SAM 1990

Missing

1990-10 " System S/C content trends: Rigid Drives Learn Self Control "

vendors will align their business with one or more of these issues to succeed in this changing business environment.

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For more information or to register, please contact Becky Tonnesen at becky.tonnesen@gartner.com.

Teleconferences

Register Now — 3rd Quarter 2007 Semiconductor Forecast Update Teleconference

29 August 2007, 11:00 a.m.-12:00 p.m. EST

Gartner's expectation of low-single-digit growth for the overall semiconductor market in 2007 is essentially unchanged compared with our second quarter of 2007 update. However, in specific device markets, there have been some significant shifts in the short-term growth outlook.

The most notable update to our device forecast in the third quarter of 2007 is an upward revision to the short-term NAND flash memory market outlook as we factor in firmer ASPs because of supply-side capacity constraints in the face of higher bit growth due to increased demand. In addition, the recent rebound in DRAM ASPs, together with stronger-than-expected PC MB content growth, has improved DRAM market conditions.

In contrast, market conditions for ASICs and ASSPs remain challenging, especially in the consumer electronics sector, in which shifting system demand patterns are having a direct impact on the performance of application-specific semiconductor device vendors.

For the medium term to long term, our forecast remains in line with last quarter's update. A flat market in 2007 means that capital spending is being reined in, which will result in a tighter supply side, firmer device ASPs and modest revenue growth in 2008 and 2009 (assuming demand remains healthy). We expect a mild cyclical downturn in 2010, followed by the beginning of the next industry cycle in 2011.

For more information or to register, visit http://www.gartner.com/it/page.jsp?id=512323.

Replay — 3Q07 Semiconductor Manufacturing Forecast Update, 10 July 2007

Semiconductor Application Markets Newsletters 1990

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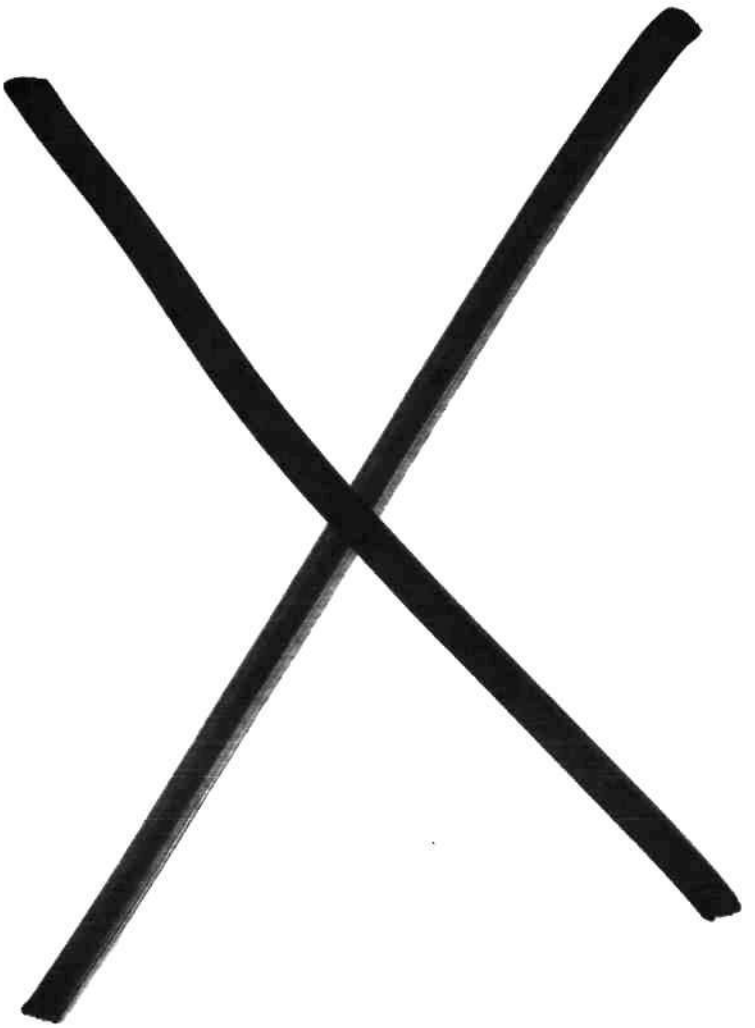

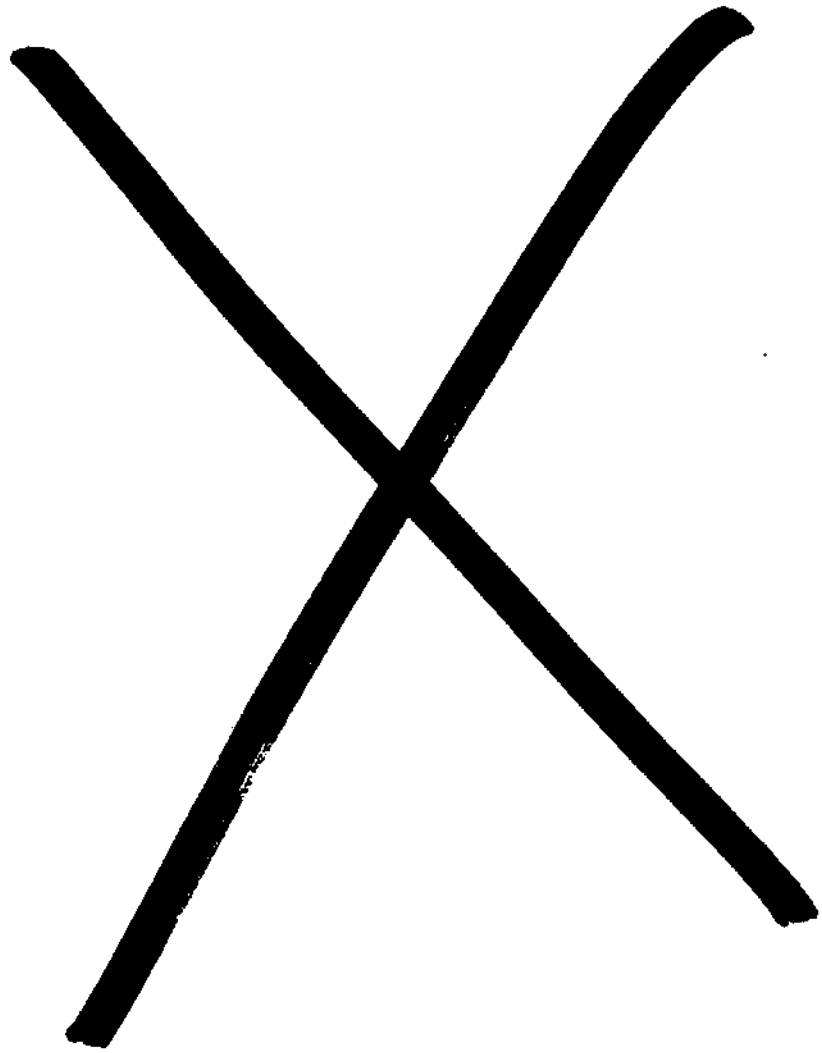

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Research *Bulletin*

SAMONITOR: SYSTEMS MARKETS' GROWTH PROSPECTS IMPROVE—SLIGHTLY

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 BUSINESS CLIMATE

Contrary to the doom and gloom forecast by the popular press, Dataquest believes that the most likely scenario is a short and shallow recession. Dataquest's corporate parent, The Dun & Bradstreet Corporation, expects U.S. overall economic activity to continue to contract in Q1 1991 at negative 0.5 percent real GNP growth, compared with negative 2.3 percent decline in Q4 1990. Beyond the first quarter, we expect real GNP growth to be positive and accelerating. Overall, real GNP growth will decelerate to 0.6 percent in 1991, down from 0.9 in 1990.

At best, the world economy faces a prospect of slow growth in 1991. However, enough *avoidable* hazards—e.g., a liquidity crisis caused by an unexpected rash of bank failures or a full-blown trade war—exist to create a probability of the short and shallow recession turning into a long and deep one.

EQUIPMENT MARKETS

Computer and office equipment orders growth for the three months ended in November was 4.4 percent above year-earlier orders, compared with 1.4 percent growth in October (Figure 1). Since July, orders growth has gone from monthly acceleration to deceleration, showing a distinct lack of trend.

Computer manufacturers are drawing down inventories to fill orders, making a conscientious and successful effort to control overhead costs. Inventories fell 0.3 week in November, a healthy 1.1 weeks below last year (Figure 2); and three-month shipments ended in November were up 4.7 percent over 1989 levels, compared with 4.4 percent in October.

The popular press' portrayal of doom and gloom in the electronics business notwithstanding, the *top-tier* PC manufacturers should be fruitful ground for chipmakers in 1991. Strength will stem from strong product lines and aggressive pricing strategies, as follows:

- Continued price cuts and the expected February introduction of a lightweight portable should boost IBM sales.
- Apple's business will be helped by the new low-priced Macintosh Classics line introduced last October.
- Compaq's business should thrive from the new PC line introduced last year and its fast-selling PC notebooks.
- AST Research's laptop and 486-based machines should ensure top-tier competitiveness.

Relatively higher saturation and slower economic growth indicate that U.S. shipments growth will fall short of European and Japanese shipments.

The second-tier manufacturers of relatively undifferentiable (i.e., commodity) PCs will feel the brunt of the tough business climate in 1991 as they continue to exploit their sole competitive edge—low price.

Communications equipment orders growth for the three months ended in November fell by 18.2 percent below 1989 orders from negative 5.1 percent in October. Recent losses are due to defense-communications equipment; the commercial sector still holds up relatively well. Growth should rebound to low single-digit rates in the next three months. Communications inventories declined 0.2 weeks in November to 9.1 weeks, down 1.2 weeks from 1989 levels.

Instrument equipment order growth for the three months ended in November fell to negative 5.1 percent below year-earlier orders from negative 1.4 percent in October. Instrument inventories

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SAM Newsletters 1991: January-March 1991-01

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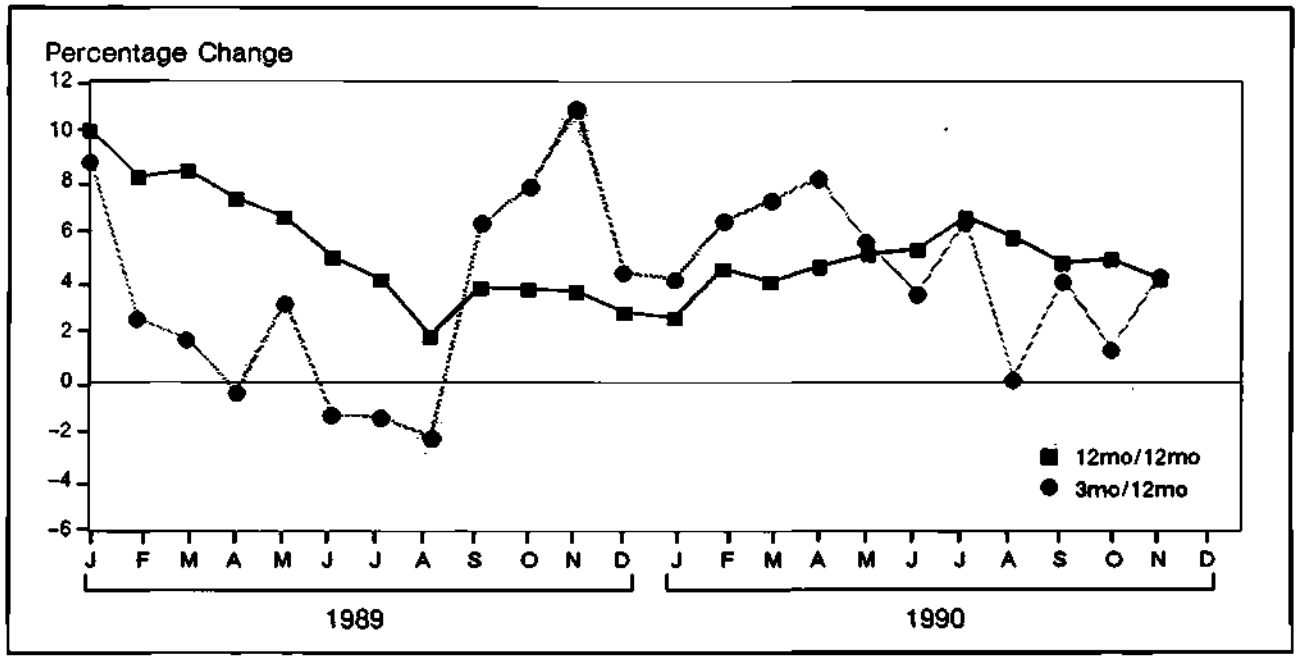
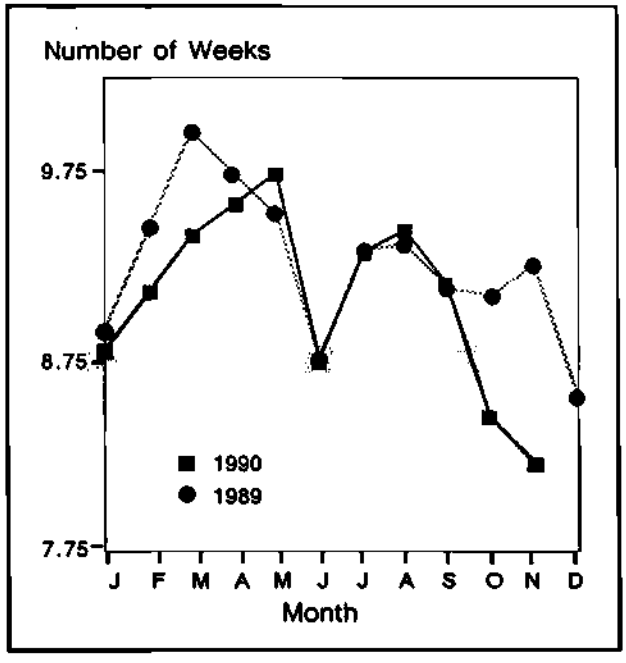
FIGURE 1
U.S. Computers and Office Equipment
Orders Growth
(1989-1990)



Source: U.S. Department of Commerce

FIGURE 2
U.S. Computers and Office Equipment
Inventory-to-Shipments Ratio (Weeks)



Source: U.S. Department of Commerce

stayed unchanged at 9.6 weeks in November, down 0.6 weeks below year-earlier levels.

Dataquest's monthly survey of major OEM semiconductor procurement managers continues to support improvement in the systems-market outlook: Overall, six-month systems sales are expected to grow 6.9 percent, up from 4.1 percent in December. Data-processing OEMs' expected six-month growth moved up to 8.5 percent, compared with 6.8 percent in December. January represents the second consecutive month of increased optimism in six-month systems-business expectations.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

We expect systems markets to grow 3 to 5 percent in the first half of 1991. Low inventories are evidence that while business conditions are lackluster and the Middle East war hampers planning, systems companies do an excellent job of managing operations. Lean inventories will help minimize the whipsaw effect and price swings as systems production growth picks up later this year.

We advise semiconductor manufacturers to not let expectations be dampened by recent economic and geopolitical events. The best way to catch the modest growth wave this year is to concentrate on technology factors yielding long-term competitive advantage and not be sidetracked by short-run uncertainties.

Terrance A. Birkholz

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Research *Bulletin*

OEM MONTHLY: APPLICATION OPPORTUNITIES IN A TOUGH MARKET

OUTLOOK

It appears as though 1991 will be only marginally better than 1990 for the worldwide semiconductor industry. The Gulf War, combined with a global credit crunch, will probably further weaken the principal electronics-buying economies. Desktop PC and PC peripheral applications, most recently among the industry growth drivers, are expected to be less robust this year. This event, combined with sluggishness in other broad application areas such as consumer electronics, is forcing semiconductor companies to focus on new equipment markets.

SOME INDEPENDENT MARKETS

Key worldwide application market opportunities are as follows:

- Data Processing
  - Workstations (entry-level through graphics supercomputer)
  - File servers
  - Portable computers
  - High-density/small-format rigid disk drives
  - LED-based printers
  - Smart/memory cards
  - Digital document management systems
- Communications
  - Cellular/personal equipment
  - Local area networks (LANs/WANs/Inter-LANs)
  - Video teleconferencing systems
  - Satellite earth stations
  - Voice messaging systems
  - Fax machines/boards (home, digital, bond paper)
- Industrial
  - Next-generation portable instrumentation
  - Next-generation ATE
  - Next-generation I/O boards
  - Electronic utility meters
  - Next-generation medical imaging systems
- Consumer
  - Consumer equipment to the Third World (low-end audio/video)
  - Small camcorders (e.g., VHS-C)
  - Digital-audio tape players
  - Advanced TV (those using existing broadcast standards)
- Automotive
  - Air-bag/restraint controls
  - Antilock braking systems
  - Engine management (Europe/Asia)
- Military/Aerospace
  - Civil aircraft avionics
  - Air-traffic control systems
  - Military aircraft avionics upgrades
  - Civil and military satellites/launchers/space stations
- General Applications
  - Color active-matrix flat panel displays
  - Intelligent motor controls

Decentralization of computing power and peripheral control will continue driving opportunities in the data processing area. The need for decentralization is also driving many of the opportunities in communications. The LAN, cellular, and even satellite earth station booms can trace their

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origins to the need for independence from existing communication methods. The conversion to digital implementations is an ongoing opportunity in switching and transmission equipment.

Trends in instrumentation, medical, and manufacturing systems continue to be evolutionary, with new systems exploiting improved sensing and DSP technology. Opportunities in consumer electronics can also be generally characterized as evolutionary. A bright spot for consumer electronics is the surging demand for low-cost audio and video systems in developing countries.

Legislative mandates for clean air, improved gas mileage, and safety continue driving automotive applications. Civilian applications will play a larger role along with upgrades of existing military platforms in the military/aerospace semiconductor market.

Table 2 presents more specifics on some examples of high-growth semiconductor applications.

DATAQUEST CONCLUSIONS

The principal problem with focusing on applications is that it takes extra resources. In order to effectively serve these markets, companies often must invest in system experts and tailored products. If approached early in the system's development cycle, these applications are potentially lucrative, especially if semicustom or proprietary semiconductor products are needed.

Gregory Sheppard

TABLE 2
Worldwide Selected Growth Applications

Equipment	Cumulative 1991-1994 Units (Millions)	Semiconductor Content ($)	Key Semiconductors	Key OEMs
Hand-held PCs	10.6	100	Low-power DRAM TFT displays	Sharp, Casio, Poquet
Ink-jet printers	13.4	54	DRAM, ROM, ASIC	HP, IBM, Canon
Entry-level workstations	3.0	950	32-bit RISC DRAM, VRAM, ASIC, chip sets, compression ICs	Sun, Silicon Graphics, Digital Equipment Corp.
2.5-inch rigid disk drives	16.7	45	Mixed-mode ASIC DSP, encoding compression ICs	Seagate, Conner, Quantum, PrairieTek
Memory cards	40.0	80	Flash, SRAM	Memory IC vendors
Ethernet/Token Ring—twisted pair	18.4	55	LAN chip sets	3Com, Western Digital
Video conferencing systems	0.15	850	DSP (CODEC), ASICs	Compression Labs, NEC
16-bit video Game/cartridge	35/250	20/5	16-bit MCU, ROM, SRAM	Nintendo, NEC, SEGA
Digital telephone answerers	17.0	18	DRAM, CODEC	AT&T, Code-a-Phone
Global positioning navigation units	0.8	240	GaAs, CMOS, ASIC	Trimble, SCI, Magellan
Air-bag controls	17.5	17	MCU, Sensors	TRW

Source: Dataquest (February 1991)

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Research *Bulletin*

SAMONITOR: FEW BRIGHT SPOTS IN FIRST HALF SYSTEMS OUTLOOK

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 BUSINESS CLIMATE

The Middle East war should not create a fiscal crisis. The Congressional Budget Office, after reviewing a variety of credible military outcomes, set broad fiscal boundaries for the war of between $28 billion and $86 billion, to be paid out over several years. Of course, the final bill will depend on the length of the war, the allies' financial support, and the extent of replacement of weapons stocks. But even this initial range places the annual amortized cost at *less than 0.5 percent of the United States' $5.5 trillion GNP.*

Despite the war, Dataquest continues to stand by its forecast of a short and shallow recession. Our corporate parent, The Dun & Bradstreet Corporation, expects U.S. real GNP growth to contract negative 0.5 percent in first quarter 1991, compared with negative 2.3 percent growth in fourth quarter 1990. Beyond the first quarter, real GNP growth is expected to be positive and accelerating. The worst (war) scenario would delay recovery until the third quarter of 1991. Overall, we expect real GNP growth to slow to 0.6 percent in 1991, down from 0.9 percent in 1990.

EQUIPMENT MARKETS

The recessionary virus infected the computer business in a big way in December. Computers and office equipment orders growth for the three months ended in December was 4.3 percent below year-earlier orders, compared with 4.3 percent growth in November (Figure 1).

Manufacturers have not been caught off guard, however: Companies draw down inventories to fill orders. Inventories fell 0.5 week in December, maintaining November's 1.1 week differential below last year's stocks (Figure 2). Overall, computer orders were up 2.5 percent in 1990, compared with 2.8 percent in 1989.

Among the fastest-growing data processing segments was the PC disk drive arena; makers of 3.5-inch drives had especially good growth. For example, the following companies reported the following revenue increases in fourth quarter 1990 over fourth quarter 1989:

- Maxtor Corporation—110.6 percent
- Quantum Corporation—108.3 percent
- Conner Peripherals—85.3 percent

Communications orders growth for the three months ended in December fell 15.4 percent below 1989 orders from negative 18.1 percent in November. *December was the fourth consecutive quarter of orders contraction.* Defense-communications orders continue to pull down aggregate orders growth. Overall, communications equipment orders were down 2.5 percent in 1990, compared with 10.1 percent in 1989.

Instruments equipment order growth for the three months ended in December fell 5.7 percent below year-earlier orders from negative 5.2 percent in November. As in communications, *December was the fourth consecutive quarter of orders contraction.* An unusually strong fourth quarter 1989 combined with sluggish capital investment spending to depress orders activity. Overall, instruments orders were up 1.4 percent in 1990, compared with 3.7 percent in 1989.

