are shown in Table 3.

Table 3

Surface-Mount Component Standards

	Use Standard	Use Part of Standard	Do Not Use	Unaware of Standard
EIA RS 481A--Taping of SM Components for Automatic Placement	30.6%	18.8%	17.6%	20.0%
EIA PDP 100--Mechanical Outline for Registered and Standard Electronic Parts	14.1%	29.4%	16.5%	27.1%
EIA JEP 95-JEDEC--Registered and Standard Outlines for Semiconductor Devices	24.7%	36.5%	17.6%	16.5%
EIA JESD 11--Chip Carrier Pinouts for CMOS 4000HC and HCT Circuits	9.4%	17.6%	16.5%	44.7%

Source: EIA/IPC Surface Mount Council

In addition, many organizations worldwide have established committees to discuss issues related to surface-mount technology. A list of these is shown as follows:

- ACPI (Automated Component Placement and Insertion Group)—c/o AMP, 1000 AMP Drive, Harrisburg, PA 17112
- ANSI (American National Standards Institute)—1430 Broadway, New York, NY 10018
- ASTM (American Society of Testing and Materials)—1916 Race Street, Philadelphia, PA 19103
- BSI (British Standards Institute)—2 Park Street, London, W1A 12BS, United Kingdom
- CSA (Canadian Standards Association)—178 Rexsdale Boulevard, Rexsdale, Ontario, Canada
- DOD (U.S. Department of Defense, Naval Publications Center)—5801 Tabor Road, Philadelphia, PA 19120
- EIA (Electronic Industries Association)—2001 Eye Street N.W., Washington, D.C. 20006
- EIAJ (Electronic Industries Association of Japan)—250 West 34th Street, New York, NY 10119
- EMPF (Electronics Manufacturing Productivity Facility)—1417 North Norma Street, Ridgecrest, CA 93555
- IEC (International Electrotechnical Commission)—3 Rue de Varembe, 1211 Geneva 20, Switzerland
- IEPS (International Electronic Packaging Society)—114 North Hale Street, Wheaton, IL 60187
- IPC (The Institute for Interconnecting and Packaging Electronic Circuits)—7380 N. Lincoln Ave. Lincolnwood, IL 60646
- ISHM-I/SMT (International Society of Hybrid, and Microelectronics, Interconnect and SMT Division)—Box 2698, Reston, VA 22090
- SEMI (Semiconductor Equipment and Materials—International)—805 E. Middlefield Road, Mountain View, CA 94043
- SMART (Surface-Mount and Related Technologies Group)—3 Lattimore Rd., Wheathampstead, Herts AL4 8QF, United Kingdom
- SMC (Surface-Mount Club)—British Overseas Trade Board, 1 Victoria St., London SW1H 0ET

- SMC (Surface-Mount Council--Joint ASTM/IPC/EIA/JEDEC Committee)—c/o IPC, 7380 Lincolnwood Ave., Lincolnwood, IL 60646

- SMEMA (Surface-Mount Equipment Manufacturers Association)—71 West St., Medfield, MA 02052

- SMTA (Surface-Mount Technology Association)—5200 Wilson Road, Suite 107, Edina, MN 55424

- STACK (Standard Computer Komoponenten GmbH)—5775 Wayzata Blvd #700, Minneapolis, MN 55416

- VRCI (Variable Resistive Component Institute)—c/o Bourns, Inc., 1200 Columbia Avenue, Riverside, CA 92507

DATAQUEST CONCLUSIONS

We believe that package proliferation will continue as the ASIC market develops. Many new packaging schemes will arise to meet the speed, thermal, and density requirements needed. Custom and semicustom packaging, including multichip modules using COB and TOB, will become more prevalent. Procurement of semiconductor integrated circuits will depend upon package needs and functions in addition to the basic electrical parameters of the chip. As a result, purchasers will need to specify even more details when ordering.

Mark Giudici

Appendix A

Package Standards

PLCC	JEDEC Publication 95, MO-047AA-AH
PQFP	JEDEC Publication 95, MS-069
QFP	EIAJ Specification IC-74-4, 1986
VQPF	EIAJ Specification IC-74-4-I, 1988
TapePak	JEDEC Publication 95, MO-071
TQFP	JEDEC Publication 95, under consideration
PGA	JEDEC Publication 95, MO-083
COB	Standards not available. Use TOB guidelines.
TOB	JEDEC UO-017 and Surface Mount Council--IPC/EIA/ASTM Publication SMC-TR-001, Guideline Introduction to Tape Automated Bonding Fine Pitch Technology
Micropak	Based on DIN 15851

Dataquest

Conference Schedule

1989

Semiconductor User/ Semiconductor Application Markets	February 27-28	Le Meridien Hotel San Francisco, California
Japanese Components	April 20-21	Tokyo Bay Hilton International Tokyo, Japan
Computer Storage	April 26-28	The Doubletree Hotel Santa Clara, California
Document Processing	May 16-18	Monterey Sheraton Hotel Monterey, California
Copiers	May 16-17	
Printers	May 16-17	
Electronic Publishing	May 18	
Imaging Supplies	May 18	
Color	May 18	
SEMICON/West Seminar	May 24	The Dunfey Hotel San Mateo, California
Telecommunications	June 5-7	Silverado Country Club Napa, California
European Components	June 7-9	Park Hilton Munich, West Germany
Asian Semiconductor and Electronics Technology Seminar	June 28	Radisson Hotel San Jose, California
Financial Services	August 22-23	The Doubletree Hotel Santa Clara, California
Technical Computing and Applications	September 11-13	The Doubletree Hotel Santa Clara, California
European Copying and Duplicating	September 18-19	Majestic Hotel Cannes, France
Western European Printer	September 20-22	Majestic Hotel Cannes, France
Taiwan Conference	September 25-26	Grand Hotel Taipei, Taiwan
Distributed Processing	September 26-28	The Doubletree Hotel Santa Clara, California
SIA/Dataquest Joint Conference	September 27	Santa Clara Marriott Santa Clara, California
Information Systems	October 2-6	Tokyo American Club Tokyo, Japan
Semiconductor	October 16-18	Monterey Sheraton Hotel Monterey, California
Asian Semiconductor and Electronics Technology	November 2-3	Kunlun Hotel Beijing, China
European Telecommunications	November 8-10	Grand Hotel Paris, France
European Personal Computer	December 6-8	Athens, Greece

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WILL THE JAPANESE OWN THE 3.5–INCH RIGID MARKET?

SUMMARY

As of the end of 1988, no Japanese companies were credited with as much as 10 percent of the sales of the world's 3.5–inch rigid disk drives. This statistic probably will come as a surprise to most readers because Japan has effectively captured large shares of computer storage–related commodity markets.

This newsletter will examine the reasons behind the slowness of the Japanese in capturing this lucrative market. We will also lay out a time table for a reversal of the situation and the inexorable loss of one more U.S. market.

BACKGROUND

The first warning that we were about to lose the floppy disk drive (FDD) market should have been when the Japanese sewing machine industry (also once an American stronghold) converted its factories to the automated manufacture of 5.25–inch floppy drives. The U.S. drive–makers gave up and relinquished the FDD market to the low–cost assemblers. Today, no volume FDD factories are located in the United States, whereas, in 1981, 80 percent of these products bore the Made In USA label.

The large Japanese system companies also have kept pace with U.S. drive companies on rigid disk drives (RDDs), and are largely self–sufficient through captive production of 8– to 14–inch diameter products. Some of these drives have been well–accepted by OEM buyers around the world, with Fujitsu, NEC, and Hitachi often showing up as leaders in the high–capacity segments of the market. This Japanese leadership has not, however, excluded the U.S. firms, and the market has been fairly evenly divided around the world.

With the advent of the 5.25–inch RDD in 1980, it looked very much as if Americans might have found a new product where they could establish their leadership and maintain it for a long period of time. So far, the U.S. companies' market shares continue to exceed 80 percent. Unfortunately, however, only a small portion of the world's 5.25–inch disk drives are actually manufactured in the United States; most of these drives are coming from the Asian Rim where manufacturing costs can be minimized.

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Experienced disk drive producers were the first to enter the 3.5-inch business, with initial units coming from American factories. As volumes increased, however, competitive pressures forced a rapid move to off-shore production facilities. Today, 90 percent of the 3.5-inch products are made by U.S. companies but are produced outside of the United States.

SO WHAT'S THE ALARM?

Even though the Japanese have so far been unable to make their presence felt in the 3.5-inch market, nearly one-third of all these products are manufactured in Japan. Whoops. . . . We have lost it again.

IBM has proven to be the world leader in 3.5-inch drive production from its factory in Fujisawa, Japan, where nearly 2 million units were made in 1988. The other U.S. company with drives coming from Japan is Quantum. Through a manufacturing relationship with Matsushita Kotobuki, Quantum and its subsidiary, Plus Development, are prepared to produce more than a million of these devices in 1989. The differentiating feature of the products from IBM and Quantum is their exceptional quality and reliability.

IBM's production is predominantly for captive use in the PS/2 desktop computers, although an increasing number of these little drives are showing up in the OEM and retail distribution channels. The luxury of having a captive requirement to fortify production economy-of-scale keeps IBM able to be price competitive in the distribution market.

Quantum's products are positioned in the high-performance, high-quality market and command a premium price. This extra revenue can be used to offset the dollar-yen imbalance and higher labor costs for a short period of time, but Matsushita Kotobuki probably will move offshore in order to be competitive in the future.

Although LaPine Technology established a manufacturing agreement with Kyocera to produce commodity 3.5-inch drives, the costs were high and the business relationship was tenuous. Kyocera is now left on its own and the lawyers will make more money on the venture than either of the principals.

THE DOMINOS WILL FALL

We have examined the American companies now leading the 3.5-inch fray and their movement into Japan for production. But what of the Japanese producers themselves?

The Japanese jumped into the 3.5-inch market in 1985 with Alps Electric, Epson, Fuji Electric, JVC, and NEC Information Systems the first to compete. By the time these companies had determined a worldwide sales strategy, they found they were not competitive. The U.S. marketeers had already established effective distribution channels and pricing policies with their 5.25-inch products, and the Japanese found themselves out-classed. Most of these Japanese companies have now retreated to their own country and to key OEM relationships with major electronic manufacturers.

We believe that the situation in 1989 will differ from that of 1985 in the following areas:

- The worldwide 3.5-inch RDD market will exceed 10 million units in 1989.

- The worldwide factory revenue available to 3.5-inch RDD sellers will approach $4 billion in 1989.

In other words, it has now become an interesting business for manufacturers of high-quality, commodity products.

Recently, we have seen announcements of, or have heard rumors regarding, a series of new products soon to be offered by major Japanese disk drive vendors. Most of these companies are vertically integrated manufacturers of components for 3.5-inch rigid drives, and most of them have demonstrated previous expertise in manufacturing automation techniques. What we are about to see is a logical extension of the capabilities we knew were there. Japan is ready to roll.

Matsushita Communications, better known in the United States as Panasonic, has constructed an awesome, robotically controlled factory for the assembly and test of 3.5-inch RDDs, with an estimated capacity of at least 100,000 units per month. Already shipping 100-Mbyte drives to Maxtor for remarketing, Panasonic has entered into a joint-development relationship with Priam for new, high-capacity drives. The team that designed the impressive Priam 760-Mbyte, 5.25-inch product is working on the next Panasonic family of drives.

Sony Corporation has not been effective in the RDD market but continues to offer noteworthy 3.5-inch FDD products. Sony owns a proprietary thin-film-media process and could easily become a world force in the high-density media market. This electronics giant has quietly entered the 3.5-inch RDD wars with products meeting or exceeding most of those available from U.S. companies. A long-standing relationship with Apple Computer has provided a built-in customer for volume purchases of drives. Dataquest anticipates that Sony will shortly offer a broad range of drives with between 40 and 200 Mbytes and access times well below 20 milliseconds.

Fujitsu has already announced SCSI-interfaced, 3.5-inch drives in the 100- to 200-Mbyte range, with access times in the 20-millisecond range. Matsushita Kotobuki is marketing the Quantum drives in Japan through Matsushita Electronics (in competition with Matsushita Communications). The manufacturing giant, Alps Electric, is known to be developing low-cost OEM devices with superior specifications. It is only a matter of a few months before other respected Japanese drive companies gear up for combat in this market.

DATAQUEST CONCLUSIONS

We are approaching a period when U.S. leaders such as Miniscribe, Western Digital, Conner, Quantum, and Seagate will expand their facilities to meet the intramural competition, showing little regard for the sleeping giant that is about to absorb the 3.5-inch RDD industry. A quick look over the shoulder might be appropriate at this time.

The Japanese may well make further moves into the Asian Rim countries to further reduce manufacturing costs. In fact, there seems to be continued interest in U.S. factories for Japanese vendors. It is not the currency imbalance that is dictating these moves because most of the large corporations can profitably weather an exchange rate of 110 yen/dollar.

American industry leaders can do little to slow the inevitable. Caution in technology exchanges, awareness of coming competition, and continued searches for the best low-cost, high-quality manufacturing situation are the only protective measures available. Partnerships are unavoidable and will become more commonplace.

The struggle will be to retain a reasonable market share for the U.S. drive business. The futures of many companies are tied to the outcome of this global industrial struggle, and, once again, the resolution is unlikely to be in the favor of the incumbent.

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Terrance A. Birkholz
Phil Devin

Dataquest

Conference Schedule

1989

Semiconductor User/ Semiconductor Application Markets	February 27-28	Le Meridien Hotel San Francisco, California
Japanese Components	April 20-21	Tokyo Bay Hilton International Tokyo, Japan
Computer Storage	April 26-28	The Doubletree Hotel Santa Clara, California
Document Processing	May 16-18	Monterey Sheraton Hotel Monterey, California
Copiers	May 16-17	
Printers	May 16-17	
Electronic Publishing	May 18	
Imaging Supplies	May 18	
Color	May 18	
SEMICON/West Seminar	May 24	The Dunfey Hotel San Mateo, California
Telecommunications	June 5-7	Silverado Country Club Napa, California
European Components	June 7-9	Park Hilton Munich, West Germany
Asian Semiconductor and Electronics Technology Seminar	June 28	Radisson Hotel San Jose, California
Financial Services	August 22-23	The Doubletree Hotel Santa Clara, California
Technical Computing and Applications	September 11-13	The Doubletree Hotel Santa Clara, California
European Copying and Duplicating	September 18-19	Majestic Hotel Cannes, France
Western European Printer	September 20-22	Majestic Hotel Cannes, France
Taiwan Conference	September 25-26	Grand Hotel Taipei, Taiwan
Distributed Processing	September 26-28	The Doubletree Hotel Santa Clara, California
SIA/Dataquest Joint Conference	September 27	Santa Clara Marriott Santa Clara, California
Information Systems	October 2-6	Tokyo American Club Tokyo, Japan
Semiconductor	October 16-18	Monterey Sheraton Hotel Monterey, California
Asian Semiconductor and Electronics Technology	November 2-3	Kunlun Hotel Beijing, China
European Telecommunications	November 8-10	Grand Hotel Paris, France
European Personal Computer	December 6-8	Athens, Greece

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Research *Bulletin*

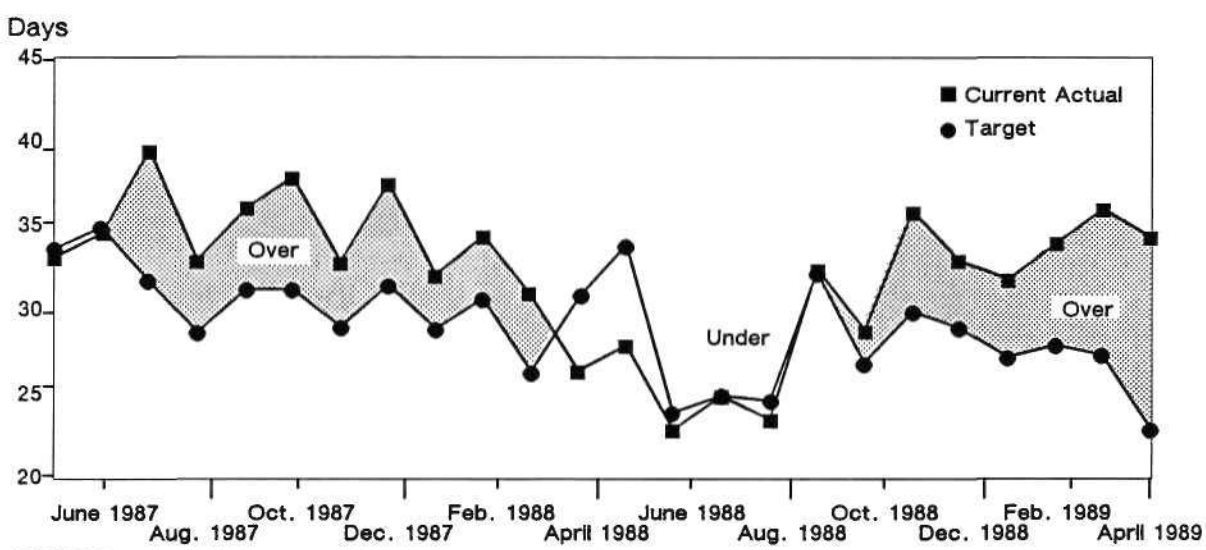
SAM Code: Newsletters 1989: April–June
1989–17
0003616

APRIL PROCUREMENT SURVEY: ORDER RATES STEADY, OVERALL AVAILABILITY DROUGHT OVER!

The semiconductor availability bubble has burst, according to this month's procurement survey respondents. Lead times have declined below eight (7.95) weeks for the first time since we began this poll. Although semiconductor booking rates remain relatively the same compared with last month's survey, half of our sample noted no difficulty in obtaining semiconductors (another survey first). Static RAM products still present somewhat of an availability problem for the other half of the survey population, however. Inventory levels for all OEMs (both target and actual) fell to 23.1 and 34.4 days, respectively, as shown in Figure 1.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



0003616–1

Source: Dataquest April 1989

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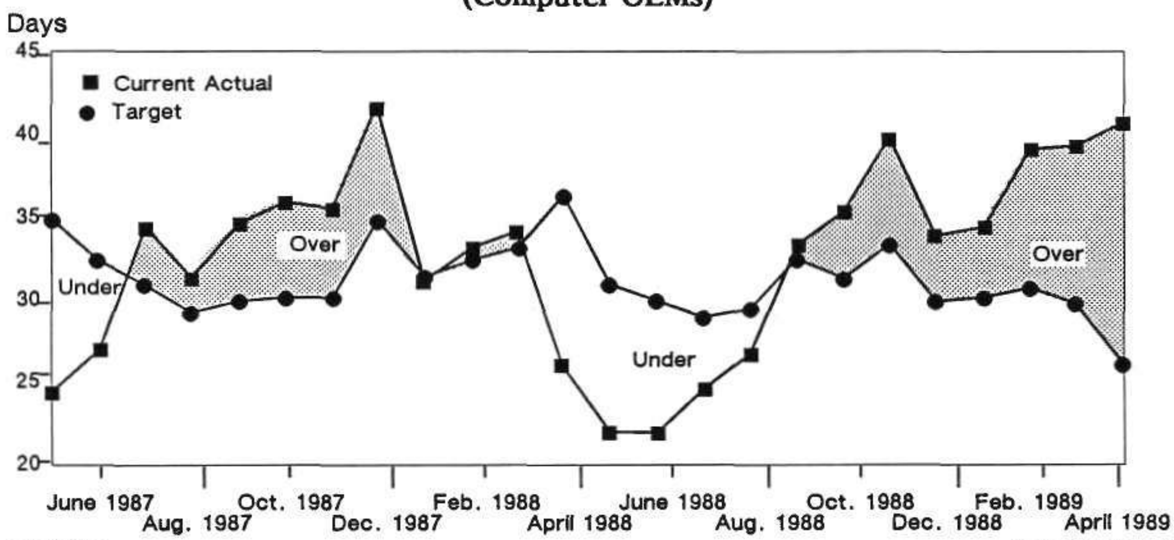
Conversely, as Figure 2 shows, the actual inventory situation in the computer segment has not improved. Targeted levels have declined, causing the current delta between target (26.2 days) and actual (40.8 days) to increase to 14.6 days versus the 9.6-day difference noted last month. The combined effect of increased key component availability and continued honoring of contracts made when parts were scarce keeps computer manufacturers grappling with inventory control. With system sales expected to range between flat and +10 percent during the upcoming 12 months, declines in semiconductor order rates are expected to control inventory levels.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels
(Computer OEMs)



0003616-2

Source: Dataquest
April 1989

In line with the improved availability, overall pricing is gradually declining down a competitive-cost-induced curve. As mentioned above, the only areas that remain an availability problem are the devices dependent on 1Mb DRAM capacity (slow SRAMs, video RAMs, x4 DRAMs, and fast DRAMs). Quality requirements have become more stringent as availability becomes less a factor. Overall targeted functional reject rates in ppm declined by 10 percent from last month's figures.

DATAQUEST ANALYSIS

The market, with some exceptions, continues to show signs of balance between aggregate supply and demand. The direct implication for users is that overall prices and lead times will continue to decline at an accelerating rate as yields and run rates of 1Mb DRAM products improve and directly affect the rest of the semiconductor industry.

Users should write into their contracts (if they have not done so already) clauses that allow for quarterly price reviews. Opportunities for attractive margins will continue for semiconductor manufacturers who supply specialty memory, high-end 32-bit microprocessors, and CMOS PLD markets. With flat-to-moderate equipment sales expected, the requirement of accurate component forecasting still remains the number one tool to keep costs, inventories, and supply lines under control.

Mark Giudici

July-September

The following is a list of newsletters in this section:

THE PC CHIP SET MARKET: WADE IN CAREFULLY—THE POOL IS FULL! (1989-35)

Worldwide, there were 6 PC logic chip set vendors in 1987, 13 in 1988, and an estimated 19 by the end of 1989. This newsletter reviews the high growth rates that attract entrants, supplier overcapacity, critical success factors, and opportunities in embedded DOS and workstation markets. Dataquest anticipates that the vendors with access to low-cost foundries, appropriate design tools and expertise, and high-quality global sales organizations will stand the best chance of success.

PCs '88 REVIEW; '89 INSIGHT (1989-36)

Was 1988 a really great year for the PC industry? This newsletter looks at unit shipment and if-sold-value (ISV) numbers, compares market share growth, and analyzes the key events of 1988 and their probable effects on the industry in 1989 and beyond. Dataquest also briefly reviews the top PC vendors for 1988 in light of what we may expect for 1989.

OEM MONTHLY—JULY 1989
BUSINESS EQUIPMENT IN THE HOME (1989-37)

OEM Monthly provides insight into application markets so that clients can make better strategic and technical marketing decisions. This bulletin examines the forces and forecasts behind the work-at-home trend and the resulting impact on semiconductor consumption. We recommend that semiconductor suppliers look at the business equipment sold to the home for additional revenue during recessions.

FINALLY, AN EFFECTIVE STRATEGY FOR INTEGRATING MANUFACTURING ARRIVES (1989-38)

This newsletter contains a summary of research performed by Dataquest's Computer Integrated Manufacturing (CIM) group earlier this year and an overview analysis of all major product segments. We conclude that global competitive pressures are forcing manufacturers to make increasing capital expenditure for CIM systems, and end users are gaining productivity benefits by installing microcomputer-based products in a modular approach to integration. This environment is providing significant market growth opportunities for vendors of most—but not all—CIM product segments.

8514/A, TIGA, OR VESA: WHAT'S THE NEXT PC GRAPHICS STANDARD? (1989-39)

It is a tradition in the IBM environment that a new-and-improved graphics hardware standard comes into vogue every two years. This newsletter examines standards in the IBM environment; the standards battle between 8514/A, TIGA, and VESA; market dynamics; and vendor activity. Dataquest believes that the 8514/A-type products are most suited for the next-generation mainstream graphics market.

SYSTEM SEMICONDUCTOR CONTENT TRENDS: POWER SUPPLIES "POWER" GROWTH IN ANALOG, DISCRETE, AND MOS LOGIC MARKETS (1989-40)

Dataquest's recently completed analysis of trends in the semiconductor content of North American-made power supplies reveals substantial long-term opportunity for manufacturers of discrete semiconductors, analog ICs, and MOS logic. This newsletter examines the equipment forecast, power supply semiconductor content, semiconductor consumption forecast, and power supply systems. Dataquest conservatively forecasts 1993 North American merchant market production of these systems to be $2.4 billion.

EISA AND MCA: THE BEGINNING OF THE END OF THE BUS WARS (1989-41)

On July 14, just four days after Intel Corporation announced the industry's first Extended Industry Standard Architecture (EISA) chip set, Compaq Computer Corporation announced the signing of a patent cross-licensing agreement with IBM. This newsletter reviews the background, agreement, and industry response. Does this mean that EISA is a failure? Hardly—it now appears that the Gang of Nine members will have access to MCA on terms that they can live with.

COMMUNICATIONS TECHNOLOGY TO WATCH (1989-42)

Technology is changing system designs. This newsletter reviews the application technologies that are now in an early stage of development and are likely to become commonplace within a few years. We recommend that semiconductor suppliers become familiar with them because they represent large potential markets in the future.

TECHNICAL WORKSTATIONS: AND THE GROWTH CONTINUES (1989-43)

Two Dataquest news articles have stated the estimated 1988 value of the technical workstation market, and with each newsletter, the value is higher. This adjustment indicates just how fast this industry is growing. Dataquest reviews the technical workstation market and the reasons why this growth is occurring.

OEM MONTHLY—AUGUST 1989
TV AT 50—WHERE IS IT HEADED? (1989-44)

OEM Monthly provides insight into application markets so that clients can make better strategic and technical marketing decisions. This bulletin examines today's video and tomorrow's visions. Dataquest recommends that semiconductor suppliers work closely with Japanese R&D centers in the U.S. if they want to penetrate the video IC market.

U.S. FACSIMILE MARKET: GROWTH EXCEEDS ALL EXPECTATIONS AS MARKET EXPLODES (1989-45)

A major milestone was reached in the U.S. facsimile marketplace in 1988 as annual placements exceeded the 1 million mark for the first time. This newsletter presents Dataquest's "1988 fax scorecard" and analyzes the changing market positions of the players and the trends and issues leading to this remarkable growth. No matter what the outcome is and who the real winners are, the expansion of this market over the past few years and its projected growth into the future guarantee large revenue flows and excitement for many years into the future.

SYSTEM SEMICONDUCTOR CONTENT TRENDS: MEDICAL IMAGING SYSTEMS DRIVE DEMAND FOR MOS MICROCOMPONENTS, MOS LOGIC, AND ANALOG ICs (1989-46)

Dataquest's analysis of trends in the semiconductor content of medical imaging systems (ultrasonic scanners) depicts solid growth prospects for manufacturers of MOS semiconductors, MOS logic, and analog ICs. This newsletter reviews the equipment forecast, medical imaging system (ultrasonic scanner) semiconductor content, semiconductor consumption forecast, and convergence of system and semiconductor technologies. Dataquest projects 1993 North American production of medical electronic systems at $7.5 billion, which translates into semiconductor consumption of $555 million.

HOME AUTOMATION BLUEPRINTS FUTURE WORLD (1989-47)

Home automation refers to a comprehensive program that will change the way houses are built and occupied. This newsletter reviews the long-term developments in energy, houses, and appliances. Dataquest concludes that it is not too early for semiconductor suppliers to work closely with appliance manufacturers if they want to capture any part of this opportunity in the short term.

OEM MONTHLY—SEPTEMBER 1989
COLOR MONITORS DISPLAY SALES GROWTH AND DESIGN INNOVATION (1989-48)

OEM Monthly provides insight into application markets so that clients can make better strategic and technical marketing decisions. This bulletin reviews monitor shipments and monitor innovations. Dataquest realizes that only a few semiconductor companies will have the high-frequency transistor and hybrid component capabilities needed to develop integrated monitor circuits, but we featured color monitors in this issue of *OEM Monthly* to illustrate how entrepreneurial thinking can lead to the discovery of hidden needs and create proprietary solutions.

SYSTEM SEMICONDUCTOR CONTENT TRENDS: INTELLIGENT PRINTERS OFFER CHALLENGES, OPPORTUNITIES FOR APPLICATIONS FOCUSED SEMICONDUCTOR VENDORS (1989-49)

The printer industry is undergoing a quiet revolution, and laser printers are leading the way. This newsletter provides a quantitative analysis of this market at the component level and will examine the critical price and performance issues facing semiconductor suppliers seeking to meet the needs of this dynamic market. Dataquest concludes that the growing popularity of intelligent printers, along with current performance shortfalls, virtually assures enthusiastic market reception for high-performance application-specific products that reduce total system cost.

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Research Newsletter

SYSTEM SEMICONDUCTOR CONTENT TRENDS: INTELLIGENT PRINTERS OFFER CHALLENGES, OPPORTUNITIES FOR APPLICATIONS-FOCUSED SEMICONDUCTOR VENDORS

SUMMARY

The emerging printer controller market promises rich and growing opportunities for manufacturers of memory devices and application-specific microprocessors. ASIC manufacturers, on the other hand, face a less certain market, with opportunities tempered by the threat of controller board consolidation. Dataquest recommends that suppliers of logic and microprocessor products develop performance-enhancing, application-specific products for this market.

This newsletter will provide a quantitative analysis of this market at the component level and will examine the critical price and performance issues facing semiconductor suppliers seeking to meet the needs of this dynamic market.

OVERVIEW

The printer industry is undergoing a quiet revolution, and laser printers are leading the way. A new class of printer, the intelligent printer, is rapidly displacing the simple, traditional dot matrix as the business printer of choice.

For the purpose of this analysis, an intelligent printer is defined as any printer that interprets a high-level page description language (PDL). At present, these are the page (commonly referred to as laser) and the ink jet class printers. Intelligent printers are experiencing explosive growth, and we believe that they will eventually dominate the market. Figure 1 shows Dataquest's estimate of the North American printer market for 1988 and our forecast for 1993.

Because the vast majority of print engines are manufactured in Japan, this subsection will focus on the control logic used to interpret a PDL. This circuitry usually occupies a separate controller board.

MARKET ISSUES AND OPPORTUNITIES

In order to fully appreciate future demands on printer controller designs, it is necessary to examine the competitive issues and technical challenges facing the page printer industry today. The two most critical issues are simply the usual high-technology cliché: price and performance.

Although market acceptance has been enthusiastic, growth would be faster still if page printers were more affordable. In fact, it can be argued that the high price of today's laser printers has forced many customers to use them as a shared resource (e.g., as a departmental printer), thereby shrinking the market.

Performance is also a problem. Although users like the quality and features of the page printer, they tend to be dissatisfied with the speed of this device. Higher-performance laser printers are likely to enjoy a substantial competitive edge over today's slower models. The challenge that faces suppliers is to help page printer manufacturers increase performance *while* bringing printer costs down.

We believe that these challenges translate directly into market opportunities for semiconductor manufacturers. Products that reduce total system costs and/or boost system performance will not only be well received by the industry, but could actually accelerate market expansion. Table 1 summarizes Dataquest's view of this semiconductor market opportunity.

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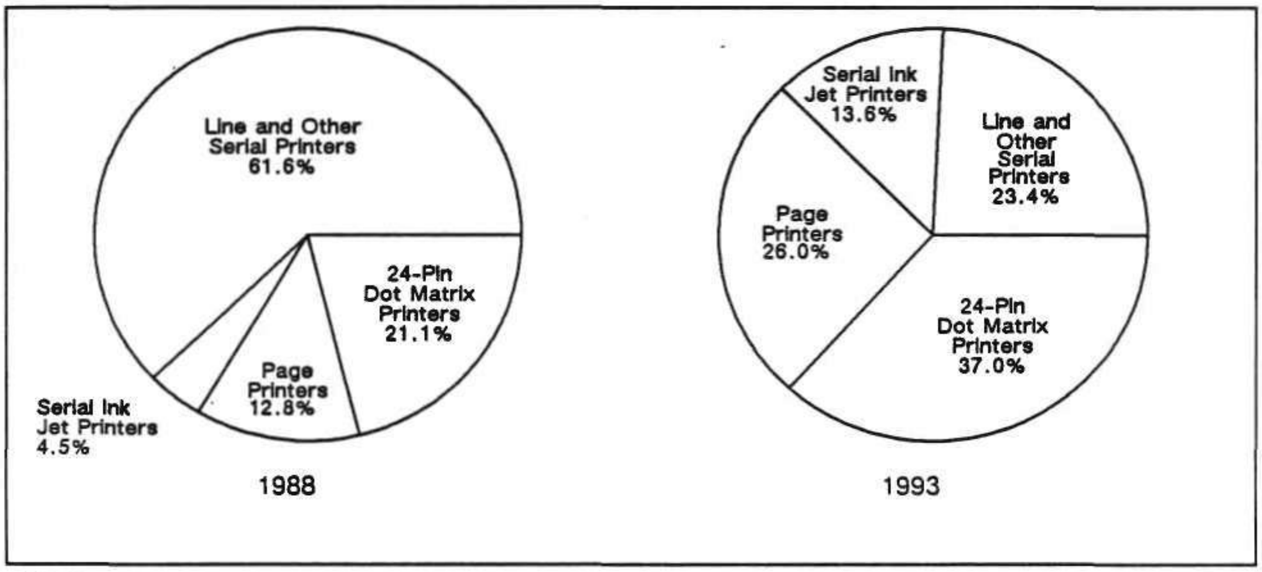
Figure 1
Unit Market Share by Printer Type



0005039-1

Source: Dataquest
September 1989

Table 1
Estimated Page Printer Semiconductor Content Trends

	1988	1993	CAGR 1988-1993
Worldwide Production			
Units (K)	1,565	4,950	25.9%
Millions of Dollars	$5,044.0	$11,979.0	18.9%
ASP	3,223	2,420	(5.6%)
Semiconductor Consumption	$ 607.2	$ 2,408.2	31.7%
Semiconductor Content (Percent of Printer Cost)	12.0%	20.1%	
Fastest-Growing Semiconductor Market	MOS Microcomponents		
	$ 39.1	$ 321.8	52.4%

Source: Dataquest
September 1989

The Trend Toward Intelligent Printers

Traditional printers are primarily mechanical devices that apply ink to paper as specified by the host computer. Laser printers, on the other hand, are controller based. The host computer issues output information in the form of a PDL, such as Adobe's PostScript or Hewlett-Packard's PCL. The controller (usually located within the printer itself) then interprets this high-level output description and generates detailed instructions for the print engine. Although they lack the sophistication and power of the laser printer, most new ink jet printers qualify as smart in that they usually have a microprocessor-based controller that interprets a PDL.

Implementation

In order to interpret PDL commands and drive the print engine, the controller must implement the basic functions of system interface, display generation, and print-engine control. The controller also requires its own subsystem clock as well as page and software storage. Figure 2 shows a typical printer controller block diagram.

System Interface

Versatility Is Key

The system interface block implements the functions of interface protocol and handshaking along with the buffering of input data and instructions. Because there are several different connector standards, the controller must be capable of receiving data via a variety of serial and parallel connectors. In addition, data may also be transmitted via a system bus such as AppleTalk or SCSI.

Systems interface circuitry usually consists of transceiver chips coupled to off-the-shelf peripheral communications devices for the serial interface and an interface logic section for the parallel and/or bus interface. The growing acceptance of intelligent subsystems busses, such as SCSI and AppleTalk, is likely to call for an ASIC or application-specific standard product (ASSP) solution, which would provide designers with a universal systems interface building block.

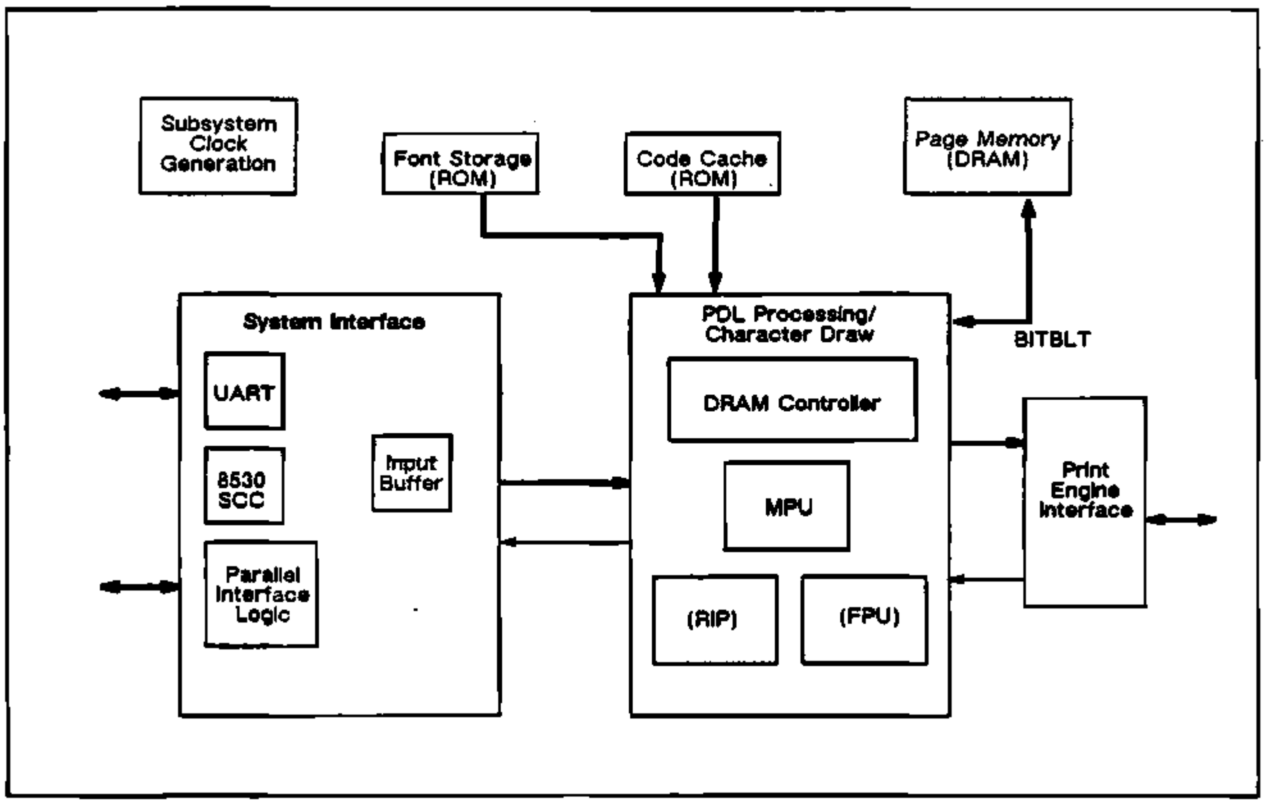
The typical input buffer is currently implemented in a simple FIFO configuration (usually two 512 x 9 FIFOs).

Processor Core

Toward a Specialized Compute Engine

Once the PDL data and commands are cued into the input buffer, the microprocessor (MPU) must execute the commands in order to generate output images. Although this could be done by the

FIGURE 2
Laser Printer Controller Block Diagram



0005039-2

Source: Dataquest September 1989

MPU alone, character generation and graphics tasks sometimes are off-loaded to a raster image processor (RIP) and/or a floating-point unit (FPU). In addition, the bit-block transfer (BITBLT) function can be assigned to a dedicated "traffic cop" in order to streamline operations.

Current implementations tend to use a standard general-purpose microprocessor. This results in severe performance bottlenecks due to the processor-intensive nature of the BITBLT and character drawing and manipulation operations.

In Dataquest's opinion, this is a temporary solution that will soon give way to chip set implementation, in which the various drawing, manipulation and image-transfer functions are executed by separate dedicated blocks of customized logic.

We believe that this will be the next logical step, as it allows for the optimization of each logic block to a particular function (character drawing and BITBLT, for example, make very different demands on the CPU) and then allows them to run concurrently. A chip set approach enables system designers to mix and match, making the price/performance trade-offs necessary to position the printer for a particular end-user segment (such as single-user or departmental print server).

Because high-performance applications will continue to place speed ahead of system cost, high-end controllers should feature multiple device implementations for the foreseeable future. We expect to see the current implementation, using PLDs and other fast logic to augment a standard processor, giving way to high-performance chip sets.

Low-end laser and ink jet printers are another matter, however. In order for single-user printers to achieve maximum market penetration, total system cost must decline substantially. This cost pressure argues for the eventual use of a low-cost, single-chip, application-specific processor. Interim solutions should feature low-cost standard microprocessors that are augmented by simple ASICs.