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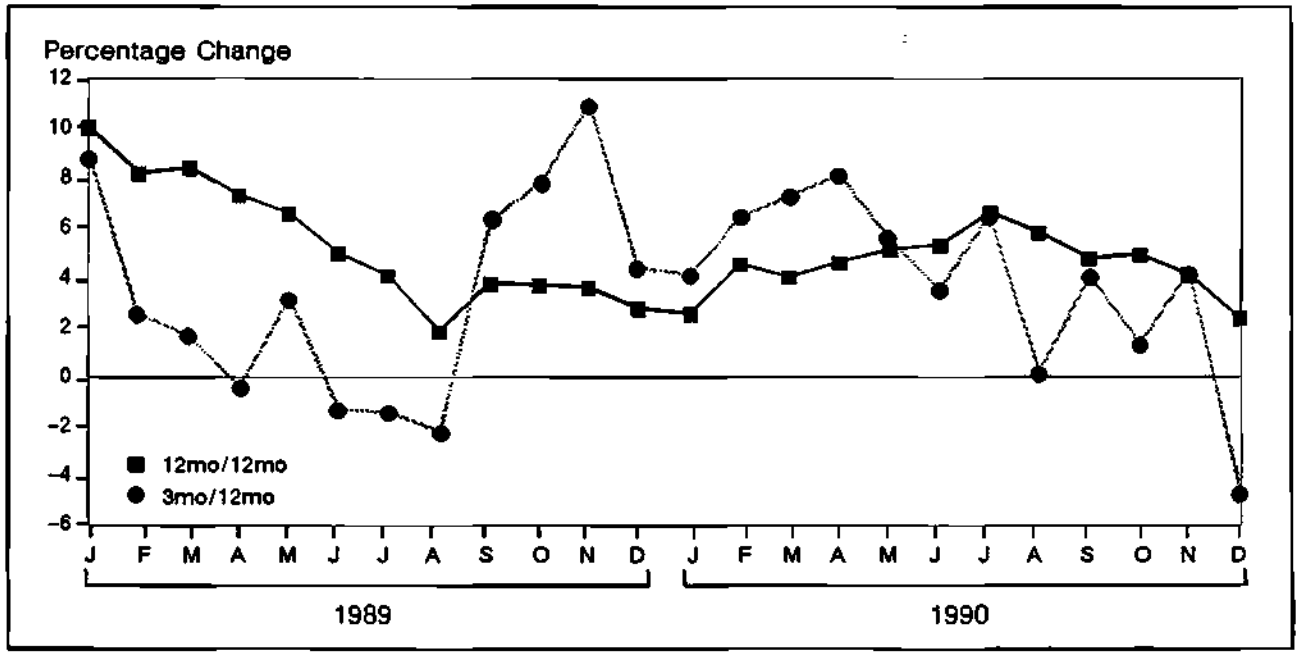
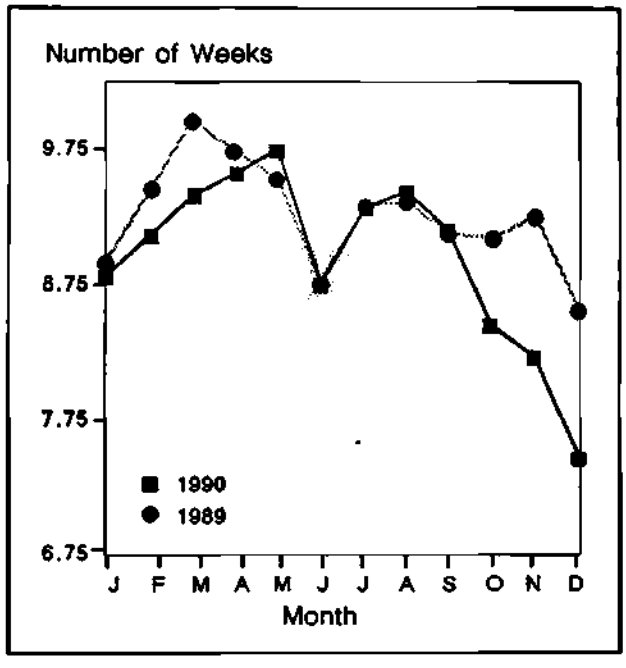
FIGURE 1
U.S. Computers and Office Equipment Orders Growth (1989-1990)



Source: U.S. Department of Commerce

FIGURE 2
U.S. Computers and Office Equipment Inventory-to-Shipments Ratio (Weeks)



Source: U.S. Department of Commerce

According to Dataquest's monthly survey of major OEM semiconductor procurement managers, overall six-month systems sales are expected to grow 3.7 percent, down from 6.9 percent in January. Data processing OEMs' expected six-month growth also moved down to 5.9 percent, compared with 8.5 percent in January. The steep revision in February's expectations is more the result of over-optimism in January than a *deepening* pessimistic outlook.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Systems orders growth will not pick up significantly until business investment spending begins to recover during the second quarter. Until then, computer orders growth will hover in the 2 to 4 percent range. Most of this year's growth will occur during the second half.

In the meantime, the best chip growth opportunities are desktop peripherals, laptops, and workstations. Companies that continue with this business during the first half will have an advantage over the competition when the marginal systems areas follow suit during the second half.

Terrance A. Birkholz

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Research Newsletter

1991 SEMICONDUCTOR PROCUREMENT SURVEY: BASICS ARE BACK

SUMMARY

This newsletter highlights the results of the Sixth Annual Dataquest Semiconductor Procurement Survey that was taken in the November-December 1990 time frame. The three key findings of the survey were as follows:

- Respondents expect to increase their 1991 semiconductor purchases by 10 percent.
- The majority (88 percent) of respondents expect equipment sales to grow or stay at 1990 levels.
- The three top issues are price, availability, and cost control.

METHODOLOGY

As in past procurement surveys, Dataquest used the *Electronic Business* Top 200 company listings as a basis for the survey. We removed from the sample all companies that made or distributed semiconductors or software in an attempt to ensure that we dealt with potential semiconductor users only. This reduction brought our sample down to 170 companies. From this base, we surveyed by telephone 760 procurement sites of these companies and received 193 responses (25 percent response rate). As seen in Figure 1, the majority (52.8 percent) of the respondents were from the Pacific (29.5 percent) and Northeast (23.3 percent) regions because of the larger concentration of technology manufacturing in those areas.

Figure 2 shows the total respondent breakdown by application segment in 1990 purchasing dollars. The survey's total respondent 1990 purchasing power totaled $2.74 billion, or 15.6 percent of the North American semiconductor market.

SEMICONDUCTOR USER OUTLOOK

User Expectations

A strong showing of over three-fourths (82.5 percent) of this year's respondents expect to either increase or stabilize their system sales in 1991 relative to 1990 levels, as shown in Figure 3. The level of optimism is slightly less than last year, with a few more respondents expecting to see lower sales (10.9 percent in 1991 versus 6.5 percent in 1990). Despite the lower system sales outlook, buyers still expect to purchase 10 percent more semiconductors in 1991 than in 1990. Relative to the past five annual forecasts, this level of increase falls slightly below the forecast mean of 12.4 percent.

The survey was taken in the midst of a foreboding economic environment for 1991, and the electronic sales outlook has wavered a bit more now in response to the Gulf War. Our monthly survey data on system sales and semiconductor purchases reflect a slight lessening of optimism due primarily to the overall economic situation, which is being exacerbated by the psychological impact of the war. In comparison with recent semiconductor supplier forecasts that we have seen, the 10 percent forecast appears to be a formidable, yet realistic, growth target.

The overall response in terms of 1991 equipment sales expectations was split evenly between increased sales (44 percent) and sales remaining at 1990 levels (44 percent). As seen in Figure 3, all respondents (except military/aerospace) expect their respective applications to increase in equipment sales. The application with the highest expectation to maintain flat business levels (after the small transportation sample) is the military/aerospace segment. Figure 4 illustrates that the level of growth for more than 90 percent

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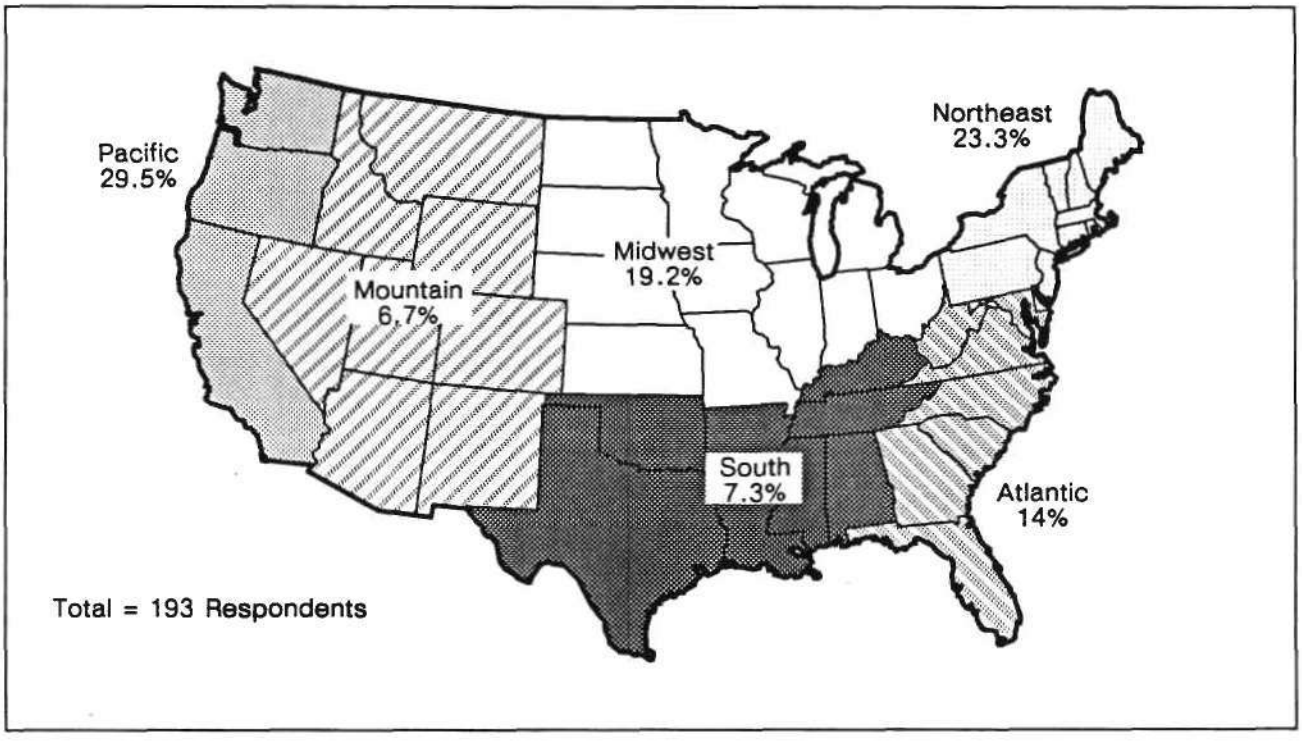
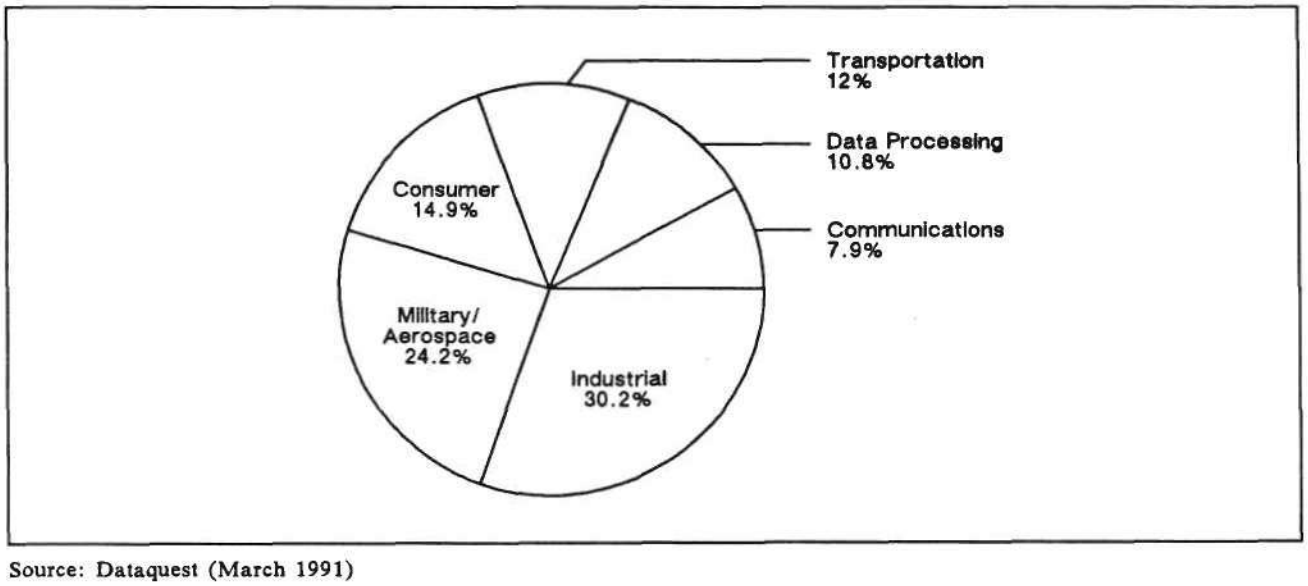
SAM Newsletters 1991-04

FIGURE 1
Procurement Survey Audience



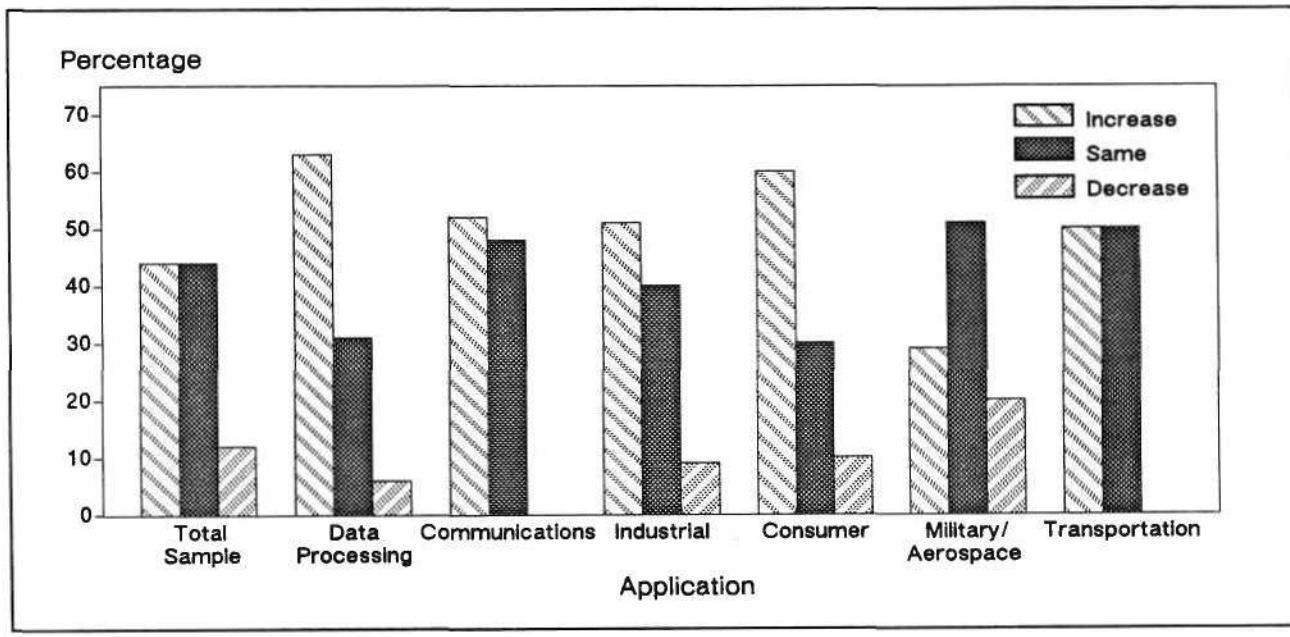
Source: Dataquest (March 1991)

FIGURE 2
1990 Survey Respondents' Purchasing Dollars



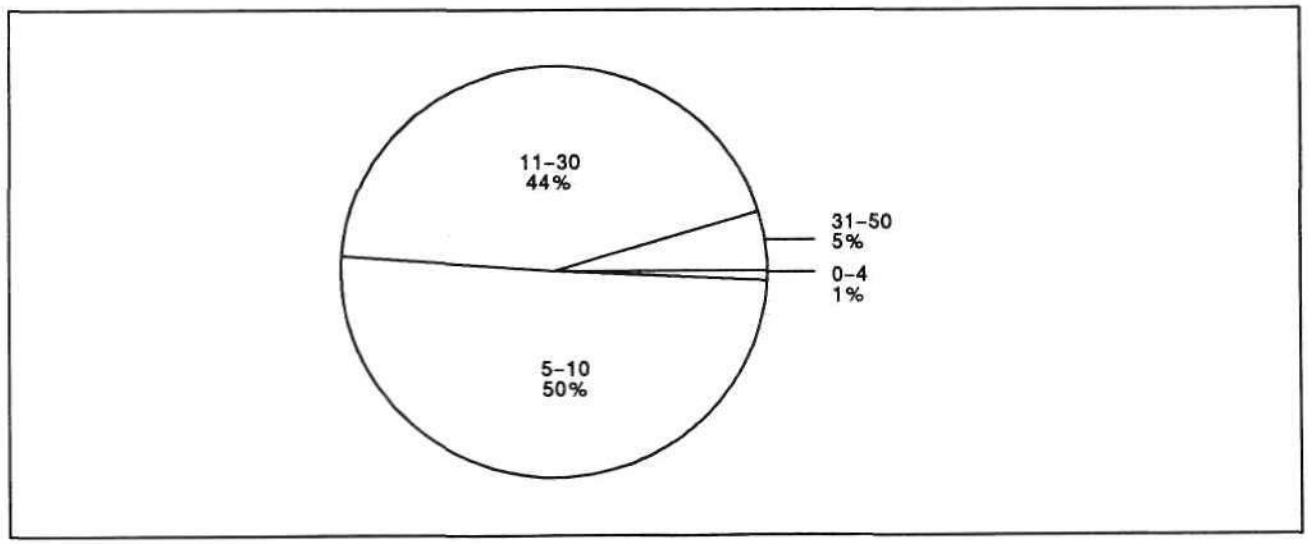
Source: Dataquest (March 1991)

FIGURE 3
1991 Equipment Sales Expectations



Source: Dataquest (March 1991)

FIGURE 4
Growth Expectations of Respondents Forecasting Growth



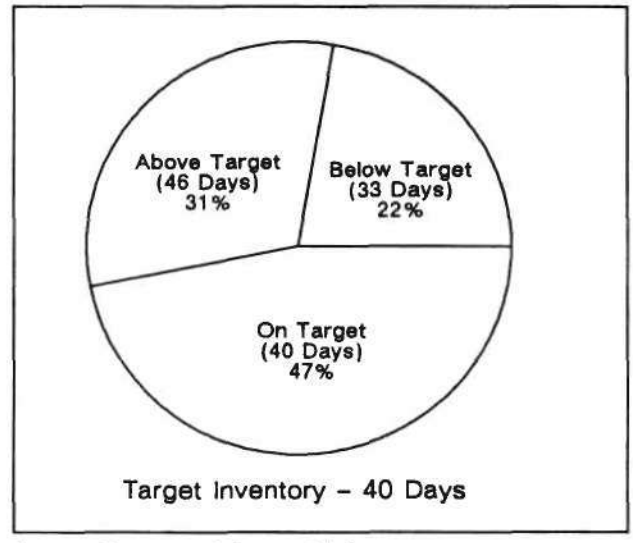
Source: Dataquest (March 1991)

(94.7 percent) of the overall sample expecting growth ranges from 5 to 30 percent, while Figure 5 shows that respondents in the industrial application expect to have the highest mean growth.

User Inventory Plans

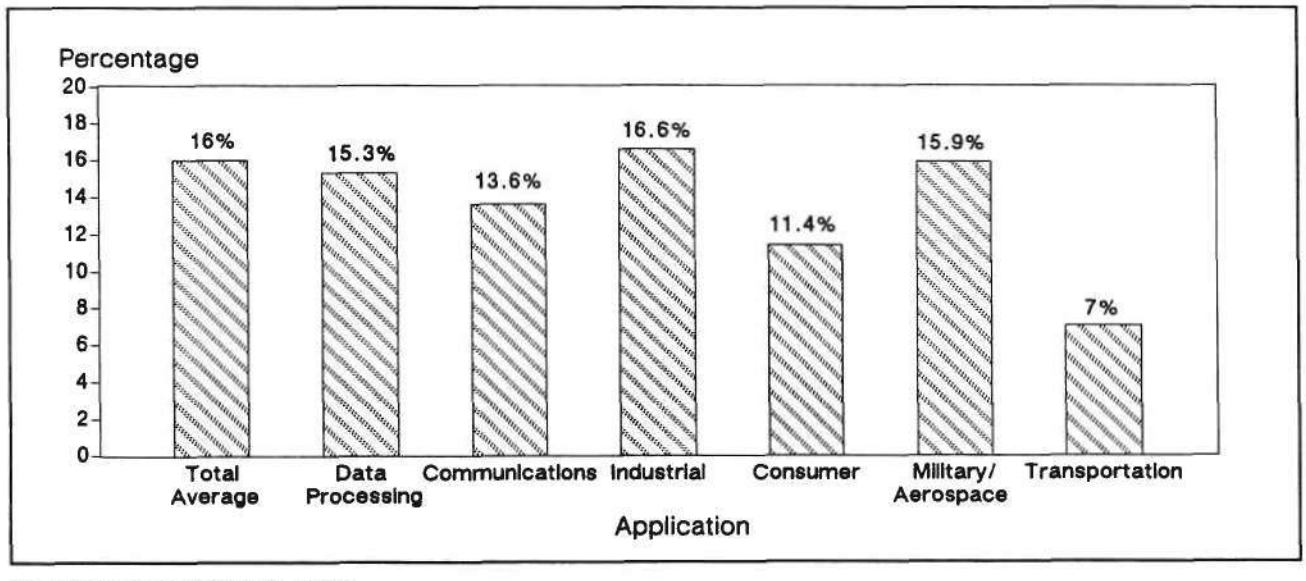
The targeted semiconductor level has dropped to 40 days, down 15 percent from last year's average target of 47 days. As shown in Figure 6, close to half (47 percent) of this year's respondents maintained average inventory levels at targeted levels of 40 days. Less than one-third (31 percent) of the sample were above target last year, averaging 46 days, and over one-fifth (22 percent) of respondents were below target, averaging 33 days of semiconductor inventory. This reduction in average inventory target levels, including a representative military response, reiterates the message that the preaching and practice of cost/inventory control is being acted upon. Another reinforcing message for future inventory control is illustrated by Figure 7, where 86 percent of the responding sample will either retain or reduce their 1990 semiconductor inventory target levels in 1991. This trend of lowered inventory targets is currently being reflected in Dataquest's monthly sample of procurement managers, where there now is an average 20-day inventory target.

FIGURE 6
Respondents' Inventory Levels



Source: Dataquest (March 1991)

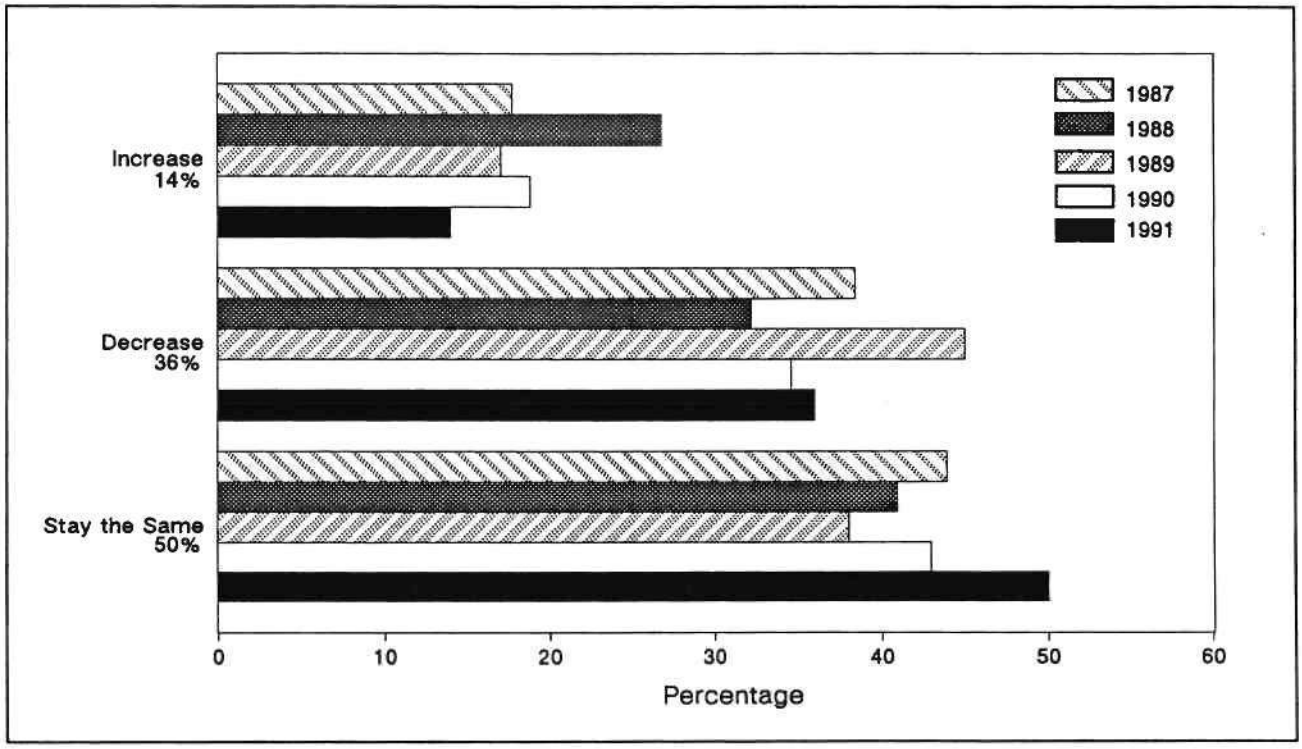
FIGURE 5
Growth Expectations by Semiconductor Application



Source: Dataquest (March 1991)

Source: Dataquest (March 1991)

FIGURE 7
Expected Change in Target Inventory Levels



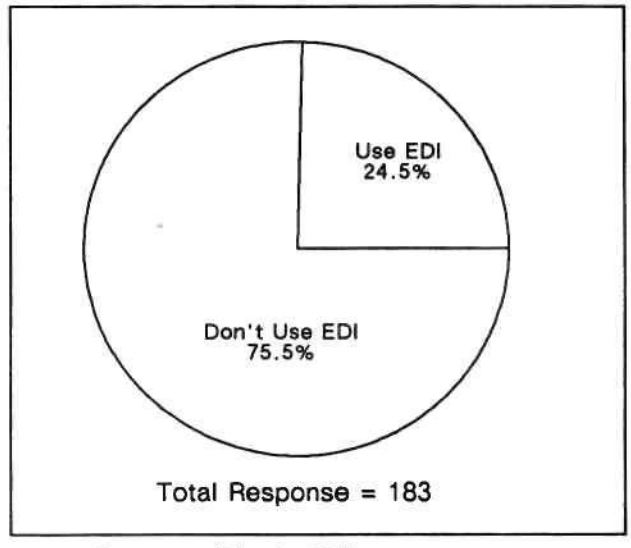
Source: Dataquest (March 1991)

This year, we included a question regarding the use of electronic data interchange (EDI) to check the status of this mode of order and inventory control. As Figure 8 shows, less than one-fourth of the respondents (24.5 percent) currently use EDI; of those that use it, close to half (48.9 percent) use it for only 10 percent or less of their semiconductor orders. The low utilization of EDI apparently is due to the real or perceived costs involved in setting up the equipment and to the relationships necessary for it to work. We will continue to track this area of procurement in the future.

Top User Issues Focus on Cost Control

After being the number two issue for the past four years, this year's respondents listed semiconductor price as the number one issue facing them in 1991, as shown by Table 1. Last year's number one issue—on-time delivery—dropped to number six in priority, primarily because of improvements in forecasting and delivery commitments achieved in 1990. Tied in closely with price (and rising from last year's number four), the new number two issue is availability, followed closely by an unchanged number-three ranked cost control.

FIGURE 8
Electronic Data Interchange Usage



Source: Dataquest (March 1991)

Rounding out the top four issues that focus on cost control is just-in-time delivery/inventory control. Quality/reliability has risen to number five among issues for procurement managers in 1991. The shift from supplier performance seen in 1990 to a focus on overt cost control in 1991 reflects the way that most companies are coping with the current economic environment. Performance to commitments is being de-emphasized in part because many companies are satisfied with the level of support of their suppliers. A new entrant to the top 10 issues in 1991 (number nine) is "petroleum-based pricing issues," again reflecting cost concerns mixed over uncertainty with developments in the Middle East. As mentioned in the SUIS newsletter highlighting the annual Semiconductor Supplier-of-the-Year Award presentation (number 1991-12, entitled "Semiconductor Supplier of the Year—Awards to Motorola, Analog Devices, and Maxim") the following three companies exhibited to buyers their commitment to meet last year's top issues:

- Major supplier—Motorola
- Midsize supplier—Analog Devices
- Niche market supplier—Maxim Integrated Products

Companies wishing to win an award next year should take this year's list of top issues to heart to best meet their customers' needs.

DATAQUEST PERSPECTIVE

This year's survey confirms many of the trends that Dataquest has previously reported; in addition, it also highlights new issues on which semiconductor users are focusing. The user community's relatively positive outlook for system sales and semiconductor procurement in the face of an uncertain economic environment is still being reflected in Dataquest's monthly *Procurement Pulse* survey. The perceived or real impediments to EDI use were reflected in the relatively low level of use by this year's respondents. As ease of use improves, EDI implementation should increase for future sampled companies. The overall "back to basics" theme of this year's responses reflects the concern of many companies that cost-cutting measures come first in uncertain times. Suppliers that provide users with both the nuts and bolts of low overall prices and superior delivery and service (totaling low overall costs) will be meeting most of this year's users' needs.

Gregory Sheppard
Mark Giudici

TABLE 1
User Issues

1991 Rank		1990 Ranking	1989 Ranking	1988 Ranking
1	Pricing	2	2	2
2	Availability	4	1	1
3	Cost control	3	7	4
4	JIT/inventory control	5	6	9
5	Quality/reliability	6	4	6
6	On-time delivery	1	3	3
7	New products/obsolescence	7	8	8
8	Government regulation	10	-	-
9	Petroleum-based pricing issues	-	-	-
10	Reducing vendor base	8	-	7

Source: Dataquest (March 1991)

Dataquest
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Research Newsletter

OEM MONTHLY—INDUSTRIAL OUTLOOK

INTRODUCTION

Dataquest forecasts the six electronic equipment markets twice a year and has just completed the March forecast. The following are the assumptions and analyses behind the industrial segment of the electronic equipment forecast.

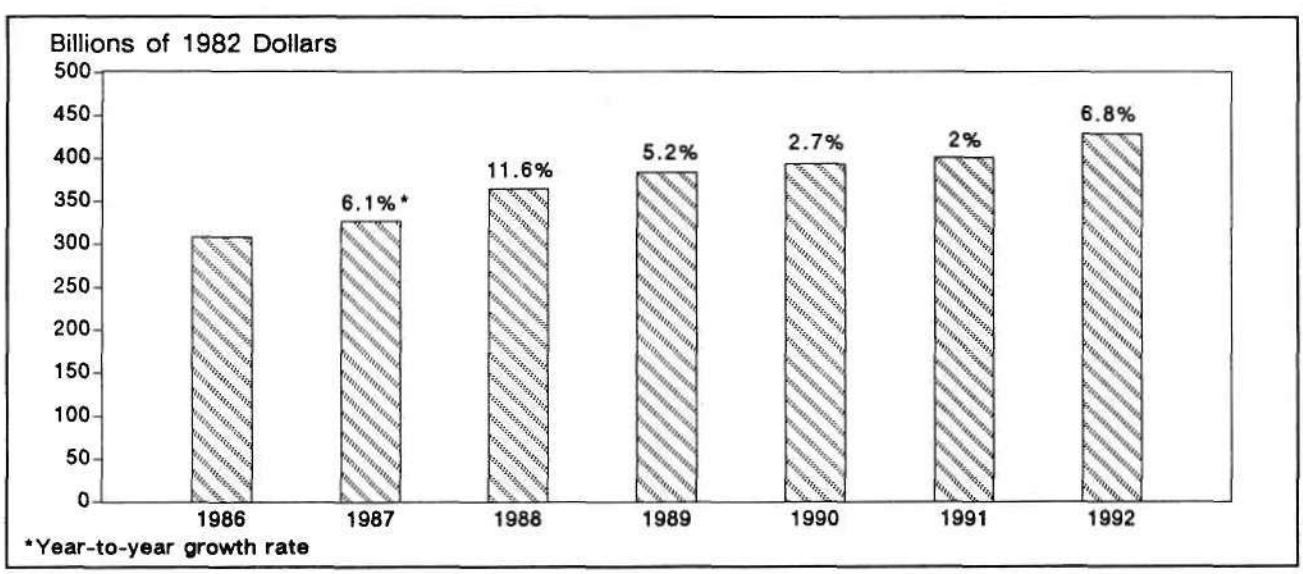
Business Environment

The year 1990 proved to be one of decline as the United States headed into a recession. Business fixed investment for equipment declined from 5.2 percent growth in 1989 to 2.7 percent growth in 1990. Residential fixed investment declined from a negative 4 percent in 1989 to a negative 5.3 percent in 1990. Both of these factors directly affect the amount of industrial equipment sold into the commercial and residential market because they determine the amount of money available for these capital purchases. However, Dataquest anticipates a resurgence of growth in both the equipment and residential fixed investments through 1992 (see Figures 1 and 2), translating into increased growth in the industrial equipment outlook (see Table 1).

Security/Energy Management

The security (fire and intrusion detection) systems are closely tied to the amount of capital expenditure for business structures and residential construction. The years 1989 to 1991 have had moderately slow growth in the security area, but as capital expenditure for structures increases again, Dataquest anticipates that the market for security

FIGURE 1
Equipment Fixed Investment
Billions of 1982 Dollars



Source: Economic Analysis Department, The Dun & Bradstreet Corporation

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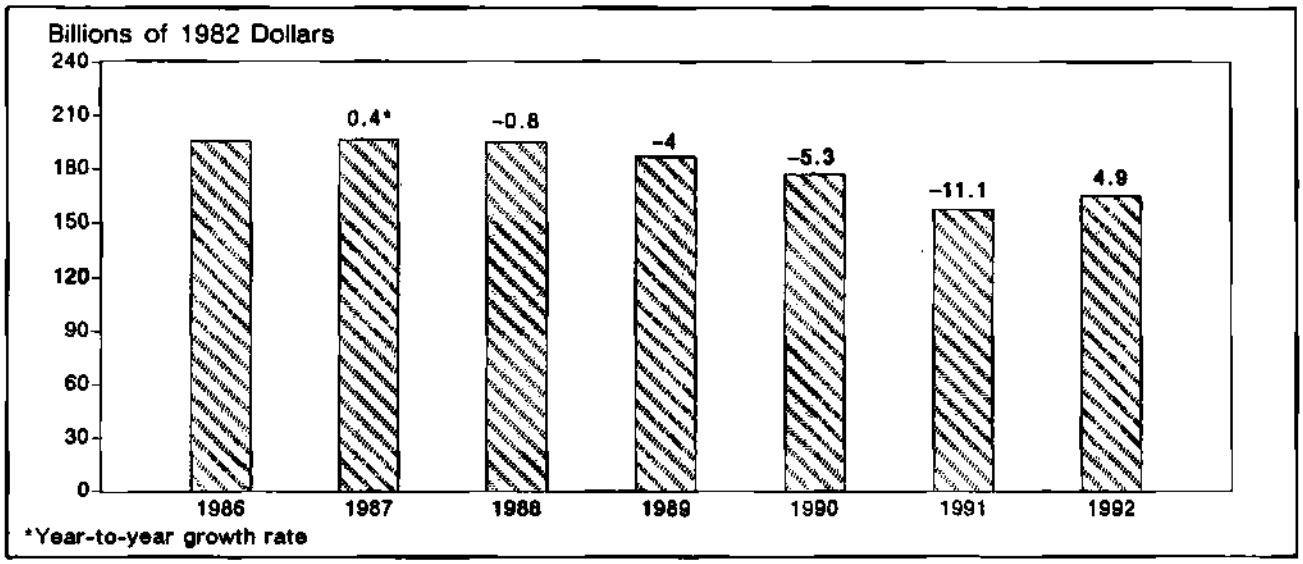
FIGURE 2
Residential Fixed Investment Forecast
Billion of 1982 Dollars



Source: Economic Analysis Department, The Dun & Bradstreet Corporation

systems will increase. Another driving factor for security systems is the steady need for either upgrades or replacements.

MANUFACTURING SYSTEMS

Semiconductor Production

Semiconductor capital spending has been down in the 1989 to 1991 time frame, creating less demand for semiconductor production equipment. However, market recovery is forecast for 1992, and an estimated 22 percent growth could be seen in this equipment area from 1991 to 1992.

Controls and Actuators

Numerical controls continue to be a leading instrument in the growth of the control industry. The new computer numerical controls are replacing traditional numerical controls using the standard PC/workstation with specialized add-in boards to customize to industrial needs. Because of the devaluation of U.S. currency, Dataquest believes that the export market for electronically controlled machine tools will also be an attractive market for numerical control suppliers.

Sensor Systems

The development of local area networks (LANs) for the factory environment is an important driver for additional growth in the sensor market. Currently, this market is dominated by U.S. vendors, but more foreign competition may be seen in the future. Dataquest has also observed increased movement toward embedding solid state or electronic sensors in systems—again stimulating growth in the sensor market.

Management Systems

A trend is seen in management systems of the migration of a collage of integrated systems toward standardization. Some of the options toward standardization are the use of the personal computers, possibly with ruggedized features, for the low-end systems and workstations or dedicated systems for the higher-end systems. (Dataquest also tracks the data processing systems markets in the Semiconductor Application Markets Service.) We believe that there is also a growing market for bus-based systems using Multibus, VME, or use of Futurebus+ as a high-performance, wide-bandwidth bus.

Robotics

Dataquest sees maturity in the robotic market, leading to a resurgence of replacements or upgrading of currently installed systems. A few key growth areas likely to be driving the demand for new robotic systems are noncontaminating robots for clean room applications, semiconductor board assembly, vision systems, and robots for use in the space station. Vision systems are a

TABLE 1
Estimated North American Electronic Equipment Production—Industrial
(Millions of Dollars)

Equipment	1989	1990	1991	1992	1993	1994	1995	CAGR (%) 1989-1990
Intrusion Detection	804	875	923	974	1,050	1,129	1,197	8.8
Fire Detection	477	532	570	602	633	666	701	11.7
Alarm Systems	1,281	1,407	1,493	1,575	1,682	1,795	1,898	9.9
Energy Management	2,209	2,284	2,332	2,412	2,520	2,641	2,768	3.4
Total Security/Energy Management	3,490	3,691	3,826	3,987	4,202	4,436	4,666	5.8
Semiconductor Production	1,696	1,691	1,835	2,239	2,700	2,936	3,053	-0.3
Controls and Actuators	3,895	3,985	4,164	4,476	4,807	5,134	5,494	2.3
Sensor Systems	1,640	1,765	1,874	2,030	2,206	2,385	2,595	7.6
Management Systems	3,570	3,684	3,791	3,909	4,026	4,139	4,242	3.2
Robotics	256	274	296	325	360	360	398	7.0
Total Manufacturing Systems	11,057	11,398	11,960	12,979	14,100	14,954	15,782	3.1
ATE-Semiconductor	635	616	639	786	919	1,032	1,167	-3.0
ATE-Other	1,517	1,547	1,601	1,754	1,878	2,019	2,160	2.0
Oscilloscopes and Waveform Analyzers	785	836	881	933	991	1,053	1,117	6.5
Nuclear Instruments	625	636	651	676	706	748	794	1.7
Electrical Test Instruments	1,003	1,029	1,060	1,093	1,131	1,173	1,214	2.6
Other Test and Measurement	3,295	3,509	3,744	4,021	4,299	4,578	4,903	6.5
Total Instrumentation	7,860	8,173	8,577	9,263	9,924	10,604	11,355	4.0
X-Ray	1,725	1,756	1,784	1,818	1,862	1,901	1,939	1.8
Ultrasonic and Scanning	320	329	339	353	370	387	407	2.8
Blood and Body Fluid Analyzers	605	618	633	655	681	705	731	2.1
Other Diagnostic	1,160	1,278	1,411	1,589	1,808	2,049	2,340	10.2
Total Diagnostic	3,810	3,981	4,167	4,416	4,721	5,042	5,417	4.5
Patient Monitoring Equipment	305	313	321	330	338	345	353	2.7
Other Therapeutic	2,240	2,386	2,531	2,746	2,999	3,242	3,511	6.5
Total Therapeutic	2,545	2,699	2,852	3,076	3,337	3,587	3,864	6.0
Medical Equipment	6,355	6,680	7,019	7,492	8,059	8,629	9,281	5.1
Other Industrial Systems	3,625	3,748	3,853	4,115	4,420	4,632	4,980	3.4
Total Industrial	32,387	33,691	35,235	37,836	40,704	43,256	46,063	4.0

Source: Dataquest (March 1991)

much-improved robotic inspection system. These vision systems add optics and advanced software to the robot, creating a system that is able to offer some decision-making capabilities that were not previously available.

INSTRUMENTATION

ATE—Semiconductor

The automatic test equipment (ATE) market is tied closely to the growth or slumping of overall semiconductor industry trends. Slow growth in the semiconductor industry has occurred for the past two years, causing less demand for new test equipment. However, as the forecast growth of the semiconductor industry develops during the next two years, a renewed interest in test equipment should emerge. The demand for high-performance semiconductors for continually more advanced applications will also stimulate growth in >100-MHz, 512-pin test equipment. Mixed-signal testers are again a rapid-growth area as analog and digital on a single chip becomes more prevalent and equipment to test them is needed.

ATE—Other

As the movement toward surface-mount technology packaging increases, the board tester market will need to upgrade or replace the current testers to handle testing of the new type of packaging.

Oscilloscopes and Waveform Analyzers

The intervention of digital oscilloscopes has created competition for the analog oscilloscope market. Compared with analog, digital instruments are able to reach much higher performance levels at prices competitive with analog, creating rapid sales of digital oscilloscopes.

Instruments—General Trends

Rapid growth in the instrumentation market is seen in the palmtop, portable instrument area for all types of instruments (e.g., scopes, signal generators, logic analyzers). Many of these portable instruments employ memory card data capture systems that make it easy to use the portable instrument with the memory card to store data out in the field and then plug the card into the main system when back in the office. However, Dataquest expects increased foreign competition in the low-end instrumentation market, relegating North American suppliers to the higher-performance systems.