Storage

Color, High-Resolution Demand More Bits

Memory requirements fall into two categories: nonvolatile memories (typically ROM), which are used for code and font storage, and page memory (typically DRAM), which is used to store the bit-mapped images of the page to be printed.

Typical nonvolatile applications require 1 or 2MB of memory, depending on the number of fonts supported. By 1993, the typical high-performance laser printer could contain as much as 4 to 6MB of ROM. This figure will depend on the variety of fonts required and on the amount of memory required to support each font (which, in turn, varies according to the sophistication of the PDL). Dataquest anticipates that future systems will store many more fonts in three to four times the memory of current systems.

Page memory applications can require anywhere from 512 KB to 8MB of DRAM, but the majority currently use 1 to 1-1/2MB. Most printers with less than 1MB use a technique known as band buffering, in which only a fraction of a page is stored at a given time. Banding can greatly reduce memory costs; however, the substantial speed trade-off imposed by banding argues against widespread use of this technique in the future.

Performance enhancements and the addition of color output capabilities are likely to increase memory requirements substantially over the next five years. By 1993, we expect that the average system will utilize 8MB of DRAM.

Print Engine Interface

Standardization, Consolidation to Come

Although much of the interface functionality could eventually be integrated into the processor core, current design constraints should ensure that the print engine interface remains an independent functional block for the foreseeable future. The print sequencer, status monitoring, and control functions can be implemented in an ASIC or through the use of either a standard microcontroller (such as the 68008) or a dedicated interface chip (such as the WD65C10). Because they represent support logic rather than core logic, these functions are likely candidates for consolidation into future generations of chip sets or ASSPs. Figure 3 summarizes the anticipated evolution of the various functional blocks.

SEMICONDUCTOR CONTENT/ CONSUMPTION FORECAST

The previous discussion deals with the entire class of intelligent printers. The quantitative portion of this analysis, however, addresses only the page printer portion of the intelligent printer market. The

FIGURE 3
Typical Semiconductor Implementations

Function	Implementation 1989	1993	Driving Force
Page Memory	1–2MB DRAM	6–10MB DRAM	Color, Resolution, Speed
Code and Font Storage	1–2MB (ROM)	4–8MB (ROM)	Font Variety, Font Compression
System Interface	Standard Transceiver Components		
Processor Core	Standard µP+ASIC (PAL) →	Application-Specific µP +Chip Set	Chip Count (Cost), Performance Architectural Flexibility
Printer Interface	Standard µ Controller or ASIC (Some ASSP)		

0005039-3

Source: Dataquest September 1989

other significant segment, ink jet printers, is not expected to surpass page printers in either dollar or unit terms by 1993. With lower average selling prices (ASPs) putting strong pressure on component costs, the total available semiconductor market for ink jet printers is expected to remain substantially smaller than that of the page printer through 1993.

Table 2 summarizes Dataquest's estimated worldwide semiconductor market for page printer controllers. We expect total semiconductor demand for these controllers to increase from $613.1 million in 1988 to more than $2.4 billion in 1993. During this period, compound annual growth rates (CAGRs) are forecast to range from a negative 15.9 percent for bipolar logic to a positive 52.4 percent for MOS microcomponents, with an overall growth rate of 31.6 percent. Although it is not the highest growth area in percentage terms, MOS memories should realize the greatest growth in absolute terms.

Table 3 summarizes Dataquest's estimated semiconductor content trends for the page printer market. Three factors drive the shifts in semiconductor content. First, the sliding price of page printers exaggerates the increase in semiconductor content percentages. Second, recent high memory costs have encouraged printer manufacturers to minimize their memory content—the falling cost per bit of most memory products along with the increasing requirements discussed earlier should combine to push the memory content percentage up sharply. Finally, the rapid increase in microcomponent content is a direct result of that category's cannibalization of the other logic categories.

DATAQUEST CONCLUSIONS

Laser printer controllers appear to be the next emerging imbedded control market. Unlike most past nonreprogrammable applications, it appears that the processing requirements of intelligent printer control cannot be fully satisfied using standard microcomponents alone. This calls for the emergence of high-performance, application-specific standard products to serve this market.

The growing popularity of intelligent printers, along with current performance shortfalls, virtually ensures enthusiastic market reception for high-performance application-specific standard products that reduce total system cost.

DATAQUEST RECOMMENDATIONS

Memory Suppliers

Because memory costs represent a large portion of total controller cost, system designers are likely to continue using standard, lower-cost memories wherever possible. Competition for memory suppliers should turn on the issues of price and availability. However, because this market is a rapidly changing one, in terms of both market growth and system architectures, we recommend that memory suppliers keep close ties with systems designers in order to accommodate any changes in future systems requirements.

Microprocessor Suppliers

Today's compute engines have provided only marginal system performance, partly as a result of the specialized requirements associated with PDL implementation. We therefore recommend that MPU manufacturers develop compute engines that are specifically optimized for this application.

TABLE 2
Estimated North American Semiconductor Consumption Equipment Type: Laser Printers (Millions of Dollars)

	1988	1993	CAGR 1988-1993
Equipment Production	$5,044	$ 11,979	18.9%
Total Semiconductor	$613.1	$2,416.8	31.6%
IC	$612.7	$2,415.6	31.6%
Bipolar Digital	$23.5	$ 9.9	(15.9%)
Memory	0	0	N/M
Logic	23.5	9.9	(15.9%)
MOS Digital	$583.7	$2,398.3	32.7%
Memory	489.8	2,049.3	33.1%
Microcomponents	39.1	321.8	52.4%
Logic	54.8	27.2	(13.0%)
Analog	$ 5.5	$ 7.4	6.3%
Discrete	$ 0.4	$ 1.2	24.9%

Source: Dataquest
September 1989

TABLE 3
Semiconductor Content Forecast

	1988	1993
Total Semiconductor	12.2%	20.2%
IC	12.1%	20.2%
Bipolar Digital	0.5%	0.1%
Memory	0	0
Logic	0.5	0.1
MOS Digital	11.6%	20.0%
Memory	9.7	17.1
Microcomponents	0.8	2.7
Logic	1.1	0.2
Analog	0.1%	0.1%
Discrete	0	0

Source: Dataquest
September 1989

TABLE 4
Recommendations

Supplier Group	Key Issues	Recommendations
Memory Suppliers	Price, availability	Emphasize good communications; JIT delivery
Microprocessor	System performance, chip count	Develop application-specific compute engine; offer broad price/performance range
ASIC	Increasing integration, consolidation	Develop application-specific cores; evolve into standard chip set products
Chip Set	System expertise, stability of architecture	Follow market closely; enter when architecture stabilizes

Source: Dataquest
September 1989

Certain companies are already modifying existing designs for this purpose while others are creating completely new processors. In addition, system designers are likely to have strong preferences toward designing around a single compute engine for their entire product lines. We therefore recommend that MPU suppliers offer a complete product line with a full price/performance range of its own.

ASIC Suppliers

Opportunities in the ASIC arena are likely to be transitional. As systems designs mature, processor-supporting ASICs should give way to ASSPs. In order to survive this transition, we recommend that ASIC manufacturers translate these designs into their own ASSPs. In diversifying into ASSPs, ASIC manufacturers will have to adjust their sales and marketing approach for these products. This adjustment usually involves establishing a standard products division.

Chip Set Suppliers

Chip set suppliers have done well in the PC arena by capitalizing on their systems-level expertise to consolidate a standard architecture. Although the time is not yet right for such a consolidation on the printer controller board, soon it will be. Chip set companies would do well to follow this market closely, looking for general acceptance of application-specific processors and then consolidating the support logic that surrounds them.

Table 4 summarizes Dataquest's recommendations for the various semiconductor supplier groups.

FINAL PREDICTION

Once this market matures and controller architecture becomes more stable, price pressure will force further consolidation. Dataquest believes that the chip count on the logic portion of the controller board will continue to decline. This will pit ASIC, chip set, and processor suppliers against one another as the controller approaches a one-chip implementation. Winners in this battle will possess strength not only in microprocessor design but also in systems design and low-cost manufacturing.

Kevin Landis

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Research *Bulletin*

OEM MONTHLY–SEPTEMBER 1989 COLOR MONITORS DISPLAY SALES GROWTH AND DESIGN INNOVATION

OEM Monthly provides insight into application markets so that clients can make better strategic and technical marketing decisions.

MONITOR SHIPMENTS

Rapidly growing sales of color monitors have caught the attention of semiconductor suppliers, and some of these companies are ending up with a big piece of the action. The results are application-specific standard products (ASSPs) that improve performance and reduce costs.

Dataquest's worldwide forecast of color monitors is presented in Table 1. Low- and high-resolution monitors have five-year compound annual growth rates (CAGRs) of 10 and 65 percent, respectively.

Monochrome displays are losing market share. We estimate that 58 percent of the PCs and workstations sold in 1988 had color monitors, and that this ratio will increase to 65 percent by 1993.

TABLE 1
Forecast of Worldwide Color Monitor Shipments (Millions of Units)

Year	Low Resolution	High Resolution
1988	11.2	0.19
1989	12.7	0.41
1990	13.2	0.93
1991	14.6	1.91
1992	15.2	3.50
1993	16.6	4.80

Source: Dataquest
September 1989

MONITOR INNOVATIONS

A color system includes a monitor connected to a PC or workstation (see Figure 1).

The video DAC in the PC/workstation changes the information to be displayed from digital data to red, green, and blue (RGB) analog signals. After amplification by the video circuits in the monitor, these signals appear on the cathode-ray tube (CRT) as either text or graphics.

High-resolution displays present greater challenges to engineers because wideband analog circuits are more difficult to design and build. Low- and high-resolution graphics require monitor bandwidths in the 5- to 50- and 50- to 200-MHz ranges, respectively (see Table 2 for a listing of screen and bandwidth requirements).

Integrated Wideband Analog Circuits

Until recently, the video amplifiers in high-resolution color monitors have been built with discretes. (The 1-volt signals from the video DAC must be boosted to 60 volts for the CRT.) Today, companies such as National Semiconductor and TRW/Motorola have introduced monolithic and hybrid amplifier circuits designed specifically for use in these monitors.

A major benefit of this integration is a 50 percent reduction in the number of adjustments needed to align the RGB channels in the monitor. Another benefit is the need for fewer parts, which also reduces assembly time and cost.

DATAQUEST CONCLUSIONS

There is still room for further innovations in color monitors. For example, the monitor channels

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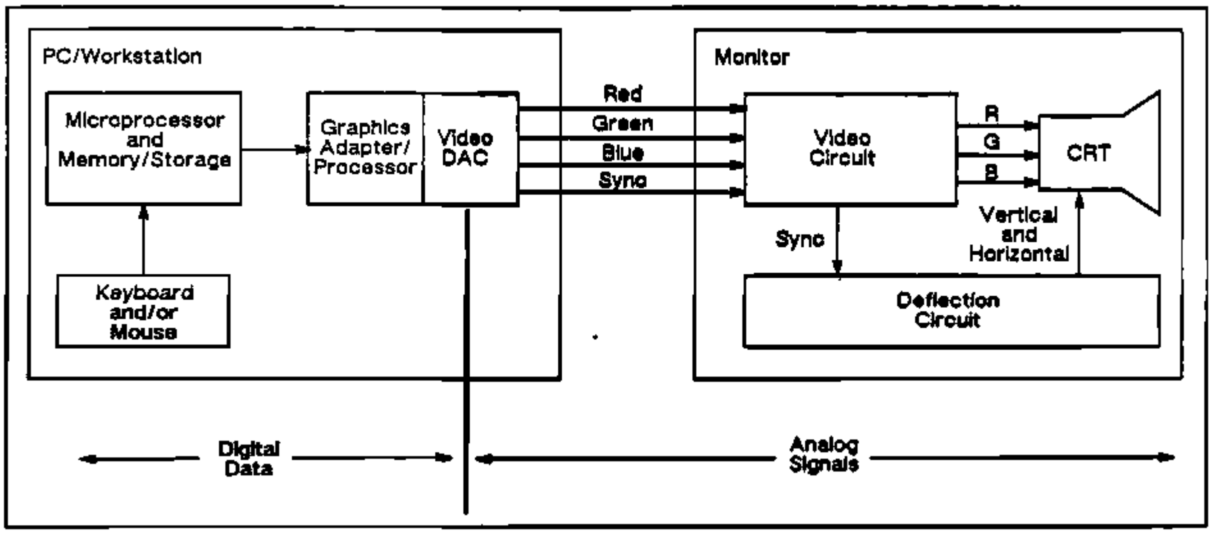
FIGURE 1
Block Diagram of a Color Display System



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Source: Dataquest
September 1989

TABLE 2
Graphics Display Requirements for Color Monitors

Segment	Standard	Screen	Bandwidth (MHz)
Low-Resolution Graphics	CGA	640 x 200	10
	EGA	640 x 350	20
	VGA	640 x 480	25
	VESA	800 x 600	35
High-Resolution Graphics	8514/A, TIGA	1,024 x 768	60
	Workstation	1,152 x 900	80
	Workstation	1,280 x 1,024	100
	Workstation	1,664 x 1,248	160

Source: Dataquest
September 1989

still must be aligned so that the correct colors will appear on the screen. These adjustments now are done manually and take approximately five minutes to complete.

This adjustment time could be reduced to less than five seconds using electronic methods. Digitally controlled monitor circuits, for example, could be aligned initially at the factory. The settings might then be updated regularly by a microcontroller in the monitor to compensate for the wear that causes the display to look fuzzy (e.g., CRT aging).

The result would be a high-resolution display that always looks sharp. Dataquest believes that these "smart monitors" are being developed now for market introduction by 1991.

Dataquest realizes that only a few semiconductor companies will have the high-frequency transistor and hybrid component capabilities needed to develop integrated monitor circuits. We featured color monitors in this issue of *OEM Monthly* to illustrate how entrepreneurial thinking can lead to the discovery of hidden needs and create proprietary solutions.

Roger Steciak

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Research *Newsletter*

HOME AUTOMATION BLUEPRINTS FUTURE WORLD

SUMMARY

Home automation refers to a comprehensive program that will change the way houses are built and occupied. Tomorrow's construction industry will be mechanized and computerized; tomorrow's house will be modularized and automated.

Several technologies will be necessary to support home automation (see Table 1). Communications will be needed both inside and outside the home, computers will be needed for house design and energy compliance, and control will be needed for added appliance efficiency.

In this newsletter, Dataquest reviews the long-term developments in energy, houses, and appliances. We conclude that it is not too early for semiconductor suppliers to work closely with appliance manufacturers if they want to capture any part of this opportunity in the near term.

HOUSE OF THE FUTURE

Several developments are now under way that will dramatically change the houses in which people live. In this section of the newsletter, Dataquest projects what typical housing might be like in the year 2000.

Operation Scenario

Minimum energy consumption is the goal. Each house will be provided with an energy budget based on its geographic location (i.e., local weather), occupant lifestyle (i.e., family size), and power sources (i.e., gas or electricity). This whole-house energy consumption program will include incentives to encourage conservation (see Table 2). The broader goal is to reduce the need for more electric power plants because capacity must be built for seasonal peak loads and future demand growth.

Some appliances will need to be kept constantly in adjustment for maximum energy efficiency; to do this, they probably will have self-test capability. They also may be connected to the telephone network to let repair services monitor them remotely.

Zone Control

Zoned sections of the house (i.e., one or more rooms) will have their own thermostats and the capability to lower energy use automatically when unoccupied. Zone control provides comfort without having to heat or cool the entire house as single-point control does.

TABLE 1
Key Technologies for Home Automation

Communications	High-definition TV (HDTV), teletext, videotex, local area networks (LANs) for intrahome communication, wide area networks (e.g., ISDN)
Computers	Architecture workstations, computer-integrated manufacturing (CIM), laptop computers
Control	Embedded microcontrollers, smart-power semiconductors, solid-state sensors

Source: Dataquest
August 1989

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TABLE 2
Whole-House Energy Consumption Incentives (Scenario for the Year 2000)

Time-of-use pricing	Lower rates during off-peak hours encourage rescheduling chores that are not time critical
Load shedding and duty cycling	Power company shuts down selected appliances when neighborhood energy use exceeds budget
Off-peak storage	Energy is stored locally during off-peak hours for later use during peak load hours

Source: Dataquest
August 1989

Construction Scenario

The goal is to design and build houses that meet prescribed energy consumption regulations. Today's houses must meet building codes, but energy use never was considered when earlier standards were drafted. Tomorrow's building codes will probably have a mandatory energy component.

Tomorrow's house may be designed on an architecture workstation that takes energy seasonal budgets into account. In addition, 90 percent of the house (up from 55 percent today) will be built offsite to guarantee that the stringent quality assurance procedures are being met.

Life Cycle Costing

Tomorrow's housing market should normalize the cost of ownership over the entire life (several decades) of a typical building. A well-insulated home costs more to build and less to operate. Lenders and insurers will likely favor automated homes because their standardized safety and energy features will have less risk than nonstandard designs.

Retrofit Scenario

The installed base of existing houses will not be exempt from energy regulations. Current homes will have to be upgraded to meet local energy codes; the easiest way to police this will be at the time of sale. Separate utility programs have been and continue to be used to encourage insulation.

FORCES DRIVING HOME AUTOMATION

The era of abundant, low-cost energy is over. Energy users (e.g., homes, automobiles, and factories) all are part of the energy equation. They also are all part of the energy solution.

A systems approach has been adopted to consider all possibilities at once. For example, the mileage and emissions standards for automobiles help deal with this crisis. Revised, as well as new, draft standards also are being written for energy use in the home.

Energy

Today's consumers enjoy home comforts such as air conditioners, dishwashers, dryers, freezers, furnaces, ovens, refrigerators, stoves, and washing machines. Average electricity use per household increased approximately 220 percent between the years 1962 and 1985. This energy use trend has serious implications for national security because a greater amount of the needed energy cannot be supplied from domestic sources. However, less per-capita consumption would mean less dependence on imported energy. Home automation is one of the many programs that will enhance energy independence.

Environment

Heat and pollution from electricity-generating plants are the source of 60 percent of the harmful effects in the environment. The result is a possible increase of a few degrees in the earth's temperature during the next 100 years. This global warming could be enough to cause a major disruption in the world's population because it could change the latitudes where people can live, grow food, and conduct business. Although not all scientists agree that there is a warming trend, politicians are not taking any chances. Reduced consumption means fewer facilities, slower warming, and more time to find permanent solutions.

Economy

Wasted energy means wasted money and reduced competitiveness, and the cost of this inefficiency to the economy is substantial. The United States uses 75 percent more energy per unit of GNP than do its trading partners France and Japan.

Conservation efforts made since 1973 already are saving the United States $150 billion per year in energy costs. However, additional potential savings of $150 billion to $400 billion annually are believed to be possible through further conservation efforts.

ROLE OF CONSUMER APPLIANCES

The elements of residential energy consumption are building thermal efficiency and appliance operating efficiency. The National Appliance Energy Conservation Act of 1987 provides for progressively tougher requirements for appliances during upcoming years.

Certified Efficiencies

Certain appliances (see Table 3) are candidates for energy efficiency certification between now and January 1, 1994. Appliances that consume a large portion of daily energy in the home could be scheduled for further regulatory controls that are not now covered by past standards.

Appliance efficiency increases will be accomplished with a variety of electrical and mechanical designs. Electronics are expected to be used widely to increase appliance efficiency just as they have been used to increase automobile efficiency.

Technology Advancements

Improvements in mechanical components also are expected, and these will require electronic components for sensing and driving. An example of a mechanical advancement is Hitachi's new scroll compresser, which has an improved refrigeration efficiency.

Chlorofluorocarbons (CFCs) also are being outlawed to prevent them from destroying the ozone layer of the atmosphere. (CFCs now are used in refrigeration systems and appliance insulation.) Many other opportunities exist for innovation in appliance design.

POTENTIAL FOR SEMICONDUCTOR COMPONENTS

Home automation represents a major change in the way houses are built and energy is used. As a result, there will be a phase-in period during the

TABLE 3
Candidate Appliances for Energy Certification (U.S. Consumption)

Appliance	1988 Unit Shipments (Millions)	1985-1988 CAGR
Air Conditioners	7.8	8.6%
Clothes Dryers	4.6	15.3%
Dishwashers	3.9	2.7%
Freezers	1.6	1.6%
Furnaces	3.4	9.1%
Portable Heaters	3.6	(5.9%)
Ranges/Ovens	7.9	8.0%
Refrigerators	8.2	6.0%
Television Sets	23.6	3.0%
Washing Machines	6.5	5.2%
Water Heaters	7.3	1.0%
Total	78.4	5.0%

Source: Industry Data
Dataquest
August 1989

early 1990s. The years 1991 through 1995 will create much turbulence as this program gets under way.

Network Connections

A local area network (LAN) will connect appliances so their operations can be coordinated. The dishwasher, for example, might signal the water heater to begin operation. (The water heater normally would be in a standby mode to save energy.)

One purpose of the LAN would be to reduce peak loading by rescheduling the load to other times of the day. Another would be to allow telephone access for appliance status monitoring or time-of-operation reprogramming.

Communication semiconductors will be needed to connect the appliances to the LAN. Protocol choices include CEBus, LON, SmartHouse, and X-10. Media choices include powerline carrier, coaxial cables, radio waves, infrared waves, and optical cables.

The annual connection potential is approximately 75 million units per year in the United States (see Table 3). Dataquest believes, however, that this potential will not be reached until after the mid-1990s, because the home automation program first must pass though its start-up phase.

Power Signals

Motors are present in most appliances. Pulse width modulation (PWM) is a technique for shaping power signal waveforms to improve efficiency. PWM can also be used to generate synthesized AC from AC/DC sources for both standard operation and as an emergency-conditions feature during power outages.

Power semiconductors will be needed to shape the waveforms of power signals. Smartpower IC technology is being developed today for automotive applications. Appliance engineers will use automotive smartpower initially because it is available.

In the long term, however, the appliance industry may want its own version of smartpower. Semiconductors that can operate directly off of the 110 VAC line will not need transformers. Another application for this technology will be general-purpose 110V power supplies.

The evolution of technology and standards is open-ended. For example, cost and efficiency improvements in DC motors are expected to occur toward the late 1990s, and the benefit will be better appliances. Such advancements are likely to be reflected in the standards once they are updated.

Embedded Control

Temperature control in appliances today is done with thermostats. Two metals with different coefficients of thermal expansion are used to open and close a circuit that starts and stops a motor. This approach has worked well for more than 100 years.

Greater control precision is possible with a solid-state sensor chip connected to a microcontroller (MCU). The microcoded program in the MCU can decide whether or not to start or stop a motor based on a variety of conditions.

For example, a solid-state sensor can provide a range of measurements rather than just the single on/off reading of a thermostat. The MCU can make control decisions that are based on the actual temperature of the room, not just whether the temperature is higher or lower than some preset value.

The result of the embedded system is a more sophisticated controller that causes a higher energy efficiency. Embedded control alone will not make appliances more efficient, but several approaches ranging from electronics to mechanical components will be combined to do so.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The need to conserve energy was recognized 20 years ago. Conservation in automobiles is easy to handle because production is concentrated in a few suppliers. Housing, on the other hand, is dispersed among thousands of producers and millions of users and decision makers.

Housing efficiency therefore is best left to local conditions, and that is what the National Environmental Policy Act of 1969 did. However, the states (except for California and Florida) have done little since 1975 to improve building efficiencies, so the federal government now is mandating minimum residential energy standards.

Learning from Past Generations

Houses built in the next millennium most likely will use techniques learned earlier in this millennium. In the Middle Ages, for example, people living in cold climates discovered through trial and error that two-story buildings with tapestry-covered walls were warmer than other designs.

Home automation will use workstations to design efficient houses and robots to assemble those houses from advanced materials. The main difference is that Middle Ages society was limited by a lack of computer tools, while modern society is becoming limited by dwindling sources of proven fuel reserves.

Showcase homes are being built to examine automation use under actual conditions. For example, Diablo Research is building a house based on the CEBus standard, and Hometronics is planning regional CEBus demonstrations. There are an estimated 100,000 custom-automated homes in the United States today.

Living with the Unknowns

Dataquest believes that the major semiconductor opportunities in home automation will come from the use of microelectronics in appliances. The standards and the markets, however, will emerge slowly because they are just tiny pieces of the much bigger panoramic energy puzzle.

We recommend that semiconductor suppliers that want to capture part of this opportunity should do so by working closely with appliance manufacturers. Sharing plans in the short term will help ensure that component and equipment strategies are aligned.

Roger Steciak

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Research Newsletter

SYSTEM SEMICONDUCTOR CONTENT TRENDS: MEDICAL IMAGING SYSTEMS DRIVE DEMAND FOR MOS MICROCOMPONENTS, MOS LOGIC, AND ANALOG ICs

SUMMARY

Dataquest's analysis of trends in the semiconductor content of medical imaging systems (ultrasonic scanners) depicts solid growth prospects for manufacturers of MOS microcomponents, MOS logic, and analog ICs. Table 1 summarizes key points in this second newsletter from Dataquest's series on system semiconductor trends. Dataquest recommends that semiconductor manufacturers keep pace with industrial market trends by forging strategies now for securing a share of lucrative opportunities in the projected $7.5 billion North American medical electronics marketplace of 1993.

PREVIEW

The information summarized in Table 1 is derived from Tables 2 and 3. Table 2 shows the estimated system semiconductor content (expressed in percentages) for this equipment for 1988 and 1993. Dataquest bases its analysis of this system's semiconductor content and that of 17 other electronic systems on sources such as system breakdowns, industry bills of material, and consultations with system and semiconductor analysts.

For semiconductor manufacturers, Table 3 translates Table 2 into dollars by converting the medical imaging system content information into a dollar forecast of semiconductor consumption for the period from 1988 through 1993. Dataquest views trends in ultrasonic medical imaging systems as a window of insight into developments in the entire medical electronics marketplace. Table 4 presents Dataquest's 1988 through 1993 forecast of semiconductor consumption by North American manufacturers of all medical electronic equipment, which is based on the analysis of medical imaging system content trends.

Table 5 provides semiconductor suppliers with a technology road map regarding medical imaging system requirements for 1989 and 1993.

TABLE 1
Estimated Medical Imaging System Semiconductor Content Trends

	1988	1993	CAGR
North American Production ($M)	$ 208	$ 284	6.4%
Current System Average Selling Price Assumption (excludes displays)	$150,000	N/A	N/M
Semiconductor Consumption ($M)	$ 14.65	$23.13	9.6%
Total Semiconductor Content	7.0%	8.1%	N/M
Fastest-Growing Semiconductor	MOS Microcomponents		
Market (by product and $M)	$ 0.5	$ 2.5	39.5%

N/A = Not Available
N/M = Not Meaningful

Source: Dataquest
August 1989

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Table 6 translates the information in Tables 1 through 5 into the hot product prospects for semiconductor manufacturers over the long term.

TABLE 2
Estimated North American Semiconductor Content of Medical Imaging Systems

	1988	1993
Total Semiconductor	7.0%	8.1%
IC	4.2%	5.8%
Bipolar Digital	0	0
Memory	0	0
Logic	0	0
MOS Digital	2.7%	4.0%
Memory	0.9%	1.0%
Microcomponents	0.2%	0.9%
Logic	1.7%	2.2%
Analog	1.5%	1.7%
Discrete	2.1%	1.8%
Optoelectronic	0.7%	0.6%

Source: Dataquest
August 1989

EQUIPMENT FORECAST

Dataquest forecasts a 6.4 percent compound annual growth rate (CAGR) for the North American production of medical imaging systems between 1988 and 1993. We expect this market to grow from $208 million during 1988 to $284 million by 1993. Dataquest expects the entire North American output of medical electronic equipment to expand from $5.8 billion during 1988 to $7.5 billion during 1993 (a 5.4 percent CAGR).

MEDICAL IMAGING SYSTEM (ULTRASONIC SCANNER) SEMICONDUCTOR CONTENT

Table 2 presents detailed 1988 and 1993 semiconductor content for ultrasonic medical imaging equipment. The semiconductor content information shows system manufacturers the relative output value in a medical imaging system (expressed in percentages) generated by the use of a given semiconductor in the system. As shown in Table 2, the trend in semiconductor demand by North American producers of medical imaging systems means growth opportunity for manufacturers of MOS microcomponents, MOS logic, and analog ICs. The table also reveals that suppliers of discrete

TABLE 3
Estimated North American Semiconductor Consumption by Manufacturers of Medical Imaging Systems, 1988-1993 (Millions of Dollars)

	1988	1993	CAGR 1988-1993
Equipment Production	$208.00	$284.00	6.4%
Total Semiconductor	$ 14.65	$ 23.13	9.6%
IC	$ 8.77	$ 16.37	13.3%
Bipolar Digital	0	0	0
Memory	0	0	0
Logic	0	0	0
MOS Digital	$ 5.69	$ 11.47	15.0%
Memory	$ 1.77	$ 2.90	10.3%
Microcomponents	$ 0.47	$ 2.46	39.5%
Logic	$ 3.45	$ 6.11	12.1%
Analog	$ 3.08	$ 4.89	9.7%
Discrete	$ 4.39	$ 4.98	2.6%
Optoelectronic	$ 1.49	$ 1.79	3.7%

Source: Dataquest
August 1989

semiconductors and optoelectronic devices can expect relatively steady future business in this marketplace.

SEMICONDUCTOR CONSUMPTION FORECAST

Table 3 provides Dataquest's forecast of semiconductor consumption by North American manufacturers of medical imaging systems during the 1988 through 1993 period.

As shown in this table, semiconductor manufacturers can expect demand by medical imaging systems manufacturers to expand from $14.7 million during 1988 to $23.1 million by 1993, a CAGR of 9.6 percent. At first, this consumption forecast may seem unimpressive, but the growth rates associated with products such as MOS microcomponents (39.5 percent CAGR), MOS logic (12.1 percent CAGR), MOS memory (10.3 percent CAGR), and analog ICs (9.7 percent CAGR) translate into an attractive opportunity for IC suppliers that target the medical electronics arena.

Table 4—which presents Dataquest's long-term projection of semiconductor consumption by North American manufacturers of all medical equipment—reveals the magnitude of the opportunity in medical electronics for semiconductor suppliers.

As shown in this table, by 1993 Dataquest expects the medical electronics business to become a more than $100 million opportunity for suppliers of MOS logic ($174 million) and analog ICs ($140 million), as well as a substantial market for manufacturers of discrete semiconductors ($97 million), MOS memory ($77 million), and MOS microcomponents ($55 million).

CONVERGENCE OF SYSTEM AND SEMICONDUCTOR TECHNOLOGIES

The trend toward converging system and semiconductor technologies in medical systems means challenge and opportunity for semiconductor suppliers.

Medical Imaging System Technology

For semiconductor manufacturers, the medical imaging equipment business can be viewed as a niche market that serves as an avenue into the projected $7.5 billion medical electronics marketplace of 1993. Figure 1 shows a block diagram of an ultrasonic medical imaging system.

TABLE 4
Estimated North American Semiconductor Consumption by Manufacturers of Medical Equipment, 1988-1993 (Millions of Dollars)

	1988	1993	CAGR 1988-1993
Equipment Production	$5,785.00	$7,530.00	5.40%
Total Semiconductor	$ 339.70	$ 555.30	10.30%
IC	$ 243.90	$ 445.80	12.80%
Bipolar Digital	0	0	0
Memory	0	0	0
Logic	0	0	0
MOS Digital	$ 155.80	$ 305.90	14.45%
Memory	$ 46.90	$ 76.60	10.31%
Microcomponents	$ 10.40	$ 54.90	39.48%
Logic	$ 98.50	$ 174.40	12.10%
Analog	$ 88.10	$ 139.90	9.69%
Discrete	$ 85.70	$ 97.40	2.59%
Optoelectronics	$ 10.10	$ 12.10	3.68%

Source: Dataquest
August 1989

The figure pinpoints market opportunities for semiconductor suppliers in the medical imaging arena.

Semiconductor Technology Requirements of Medical Imaging Systems

Table 5 converts Figure 1 into a technology road map. This table compares the typical semiconductor requirements of a medical imaging system during 1989 with the projected needs of a 1993 system.

Hot Semiconductor Prospects

Table 6 summarizes some key product opportunities for semiconductor manufacturers based on system needs as shown in Figure 1 and Tables 2 through 5.

DATAQUEST CONCLUSIONS

Dataquest's recent analysis of the semiconductor content of medical imaging systems reveals genuine long-term opportunity for suppliers of

TABLE 5
Medical Imaging System's Semiconductor Requirements Forecast
1989 and 1993

System Requirement	1989 System	1993 System
MOS Microprocessor (MPU)	16-bit MPU	32-bit MPU
Logic	Standard logic	Embedded chip set
Memory	DRAM	DRAM, high-speed SRAM, video RAM
Data Conversion	8-bit DAC, 8-bit ADC, 8-bit video DAC	12-bit DAC, 12-bit ADC, 16-bit video DAC
Transducer	Linear array	2-D linear arrays, symmetrical phased arrays
Transmitter	High-power amplifier	High-power radio frequency amplifier
Receiver	High-speed receiver	High-frequency superheterodyne receivers

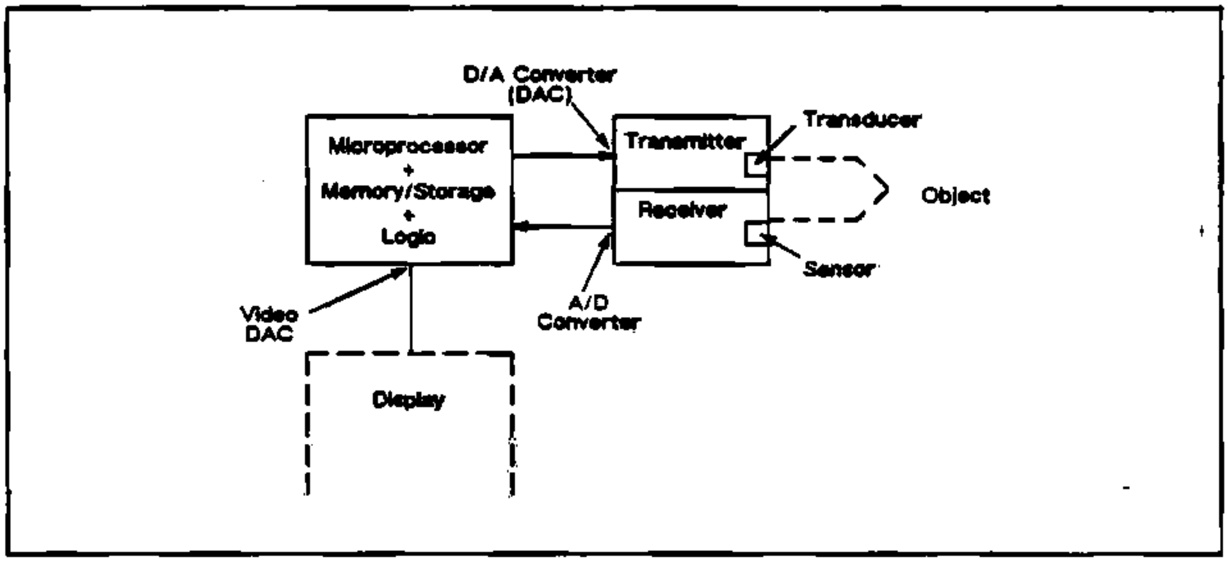
Source: Dataquest
August 1989

TABLE 6
Key Semiconductor Products For Medical Imaging Systems

Semiconductor Segment	Segment's CAGR 1988-1993	Representative High-Growth Products
MOS Microcomponents	39.5%	32-bit microprocessors; digital signal processors; controller-CPU interfaces
MOS Logic	12.1%	Embedded chip sets
MOS Memory	10.3%	Fast dual-port memories
Analog	9.7%	High speed analog-to-digital and digital-to-analog converters of 8 bits and more; high-frequency receivers and amplifiers; phased arrays and 2-D linear arrays

Source: Dataquest
August 1989

FIGURE 1
Medical Imaging System Block Diagram



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Source: Dataquest
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MOS microcomponents, MOS logic, MOS memory, analog ICs, and discrete semiconductors. For semiconductor suppliers, the opportunity lies not only in the medical imaging segment but throughout the medical electronics marketplace. MOS microcomponents such as 32-bit microprocessors represent the fastest growth prospect (39.5 percent CAGR) in medical electronics; however, the big opportunities of 1993 are predicted to flow to suppliers of MOS logic ($174 million), analog ICs ($140 million), discrete semiconductors ($97 million), and MOS memory ($77 million).

DATAQUEST RECOMMENDATIONS

We recommend that strategic planners for semiconductor manufacturers take advantage of Dataquest's insight into medical imaging systems semiconductor analysis by carefully pursuing long-term opportunities in the medical electronics marketplace, which is a large but relatively new industrial market segment for many chip suppliers. Suppliers that can meet heavy system requirements for microprocessor-based analog/digital data conversion will be strategically positioned for success in the medical marketplace. Dataquest projects 1993 North American production of medical electronic systems at $7.5 billion, which translates into semiconductor consumption of $555 million.

Ronald A. Bohn

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Research Newsletter

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U.S. FACSIMILE MARKET: GROWTH EXCEEDS ALL EXPECTATIONS AS MARKET EXPLODES

SUMMARY

A major milestone was reached in the U.S. facsimile marketplace in 1988 as annual placements exceeded the 1 million mark for the first time. The placement of 1,039,200 units represents a remarkable 145 percent increase over the 423,900 units placed in 1987. In this newsletter, Dataquest presents its "1988 fax scorecard," analyzing the changing market positions of the players and the trends and issues leading to this remarkable growth.

THE RECENT UPSURGE

Since 1983, the compound annual growth rate (CAGR) for facsimile placements in the United States has averaged more than 95 percent, growing from just under 37,000 units in 1983 to the greater than 1 million mark last year, as depicted in Figure 1. Although annual growth was relatively low during the beginning of that five-year period, the growth in placements in 1987 and 1988 was 126 percent and 145 percent, respectively.

The phenomenal explosion since 1986 has been fueled by many factors in the marketplace including the growing user awareness of the product and the product's inherent, unique capabilities to solve business communications problems. The recent trend to expand the use of facsimile from medium and large offices to the estimated 13 million to 15 million smaller businesses and residential offices in the United States has also added to the rapid market expansion.

Pricing

The sharp drop in average unit prices over the past five years can also be correlated to the tremendous increase in the number of installed units in the United States. Figure 2 is a graphic representation of the dramatic drop in manufacturer suggested retail prices and the increase in installed units between 1983 and 1988. During that period, the average unit price dropped from $5,495 to $1,709 and the installed base expanded from 75,000 units to more than 1.6 million units.