MEDICAL EQUIPMENT

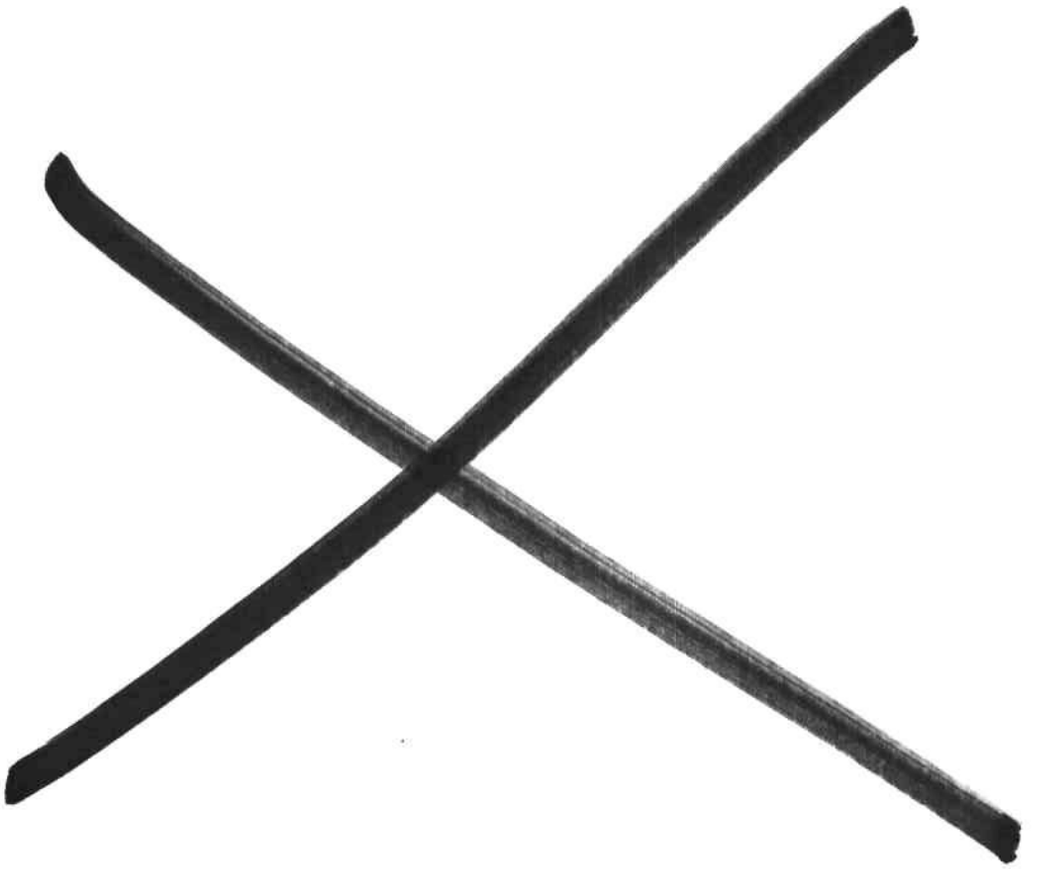
Dataquest foresees accelerated growth of the elderly population of U.S. demographics. There is a trend toward employing medical equipment in the home rather than staying in the hospital as hospital in-patient costs escalate. Instrumentation is also being purchased by small doctors' offices to run tests rather than these offices' traditional reliance on large clinics to run tests. The large, high-end equipment market is stable, with most growth occurring in the small niche markets such as home health care and ambulatory (outpatient) equipment.

As public awareness of cholesterol and disease monitoring increases, so has the growth of blood analyzers. Ultrasonic scanning is also moving toward high-end color Doppler, which is opening up more areas in which this type of scanning can be used.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The total industrial market forecast from 1990 to 1995 shows a compound annual growth rate (CAGR) of 6.5 percent. The industrial market is a highly fragmented market with some niche equipment areas showing above-average growth and other markets reflecting average to below-average growth. The key for semiconductor companies is to be cognizant of the high-growth areas and to focus on them directly through marketing campaigns.

Anna L. Cahill



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Research *Bulletin*

SAMONITOR: THE SILVER LINING OF A SLOW MARKET RECOVERY

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 BUSINESS CLIMATE

A quick check of the economy's pulse indicates that the recession is still with us: In January, retail sales were down 0.9 percent; durable goods orders were down 0.7 percent; industrial production was down 0.4 percent; and in February, the civilian unemployment rate rose to 6.5 percent from 6.2 percent.

Four factors suggest that the economy should soon stabilize. One, inflation is pretty well under control, giving the Fed room to ease monetary policy. Two, actual inventory stocks are close to desired levels, so a pickup in aggregate spending should translate relatively quickly into a pickup in production. Three, the slight revival in consumer confidence that has begun should, by adding quickly to spending, begin to pull the economy out of recession. Four, low oil prices—now below preinvasion levels—will help by raising consumers' purchasing power.

The recovery, expected this spring, will be slow. The reasons include the absence of the usual strong stimulus from federal fiscal policy, the absence of the typical stimulus from financially strapped state and local sectors, less of an inventory rebound due to a milder-than-normal inventory cycle, and a prolonged slump in the construction business. Furthermore, potential growth in the next few years will be constrained by slower growth in labor force and productivity.

EQUIPMENT MARKETS

In keeping with the recession, orders growth was negative across the major electronic equipment markets in January. Computers and office equipment orders growth for the three months ending in January was 3.1 percent below year-earlier orders, compared with negative 3.8 percent growth in December (see Figure 1). Inventories are at 8.1 weeks in January, down 0.7 weeks from January 1990 stocks (see Figure 2).

Communications orders growth for the three months ending in January was 15.8 percent below year-earlier orders, compared with negative 13.9 percent growth in December. *January was the fifth consecutive month of orders contraction.*

Instruments equipment orders growth for the three months ending in January fell 6.4 percent below year-earlier orders from negative 5.6 percent growth in December. As in communications, *January was the fifth consecutive month of orders contraction.* Inventories in both communications and instruments have been further tightened below year-earlier levels.

Despite a bleak showing in January, there is good news on the trade front: The U.S. trade deficit in electronic products *fell 54.3 percent in 1990,* according to statistics recently released by the Electronics Industry Association. The shrinkage was due primarily to a boost in computer exports.

Electronics exports grew 11.6 percent in 1990, and electronics imports grew 0.4 percent in 1990. Almost one-half (49.5 percent) of the dollar growth in exports was due exclusively to computer and industrial electronics gear. Dataquest believes that most of this gain is explained by the strong worldwide presence of U.S.-made workstations and the strong penetration of PCs in the European market.

For example, PC manufacturer Dell Computer Corporation's worldwide sales grew 41 percent in fiscal year 1991, which ended February 3, 1991; international sales grew 112 percent, and domestic sales grew 20 percent.

According to Dataquest's monthly survey of major OEM semiconductor procurement managers, overall six-month systems sales are expected to grow 5.2 percent, up from 3.7 percent in February. Data processing OEMs' expected six-month growth also moved up to 8.4 percent, compared with 5.9 percent in February. The upward revision in March's expectations reflects heightened business

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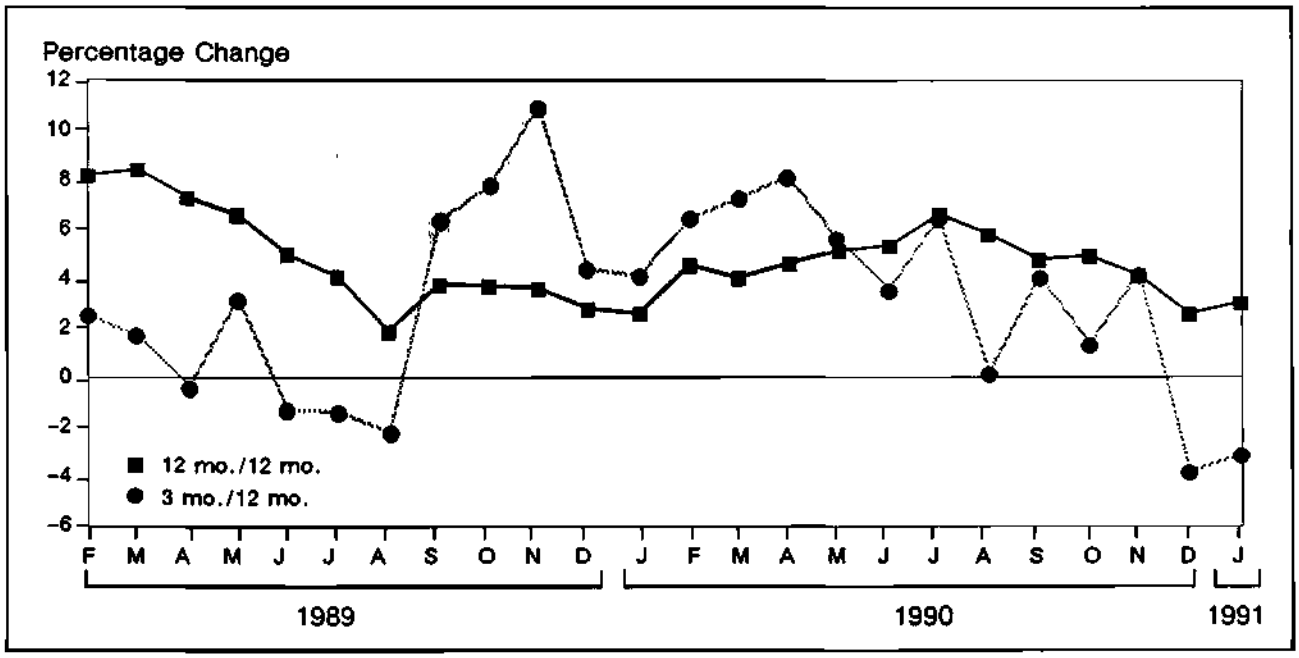
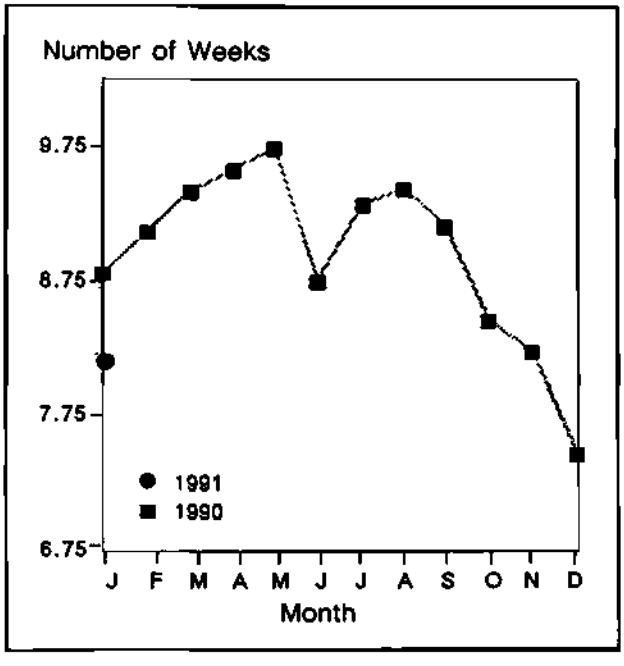
FIGURE 1
U.S. Computers and Office Equipment Orders Growth (1989-1991)



Source: U.S. Department of Commerce

FIGURE 2
U.S. Computers and Office Equipment Inventory-to-Shipments Ratio (Weeks)



Source: U.S. Department of Commerce

confidence stemming from the swift victory in the Gulf War.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Systems orders growth will not return to a sustained positive trend until business investment spending recovers in the second quarter. However, the aforementioned factors that are expected to hold back the economic recovery are also likely to moderate systems markets' growth.

However, moderate recovery is not necessarily undesirable. Experience has shown that slower market growth is typically less variable than—and therefore preferable to—faster growth. Simply put, it is an easier and more forgiving environment. Business planners can execute a more continuous strategy than an abrupt stop-and-go policy.

Some will say that slower growth entails the risk of an industry that is operating too close to the edge of another downturn being pushed into it by some unexpected event. This, also, is not necessarily the case. Slower growth, close to the systems and semiconductors industries' potential, is more stable and sustainable than growth in excess of its potential, leading to further downturns and all the instability and housecleaning such an outcome would entail.

Terrance A. Birkholz

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Research Newsletter

THE CASE OF (FOR) THE DISAPPEARING FAX MACHINE

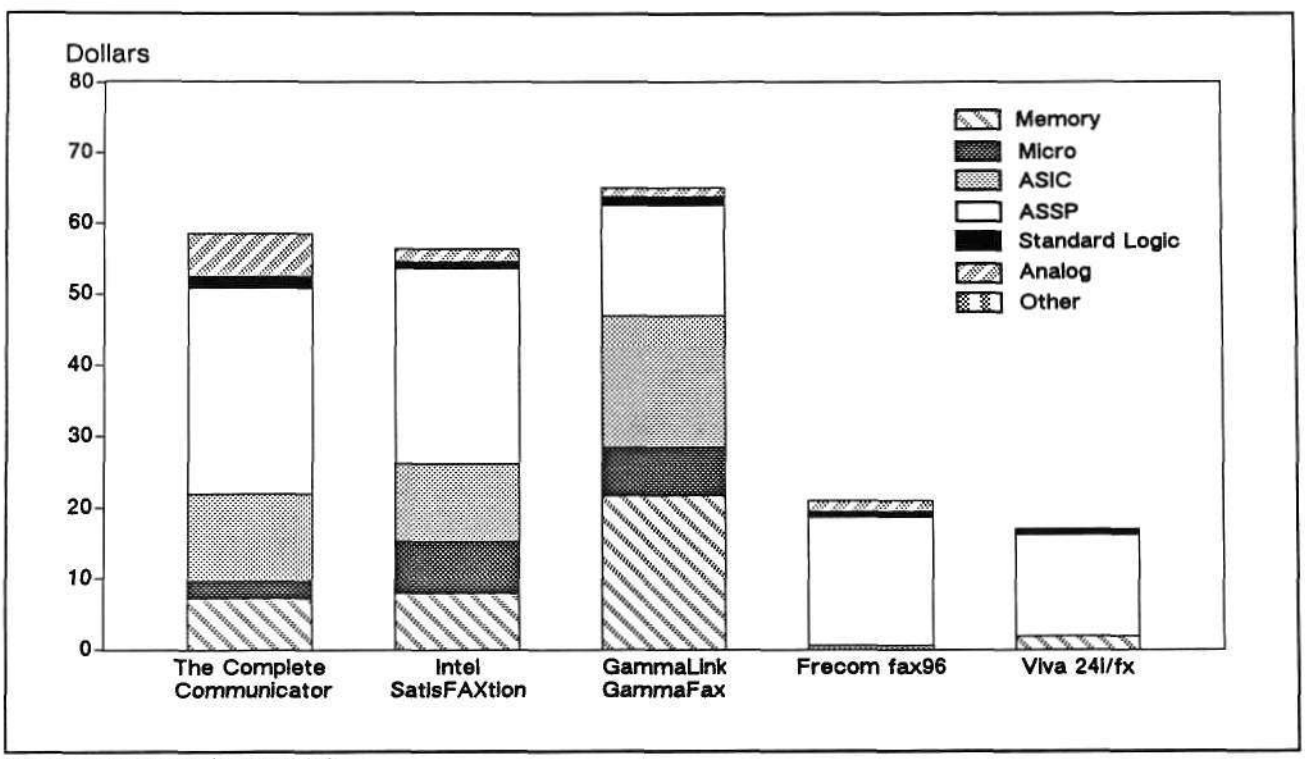
SUMMARY

This newsletter provides a detailed look at the semiconductor content of several PC fax cards. The models examined here were selected not only as representative of current designs but also as illustrative of the issues faced in adapting the fax function to PC constraints. Dataquest believes that the PC fax card offers a preview of the eventual inclusion of this function into the standard portable computer.

INTRODUCTION AND OVERVIEW

Figure 1 shows the estimated component cost of The Complete Communicator by The Complete PC, the Intel SatisFAXtion card, the GammaLink GammaFax, the Frecom fax96, and the Viva 24i/fx. The pricing data contained in this analysis are based on the Semiconductor User Information Service's pricing study, assuming a 10,000-piece contract buy. Because manufacturers enjoy varying degrees of purchasing leverage and may secure

FIGURE 1
Component Cost Breakout



Source: Dataquest (April 1991)

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greater quantity discounts for certain components, these cost figures should be used for comparison purposes only.

ISSUES

Facsimile technology is the fastest-growing form of communication in the world today. Until a few years ago, the only way to send a fax was via a standalone fax machine. This is changing, however, as cost, space, and power reductions in the IC implementation have enabled fax functionality to migrate into the PC.

The evolutionary path is apparent in the relative sizes of today's markets: While new placements of standalone fax machines are expected to top 5 million units this year, the PC fax market still consists of about a few hundred thousand units.

But although today's standalone fax market dwarfs the PC fax market, the potential size of the portable PC market suggests that most of the growth in fax placements could well be realized in the form of fax capabilities embedded within PCs.

Table 1 compares the system specifications of these products.

Product Discussion

The Complete Communicator

As an innovator in PC peripheral products, The Complete PC has had several interesting products in the market for some time. The Complete Communicator is a reflection of both early entry and ambitious product capabilities. An older design, The Complete Communicator has the

TABLE 1
Key User Features for Facsimile Boards

Manufacturer	GammaLink	Frecom	The Complete PC	Intel	Viva
Model Name	GammaFax CP	fax96	Communicator	SatisFAXtion	Viva24i/fx
Suggested Retail ($)	995	195	699	499	199
First Released	12/88	2/90	2/89	9/90	7/90
Warranty	3 yrs.	2 yrs. or 24K faxes	5 yrs.	5 yrs.	5 yrs.
Scanner Port	No	No	Yes	Yes	No
Trans./Receive	Yes	Yes	Yes	Yes	Trans. Only
Background	Yes	Yes	Yes	Yes	No
Send from Application	No	Yes	Yes	Yes	No
Cover Sheet	Yes	Yes	Yes	Yes	Yes
Polling	Yes	Yes	Yes	Yes	No
Broadcasting	Yes	Yes	Yes	Yes	Yes
Downloadable Fonts	Yes	No	Yes	Yes	No
Auto Phone Directory	Yes	Yes	Yes	Yes	Yes
Activity Logs	Yes	Yes	Yes	Yes	Yes
Group 2 and 3	3	2 & 3	3	2 & 3	3
Error Correction Mode	Optional	No	Yes	No	No
Auto Step-Down	Yes	Yes	Yes	Yes	Yes
Step-Up Capability	Yes	Yes	No	Yes	No
Std. Transmit Speed (Baud)	9,600	9,600	9,600	9,600	4,800
Auto Re-try	Yes	Yes	Yes	Yes	Yes
Voice Mail	No	No	Yes	No	No
Resolution	Std./fine	Std./fine	Std./fine	Std./fine	Std.

Note: Auto send/receive in background—software that provides commands for automatically processing designated fax in background, thus freeing the computer for other work.
Source: Dataquest (April 1991)

highest chip count of any of the boards we examined, but it also has one of the fullest feature sets.

These advanced functions include voice mail, background-mode operation, file conversion capabilities, and group list features. Such a powerful feature set, along with user-friendly software, enhances this product's appeal for home office users as well as early adopters.

Table 2 shows the semiconductor content of The Complete Communicator.

As one might expect, The Complete Communicator includes several additional ICs, which are directly attributable to some of its advanced features such as a dedicated microprocessor for full background operation, proprietary ASICs for voice mail, separate fax and modem modules, and buffer memory.

The Complete Communicator is one of the oldest designs examined, which is clearly reflected in the high chip count (28). Many of the ICs present are low-cost, low-integration components that could easily be designed out should The Complete Communicator be redesigned for a portable application.

As one of the early *desktop* PC fax cards, The Complete Communicator serves as an interesting starting point for observing the shrinking of these functions.

The Intel SatisFAXtion Board

Without question, Intel has been a leading force in directing the evolution of the PC. But with the high-profile 80X86 microprocessors drawing so much attention at the center of the architecture, it is easy to overlook the Oregon-based Personal Computer Enhancement Operation's equally interesting work on the periphery.

Typical of the current generation of fax cards, the SatisFAXtion offers rich hardware functionality but its user-friendly software provides product differentiation. The SatisFAXtion board provides such amenities as designating LPT2 as fax output and offers what Intel calls WYPIWYF (what you print is what you fax).

Table 3 shows the semiconductor content of Intel's SatisFAXtion.

Like The Complete Communicator, the SatisFAXtion includes its own microprocessor for full background capability, a proprietary ASIC, and dedicated fax and modem ICs, along with on-board memory. As a newer design, it is not surprising that the SatisFAXtion has just under two-thirds the component count of The Complete Communicator.

The GammaLink GammaFax CP

As the inventor of the PC fax board, GammaLink has been, by definition, an innovator. The GammaFax CP contains several interesting ICs not found on the other cards, suggesting that GammaLink is still pushing its hardware design.

One of the drawbacks of being the frontrunner is that other semiconductor suppliers tend to erode product differentiation. By offering a more complete IC solution, semiconductor suppliers make it much easier for a new competitor to design its first PC fax card. At the limit, this leads to a convergence of multiple vendors to the same basic hardware design.

Table 4 shows the semiconductor content of the GammaFax CP.

Like other high-end fax cards, the GammaFax CP includes memory and microprocessor devices for full background operation. It uses the same Rockwell fax module as does The Complete Communicator, but differs in the use of an advanced field-programmable gate array from Xilinx. The use of an FPGA suggests that GammaLink may still be seeking to achieve product differentiation at the hardware design level.

The Frecom fax96 and the Viva 24i/fx

Both of these products are positioned as low-cost commodity PC fax boards. As such, they are designed to provide acceptable functionality at minimal cost.

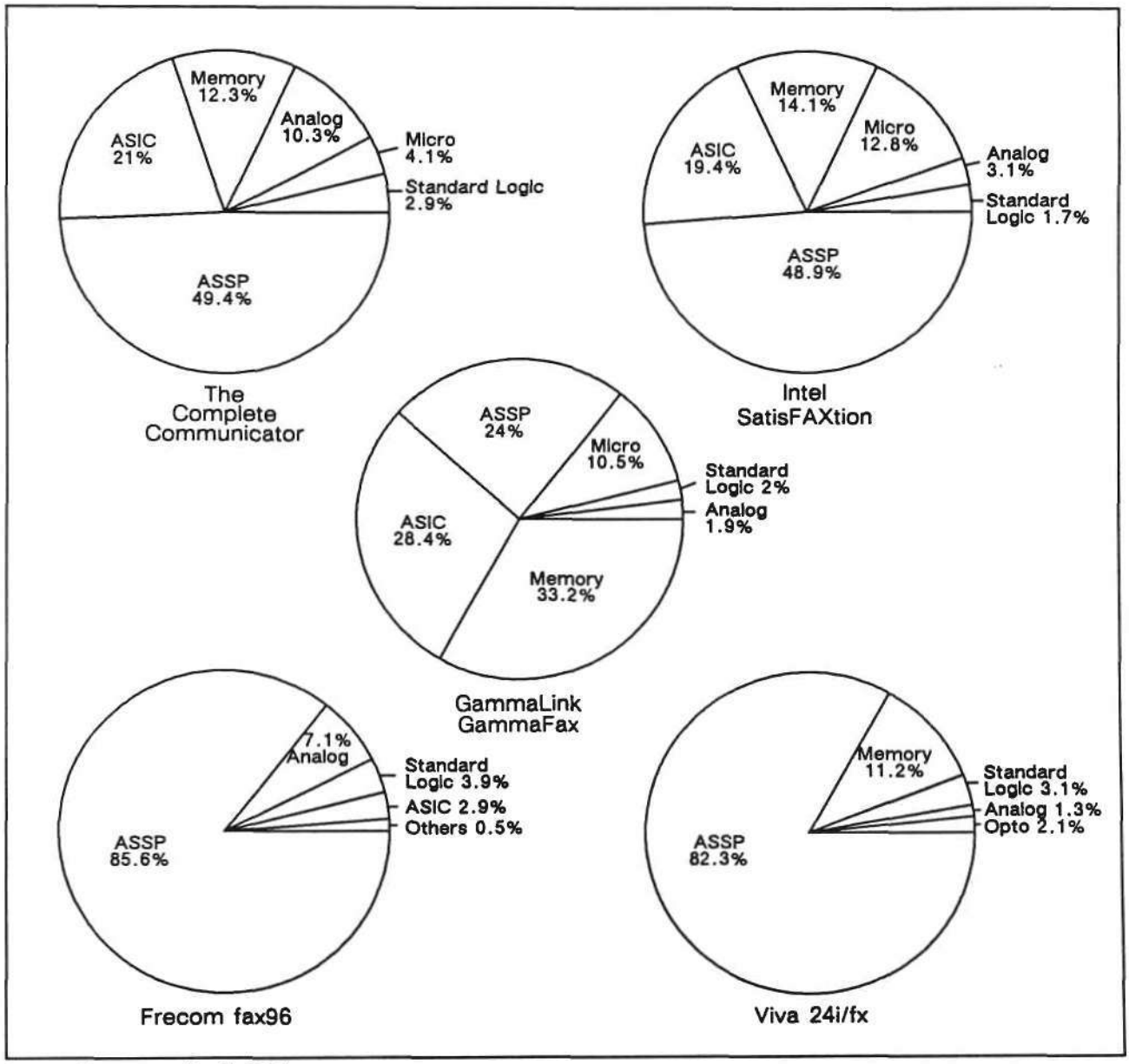
Tables 5 and 6 show the semiconductor content of the fax96 and the 24i/fx.

These designs have eliminated both the microprocessor and the buffer RAM, trading background capability against cost. By using only off-the-shelf standard semiconductors, both designs similarly trade hardware differentiation for merchant market cost.

DATAQUEST CONCLUSIONS

Figure 2 shows the IC cost distributions of these products by semiconductor type. Although there are some very real opportunities for MPU and memory vendors, it is clear that the greatest opportunity lies in the fax/modem ASSPs. As these ASSPs become more fully integrated, they are likely to feed off of the standard logic, commodity analog, and eventually, the MPU sockets.

FIGURE 2
Semiconductor Cost Distributing



Source: Dataquest (April 1991)

Chip Positioning

Rockwell pioneered the fax IC and enjoys a dominant position in the standalone fax market, but winning the PC fax socket requires clearing a different set of hurdles. Yamaha, for instance, has enjoyed considerable success in the PC side of the business by paying attention to power, space, and cost issues.

Few would disagree with this trend. In fact, virtually all fax device vendors are targeting the portable PC fax socket with lower-power, higher-integration products.

PC fax offers the potential for explosive unit growth, but it is important to examine these products in the proper context. Today's PC fax products are best viewed as signposts along the path to the eventual motherboard implementation. Winning *that* socket will require low cost, low power, and the ability to provide a complete systems level solution.

Kevin Landis

TABLE 2
The Complete Communicator

	Vendor	Part No.	Quantity	Description	Estimated Cost ($)	Package	Function/ Comment
Microprocessor	UMC	UM6502CE	1	8-bit microprocessor	2.40	40-pin DIP	
ASIC	CPC	DP-2010-01	1	Gate array	3.87	44-pin QFP	
	CPC	DP-1710-01	1	Gate array	8.40	100-pin QFP	
Memory	Signetics	27C256-15PA	1	32Kx8, 150ns EPROM	1.95	28-pin DIP	Window, socketed
	Hyundai	HY6264LP-15	1	8Kx8, 150ns SRAM	1.77	28-pin DIP	
Standard Logic	National	DM74LS245N	1	Octal bus transceiver	0.21	20 pin DIP	
	National	DM74LS244N	1	Octal 3-state driver	0.21	20-pin DIP	
	National	DM74LS175N	1	Quad D flip-flop	0.17	16-pin DIP	
	National	DM74LS14N	1	Hex. Schmidt trigger	0.10	14-pin DIP	
	National	DM74LS10N	1	3-in. NAND	0.10	14-pin DIP	
	Harris	CD74HCT02E	1	Quad 2-in. NOR	0.12	14-pin DIP	
	Signetics	74LS04N	1	Hex. inverter	0.10	14-pin DIP	
	Signetics	7416N	1	Hex. buffer/driver	0.10	14-pin DIP	
	F	74LS139	1	Dual 2 of 4 decoder	0.15	16-pin DIP	
	F	74LS273	1	Octal D flip-flop	0.21	20-pin DIP	
Analog	National	LM324N	1	Quad op amp	0.19	14-pin DIP	
	National	CD4053BCN	2	Switches	0.38	16-pin DIP	3 each SPDT (CMOS)
	National	TP3054J	1	CODEC/filter	3.15	16-pin DIP	
	SSI	75T204CP	1	DTMF receiver	1.85	14-pin DIP	
Subtotal			20		25.43		
Modem							
ASSP	Sierra	SC22201CN	1	128x8, EE NVRAM	1.45	18-pin DIP	
	Sierra	SC11006CV	1	Modem analog peripheral	5.22	28-pin PLCC	
	Sierra	SC11011CV	1	Modem controller	8.10	68-pin PLCC	2,400-bps, built-in UART
Memory	AMD	AM27C128-155DC	1	16Kx8, 150ns EPROM	2.05	28-pin DIP	Window, no socket
Standard Logic	National	DM74LS245N	1	Octal bus transceiver	0.22	20-pin DIP	
Subtotal			5		17.04		
Fax							
ASSP	Rockwell	5537-12	1	Analog front-end	6.75	64-pin DIP	
Memory	Rockwell	6629-12	1	Fax controller	8.85	64-pin DIP	
Analog	Signetics	MC1458N	1	Dual op amp	0.43	8-pin DIP	
Subtotal			3		16.03		
Total			28		58.50		

Source: Dataquest (April 1991)

Table 3
The Intel SatisFAXtion

	Vendor	Part No.	Quantity	Description	Estimated Cost ($)	Package	Function/ Comment
Microprocessor	Intel	N80C186-16	1	MPU	7.20	68-pin PLCC	
ASIC	LSI Logic	L1A5998	1	Gate array	10.94	144-pin QFP	
ASSP	Rockwell	R96DFX	1	Fax IC	22.00	68-pin PLCC	
	Rockwell	RC2424DP/1	1	2,400-baud modem	5.50	68-pin PLCC	
Memory	Hyundai	HY53C464LF-10	4	64Kx4, 100ns DRAM	7.48	18-pin PLCC	Socketed
	Hyundai	93C46	1	64Kx16, 400ns EEPROM	0.49	8-pin DIP	
Standard Logic	TI	LS04	1	Hex. inverter	0.10	14-pin SOG	
	TI	F374	1	Octal 3-state	0.23	20-pin SOG	
	TI	AS374	1	Octal 3-state	0.26	20-pin SOG	
	Signetics	74LS245D	1	Octal bus transceiver	0.21	20-pin SOG	
	Intel	D2917, L0181545	1	Bus transceiver	0.18	16-pin DIP	
Analog	TI	TL494CN	1	Switching regulator	0.52	16-pin DIP	
	Motorola	MC14052BCP	1	Analog MUX	0.39	16-pin DIP	
	National	LM386N-1	1	Single power amp	0.23	8-pin DIP	
	TI	TL084A	2	Quad op amp	0.62	14-pin SOG	
Total			17		56.35		

Source: Dataquest (April 1991)

TABLE 4
The GammaLink GammaFax CP

	Vendor	Part No.	Quantity	Description	Estimated Cost ($)	Package	Function/Comment
Memory	Micron	4C4256-8	4	256Kx4, 80ns DRAM	19.72	20-pin DIP	Socketed
	AMD	27C256-15	1	32Kx8, 150ns EPROM	1.95	28-pin DIP	Socketed
Microprocessor	Intel	80C188	1	MPU	6.80	68-pin PLCC	Socketed
ASIC	Xilinx	XC2018-50	1	Logic cell array	15.00	84-pin PLCC	Socketed
	Lattice	GAL22V10-25LP	1	25ns GAL	1.42	24-pin DIP	Socketed
	CP	3118-023	1		2.05	24-pin DIP	Socketed, Rev. A
Standard Logic	TI	SN74LS652NT	2	Octal bus transceiver	0.44	24-pin DIP	
	TI	SN74LS245N	1	Octal bus transceiver	0.21	20-pin DIP	
	Signetics	74LS04	1	Hex. inverter	0.10	14-pin DIP	
	Signetics	74LS74AN	1	Dual D flip-flop	0.11	14-pin DIP	
	Signetics	74LS273	1	Octal D flip-flop	0.21	20-pin DIP	
	National	DM74LS244N	1	Octal 3-state driver	0.21	20-pin DIP	
Analog	National	LM386N	1	Single power amp	0.23	8-pin DIP	
	SGS-Thomson	LM348N	1	Quad op amp	0.57	14-pin DIP	High gain, programmable
Subtotal			11		49.02		
ASSP	Rockwell	R6629-12	1	Fax controller	8.85	64-pin DIP	
	Rockwell	R5537-12	1	Analog front-end	6.75	64-pin DIP	
Analog	Signetics	MC1458N	1	Dual op amp	0.43	8-pin DIP	
Subtotal			3		16.03		
Total			14		65.05		

Source: Dataquest (April 1991)

TABLE 5
The Frecom fax96

	Vendor	Part No.	Quantity	Description	Estimated Cost ($)	Package	Function/ Comment
ASSP	Yamaha	YM7109-D	1	Fax modem	18.00	40-pin DIP	Socketed
ASIC	TI	PAL16L8-25CN	1	25ns, CMOS PLD	0.60	20-pin DIP	
Standard Logic	National	DM74LS245N	1	Octal bus transceiver	0.21	20-pin DIP	
	National	DM74LS125AN	1	Quad 3-state buffer	0.15	14-pin DIP	
	National	DM74LS273N	1	Octal D flip-flop	0.22	20-pin DIP	
	National	74F240PC	1	Octal 3-state driver	0.23	20-pin DIP	
Analog	National	LM386N-1	1	Single power amp	0.23	8-pin DIP	
	National	LM387N	1	Analog switch	0.88	8-pin DIP	CMOS, SPDT, 15V
	National	LF347N	1	Quad op amp	0.38	14-pin DIP	Bipolar, JFET
Others	Sharp	PC824	1	NA	0.10	8-pin DIP	
Total			10		21.00		

NA = Not applicable
Source: Dataquest (April 1991)

Table 6
The Viva 24i/fx

	Vendor	Part No.	Quantity	Description	Estimated Cost ($)	Package	Function/ Comment
ASSP	Sierra	SC11046CN	1	2,400-bps modem	6.18	28-pin DIP	
	Sierra	SC11011CV	1	Modem controller	8.10	68-pin PLCC	2,400-bps, built-in UART
Memory	TI	27C256-15JL	1	32Kx8, 150ns EPROM	1.95	28-pin DIP	Socketed
Standard Logic	Signetics	74LS30N	1	8-in NAND	0.10	14-pin DIP	
	TI	SN74LS368AN	1	Quad 2-in XOR	0.22	16-pin DIP	
	TI	SN74LS245N	1	Octal bus transceiver	0.21	20-pin DIP	
Analog	Samsung	LM386	1	Single power amp	0.23	8-pin DIP	
Opto	Philips	4N35	1	Optocoupler	0.37	6-pin DIP	
Total			8		17.36		

Source: Dataquest (April 1991)

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Research *Bulletin*

SAMONITOR: A (FAINT) 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 BUSINESS CLIMATE

If ever there were the necessary conditions for the U.S. economy to resume expansion, they are certainly in place now, as shown in the following list:

- Decisive Gulf War victory boosting consumer and producer confidence
- Expectations of (continued) low world oil prices
- Low U.S. short-term interest rates
- Easing of Fed monetary policy

It is no coincidence that The Dun and Bradstreet Corporation's latest economic forecast calls for the U.S. real GNP to resume positive growth in the second quarter and for real GNP to grow 1 percent in 1991, the same rate as in 1990. Such a scenario would make the recent recession, and subsequent recovery, one of the mildest on record.

Several good reasons to expect a mild recovery are outlined as follows:

- Improved inventory control would negate the need for a steep ramp-up of production to build a cushion of product in anticipation of future consumption.
- The private sector's heavy debt burden will tend to divert marginal cash flows to debt service instead of capital formation.
- The fall in households' wealth due to the decline in home values in 1990 will tend to divert marginal income to saving instead of spending.
- Companies are reluctant to step up hiring plans because of concern over the durability and strength of growth.
- Decelerating growth in Germany and Japan will constrain U.S. exports.

This is the backdrop against which electronics manufacturers will operate for the remainder of 1991.

EQUIPMENT MARKETS

A recent survey indicates that this optimism is not misplaced. The *Computer Reseller News* (CRN) March PC Index of microcomputer purchasing among Fortune 1000 companies found that just 30 percent of the respondents to a survey believed that the recession will last another six months. In comparison, the February PC Index found that 54 percent believed that the recession would last that long.

Also, if actual February spending levels are any indication, March should also be a strong month. February purchasing data show that spending is already growing, with the average Fortune 1000 company spending 42 percent more than expected for microcomputer hardware and software in February. Significantly, February is the second consecutive month in which actual spending outpaced projections. In January, CRN's PC index found that the average Fortune 1000 company spent 10 percent more than expected on PC hardware and software.

The end of the Gulf War had a lot to do with the burst in February spending. Indeed, there are signs that the postwar euphoria is subsiding: According to Dataquest's monthly survey of major OEM semiconductor procurement managers, overall six-month systems sales are expected to grow 3.4 percent, down from 5.2 percent in March. Data processing OEMs' expected six-month growth also moved down to 7 percent, compared with 8.4 percent in March. The downward revision in April's expectations reflects the moderation (not elimination) of business confidence from the swift victory in the Gulf War.

A review of February orders indicates that expectations of recovery need to be tempered: Computers and office equipment orders growth for the three months ended in February was 2.5 percent below year-earlier orders, compared with negative

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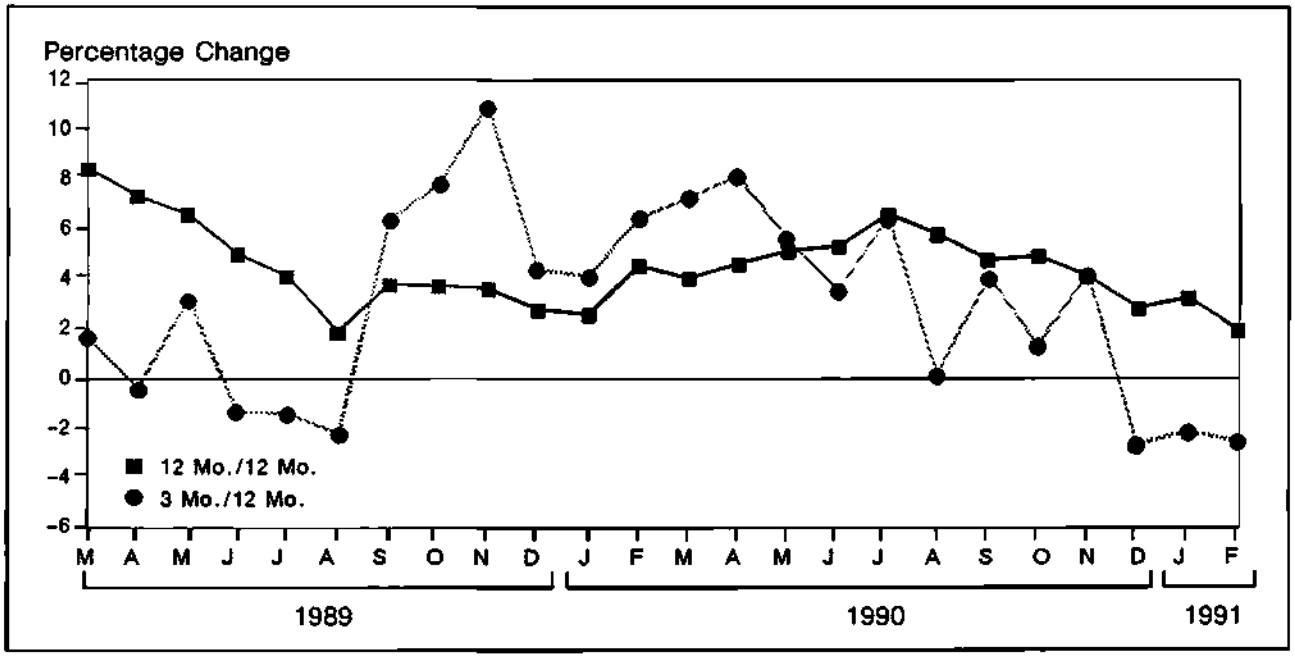
FIGURE 1
U.S. Computers and Office Equipment Orders Growth (1989-1991)



Source: U.S. Department of Commerce

2.1 percent growth in January (see Figure 1). Inventories are at 8.2 weeks in February, down 0.5 weeks from February 1990 stocks (see Figure 2). *February was the third consecutive month of orders contraction.*

Communications orders growth for the three months ended in February was 3.6 percent below year-earlier orders compared with negative 16 percent growth in January. *February was the sixth consecutive month of orders contraction.*

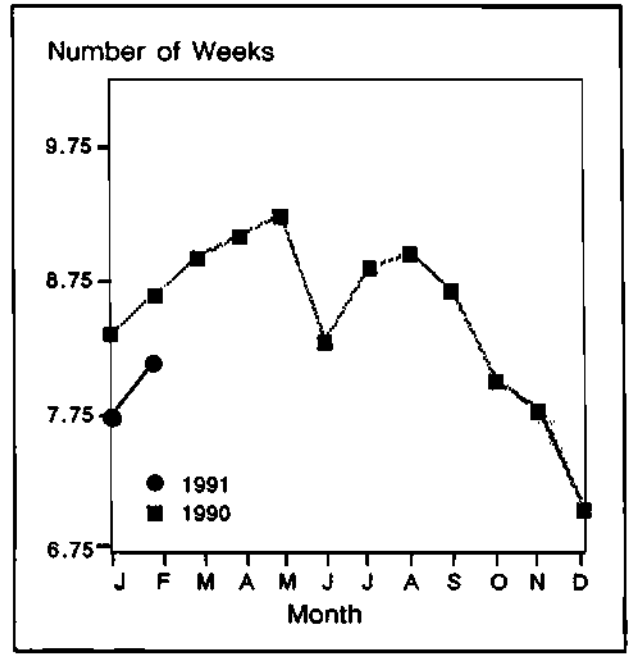
Instruments equipment order growth for the three months ended in February moved up 1 percent above year-earlier orders from negative 6.2 percent growth in January. *February was the first month of positive orders growth after five consecutive months of contraction.*

Inventories in communications and instruments are 6 and 11 weeks, or 0.5 and 0.6 weeks below year-earlier levels, respectively.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

There are signs, albeit faint ones, that a resumption of systems production is due in the second quarter. Whatever the timing of the turnaround, however, Dataquest believes that the coming expansion will be chiefly characterized by slow and steady acceleration in orders and shipments growth. Growth will likely accelerate through year-end and into 1992. There is a light at the end of the tunnel, and we do not believe that it is an approaching train.

FIGURE 2
U.S. Computers and Office Equipment Inventory-to-Shipments Ratio (Weeks)



Source: U.S. Department of Commerce

Terrance A. Birkholz

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Research Newsletter

OEM MONTHLY: THE LAN RUBIK'S CUBE

OVERVIEW

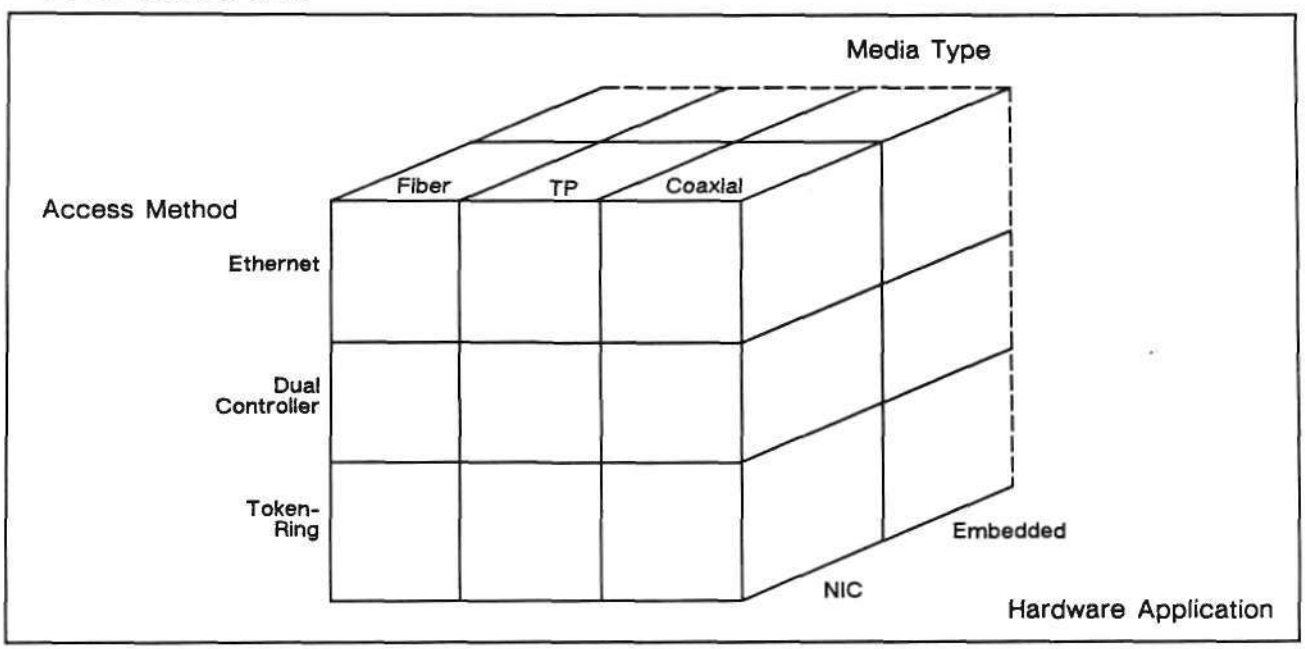
The main feature of the Rubik's Cube puzzle is that it can be manipulated to derive many different color combinations, but it is a very difficult puzzle to solve. The local area network (LAN) market could be likened to the Rubik's cube in that a variety of networking solutions can be derived, but it is difficult to find one solution to solve all users' needs.