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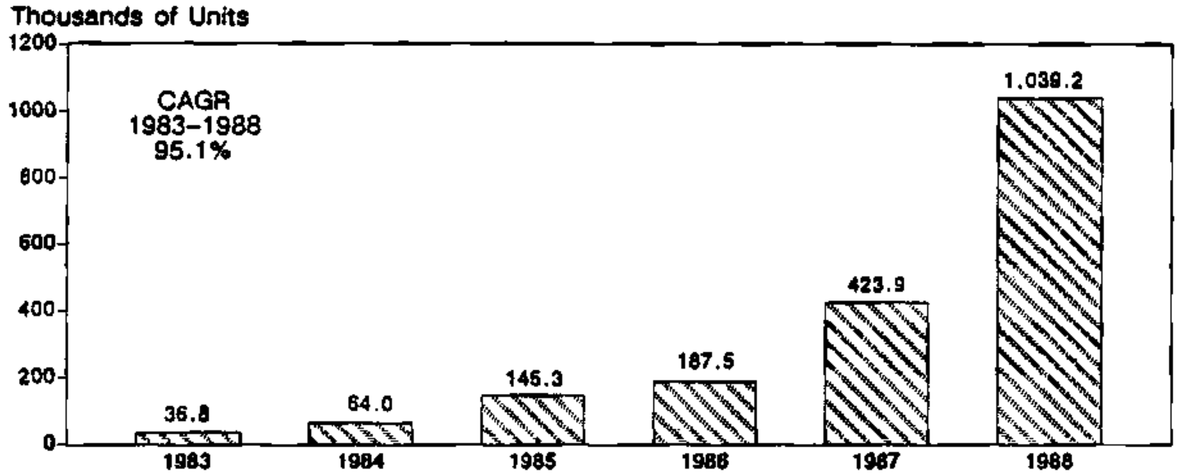
Figure 1

Historical Market Performance



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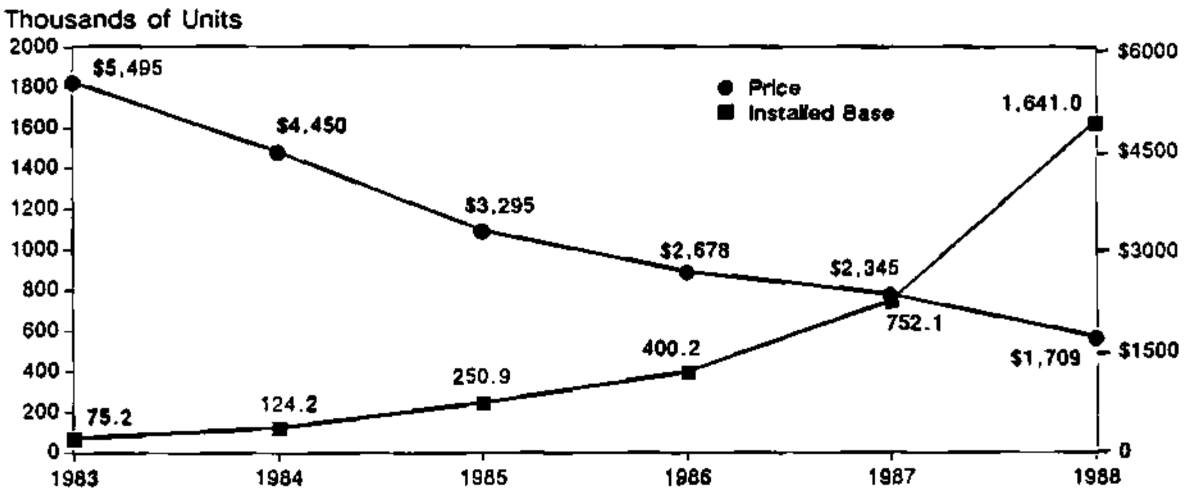
Source: Dataquest
August 1989

Figure 2

Historical Growth Pattern
Average Price and Installed Base



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Source: Dataquest
August 1989

Because heavy discounting from the manufacturer's suggested retail price is a common practice in the fax marketplace, Dataquest estimates that end-user prices are significantly below those shown. Recent Dataquest estimates, based on a survey given during the first quarter of 1989, show the range of "street prices" to be between $716 for low-end models and $3,156 for full-featured products, with the average price of $1,500 for all units. Heavy price competition will apparently continue in the marketplace as manufacturers and distributors scramble for market share.

PRODUCT SEGMENTATION

Market Share by Price Segment

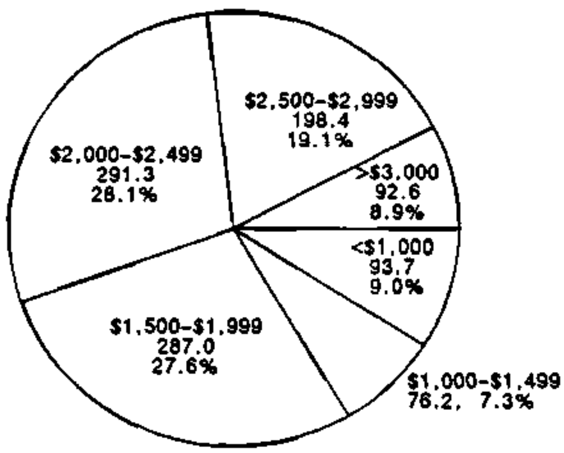
Dataquest segments the facsimile market into six distinct price-based categories as follows:

- Less than $1,000
- $1,000 to $1,499
- $1,500 to $1,999
- $2,000 to $2,499
- $2,500 to $2,999
- $3,000 and above

The 1.04 million placements made during 1988 are shown distributed across these segments in Figure 3. The two largest segments, accounting for more than 55 percent of all unit placements in 1988, are the $2,000 to $2,499 segment and the $1,500 to $1,999 segment, with 28.1 percent and 27.6 percent, respectively. The third-largest segment, $2,500 to $2,999, contributed 19.1 percent of all placements. Together, these three segments, spanning the $1,500 to $2,999 price range, contributed 75 percent of 1988's fax activity. However, Dataquest expects more and more activity to move to the lower-end segments (less than $1,500) as retail channels, "personal fax," and the home office become more significant factors in this dynamic marketplace.

Figure 3

1988 Market Share by Segment
(Thousands of Units)



Total = 1,039,200 Units

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Source: Dataquest
August 1989

Market Share by Company

As is the case very often in new, high-growth industries, the market participants, as well as their relative share of the business, are likely to vary a great deal from year to year. The facsimile market is no exception to this. The market is growing so rapidly that doubling or even tripling an individual company's placements from year to year cannot guarantee that company's relative market share position over the same period. In 1986, the top five share leaders in the U.S. marketplace, based on end-user placements of fax machines were Ricoh, Canon, Pitney Bowes, Sharp, and Fujitsu, in that order. Table 1 lists the top 10 market leaders in 1988. Although the absolute unit placements of each of the top five companies from 1986 grew tremendously, their relative positions in the industry have changed significantly.

Sharp has moved up dramatically from number four in 1986 to the industry leader (20.8 percent share). Murata (15.0 percent), a company not even in the top five two years ago (actually number 10), has secured a solid number two position. Both these companies have moved to the top of the list based on their successful exploitation of the low end of the fax market as the market moves in that direction. Their leadership in effectively managing distribution channels, especially their move into the retail channel, contributed greatly to their success.

Canon (10.5 percent) remains in the top three, slipping just one notch to number three. Pitney Bowes, still somewhat successful with its emphasis on pursuing major account penetration, is now number five. Ricoh holds the number four position and capitalizes upon the depth and breadth of its product line with major activity in the top five price segments. Fujitsu (3.5 percent) had dropped to number 11 by Dataquest's estimate in 1988.

Table 1

Estimated 1988 Market Shares
(Thousands of Units)

Company	Units	Market Share
Sharp	216.1	20.8%
Murata	155.9	15.0
Canon	109.6	10.5
Ricoh	102.5	9.9
Pitney Bowes	57.8	5.6
Toshiba	57.1	5.5
Panafax	54.5	5.2
Xerox	44.9	4.3
Harris/3M	39.4	3.8
Telautograph	38.7	3.7
Others	162.7	15.7
Total	1,039.2	100.0%

Source: Dataquest
August 1989

DATAQUEST FORECAST

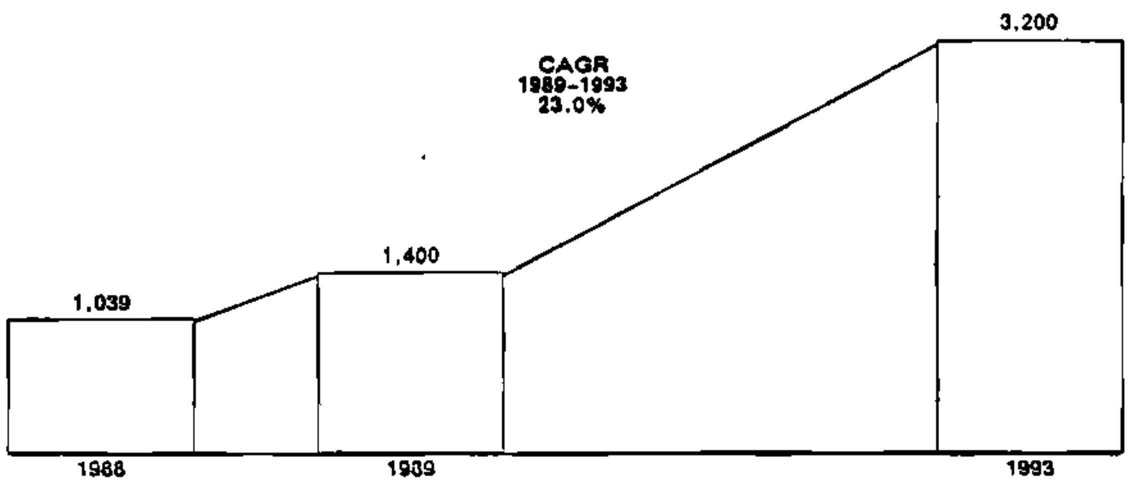
Dataquest predicts strong growth of unit placements in the future. Although it is unlikely that the annual growth rates of 1983 though 1988 (95 percent) will be repeated, we anticipate high growth of 23 percent annually through 1993. This growth will bring annual unit placements to 3.2 million in 1993, more than three times the 1988 placement total of 1.04 million (See Figure 4). We expect the market to begin leveling off in the mid-1990s as market saturation and the resulting maturation begin to affect placements.

Revenue growth will also continue through the forecast period. We expect continued strong competition and increased penetration of the low end of the market to drive the average price per unit downward until the average price per unit is near the $1,000 mark in 1993. This price decrease will result in total revenue of $3.2 billion in 1993. As depicted in Figure 5, we estimate average annual growth to increase 12.2 percent annually between 1989 and 1993.

Channel distribution will continue to evolve as the market matures and prices drop. A move from dealer channels to retail channels will occur as margins are squeezed and the products filter down to smaller businesses and residences requiring low prices and little support. Telephony-related distributors (i.e., RBOCs, interconnects, independent Telcos, and other distributors of small business equipment and PBX/key telephone systems) will gain share when they begin to sell fax more extensively as "tag-along" sales to supplement their product lines and when the market for Group IV fax becomes better developed.

Figure 4

Estimated U.S. Facsimile Equipment Market (Thousands of Units)



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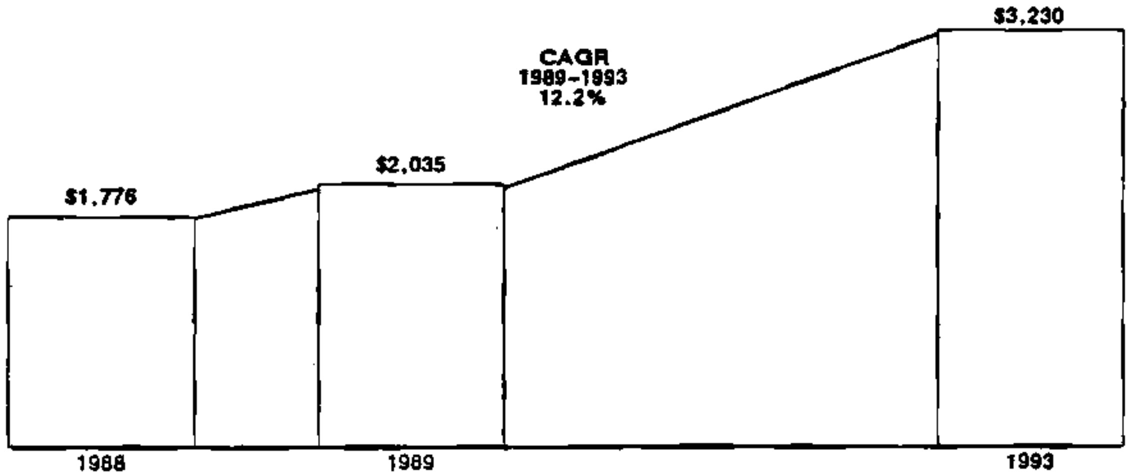
Source: Dataquest August 1989

Figure 5

Estimated U.S. Facsimile Equipment Market (Millions of Dollars)



0004818-5

Source: Dataquest August 1989

Table 2 reflects these shifts through 1993, when Dataquest estimates that 33 percent of the placements will be delivered via dealers, almost 40 percent will be delivered through retail channels, and 8 percent will use telephony-related channels. We expect the direct channel to stay relatively constant in the 20 percent range, catering to the larger purchaser typically requiring a full-service channel.

Table 2

U.S. Facsimile Equipment Distribution Channels

Channel	1988	1989	1993
Dealer	47.3%	41.5%	33.2%
Direct	22.4	22.8	20.2
Retail	26.9	31.2	38.5
Telephone Interconnect	3.4	4.5	8.1
Total	100.0%	100.0%	100.0%

Source: Dataquest August 1989

RELATED PRODUCTS AND FUTURE SERVICES

Several peripheral or fax-related products have come on the scene and have begun to have an effect on the fax marketplace. Examples of these products are a PC "fax board," which enables an MS-DOS PC to emulate a Group III fax machine; a "fax switch," which allows a telephone, an answering machine, and a fax machine to be attached to a common phone line and switches between the three devices as required; and a laser jet printer adjunct device, which allows an ordinary laser printer to act as a receive-only fax machine delivering high-quality fax copies on plain paper. Each of these products has some merit but all have been relatively slow to catch on for a variety of reasons.

Fax switches, primarily designed to save money in the smaller business environment where fax usage is not heavy enough to justify giving the machine a separate telephone connection, have had some technical problems because of slight differences in answering machines and the sometimes subtle differences in Telco services from company to company. All switches do not work equally well with different answering machines or from office to office.

The PC fax board has been slow to take off primarily because of the lack of a distribution channel that can deal with the convergence of the two products involved, the PC and the fax machine. Traditional fax distributors know little about PC distribution, and PC retailers are not geared to deal with the typical fax customer, especially in the growing low-end or retail segments of the market. The relatively high price of a laser printer adjunct box, currently selling for more than $1,200, makes this box impractical because the prices of new, full-featured fax machines are decreasing into the same price range.

Although none of these products have had a major effect on the fax market in terms of revenue or shipments to date, Dataquest will continue to monitor these products, as well as new developments in these areas for potential impact.

Group IV fax machines, requiring a 64-Kbps digital circuit to deliver a 400-dot-per-inch (dpi) plain-paper copy in less than four seconds per page, are already on the market. However, until ISDN service is tariffed and available on a country-wide basis, use of these machines will be limited to relatively large companies with their own private, wideband digital networks. The cost of one of these machines is still very high, ranging from approximately $7,000 to $25,000 or even $30,000 at the high end.

When ISDN is generally available, we have little doubt that Group IV fax will have a significant effect on fax placements. Dataquest forecasts this to be several years off, most likely the mid- to late 1990s.

DATAQUEST CONCLUSIONS

The explosive fax market is exceeding the expectations of even the more optimistic forecasts compiled over the last few years. The past two calendar years have seen the peak of this rapid growth. Placements of fax machines have more than doubled in each of these two years when compared to the previous year's placements. This rate of growth will certainly subside throughout the forecast period as the market matures, but it will maintain a relatively healthy pace, estimated to be 23 percent for units and 12 percent for revenue. The market will begin to level off in the mid-1990s at the $3.2 million to $3.5 billion range.

For manufacturers and distributors, the next few years will be much like the past few. The rapid growth will allow manufacturers that are able to differentiate their products through promotion, training, and incentive plans aimed at dealers to better position themselves to succeed in the medium to high segments. Vendors will have to spend money on advertising and aftermarket support (e.g., training, diagnostic and maintenance centers). As in the past, marketing and distribution will continue to play a critical role in the fax market.

Vendors successfully dealing in lower-priced products will find their way into the ever-expanding retail channels, which will provide much opportunity to build market share rapidly. Fax mania will penetrate the lowest levels of small business and then the areas of residential, personal, and public fax. These trends have already begun, and the large numbers of potential customers will, no doubt, make this a game with very large stakes and potentially high profits.

Pursuing the entire market with a broad product line serving all price segments will become increasingly difficult as the market expands and matures. Vendors may be better advised to select their preferred market segments, target those markets, and position themselves accordingly.

Dataquest will continue to closely monitor and report on this volatile market. No matter what the outcome and who the real winners are, the expansion of this market over the past few years and its projected growth into the future guarantee large revenue flows and excitement for many years into the future.

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Terrance A. Birkholz
Ken Landoline

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Research *Bulletin*

OEM MONTHLY—AUGUST 1989
TV AT 50—WHERE IS IT HEADED?

OEM Monthly provides insight into application markets so that clients can make better strategic and technical marketing decisions.

TODAY'S VIDEO

TV was first introduced to the public at the 1939 New York World's Fair and has since become very popular (see Table 1). Now this 50-year-old innovation is creating a whole new video revolution.

Dataquest estimates that 61 million color TV sets are made worldwide each year, with the United States expected to produce an estimated 11 million TV sets in 1989. Each color TV has approximately $25 worth of semiconductors. The worldwide consumption of TV semiconductors is estimated at $1,525 million, with $275 million of TV semiconductors consumed in the United States.

TOMORROW'S VISION

Today's TV set is a digital-controlled analog processor; tomorrow's is expected to be an all-digital implementation. High-definition TV (HDTV) and the improvements planned for today's TV—improved-definition TV (IDTV) and enhanced-definition TV (EDTV)—will process TV signals digitally to provide sharper-looking pictures.

Today's TV set is a terminal of an entertainment network; tomorrow's is likely to be an inter-

TABLE 1
Video Equipment in U.S. Households

Video Items	Market Intro.	Household Penetration	1988 Shipments (Millions of Units)	5-Year CAGR*
TV Sets (total)	1939	98%	23.60	3%
Monochrome TVs	1939	58%	3.20	(10%)
CATV Services	1940s	53%	2.50	5%
Color TVs	1954	95%	20.40	6%
VCRs	1972	61%	10.70	9%
Projection TVs	1973	4%	0.30	12%
Video Games	1976	17%	5.00	N/M
Home Satellite Earth Stations	1979	2%	0.30	(23%)
Pocket (LCD) TVs	1982	2%	0.80	20%
Stereo TVs	1984	15%	5.10	115%
Videophones	1986	N/M	0.05	N/M

*Compound annual growth rate
N/M=Not Meaningful

Source: Industry Data
Dataquest
August 1989

SAM Newsletters 1989: July-September 1989-44

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active unit of an integrated network. The HDTV set is expected to include a powerful PC with links to the ISDN telephone network and the home automation system. Uses of the HDTV set include entertainment, education, and two-way visual communication.

If the history of past consumer video products is any indication, decades may be required for HDTV sales to become large. For example, 3 years were required for monochrome TV sales to reach 1 million sets per year, but 13 years were required for color TV sales to reach the same level. HDTV offers viewers only minor benefits, and this fact is expected to slow sales.

In the meantime, industrial HDTV—or videocomputing—shows promise of being the next electronics boom. Videocomputers would do three-dimensional modeling, simulation, and instruction. Components include parallel RISC processors, megabit memory chips, optical disks, and sensors.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Several Japanese companies recognize this trend to high-end computing and have established R&D centers in the United States. Dataquest believes that one of their goals is to help U.S. suppliers develop chips that are designed for use in these advanced systems. As a result, these Japanese companies will be able to buy more U.S.-made ICs.

Videocomputers and HDTV sets are likely to replace laser printers by the late 1990s as the major market for embedded processors. Therefore, we recommend that semiconductor suppliers work closely with these R&D centers if they want to penetrate the video IC market.

Roger Steciak

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Research Newsletter

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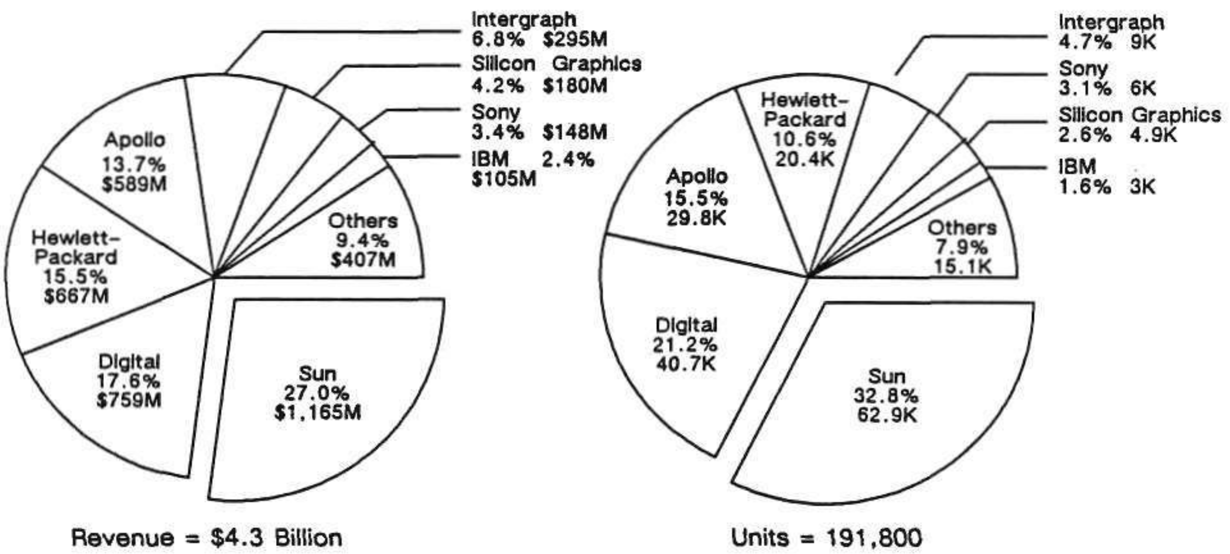
TECHNICAL WORKSTATIONS: AND THE GROWTH CONTINUES

Two Dataquest news articles have stated the estimated 1988 value of the technical workstation market, and with each newsletter, the value is higher. This adjustment indicates just how fast this industry is growing. In 1988 alone, technical workstation revenue amounted to $4.3 billion, a 60.0 percent increase over 1987, and shipments amounted to approximately 192,000 units, a 60.9 percent increase over 1987. Figure 1 shows the 1988 workstation market share.

Figure 1

**Worldwide Technical Workstation Market
1988**



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Source: Dataquest
August 1989

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However, some people are wondering just what a technical workstation is. To define it in simple terms, it is a single-user standalone computer that uses one or more 32-bit processors, either RISC- or CISC-based; it is multitasking; it has integrated graphics, an integrated floating-point processor, distributed networking, and supercharged graphics; it runs UNIX and a wealth of technical applications.

In terms of hardware, technical workstations are slightly different from high-end personal computers in the technical marketplace. PCs offer optional integrated graphics, integrated floating-point processors, and distributed networking. Because there is not much difference in hardware alone, which can be difficult to measure, Dataquest looks at other factors such as limitations and distribution channels. For instance, PCs do have a ceiling in regard to performance, storage and memory capacity, and graphic abilities. Additionally, PCs sell mainly through distributors and retailers, while technical workstations sell directly and through OEMs. Table 1 outlines these general characteristics. The shaded area illustrates where we believe that the collision occurs between PCs and technical workstations—at the entry-level workstation segment.

In 1988, the technical PC market amounted to $3.6 million, and shipments amounted to 889,000 units.

The technical workstation market is expected to flourish, reaching $16.0 billion in revenue by 1993 at a compound annual growth rate (CAGR) of 30.4 percent. Shipments are expected to reach 1.2 million units or a CAGR of 44.7 percent. Figures 2 and 3 depict the growth of the technical workstation market for each segment.

One might ask why this growth is occurring. There are several reasons, as follows:

- The penetration level of technical workstations still is quite low.

- Many application areas where technical workstations are just penetrating still exist, such as on the stock market trading floor and in stock brokerage houses.

- Prices are decreasing, which makes purchasing a technical workstation more attractive.

- Performance is increasing, reaching application markets that technical workstations were not able to sell into previously, such as computational chemistry and molecular modeling.

- Ease of use allows mainstream power users to more readily accept technical workstations. These people include corporate decision makers, executives, and consultants.

In short, rapid growth in the technical workstation industry is expected to continue as demand expands.

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Kevin Landis
Kathleen Hurley

Table 1

Technical Personal Computers and Workstations Classification

Feature	Traditional Personal Computers	Entry Workstations	Traditional Workstations	Super Workstations	Graphic Super Computers
CPU Performance (mips)*	<12	2-12	4-15	8-20	20-40
CPU Performance (mflops-DP)	<1	0.5-1.5	0.5-2.0	2.0-16.0	16.0-50.0
Floating-Point Coprocessor	Opt.	Yes	Yes	Yes	Yes
Main Memory (MB)	1-16	4-16	8-64	8-128	16-1,024
Typical Disk Sotrage (MB)	20-160	40-600	80-600	600-1,300	1,024+
Screen Sizes (inches)	12-19	12-19	12-19	15-19	19
No. of Displayable Colors	16-256	16-256	256-496	256-16,700	256-16,700
Typical Pixel Resolution	640 x 480- 1,024 x 768	1,024 x 768- 1,280 x 1,024	1,100 x 900- 1,280 x 1,024	1,280 x 1,024	1,280 x 1024
2-D Vector Transforms/ Second (est.)	50K-100K	65K-400K	100K-500K	100K-500K	100K-500K
3-D Vector Transforms/ Second (est.)	Opt.	Opt.	100K-150K	100K-300K	100K-600K
Gouraud Shaded Polygons/ Second (est.)	N/A	N/A	2K-10K	10K-25K	25K-150K
LAN (Mbits/second)	Opt.	10	10	10-125	10-1000+
Price ($K)	<$10	$5-$15	$15-$50	$40-$80	$75-$150

*Single CPU
N/A = Not Available
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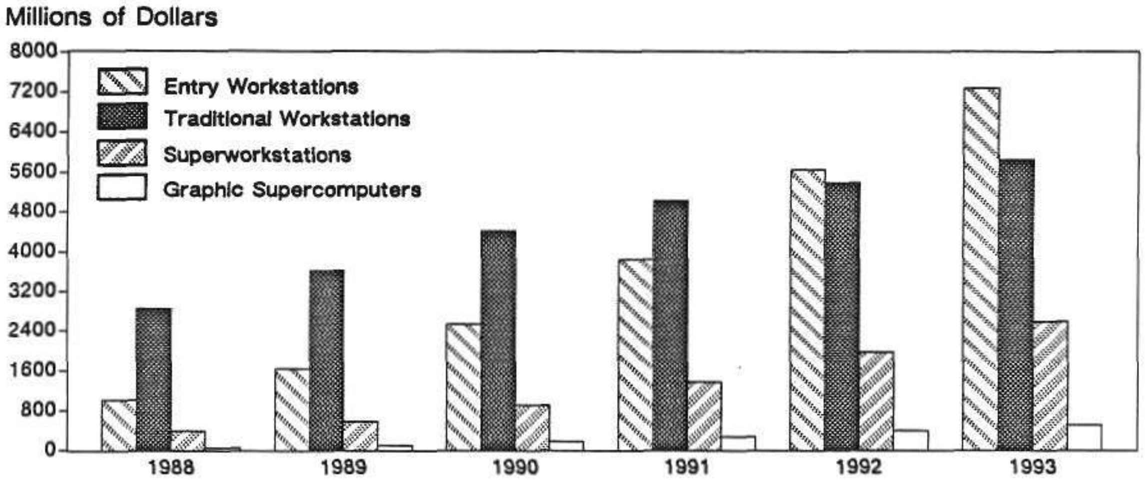
Source: Dataquest
August 1989

Figure 2

Workstation Segment Factory Revenue 1988–1993



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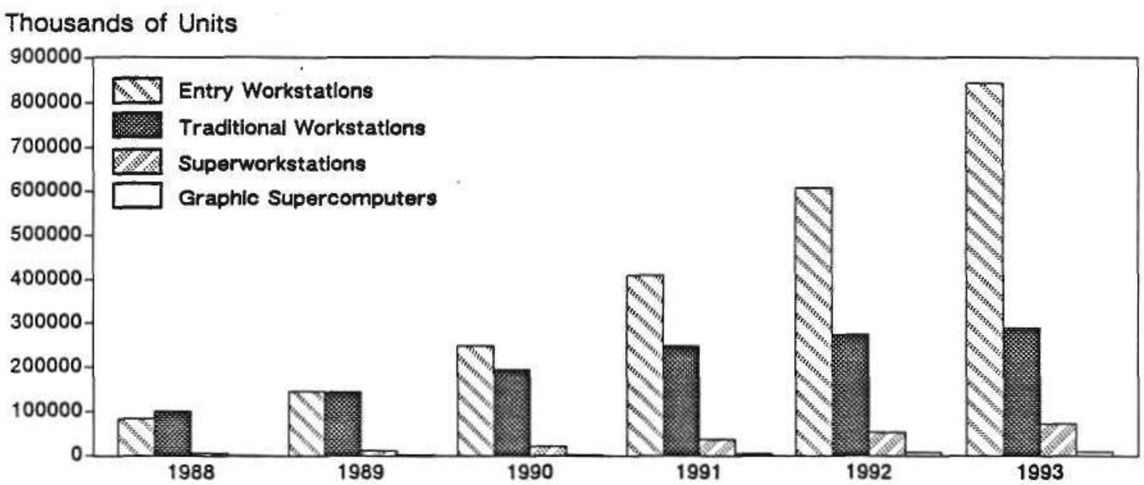
Source: Dataquest August 1989

Figure 3

Workstation Segment Shipments 1988–1993



0004644-3

Source: Dataquest August 1989

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Research Newsletter

COMMUNICATIONS TECHNOLOGY TO WATCH

SUMMARY

Technology is changing system designs. Circuit implementations that once were considered futuristic are now practical with today's ability to build high-density, high-performance semiconductors. This capability, in turn, is leading equipment designers to apply some very sophisticated techniques as they develop the next generation of systems.

This newsletter reviews the application technologies (see Table 1) that are now in an early stage of development and are likely to become commonplace within a few years. We recommend that semiconductor suppliers become familiar with them because they represent large potential markets in the future.

WIRELESS CONNECTIONS

Electronic equipment is being connected to networks. PCs in the office, telephones in the car, robots in the factory, and appliances in the home either are connected already or will be someday. Users would prefer that all gadgets be networked with wireless means because wires have to be installed and cords always get in the way.

Spread Spectrum

Radio waves are used in cordless telephones and garage door openers, but interference and eavesdropping become problems when there are several radios in an area. Spread spectrum provides interference-free, encrypted communications. Potential applications include wireless local area networks (LANs), wireless PBXs, cordless mice, and automated homes.

Examples of wireless systems using spread spectrum include LANs made by Agilis Corp. and O'Neill Communications, and the supermarket price displays developed by Diablo Research and Hillier Controls. These systems are made legally possible by a 1985 FCC decision that establishes rules for nonlicensed spread spectrum use.

Spread spectrum has been used for years in military and satellite systems. Only recently has it been possible to design inexpensive spreader-correlator circuits that make this technique practical

TABLE 1
Technology, Needs, and Implementations

Technology Directions	User Needs	Implementation Techniques
Wireless connections	Convenience	Spread spectrum
		Infrared
		Digital cellular
Integrated components	Performance	Monolithic microwave ICs
		Optical interconnects
		Chip sets
Programmable systems	Features	Digital signal processing

Source: Dataquest
August 1989

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in a variety of equipment. We expect the cost of a spread spectrum transceiver to be less than $20 in original equipment manufacturer (OEM) quantities.

Infrared (IR)

Infrared already is used in TV and VCR remote controls, with potential applications in wireless LANs and automated homes. A wireless infrared LAN is made by Photonics Inc. Links must be line-of-sight type, and this requirement prevents its use where signals must go around corners, but it does provide some protection against eavesdropping.

Digital Cellular

Car telephones have become popular because they provide the freedom to make and receive telephone calls while on the road. Demand is expected to increase even more as the prices of some units fall to less than $500. Cellular telephones might even be offered as standard options on some car models beginning in the early 1990s.

Cellular networks in some cities will reach capacity in the early 1990s. These systems use analog transmission—digital transmission is being proposed for more efficient spectrum use. A pan-European cellular network that will be digital is scheduled to be in use in 1991, and a digital plan for the United States is under discussion.

INTEGRATED COMPONENTS

The easy part of the radio spectrum is taken. New services are being assigned now to frequencies of more than 900 MHz. At the same time, mainstream computer and communications equipment clock speeds are increasing rapidly toward 50 MHz. Users demand these high levels of performance; component integration will make them affordable.

Monolithic Microwave ICs (MMICs)

Today's microwave frequency circuits are made with discretes and hybrids; tomorrow's will be made with monolithic gallium arsenide (GaAs). Potential MMIC applications include guidance, radar, and communications systems for the military and direct broadcast satellite (DBS) receivers for consumer television viewers.

MMICs have a way to go before they become practical in mass-produced equipment. In addition, the DBS market is expected to develop slowly. However, MMICs are expected to become widely available during the 1990s. Advantages expected of MMICs include lower cost, better reliability, and a higher-frequency performance when compared with hybrids.

Optical Interconnects

Fiber optics already are being used in the long distance network and are being readied for the local loop. Another application for optics is the wiring inside equipment. For example, large PBXs use optical cables in their backplanes to take advantage of the large bandwidth.

Higher electronics density is making interchip communication more difficult. Integrated optical components (IOC) are a potential solution. (Superconduction also is under investigation as a solution.) IOCs still are in the laboratory, and commercialization for mass-production applications is projected for the late 1990s.

Chip Sets

Chip sets have revolutionized PCs by reducing the parts count and the manufacturing cost. A similar revolution is likely to occur with telecommunications equipment in the 1990s. The T-carrier and Sonet standards are basic to telecom, and application-specific ICs for these functions would provide a more efficient implementation.

PROGRAMMABLE SYSTEMS

Users want electronic equipment with many features, and designers can provide them when they can implement circuit functions at low cost. Programmable hardware may be used in more than one model so that users can benefit from scale economies.

Digital Signal Processing (DSP)

Electronic equipment has circuits to process electrical signals, and these circuits are usually in an analog form. However, equipment that uses digital representations of signals and processing functions can give users more elaborate features and give manufacturers lower costs. Computer technology is harnessed for its flexibility and automation benefits.

Potential applications for DSP include the elimination of undesired signals or the compression of signals for more economical transmission and storage. For example, DSP can be used to remove the road noise that is inadvertently picked up by a car telephone handset. Solid-state answering machines also could use DSP to reduce the amount of memory needed.

DATAQUEST CONCLUSIONS

The Importance of Technology

Technology is one way an equipment manufacturer can provide better solutions to equipment users' needs. Semiconductor components make the implementation of this technology practical.

Technology can benefit the user directly by providing new features, more performance, or longer equipment operating life. Technology also can benefit the user indirectly by providing the manufacturer with cost savings that result from scale economies, automated production, or fewer parts.

Competing in the 1990s

Some emerging communications technology will be implemented with semiconductors that can provide special performances. For example, chips capable of high-frequency operation must be built with fab processes that are designed specifically for high frequencies. Suppliers of these chips will be competing on the basis of superior technology.

Other emerging communications technology will be implemented with semiconductors that provide circuits specific to the application. For example, telecom chip sets must be designed for the processing functions that are specific to telecom circuits. Suppliers of these chips will be competing on the basis of superior applications know-how.

Advances in semiconductors will continue to make practical more of the communications technology discussed in this newsletter, and this technology will find widespread use in electronic equipment as a result. Dataquest recommends that semiconductor suppliers actively monitor this technology and pursue market opportunities that have a strategic fit.

Roger Steciak

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Research *Newsletter*

EISA *AND* MCA: THE BEGINNING OF THE END OF THE BUS WARS

SUMMARY

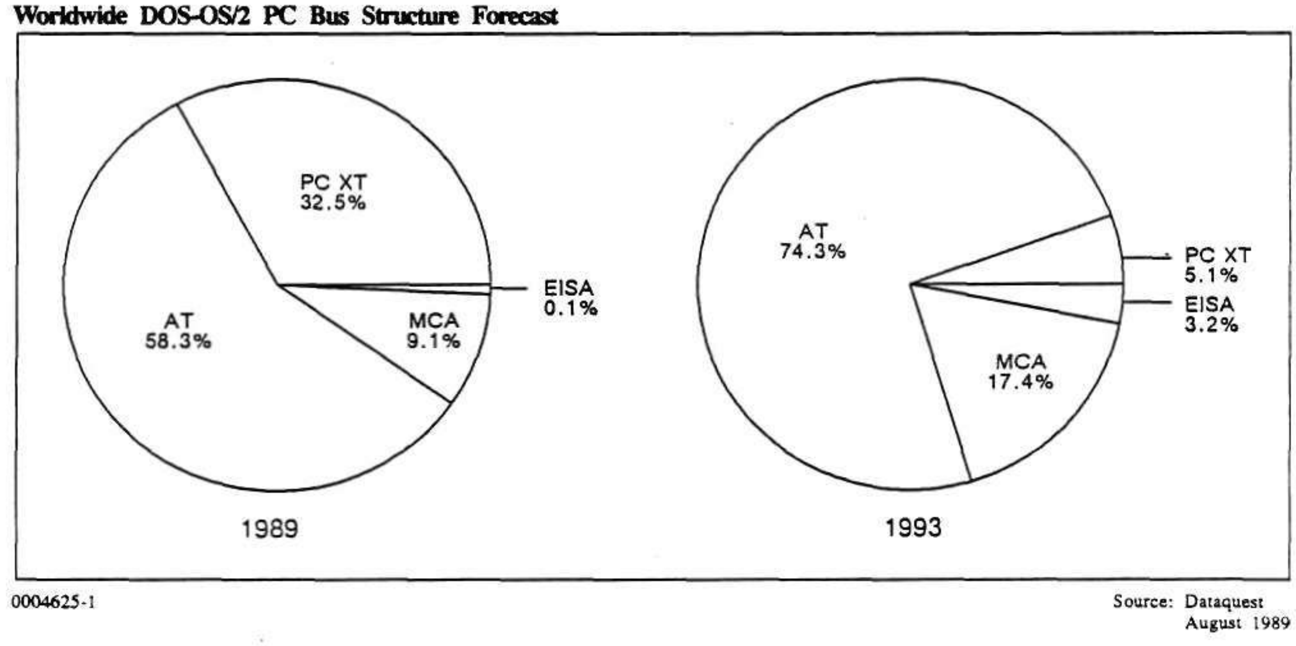
On July 14, just four days after Intel Corporation announced the industry's first Extended Industry Standard Architecture (EISA) chip set, Compaq Computer Corporation announced the signing of a patent cross-license agreement with IBM. The agreement covers a broad range of technologies, including Micro Channel Architecture (MCA) patents. In its press release, Compaq reiterated its commitment to EISA, stating once again that it is not currently developing, and has no plans to develop, MCA-based products. Dataquest believes that this statement accurately reflects Compaq's current position; however, now that Compaq has access to this technology, we must ask: Is it prudent for Compaq *not* to introduce an MCA product?

BACKGROUND

Compaq is generally considered to be the leader of the EISA consortium, which was started by a group of PC manufacturers who did not want to pay royalties to IBM for using the Micro Channel Architecture. The consortium charged that IBM developed MCA as a strategy to increase its market share and to limit the number of PC manufacturers by increasing barriers to entry for low-cost manufacturers. IBM has denied this charge, stating that the MCA bus was developed because of its technical superiority and ability to meet future computing demands.

Figure 1 shows Dataquest's DOS-OS/2 personal computer forecast by bus type. IBM has been shipping MCA bus PCs since April 1987. Dataquest estimates that 1.8 million MCA-based

FIGURE 1
Worldwide DOS-OS/2 PC Bus Structure Forecast



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systems were installed worldwide by the end of 1988, growing to 3.2 million installed systems by the end of 1989. Whereas, the first EISA bus PC announcement is not expected until late this year.

Within the industry and the trade press, a great deal of debate exists as to the relative merits of both standards as well as speculation over which standard will be embraced by the user community. In Dataquest's opinion, MCA will become the accepted standard, although EISA may play an interim role in extending the product life of the AT architecture; however, we believe that EISA will not survive in the long term. We base our argument on MCA's two-and-a-half year headstart, during which PC clone makers and third-party add-in board manufacturers have developed a substantial base of MCA products, which automatically lends credibility to the standard. The reluctance of manufacturers to invest resources in a nonexistent market, IBM's influence, and fragmentation within the EISA ranks will further hinder acceptance of the EISA standard.

THE AGREEMENT

Compaq has been negotiating the recently consumated cross-licensing agreement with IBM since 1987, when IBM first introduced MCA. The issue arose when IBM began to push for royalties from manufacturers of PC XT and PC AT products. Because Compaq had anticipated paying some form of licensing fee, it had set up a reserve fund while negotiating an acceptable fee.

According to this agreement, both companies are granted a worldwide, nonexclusive license that covers patents filed prior to July 1, 1993. The agreement covers patents relating to personal computers, peripherals, and other advanced technologies, including MCA. Because of the relative size of each company's patent portfolio, Compaq will pay a fixed net cash payment to IBM, which will be paid in five annual installments. According to a July 17, 1989, article in *The Wall Street Journal*, the fee would amount to approximately 0.5 percent of Compaq's anticipated total revenue for the five-year period, which is considered very low for an IBM licensing fee.

The most obvious benefit to IBM from this agreement is the revenue generated from the licensing fee. However, the more subtle benefit is the effect that this agreement may have on the remaining members of the EISA consortium. Only four of the original "Gang of Nine" have yet to execute an MCA cross-licensing agreement. More important, IBM now has removed the major barrier to Compaq's embracing MCA. In fact, the fixed payment may actually maximize the incentive for Compaq to sell as many MCA machines as possible, because apparently there is no additional per-machine royalty payment included in the terms of this agreement.

For Compaq, the announcement of this agreement resolves the uncertainty of the potential cost of these fees to the company, which is a positive sign for investors. Compaq has been setting aside reserves for these costs since 1987, but analysts were concerned, nevertheless, that the reserves would be inadequate.

Access to a broad range of IBM technology must be considered an asset. Most important, whether or not Compaq sought MCA, the company now has access to the technology. This represents a fallback alternative to its current EISA strategy.

INDUSTRY RESPONSE: A QUIET AVALANCHE?

Prior to July 10, the MCA/EISA issue was variously referred to as EISA versus MCA, The Bus Wars, or Compaq Battles IBM. On July 10, Intel announced the availability of the first EISA chip set and distributed a product background paper entitled "MCA *and* EISA: A New Road To Travel." This title reflects a subtle change in Intel's posture. Intel is no longer interested in fighting a bus war, it is only interested in selling silicon. Intel recognizes that the real market segment is the 32-bit personal computing market, not the MCA or EISA market. The logic of this strategy applies to systems as well as silicon. Why pursue a strategy that will bar access to the whole market? Or, more simply, if the customer wants a blue suit, sell him a blue suit.

Five of the original Gang of Nine EISA members already have licensed MCA from IBM. Pressure to follow these members will increase dramatically as the logic of the Intel strategy is recognized. Additionally, widespread acceptance of MCA over EISA may further weaken the bargaining position of firms seeking an MCA license. The Compaq/IBM agreement makes it clear that the terms now available are not as disagreeable as the clone makers first feared. This attitude may be attributable, in large part, to the arrival of the EISA chip set. Viewed in this context, the EISA strategy can be considered a success, in that it has delivered MCA at a palatable price.

DATAQUEST CONCLUSIONS

Now that Compaq has successfully negotiated a license agreement, Dataquest expects the remainder of the EISA consortium to begin settling accounts with IBM. Regardless of Compaq's stated intent, we believe that this agreement will cause third-party systems and peripherals manufacturers to have even less enthusiasm (if that is possible) toward developing EISA products. We also expect Compaq to rethink its MCA position and to eventually address the entire 32-bit personal computing market by offering products supporting both bus standards. This transition will present some awkwardness for Compaq, but we can envision a scenario in which the company determines that success requires satisfying key customer needs, which include the ability to choose between EISA *and* MCA. Does this mean that EISA is a failure? Hardly—It now appears that the Gang of Nine members will have access to MCA on terms that they can live with.

Kevin Landis
Ken Pearlman

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Research Newsletter

SYSTEM SEMICONDUCTOR CONTENT TRENDS: POWER SUPPLIES "POWER" GROWTH IN ANALOG, DISCRETE, AND MOS LOGIC MARKETS

SUMMARY

Dataquest's recently completed analysis of trends in the semiconductor content of North American-made power supplies reveals substantial long-term opportunity for manufacturers of discrete semiconductors, analog ICs, and MOS logic. Table 1 highlights the results. Dataquest recommends that semiconductor manufacturers take advantage of this insightful tool for strategic planning activities, and, in support of that goal, Dataquest will generate a series of newsletters during 1989 on system semiconductor content trends.

OVERVIEW

The information summarized in Table 1 is derived from Tables 2 and 3. Dataquest regards this forecast as conservative because it excludes captive production. Table 2 reveals the estimated system semiconductor content (expressed in percentages) for this equipment for 1988 and 1993. Dataquest bases its analysis of this system's semiconductor content and that of 17 other systems on sources such as system breakdowns, industry bills of material, and consultations with system and semiconductor analysts.

For semiconductor manufacturers, Table 3 translates Table 2 into dollars by converting the power supply production forecast and the system content information into a dollar forecast of semiconductor consumption for the period from 1988 through 1993.

EQUIPMENT FORECAST

Dataquest forecasts a 7.9 percent compound annual growth rate (CAGR) for the North American merchant market production of power supplies between 1988 and 1993. We expect this market to grow from $1.65 billion in 1988 to $2.43 billion by 1993.

TABLE 1
Estimated Power Supply System Semiconductor Content Trends

	1988	1993	CAGR
North American			
Merchant Production	$1,665	$2,430	7.9%
Current System Average			
Selling Price Assumption	$300[1]	N/A	N/M
Semiconductor Consumption (Millions)	$104.7	$177.4	11.1%
Total Semiconductor Content	6.3%	7.3%	N/M
Fastest Growing Semiconductor	MOS Logic	MOS Logic	MOS Logic
Market (by product and $M)	$19.0	$40.8	16.5%

[1]Includes merchant custom-made
N/A = Not Available
N/M = Not Meaningful

Source: Dataquest
August 1989

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Power Supply Semiconductor Content

Table 2 presents detailed 1988 and 1993 semiconductor content for power supply equipment.

The semiconductor content information shows system manufacturers the relative output value in a power supply system (expressed in percentages) generated by the use of a given semiconductor in the system. As shown in Table 2, the trend in semiconductor demand by North American producers of power supplies means growth opportunity for manufacturers of discrete semiconductors, analog ICs, and MOS logic, and it presents a challenge for suppliers of optoelectronic devices.

Semiconductor Consumption Forecast

Table 3 provides Dataquest's forecast of semiconductor consumption by North American merchant market manufacturers of power supplies during the 1988 through 1993 period.

As shown in Table 3, discrete semiconductor manufacturers can expect demand by power supply suppliers to expand from $41.4 million during 1988 to nearly $70 million by 1993, representing an impressive CAGR of 10.8 percent. Analog IC suppliers will battle against discrete manufacturers for market share. Analog IC consumption is forecast to grow from $28.5 million in 1988 to $50.6 million during 1993, for a 12.2 percent CAGR. MOS logic suppliers can look forward to very impressive growth in consumption, from less than $20.0 million during 1988 to an anticipated $41.0 million by 1993. We expect this category to have a 16.5 percent CAGR.

Table 2
Estimated North American Semiconductor Content of Power Supplies

	1988	1993
Total Semiconductor	6.3%	7.3%
IC	2.8%	3.8%
Bipolar Digital	0	0
Memory	0	0
Logic	0	0
MOS Digital	1.1%	1.7%
Memory	0	0
Microcomponents	0	0
Logic	1.1%	1.7%
Analog	1.7%	2.1%
Discrete	2.5%	2.8%
Optoelectronic	0.9%	0.7%

Source: Dataquest
August 1989

The Power Supply Systems

The power supply marketplace represents a large and relatively untapped opportunity for semiconductor manufacturers. As noted, North American market production of power supplies is expected to reach $2.4 billion by 1993. Indeed, every nonportable electronic system requires a power supply, so the ultimate end market for chip manufacturers is a truly large and growing arena, encompassing the virtual universe of the electronics industry.

Underlying Assumptions

Given the size and diversity of the power supply business, Dataquest geared the analysis of semiconductor content to provide a composite view of the current mainstream reality, as well as a view of future trends. For this effort, Dataquest looked at the systems of several mainstream suppliers.

Linear Supplies

Linear supplies were examined as part of the analysis. Until the mid-1980s, they dominated in terms of supply and demand. A few semiconductor suppliers now dominate the market in terms of supplying voltage regulators, power transistors, MOS logic, and related circuitry for use in linear supplies.

Trend to Switchmode Supplies

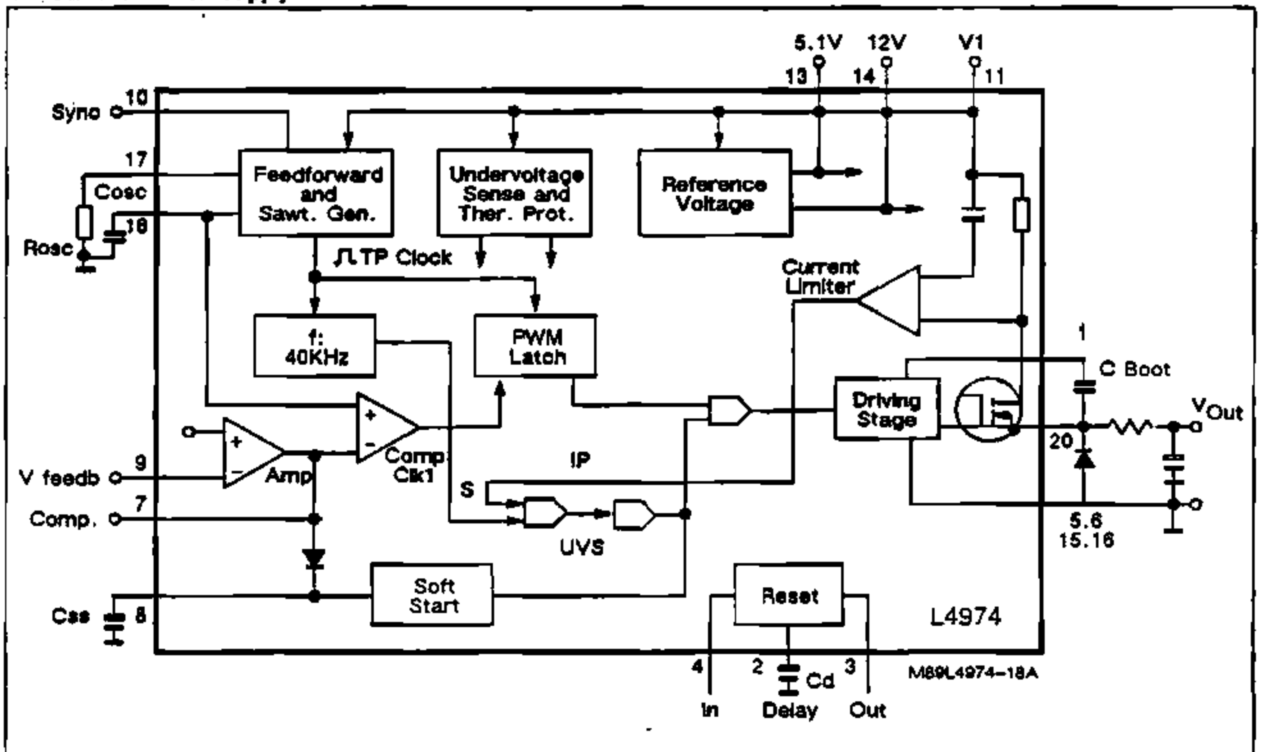
A clear market trend toward increasing use of switchmode power supplies translates into a steady long-term growth opportunity for both current and future suppliers of power MOSFET, power ICs, and MOS logic. The switchmode system will play a major role in the evolution of the power supply business and semiconductor consumption trends. Figure 1 shows a block diagram of a switchmode power supply.

TABLE 3
Estimated North American Semiconductor Consumption by Manufacturers of Power Supplies, 1988-1993 (Millions of Dollars)

	1988	1993	CAGR 1988-1993
Equipment Production	$1,665.00	$2,430.00	7.0%
Total Semiconductor	$ 104.65	$ 117.40	11.1%
IC	$ 47.45	$ 91.36	14.0%
Bipolar Digital	0	0	0
Memory	0	0	0
Logic	0	0	0
MOS Digital	$ 18.98	$ 40.80	16.5%
Memory	0	0	0
Microcomponents	0	0	0
Logic	$ 18.98	$ 40.80	16.5%
Analog	$ 28.47	$ 50.56	12.2%
Discrete	$ 41.40	$ 69.19	10.8%
Optoelectronic	$ 15.80	$ 16.85	1.3%

Source: Dataquest
August 1989

FIGURE 1
Switchmode Power Supply



0004598-1

Source: SGS-Thomson

Unresolved Issues

Dataquest realizes that system semiconductor content analysis holds promises and limitations for strategic planning purposes. The large size and diversity of the power supply marketplace highlights this factor in several ways. For example, the analysis broadly shows that suppliers of discrete semiconductors and MOS logic have a long-term future in the power supply business. The analysis also reveals a surprisingly high optoelectronic content as of 1988, although that is expected to decline over time. Even so, the analysis at this stage confronts a limitation in terms of fully capturing dynamic trends in this huge business, such as the displacement of bipolar power transistors by MOSFETs and analog power ICs. Future interaction between Dataquest clients and analysts should overcome this limitation.

Dataquest Conclusions

Dataquest's recently completed analysis of the semiconductor content of power supply systems clearly indicates opportunity for suppliers of MOS logic, discrete semiconductors, and analog ICs. These devices include power MOSFETs, pulse-width modulators, and power ICs. By 1993, Dataquest conservatively forecasts that North American merchant market manufacturers of these systems will consume $177 million worth of semiconductors (an 11.1 percent CAGR from 1988 to 1993), driven in large part by growth in the switchmode power supply segment. By 1993, discrete semiconductor consumption will push $70 million (10.8 percent CAGR), while analog IC and MOS logic consumption will break the $50 million (12.2 percent CAGR) and $40 million (16.5 percent CAGR) barriers, respectively.

Dataquest Recommendations

Dataquest makes the following two different, but related, recommendations:

- Manufacturers of discrete semiconductors, analog ICs, and MOS logic should aggressively pursue long-term opportunities in the power supply business, a large and traditionally overlooked industrial market segment. Excluding captive consumption, Dataquest conservatively forecasts 1993 North American merchant market production of these systems to be $2.4 billion.
- Strategic planners for semiconductor manufacturers should take advantage of the powerful insight provided by system semiconductor analysis. Dataquest analysts have amassed critical information on the semiconductor content of 18 mainstream and/or leading-edge electronic systems. Dataquest will support strategic planners by generating a series of newsletters on these systems and is in a good position to customize this information to fit clients' specialized needs.

Ron Bohn

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Research Newsletter

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8514/A, TIGA, OR VESA: WHAT'S THE NEXT PC GRAPHICS STANDARD?

SUMMARY

It is a tradition in the IBM environment that a new-and-improved graphics hardware standard comes into vogue every two years. Though the video graphics array (VGA) is the current fashion, the next style is being readied, and the stakes are high for the winner. The main contenders are IBM and third-party IBM-compatible vendors, third-party Texas Instruments-compatible vendors, and, to a lesser extent, vendors of enhanced VGA products.

Texas Instruments (TI) contends that boards based on its 34010 chip are the best choice because it offers the best performance at a low price and has good software support. Although it does offer good price, performance, and compatibility, it is unclear why the market needs something other than the de facto IBM standard. Dataquest believes that, even though TI may serve a high-performance niche in specialized PC graphics markets, its push into the mass market may further confuse the user.

There is a coalition called VESA (for Video Electronics Standards Association) that wants to market standardized medium-resolution (800 x 600) products. Basically, this is a VGA-type market, with enhancements, and should have moderate success, distinct from the TI or IBM standards.

The IBM standard is based on its 8514/A graphics board, which was introduced in 1987, but is only now beginning to show impressive results. It is clearly the de facto standard for high resolution on IBM's PS/2 machines. Chip vendors are already offering 8514/A-compatible products. TI is competing with third-party 8514/A vendors for this market. Dataquest believes that the 8514/A-type products are most suited for the next-generation mainstream graphics market.

STANDARDS IN THE IBM ENVIRONMENT

A graphics hardware standard allows a world of software to run on a family of machines from various vendors. The need for consistent display standards is acute in the IBM environment, where improvements in special resolution and number of colors is a constant but problematic process (unlike the Macintosh environment, where resolution density is fixed and the QuickDraw standard has been unwavering).

Under IBM, there have been two standards: the enhanced graphics adapter (EGA) standard was introduced in 1984 and was superseded in 1987 by the introduction of the VGA. The EGA was the best-selling product until 1988; now the VGA is the dominant standard. But there is considerable lag between when a standard is first introduced and its widespread availability and use. This lag is a result of the following requirements:

- Widespread software support
- Availability of third-party graphics chips, boards, and monitors
- Readiness of the distribution channel
- Acceptance by the user community

We expect the VGA to continue to be the best-selling product for the foreseeable future, although the next standard after VGA will build up momentum over the next 18 months.

There is a historical trend worth noting that follows the introduction of a new graphics standard by IBM. The steps are as follows:

- Phase I—IBM introduces a new graphics standard.
- Phase IIA—Third-party vendors introduce a semicompatible product.
- Phase IIB—Third-party vendors introduce a fully compatible product.
- Phase IIC—Third-party vendors introduce a fully compatible, but enhanced, version.
- Phase III—The original standard becomes a full commodity product.
- Phase IV—A new graphics standard is introduced.

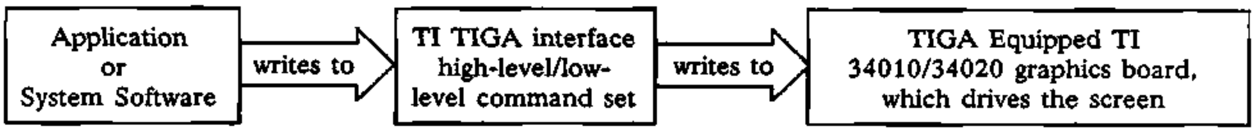
This cycle can take about three years. In terms of current standards, the industry is at about Phase III with the VGA and Phase IIB with the 8514/A. However, there is still considerable argument with regard to the acceptance of the 8514/A as the next standard after VGA, from certain camps that have alternative products to sell.

Current Situation of Standards

According to the trade press and third-party vendors, there are arguments among various camps regarding the next standard after VGA. Discussions of the camps follow.

The TI 34010/34020 TIGA

The Texas Instruments Graphics Architecture, or TIGA, is a new software interface from TI that will run on its 34010/34020 graphics processors. It will allow software written to the TIGA standard to run on any TI 34010/20-based graphics board that has been made TIGA compatible. This works as follows:



TI is promoting the above scheme as the next-generation mainstream graphics standard, as opposed to IBM's 8514/A standard.

IBM's 8514/A

The 8514/A is IBM's 1,024 x 768 resolution add-on board, and is based on proprietary VLSI parts. Software writes to the 8514/A as follows:

Third-Party Consortium's VESA

VESA is a screen-addressing scheme from a consortium of third-party graphics vendors. The scheme is an extension of IBM's VGA standard for offering resolution higher than that offered on VGA, at 16 or 256 colors. It is intended as an interim step between the basic VGA (640 x 480 resolution, 16 colors) and the next 1,024 x 768 resolution standard. The consortium consists of graphics board, chip, and monitor vendors.

Each of these standards can support interlaced or noninterlaced screens, which is irrelevant to the applications software or graphics standard.

THE STANDARDS BATTLE: 8514A, TIGA, AND VESA

Which one of the above standards or proposals is going to be the mainstream standard of the next few years?

To begin with, the VESA proposal is only an interim scheme that is to be used mainly with the current generation of 800 x 600 resolution-type multisynch monitors, and, in our view, it is not a long-term solution for 1,024 x 768 screens. The VESA proposal is acceptable for allowing enhanced VGA boards (which are mainly nonintelligent in nature) to come under one standards umbrella. The real battle is for an intelligent or processor-based 1,024 x 768 graphics standard, the two contenders for which are TI and IBM.

TI versus IBM

In Dataquest's view, there are four important fronts in the battle over the next graphics standard:

- Performance
- Compatibility
- User frustration
- Price

Performance

Historically, performance has been the most misused and abused area of comparison in all categories of graphics hardware before PC graphics—and this is again true in the current PC graphics battleground. Graphics performance numbers tend to be used like many statistics; that is, they are creatively selected and tailored to support any cause. So PC graphics performance numbers must be taken with a grain of salt. In general, however, several points can be safely observed:

- TI 34010 (and the resulting board) is a midrange to high-performance part. But being software-programmable as a general-purpose processor, it does not have the very high performance of a special-purpose processor hardwired to perform a specific function. The 34020 will be significantly faster—as will be the second iterations of competing parts.
- The IBM 8514/A chip set is a midrange part, specifically optimized for high performance in the IBM PC environment. It offers at least comparable, and often better, performance in the three important areas of BITBLT, line drawing, and character support.

The fundamental difference between the two competing parts is that, although the IBM part is hardwired to perform a limited set of functions quickly, it pays for this by not being as flexible as a general-purpose processor.

On the other hand, the TI part is a general-purpose, software-programmable microprocessor, which is why it is also usable in print controllers and fax machines. But it pays for this flexibility in raw drawing speed. (The old "no free lunch" principle—even the ill-fated, hardwired Intel 80786 was faster in some areas.)

The raging debate and hype (particularly from the TI camp) is that one part guarantees better performance than the other. We believe that the two parts are more similar in performance than dissimilar. Each is faster in some areas (TI does not own performance, although that is the message in the media), and each is expected to enhance its performance in the future. Furthermore, it would be naive to assume that third-party 8514/A parts will not be able to offer comparable performance in many cases and better performance in others.

Performance improvement is an ongoing process, provided one starts with a reasonable architecture, which is true for TI and IBM.

Compatibility

The fundamental mandate is to be compatible with all software written for the MS-DOS and OS/2 market at 1,024 x 768 resolution. This can be achieved in a number of ways:

- Be TI/TIGA compatible, and hope that most future software will support TIGA either directly or under Windows and Presentation Manager (PM). This is a reasonable assumption.

- Be IBM 8514/A compatible, either directly or through Windows/PM. This is a good bet because we expect the 8514/A to become a de facto standard.

The User Frustration Factor

Although TI is doing a very good job of eliciting software support for TIGA, there can be little doubt about the support IBM will continue to command. It would appear that the question is which product is expected to have the most support. But even if the answer is IBM's 8514/A, there is a larger question with regard to what we call the UFF, or the user frustration factor.

Dataquest believes that the aggravating incompatibilities in the PC environment make the PC less friendly to the average user than the Macintosh environment. Do users really need yet another standard? If vendors continue to muddy the waters with competing standards—in order to sell hardware at the expense of user friendliness—will the IBM platform ever be as friendly as the Mac?

Price

The TI 34010 costs approximately $20 to $40. The 8514/A parts from clone vendors are expected to be priced in the same range, although it will be higher at first. (This price is a small premium over VGA prices). Although the prices are similar for the graphics engine, what is different is the glue logic required for the finished board and its associated cost—which is expected to be lower for the more highly integrated 8514/A solutions. Another important issue is the expected economies of scale. If the 8514/A catches on as is forecast, there should be significant cost reductions. The competitive environment will also heavily impact prices: more than five vendors are expected to sell 8514/A parts, versus the sole-sourced TI part. Of course, such a highly competitive environment affects more than just pricing.

MARKET DYNAMICS

In this section, we present some of our forecasts, based on qualitative as well as quantitative factors. In the case of the 8514/A, such factors are the following:

- Installed base, growth rate, and backlog for the IBM 8514/A

- Current and expected software support

- Expected availability, pricing, and performance of third-party 8514/A chips
- Expected availability and pricing of compatible monitors, both interlaced and noninterlaced
- Growth in the PC and PS/2 market, as well as in the CAD, desktop publishing, and business graphics segments
- IBM's commitment to the standard, and its implementation on future PS/2 motherboards.

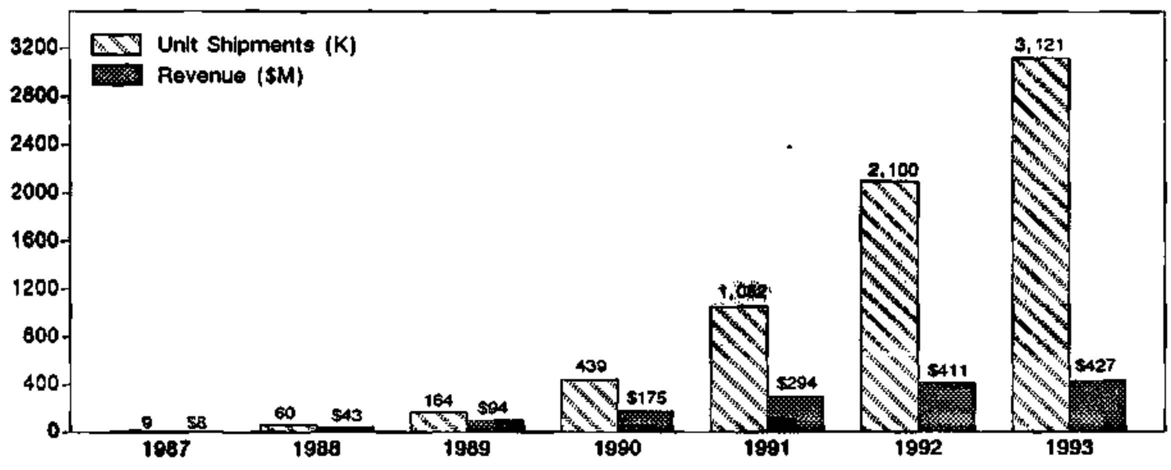
Figure 1 shows our forecast for 8514/A compatibles. Although we originally designed the 8514/A-compatibles forecast to include products that are at least AIFS, or software compatible, we expect that from 1990 onward, most 8514/A compatibles also will be hardware register-level compatible. We also expect that the non-8514/A-compatible market will be dominated by TI 34010/34020-based products.

Figure 2 shows Dataquest's forecast for high-end PC graphics products from all application segments, using all types of graphics engines. Our definition of high-end PC graphics includes mostly those products that have some intelligence, using any type of processor, and does not include "frame buffers" such as EGA/VGA and enhanced VGA.

Figure 3 is a forecast for all VGA compatibles.

Figure 1

High-End PC Graphics
8514/A Compatibles
Worldwide Forecast

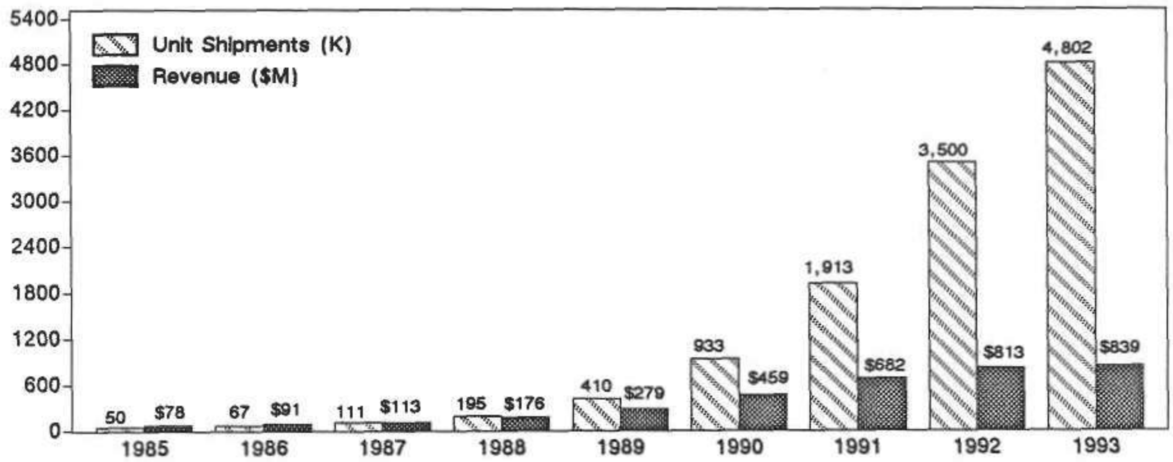


0004585-2

Source: Dataquest
June 1989

Figure 2

Total High-End PC Graphics
Worldwide Forecast



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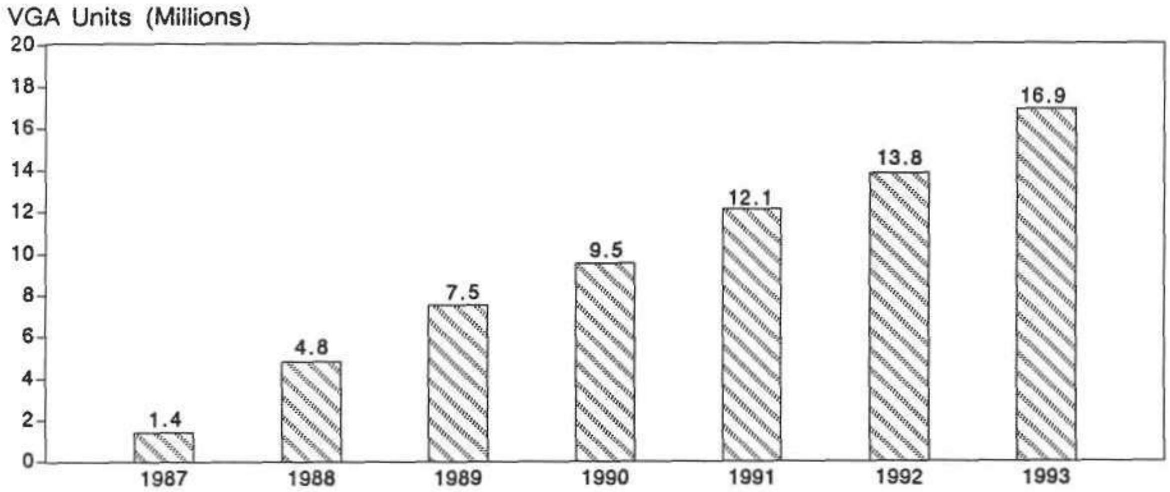
Source: Dataquest
June 1989

Figure 3

PC Graphics VGA Market
Worldwide Forecast



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Source: Dataquest
June 1989

VENDOR ACTIVITY

Texas Instruments

TI continues to promote its TI 34010 very aggressively and recently announced its standard graphics interface, called TIGA. Future graphics boards based on the TI part will be TIGA compatible, and software support is expected to be good. A number of vendors, including Compaq, Dell, Hewlett-Packard, and Wyse, have announced products based on the TI part. (Compaq is having its board done by Renaissance GRX of Bellevue, Washington.)

Tseng

Tseng initially had aggressive plans to target the 8514/A with its own VLSI, as it did in the VGA market. However, how soon the company gets in the running is currently not known.

Chips and Technologies

Chips announced its 8514/A compatible single-chip solution, the 82C480, on June 27, 1989. The company is providing an interface driver, the Adapter Interface (AI), and will also release a register specification document, giving software developers the option of bypassing the AI. The 82C480 offers ISA and MCA bus support (no EISA), interlaced display support to 1,600 x 1,200 resolution, and noninterlaced display support up to 2,360 x 1,770 resolution.

Western Digital Imaging

Western Digital Imaging (WDI) was the first vendor to announce an 8514/A-compatible chip set. On June 7 WDI announced a two-chip set, called the Personal Workstation Graphics Array 1 (PWGA1). The PWGA1 offers ISA, MCA, and EISA bus support and supports both interlaced and noninterlaced monitors at up to 1,280 x 1,024 resolution. The company will provide register-level interface specifications for software vendors.

Headland Technology

Headland Technology (formerly Video 7) reportedly is developing its own 8514/A-compatible chip set. The company is not expected to finish development in 1989, but it is planning to have 8514/A compatibles for 1990. In the past, it has offered boards based on another vendor's chip sets, and it may do so again.

Integrated Information Technology (IIT)

IIT is a new Santa Clara, California-based semiconductor company, the first products of which were math coprocessors. It plans to sell a register-level compatible 8514/A and VGA on a single chip product this year, with plans to sample in August 1989. The full-custom single chip will be offered as a 144-pin package. It uses a common memory space for both 8514/A and VGA screens. The part is initially to be sold for less than $100, and the company plans to come down the price curve aggressively. IIT intends to be in the chip business only; board sales are not anticipated.

IBM

IBM, the inventor of the 8514/A, has been shipping the product since third-quarter 1987, although shipments initially were very slow in ramping up. Since then, a significant body of software has been created that supports the device. IBM has shipped more than 100,000 of its 8514/A products and is expected to ship up to 150,000 in 1989 alone. Its backlog is considerable, and there is a wait of several weeks for products. So far, this activity has been without much of a marketing effort. IBM is now aggressively promoting the product for its PS/2 machines; it has no intention of offering it for the PC AT market. Furthermore, IBM is expected to implement it as a chip set on the motherboard of its higher-end PS/2s, starting early next year.

DATAQUEST ANALYSIS

In the battle between TI and 8514/A vendors, the question is not really about which is the better part. In Dataquest's opinion, TI has the more versatile part in general, while the IBM standard is specific to the PC and PS/2 environment. And all claims to the contrary, we believe that the IBM part does quite well—even better in many cases—against the TI part. Because the two choices are at least comparable in performance, we do not believe that performance should be the centerpiece of the argument when discussing the mainstream power-user market. (The TI 34010/34020, we believe, is well suited for certain line-drawing performance demanding markets such as CAD.)

For the mainstream market, the question is, if IBM compatibility is important, what is the more suitable part for IBM compatibility? The answer is the 8514/A.

But why is IBM compatibility important? Certainly, users will gain the peace of mind that any future software that supports high resolution will run on IBM and compatible hardware. That being the case, why do we need another standard? Dataquest contends that we do not. Establishing yet another standard is tedious and confuses a market that has had enough confusion (particularly with regard to bus structures—MCA versus EISA). With graphics standards aggravating an already tenuous situation, if the industry does not tread carefully, customers could migrate to Apple, Sun, and even IBM itself, at the expense of the IBM-compatible community.

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Research Newsletter

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FINALLY, AN EFFECTIVE STRATEGY FOR INTEGRATING MANUFACTURING ARRIVES

SUMMARY

This newsletter contains a summary of research performed by Dataquest's Computer Integrated Manufacturing (CIM) group earlier this year and an overview analysis of all major product segments.

1988 Highlights

Dataquest market intelligence has shown that 1988 was an improved year for the CIM industry worldwide compared with 1987. Competitive pressures on manufacturing end users increased during a period of relative global calm. The concept of the top–down, all–encompassing project that can magically transform an old plant, old equipment, and poorly trained employees into world–class competition—by throwing a lot of money at the problems—came to a full stop.

Instead, decentralization; downsizing; employee involvement and training; and incremental, continuous improvements in both methods and equipment became more common. What this means is that, in 1988, vendors of CIM systems and products experienced the following:

- Growing market opportunities, but smaller project investments
- Migration from large computers to PCs and microprocessors
- Software unbundling and downsizing to fit the hardware trends
- Major growth in factory networking and factory data collection systems to link the distributed computers into an integrated information system
- Market share positions that changed only slightly at the top, while the highly fragmented, lower–tier vendor level felt major shifts as alliances and mergers continued apace

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Expected 1989 to 1993 Highlights

Dataquest expects 1989 to be another year of growth for the worldwide and North American CIM industry. However, growth will slow in 1990 due to a business slowdown in North America, which will not be felt until 1991 in the rest of the world. The decline is expected to be mild, with full recovery within one year. We forecast a five-year compound annual growth rate (CAGR) of more than 13 percent from 1989 to 1993.

Key trends in the CIM market include the following:

- Networks and factory data collection systems will experience the highest growth of all CIM product segments.
- Computer and controller revenue will slow as microprocessors and desktop computers become the primary CIM hardware platforms.
- Manufacturing information systems will be real-time, distributed systems developed by and controlled by technically sophisticated workers.
- Alliances and joint ventures will be the common strategy used to cope with global markets and competitors.
- CIM industry fragmentation will decline as the top vendors expand their CIM scope and the smaller vendors are left to hope that they can be a part of the larger groups.
- Worldwide CIM markets will continue to expand as manufacturers of all sizes and industries are forced to automate to stay in business.

WHAT HAPPENED IN 1988?

Perhaps the most significant development in 1988 was the recognition by North American policymakers of a fact that has been known all along by their European and Asian counterparts: Manufacturing matters. Its corollary, that computer hardware, software, and networking make manufacturing more efficient than manual operations, has resulted in expanded business opportunities for CIM systems vendors.

In 1988 microprocessors began to change the way that end users approach CIM. Weary and wary of the top-down, centralized, mainframe-oriented MIS factory automation concepts, end users adopted a new method for implementing CIM through bottom-up, decentralized, microcomputer-oriented work-group development. The results were as follows:

- Smaller second- and third-tier manufacturing sites began to bring computer-based control systems into their factories.
- Desktop PCs were turned into real-time monitoring and control systems by means of application-specific add-in boards.
- Focus shifted from total systems solutions to lowest-level applications implemented largely by the systems users, not MIS or outside vendors.

- Networking and relational data base management systems became areas of critical concern.

- Microcomputer software for statistical process control and data input boomed.

- Design for manufacturability (DFM) concepts emerged as a key factor in being able to bring new products to market quickly.

CIM SYSTEM VENDORS' 1988 MARKET SHARE POSITIONS

In January and February of 1989, Dataquest sent primary research survey questionnaires to more than 600 North American CIM systems and products vendors. Market share positions were estimated for both domestic and worldwide revenue for each vendor that had manufacturing facilities within the North American region. Vendor share positions for 1988 are based upon worldwide revenue, as shown in Table 1.

Table 1

1988 Top 20 Market
Total CIM
(Millions of Dollars)

	Revenue			Market Share		
	North America	Rest of World	World-wide	North America	Rest of World	World-wide
IBM	2,751.0	2,980.0	5,731.0	23.1%	33.9%	27.7%
Digital Equipment	1,714.0	1,460.0	3,174.0	14.4%	16.6%	15.3%
Hewlett-Packard	1,050.0	1,050.0	2,100.0	8.8%	12.0%	10.1%
Unisys	902.0	769.0	1,671.0	7.6%	8.8%	8.1%
Honeywell	478.0	477.0	955.0	4.0%	5.4%	4.6%
Allen-Bradley	332.0	203.0	535.0	2.8%	2.3%	2.6%
MODICON/AEG	300.0	.0	300.0	2.5%	.0%	1.4%
Foxboro	128.0	156.0	284.0	1.1%	1.8%	1.4%
General Electric/Fanuc	241.0	.0	241.0	2.0%	.0%	1.2%
Bailey Controls	120.0	120.0	240.0	1.0%	1.4%	1.2%
Measurex	125.0	84.0	209.0	1.0%	1.0%	1.0%
Prime Computer	92.0	83.0	175.0	.8%	.9%	.8%
Tandem Computers	68.8	102.0	170.8	.6%	1.2%	.8%
McDonnell Douglas Info. Sys.	106.0	63.0	169.0	.9%	.7%	.8%
MSA	131.4	34.2	165.6	1.1%	.4%	.8%
Apple Computer	113.0	20.0	133.0	.9%	.2%	.6%
NCR	89.4	40.1	129.5	.8%	.5%	.6%
AccuRay	68.0	46.0	114.0	.6%	.5%	.6%
Data General	77.0	33.0	110.0	.6%	.4%	.5%
Fisher Controls International	53.0	52.0	105.0	.4%	.6%	.5%
Texas Instruments	83.0	20.0	103.0	.7%	.2%	.5%
Other Companies	2,897.8	988.5	3,886.3	5.9%	2.7%	4.5%
All Companies	11,920.4	8,780.8	20,701.2	100.0%	100.0%	100.0%

Source: Dataquest
July 1989

IBM has almost twice the worldwide share of its nearest rival, Digital Equipment Corporation. This first-place position is achieved through IBM's strengths in mainframe and PC hardware and its dominant position in manufacturing software revenue. Although not included in CIM revenue, IBM's CIM position is greatly strengthened strategically by its number one market share positions in both CAD/CAM and office automation systems installed in manufacturing sites. A balanced base will be of increasing importance strategically to both vendors and end users as the concept of CIM widens out to include all functional activities in a manufacturing enterprise.

Digital Equipment Corporation ranked second in market share position in 1988, not only in total CIM, but also in all three CIM product segments. Digital's strengths in the CIM market stem from its long-standing acceptance by the engineering and production operations end users, and from the ease of integration of both networking and connectivity. A significant event for Digital in the CIM market in 1988 was the joint development of the Pyramid Integrator that allows Allen-Bradley's PLCs to communicate with Digital's batch-oriented, higher-level computers. Alliances between CIM vendors that provide users with a full spectrum of compatible products should continue to make CIM implementation more feasible in the future.

Hewlett-Packard was in the number three market share position in total CIM as well as in all three product segments. As with IBM and Digital, HP's balanced product capability has been an effective market strategy in the CIM industry. HP's reputation for product quality and service integrity has no doubt been a major source of competitive strength. Furthermore, HP president John Young and other top executives have strong manufacturing backgrounds. Mr. Young was chairman of the President's Commission on Industrial Competitiveness, and he is strongly committed to fostering CIM capabilities in U.S. industry.

Unisys held the fourth-ranked market-share position in total CIM in 1988. The major strength of this vendor has been in the aerospace industry and in medium-size enterprises across a broad range of manufacturing industries. Most of its revenue is obtained from mainframe-oriented hardware and software for planning, control, and procurement/distribution applications. Unisys is building a broader base of CIM products. In 1988, major new products were announced by AutoFact, indicating that this corporation is committed to the CIM industry as a strategic market target.