INTRODUCTION

A LAN is a method of connecting computer systems so that they can communicate with each other. An access method is the means by which a computer system attempts to access this network. The two most prevalent access methods in the LAN market today are Ethernet (IEEE 802.3) and Token-Ring (IEEE 802.5), with FDDI coming in as the high-performance access method. Both Ethernet and Token-Ring perform the task of networking groups of computers together, but they accomplish this task in a fundamentally different manner. Other standards such as Arcnet and AppleTalk also exist in the LAN market, along with some proprietary access methods. ISDN may also be a viable solution to networking, but it is still in its infancy and is forecast to gain momentum sometime in the late 1990s.

A network interface card (NIC) is placed in a computer system, and the computer uses the NIC to

FIGURE 1
The LAN Rubik's Cube



Source: Dataquest (May 1991)

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

communicate on the network using a particular access method. As the networking of data processing equipment becomes more common, Dataquest believes that the access method will be embedded directly on the motherboard, bypassing the need for the NIC.

A number of media types may be used to link the network together. Coaxial and twisted pair (TP) are the most common media types, with fiber optics emerging in a variety of cost and performance versions. However, each media type requires a slightly different interface to the access method, making it difficult to standardize the chip set.

TWO STRONG EXISTING STANDARDS

Ethernet and Token-Ring exist as competing access method standards. Ethernet is an access method that allows all users the opportunity to send information across the network at any given time. However, two users sending data at the exact same time can result in data collision, creating the need for the data to be retransmitted. As network users shift from transmitting word processing documents and spreadsheets to accessing large databases and printing for sophisticated graphics, the networks are being more heavily loaded and data collision occurs more often.

The Token-Ring access method is structured in a manner that allows users to access the network only when the token is passed to their computer. If the network is heavily loaded, a user rarely notices because of Token-Ring's regulating capability.

Ethernet has a 10-megabits-per-second (Mbps) transmission rate, and, depending on the media type, is a one- to three-chip solution. The unshielded twisted pair (UTP) Ethernet standard named 10BASE-T has made it possible to shrink Ethernet to a one-chip solution, because the 10BASE-T transceiver does not need to be electrically isolated. However, when using coax media, the transceiver needs to be electrically isolated, making it much more difficult to reduce the chip set to one chip.

10BASE-T has also enabled Ethernet supporters to begin driving standards to implement more sophisticated network management into Ethernet. The proposed 10BASE-T hub management standard operates by having nodes communicate to a hub, which allows the hub to command and monitor the network. The standards for hub management are in draft form and are currently being negotiated.

Token-Ring is available in two versions, a low-cost 4-Mbps and a 16-Mbps version, depending on users' performance needs. Token-Ring is a two-chip solution but still requires some additional buffer memory.

The Token-Ring chip set solution claims to embody intelligent architecture that is able to provide a high level of built-in network management. This intelligent solution performs such tasks as preventative maintenance through nodes reporting back to the network when a potential problem may be developing. It benefits the users by decreasing down time and increasing network reliability.

HERE TO STAY OR GOING AWAY?

The majority of the LAN access methods are currently implemented into a system through the NIC. Technical workstations, however, were developed in a networked environment and therefore had the access method integrated as a standard feature. Companies such as Sun Microsystems and Digital Equipment Corporation have chosen Ethernet and currently embed the access method directly onto the system's motherboard.

Several conditions, shown in the following list, must be met, however, before widespread migration to the motherboard occurs:

- Standards that are viable solutions must exist—Ethernet and Token-Ring both meet this requirement.
- Widespread adoption of one standard or interchangeable standards must exist so that the user is not limited when choosing to embed an access method.
  - A possible solution to widespread adoption of Ethernet or Token-Ring would be the development of a dual-access method controller, allowing the use of either access method.
- The chip set needs to occupy as little real estate on the motherboard as possible.
  - The chip set is continually shrinking and in some cases is already a one-chip solution.
- The cost of the chip set must be low enough that it does not make a significant difference to the buyer in the system cost.
  - As chip set costs continue to decrease, it will become more feasible to embed the chip without a significant impact on the buyer.

Another factor that could impact the rate of change from the NIC to embedding is the role of the network operating system (NOS) companies. The NOS companies currently interface with the NIC companies for specifications, but this relationship would need to be altered to include the chip set vendor as a NOS customer. The flexibility of the NOS companies may determine how quickly the chip set companies would be able to embed on the system. However, in the case of a proprietary network, the NOS is often handled internally.

Dataquest believes that as these conditions are fully worked out and networking personal computers becomes the rule rather than the exception, the effect will be a greater number of PCs sold with an access method embedded on the motherboard.

The laptop market, which traditionally has not been networked, is another key market for embedding the access method and the dual-access method controller. Laptop computer users transport their systems to networked environments that require an access method or a variety of access methods to be available. Also, the laptop is so small that the access method needs to be embedded on the motherboard because there is not enough room for an NIC. Because of the increasingly smaller size of the laptop, there is a need to embed the chip set and also a need for a dual access controller to allow flexibility between access methods.

A PLETHORA OF MEDIA TYPES

Three types of media may be used with Ethernet or Token-Ring—coaxial, TP, and fiber. All of these media types have advantages and disadvantages to the user. To the chip supplier, it is also very difficult to standardize the chip set with so many electrical differences between the three types of media. One solution to this media problem is to install a multimedia connector that could accept all media types.

Coaxial traditionally has been used when networking an environment. However, it is not very flexible, it is very difficult to install in an existing building, and it can become very expensive. From the chip side, the coax driver needs to be electrically isolated, making it very difficult to respond to the market demand of a one-chip access method solution. This need for isolation, along with the cost associated with installation of coax media, may influence the market more toward using TP or fiber.

TP has gained momentum because of its flexibility in installation and the lower costs associated with both. TP is available in unshielded twisted pair and in shielded twisted pair. Both Ethernet and Token-Ring are able to use UTP, but Token-Ring is usually associated with STP. However, some industry sources believe that TP could be lacking in its high-end graphics transfer capability as upgrading occurs to higher transmission rates. Because of this lack, some users may bypass TP and convert from coax directly to fiber.

Fiber is still in its infancy and is forecast to become the high-performance media type as transmission rates with access methods such as FDDI reach 100 to 200 Mbps. However, a lower-cost, less complex fiber is available for Ethernet and Token-Ring, but currently only a small percentage of the market is taking advantage of this media type.

DATAQUEST RECOMMENDATIONS AND CONCLUSIONS

The LAN market currently has numerous combinations of access method, hardware implementation, and media solutions. However, this makes the decision of a networking solution very difficult for users and keeps suppliers constantly guessing.

For semiconductor suppliers, a possible approach would be to play all sides of the Rubik's Cube and be able to adjust to a new combination if market demands require. For example, semiconductor suppliers may see an augmentation to their current client base to include the platform vendors. This changing market will require tracking and being aware of the many solutions available and being flexible enough to develop new options.

Anna L. Cahill
Shirley Hunt

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Research *Bulletin*

SAMONITOR: MARKETS: TO YOUR MARK, SET, . . .

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 BUSINESS CLIMATE

Recently released economic statistics sent more intimations that a recovery is on the way, although it will be several months before it arrives.

The DOC's index of leading economic indicators rose a modest 0.5 percent in March, largely due to a burst of consumer optimism. This is the second consecutive increase—the indicators jumped 1.2 percent in February—after six months in a row of decline. The components of the index that tend to give the longest advance signal provided this increase.

Also, the DOC's initial report on the economy's overall health in the first quarter showed a deeper and broader-based weakness than was earlier expected. U.S. real GNP growth contracted at a 2.8 percent annual growth rate after declining by 1.6 percent in the fourth quarter of 1990.

EQUIPMENT MARKETS

According to Dataquest's monthly survey of major OEM semiconductor procurement managers, expectations of short-term production have improved: Overall six-month systems sales are expected to grow 6.5 percent, up from 3.4 percent in April. Data processing OEMs' expected six-month growth also moved up to 10 percent, compared with 7 percent in April.

Table 1 highlights Dataquest's expectations of the worldwide personal computer market. Overall, PC production is expected to decelerate to 9.6 percent unit growth in 1991, down from 9.8 percent in 1990. Unit growth is expected to accelerate to 11.3 percent in 1992, however, reflecting the improvement of the business climate next year. Laptop and notebook growth should remain well above average through 1992. Desktop PC production, though, will be tightly squeezed from four fronts: a dearth of remaining available desktops, weak business conditions leading firms to postpone *marginal* PC purchases, substitution of low-end workstations for high-end PCs, and substitution of portable PCs for desktop units.

Dataquest expects the value of the worldwide workstation market to grow 25.1 percent in 1991, up from 20.1 percent in 1990, and to further accelerate to 32.6 percent in 1992.

Reviewing first-quarter performance, computers and office equipment orders growth for the three months ending in March was 0.1 percent above year-earlier orders, compared with negative 2.1 percent growth in February (see Figure 1). Inventories are at 8.5 weeks in March, down 0.4 weeks from March 1990 stocks (see Figure 2). *March was the first month of positive orders growth following three consecutive months of contraction.*

TABLE 1
Estimated Worldwide Personal Computer Shipments (Units)
Unit Growth (%) per Share of Total Unit Shipments (%)

	1990
Total PC Shipments	9.8/100.0
Desktop	3.7/84.4
Laptop (DC)	37.4/11.1
Notebook	1,175.0/1.7

Source: Dataquest (May 1991)

Table 1
See attached
Errata -- do
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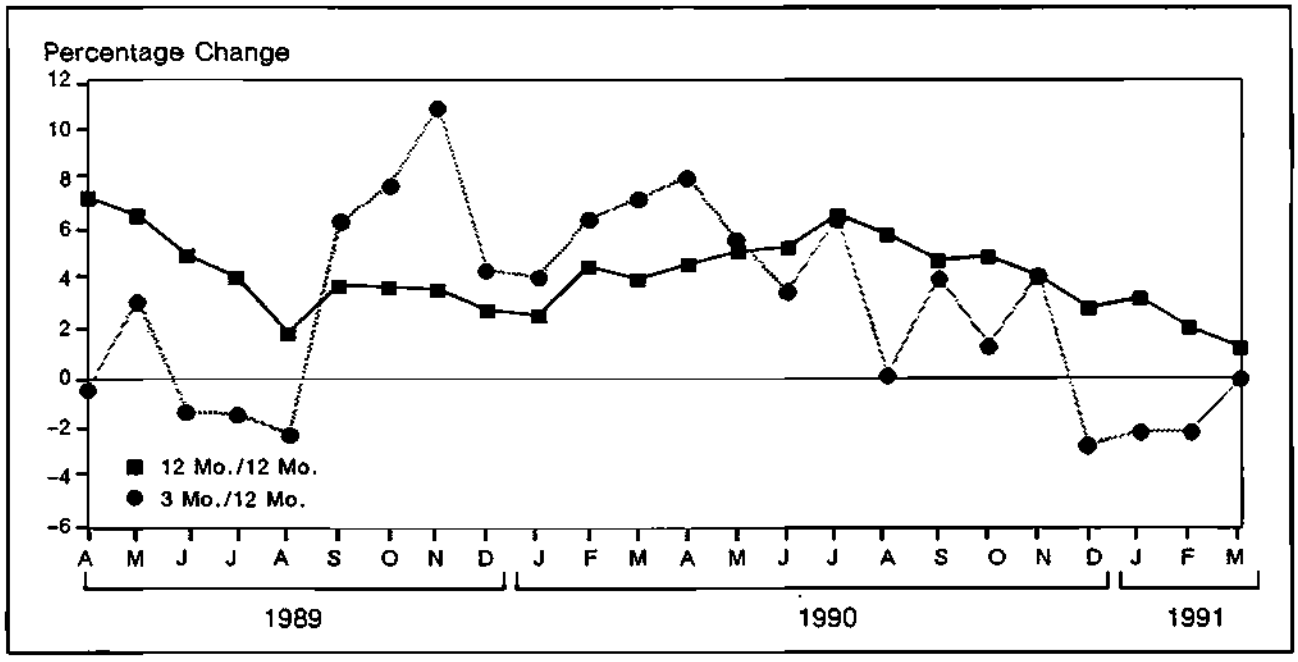
table - title incorrect
% per Share

SAM Newsletters 1991: April-June 1991-10

FIGURE 1
U.S. Computers and Office Equipment Orders Growth (1989-1991)



Source: U.S. Department of Commerce

The defense-related sector continues to depress communications production. Communications orders growth for the three months ending in March was negative 2.4 percent below year-earlier orders, compared with negative 2.9 percent in February. However, *nondefense*-related communications orders growth is a *positive* 2.5 percent year to date in March.

Instruments were hurt by sluggish manufacturing activity. Order growth for the three months ending in March was negative 3.9 percent below year-earlier orders, down from a positive 1.1 percent in February.

Systems manufacturers continue to be cautious about prematurely ramping up production; they fill orders by drawing down their inventories. Communications and instruments inventories are 6.4 weeks and 11.9 weeks, or 0.4 and 0.3 weeks below year-earlier levels, respectively.

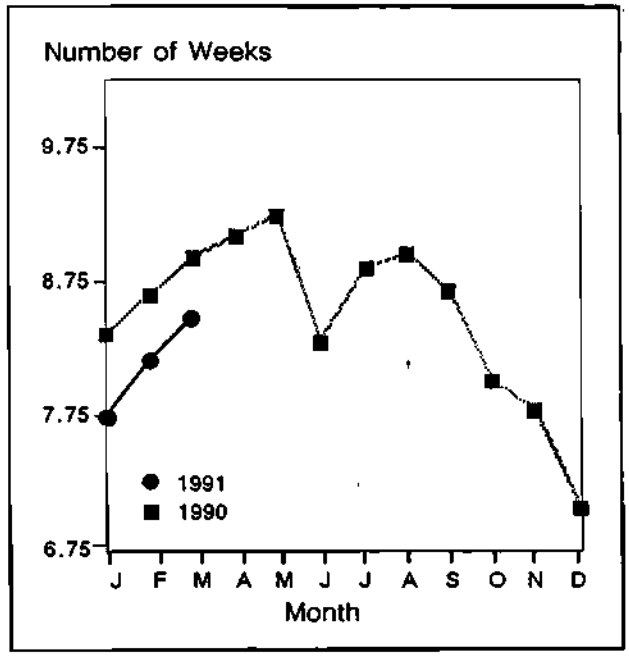
DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The signs of a recovery in systems production growth remain faint. The April semiconductor book-to-bill ratio of 1.15, although strong and very welcome, overpredicts the short-term strength of the chip market.

We believe that systems production will resume positive growth approximately in synch with overall business conditions during the second half; the chip market will follow suit. Probably the surest sign that the business investment climate will improve is the Fed's recent easing of its monetary policy: Experience shows that the lag time between a policy change and its stimulation of business activity can be as short as six months. Once the Fed jump starts the expansion, the biggest concern will then be a resurgence of accelerating inflation.

Terrance A. Birkholz

FIGURE 2
U.S. Computers and Office Equipment Inventory-to-Shipments Ratio (Weeks)



Source: U.S. Department of Commerce

TABLE 1
Estimated Worldwide Personal Computer Shipments (Units)
Unit Growth (%)/Share of Total Unit Shipments (%)

	1990	1991	1992
Total PC Shipments	9.8/100.0	9.6/100.0	11.3/100.0
Desktop	3.7/84.4	2.6/80.7	0.6/74.7
Laptop (DC)	37.4/11.1	22.6/12.6	13.2/13.2
Notebook	1,175.0/1.7	68.1/2.7	110.1/5.3

Source: Dataquest (May 1991)

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Research Newsletter

OEM MONTHLY: PERSONAL COMMUNICATIONS STIMULATES RF MARKET

NEW LIFE

The market for RF, or radio frequency, semiconductor technology, in both its bipolar and GaAs forms, is being energized by several new applications. An era of wireless personal communications applications is emerging to complement a market previously dominated by consumer receivers, communication transmission equipment, and military uses.

APPLICATION DRIVERS

Look to untethered personal communications to drive a large part of RF semiconductor demand. The concept of personal communications covers the range from cellular telephones and pagers to wireless PCs, LANs, and fax machines for office and portable use. RF ICs and discretes (generally defined as frequencies above 30 MHz) serve principally as the front-end interfaces to the outside world and can account for as much as 35 percent of the semiconductor value of the systems they are in. Typical RF circuits include dividers, synthesizers, receivers, and a variety of amplifiers and specialized functions. Some popular RF applications are noted in Table 1.

Table 2 lists RF applications ranging from microwatts to kilowatts in power-handling ability.

Cellular to PCNs

The age of Dick Tracy-style personal communications is approaching, and its impact on RF as well as DSP semiconductor demand will be significant. Demand will be spurred by the opening of new markets in Eastern Europe and Asia; by

TABLE 1
Selected RF Applications

Equipment	Cumulative[1] 1991-1994 Units (Millions)	Frequencies (GHz)
Cellular Telephones	26.9	0.8-1.2 GHz
Cordless Telephones	69.8	50 MHz
Identification Tags/Readers	350.0	150 KHz-6 GHz
Earth Stations (VSAT and DBS)	10.0	10-14 GHz
Global Positioning Units	0.8	1-2 GHz
Radar, C(3)I, EW, Guidance	2.0[2]	30 MHz-35 GHz

[1] U.S., European, and Japanese markets
[2] Modules
Source: Dataquest (June 1991)

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SAM Newsletters 1991: April-June 1991-11

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TABLE 2
RF Applications

Consumer	Communications	Industrial/Military
Car Lock/Security	Cellular Phones	ATE
Garage Door Openers	Cordless Phones	Communication Test Equipment
TV, VCR, Radio Receivers	Pagers	General Test/Measurement
Remote Control Toys	Two-Way Radio	Process Controls
Automotive Collision Avoidance	Base Stations	Medical Imaging
	Transmitters	ID Tags
	Microwave Communication	Radar
	Telemetry	Electronic Warfare
	RF Modems/Fax	C(3)I
	RF LANs/WANs	Navigation
	Satellite Communication	Weapon/Missile Guidance
	Remote Data Entry	

Source: Dataquest (June 1991)

enhanced functionality delivered by digital processing; and because of new "wireless" applications such as data and image communications.

Perhaps the grandest of all the personal communications plans is Motorola's Iridium system, which would ring the world with 77 low-orbit satellites (to be built by Lockheed) that would act like a digital switched communication system. With up/down link frequencies at 1.5 to 1.6 GHz, subscribers in the vast rural areas of the world could communicate over low-cost cellular telephone units. PTT approvals are currently being sought from the various countries to be serviced by the system.

A more immediate market opportunity is hardware development for the Groupe Speciale Mobile (GSM) standard (900 MHz), which has gained favor as the digital cellular phone system for all of Europe. In fact, GSM capacity is already being installed this year. Key GSM players include Ericsson, Motorola, Siemens, and Toshiba. The RF semiconductor content for first-generation GSM cellular phones can exceed $50 per handset.

The concept of personal communications networks (PCNs) is promising to bring cellular-type technology to the home and office beyond where existing cellular utility has penetrated so far. Various consortia in Europe have taken the lead in defining and implementing standards for PCNs that use microcells and digital signal processing (DSP) techniques. CT2, CT3 (Ericsson), DECT, and DCS 1800 are standards oriented toward microcells (100+ meter radius) and have typical transmitter power of 1 watt. CT2 and CT3 operate in the 800-MHz range and the other two operate at 1.8 GHz. The DCS 1800 standard, a derivative of GSM with a range of 2km, is projected to gather as many as 9 million users in the United Kingdom alone by the year 2000. Key DCS 1800 players include Matra, Motorola, Orbitel, and STC.

PCNs are known as Personal Communication Systems (PCS) in the United States. As of the end of 1990, 40 experimental licenses had been granted by the FCC to test the viability of PCS technology. Most of the standards from Europe are included in the trials. Dataquest believes that it will be two to three years before PCSs are operational in the United States.

Why Digital?

One of the key reasons behind adopting digitally based technology is to expand airwave capacity through more efficient use of allocated frequencies. Channel overloading is a crucial problem in many large cities with the existing analog system (AMPS in the United States). By using speech

compression, multiplexing (TDMA, E-TDMA, or CDMA/spread spectrum), and transmission suppression during pauses, DSP-oriented technology can help achieve greater frequency use; therefore, more users can be added to a given cell. Other advantages for digitally based technology include easy encryption for security-minded users and a generally less noisy line because of noise-reduction processing. A digitally based system also allows for easier ISDN interoperability, especially when wireless data, facsimile, and image transmission are demanded.

In the United States, the TDMA multiplexing scheme has won the approval of the Cellular Telecommunications Industry Association and appears to be on its way toward implementation in some of the major cities by year-end. It will probably take the rest of the decade to convert all the base stations and phone sets in the United States over to new digital versions. In the interim, phone sets will need to handle both the analog and digital standards. The price of a hybrid phone set could run at least $1,500 initially, depending upon the amount of subsidies offered by service providers. Dataquest estimates that the need for extra DSP circuitry (e.g., TDMA) will drive the semiconductor content of a hybrid phone set to $150, including $50 of RF circuitry.

Wireless Datacom

Several companies, including Apple, Ericsson, Motorola, NCR, and NTT, have proposed wireless data connections for office and portable use. Such a capability would bypass the need for wiring between computers and peripherals and allow ultimate flexibility for changing office arrangements. Wireless connections would typically be made through the PBX or via LANs.

As an example, Motorola is marketing an Ethernet standard, which operates on an 18-GHz carrier. Because these wireless proposals are relatively new, it will be several years before they become a reality, but the utility of the concept is overwhelming and "wirelessness" should become an important worldwide market by the end of the decade.

ID Tags

RF identification (ID) tags are potentially an extremely large consumer of RF technology. They are being used increasingly for such applications as inventory management and as toll booth cards for commuters. RF ID is needed when either the reading device or tag cannot come close enough for other solutions to work (e.g., optical bar code readers) or information needs to be accumulated on the tag. The automotive industry uses the latter for assembly and inventory coordination. The lack of broadly adopted standards to date is keeping each application unique, but the interest in RF ID is growing anyway.

The tags comprise a transmitter, receiver, logic, and memory (as much as 256Kb of ROM, EPROM, EE, or Flash). The logic can include error detection and correction as well as encryption. Some tags use their own batteries, while others use transmitted power from the reader by using the surface acoustic wave (SAW) effect. Companies selling these systems include Allen-Bradley, Amtech, Cotag, NDC Automation, Texas Instruments, and XCI.

Global Positioning System

GPS is a good example of a military system finding commercial uses. GPS is a worldwide 3-D location information system that uses a constellation of 24 satellites. In application, GPS receivers gather signals from various line-of-sight satellites and use a form of triangulation to determine the position of the receiver. The receivers can be on boats, trucking fleets, cars, surveying instruments, or can be hand-held. In addition, there are military navigational uses on various sea, air, and land platforms and weapons. The receiver can then be tied into navigation controls or used to update location information on electronic displayed maps.

The GPS satellites, which are controlled by the U.S. Air Force, can be used in military and civilian modes, with the military mode offering locational accuracies to 59 feet and civilian at 330 feet. An ongoing controversy remains as to whether or not civilian users should be allowed ongoing access to military mode accuracies during times of crisis (e.g., the Persian Gulf War). Dataquest estimates the bulk of the growth for GPS systems will come after 1994 when system prices should break the $500 dollar mark, thus stimulating a broader fleet and consumer market.

Manufacturers of GPS equipment include Magellan Systems, Rockwell Communications, SCI, and Trimble Navigation. Prices range from $450 for a 2.5 × 4-inch board by Rockwell, to $1,500 for the civilian hand-held units, to tens of

thousands of dollars for sophisticated military ship and aircraft versions. The RF content of the Rockwell version is mainly in the form of the GaAs-based RF/IF receiver, which has 1,300 components. Other ICs on the Rockwell board include a 42,000-gate DSP, a RISC MPU, a frequency standard, 2MB of ROM, and 2 low-density SRAMs.

Military Applications

Military electronic applications are calling for improved missile and smart weapon guidance, phased-array radar (transmit/receive modules), warning receivers, countermeasures (e.g., jamming), and communications and navigations for air, land, and sea. The bulk of needs stem from the desire to improve performance (higher frequencies) and reduce size, weight, power consumption, and cost. In the United States, the MIMIC program is being used as a means of stimulating the development of producible (design, test, and package) microwave and millimeter-wave (up to 30 Ghz) ICs.

DATAQUEST PERSPECTIVE

Dataquest is optimistic about the outlook of this vital technology. Several multimillion-unit class applications have either emerged or are still developing. Most of the new revenue opportunity lies in the higher (>1 GHz) frequencies applications with personal communications. The RF ID tag area is a good opportunity, but a lack of standards may inhibit growth in the near term.

Semiconductor companies that traditionally have strengths in RF or are part of OEM teams that specialize in RF system products are the best positioned to capture the bulk of future growth. RF semiconductor technology and systems are difficult to design, test, and package and therefore create a natural competitive barrier. On the other hand, innovative, focused competition seems to be always attracted to growth markets.

Gregory Sheppard

Dataquest
a company of
The Dun & Bradstreet Corporation

Research Newsletter

WORLDWIDE ELECTRONIC PRODUCTION OUTLOOK: MODERATE EXPANSION TRACKS RECOVERY IN BUSINESS INVESTMENT

SUMMARY

The economic expansion expected in the next few months also will help stimulate electronics production. Worldwide systems growth is expected to accelerate to 7.8 percent in 1991, up from 5.4 percent in 1990, and to further accelerate to 9.0 percent in 1992. Trend growth is expected to have a 7.8 percent compound annual growth rate (CAGR) during the 1990 to 1995 period. Growth through 1995 is expected to be less variable than in the 1980s as the dominant markets mature. As in past years, trend growth will be driven by business investment in decentralized computing systems, data communications systems, and data processing peripherals. In contrast to the 1980s, however, business spending on these systems will be relatively more sparse and drawn out because of the high saturation of the installed base of equipment, the comparative complexity of investment decisions, and/or the expected moderation of overall business activity.

ECONOMIC SITUATION AND OUTLOOK

First-quarter real, inflation-adjusted GNP fell at a 2.8 percent annual rate, the largest one-quarter drop since 1982. This fall follows a 1.6 percent decline in real GNP growth in the first quarter. About two-thirds of the GNP decline in the first quarter was attributable to a big pullback in business investment in plant and equipment. By contrast, most of the fourth-quarter weakness came from a sharp drop in consumer spending while business investment was flat. Consumer spending was also off in the first quarter, but fell by less than one-half the amount of the fourth-quarter decline.

In the first quarter, an improved foreign trade picture aided the economy as exports of goods and services exceeded imports for the first time in eight years. Total exports were at a $646.5 billion annual rate, while imports were at a $644.3 billion rate.

However, the improvement came from a big drop in imports; exports also fell by a smaller amount. The slowdown in the economies of many of the United States' biggest trading partners will probably make it difficult to keep up the export growth of recent years; furthermore, imports may pick up again with the strengthening of the U.S. economy.

The forerunners of resumed economic expansion are emerging. Lower interest rates, stepped-up growth in the money supply, recovery in consumer and business confidence, relatively lean inventories, and tentative signs of improvement in housing support this expectation.

The index of the National Association of Purchasing Manager, based on a survey of purchasing managers at 300 industrial companies, rose for the third month in a row to 45.4 percent in May—its highest level since August—from 42.1 percent in April. The new number suggests that although manufacturers still have problems, the overall economy has begun to grow again.

Much of the strength in the index came from a rise in new orders, which ended 10 months in a row of readings that suggested declining orders. The boost in orders should result in increased production over the next 30 to 60 days.

The Dun and Bradstreet Corporation, Dataquest's corporate parent, expects the rate of U.S. economic growth to slowly accelerate through the remainder of 1991. The pickup will be very modest compared with other postrecession periods, but it still will be a marked improvement over 1990. Most of the improvement will occur in capital equipment spending, the result of 1990's lower interest rates, and in exports, as the trade-weighted

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dollar fell almost 10 percent in 1990. By late 1991 and into 1992, consumer spending should also pick up, leading to 0.2 percent growth in 1991 (with most of the weakness occurring in the beginning of the year) and 3.4 percent growth in 1992 (see Figure 1). This rebound will be mild compared with other postrecession recoveries as weak labor force growth and sluggish productivity growth hold down aggregate output. For some sectors, notably housing and construction, it may take several years for demand to return to pre-1989 levels.

This is the backdrop against which electronics manufacturers will operate in the coming quarters. Don't expect growth to return to the extraordinary rates of the 1980s. A moderate expansion is expected.

The good news is that growth held close to its long-run rate is typically less variable and more sustainable than faster growth that exceeds potential. Simply put, it is easier to execute a continuous business strategy when the background noise is low.

WORLDWIDE ELECTRONIC PRODUCTION FORECAST BY APPLICATION MARKET

Worldwide electronic production is expected to grow 7.8 percent in 1991 to $661.3 billion from $613.3 billion in 1990. Growth in 1990 was 5.4 percent. The CAGR from 1990 through 1995 is expected to be 7.8 percent.

Table 1 gives the worldwide production forecast by application market. The forecast is also illustrated in Figure 2.

Table 2 and Figure 3 present the worldwide production forecast by regional market.

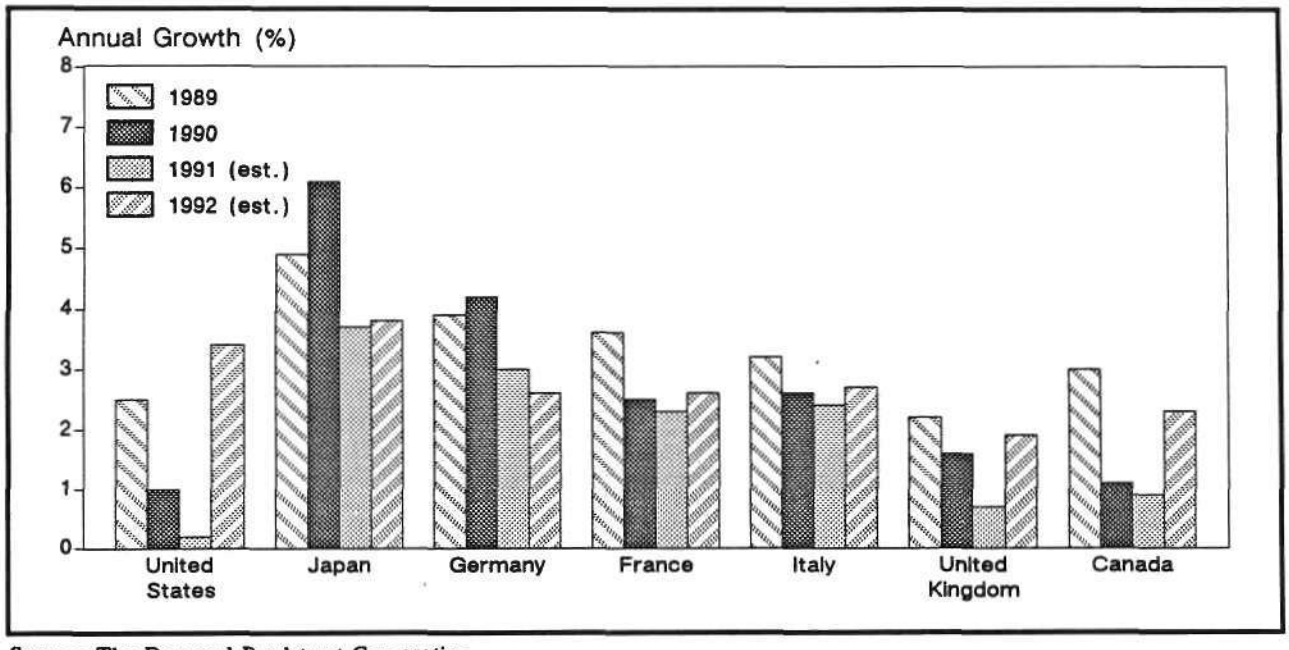
The remainder of this newsletter discusses important application market and regional aspects of the forecast.

Data Processing

The mildness of the coming business expansion is likely to hasten the transition from large centralized systems to distributed systems. The reason is financing requirements. In terms of cash flow, investments in central processing systems are typically more "lumpy" or discontinuous than investments in decentralized systems, where additions can be made in in smaller increments.

The forecast calls for distributed computing systems and peripheral systems to continue to be the primary drivers of growth. For example, the value of workstation production is expected to

FIGURE 1
Growth of Real GNP/GDP Annual Rate



Source: The Dun and Bradstreet Corporation

TABLE 1
1990-1995 Worldwide Electronic Equipment Production Forecast by Application Market
(Factory Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	Growth 1989-1990	Growth 1990-1991	CAGR (%) 1990-1995
Data Processing	184,983	206,058	227,664	249,173	269,139	292,775	3.9	11.4	9.6
Communications	95,984	106,477	116,482	126,603	135,088	146,753	10.1	10.9	8.9
Industrial	93,037	100,343	108,517	117,085	124,255	132,717	5.4	7.9	7.4
Consumer	136,067	147,931	161,298	170,161	179,872	192,714	7.1	8.7	7.2
Military/Aerospace	87,620	83,698	88,195	91,923	95,446	99,703	0.5	-4.5	2.6
Transportation	15,624	16,795	18,916	21,290	24,000	26,481	8.9	7.5	11.1
Total	613,315	661,302	721,072	776,235	827,800	891,143	5.4	7.8	7.8

Source: Dataquest (July 1991)

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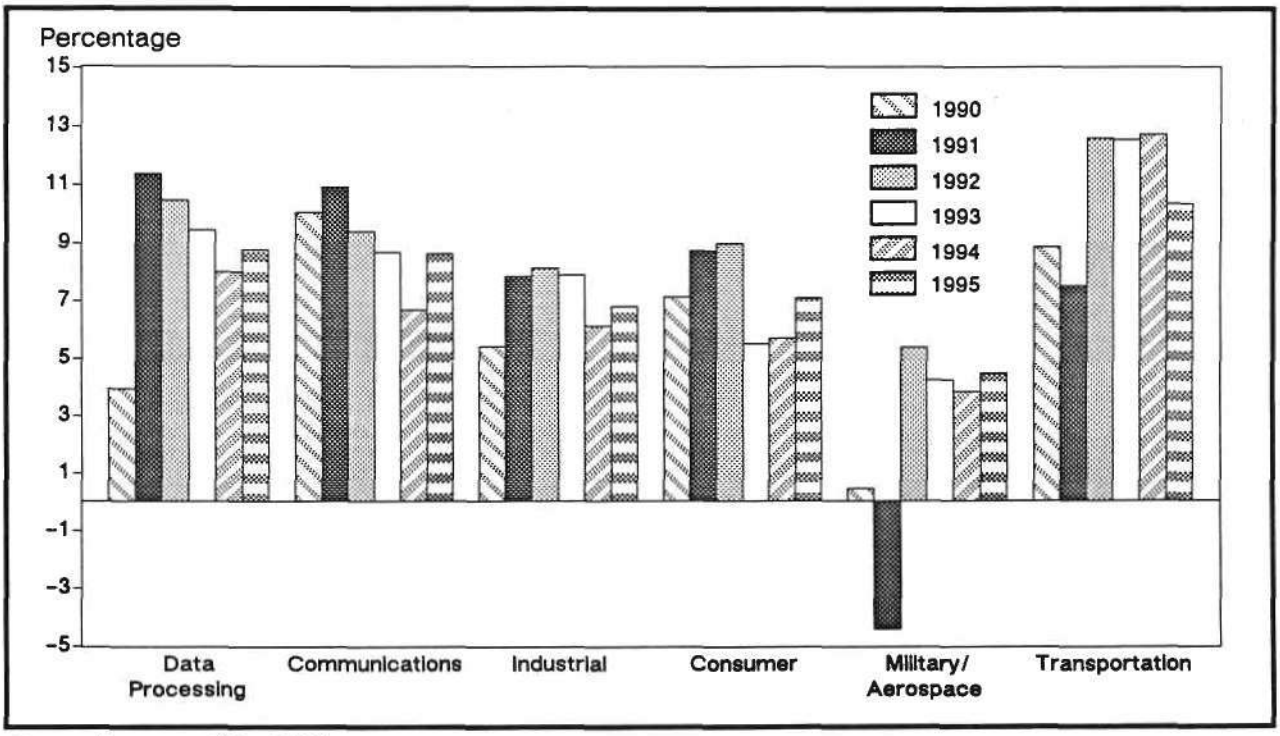
FIGURE 2
1990-1995 Worldwide Electronic Equipment Production Forecast by Application Market (Annual Growth, in Percent)



Source: Dataquest (July 1991)

grow 25.1 percent in 1991, up from 20.1 percent in 1990, and to further accelerate to 25.8 percent CAGR during the 1990 to 1995 period.

Personal computer growth is also expected to accelerate to 10.0 percent growth in 1991, up from 6.0 percent growth in 1990, and to settle down to a 1990 to 1995 CAGR of 9.4 percent. As office environments become more saturated with desktop machines, however, incremental growth will stem from laptops, notebooks, and newly introduced 80486/68040 machines that compete with the low-end RISC workstation market.

Page printer growth will decelerate from 28.0 percent growth in 1990 to 18.0 percent growth in 1991, a 1990 to 1995 CAGR of 14.7 percent. Overall, growth will be held back by mainframe and midrange computer systems. In 1991, worldwide mainframe and midrange growth is expected to be negative 2.0 percent and 2.2 percent, respectively, down from 3.0 and 7.1 percent, respectively, in 1990. Long-term prospects look anything but bright: The 1990-through-1995 CAGR for mainframes and midrange systems is negative 1.1 percent and 3.0 percent, respectively.

Communications

Three different growth dynamics are involved in the three most important communications systems groups: premise equipment, public equipment, and mobile telecommunications equipment.

Worldwide, premise equipment production is expected to grow 10.8 percent in 1991, up from 7.7 percent in 1990, and achieve a 1990 through 1995 CAGR of 9.1 percent. Incremental growth will come from video teleconferencing, local area networks, and network management equipment. Standards-fueled price declines plus growing PC-modem board business will retard growth the datacom sector through 1995.

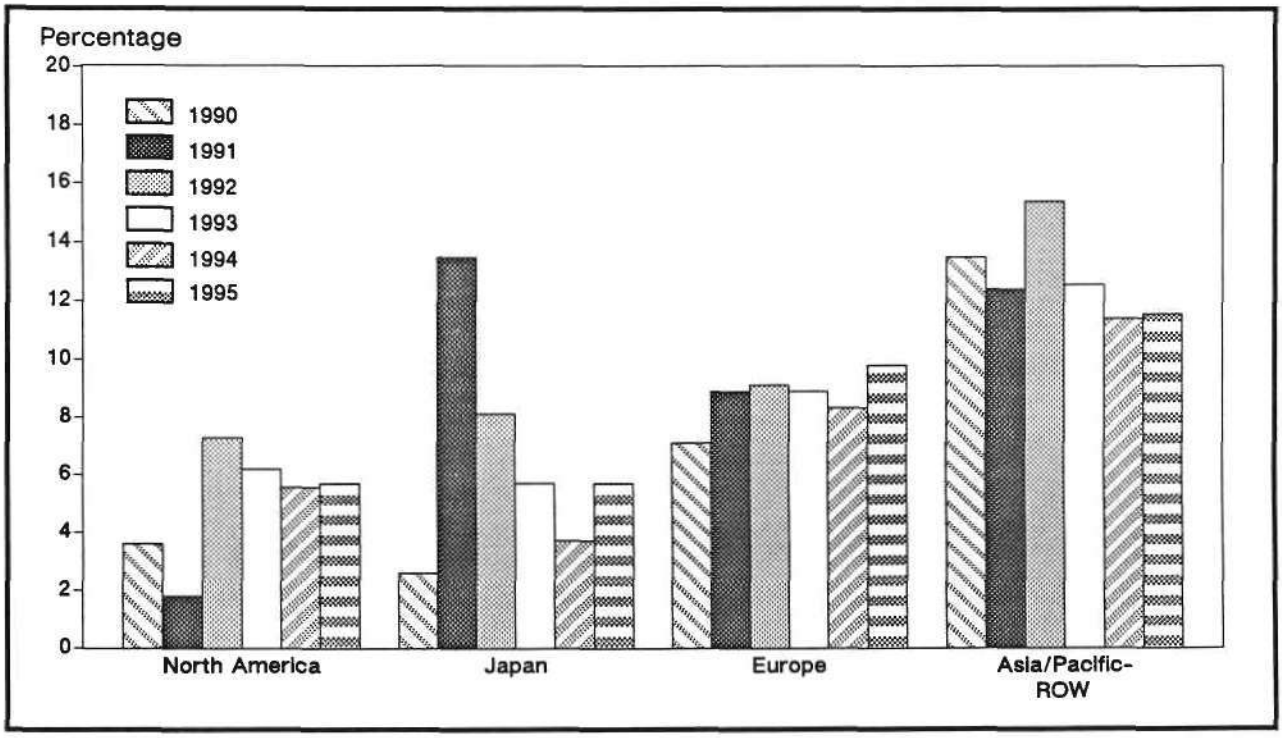
With its relatively long production cycle, public telecommunications equipment will provide "base" growth. Growth in 1991 is likely to decelerate to 12.1 percent from 13.3 percent in 1990 and attain a 1990-through-1995 CAGR of 8.8 percent. Faster-than-average growth will stem from public telephone company investments in microwave and satellite equipment. Investment

TABLE 2
1990-1995 Worldwide Electronic Equipment Production Forecast by Region
(Factory Revenue in Millions of Dollars

	1990	1991	1992	1993	1994	1995	Growth 1989-1990	Growth 1990-1991	CAGR (%) 1990-1995
North America	228,418	232,617	249,665	265,329	280,091	296,124	3.6	1.8	5.3
Japan	150,917	171,296	185,268	195,864	203,139	214,714	2.6	13.5	7.3
Europe	160,041	174,250	190,139	206,998	224,236	246,112	7.1	8.9	9.0
Asia/Pacific-ROW	73,939	83,139	96,000	108,044	120,334	134,193	13.5	12.4	12.7
Total	613,315	661,302	721,072	776,235	827,800	891,143	5.4	7.8	7.8

Source: Dataquest (July 1991)

FIGURE 3
1990-1995 Worldwide Electronic Equipment Production Forecast by Application Market
(Annual Growth in Percent)



Source: Dataquest (July 1991)

growth in central office equipment will be slower than average, but it looks best in Europe as the region upgrades marginal relay-switching systems in the EC periphery to digital switching equipment.

Worldwide, mobile telecommunications equipment production growth is expected to decelerate from 11.4 percent in 1990 to 10.9 percent in 1991 and grow at a CAGR of 9.5 percent during the 1990-through-1995 period. Although cellular telephones will continue to be a key driver in the system group, we expect production growth to closely track and accelerate with overall business conditions. Although cellular systems can put a step improvement in an business operation's productivity, they are also one of the easiest investments to put on hold until business conditions sufficiently improve.

Industrial

Industrial electronics systems growth will improve in 1991 to 7.9 percent, up from 5.4 percent in 1990, and reach a 7.4 percent CAGR in the 1990-through-1995 period. Growth will be constrained by business' reluctance to make the marginal capital investments, instead favoring to strengthen their balance sheets by paying off corporate debt.

Medical equipment, relatively less subject to the verities of the investment cycle, remains one of the bright areas as soaring health care costs provide incentive for manufacturers to develop patient-operated therapeutic equipment that lowers costly doctor-patient interaction.

With worldwide oil prices back down below preinvasion levels, we do not expect superlative additions to the stock of energy-saving/management equipment in the home and workplace. Worldwide oil prices are now below preinvasion levels and will probably stay there for the foreseeable future, making previously unplanned conservation-oriented investments difficult to justify. Besides, considerable energy-saving investment has already taken place. Developed countries use 40 percent less fossil fuels per dollar of GNP than they did 15 years ago. Incremental investments will probably only replace capital already scheduled for retirement.

Consumer

Moderate economic recovery will help consumer electronics growth this year. Growth is expected to accelerate in 1991 to 8.7 percent from 7.1 percent in 1990 and to have a CAGR of 7.2 from 1990 through 1995. However, in the United States, consumer electronics production is expected to remain sluggish with 2.3 percent growth in 1991.

The recent surge in consumer confidence will likely provide a short-lived boost of growth to consumers' expenditures on home electronics gear. But offsetting this surge will be the longer-lived consequences from the decline in household wealth in 1990. West and East Coast U.S. home prices fell last year, and households will probably divert the marginal stream of income to savings—instead of consumer durables—to help rebuild their wealth. Naturally, the items most likely to be put on hold will be the ones whose postponement entails the least amount of sacrifice. Therefore, it would not be surprising to see worldwide video equipment growth decelerate to 6.1 percent in 1991, down from 7.8 percent in 1990.