Honeywell ranks fifth in total CIM market share and first in the networks and data input systems product segment. Honeywell's primary revenue is derived from its distributed control system products such as the TDC 3000 and its associated proprietary network. Most of the revenue is obtained from the continuous process industries, with petrochemicals being the largest buyer.

Other top 20 market share vendors are shown in Table 1. Even though the vendors are North American-based, the large percentage of revenue derived from the rest of the world emphasizes the global nature of the CIM industry. Vendors that expect to be significant participants in the market will be forced to sell worldwide. Many vendors either have, or are in the process of establishing, multinational alliances.

MARKET FORECAST BY PRODUCT SEGMENTS

Dataquest worldwide estimates for the CIM market between 1989 and 1993 are summarized in Table 2. The CAGR includes the assumptions of a business slowdown in 1990 and an annual inflation rate of 4 percent each year.

Table 2

Worldwide Revenue—North American Vendors
CIM Forecast
All Product Segments
(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	CAGR 89-93
Computers and Controllers	10,652.2	11,762.7	12,864.4	14,097.3	15,497.4	17,055.7	9.7%
Software	5,082.1	5,900.5	6,791.3	7,866.2	9,229.2	10,955.8	16.7%
Networks & Data Input	1,804.1	2,156.2	2,564.7	3,074.5	3,786.5	4,724.4	21.7%
Service	3,162.8	4,021.4	4,501.5	5,036.5	5,663.1	6,417.5	12.4%
Total	20,701.2	23,840.7	26,721.9	30,074.6	34,176.2	39,153.4	13.2%

Source: Dataquest
July 1989

The market for all major product segments is expected to nearly double in revenue between 1988 and 1993. Computers and controllers, the largest segment, will have the lowest CAGR. The smallest segment, networks and data input, will see the highest CAGR. The software CAGR will approximate the overall 13.2 percent CIM growth rate.

The major reasons for the different CAGRs are as follows:

- Trend toward distributed microcomputer-based hardware in place of centralized mainframe and minicomputer platforms, thus reducing hardware unit revenue but expanding unit shipments

- Expansion of revenue for networking computer systems to achieve distributed data base access across functional groups and between levels of organization

- Growth of third-party, application-specific software vendors along with simultaneous reduction of unit revenue as software migrates from mainframes toward microcomputers

- Overall growth in the CIM market revenue as global competition intensifies and automation technologies mature

Manufacturing Computers and Controllers

Dataquest estimates that worldwide revenue for computers and controllers will have a CAGR of 9.7 percent between 1989 and 1993. During this period Dataquest forecasts the following key trends:

- Workstations and PCs will merge functionally, and vendors from each segment will compete in the CIM market.
- Microprocessor boards added to PCs will take revenue away from PLCs.
- Minicomputers will be replaced by industrial controllers that are specifically designed for real-time process control applications.
- Mainframes will be used primarily for data base management, communications control, and high-level planning functions.

Manufacturing Software

Software for the CIM industry is provided by literally thousands of small vendors. Language barriers between cultures tend to make the market less global than the hardware or networking segments of CIM. Furthermore, software tends to follow hardware developments—such as 32-bit microprocessor and RISC architectures—by several years.

Although hardware vendors supply a sizable proportion of manufacturing software, the trend is toward third-party vendors that often form alliances with hardware vendors. Examples include MSA with Tandem Computers, ASK Computers with Hewlett-Packard, McCormick & Dodge with Digital Equipment, and Cincinnati Milacron with IBM.

Major trends that Dataquest expects in the software segment include the following:

- A boom in software for quality assurance applications
- Growth in software tools and graphical user interface languages
- Application-specific, board-level software developments for test instrumentation and data collection
- Major vendors developing cell control, real-time shop floor control, and FMS software packages
- Revenue growth rates stabilizing at 15 to 18 percent annually

Networks and Factory Data Input Systems

This segment will be the most dramatic in terms of vendor emergence and demise, technology developments, user implementation, and market revenue growth rate. The push by users to change manufacturing facilities from fragmented islands of automation into a single, networked site is forcing both hardware and software vendors to consider how their products will fit into the system.

The fastest-growing part of this segment is factory data collection systems (FDCS). Users recognize that, without the ability to determine the status of the production operations in real time, they cannot be responsive to the ever-changing needs of the factory. This requirement will cause FDCS to be the largest revenue source in the network segment of CIM.

Key trends in this segment include the following:

- Differentiation of products based upon software instead of hardware

- Emergence of fiber optics as the primary LAN backbone technology

- Acceptance of both MAP and Ethernet as standards for different application requirements

- Integration of FDCS into factory LANs

- Decreasing industry fragmentation as vendors merge

MARKET FORECAST BY REGION

Dataquest estimates that the total worldwide CIM market will reach approximately $40 billion by 1993. This represents roughly 3 percent of the expected worldwide capital investments in manufacturing plants and equipment. A larger proportion of revenue in manufacturing comes from systems such as programmable machine tools, automated materials handling, and inspection/test systems. Even so, compared with the proportion of investments in office automation, manufacturing automation investment is still in its infancy.

Table 3 summarizes Dataquest's regional revenue by North American vendors domestically, internationally, and worldwide. In 1988, approximately one-third of all revenue was derived from international sales. By 1993, nearly half of the revenue of these vendors is expected to come from outside of the North American region. Some of the key reasons for this dramatic change are as follows:

- Products from North American computer vendors will continue to be in demand worldwide because of their technical innovation, especially in microprocessors and workstations, the segments with the largest expected growth.

- Software from North American vendors will be dragged along with hardware into the Rest of World (ROW) segment.

- Continuing weakness of the U.S. dollar will make automation systems from North America attractive in terms of price when compared with European and Japanese systems.

- ROW will continue to invest in CIM at a higher rate than in North America because of the available capital in these regions. This investment will expand the market opportunities in ROW more than in North America.

Table 3

Forecast by Region
Total CIM
(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	89-93 CAGR
North America	11,920.4	12,880.0	14,102.0	15,691.6	17,588.2	19,845.7	11.4%
Rest of World	8,780.8	10,960.7	12,619.9	14,383.0	16,588.0	19,307.7	15.2%
Worldwide	20,701.2	23,840.7	26,721.9	30,074.6	34,176.2	39,153.4	13.2%

Source: Dataquest
July 1989

Many of the largest North American computer vendors have manufacturing facilities in Europe and Asia. These facilities provide local production of products that match the cultural needs of that area. The local presence also provides a sales channel for products that are exported by the company from North American manufacturing facilities.

This local regional presence also diminishes the impact of local trade barriers. For example, parts produced in North America may be assembled locally, thus permitting revenue to be generated from the parts that are made in North America and exported for local assembly.

Manufacturing software is less portable than hardware because of language and local practice barriers in the rest of the world. However, many North American software vendors have recognized the large market potential in the rest of the world. They have translated and customized their products to fit the needs of local markets.

Dataquest forecasts a higher rate of software growth for North American vendors between 1989 and 1993 in the ROW segment than is expected in the domestic market segment. This forecast is based in part on the fact that growth starts from a lower base in the rest of the world, and in part on the fact that the levels of capital investment in manufacturing are higher in the rest of the world than in North America.

Dataquest forecasts that the North American market will remain the largest revenue source for networks and factory data collection systems between 1989 and 1993. Starting from a smaller base, the rest of the world will have a CAGR that is approximately 5 percent higher than North America during this period. Because of the competitive pressures to increase production efficiency, both European and Japanese manufacturers are expected to implement factory networks at growth rates that exceed most of the manufacturing high-technology products.

DATAQUEST ANALYSIS

Global competitive pressures are forcing manufacturers to make increasing capital expenditures for CIM systems. End users are gaining productivity benefits by installing microcomputer-based products in a modular approach to integration. This environment is providing significant market growth opportunities for vendors of most, but not all, CIM product segments.

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Terrance A. Birkholz
David C. Penning

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Research *Bulletin*

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OEM MONTHLY—JULY 1989
BUSINESS EQUIPMENT IN THE HOME

OEM Monthly provides insight into application markets so that clients can make better strategic and technical marketing decisions.

Figure 1
U.S. Working-at-Home Forecast

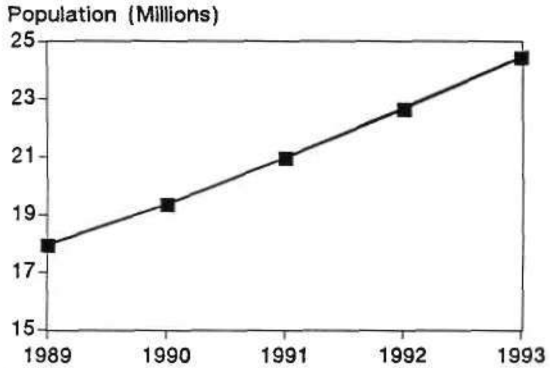


Figure 2
Estimated U.S. Household Penetration

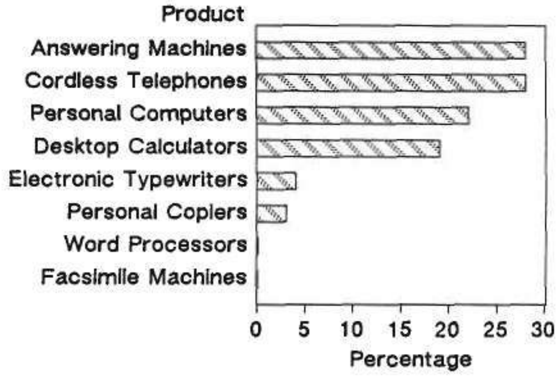


Figure 3
Estimated 1989 Shipments to U.S. Homes

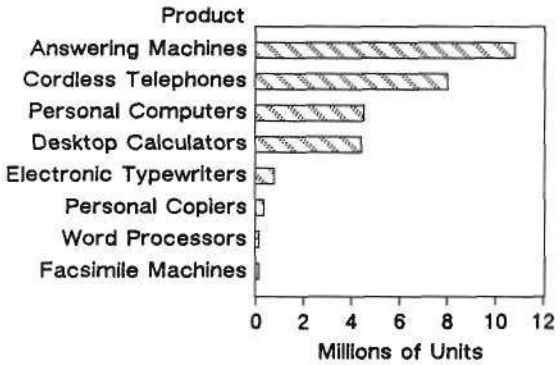
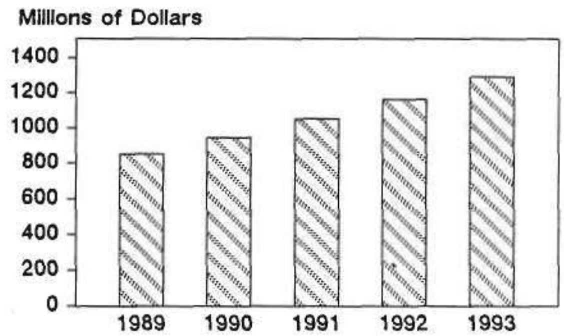


Figure 4
Semiconductor Content Forecast



0004534-1

Source: Dataquest
July 1989

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

LIFESTYLE SHIFTS

More Americans are planning to work at home in the future (see Figure 1). Part-timers will either moonlight in home businesses or "telecommute" for a few days each month, while full-timers at home may be midcareer refugees from the corporate world.

Dataquest estimates that 69 million persons, or 59 percent of the 116-million-person U.S. work force, are employed as information workers. We also estimate that the total potential for home offices in the United States is 55 million, or 59 percent of the 93 million U.S. households.

HOUSEHOLD CONSUMPTION

Advances in electronics have made business equipment (e.g., personal computers, personal copiers, and fax machines) affordable to home users. The resulting ease of starting a business in the home has in turn created a large demand for business equipment there (see Figures 2 and 3).

Items such as telephones and answering machines may be purchased for nonbusiness purposes, but become necessities in a home business. Items such as fax machines and personal copiers, however, usually are purchased to increase business productivity.

Marketing channels to the home are evolving. For example, Computer Supercenters International is planning to build 20 stores over the next five years to tap the emerging home and small business markets. These stores will be 25,000 square feet in size and are much larger than the existing 5,000 square foot stores that sell to larger businesses.

SEMICONDUCTOR CONTENT

Dataquest estimates that shipments of business equipment to the home are increasing at a compound annual growth rate (CAGR) of 11 percent and that this market growth is creating additional demand for semiconductor components (see Figure 4).

Most of the products purchased by home businesses are the low-cost models of the same equipment sold to large corporations. As the size of the home market increases, however, Dataquest believes that equipment models will be developed exclusively for home users' special needs.

DATAQUEST CONCLUSIONS

More businesses are started during hard times than during good times because a person out of work no longer has the security of a steady job. We recommend that semiconductor suppliers look at the business equipment sold to the home market for additional revenue during recessions.

Roger Steciak

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Research Newsletter

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PCs
'88 REVIEW; '89 INSIGHT

INTRODUCTION

Was 1988 a really great year for the PC industry? For some PC vendors, it was a banner year—for others, barely survival. For still others, actual volume growth still resulted in some market share loss. In this newsletter, we will look at the unit shipment and if-sold-value numbers, compare market share growth, and analyze the key events of 1988 and their probable effects on the industry in 1989 and beyond. We will also briefly review the top three PC vendors for 1988, in light of what we may expect for 1989.

INDUSTRY GROWTH

Tables 1, 2, 3, and 4 identify the prominent members of the 1988 PC marketplace. Tables 1 and 2 depict the estimated worldwide shipments and if-sold value for each of the top 10 major vendors, based on 1988 ranking. Tables 3 and 4 show the top 10 players for PCs shipped into the United States, in both units and if-sold value. We have listed relative market share gains and losses in both cases, compared to 1987, and our estimated ranking for 1989 in both categories. Please note that we have changed our method for computing if-sold value. In the past we have attempted to estimate street pricing for PC models and configurations in order to reflect the role up for industry valuation. This was accomplished by applying an "average" discount rate to the manufacturer's suggested retail price for each model. However, distribution methods recently have changed significantly. There is no longer any way to closely approximate an "average" discount. This is due in large part to the ever-increasing use of alternate distribution channels such as mail order direct, mass merchandising, club distribution, widely varying discount rates that are dependent upon unit commitments, and the increasing use of the VAR channel.

Dataquest now believes that the only way we can fairly represent the if-sold value of the various manufacturers' models and configurations is to reflect their suggested retail price, while assuming an "average" configuration per model. In this way, we can "level the playing field" and our clients can make valid comparisons between manufacturers, regardless of the discount pricing strategies employed by each one. This change has been used in computing the 1988 and 1989 if-sold values shown in Tables 2 and 4. These tables reflect the changes in if-sold-value valuation methods. The 1987 to 1988 Growth columns use 1987 valuation, in order to show the actual dollar growth. The 1988 to 1989 Growth columns reflect 1988 valuation. The affected columns are noted with an asterisk. Relative market share between vendors remains unchanged within a given year.

Table 1

Estimated Worldwide Unit Shipment and Market Share of Top 10 PC Vendors Ranked by 1988 Unit Shipments (Thousands of Units)

	1987	1987	1988	1988	1989	1989	1987 to 1988 Growth			1988 to 1989 Growth		
Vendor	Units	M/S	Units	M/S	Units	M/S	Unit	Percent	M/S	Unit	Percent	M/S
IBM	2,244.0	13.4%	2,157.0	11.3%	2,292.0	10.8%	(87.0)	(3.9%)	(2.1%)	135.0	6.3%	(0.4%)
Apple	1,514.0	9.0	1,769.0	9.2	2,083.0	9.8	255.0	16.8%	0.2%	314.0	17.8%	0.6%
Commodore	1,621.0	9.7	1,622.4	8.5	1,719.4	8.1	1.4	0.1%	(1.2%)	97.0	6.0%	(0.3%)
NEC	838.0	5.0	923.1	4.8	1,011.4	4.8	85.1	10.2%	(0.2%)	88.3	9.6%	0
Atari	857.0	5.1	862.0	4.5	914.0	4.3	5.0	0.6%	(0.6%)	52.0	6.0%	(0.2%)
Amstrad	1,337.0	8.0	754.3	3.9	813.5	3.8	(582.7)	(43.6%)	(4.0%)	59.2	7.8%	(0.1%)
Tandy	690.0	4.1	613.1	3.2	684.4	3.2	(76.9)	(11.1%)	(0.9%)	71.3	11.6%	0
Zenith	448.0	2.7	562.0	2.9	622.7	2.9	114.0	25.4%	0.3%	60.7	10.8%	0
Compaq	401.0	2.4	527.0	2.7	620.4	2.9	126.0	31.4%	0.4%	93.4	17.7%	0.2%
Olivetti	358.0	2.1	440.1	2.3	564.9	2.7	82.1	22.9%	0.2%	124.8	28.4%	0.4%
Others	6,487.0	38.6	6,941.6	46.6	9,822.2	46.4	2,454.6	37.8%	8.0%	880.6	9.8%	(0.2%)
Total	16,795.0	100.0%	19,171.6	100.0%	21,147.9	100.0%	2,376.6	14.2%	-	1,976.3	10.3%	-

Source: Dataquest
July 1989

Table 2

Estimated Worldwide If-Sold Value and Market Share of Top 10 PC Vendors Ranked by 1988 If-Sold Value (Millions of Dollars)

Vendor	1987 ISV	1987 M/S	1988 ISV*	1988 M/S	1989 ISV	1989 M/S	1987 to 1988 Growth ISV**	1987 to 1988 Growth Percent	1987 to 1988 Growth M/S	1988 to 1989 Growth ISV	1988 to 1989 Growth Percent	1988 to 1989 Growth M/S
IBM	$ 8,063.0	24.5%	$ 8,031.6	15.5%	$ 8,955.9	13.9%	($1,557.4)	(19.3%)	(8.9%)	$ 924.3	11.5%	(1.6%)
Apple	3,190.0	9.7	5,068.3	9.8	6,260.2	9.7	915.3	28.7%	0.1%	1,191.9	23.5%	(0.1%)
Compaq	1,695.0	5.1	3,034.8	5.9	3,795.8	5.9	763.2	45.0%	0.7%	761.0	25.1%	0
NEC	2,017.0	6.1	2,662.1	5.2	3,369.4	5.2	139.3	6.9%	(1.0%)	707.3	26.6%	0.1%
Zenith	1,225.0	3.7	2,539.6	4.9	3,135.4	4.9	832.1	67.9%	1.2%	595.8	23.5%	0
Commodore	1,030.0	3.1	1,730.6	3.3	1,725.0	2.7	371.8	36.1%	0.2%	(5.6)	(0.3%)	(0.7%)
Olivetti	898.0	2.7	1,217.1	2.4	1,995.8	3.1	87.9	9.8%	(0.4%)	778.7	64.0%	0.7%
Tandy	1,029.0	3.1	874.7	1.7	1,243.3	1.9	(320.5)	(31.1%)	(1.4%)	368.6	42.1%	0.2%
Epson	543.0	1.6	862.0	1.7	911.1	1.4	155.2	28.6%	0	49.1	5.7%	(0.3%)
Toshiba	640.0	1.9	776.5	1.5	1,257.9	2.0	(11.0)	(1.7%)	(0.4%)	481.4	62.0%	0.5%
Others	12,630.0	38.3	24,880.0	48.1	31,738.0	49.3	7,522.8	59.6%	9.8%	6,858.0	27.6%	1.1%
Total	$32,960.0	100.0%	$51,677.3	100.0%	$64,387.8	100.0%	$8,898.7	27.0%	-	$12,710.5	24.6%	-

*1988 ISV uses Manufacturers' list price valuations.
**Growth for 1987 to 1988 based on 1987 valuation method. Growth for 1989 based on 1988 valuation method.

Source: Dataquest
July 1989

Table 3

Estimated U.S. Unit Shipment and Market Share of Top 10 PC Vendors Ranked by 1988 Unit Shipments (Thousands of Units)

Vendor	1987 Units	1987 M/S	1988 Units	1988 M/S	1989 Units	1989 M/S	1987 to 1988 Growth Unit	1987 to 1988 Growth Percent	1987 to 1988 Growth M/S	1988 to 1989 Growth Unit	1988 to 1989 Growth Percent	1988 to 1989 Growth M/S
Apple	1,242.0	14.3%	1,271.8	12.8%	1,412.8	12.9	29.8	2.4%	(1.5%)	141.1	11.1%	0.1%
IBM	1,555.0	17.8	1,229.5	12.4	1,480.4	13.5	(325.5)	(20.9%)	(5.5%)	250.9	20.4%	1.1%
Commodore	679.0	7.8	665.2	6.7	670.6	6.1	(13.8)	(2.0%)	(1.1%)	5.4	0.8%	(0.6%)
Tandy	590.0	6.8	539.6	5.4	574.9	5.2	(50.4)	(8.5%)	(1.3%)	35.3	6.5%	(0.2%)
Zenith	369.0	4.2	442.4	4.4	489.8	4.5	73.4	19.9%	0.2%	47.4	10.7%	0
Atari	402.0	4.6	400.9	4.0	408.8	3.7	(1.1)	(0.3%)	(0.6%)	7.9	2.0%	(0.3%)
Compaq	314.0	3.6	347.8	3.5	381.5	3.5	33.8	10.8%	(0.1%)	33.7	9.7%	0
Epson	192.0	2.2	212.2	2.1	218.5	2.0	20.2	10.5%	(0.1%)	6.3	3.0%	(0.1%)
HP	108.0	1.2	187.3	1.9	204.2	1.9	79.3	73.4%	0.6%	16.9	9.0%	0
Toshiba	141.0	1.6	173.3	1.7	191.2	1.7	32.3	22.9%	0.1%	17.9	10.3%	0
Others	3,123.0	35.8	4,484.0	45.0	4,932.1	45.0	1,361.0	43.6%	9.2%	448.1	10.0%	(0.1%)
Total	8,715.0	100.0%	9,954.0	100.0%	10,964.9	100.0%	1,239.0	14.2%	-	1,010.9	10.2%	-

Source: Dataquest
July 1989

Table 4

Estimated U.S. If-Sold Value and Market Share of Top 10 PC Vendors Ranked by 1988 If-Sold Value (Millions of Dollars)

	1987	1987	1988	1988	1989	1989	1987 to 1988 Growth			1988 to 1989 Growth		
Vendor	ISV	M/S	ISV*	M/S	ISV	M/S	ISV**	Percent	M/S	ISV	Percent	M/S
IBM	$ 5,491.0	29.7%	$ 4,578.0*	15.7%	$ 5,783.7	15.8%	($1,782.82)**	(32.5%)	(14.0%)	$1,205.7	26.3%	0.1%
Apple	2,550.0	13.8	3,550.3*	12.2	4,147.2	11.3	325.74**	12.8%	(1.6%)	596.9	16.8%	(0.8%)
Compaq	1,350.0	7.3	2,003.0*	6.9	2,334.4	6.4	272.43**	20.2%	(0.4%)	331.4	16.5%	(0.5%)
Zenith	1,022.0	5.5	1,997.5*	6.8	2,466.1	6.7	237.06**	23.2%	1.3%	468.6	23.5%	(0.1%)
Tandy	899.0	4.9	769.7*	2.6	1,044.4	2.9	(275.54)**	(30.6%)	(2.2%)	274.7	35.7%	0.2%
Commodore	483.0	2.6	709.5*	2.4	672.7	1.8	91.70**	19.0%	(0.2%)	(36.8)	(5.2%)	(0.6%)
NEC	295.0	1.6	701.1*	2.4	1,258.2	3.4	272.89**	92.5%	0.8%	557.1	79.5%	1.0%
HP	330.0	1.8	619.7*	2.1	879.4	2.4	171.95**	52.1%	0.3%	259.7	41.9%	0.3%
Wyse	223.0	1.2	570.2*	2.0	608.9	1.7	238.86**	107.1%	0.7%	38.7	6.8%	(0.3%)
Toshiba	331.0	1.8	563.1*	1.9	804.4	2.2	125.11**	37.8%	0.1%	241.3	42.9%	0.3%
Others	5,544.0	29.9	13,126.7*	45.0	16,609.7	45.4	5,088.62**	91.8%	15.0%	3,483.0	26.5%	0.4%
Total	$18,518.0	100.0%	$29,188.8*	100.0%	$36,609.1	100.0%	$4,766.01**	25.7%	-	$7,420.3	25.4%	-

*1988 ISV uses Manufacturers' list price valuations.
**Growth for 1987 to 1988 based on 1987 valuation method. Growth for 1989 based on 1988 valuation method.

Source: Dataquest
July 1989

On a worldwide basis, the industry did very well, growing approximately 14.2 percent and 27.0 percent over 1987 in unit shipments and dollar volume, respectively. More than 19 million PCs were shipped, accounting for a healthy $51.6 billion (1988 valuation model) in if-sold value. We expect 1989 to reflect continued growth in the industry, but at a slightly slower rate, especially in the United States. The worldwide shipment count is expected to top 21 million units, generating an if-sold value of over $64 billion. This would represent a 10.3 percent growth in units and a 24.6 percent growth in revenue for 1989. The reason for the surge in revenue is the focus on the more expensive i386 processor, together with recent introductions from many vendors of the 33-MHz models, and a dramatic increase in memory requirements for these systems. We expect the average PC memory configuration to be between 2 and 4MB on these bigger systems, and up to 8MB on PCs used as data base and communications servers. Software operating environments such as OS/2 and the attendant large applications will need at least 2 to 3MB of DRAM, in order to run even small applications.

Worldwide, IBM still holds the number one spot in both units shipped and if-sold value. They did, however, lose more than 2 percent market share in units and almost 9 percent market share in if-sold value. We will review some of what we believe are the key reasons for this continued market share slide later in this newsletter.

DATAQUEST ANALYSIS

In the United States, the big news is that Apple has surpassed IBM as the number one PC vendor in units shipped. The majority of these shipments were Macintosh, but the Apple II line, led by the Apple IIGS, still accounted for 46 percent of Apple shipments. Without detracting from Apple's continued growth, the most significant reason for this exchange of the top spot is a significant increase of market share in the United States by a host of vendors, the vast majority of which are Taiwanese and Korean. Evidence of this is the dramatic increase in the Other category's shipments during 1988. This category accounted for 45.0 percent of the U.S. market in 1988, compared with only 35.8 percent in 1987. By combining the increase in the Other category, continued steady growth for Apple, and IBM's dramatic 20.9 percent decline in units shipped, and comparing these figures with 1987 volumes, the results become apparent. The same did not hold true, however, for if-sold-value performance. IBM retained the number one spot with more than $4.5 billion in PC platform if-sold value. Nevertheless, this figure did represent a staggering 32.5 percent reduction in value of shipments, compared with 1987. This translates to a market share loss of 14.0 percent, leaving IBM with 15.7 percent of the U.S. PC market.

The overall market in the United States grew 14.2 percent from 1987 to 1988 in unit shipments and 25.7 percent in if-sold value. The most dramatic growth was demonstrated by Hewlett-Packard Company, whose shipments of the Vectra series grew at a 73 percent rate, from 108,000 to 187,000 units. HP has moved into the top 10 and is now ranked number nine in U.S. unit shipment and number eight in if-sold value. We expect the strong growth to continue in the PC market for 1989, but at a slower rate than previously. The growth rate for the U.S. market in 1989 is expected to be 10.2 percent in units and 25.4 percent in if-sold value. The worldwide market is expected to grow 10.3 percent in units shipped and 24.6 percent in if-sold value.

The Top Three 1988 Vendors

IBM

IBM continued to lead the worldwide market both in units shipped and in revenue, despite significant market share loss both in the United States and worldwide. This was a result of a combination of many elements—the abandonment of the AT bus, when it was anything but clear that customers were ready to shift, wholesale, to the Micro Channel platform; considerable confusion within IBM management as to the companies' strategic direction; some significant issues within the dealer channel relationships; and the much stronger competition from Compaq, HP, NEC, Olivetti, Zenith, and the many new Asian clones. The introduction of the model 30-286 in mid-1988 sent some messages of unclear strategic direction for IBM. However, the company recently has begun to solidify its strategic direction with continued emphasis on OS/2, EE, and SAA. IBM has shown real market strength in Europe. We expect IBM to continue to be the market leader and protect its market share with increased applications ported to OS/2 and significantly more MCA add-in cards available in 1989. The recent and long-awaited announcement of the PS/2 Model 55 SX addition to IBM's product line supports its responsiveness to customer needs. The introduction of the new PS/2 model is also consistent with IBM's overall product plan, which was outlined in early 1988. We also expect IBM to introduce a 33-MHz 386 this summer and possibly an i486 configuration by year-end. A PS/2 model 70 with an i486 on board for demonstration purposes was shown at Spring Comdex.

Apple

A solid number two in market share is Apple. While this company has had its share of somewhat public management problems during 1988, its success with the Macintosh and Apple II lines with customers cannot be disputed. Apple has benefited from the EISA/MCA controversy because it has not varied from its NuBus platform. In 1988 the industry experienced an explosion of PC LAN connectivity products aimed at the Macintosh. Macs can now communicate with host computers from Cray, Digital Equipment Corporation, HP, IBM, and Sun Microsystems. Mac products now support Ethernet, TCP/IP, DECnet, fiber optics, telephone wire, bridges, and gateways. We expect future products from Apple that support LU 6.2, token ring, and OSI. The recent SE30 and Mac IIcx systems have met with substantial early success. Look for Apple to release new, more modular systems and actually enter the portable market in 1989.

Compaq

Compaq had a banner year in 1988. The introduction of the 386S desktop system and the SLT/286 portable met with major success. Compaq is totally committed to the EISA bus architecture and will, together with the other members of the consortium such as Zenith, HP, Wyse, Tandy, and Olivetti, introduce a prototype in midyear and expect production late in 1989; for instance, we already have seen glimpses of card connectors. Dataquest does anticipate that only high-performance systems will be made available with the EISA bus. The i386s in the 20-, 25-, and 33-MHz range, and probably the i486, will be introduced during the last quarter of this year or the first quarter of next. We fully expect Compaq to continue its winning ways. The recent dissolution of its business relationship with Businessland will, we believe, not have a significant effect on Compaq's long-term success.

Hardware and Software Technology

Many issues captured the attention of manufacturers, distributors, value-added resellers, and end users during 1988. Let's examine some of those that have had a profound effect on the health of the industry during this past year. We fully expect these issues to have a continued effect on the industry for some time to come. We will divide these into hardware platform and software application areas and look carefully at each.

Hardware Technology

In the platform area, it may have seemed as if someone was introducing yet one more 16-, 20-, or 25-MHz i386 machine every week. Actually, that rate is pretty close. There are more than 100 PC manufacturers worldwide, producing more than 400 PC models, and most have introduced new 386s in 1988. The competition in the 286 and 386 areas has been fierce. Price erosion and, in some cases profit erosion, are the natural results of the battle for market share and effective distribution channels. There is no absolute, dominant supplier (IBM is number one with 11.3 percent market share worldwide); the "field is still pretty open." The Japanese, Korean, Taiwanese, and some European offerings account for well over half the market share. U.S. domestic manufacturers account for the balance. Dataquest expects this level of competition to stiffen in 1989 as the battle for distribution intensifies. New distribution channels will be explored. Look for increased focus on the mass-merchandise channel during the year. Also, because Dell Computer has legitimized the mail-order channel by building a strong reputation for quality, service, and support, we will see more vendors focusing in this area. Look also for a significantly increased effort toward service and support from both major retailers and PC vendors, which hope to establish a clear competitive advantage and company differentiation.

Another issue that came to light in 1988 was the Micro Channel (MCA) and Extended ISA (EISA) controversy. This is becoming old news, but for purposes of review, it concerns two proposals for a new industry-standard bus structure for the next generation of PCs, which have both 32-bit memory and I/O highways. IBM's MCA makes a radical departure from the de facto standard AT(ISA) bus, allowing for full 32-bit I/O and memory highways and Bus Master coprocessors. EISA claims the same or superior technical advantages, but it allows for retention of 8- and 16-bit cards previously used in the AT bus. Both are competing to claim the title of "next-generation standard" for 32-bit bus architecture. This issue has been debated continually since the formation of the EISA consortium in midyear 1988. Arguments have focused on licensing fees, protection of add-in card investments, protection of software application investment, and the need for the computing community to establish an industry standard for I/O and memory buses so that application environments can take full advantage of multiprocessing and concurrent I/O in a completely networked environment. This controversy has introduced one more uncertainty into the milieu of ongoing issues in the industry. This uncertainty as to expected architectural standards will cause some buyers to postpone PC purchases until there is an industry consensus as to which standard(s) prevails.

Software Technology

In the software side of the business, perhaps the biggest issue that will have long-term effect is the OS/2 versus MS-DOS versus UNIX area. For our purposes here, we will restrict the discussion to OS/2 and DOS, because UNIX is multiuser by design, while the focus here is a single, probably networked, user. We do not see OS/2 and UNIX competing for the same platform, at least in the near future. The release of Presentation Manager and Extended Edition for OS/2 occurred in 1988; these elements were crucial to encourage application and solution vendors to port their software to OS/2. At Fall Comdex, IBM showed the names of more than 800 applications that have been ported thus far. Now the list has grown to more than 1,000. IBM has also recently been able to demonstrate OS/2 with its Extended Edition, running on a PS/2, performing remote data base queries from multiple remote machines, while running a separate background application. It appears that IBM has finally been able to put the pieces together and articulate a complete MCA story, even its role within SAA. We should begin to see some of the long-awaited "killer" applications running on OS/2 during 1989. We also expect to see DOS continue to be the predominant PC environment for some years to come, with OS/2 shipments catching DOS shipments during late 1992 or early 1993.

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Kevin Landis
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Dataquest
a company of
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Research Newsletter

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1989–35
0004445

THE PC CHIP SET MARKET: WADE IN CAREFULLY—THE POOL IS FULL!

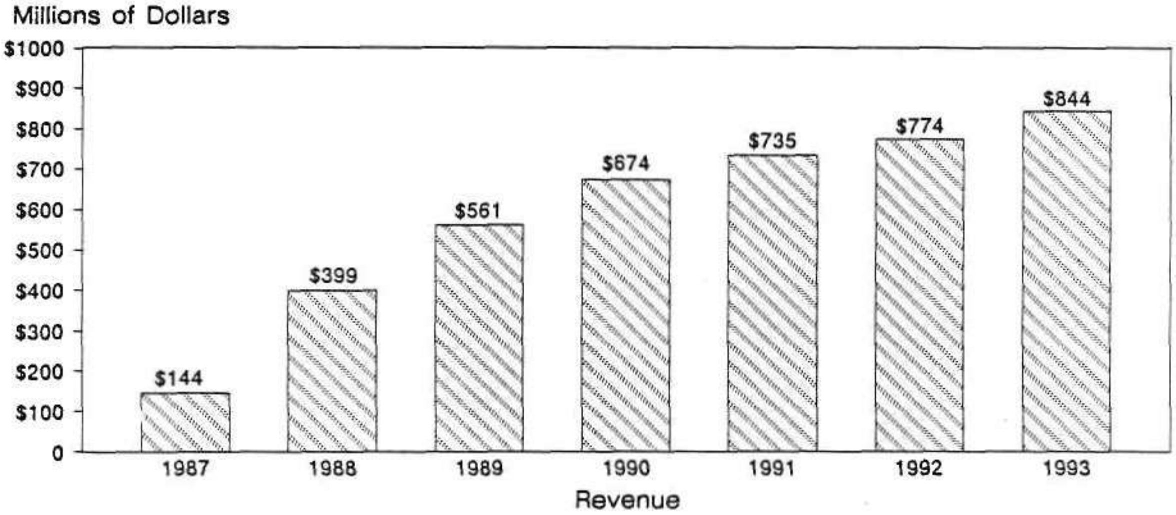
INTRODUCTION

Worldwide, there were only six PC logic chip set vendors in 1987. In 1988, the number climbed to 13, and by the end of this year Dataquest expects to see 19 vendors worldwide. The new entrants are both large, well–capitalized semiconductor manufacturers and small, start–up design houses. These new suppliers have been attracted by the tremendous growth rate of the market and the initially small number of participants. This is characteristic of any emerging market. The main differences between this market and other emerging markets are the large amount of standardization already present and the ease of sizing the market by examination of the total number of PCs shipped.

Dataquest believes that the rapid increase in new entrants and capacity will bring this industry to the saturation level by the end of this year, based on the Dataquest PC shipment forecast. We expect this saturation to lead to aggressive price competition, driving vendors to look for penetration of these products into new applications and markets. Figure 1 presents Dataquest's estimated actual and forecast revenue for the worldwide PC logic chip set market.

Figure 1

Worldwide PC Chip Set Market Forecast
(Millions of Dollars)



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Source: Dataquest
July 1989

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

HIGH GROWTH RATE ATTRACTS MANY NEW ENTRANTS

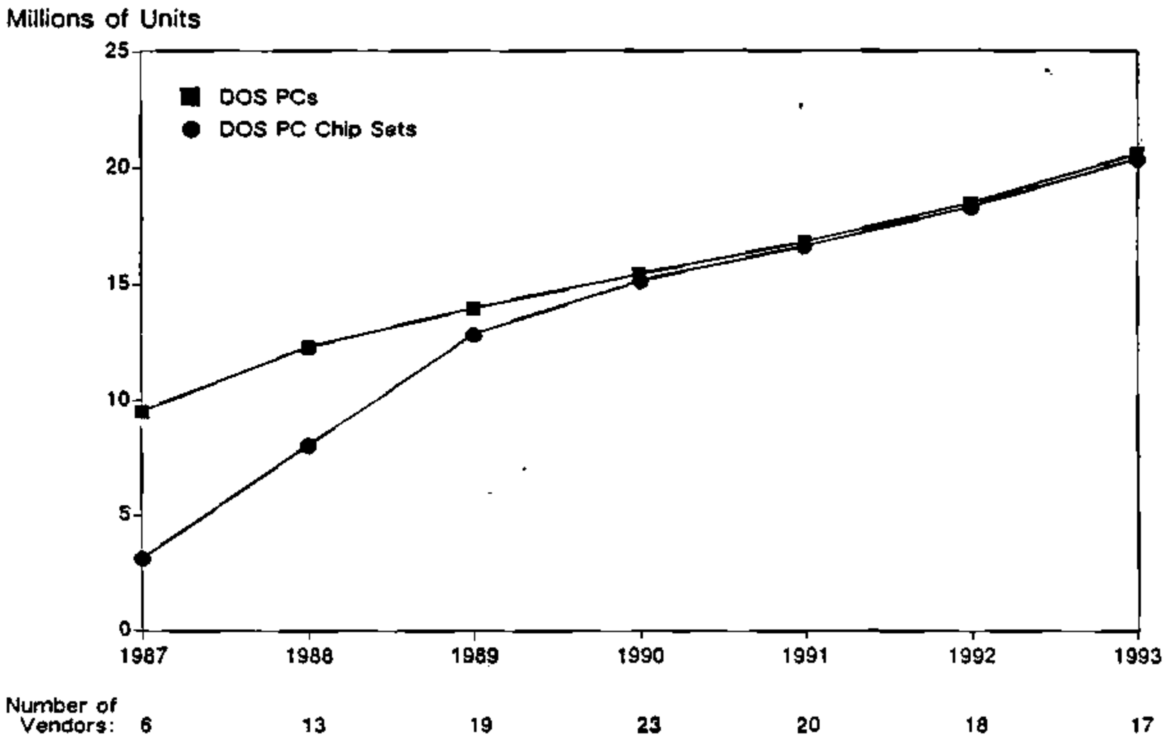
Dataquest estimates the compound annual growth rate (CAGR) for chip set unit shipments from 1987 to 1993 to be about 37 percent, an attractive rate of growth to investors, which should entice them to seek ways to participate in this industry. However, because of the nature of the relationship between PC consumption and chip set consumption, it is important for potential new entrants to look at the development of this market in terms of the product life cycle.

Figure 2 graphs shipments of chip sets against the shipments of DOS PCs, showing the rapid rise of chip set shipments as they approach the level of PC shipments. Between 1987 and 1988, chip set shipments grew by 158 percent. The estimated CAGR for 1987 to 1990 is still almost 70 percent. Dataquest estimates that during this same period, the number of chip set vendors will increase from 6 to 23.

Dataquest believes that, in 1990, the penetration of chip sets into PCs will likely approach saturation. By the end of 1989, the penetration will be about 92 percent. At this point, the growth rate of chip set shipments will be tied directly to the growth rate of PC shipments. In fact, the CAGR for chip set shipments from 1989 to 1993 is estimated at only 12.6 percent. This level of growth should attract fewer new entrants and cause some participants to exit the industry.

Figure 2

Worldwide PC Logic Chip Set Market Forecast as Compared with the DOS PC Forecast (Millions of Units)



0004445-2

Source: Dataquest July 1989

A Case of Overcapacity

According to a Dataquest survey, worldwide logic chip set vendors expect to ship more than 15 million units in 1989. Table 1 lists the results of this survey along with Dataquest's estimated actual and forecast numbers for chip set and PC unit consumption for 1987 through 1989. The vendors expect to ship 19 percent more than the forecast for chip sets in 1989 and 9 percent more than the forecast PC consumption.

Table 1

Worldwide PC Chip Set Vendor Survey Results (Thousands of Units)

	1987	1988	1989
Dataquest DOS PC Consumption Estimate	9.5	12.3	13.8
Dataquest DOS Chip Set Consumption Estimate	3.1	8.0	12.7
Vendor-Estimated Chip Set Shipments	-	-	15.1

Source: Dataquest July 1989

The difference between the vendors' expectations and the Dataquest forecast might be explained by aggressive goal setting on the part of the vendors. One could also argue that some units will be shipped into inventory. It is clear, however, that more than enough capacity exists to satisfy the demand for chip sets, and it is expected that new entrants to the industry will aggravate this situation.

The implications of this analysis should be obvious. The competition for market share in this industry is likely to lead to aggressive, if not predatory, pricing policies on the part of participants. Given the degree of standardization of these products, they will take on more of the attributes of a commodity, where pricing and service are the keys to success.

FORECAST METHODOLOGY AND ASSUMPTIONS

The PC chip set forecast is derived from the Dataquest Personal Computer Industry Service PC forecast and from a survey of worldwide chip set vendors. Each year, Dataquest forecasts worldwide shipments of personal computers. Table 2 gives the Dataquest estimated worldwide shipments for DOS PCs. Dataquest's new chip set forecast for 1989 through 1993 is derived as a function of saturation of the DOS market. The estimates for 1987 and 1988 are based on the chip set vendor survey and Dataquest analysis. The following significant assumptions were made in these forecasts:

- The worldwide DOS PC market will continue to grow through the period at a CAGR of about 13 percent.
- As a general trend, discrete chips will be displaced by very large scale integration. In personal computers specifically, discrete logic chips will be replaced by logic chip sets. Because of the advantages of chip sets for the systems manufacturers—lower cost, better performance, faster time to market—this displacement has happened very rapidly.

- Average selling prices (ASPs) will fall in 1989 because of price competition. They will rise in 1990 as the introduction of EISA chip sets and increased penetration of the MCA chip sets shifts the product mix toward the high end. ASPs will then come down slowly through the rest of the period as price decreases are offset by the continued move in product mix toward the high end.

Table 2

Worldwide PC Logic Chip Set Market Forecast
(Thousands of Units)

	1987	1988	1989	1990	1991	1992	1993	1987-1993 CAGR
DOS PC Shipments	9.6	12.3	13.8	15.4	17.1	18.7	20.6	13.6%
Chip Set Shipments	3.1	8.0	12.7	15.1	16.9	18.5	20.4	36.8%
Chip Set Saturation	33%	65%	92%	98%	99%	99%	99%	
Chip Set ASP	$ 46.13	$ 49.66	$ 44.09	$ 44.71	$ 43.53	$ 41.89	$ 41.38	(1.8%)
Chip Set Revenue ($M)	$144.00	$399.00	$561.00	$674.00	$735.00	$774.00	$844.00	34.3%
Chip Set Revenue Growth	N/A	177.6%	40.5%	20.3%	9.0%	5.2%	9.1%	

N/A = Not Available

Source: Dataquest
July 1989

DATAQUEST ANALYSIS

Critical Success Factors for Participants

In order to participate successfully in this industry, vendors will require certain capabilities and resources, including the following:

- Systems Expertise—Systems designers are looking for vendors that can work with them from the beginning of the board design to integrate and sometimes customize a chip set into the system. Chip set vendors with board design and systems expertise will be able to provide this capability.

- Design Tools—Fast chip design turnaround will be required because of short product life cycles. Access to design tools will allow vendors to offer products as a core that can be modified to allow customers some degree of differentiation.

- High-Volume/Low-Cost Manufacturing—Because of the increasing commodity status of these products, access to high-volume/low-cost foundries will be essential.

- Customer Service/Support—Because of the lack of any major differentiation in these products, service and customer support is as important as pricing. A user might not switch vendors for either better pricing or better service, but if offered both, will find it difficult to resist.

Opportunities

As the chip set market approaches saturation and vendors find themselves with excess capacity, they will be forced to look for new applications for logic chip sets outside of the personal computer. Two areas that will benefit from this are the embedded DOS market and the personal workstation market.

Embedded DOS Market

At least one chip set vendor is pursuing embedded DOS applications as its primary strategy, and most others have thought about it as a secondary strategy but have not yet dedicated resources toward this market. The embedded DOS market can be defined as having applications that contain some form of keyboard (input device) and some sort of display (output device) that could benefit from the protocol of the DOS PC logic interface. These applications tend to be for low-end PC logic products. Examples are vending machines, traffic controllers, process controllers, communications, and medical and analytical instrumentation.

Personal Workstation Market

As the high-end personal computer products approach the functionality of low-end workstation products, a segment is developing that some have called the personal workstation market. With the introduction of the Intel 80486 and i860 microprocessors, opportunities exist to develop high-end chip sets that will combine the use of complex-instruction-set computer (CISC) and reduced-instruction-set computer (RISC) microprocessors to offer a system that will run both DOS and UNIX applications. One chip set vendor already has announced plans to develop a RISC chip set.

This market is not well defined. Questions exist as to the size and viability of this segment, and standardization issues need to be resolved.

DATAQUEST CONCLUSIONS

The rapid initial growth rate of the DOS PC logic chip set market has invited many new entrants to this industry and has brought the market from infancy to saturation in a very short period of time. Although a change in product mix toward the high-end products will somewhat offset price declines over the next several years, pricing pressure will be considerable. This will cause some vendors to exit this market altogether and others to dedicate resources to seeking out new applications for these products. Vendors with access to low-cost foundries, appropriate design tools and expertise, and high-quality global sales organizations will stand the best chance of success.

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Kevin Landis
Ken Pearlman

NEW DIRECTORY OF DATAQUEST PUBLICATIONS

A new directory describing 30 Dataquest Research Publications is now available from Dataquest's Direct Marketing Group. The directory includes information on the following:

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October-December

The following list describes the newsletters in this section:

OEM MONTHLY—OCTOBER 1989: INTERCONNECT—THE NEXT MAJOR CHALLENGE FOR ELECTRONICS (1989-50)

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions. This bulletin discusses the problems associated with faster ICs, possible packaging solutions to these problems, and the likely impact on electronics assembly. Dataquest recommends that chipmakers approach Stack (in Europe), EIAJ (in Japan), and JEDEC (in the United States) today to establish the industry's interconnect standards.

THIRD QUARTER ELECTRONIC EQUIPMENT UPDATE: GREAT WORK, IF YOU CAN FIND IT (1989-51)

Dataquest expects North American electronic equipment production growth to remain relatively stable. This newsletter reviews the outlook by application market (i.e., data processing, communications, industrial, consumer, military, and transportation). Until growth becomes more broadly based—probably in 1991 and beyond—Dataquest believes that giving undivided attention to helping customers meet their most pressing current needs (inventory and cost control) will be the best policy for ensuring tomorrow's business.

SAMonitor: THE LAZY DAYS OF SUMMER TURN TO FALL (1989-52)

The *SAMonitor* is a monthly update that closely monitors changes in key electronic equipment markets. It presents important tactical leading indicators of semiconductor business activity and discusses the potential impact of equipment market fluctuations on chip orders and shipments. To be competitive in this chip buyer's market, Dataquest recommends that semiconductor manufacturers be vigilant in their commitment to running a lean and nimble operation and competing on intangibles, such as customer service and satisfaction.

SYSTEM SEMICONDUCTOR CONTENT TRENDS: TV SETS (1989-53)

Dataquest's analysis of trends in the semiconductor content of TV sets depicts mild growth prospects for manufacturers of consumer components. This newsletter reviews the TV equipment forecast, semiconductor content, semiconductor consumption forecast, and convergence of system and semiconductor technologies. We recommend that semiconductor manufacturers keep pace with consumer equipment trends, including high-definition TV (HDTV), by forging strategies with Japanese R&D centers in the United States to secure a share of the projected $6.4 billion North American consumer video equipment production in 1993.

FACSIMILE INDUSTRY POLARIZATION: A TALE OF TWO MARKETS (1989-54)

The facsimile industry is now divided into two very distinct markets. This newsletter analyzes the market segments involved (i.e., commercial business market and mass retail market) and the ramifications of this polarity. Dataquest believes that commanding a leadership role in both of these dramatically different markets will be difficult.

TELECOM TECHNOLOGIES FOR THE 1990s (1989-55)

Dataquest does not foresee a revolution in telecom technology during the next 10 years; rather, we see a continued evolution. This newsletter explores six key areas: connectivity, interoperability, networking, network management, integrated applications, and personal communications. We believe that the collective task for suppliers and end users will be to take all forms of information technology to the level of universality that the telephone has achieved already.

OEM MONTHLY—NOVEMBER 1989: MILITARY SYSTEMS SALUTE PROFIT-MOTIVATED CIVILIAN TECHNOLOGY (1989-56)

This month's *OEM Monthly* reviews the languishment of military electronics today and the plan for putting high-rel back on track. Dataquest recommends that, where appropriate, IC makers use military seed money to fund advanced R&D.

LASER PRINTERS: WHAT DRIVES THESE ENGINES? (1989-57)

This newsletter provides a detailed look at the semiconductor content of several recently announced laser printers. The models examined in this newsletter were selected as representative of current and likely future system configurations. Each manufacturer is an industry leader, and each product represents a recent, significant product offering.

SAMonitor: LIGHT AT THE END OF THE TUNNEL (1989-58)

In this month's *SAMonitor,* Dataquest encourages semiconductor manufacturers not to be unduly preoccupied with current market conditions, but to be light on their feet and ready to spring into action during the coming year.

OEM MONTHLY—DECEMBER 1989: DSP TECHNOLOGY SAMPLES GROWING MARKET ACCEPTANCE (1989-59)

This month's *OEM Monthly* discusses the increasing complexity of modern electronics and the trend to letting computers do the work of design simulation and signal processing. Dataquest recommends that semiconductor suppliers in the "integrated solutions" business acquire DSP expertise now (if they haven't already) to prepare for this development.

SAMonitor: SYSTEM MARKETS MARKED BY CONTINUED IMPROVEMENT (1989-60)

In this month's *SAMonitor,* Dataquest encourages semiconductor manufacturers to be patient during the next few months while the foundation solidifies and to be prepared for business conditions to improve by early 1990.

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Research *Bulletin*

SAMONITOR: SYSTEM MARKETS MARKED BY CONTINUED IMPROVEMENT

The *SAMonitor* is a monthly update that closely monitors changes in key electronic equipment markets. It presents important tactical leading indicators of semiconductor business activity and discusses the potential impact of equipment market fluctuations on chip orders and shipments.

THE EQUIPMENT MARKETS

Computers and Office Equipment

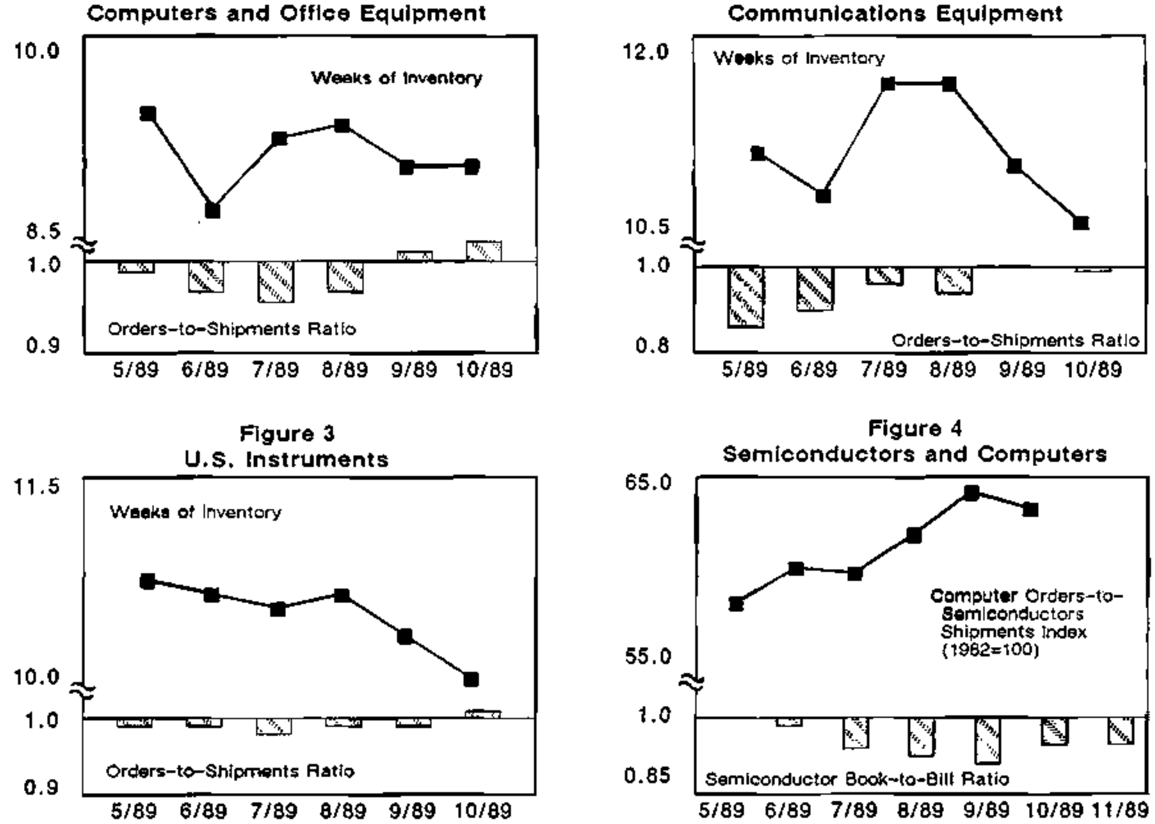
New orders growth in October in this market was 3.0 percent above year-earlier orders. *This is the second consecutive month since March that*

Figure 1
Computers and Office Equipment

Figure 2
Communications Equipment

Figure 3
U.S. Instruments

Figure 4
Semiconductors and Computers



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Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
December 1989

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monthly growth of new orders from year-earlier levels has been positive. Unfortunately, shipments growth continues to decelerate: For the three-month period ended in October, shipments were up 2.5 percent from the same period last year, compared with 3.5 percent in September. As shown in Figure 1, the orders-to-shipments ratio rose slightly to 1.02 in October from 1.01 in September. *This is the highest it has been since August 1988, when the ratio was 1.03.* Inventory levels are well managed and remained unchanged in October, at 9.1 weeks. Dataquest believes that recent trends in orders and inventory activity have helped solidify the computer market's fundamentals. We continue to forecast a period of stable and sustained systems orders and shipments growth during the first quarter of 1990, leading to a recovery in chip orders and shipments growth in the second quarter.

Communications Equipment

Resurgence in order growth in this equipment segment has stimulated acceleration in shipments growth. For the three-month period ending in October, shipments growth was 7.1 percent from the same period last year, compared with 5.1 percent growth in September. *This is the fastest three-month shipments growth since February 1988.* Three-month orders growth slowed to 8.9 percent in October. Although this growth is down from (an unsustainable) 13.2 percent growth in September, *it is second only to September in terms of orders growth in 1989.* As a result of October's slowdown in orders growth, the communications orders-to-shipments ratio fell slightly to 0.99 in October (see Figure 2), from parity in September. Manufacturers drew inventory levels down for the second consecutive month to 10.7 weeks. Recent activity in orders, shipments, and inventory bode well for the industry's performance during the next few months. Dataquest believes that improved growth is likely to extend through early next year.

Instruments

Instruments orders and shipments growth improved in October. For the three-month period ended in October, orders growth rose 7.9 percent. Shipments growth increased 6.0 percent for the same period. As a result, the orders-to-shipments ratio rose to 1.01 in October, from 0.99 in September, as shown in Figure 3. *This is the first time since February that the ratio has been above parity.* Manufacturers kept a tight reign on inventories: October levels fell for the second consecutive month to 10.1 weeks. The continuing upswing in orders and shipments growth and the lean inventory levels are laying a good foundation for future growth. Dataquest believes that both orders and shipments growth will remain positive but could be buffeted about as year-end approaches. We continue to expect a period of moderately accelerating shipments growth to begin about the first quarter of 1990, being driven by (and coinciding with the outlook of) faster capital spending growth.

SEMICONDUCTOR DEMAND

The semiconductor book-to-bill ratio remained unchanged in October at 0.93. As stated in last month's *SAMonitor,* however, although the semiconductor market is slow, it is not as soft as it seems. Prices of 1Mb DRAMs have fallen significantly since the beginning of the year, making the book-to-bill ratio look worse than the fundamentals otherwise would indicate.

While semiconductor shipments advanced 5.1 percent in October over September, October computer orders rose only 3.5 percent from September. As a result, the computer-orders-to-semiconductor-shipments index, a leading indicator of chip orders and shipments, fell slightly to 63.5 in October from 64.5 in September (see Figure 4). We believe that this is only a transitory aberration; except for October and an insignificant decrease in July, the index has risen continuously since March. Further computer orders and inventory fundamentals improved in October. We continue to believe that this trend indicates growth of both semiconductor orders and shipments nearing a cyclical trough. We also believe that computer orders and shipments growth will be on a path of sustained and stable positive growth by first quarter of 1990, with chip orders and shipments following suit in second quarter.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest believes that the faint light at the end of the tunnel is beginning to grow brighter. We believe that the past few months' indicators show a solid foundation being laid for next year's growth. If systems orders and shipments growth picks up in the first quarter of 1990, as expected, semiconductor business conditions are likely to follow suit in the second quarter of 1990. Dataquest encourages semiconductor manufacturers to be patient during the next few months while the foundation solidifies, and to be prepared for business conditions to improve by early next year.

Terrance A. Birkholz

Dataquest
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Research *Bulletin*

OEM MONTHLY—DECEMBER 1989
DSP TECHNOLOGY SAMPLES GROWING MARKET ACCEPTANCE

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

THE COMPLEXITY OF MODERN ELECTRONICS

High-performance products today use digital signal processing (DSP) technology. Examples include the adaptive echo cancellation circuits in PC modems, the image construction process in medical tomography scanners, and the signal-filtering banks in consumer radar detectors. The required amplifying and filtering functions in these products can be implemented with analog components such as operational amplifiers and comparators. DSP technology, however, allows the same high-performance requirements to be designed in less time and manufactured at lower cost.

All six semiconductor application markets now are being served by DSP technology (see Table 1).

TABLE 1
High-Performance Equipment Using DSP Technology

Communications	Industrial	Military
Modems	Test equipment	Radar
DTMF receivers	Medical equipment	Sonar
Transmultiplexers	Office automation	Navigation
Speech synthesis	Inspection equipment	Fuses
Speech recognition	Remote monitors	Communication
Speech compression	Robot systems	Reconnaissance
Mobile communications	Global Positioning Satellites	
Video teleconferencing	Motor control	
Computer	**Consumer**	**Transportation**
Arithmetic accelerators	Compact disc players	Antilock brakes
Array processors	Digital video	Distance sensors
Image processing	High-definition TVs	Lane sensors
Graphics	Electronic cameras	
Geophysical processing	Radar detectors	

Source: Dataquest
December 1989

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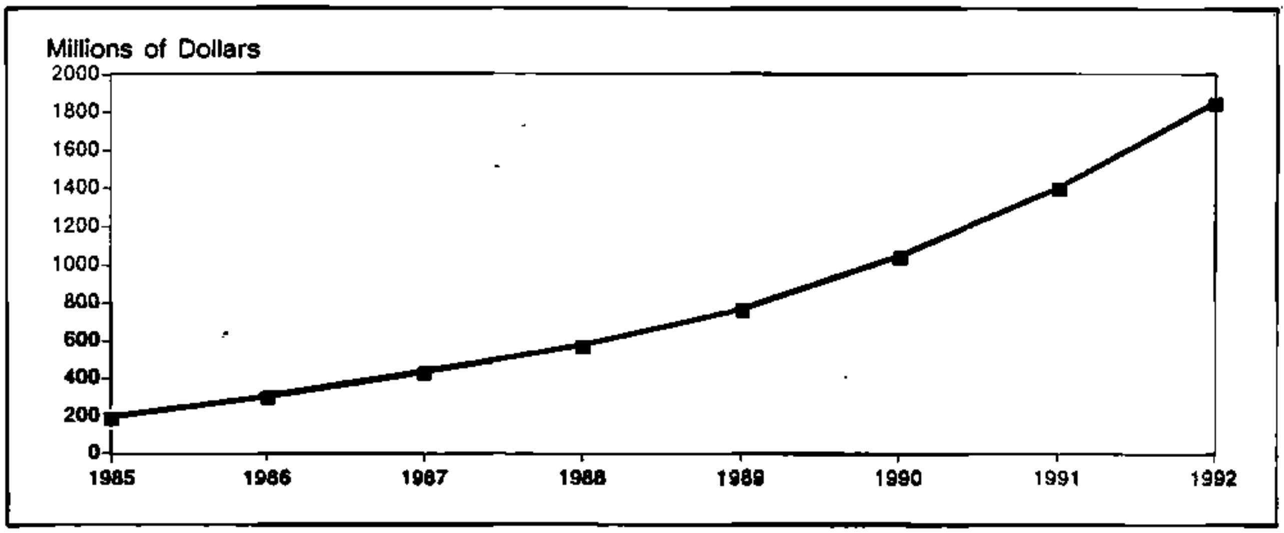
FIGURE 1
Worldwide DSP Component Revenue Forecast



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Source: Dataquest
December 1989

LETTING COMPUTERS DO THE WORK

Traditional analog signal processing systems use electrical waveforms to represent physical phenomena and use passive and active components (e.g., resistors, capacitors, inductors, amplifiers, and comparators) to shape these waveforms into the output. Systems implemented with DSP technology, on the other hand, represent physical phenomena as lists of numbers stored in computer memories and use arithmetic (i.e., addition, subtraction, multiplication, and division) to convert these numbers into the output.

Computers simulate DSP systems more easily than they simulate analog systems, and the benefits include shorter times to market for new products, smoother design "tweaks" to products already in production, and faster assembly times as a result of automated testing. DSP is expected to grow at a compound annual growth rate (CAGR) of 34 percent between now and 1992; this growth is more than twice the 16 percent CAGR that is forecast for the semiconductor market as a whole. The $800 million 1989 worldwide DSP component market (see Figure 1) also represents 1.2 percent of the $50 billion worldwide semiconductor market.

CONSUMER ELECTRONICS TO DRIVE MARKET

Component size and cost reductions are shifting the largest share of the DSP market from the military and communications segments to the consumer segment. In the 1970s, military systems used DSP units made from family logic, and each unit needed several printed circuit boards and hundreds of watts of power. The DSP ICs of today allow a DSP unit to be built with just a few components that fit on a single board. The business discipline of high volumes at low cost for consumer items such as digital audio equipment will drive DSP technology in the 1990s.

DATAQUEST RECOMMENDATION

DSP technology represents the convergence of analog and digital methods for components in high-performance systems. Dataquest expects this technology to migrate from niche to mainstream during the 1990s as its use grows in consumer electronics products such as digital audio equipment. We therefore recommend that semiconductor suppliers in the "integrated solutions" business acquire DSP expertise now (if they haven't already) to prepare for this development.

Roger Steciak

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Research *Bulletin*

SAMONITOR: LIGHT AT THE END OF THE TUNNEL

The *SAMonitor* is a monthly update that closely monitors changes in key electronic equipment markets. It presents important tactical leading indicators of semiconductor business activity and discusses the potential impact of equipment market fluctuations on chip orders and shipments.

THE EQUIPMENT MARKETS

Computers and Office Equipment

Great news: *Growth of new orders in September was a dramatic 18.2 percent above year-earlier orders! For the first time since March,*

Figure 1
Computers and Office Equipment

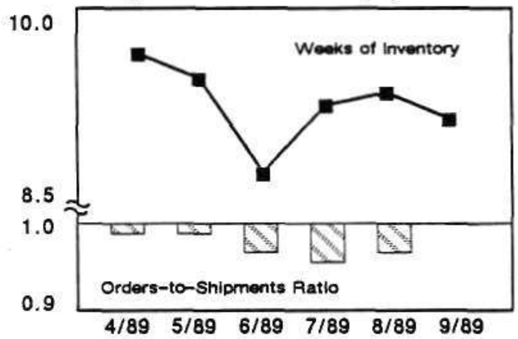


Figure 2
Communications Equipment

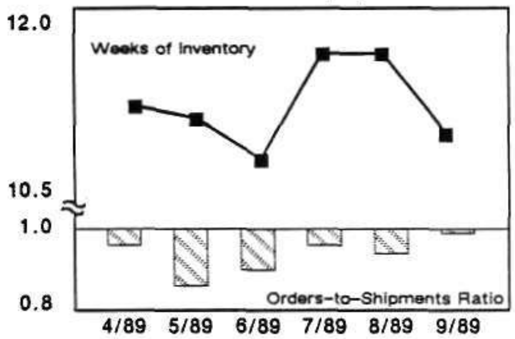


Figure 3
U.S. Instruments

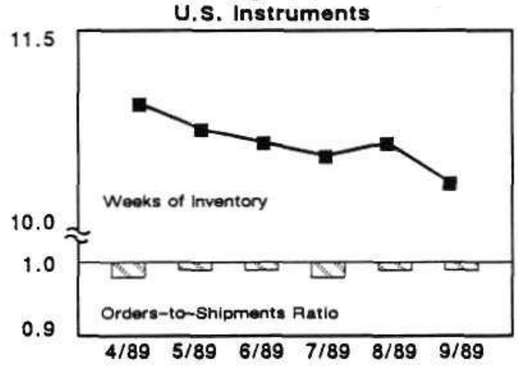
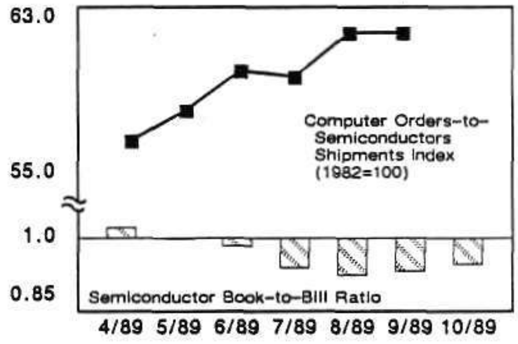


Figure 4
Semiconductors and Computers



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Source: U.S. Department of Commerce
World Semiconductor
Trade Statistics
Dataquest
November 1989

SAM Newsletters 1989: October-December 1989-58

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monthly growth of new orders has been positive when compared with year-earlier levels. Unfortunately, shipment growth continues to decelerate. For the three-month period ended in September, shipments were up 2.5 percent from the same period last year, compared with 3.6 percent in August. However, the strong showing in orders should translate into faster shipment growth in the coming months. As shown in Figure 1, the orders-to-shipments ratio rose to 1.0 in September from 0.97 in August, *the first month the ratio has been at least at parity since August 1988.* Also welcome news: Inventory levels fell slightly in September to 9.2 weeks from 9.4 weeks in August. September's exceptional order and shipment growth may not be repeated in the coming months, but Dataquest believes that solid market fundamentals for improved business growth will be in place by year-end. We still forecast a period of stable and sustained system order and shipment growth to begin in the first quarter of 1990, leading to a recovery in chip orders and shipments in the second quarter. Improved capital spending growth, combined with seasonal acceleration in order growth in the first half of 1990 should drive next year's recovery.

Communications Equipment

Communications order and shipment growth improved significantly in September. *New orders in September grew an impressive 24.5 percent above year-earlier orders, while shipments were up 11.0 percent. These percentages represent the fastest monthly growth for orders and shipments since November 1985 and January 1988, respectively.* The orders-to-shipments ratio (see Figure 2) also improved in September and achieved parity for the first time since March. Inventories are in good shape, too. Levels fell by 0.6 weeks in September. The resurgence in order growth should yield faster shipment growth through the end of the year. We believe that the market is in the initial stage of a sustained period of improved growth. A solid base for next year's growth should be in place by the first quarter of 1990.

Instruments

Instrument order and shipment growth improved in September. For the three-month period ended in September, order growth rose 3.7 percent, compared with a decline of 0.2 percent in August; shipment growth increased by 3.6 percent for the same period, compared with 1.8 percent in August. As shown in Figure 3, the orders-to-shipments ratio remained steady at 0.99 in September. September inventory levels fell from 10.7 weeks in August to 10.4 weeks; excess is not a problem. The upswing in order and shipment growth helps lay a foundation for future growth. We forecast a period of moderately accelerating shipment growth to begin about the first quarter of 1990, driven by (and coinciding with the expectation of) faster capital spending growth.

SEMICONDUCTOR DEMAND

For several months, decelerating system order growth and shipment growth have resulted in declining semiconductor orders and shipments. The semiconductor book-to-bill ratio has reflected this deceleration recently, declining from its February peak of 1.07 to 0.92 in August. This trend may be in the initial stage of a reversal, however. In October, the ratio increased for the second consecutive month to 0.93 from 0.91 in September (see Figure 4). Yet the semiconductor market, although slow, is not as soft as it seems. The prices of 1Mb DRAMs have fallen significantly since the beginning of the year, making the book-to-bill ratio look worse than the fundamentals otherwise would indicate.

Nevertheless, a dim light shines at the end of the tunnel. The computer-orders-to-semiconductor-shipments index, a leading indicator of chip orders and shipments, remained stationary in September at 60.7. Except for an insignificant decrease in July, the index has risen continuously since March. Dataquest continues to interpret this trend as a sign that growth of semiconductor orders and shipments is near its cyclical trough. We also believe that computer order and shipment growth will turn upward during the first quarter of 1990, with chip orders and shipments following suit in the second quarter.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

As reported last month, Dataquest expects no significant and *sustained* improvement in computer order and shipment growth rates through the end of the year. Furthermore, we continue to note a semiconductor buyers' market, although we think we see a ray of hope. First, the rapid decline in 1Mb DRAM prices taints the semiconductor book-to-bill, making things appear worse than they really are. Second, the computer-orders-to-semiconductor-shipments index continued to look positive in October. If system order and shipment growth picks up in the first quarter of 1990, as expected, semiconductor business conditions are likely to follow suit in the second quarter of 1990. Dataquest encourages semiconductor manufacturers not to be unduly preoccupied with current market conditions, but to be light on their feet and ready to spring into action during the coming year.

Terrance A. Birkholz

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Research Newsletter

Laser Printers: What Drives These Engines?

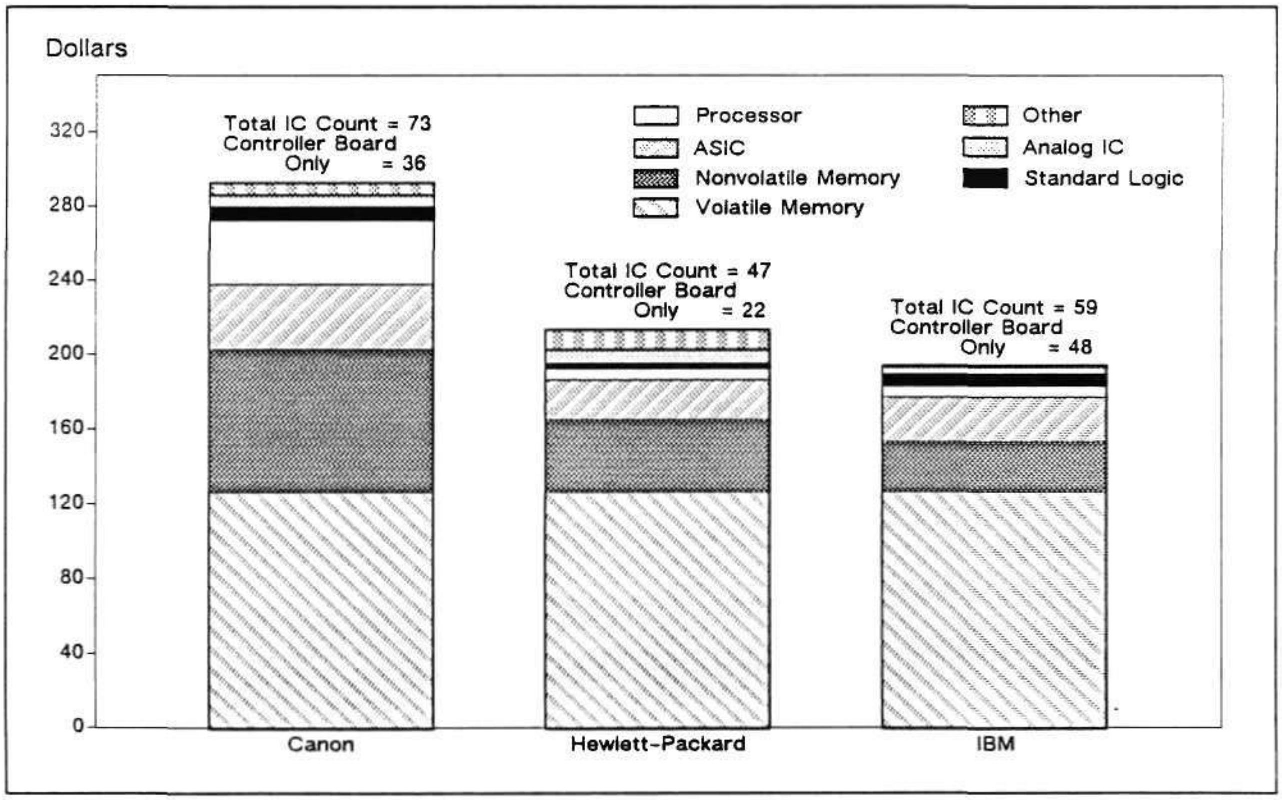
Summary

This newsletter provides a detailed look at the semiconductor content of several recently announced laser printers. The models examined in this newsletter were selected as representative of current and likely future system configurations. Each manufacturer is an industry leader, and each product represents a recent, significant product offering.

Introduction/Overview

Figure 1 shows the estimated component cost of the Canon Mark III, the HP LaserJet IIP, and the IBM 4019. The rated print speeds of these printers are 8, 4, and 10 pages per minute, respectively. The pricing data contained in this analysis are based on Dataquest's Semiconductor User Information Service's pricing study, which assumes a 10,000-piece contract buy. Because manufacturers

Figure 1
System Component Cost Breakout



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Source: Dataquest
November 1989

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enjoy varying degrees of purchasing leverage and may secure greater quantity discounts for certain components, these cost figures should be used for comparison purposes only.

Why Is It Important to Look at Laser Printers?

The laser printer market is of great strategic significance to semiconductor manufacturers for two reasons. First, laser printers represent a major IC growth opportunity (see SAM Newsletter number 1989-49 entitled "Intelligent Printers Offer Challenges, Opportunities for Applications-Focused Semiconductor Vendors"). Second, current laser printer control electronics offer excellent insights into the future electronic content of other printer types, including color, ink jet, and intelligent dot matrix printers.

Table 1 compares the system specifications of the three systems. Because memory costs tend to dominate total systems costs, it is necessary to compare systems with similar memory configurations. We have therefore included a 1MB memory expansion option in both the IIP and the 4019. Although the full memory cost is included in our cost estimates, it should be noted that the system prices reflect the base configuration of 512KB for both.

Table 1
Printer Specifications

	Canon Mark III	HP IIP	IBM 4019
Intro Date	April 1989	September 1989	October 1989
First Shipped	May 1989	September 1989	November 1989
List Price*	$2,995	$1,495	$2,595
Street Price		$995	$1,595
PPM	8	4	10
Max Resolution	300 x 300 dpi	300 x 300 dpi	300 x 300 dpi
Color Capability	No	No	No
RAM	1.5MB	1.5MB	1.5MB
ROM	1.0MB	512KB	512KB
Resident Fonts	17	14	10
PostScript Support	Q4 89	Q1 90	Q2 90
Print Method	ELS	EG	EDI
Standard Interfaces	Centronics Parallel	Centronics Parallel	IBM Parallel
	RS-232	RS-232, RS-422	RS232
Optional Interfaces	Video	None	
Control Language	LIPS	PCL 4	PPDS
Resident Emulations	Diablo 630ECS	None	Quickwriter, Quietwriter, HPGL

Note: ELS = Electrophotographic semiconductor laser; EG = Electrophotographic; EDI = Electrophotographic laser diode

*List price includes only 512KB of DRAM for HP, IBM.

Source: Dataquest November 1989

Each of these products is significant for a different reason. Canon enjoys a unique strategic position: As the leading supplier of *print engines*, Canon is well positioned for market entry; however, the company has an understandable reluctance to directly compete with its established OEM customer base. Although Canon has yet to press for industry leadership, the company's current product line enables it to gain much-needed experience in the business of manufacturing complete systems. Because this experience enhances Canon's threat of entry, Canon's designs are closely monitored.

As the undisputed industry leader, Hewlett-Packard has become the acknowledged low-end trendsetter as well. The IIP is the first laser printer widely sold for less than $1,000. More importantly, it has been positioned as a *personal* printer. Market acceptance of the IIP will reveal a great deal about the market's price elasticity, as well as consumer preferences for a personal laser printer. Unit sales of the IIP could dwarf those of prior models.

Laser printer manufacturers have long anticipated IBM's playing a more significant role in the low-end page printer market. As an established leader in the personal and high-end page printer businesses, it seemed only a matter of time before IBM moved in on this market. IBM's 4019 represents the realization of its competitors' worst fears. Inexpensive to manufacture, competitively priced and featured, the 4019 looks all the more impressive when viewed in the context of what it represents: just the first in what Dataquest expects will be a family of products from IBM.

PRINTER DISCUSSION

The Canon Mark III

The Mark III represents Canon's first attempt to sharply differentiate its laser printers from the rest of the industry and is the first printer to use National's NS32CG16 laser printer microprocessor. The chip content and board layout reflect Canon's recognition that this design is likely to undergo further iterations. Table 2 shows the semiconductor content of the Canon Mark III.

TABLE 2
Canon Mark III Laser Printer Breakdown

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comment
Controller Card						
Nonvolatile	National	93CS66N	1	EEPROM	$ 0.75	
Volatile	Panasonic	MN41C4256-08	12	1Mb DRAM	126.00	1.5MB of page memory
Processor	National	NS32CG16V-15	1	MPU	34.25	
ASICs	National	N/M	1		5.50	68-pin J-leaded quad
	Canon	N/M	1		8.50	80-pin quad flat-pack
	Canon	N/M	1		8.50	80-pin quad flat-pack
Standard Logic	TI	SN74ALS245AN	8	Transceiver	3.02	
	TI	SN74ALS374N	2	Octal 3-state	0.77	
	TI	SN74AS1004AN	1	Inverter	0.23	
	Motorola	SN74LS00N	1	Quad 2-in NAND	0.10	
	Motorola	SN74LS04N	1	Inverter	0.10	
	Fujitsu	74F373	2	3-state latch	0.60	

(Continued)

TABLE 2 (Continued)
Canon Mark III Laser Printer Breakdown

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comment
Analog	Mitsubishi	M54972P	1	Driver	0.60	8-bit serial input latch driver
	Fujitsu	MB3771	1	Controller	0.90	Power voltage data controller
	Motorola	SN74LS244N	2	Octal driver	0.75	Bus driver
Memory Card						
Nonvolatile	Mitsubishi	M5M27C100K-15	8	1Mb EPROM	76.00	Font storage
Standard Logic	TI	SN74AS1004AN	1	Inverter	0.19	
Interface Card						
Analog	Linear	LT1081CN	1	RS232 transceiver	0.78	Driver/receiver
	Motorola	MC34050P	1	UART	0.69	
Standard Logic	TI	SN74LS74AN	1	Flip-flop	0.12	
	TI	SN74LS00N	1	Quad 2-in NAND	0.16	
	TI	SN74LS02N	1	Quad 2-in NOR	0.16	
	TI	SN7407N	1	Hex buffer	0.23	
	TI	SN74LS244N	1	Driver	0.45	
	Motorola	SN74LS14N	1	Quad 2-in NAND	0.10	
	Motorola	SN74LS374N	1	Flip-flop	0.12	
Engine Controller Card		D7811H-066	1	Proprietary	3.00	64-pin DIP
		D7811H-067	1	Proprietary	3.00	64-pin DIP
ASICs			1	Proprietary	12.50	121-pin quad flat-pack
Microcomponents	Toshiba	TC9142P	1	Controller	1.50	Direct drive motor speed controller
Analog	NEC	358C	1	Dual op amp	0.45	
	Hitachi	HA17393	1	Dual comparator	0.45	
	Hitachi	HA17324	1	Quad op amp	0.55	
	TI	SN75451BP	1	Driver	0.40	Dual peripheral driver
Standard Logic	Hitachi	HA74LS04P	1	Inverter	0.16	
	TI	SN74LS07N	3	Buffer	0.47	
	TI	SN7407N	2	Hex buffer	0.45	
	TI	SN74LS05N	2	Hex inverter	0.32	
	Toshiba	74HC04AP	3	Hex inverter	0.31	
		Total	73		$293.11	

N/M = Not Meaningful

Source: Dataquest
November 1989

Canon's higher component cost and chip count are a reflection of both design criteria and performance. Canon's apparent agenda for this market is to participate in a limited way, selling into niche markets in order to gain market experience. It makes little sense, then, to invest substantial resources into the optimization of a design that is transitional in nature. Canon's higher chip count comes as no surprise.

Don't be fooled by the Mark III's eight-page-per-minute spec—this is a high-performance printer with a powerful compute engine. Although the 8-ppm print engine limitation may degrade the relative performance of the Mark III in text mode, this printer is likely to shine in high-performance graphics applications. This higher compute power is evident in the higher component cost of the Mark III. Future iterations of this printer could have substantially lower board count, chip count, and component cost.

The HP IIP

The IIP contains many of the popular features that laser printer users have come to expect. With sophisticated font storage and paper-handling capabilities, along with built-in expandability, the IIP offers users those features that they wish to pay for while minimizing the initial purchase price. The only unalterable restriction associated with the IIP is the four-page-per-minute limit on print speed.

Table 3 shows the semiconductor content of the IIP. The ICs listed are found on four separate cards: the controller card, the interface card, the engine controller card, and the optional memory expansion card.

HP's goal of cost minimization and its expectation of high production volumes are apparent in both the board layout and the reduced chip count found in this system. Future iterations of this design may include ROMs to reduce nonvolatile memory costs and still fewer standard logic devices, such as buffers.

The IBM 4019

IBM's commitment to this market is apparent in the features, the pricing, and the *content* of the 4019. Targeted directly at the HP LaserJet Series II and IID, the frightening thing about the 4019 is just how inexpensive it appears to be. Unlike most laser printer manufacturers, IBM has elected to manufacture its own print engine. This decision not only affords IBM a potentially decisive cost advantage, but commits the company to a high-volume strategy in order to justify bringing the print engine "in house." Table 4 shows the semiconductor content of the IBM 4019.

The 4019 differs from the other printers examined here in that the interface and print engine controller cards are integrated onto the main controller card. This integration should allow for greater consolidation in future iterations. Although the 4019 has a higher chip count than the IIP, we expect future versions of the 4019 to have significantly fewer standard logic components. IBM's reduced *board count* may translate into an edge in future chip count reduction.

An interesting similarity between the IIP and the 4019 is the microprocessor—both are powered by the 68000. This similarity suggests that the 10-ppm versus 4-ppm speed advantage enjoyed by the 4019 is primarily attributable to differences in the respective print engines rather than a reflection of their processing powers. In fact, differences in performance should be much less pronounced for slower, more processor-intensive applications.

TABLE 3
HP LaserJet IIP Laser Printer Breakdown

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comment
Controller Card						
Nonvolatile	Toshiba	TC571000D-20	4	1Mb EPROM	$ 38.00	Font storage
	SGS-Thomson	M9346B6	1	64x16 EEPROM	0.75	
Volatile	Mitsubishi	M5M44256AP	4	1Mb DRAM	42.00	Page and font storage
Processor	Motorola	68000	1	MPU	5.83	
ASICs	HP	N/M	1	CBIC	8.50	84-pin J-lead quad
	National	1820-6339	1	Gate array	6.50	84-pin J-lead quad
	National	1820-2075	3	PAL	3.90	Address decode
Standard Logic	TI	74ALS245	2	Buffer	0.75	
	Signetics	74F257	1	MUX	0.30	
	National	74F257APC	2	MUX	0.60	
	National	1820-6340	1	Interface	3.00	
Analog	SGS-Thomson	TL7705ACP	1	Monitor	0.60	Power supply supervisor
Memory Card						
Volatile	NEC	424256-10	8	1Mb DRAM	84.00	2MB of page memory
ASICs	National	1820-6504 (5)	2	PAL	2.60	Address decode
Standard Logic	National	1820-5672	2	Buffer	0.46	Address buffering
	National	1820-6118	1	Buffer	0.23	Data buffering
Interface Card						
Standard Logic	Phillips	74HCT374D	2	Flip-flop	0.47	
	TI	7406	1	Buffer/driver	0.23	
Analog	Linear	1820-5694	1	RS232 transceiver	0.65	
	Motorola	MC34050P	1	Transceiver	0.70	
	Motorola	MC68B50P	1	ACIA	0.90	
Engine Controller Card		MN18884	1	Proprietary	3.00	64-pin DIP
		MN18885	1	Proprietary	3.00	64-pin DIP
	Hitachi	HD74LS08P	1	Quad 2-in AND	0.10	
	Hitachi	HA17324	1	Quad op amp	0.14	
	Hitachi	ECN1310SP1	1	Motor driver	3.25	
	Fujitsu	MB3771	1	Monitor	0.90	Power supply monitor
		Total	47		$211.37	

N/M = Not Meaningful

Source: Dataquest
November 1989

TABLE 4
IBM 4019 Laser Printer Breakdown

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comment
Controller Card						
Nonvolatile	AMD		2	1Mb EPROM	$ 19.00	Font storage
	Toshiba	TC531001CP	2	1Mb ROM	7.80	Font storage
Volatile	Hitachi	HM514256JP12	4	1Mb DRAM	42.00	512KB of page memory
Processor	Motorola	68000	1	MPU	5.83	
ASICs	Oki	N/M	1		12.00	100-pin quad flat-pack
	Oki	N/M	1		12.00	100-pin quad flat-pack
Standard Logic	National	74HC374	2	Flip-flop	0.47	
	National	74HC244	1	Driver	0.23	
	National	74LS74	1	Flip-flop	0.12	
	National	74LS00	1	Quad 2-in NAND	0.10	
	National	74LS27	2	Triple 3-in NOR	0.22	
	Signetics	74F32D	1	Quad 2-in NOR	0.10	
	Motorola	LS040	1	Dual 4-in NAND	0.11	
	Motorola	LS140	3	Dual 4-in NAND	0.38	
	Motorola	F74D	1	Flip-flop	0.13	
	Motorola	ULN2003	1	Periph. driver	0.70	
	TI	LS257	1	MUX	0.30	
	TI	LS245	2	Buffer	0.45	
	TI	7406	2	Inverter	0.29	
	TI	7407	1	Buffer	0.16	
	TI	75150	1	Driver	0.45	
	TI	75154	1	Receiver	0.45	
	TI	74LS374	1	Register	0.22	
	Fujitsu	74AC18	1	Quad 2-in AND	0.23	
		Other	4	N/A	0.90	
Analog	Motorola	LM339	2	Quad comparator	0.27	
	Motorola	DAC08	1	D/A converter	0.90	
	Motorola	LM324	3	Quad op amp	1.62	
	Toshiba	TA7259P	1		0.60	
	SGS-Thomson	TEA3718	2	Motor drivers	1.19	

(Continued)

TABLE 4 (Continued)
IBM 4019 Laser Printer Breakdown

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comment
Memory Card						
Volatile	Siemens	514256J-12	8	1Mb DRAM	84.00	1MB of page memory
Standard Logic	National	74AC10	1	Triple 3-in NAND	0.23	
		74AC00	1	Quad 2-in NAND	0.23	
		74AC138	1	3-8 Decoder	0.35	
		Total	59		$194.04	

N/M = Not Meaningful
N/A = Not Applicable

Source: Dataquest
November 1989

DATAQUEST CONCLUSIONS

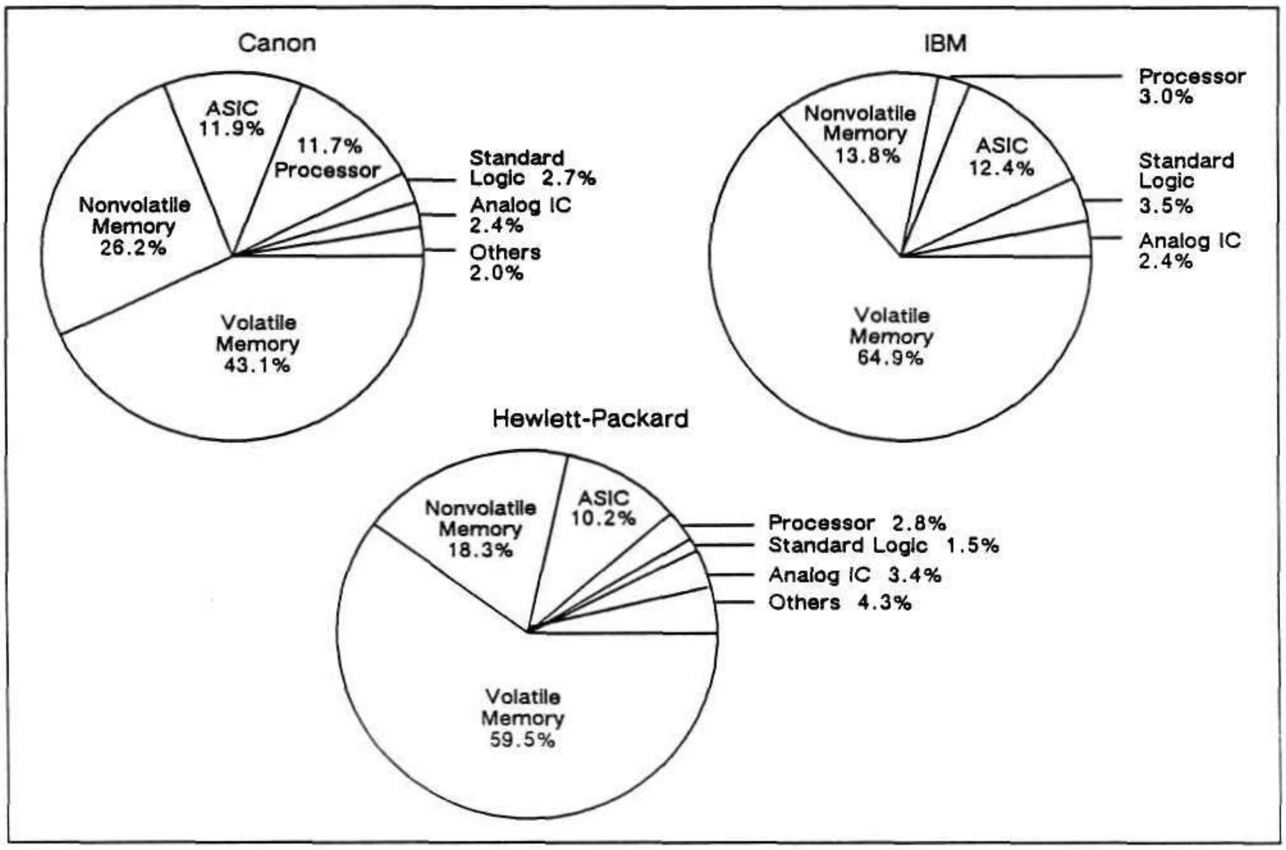
Figure 2 shows the IC cost distributions of these printers by semiconductor type, assuming a standard configuration. Although major contributors to chip count, the standard logic and analog components add very little to total component cost. As expected, memory accounts for the dominant share of total component cost.

But this figure shows only those costs associated with the base configuration. Typical configurations also include substantial memory additions (i.e., DRAM for page memory and font downloading; EPROM and ROM for font cartridges). Figure 3 shows these same IC costs, assuming a moderate expansion of system memory and font selection.

Although it is clear that laser printers offer rich opportunities for semiconductor suppliers, it is also clear that the various supplier groups will not share equally in future rewards.

Kevin Landis
Robert Fennell

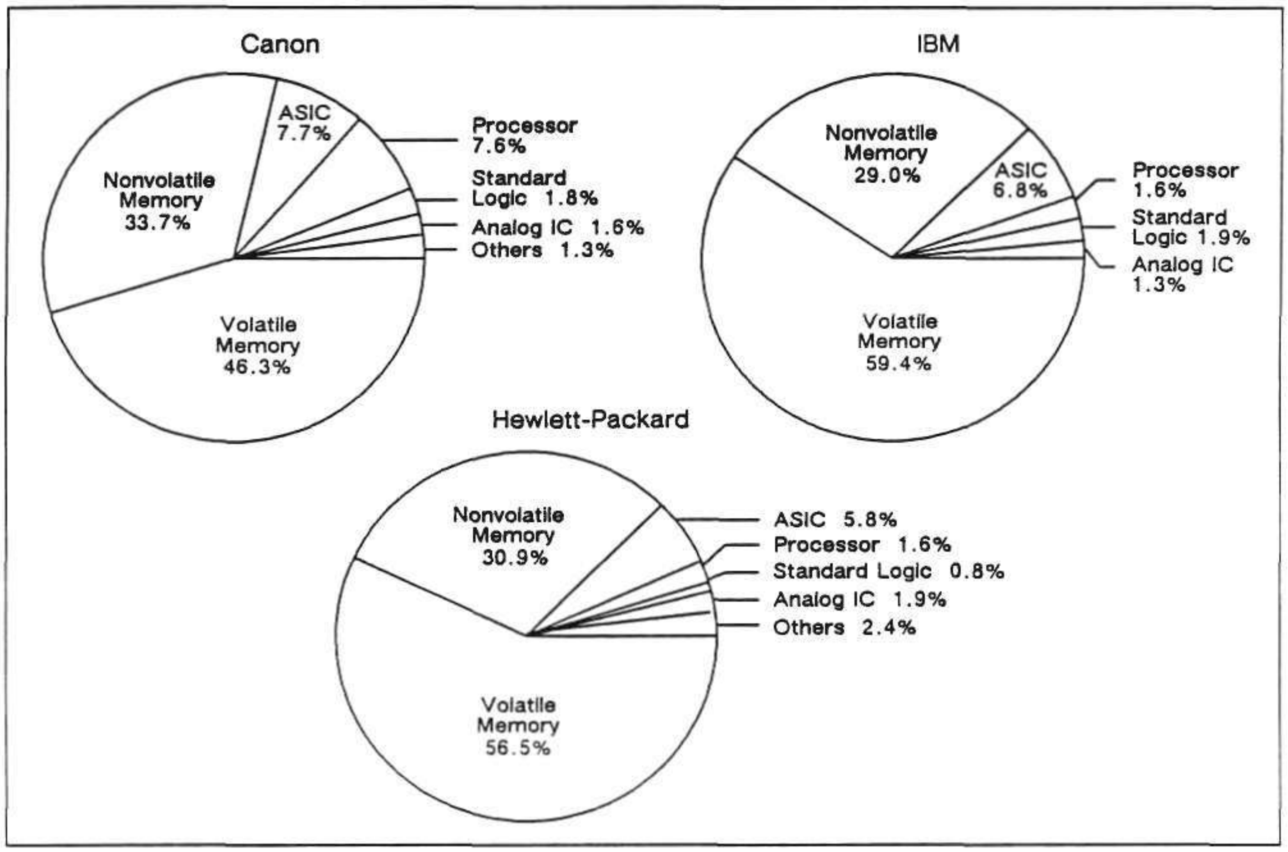
FIGURE 2
Semiconductor Cost Distributions, Base Configurations



0005489-2

Source: Dataquest
November 1989

FIGURE 3
Semiconductor Cost Distributions, Typical Configurations



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Source: Dataquest
November 1989

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Research *Bulletin*

OEM MONTHLY—NOVEMBER 1989 MILITARY SYSTEMS SALUTE PROFIT-MOTIVATED CIVILIAN TECHNOLOGY

OEM Monthly provides insight into application markets so that clients can make better strategic and technical marketing decisions.

THE LANGUISHMENT OF MILITARY ELECTRONICS

In the 1960s, military equipment consumed approximately 75 percent of the ICs produced, and the Department of Defense had a lot of clout with the industry. By 1988, however, the military segment had been reduced to only an 11 percent share. As a result, most chip companies today aim their efforts toward the needs of customers in the high-growth commercial markets (e.g., consumer electronics in the 1970s, desktop computing in the 1980s, and communications networking in the 1990s).

Why Uncle Sam Can't Get Parts

There are enough differences between the military and commercial IC markets that the needs of defense contractors are often overlooked. For example, the market life of most commercial products is less than half the program life of most weapon systems. In addition, each new generation of commercial products demands the latest technology, while many new weapon systems often prefer the proven technologies used on previous programs. As a result, the older ICs will often be obsoleted, and defense contractors will then be caught without a source of supply.

PUTTING HIGH-REL BACK ON TRACK

The defense industry plans to plug into the practices used by civilian technology to get what it needs for future weapon systems. Softer defense spending by the NATO countries means that there will be even less money in the 1990s for new weapons technology, so these countries plan instead to grant commercial firms a small amount of funds to begin developing key technologies with an initial use in military systems only. They will then depend on profit motives in the private sector to fund development once these technologies become practical in commercial systems.

The U.S. Department of Defense has identified 22 technologies as critical to future weapon systems (see Table 1) and is now working with Congress on an investment strategy. A military signal processing system, for example, will need analog and digital elements that require the speed of gallium arsenide semiconductors (e.g., critical technology #2). The military will support this development until the technology's economical use in commercial systems makes its development self-funding.

DATAQUEST RECOMMENDATION

We believe that no company should be too dependent on any one base of customers—IC suppliers should have a mix of military and commercial sales for the security that comes from diversification. This strategy is easier to implement today than in the past because the ICs needed under the hood of the family car or in technical workstations, test equipment, and medical imaging systems have performance and reliability requirements that are similar to those needed in military equipment. We therefore recommend that where appropriate, IC makers use military seed money to fund advanced R&D.

Roger Steciak

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TABLE 1
Critical Technologies and their Objectives

	Critical Technology	Objective
1.	Microelectronics Circuits and their Fabrication	The production of ultrasmall integrated electronic devices for high-speed computers, sensitive receivers, automatic control, etc.
2.	Preparation of Gallium Arsenide (GaAs) and other Compound Semiconductors	The preparation of high-purity GaAs and other compound semiconductor substrates and thin films for microelectronic substrates
3.	Software Producibility	The generation of affordable and reliable software in a timely fashion
4.	Parallel Computer Architectures	Ultrahigh-speed computing by simultaneous use of all processing capabilities in the next generation of computers
5.	Machine Intelligence/Robotics	Incorporation of human "intelligence" and actions into mechanical devices
6.	Simulation and Modeling	Testing of concepts and designs without building physical replicas
7.	Integrated Optics	Optical memories and optical signal and data processing
8.	Fiber Optics	Ultralow-loss fibers and optical components such as switches, couplers, and multiplexers for communications, navigation, etc.
9.	Sensitive Radars	Radar sensors capable of detecting low-observable targets, and/or capable of noncooperative target classification, recognition, and/or identification
10.	Passive Sensors	Sensors not needing to emit signals (hence passive) to detect targets, monitor the environment, or determine the status or condition of equipment
11.	Automatic Target Recognition	Combination of computer architecture, algorithms, and signal processing for near real-time automation of detection, classification, and tracking of targets
12.	Phased Arrays	Formation of spatial beams by controlling the phase and amplitude of RF signals at individual sensor elements distributed along an array (radar, underwater acoustic, or other)
13.	Data Fusion	The machine integration and/or interpretation of data and its presentation in convenient form to the human operator
14.	Signature Control	The ability to control the target signature (radar, optical, acoustic, or other) and thereby enhance the survivability of vehicles and weapon systems
15.	Computational Fluid Dynamics	The modeling of complex fluid flow to make dependable predictions by computing, thus saving time and money previously required for expensive facilities and experiments
16.	Air Breathing Propulsion	Lightweight, fuel-efficient engines using atmospheric oxygen to support combustion
17.	High-Power Microwaves	Microwave radiation at high power levels for weapon applications to temporarily or permanently disable sensors or to do structural damage
18.	Pulsed Power	The generation of power in the field with relatively lightweight, low-volume devices
19.	Hypervelocity Projectiles	The generation and use of hypervelocity projectiles to (1) penetrate hardened targets, and (2) increase the weapon's effective range
20.	High-Temperature/High-Strength/ Lightweight Composite Materials	Materials possessing high strength, low weight, and/or able to withstand high temperatures for aerospace and other applications
21.	Superconductivity	The fabrication and exploitation of superconducting materials
22.	Biotechnology Materials and Processing	The systematic application of biology for an end use in military engineering or medicine

Source: U.S. Department of Defense
Dataquest
October 1989

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Research *Newsletter*

TELECOM TECHNOLOGIES FOR THE 1990S

SUMMARY

Dataquest does not see a revolution in telecom technology over the next 10 years; rather, we see a continued evolution. However, a number of key areas will impact telecommunications end users, suppliers, and regulatory institutions alike.

Several areas will be key in the continuation of the development of the information age with a twist—globalization. This newsletter will briefly explore these six areas:

- Connectivity
- Interoperability
- Networking
- Network management
- Integrated applications
- Personal communication

CONNECTIVITY

As we enter the 1990s, desktop connectivity options will continue to be the focal point and solution to improving work group and enterprise personal productivity.

Dataquest estimates that by the end of 1992, the number of available desktops will grow to 72 million, and 85 percent of these will be equipped with an information device.

Dataquest estimates that 61 percent of the information devices were connected in 1988 and forecasts an 87 percent level by 1992. The leading connectivity method will be the local area network (LAN). The LAN is expected to connect 66 percent of the installed PCs in 1992.

INTEROPERABILITY

Even before deregulation in 1984, end users were looking for the best solutions at the best price. This effort led to a multivendor network and many headaches, ranging from interfaces to finger pointing.

The adoption of standards within the end-user network environment will provide a high level of interoperability and will pave the way to seamless networks. A seamless network is one in which all intermediaries between communicating parties are transparent.

The use of standards becomes especially important in a world of global competition, but standards development is a case of bad news and good news. First the bad news:

- In information technology, more than 1,000 standards either have been adopted or are in the queue of the official standards bodies.
- Not all implementations are of the full standards or even compatible subsets.
- Standards, rather than user requirements, are shaping products.
- Participation in standards development is expensive.

Now for the good news:

- More vendors are adhering to standards.
- The OSI reference model is being adopted (10 years old).
- Standards are starting to open markets.
- Corporation for Open Systems offers conformance testing and certification.

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0005262

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NETWORKING

Networking is the basic ability businesses need to rationally manage the flow of information throughout their organizations.

The 1980s have seen the Fortune 500+ companies construct private networks in order to protect themselves from fluctuating tariffs and provide an environment to handle growth and change. However, since the public network has been completely digitized and computer intelligence such as SS7 has been added, the carriers can offer services that are competitive to private networks. We will see users combine the best of private and public solutions as they take advantage of standards and telco support capabilities and build hybrid networks.

The move toward higher-bandwidth solutions will continue in wide-area networking with DS3 and broadband ISDN. Faster local area networking will be available using FDDI and proprietary gigabit LANs to keep pace with the compute power available on the desk and within the work group.

NETWORK MANAGEMENT

Bringing all information technology together is network management. Today, network management solutions are hierarchical in nature. Managers of network elements such as modem management systems and umbrella management systems such as AT&T's Accumaster Integrator will coexist.

Tomorrow's standards for network management will come from the OSI network-management model and IBM's NetView evolution. However, what will differentiate the products of the future will be ease of use, especially through the incorporation of expert systems technology. This ease of use will attack the problem of the most expensive element in managing a network—people.

Manufacturers also will expand their network management revenue opportunities via professional services such as network planning and design, installation planning, network operation training, and disaster recovery.

Bucking the post-divestiture trend toward managing one's network will be facilities management companies and carriers offering network management services.

INTEGRATED APPLICATIONS

Integrated applications refers to products and services in which the integration of voice and data is aimed at enhancing productivity. Most of today's applications involve the coordination of computer data bases and telephone calls. For example, using IBM/ROLM's Callpath product, directory information can be acquired upon receipt of a phone call and then mailed with another phone call. The evolution of integrated applications will incorporate voice recognition and conversion as well as image.

PERSONAL COMMUNICATION

Cellular radio has removed the constraints of conventional telephone access and provided freedom with growing appeal and application.

Within the next 10 years, telecom services will be available to support an expected growing number of telecommuters' home offices serving as corporate extensions.

This telecommuter phenomenon will be the result of transportation gridlock and the costs and availability of housing. If the expected regulatory relief is granted in the 1990s, the regional Bell holding companies will be supplying many of these home services, including videotex and pay-per-view television.

DATAQUEST CONCLUSIONS

Information (and its communication) has become an integral part of business today. It has allowed companies to gain a competitive advantage (e.g. Federal Express) as well as expand geographic boundaries (Macy's) and enter new business (Westinghouse). Information will continue to be used both as a strategic weapon and as a means of increasing the productivity of an estimated 68 million information workers in 1992. Information use in the 1990s will require seamless networks that are able to reach a level of operation at which any intermediaries between the communicating parties are totally transparent. And these communications could be people-to-people, people-to-machine, or machine-to-machine.

Interoperability will be the leading challenge for suppliers and end users. Their collective task will be to take all forms of information technology to the level of universality that the telephone has achieved.

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Roger Steciak
Jack Musgrove

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Research *Newsletter*

FACSIMILE INDUSTRY POLARIZATION: A TALE OF TWO MARKETS

SUMMARY

The facsimile industry is now divided into two very distinct markets. At the entry level the market is dominated by first-time users in small businesses and small groups of people sharing their first facsimile machine. The opposite end of the market is composed of sophisticated business users who are familiar with facsimile and the communication benefits it allows.

Manufacturers and vendors have aligned themselves with the market segments in order to take advantage of their strengths. The result is that today's facsimile market, given its potential size and wide-ranging customer base, can no longer be considered as a single market. Some manufacturers and their targeted customers are moving toward the mass consumer markets, while others clearly have targeted their activity toward the mainstream of commercial business communication. In this newsletter, Dataquest analyzes the market segments involved and the ramifications of this polarity.

BACKGROUND

Early in 1988, Dataquest redefined the facsimile market segmenting it into six distinct price-based categories (see July 1989 Research Newsletter "U.S. Facsimile Market: Growth Exceeds All Expectations as Market Explodes") as follows:

- <$1,000
- $1,000 - 1,499
- $1,500 - 1,999
- $2,000 - 2,499
- $2,500 - 2,999
- $3,000 +

Figure 1 reflects 1988 estimated placements and revenue by these price segments.

Now, with the emergence of two distinct markets in the facsimile industry, Dataquest further defines the criteria for each of the price-based categories within the commerical business market and the retail mass market.

COMMERCIAL BUSINESS MARKET

While the commercial business market emerges at the midpoint of Dataquest price segments, it merits first place in this discussion, for it is the origin from which the second market, the retail mass market, was able to evolve.

The commercial business market is the focus of those companies offering full-featured facsimile products. In many instances, it is the market in which features are introduced for the first time. These features are often software driven rather than technology driven and dependent upon available memory.

Prices for products in this market often start at $2,000 and can exceed $10,000 depending on the features. Most facsimile machines installed today fall within this segment. Distribution normally is via a direct sales representative or a trained dealer representative supported by the manufacturer. The products in this segment often have document feeders, cutters, sophisticated autodialers and gray scale. Many offer complete activity reporting and most offer proprietary nonstandard transmission speeds, a telephone cost-reduction feature. At the top end of the market, the products offer plain paper and sophisticated memory-based features. Canon, Panasonic, Pitney Bowes, Ricoh, and Xerox dominate this market.

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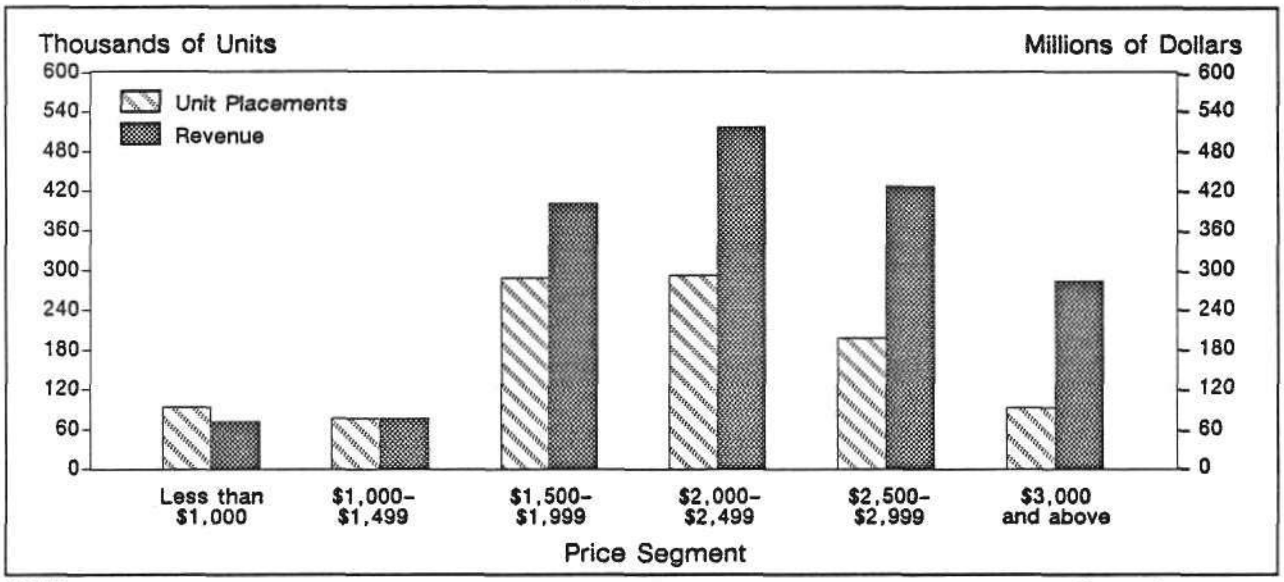
FIGURE 1
1988 Estimated Facsimile Placements by Pricing Segment and Revenue



0005263-1

Source: Dataquest
October 1989

$2,000-$2,499

Usually products in this category offer complete features and show some memory capability. They appeal to mid-size companies that understand the benefits of features such as delayed transmission. The volume demands for customers in this segment can exceed 300 pages per month, and in many cases the product is a central point for many smaller and less-featured facsimile machines to communicate with. Buyers will pay particular attention to the company supplying the machine for after-sales service. In 1988, this segment represented the majority of facsimile machine sales accounting for 28.1 percent of all placements.

$2,500-$2,999

Products in this range are full-featured and begin to provide features not generally required by every fax user. Small amounts of document memory are generally available, allowing the user to store documents for sequential broadcasting to many locations or enabling incoming messages to be stored in memory to print out at a later time. A few machines in this category offer plain paper via the thermal transfer technology. Volume requirements for users in this category range between 200 and 1,000 pages per month depending on the company and the applications.

$3,000+

Above $3,000, the fax products are often quite sophisticated. Many offer large amounts of memory for document storage and some can interface to hard disk drives for expansion of memory capabilities. As prices increase above $5,000, products offer computer interface and encryption capabilities, and some with sophisticated image store and forward capabilities. The higher-end machines offer laser and LED printers and true plain paper capabilities with additional interface ports for LAN and private data channels. Products in this category approach what will become Group 4 facsimile applications.

RETAIL MASS MARKET

This market segment has the largest unit placement potential. It is characterized by lower-priced products, a mass-distribution approach, minimum price/performance ratios, and heavy product discounting. Unit placements are often high, while margins are comparatively low. Murata and Sharp share leadership roles in this market, which is divided into three categories, based on price.

<$1,000

This category is made up of products priced less than $1,000 and is typified by products that offer limited features and functional benefits. For example, products in this category generally do not have automatic document feeders or paper-cutting capability. They often offer limited automatic dialing features and, because of a need to keep machines small in size, the internal paper roll usually is one-third the size (30 meter) of business commercial-type facsimile units. This size is not a problem when useage is less than 50 pages per month.

The buying decision for this segment is based almost entirely on price and is the fastest-growing segment of the entire facsimile market in terms of units, though it may not be as attractive in terms of revenue. Products are positioned as facsimile telephones with limited copying capability. In 1988, this segment made up 9 percent of the overall market, essentially launching the retail mass market for facsimile.

$1,000-1,499

This category offers a little more functionality to its user. Often the products in this segment have small (five pages) document feeders, and some offer limited gray scale. The products usually have expanded autodialing capabilities including the offering of telephone answering-machine ports or functions. Size is still important, and therefore units still offer smaller paper rolls. However, as functionality increases, size becomes less important, and 100-meter paper rolls can be found. In most cases, paper is torn manually or cut from the machine after reception because of the absence of a cutter in this segment. Portability is a feature sometimes offered in this category. Price is still a major buying criterion, but the buyer often requires certain features. Typical monthly machine useage is between 50 and 150 pages.

$1,500-1,999

This segment represents the "crossover" segment of the market and appeals to the widest array of users and suppliers. Typically, products in this category are full featured with full-size paper rolls (50 to 100 meters), cutters, and 10- to 30-page document feeders. The products in this segment appeal to small businesses or individual departments within a medium-size business. Many machines offer delayed dialing capabilities and gray scale at the upper end of the price range. In 1988, this segment represented 27.6 percent of overall facsimile placements in the United States. Dataquest believes that mainstream business facsimile will stabilize in this price range, representing the lower end of the commercial business market and the upper end of the retail mass market.

DATAQUEST ANALYSIS

While a more in-depth discussion of market share will be included in a subsequent newsletter, clearly future perspectives on market share may necessitate not only independent views of the commercial business market and retail mass market, but different schemes for evaluation as well. Companies high in unit market share, for example, may be only midrange in terms of revenue. Thus, market share views need to shift in order to provide the most meaning to participants in the facsimile industry.

Dataquest believes the gauntlet is down. Many participants in the facsimile market who currently are unclear on their specific targets need to focus quickly and make decisions. The marketing of a point-of-sale item requires a very different expertise and support system from addressing the facsimile network needs of the business community. Commanding a leadership role in both of these dramatically different markets will be difficult.

Successful manufacturers in the retail mass market will continue to see large growth in unit market share by promoting the utility of fax in the small business, home, and home-office environment. Distribution will continue to play a major role in the retail mass market.

Successful manufacturers in the commercial business market will need to focus on technology and its implementation. Participants will need to make decisions regarding their part in the emerging image communications market. Those who enter this market must cross over several disciplines. Strategic alliances and partnerships may be the key here as the image communications market involves already-established, strong players, as well as yet-unknown new hopefuls.

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Ruth Ann Gardner

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Research Newsletter

SYSTEM SEMICONDUCTOR CONTENT TRENDS: TV SETS

SUMMARY

Dataquest's analysis of trends in the semiconductor content of TV sets depicts mild growth prospects for manufacturers of consumer components. Table 1 summarizes key points in this newsletter from Dataquest's series on system semiconductor trends. Dataquest recommends that semiconductor manufacturers keep pace with consumer equipment trends, including high-definition TV (HDTV), by forging strategies with Japanese R&D centers in the United States to secure a share of the projected $6.4 billion North American consumer video equipment production in 1993.

PREVIEW

The information summarized in Table 1 is derived from Tables 2 and 3. Table 2 shows the estimated semiconductor content (in percentages) for this equipment for 1988 and 1993. Dataquest bases its analysis of this system's semiconductor content and that of other electronic systems on sources such as system breakdowns, industry bills of material, and consultations with system and semiconductor analysts.

For semiconductor manufacturers, Table 3 translates Table 2 into dollars by converting the TV set content information into a dollar forecast of semiconductor consumption for 1988 through 1993. Dataquest views trends in TV sets as a window of insight into developments in the entire consumer and industrial video marketplace. Table 4 presents Dataquest's 1988 through 1993 forecast of semiconductor consumption by North American manufacturers of all consumer video equipment, which is based on the analysis of TV set system content trends.

TABLE 1
Summarized Semiconductor Content Of TV Sets

	1988	1993	CAGR 1988-1993
North American Production ($M)	$5,395	$6,224	2.9%
Current System Average Selling Price Assumption	$ 385	$ 385	N/M
Semiconductor Consumption ($M)	$ 349	$ 408	3.2%
Total Semiconductor Content	6.8%	6.7%	N/M
Fastest-Growing Semiconductor Markets (By Product and $M)			
MOS Memory	$ 44	$ 61	7.1%
Microcomponents	$ 22	$ 31	7.1%

N/M = Not Meaningful

Source: Dataquest
October 1989

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Dataquest also provides semiconductor suppliers with a technology projection for TV sets for 1988 and into the future. Included in the discussion are the hot product prospects for semiconductor manufacturers over the long term.

EQUIPMENT FORECAST

Dataquest forecasts a 2.9 percent compound annual growth rate (CAGR) for North American TV set production between 1988 and 1993. We expect this market to grow from $5,395 million during 1988 to $6,224 million by 1993. Dataquest expects the entire North American output of consumer video equipment to expand from $5.6 billion during 1988 to $6.4 billion during 1993 (a 2.7 percent CAGR).

TV SET SEMICONDUCTOR CONTENT

Table 2 presents detailed 1988 and 1993 estimated semiconductor content for TV sets. The semiconductor content information shows system manufacturers the relative output value in a TV set (in percentages) generated by the use of a given semiconductor type in the system. As shown in Table 2, the trend in semiconductor demand by North American producers of TV sets is flat because low profit margins in the TV business drive manufacturers to minimize design and manufacturing costs.

TABLE 2
Estimated Semiconductor Content of TV Sets

	1988	1993
Total Semiconductor	6.8%	6.7%
IC	4.6%	4.3%
Bipolar Digital	0.6%	0.1%
Memory	0	0
Logic	0.4%	0.1%
MOS Digital	1.8%	2.0%
Memory	1.0%	1.0%
Microcomponents	0.4%	0.5%
Logic	0.4%	0.5%
Analog	2.2%	2.2%
Discrete	2.0%	2.2%
Optoelectronic	0.2%	0.2%

Source: Dataquest
October 1989

SEMICONDUCTOR CONSUMPTION FORECAST

Table 3 provides Dataquest's forecast of semiconductor consumption by North American manufacturers of TV sets during the 1988 through 1993 period.

As shown in Table 3, semiconductor manufacturers can expect demand by TV set manufacturers to expand from $349 million during 1988 to $408 million by 1993, a CAGR of 3.2 percent.

Table 4 reveals the magnitude of the opportunity in consumer electronics for semiconductor suppliers.

CONVERGENCE OF SYSTEM AND SEMICONDUCTOR TECHNOLOGIES

The trend toward converging system and semiconductor technologies in TV sets means challenge and opportunity for semiconductor suppliers.

TV Set Technology

For semiconductor manufacturers, the TV set business can be viewed as a large application-specific market that serves as an avenue into the projected $6.4 billion consumer video marketplace of 1993 and, after that, into advanced video programs. Figure 1 shows a block diagram of today's NTSC color TV set, and Figure 2 shows a block diagram of the future digital HDTV set. These diagrams pinpoint market opportunities for semiconductor suppliers in the TV set arena.

Semiconductor Technology Requirements of TV Sets

No startling changes that will translate into commercial run rates are expected in TV set technology between 1988 and 1993. Instead, digital HDTV sets (and also stepping-stone models such as improved-definition and extended-definition TV sets) will become available in the early 1990s but are expected to sell in small quantities only. Dataquest believes that the HDTV impact on semiconductor consumption will not be felt until well after the year 2000 when HDTV sets may begin to capture a significant share of new TV set sales.

TABLE 3
Estimated Semiconductor Consumption in TV Sets (1988-1993, North American Production, Millions of Dollars)

	1988	1993	CAGR 1988-1993
Equipment Production	$5,395	$6,424	2.9%
Total Semiconductor	$ 349	$ 408	3.2%
IC	$ 231	$ 271	3.3%
Bipolar Digital	22	10	(14.6%)
Memory	1	1	0
Logic	21	9	(15.6%)
MOS Digital	88	123	6.9%
Memory	44	62	7.1%
Microcomponents	22	31	7.1%
Logic	22	30	6.4%
Analog	121	138	2.7%
Discrete	$ 110	$ 127	2.9%
Optoelectronic	$ 8	$ 10	4.6%

Source: Dataquest
October 1989

TABLE 4
Estimated Semiconductor Consumption In Consumer Video (1988-1993, North American Production, Millions of Dollars)

	1988	1993	CAGR 1988-1993
Equipment Production	$5,628	$6,432	2.7%
Total Semiconductor	$ 389	$ 428	1.9%
IC	$ 264	$ 286	1.6%
Bipolar Digital	23	11	(13.6%)
Memory	2	1	(12.9%)
Logic	21	10	(13.7%)
MOS Digital	117	136	3.1%
Memory	60	70	3.1%
Microcomponents	31	36	2.8%
Logic	26	30	3.3%
Analog	124	139	2.3%
Discrete	$ 115	$ 130	2.3%
Optoelectronics	$ 10	$ 12	2.7%

Source: Dataquest
October 1989

Hot Semiconductor Prospects

The HDTV set is expected to use digital processing to enhance the picture. Even though the U.S. HDTV standard is not scheduled to be defined until 1991, the U.S. FCC has stated that an HDTV signal must be receivable on today's standard NTSC TV set as a standard-definition picture. Digital techniques will allow this backward-compatibility requirement to be met, and the HDTV set, in effect, will be an embedded special-purpose computer. The same technology, when used in workstations to perform 3-D modeling and other graphics-based processing, is called "industrial HDTV" or "videocomputing."

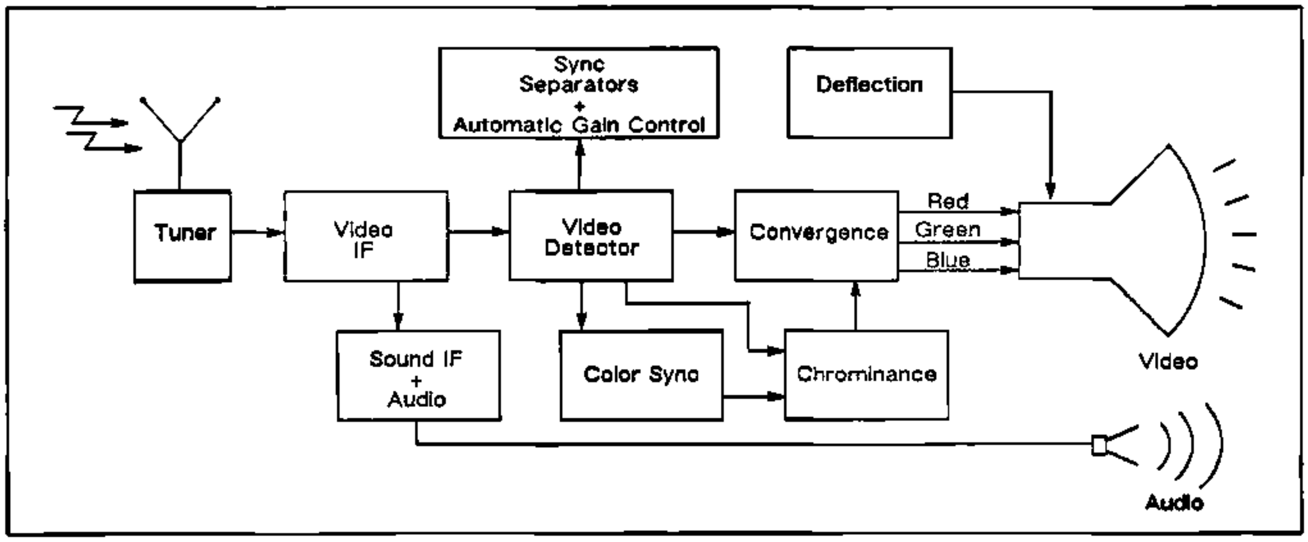
Semiconductors expected to be used for HDTV include fast parallel RISC processors and 4Mb DRAMs. Analog-to-digital and digital-to-analog converters capable of operating at video rates will be needed before and after digital processing. Semiconductors in the tuners and demodulators pull the TV signal off of the air; these are expected to be similar for both NTSC and HDTV sets. The analog wideband amplifiers that drive the HDTV picture tube, however, will require a bandwidth of 20 to 25 MHz (or about four to five times the 5-MHz bandwidth of NTSC video channels).

DATAQUEST CONCLUSIONS

Dataquest's recent analysis of the semiconductor content of TV sets reveals a genuine long-term opportunity for suppliers of consumer analog, digital, and discrete semiconductors. For semiconductor suppliers, the opportunity lies not only in the TV set segment but throughout the consumer and industrial video marketplace. The intensity and specialization of the competition, however, means that the consumer and video electronics field is not for the squeamish.

In addition, the manufacture of consumer electronics usually migrates to the countries that are the lowest-cost producers. Starting in the 1960s, the industry left the United States for Japan and then moved to Southeast Asia. In the late 1980s, the consumer electronics industry appeared to be moving back to the United States, among several other places in the world. For semiconductor manufacturers, this trend means that the industry is a dynamic one that responds to items such as exchange rates, political changes, trade regulations, technology breakthroughs, and changes in consumer preferences.

FIGURE 1
NTSC Color TV Block Diagram



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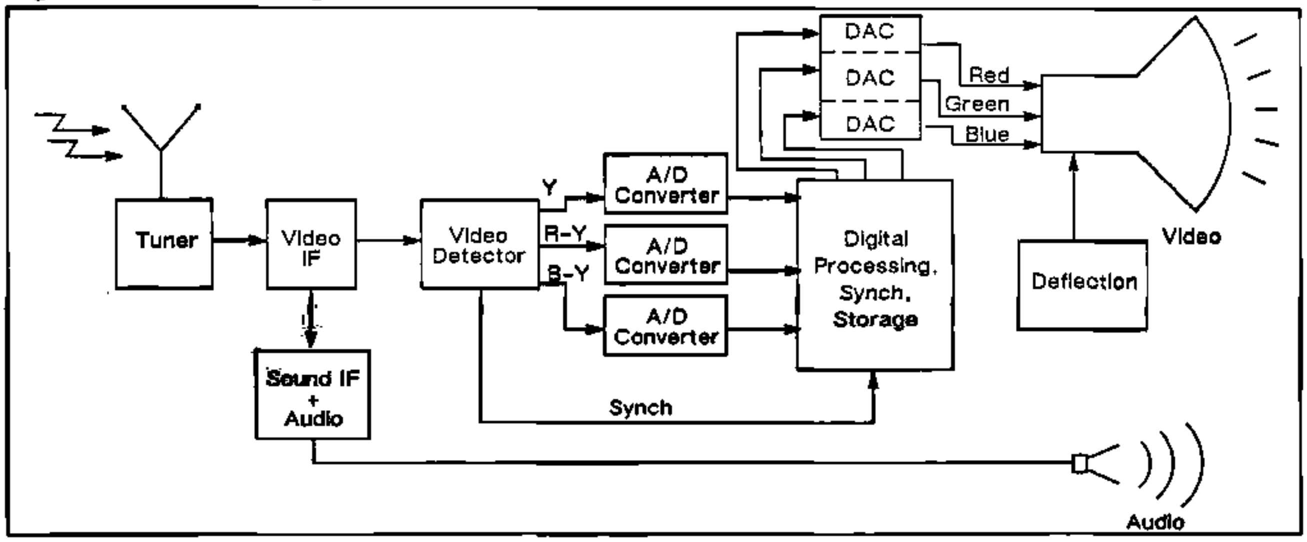
Source: Dataquest October 1989

FIGURE 2
Digital HDTV Block Diagram



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Source: Dataquest October 1989

DATAQUEST RECOMMENDATIONS

Dataquest recommends that strategic planners for semiconductor manufacturers take advantage of our insight into TV set system semiconductor analysis by carefully pursuing long-term opportunities in the TV set marketplace, which in the future will be linked heavily with developments in the application-specific embedded computer marketplace. Several Japanese TV companies have established R&D centers in the United States, and we further recommend that North American semiconductor manufacturers establish a business relationship with these centers if they want to participate in this technology market.

Roger Steciak

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Research *Bulletin*

SAMONITOR: THE LAZY DAYS OF SUMMER TURN TO FALL

The *SAMonitor* is a monthly update that closely monitors changes in key electronic equipment markets. It presents important tactical leading indicators of semiconductor business activity and discusses the potential impact of equipment market fluctuations on chip orders and shipments.

Figure 1
Computers and Office Equipment

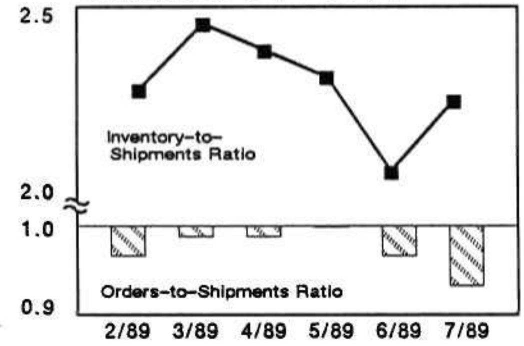


Figure 2
Communications Equipment

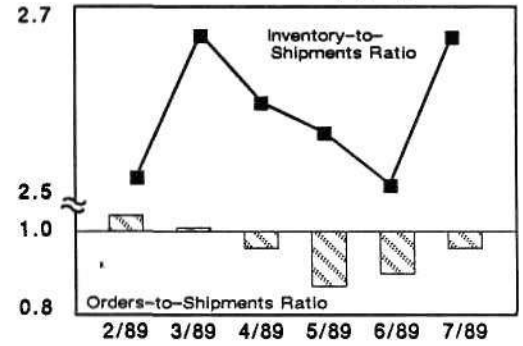


Figure 3
U.S. Instruments

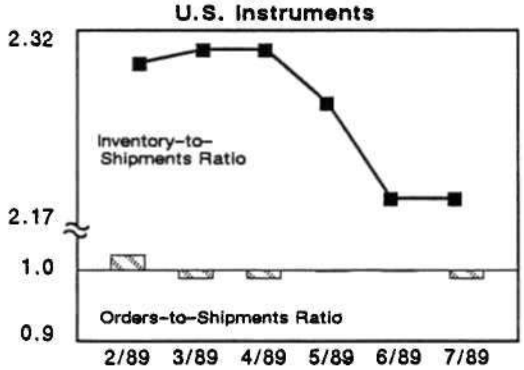
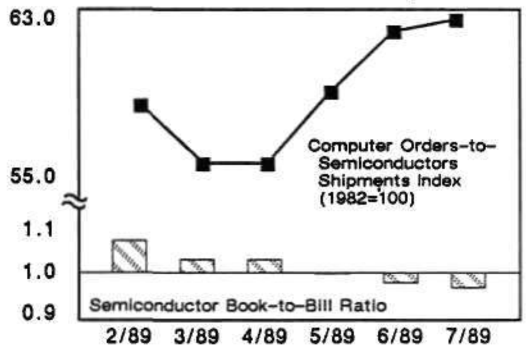


Figure 4
Semiconductors and Computers



0005201-1

Source: U.S. Department of Commerce
World Semiconductor
Trade Statistics
Dataquest
October 1989

SAM 1989 Newsletters: October-December 1989-52

0005201

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THE MARKETS

Computers and Office Equipment

The combination of inventory overhang and continued decelerating growth in orders and shipments indicates that the slowing shipments growth that began late last year is likely to continue through the end of 1989. As shown in Figure 1, the computer and office equipment orders-to-shipments ratio fell for the second consecutive month in July to 0.94, from 0.97 in June. Order growth rates are running slower than shipment growth rates, and both have been slipping since January. For the three-month period that ended in July, orders were down 2.8 percent from the same period last year, compared with a decline of 1.3 percent in June. Shipments were up 3.9 percent from the same period last year, compared with 5.0 percent in June. The inventory-to-shipments ratio shows typical seasonality with one important exception: So far this year, the ratio averages 2.17, or 0.11 above the same period last year, indicating that actual inventories are above desired inventories. In light of this and the slowing growth in orders and shipments, Dataquest expects new systems growth to continue to slip for the remainder of this year, not turning around until the first quarter of 1990. In turn, semiconductor shipments growth is not likely to turn around until the second quarter of 1990.

Communications Equipment

The gradually slowing growth that began early last year may be coming to an end. As shown in Figure 2, the July orders-to-shipments ratio rose for the second consecutive month to 0.96. For the three-month period that ended in July, orders were up 6.9 percent from the same period last year, compared with 2.5 percent in June. The inventory-to-shipments ratio jumped up unexpectedly in July, but excessive inventories should not pose an immediate problem. Through July, this year's ratio is 0.06 below last year's ratio. In view of this situation, if the recent pickup in orders growth continues, a pickup in system shipments growth is likely before year-end. Compared with the computer market, the communications market represents a relatively safe haven for chip manufacturers during the next six months.

Instruments

Instrument production may be taking a turn for the worse. As shown in Figure 3, the orders-to-shipments ratio fell slightly in July to 0.99 from 1.0 in June. More important, however, new orders and shipments in July fell 6.5 percent and 0.5 percent, respectively, from year-earlier levels. *This is the first time in more than two years that either shipments or orders have contracted, and seldom does a contraction last only a month. If history repeats itself, we're likely to face at least a few more months of shrinking orders and shipments.* Fortunately, inventory levels are appropriate for the current level of shipments.

SEMICONDUCTOR DEMAND

Since the beginning of the year, decelerating systems orders and shipments growth have translated into declining semiconductor orders and shipments. The semiconductor book-to-bill ratio peaked at 1.07 in February and has declined continuously to 0.94 in August (see Figure 4). As grim as this situation looks, there may be some light at the end of the tunnel: Dataquest's index of computer orders to semiconductor shipments, a leading indicator of semiconductor orders and shipments, rose strongly in May and June and edged up slightly in July. If this trend continues, semiconductor orders and shipments are probably near their cyclical trough. Assuming that computer orders and shipments growth begins to accelerate in the first quarter of 1990, semiconductor shipments growth also could begin to accelerate during the second quarter of 1990.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest expects no significant immediate improvement in computer order and shipment rates through the end of the year. With the semiconductor book-to-bill ratio falling since February and reaching 0.94 in August, there are a whole lot of chips out there chasing a pretty slow equipment market. Perhaps the only relief in sight is the computer orders-to-semiconductor shipments index that turned up for the third consecutive month, after falling continuously since December 1988. If the index continues to rise, semiconductor business conditions are likely to improve during the first quarter of 1990. To be competitive in this chip buyer's market, we recommend that semiconductor manufacturers be vigilant in their commitment to running a lean and nimble operation and competing on intangibles, such as customer service and satisfaction. Dedication to these matters is the best insurance for catching the next business upswing and the attendant market share.

Terrance A. Birkholz

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Research *Newsletter*

THIRD QUARTER ELECTRONIC EQUIPMENT UPDATE: GREAT WORK, IF YOU CAN FIND IT

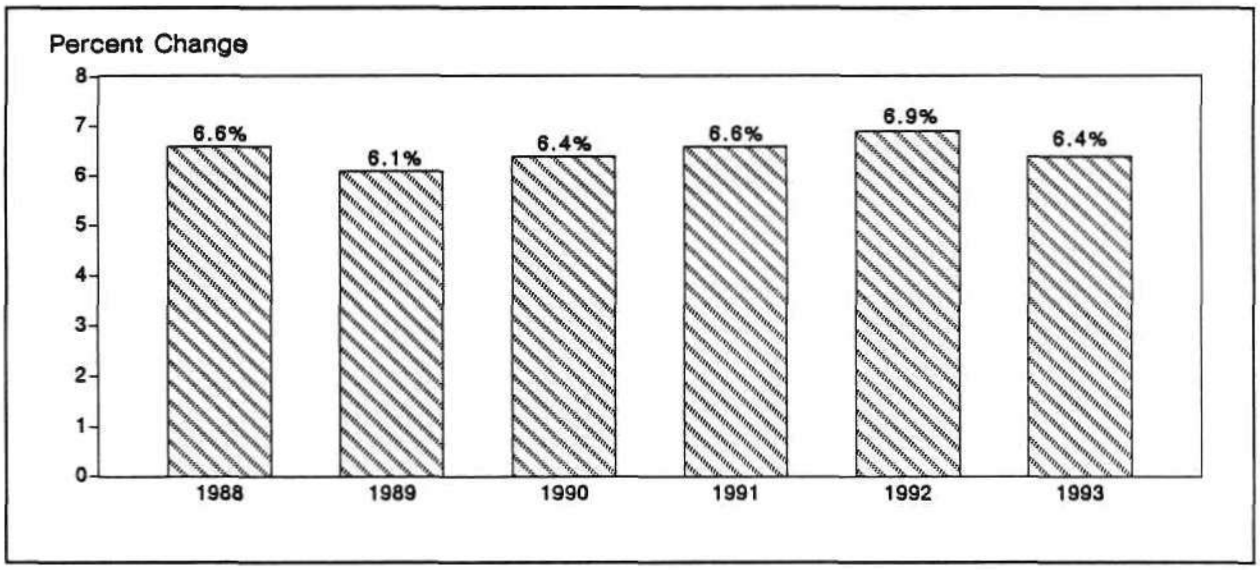
SUMMARY

Dataquest expects North American electronic equipment production growth to remain relatively stable. Electronic system production is expected to slow to 6.1 percent in 1989, down slightly from the 6.6 percent rate set in 1988 (see Figure 1). We expect the pace to pick up slightly to 6.4 percent in 1990, and to remain between 6.0 and 7.0 percent through 1993. Expected stability, however, masks an uneven distribution of growth. For example, personal computer, workstation, and local area network (LAN) production are all expected to grow much faster than the average. In general, equipment makers, such as those of distributed data processing systems and data communications systems, that continue to push their respective systems' price/performance frontiers should provide the best and also the most competitive business prospects for semiconductor manufacturers. It is going to take more than cutting-edge technology to get through to the other side of this business lull. Until growth becomes more broad based—probably in 1991 and beyond—Dataquest believes that giving undivided attention to helping customers meet their most pressing current needs (inventory and cost control) will be the best policy for ensuring tomorrow's business.

INTRODUCTION

Dataquest's Semiconductor Application Markets (SAM) service has refined its method of

FIGURE 1
North American Equipment Production (Annual Percentage Growth)



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Source: Dataquest
October 1989

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estimating North American semiconductor consumption by application market. We believe that this new method is a significant improvement over previous methods by virtue of its "bottom-up" approach. The analysis begins with the chip content of specific types of electronic equipment systems. The scope of analysis then expands to include similar types of equipment, extending to the equipment group level and finally to SAM's familiar six application markets.

Key types of specific electronic systems have been selected, with semiconductor input/output (I/O) ratios that dominate their respective equipment group and/or are expected to change significantly in the next five years. Each equipment *type* corresponds to an equipment *group* that, in turn, is related to a major application market.

In the coming months, SAM analysts will publish a series of newsletters—under the heading "Semiconductor Content Trends"—that will describe present-day and expected future generalized system architectures, their implications for semiconductor consumption, and other important findings.

This newsletter will discuss Dataquest's new North American electronic equipment production and the region's associated semiconductor consumption outlook. The second newsletter in this two-part series will discuss the effects of captive chip production and inventory changes on merchant semiconductor demand.

APPLICATION MARKET OUTLOOK

As mentioned earlier, and as shown in Table 1, Dataquest expects total equipment production growth to slow only slightly this year, to a 6.1 percent pace, down from 6.6 percent in 1988. We expect relative stability in annual growth through 1993, with a 6.5 percent compound annual growth rate (CAGR) from 1988 through 1993.

Electronic equipment production is expected to be tempered by the slower overall level of economic activity in general and slower investment spending in particular. Dataquest expects *real U.S. GNP growth to slow from its 3.9 percent annual pace in 1988 to 3.0 percent in 1989, and to decelerate further to 1.8 percent in 1990.* Faster growth should resume in 1991, at a 3.5 percent rate. The Federal Reserve Board's tight monetary policy over the last 18 months appears to have, at least temporarily, put a lid on inflation, but not without slowing current and short-term real business activity. As a result, real business fixed investment growth is projected to slow to 5.5 percent in 1989, down from 9.5 percent in 1988; we expect it to decline further to 4.4 percent in 1990 and to rebound in 1991 by 5.9 percent. *No recession is forecast.*

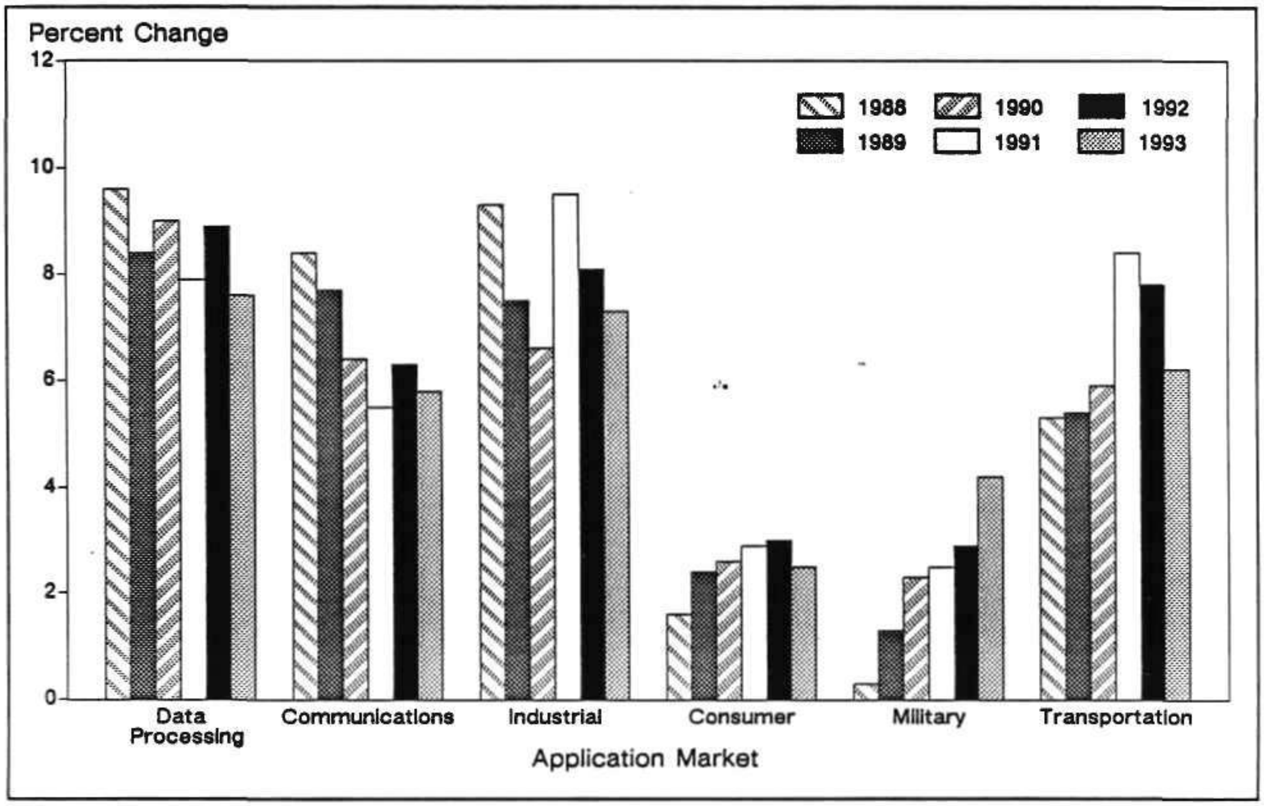
Referring again to Figure 1, we expect total equipment production annual growth to stay within the 6 to 7 percent range through 1993. Growth among the application markets is unevenly distributed, however, as shown in Figure 2, with data processing, communications, and industrial applications setting the pace. Nevertheless, even within these application markets, the distribution of growth is spotty. Personal computers, workstations, and LANs are expected to grow well above average this year at 10.4 percent, 38.4 percent, and 40.3 percent, respectively. These rather ubiquitous systems share this in common: They are expanding

TABLE 1
North American Electronic Equipment Forecast (Millions of Dollars)

	1988	1989	1990	1991	1992	1993	% Change 1988-1989	CAGR 1988-1993
Data Processing	$100,074	$108,449	$118,229	$127,570	$138,904	$149,475	8.4	8.4
Communications	27,417	29,522	31,405	33,136	35,236	37,294	7.7	6.3
Industrial	43,624	46,899	49,989	54,742	59,199	63,514	7.5	7.8
Consumer	19,970	20,457	20,986	21,598	22,239	22,789	2.4	2.7
Military	51,063	51,727	52,918	54,263	55,845	58,206	0.2	2.7
Transportation	10,744	11,319	11,984	12,986	14,002	14,864	5.4	6.7
Total	$252,892	$268,373	$285,511	$304,295	$325,425	$346,142	6.1	6.5

Source: Dataquest
October 1989

FIGURE 2
North American Equipment Production by Application Market (Annual Percentage Growth)



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Source: Dataquest October 1989

their price/performance frontiers through either faster data processing speeds or quicker transfer rates. More established technologies (i.e., mainframes and minicomputers in central processing applications) should experience slower-than-average growth, because of either market maturity or substitution of more cost-effective systems.

As shown in Table 2, we believe that the data processing sector will continue to be the largest and fastest-growing consumer of semiconductors. (In the context of this newsletter, the value of semiconductor consumption represents the total value of chips drawn from the merchant market shipments, captive sources, and inventory.) In fact, in 1988, personal computers accounted for 11.5 percent of total North American semiconductor consumption, making it the largest semiconductor end-use market. Historically, however, the PC market also has been one of the most volatile: Since 1984, North American PC production has ranged from growth of 87.5 percent in 1984 to a decline of negative 9.9 percent in 1986. Although PC business fluctuations in the late 1980s have damped relative to the mid-1980s, the chip business remains vulnerable to PC market volatility.

The remainder of this newsletter will discuss in greater detail the outlook for the equipment markets and the semiconductor implications, especially noting areas of exceptional growth.

Data Processing

The data processing market is a good example of where growth is unevenly distributed. As shown in Table 3, the North American computer equipment group is forecast to grow by 9.3 percent in 1989 and at a CAGR of 10.0 percent through 1993, driven by PC and workstation production. We forecast PC and workstations to grow 10.4 and 38.4 percent, respectively, in 1989 and at a CAGR of 10.7 and 27.9 percent, respectively, through 1993. Indeed, if workstations and PCs are removed from the data, leaving mostly mainframes and minicomputers, we expect the computer equipment group to grow 6.4 percent this year, with a CAGR of 7.5 percent.

Given that PC production accounts for 11.5 percent of North American chip consumption, it is easy to see why consumption of memories and microcomponents has been so crucial in sustaining the North American market. Despite fierce competition, these two markets should bolster equipment production and consumption growth through 1993, as distributed processing gradually replaces central processing. During the next five years, we forecast PC production growth to peak in 1992, at 13.9 percent, as the next generation of systems is brought to market. We expect workstation growth to peak in 1989, at 38.4 percent, as unrelenting competition puts pressure on prices and the installed base widens. Our forecast bodes well for memory and microcomponent companies selling into these areas. In fact, these systems' semiconductor content will get an added boost as their memory and microcomponent I/Os increase through 1993.

As noted, high-end PC systems designed around the next generation of microprocessors should enter wide-scale production in 1992. Market acceptance of the next-generation PC systems is by no means assured, however. Successful introduction will require two conditions. First, there must be sufficient applications that make use of the 80486's unique features. Second and more importantly, users will need to perceive an unambiguous increase in productivity by moving upscale. Considering the tardiness with which the 80386's complement of software arrived on the market and the detrimental effect this tardiness had on acceptance, successful launch of the next generation of PC systems is likely to require unparalleled coordination of hardware and software suppliers.

Add to this, then, the competitive effect that low-end, UNIX-based CISC or RISC systems will have on next-generation, high-end PC acceptance.

TABLE 2
North American Semiconductor Consumption by Application Market (Millions of Dollars)

	1988	1989	1990	1991	1992	1993	% Change 1988-1989	CAGR 1988-1993
Data Processing	$ 9,901	$11,150	$12,874	$14,536	$16,886	$19,390	12.6	14.4
Communications	2,416	2,571	2,756	2,934	3,121	3,304	6.4	6.5
Industrial	2,476	2,663	2,868	3,200	3,539	3,912	7.6	9.6
Consumer	1,280	1,306	1,333	1,359	1,385	1,411	2.0	1.6
Military	1,743	1,842	1,994	2,123	2,282	2,477	5.7	7.3
Transportation	1,209	1,301	1,407	1,487	1,617	1,769	7.6	7.9
Total	$19,025	$20,833	$23,232	$25,639	$28,830	$32,263	9.5	11.1

Source: Dataquest
October 1989

TABLE 3
North American Data Processing Equipment Forecast (Millions of Dollars)

	1988	1989	1990	1991	1992	1993	% Change 1988-1989	CAGR 1988-1993
PCs	$18,961	$20,942	$22,925	$24,872	$ 28,322	$ 31,539	10.4	10.7
Workstations	3,900	5,398	7,160	9,030	11,115	13,332	38.4	27.9
All Other Computers	45,908	48,822	52,437	57,122	61,821	65,837	6.4	7.5
Total Computers	$68,769	$75,162	$82,522	$91,024	$101,258	$110,708	9.3	10.0

Source: Dataquest
October 1989

TABLE 4
North American Communications Equipment Forecast (Millions of Dollars)

	1988	1989	1990	1991	1992	1993	% Change 1988-1989	CAGR 1988-1993
LANs	$ 2,580	$ 3,620	$ 4,380	$ 5,060	$ 5,760	$ 6,451	40.3	17.4
Voice Messaging	$ 472	$ 675	$ 825	$ 897	$ 917	$ 926	43.0	14.4
Other Communications	$24,365	$25,122	$26,199	$27,179	$28,559	$29,914	3.1	4.2

Source: Dataquest
October 1989

All in all, the data processing application's future is bright. But don't bother to wear sunglasses; you may not see the fierce competition ahead until it hits you.

Communications

We forecast the North American communications market to grow 7.3 percent in 1989, with a 6.3 percent CAGR through 1993. Production of data communications and other customer premises equipment will set the pace (see Table 4).

Much of the lackluster growth forecast for communications stems from the fact that public telecommunications accounts for 25.6 percent of the entire application market but is expected to grow only 1.8 percent in 1989, with a CAGR of 6.3 percent through 1993. Investment here is typically slow and plodding because of sheer cost and long capital equipment life cycles. These factors are especially true in the short run because previous years' industry consolidations and competition have constrained capital budgets, but resumption of reinvestment in the nation's public communications network should provide a boost to growth over the next five years.

Industrial

The U.S. economy is a bellwether regarding the industrial outlook: Economy-wide slowing in capital equipment investment will spill over to the industrial electronics market. We expect growth to slow from 9.5 percent in 1988 to 7.5 percent in 1989, slowing further to 6.4 percent in 1990. Under the circumstances, process control equipment and programmable machine tools—7.9 percent of the industrial electronics market—will hold up fairly well this year, achieving 8.6 percent, and 9.4 percent growth, respectively. However, record production of civilian aircraft and upgrading of the nation's air traffic control system make civil aerospace the high-flying industrial equipment group: Expect 14.5 percent production growth this year and average growth of 14.0 percent through 1993.

The drive to make industrial equipment systems "smarter" bodes well for industrial semiconductor consumption. This fact is especially true for ASICs, particularly those with embedded controllers.

Consumer

If it were not for foreign manufacturers' schemes to circumvent *possible* future protectionist local-content rules, the outlook for North American consumer equipment production would be really grim. As it is, consumer production's annual growth is expected to remain at or below 3.0 percent per year through 1993.

Consumer gear is expected to make increasing use of a broad range of chip families. In particular, advanced television technology will make increasing use of memory and analog devices. Should the U.S. electronics industry succeed in making the correct about-face in the consumer market, it may be able to take advantage of the expected upswing in the next generation of video equipment. Unfortunately, most of today's consumer electronics equipment is manufactured by vertically integrated, foreign-owned companies that prefer to procure their chips by internal means. So in the short- to midterm, little opportunity exists for domestic-owned companies to take advantage of this business.

Military

In the defense industry, slower funding growth of research and procurement is the order of the day. This situation translates into meager systems production, or a CAGR of only 2.7 percent through 1993. Nevertheless, as Table 2 indicates, chip consumption growth is expected to be moderate at 7.3 percent CAGR through 1993. Because the military business tends to be oriented to custom designs and specifications, ASIC solutions probably will provide the greatest market size and growth opportunities through 1993. Indeed, we expect ASICs to propel military MOS logic consumption from an estimated North American market size of $289.7 million in 1988 to $538.1 million in 1993, with a CAGR of 13.2 percent.

Transportation

Vehicle production growth will be constrained through the rest of this year by high inventory overhang; it is likely to be constrained next year by slower economic activity, but increased penetration should partially offset this situation. As a result, we forecast automotive electronics production growth to be 5.4 percent in 1989 and 5.9 percent in 1990. Because unit vehicle production growth is being held down, increased system penetration is responsible for much of automotive electronics growth.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The data processing sector continues to be the mainstay and leader of semiconductor consumption in North America, but a common thread permeates all end-use markets: Competitive pressure necessitates that systems manufacturers either keep pace or set the pace in expanding systems' price/performance frontiers. In an expanding economy, this is a difficult task. In a slow-growth economy (Dataquest's expectation for the 1989 to 1990 time frame) when margins are squeezed, staying on a price/performance frontier becomes even more important to long-term corporate viability.

As a practical matter, keeping pace with the expanding price/performance frontier means greater memory capacity and faster information-processing speeds. This trend manifests itself in increased penetration of memory chips, microcomponents, and ASICs. Dataquest expects the content of memories and microcomponents in all six applications to increase through 1993.

As technology becomes increasingly pervasive, however, a company's presence on the technological frontier will be only a prerequisite for long-term success. To weather this current dry spell, we believe that chip manufacturers will have to be prepared to be judged critically on all aspects of the their service. Now more than ever, it makes sense to go the extra mile to meet customer needs. This is no time to let up!

The second newsletter in this two-part series will discuss captive chip production and inventory changes—the important link between semiconductor consumption and merchant semiconductor shipments.

Terrance A. Birkholz

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Research *Bulletin*

OEM MONTHLY—OCTOBER 1989
INTERCONNECT—THE NEXT MAJOR CHALLENGE FOR ELECTRONICS

OEM Monthly provides insight into application markets so that clients can make better strategic and technical marketing decisions.

THE PROBLEM WITH FASTER ICS

Data in electrical form typically require two to five nanoseconds (i.e., billionths of a second) to travel from the inside of one chip on a circuit board to the inside of another. Because most systems in the mid-1980s had relatively low 10-MHz clock frequencies, this interchip travel time was not a major concern because it represented only 5 percent of the 100-nanosecond (i.e., the reciprocal of 10 MHz) time that was available during each clock period.

System clocks, however, are getting faster and, as a result, clock periods are being reduced. Clocks frequencies are expected to reach 50 MHz by 1991 and 100 MHz by 1994, leaving only 20-nanosecond and 10-nanosecond clock periods, respectively, for the calculation cycles. Unfortunately, the same 5-nanosecond interchip travel time now becomes a significant 25 and 50 percent of these shorter clock periods. Faster systems will not be able to process data to their fullest capabilities because they will have to spend a greater percentage of their clock periods waiting for the data to travel between chips.

Possible Solutions

Because more powerful machines result when data spend more time inside chips being processed and less time traveling between them, the industry must take a look at IC interconnection to make sure it does not become the performance bottleneck of the 1990s. Two ways to reduce interchip travel times are shorter path lengths and faster travel speeds. These could be accomplished as follows:

- Shorter path lengths would result if chips could be placed closer together in circuits. Possibilities here include surface-mounted packages, multichip modules, and wafer scale integration.
- Faster travel speeds would result if data could move at speeds closer to the speed of light. Possibilities here include lower dielectric substrates, optical interconnect, and superconductors.

THE IMPACT ON ELECTRONICS ASSEMBLY

Interconnect advances are expected to affect the structure of the electronics assembly industry starting in the 1990s. Today, chip suppliers assemble and test components, and equipment manufacturers assemble circuit boards with these components. Tomorrow's chain is expected to include a module step that merges some of today's device assembly and test at component manufacturing with some of today's circuit board assembly at equipment manufacturing (see Figure 1). Chip suppliers, contract assemblers, and equipment manufacturers are all likely participants in this new module step that today is up for grabs.

The Renaissance in Hybrids

The beginning of interconnect already has occurred in the form of surface-mounted packages, which result in shorter paths between the inside of one chip and the inside of another. Surface-mount ICs were introduced in the 1970s for digital watches. Today, their market share is expected to increase from 20 percent of the worldwide units shipped in 1988 to nearly 50 percent by 1992 (see

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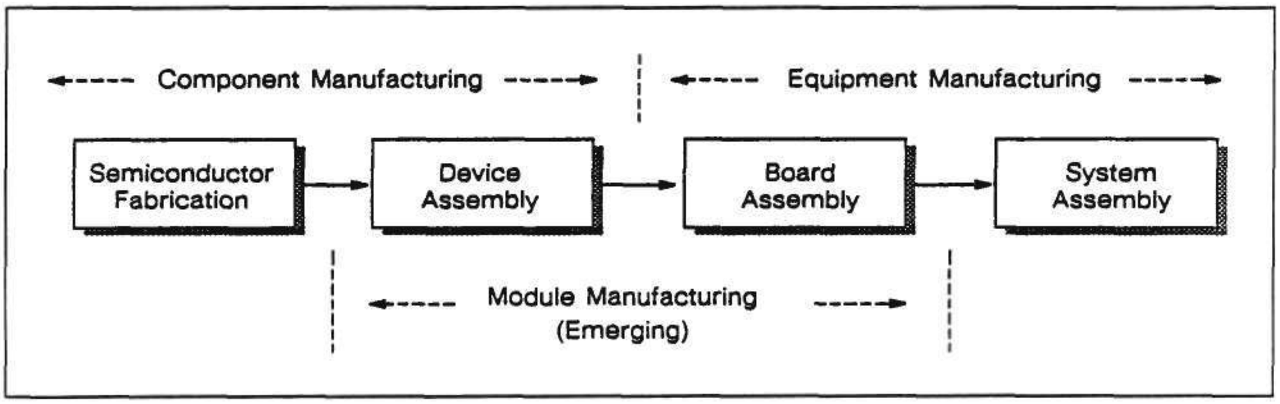
FIGURE 1
The Electronics Manufacturing Chain



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Source: Dataquest October 1989

Figure 2). Prices of most surface-mounted ICs are now less than those of comparable ICs in traditional through-hole packages; thus, today's market is being driven by better performance at lower cost.

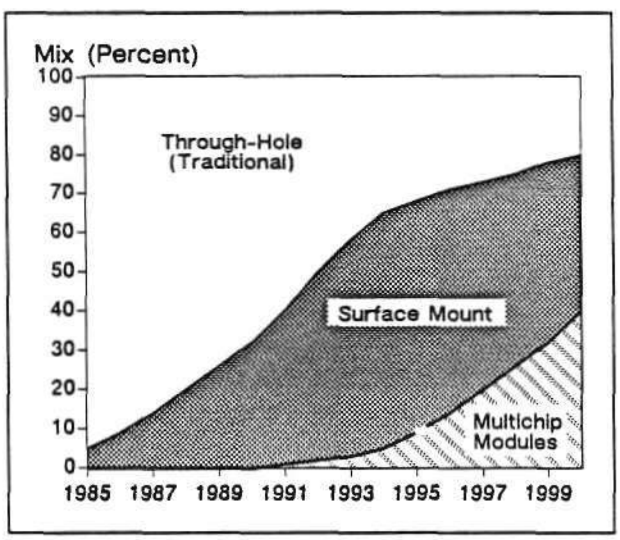
Multichip modules also result in shorter interchip paths by placing several chips close together inside the same package. This hybrid-like packaging technique is expected to increase its market share from almost nothing today to 40 percent by the year 2000 (see Figure 2). Few companies in either the United States or Europe are shipping ICs in this type of package currently, but Japanese companies are moving ahead. NEC, for example, is already using multichip modules in its new supercomputers.

DATAQUEST RECOMMENDATION

Innovation also brings with it the risk that only a few of the good ideas will ever achieve significant market shares, and businesses cannot afford to invest in something that may result in losses. In situations such as this, industries have always looked to their trade associations for standards. We recommend that chipmakers approach Stack (in Europe), EIAJ (in Japan), and JEDEC (in the United States) today to establish the industry's interconnect standards.

Roger Steciak

FIGURE 2
IC Package Mix Projections



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Source: Dataquest October 1989