An improvement in unemployment also will lag behind the recovery of aggregate production, delaying a pickup in household spending and adding to slower consumer growth in 1991.

Military/Civilian Aerospace

Despite the coalition forces' decisive victory in the Gulf war and all the optimism that it generated, military/civilian aerospace electronics growth will be a grim negative 4.5 percent in 1991, down from 0.5 percent in 1990, and have a lackluster 2.6 percent CAGR during the 1990 through 1995 period.

Except for growth in simulation systems, dedicated military computer systems, and space systems production, military electronics production should decline through 1995. Restocking the arms inventory used in the Gulf war will not be strong enough to offset already-agreed-upon cuts in defense expenditures.

Since the Gulf war, there is a new threat of downside risk in this area. The war saw the stellar performance of many of the advanced technological weapons systems developed in the '70s and '80s. Undoubtedly, many foreign military officials and agencies were so impressed that they want to add these systems to their own arsenals in the name of national security. However, such requests are likely to fall on unsympathetic ears in the western world. Western defense agencies will be more cautious about future foreign arms sales in the wake of the Gulf war. This news is anything but welcome to contractors that depend on volume production to amortize fixed costs and generate profit.

The upside risk is that *Glasnost* and *Peristroika* are hardly evolving as (optimistic) visionaries had expected. Indeed, unrest in the USSR will lead neighboring nations in Europe and the Middle East—and nations with strategic interests in these areas—to adequately defend themselves and contain political agitation.

Civil aerospace electronics production is expected to remain strong, keeping pace with replacement of aging jet airliners and upgrades of the worldwide air traffic control system. Production growth is expected to decelerate from 15.3 percent in 1990 to 12.2 percent in 1991 and stabilize at a 12.4 percent CAGR in 1990 through 1995.

Transportation

The transportation segment will continue to feel the effects of the recession this year. Electronics production growth will decelerate from 8.9 percent growth in 1990 to 7.5 percent growth in 1991 and stabilize to an 11.1 percent CAGR in the 1990-to-1995 period. U.S. auto manufacturers have been hit the hardest. The fall in U.S. household wealth last year will induce consumers to divert an increasing share of their incomes from spending to savings in an effort to rebuild wealth. One of the easiest expenditures to postpone is the purchase of a new car, certainly the most significant "capital-like" purchase for most consumers. The recent boost in consumer confidence has yet to significantly stimulate new car sales, and it is not likely to do so this year.

Through 1995, vehicle and body control systems and safety and convenience systems will drive trend growth because of relatively quick adoption. Driver information and power train systems will tend to lag behind average growth as their adoption is viewed as less critical.

THE REGIONS

North America

North American electronic production is expected to grow 1.8 percent in 1991, to $232.6 billion from $228.4 billion in 1990. Growth

in 1990 was 3.6 percent. The CAGR from 1990 through 1995 is expected to be 5.3 percent. Systems production growth will be constrained by economy-wide sluggishness in business fixed investment spending. As the reins of investment spending are loosened in 1992, systems production is expected to follow suit.

In addition to workstations, as discussed previously, laser printers and X terminals will be responsible for driving data processing growth. Production of input/output equipment is expected to be 11.2 percent in 1991, accelerating to 13.1 percent in 1992. Even quicker growth is expected in terminals production with the market's acceptance of X terminals, with 1991 growth forecast at 13.1 percent and 1992 growth at 16.4 percent.

In the communications arena, data communications equipment is expected to grow 13.2 percent in 1991 and 13.5 percent in 1992, and call processing equipment is expected to grow 18.2 percent in 1991 and 15.9 percent in 1992.

Japan

Expressed in dollars, the value of Japan electronic equipment production is expected to accelerate from 2.6 percent growth in 1990, to 13.5 percent in 1991. An abrupt depreciation of the dollar against the yen casts a veil over the true picture, however: In 1990, the yen-per-dollar exchange rate was 144; in the first quarter of 1991, the dollar depreciated 6.9 percent against the yen, to 134. The latter rate is assumed throughout the 1991-through-1995 period.

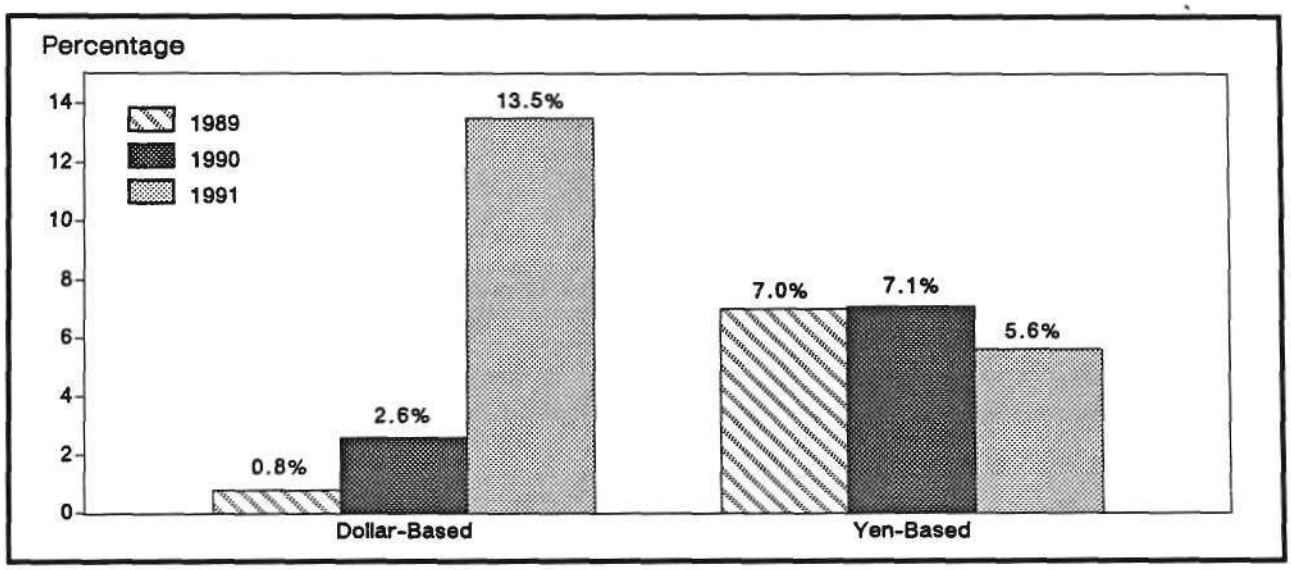
Once this exchange rate veil is removed, *expressed in yen production growth is forecast to decelerate from 7.1 percent in 1990 to 5.6 percent in 1991.* The yen-to-dollar-based growth difference is shown in Figure 4.

Except in the data processing area and some incidental growth in the military/civilian aerospace sectors, slower growth in the U.S. economy (Japan's chief electronics export market) will translate into slower but positive growth in Japan's electronics industry in 1991.

Europe

European electronics production growth is actually expected to accelerate from 7.1 percent in 1990 to 8.9 percent in 1991. Because of foreign investment, expansion is concentrated in computers, accelerating from 7.3 percent growth in 1990 to 19.1 percent in 1991; in data storage systems, accelerating from 12.4 percent growth in 1990 to 22.4 percent in 1991; and in terminals, accelerating from 1.4 percent growth in 1990 to 9.2 percent in 1991.

FIGURE 4
Japan Electronics Growth
(Factory Revenue, Annual Growth)



Source: Dataquest (July 1991)

Asia/Pacific-ROW

The infusion of foreign-owned manufacturing capacity will help spur data processing growth from 9.6 percent in 1990 to 16.7 percent in 1991. However, Asia/Pacific is also likely experience a relatively broad-based slowdown in growth until the U.S. economy resumes expansion. This is especially true in the consumer sector, where growth is forecast to slow from 16.2 percent in 1990 to 8.0 percent in 1991.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Overall economic expansion should help stimulate electronics production in 1991 and beyond. The recovery, however, is likely to be relatively moderate with respect to previous expansions. So the lack of a distinct boom is also likely to contain the acceleration of systems production growth.

Segments such as data processing and communications, where productivity gains are still above average and budget constraints are less binding, will be less affected than segments such as military aerospace or transportation. But the distinct lack of a boom will be felt throughout the industry.

Dataquest recommends that its clients do not become unduly concerned with the moderate expansion. In fact, moderate growth could well be a blessing to manufacturers: Business expansions that start with a boom typically overshoot sustainable growth and inevitably lead to a slowdown in growth (or at worst, a full-blown contraction) to purge imbalances from the market. Not having to worry about the uncertainty eminating excessively variable growth will permit manufacturers to concentrate on the fundamentals of their business strategies.

Terrance A. Birkholz

Dataquest
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Research *Bulletin*

SAMONITOR: SYSTEMS MARKETS AT (OR NEAR) CYCLICAL TROUGH

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 BUSINESS CLIMATE

Dataquest believes that the worst of the recession is now over and that the coming months will reveal less severe declines—and probably improvement—in important economic indicators. For example, in the United States:

- Industrial production was up 0.5 percent in May, the second consecutive monthly increase.
- Capacity utilization was up 0.2 percentage points to 78.7 percent in May.
- Nonfarm employment was up 58,000, the first increase in 11 months.
- Housing starts were up 0.1 percent in May.
- Retail sales were up 1.0 percent in May.
- Consumer borrowing was up 2.8 percent in April.

Also, the index of the National Association of Purchasing Managers rose for the third month in a row in May—its highest level since August 1990. Much of the strength in the index came from a rise in new orders, which ended 10 months in a row of readings suggesting declining orders.

The dynamics of the incipient recovery will likely resemble that of previous upturns: The financial markets will lead, followed by consumer-durable goods such as homes, automobiles, and appliances. The materials market will then revive, and components for machinery will see increases in orders. When production capacity levels rise to meet demand in these markets, capital equipment purchases will grow, completing the business cycle recovery.

In contrast to previous expansions, the early indications are that the recovery will be relatively slow and mild.

EQUIPMENT MARKETS

According to Dataquest's June survey of major OEM semiconductor procurement managers, expectations of short-term production remain positive. Overall six-month systems sales are expected to grow 7.6 percent, up from 6.5 percent in May. Data processing OEMs' expected six-month growth moderated to 8.3 percent compared with 10.0 percent in May.

Computer and office equipment orders growth for the three months ended in April was 4.8 percent *below* year-earlier orders compared with 0.1 percent growth in March (see Figure 1). April orders growth registered the greatest decline since growth turned negative in December. Inventories are at 8.4 weeks in April, down 0.7 weeks from April 1990 levels—a good sign that marginal orders are being filled from inventory, not incremental production.

Don't expect the PC business' competitive landscape to become any less rocky, even as overall business conditions begin to improve. Table 1 highlights Dataquest's expectations of some key segments of the PC market and the associated main memory DRAM consumption. The 80386SX system sales will take a big chunk out of 80286 system sales, particularly as these systems are loaded up with lots of memory to run the latest applications.

Communications equipment orders growth for the three months that ended in April was 0.9 percent above year-earlier orders compared with

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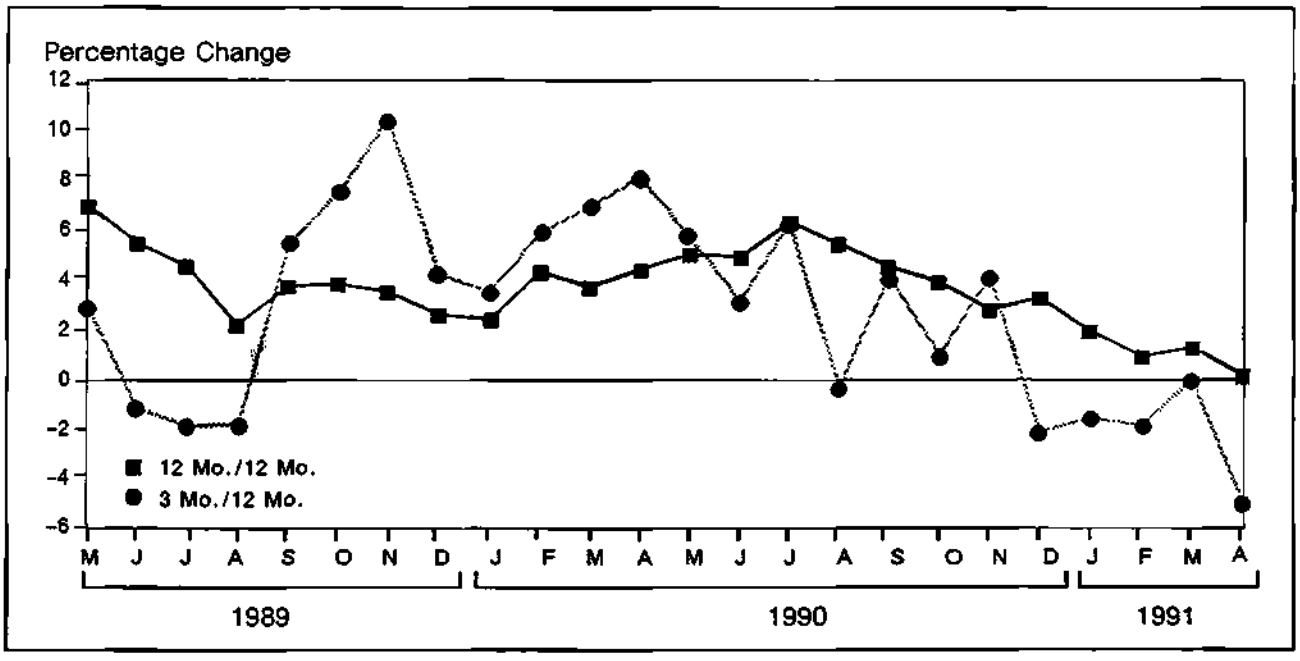
FIGURE 1
U.S. Computers and Office Equipment
Orders Growth (1989-1991)



Source: U.S. Department of Commerce

0.2 percent growth in March. Inventories are at 6.4 weeks in April, down 0.2 weeks from year-earlier levels.

Medical instruments and supplies remains the lone positive component of the instruments and controls aggregate, with orders growth for the three months ending in April up 2.3 percent above year-earlier orders compared with 1.3 percent growth in March.

Shrinking overall capital equipment spending holds back measuring and controlling equipment orders growth to negative 5.7 percent in April versus negative 5.1 percent in March. On the bright side, orders growth has been showing an improving trend—that is, declining by a smaller rate per month—since orders growth hit bottom in September.

TABLE 1
Worldwide PC Shipment and Associated DRAM Forecast by MPU
(Thousands of PCs/Thousands of MBs)

System	1990	1991	1992
80286	7,433/9,663	5,473/9,851	3,466/9,358
80386SX	4,589/6,425	6,763/16,908	8,009/32,036
80386DX	3,552/7,104	4,890/19,560	5,974/41,818

Source: Dataquest (June 1991)

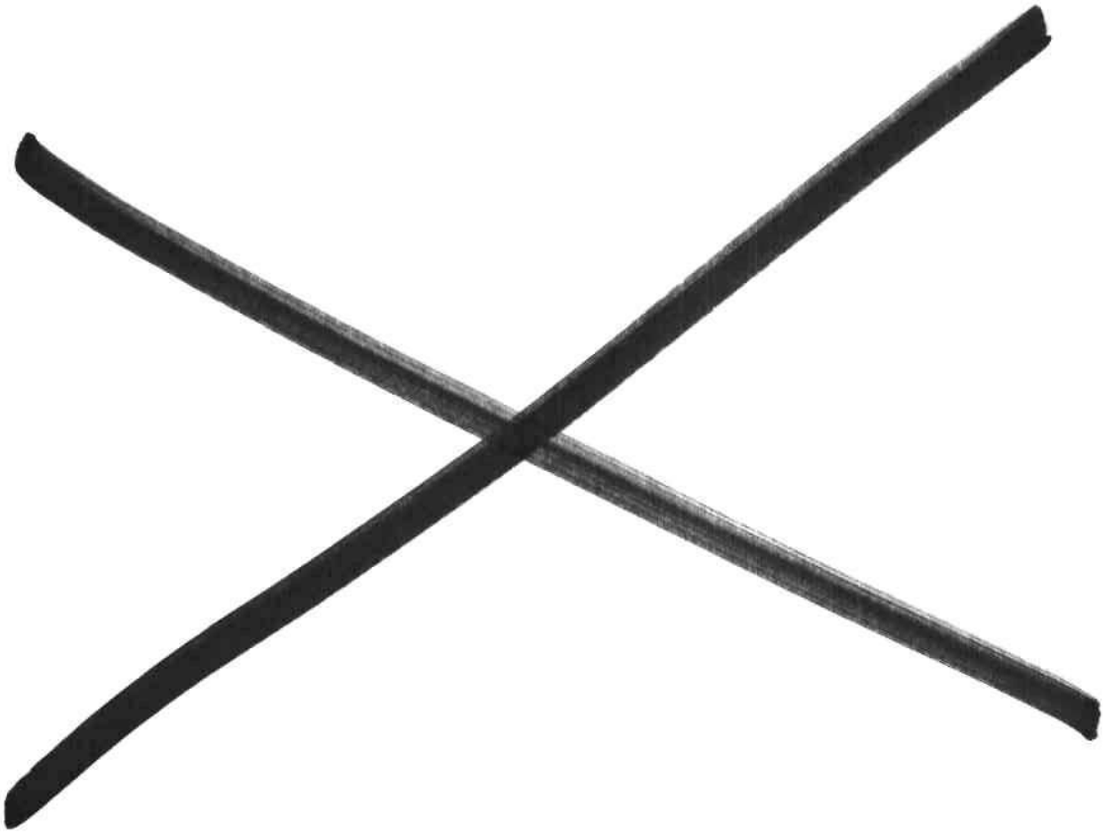
Orders for search and navigation equipment—dominated by defense related expenditures—continued to lose ground in April, declining 11.8 percent from April 1990 levels and compared with negative 8.7 percent in March.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest's corporate parent, The Dun and Bradstreet Corporation, expects real U.S. GNP to resume expansion in the second quarter and accelerate through the first quarter of 1992. Similarly, business spending on capital equipment is expected to begin recovery in the second quarter and gain strength through year-end. As in previous recoveries, capital spending will lag overall spending because producers will want to make sure that an increase in aggregate demand is not a false start before adding productive capacity.

Indeed, April's orders data generally bear out this dynamic. The electronics production indicators suggest that the systems market have reached bottom. The best advice for now—look ahead and plan for the future recovery.

Terrance A. Birkholz



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Research *Bulletin*

OEM MONTHLY: LAN MARKET FORECAST AND TRENDS

INTRODUCTION

PCs connected to local area networks (LANs) are forecast to grow from 32.1 percent of total PCs in 1990 to 56.8 percent in 1995. This rapid growth in the PC connectivity arena presents potential to LAN suppliers to increase their market shipments. However, LAN users do have a number of access methods to choose from (see SAM newsletter 1991-09 entitled "The LAN Rubik's Cube"), creating stiff competition over the next few years between the existing access methods and the suppliers of these access methods (see Tables 1 and 2).

MARKET OVERVIEW

Ethernet

The Ethernet market (IEEE 802.3) is forecast to see a steady 18.8 percent unit growth rate from 1991 to 1995, with Ethernet continuing to gain a large part of the LAN market. Some of the continued growth can be attributed to the development of 10BASE-T, which uses unshielded twisted-pair wire, making Ethernet less expensive to install, thus creating more demand for this access method. The top five Ethernet network interface card (NIC)

TABLE 1
U.S. Local Area Network Forecast Shipments*
(Thousands)

	1989	1990	1991	1992	1993	1994	1995	CAGR (%) 1991-1995
Ethernet	1,202.0	1,846.0	2,751.0	3,741.0	4,527.0	5,070.0	5,476.0	18.8
Token-Ring	764.0	832.0	1,181.0	1,666.0	2,115.0	2,433.0	2,676.0	22.7
FDDI	NA	4.1	17.9	91.5	361.6	847.0	1,489.0	202.0
Others	545.0	538.0	581.0	592.0	593.0	557.0	507.0	-3.3

*This forecast represents all LAN connections, whether they are implemented through an NIC or embedded directly on the motherboard.
NA = Not available
Source: Dataquest (July 1991)

TABLE 2
U.S. Local Area Network Forecast—
Average End-User Price* (Dollars)

	1989	1990	1991	1992	1993	1994	1995
Ethernet	348	279	251	231	217	206	196
Token-Ring	627	621	497	422	380	361	343
FDDI	NA	7,500	7,300	4,200	2,800	1,800	1,200
Others	185	172	153	142	132	124	118

*This forecast represents all LAN connections, whether they are implemented through an NIC or embedded directly on the motherboard.
Source: Dataquest (July 1991)

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suppliers for 1990 in descending order of shipments are 3Com, Western Digital, Anthem Electronics, Racal InterLan, and DEC.

The workstation environment has adopted Ethernet as the LAN of choice, and a majority of the companies are embedding Ethernet directly on the motherboard. Some workstation companies offer Token-Ring as an option, but in most cases, Ethernet is included as a standard feature. The 10BASE-T development, along with the endorsement from the workstation market, has given the Ethernet access method a stronghold in the LAN market.

Token-Ring

The compound annual growth rate (CAGR) for the Token-Ring (IEEE 802.5) access method in units is forecast at 22.7 percent from 1991 to 1995. This growth rate is slightly faster than Ethernet but does not give Token-Ring enough momentum to catch up to Ethernet. The top five suppliers in the Token-Ring NIC market for 1990, in descending order of shipments, are IBM, Proteon, 3Com, NCR, and Racore Computer.

Currently, the Token-Ring solution is more expensive than the Ethernet solution, but as volumes increase, costs should become more competitive. However, Token-Ring claims inherent intelligent architecture that is automatically included in the solution and may be reflected in the price. Continued growth for Token-Ring is forecast, as IBM in particular continues to support this standard.

FDDI

Fiber-distributed data interface (FDDI) is the high-speed LAN solution supporting up to 100-Mbps transmission rate (ANSI X3T9.5). Traffic on existing networks increases as transferring of large files incorporating sophisticated graphics occurs, creating a need for a high-speed LAN solution such as FDDI. Dataquest forecasts the FDDI compound unit growth rate to be 202 percent from 1991 to 1995 to meet these growing needs. The early applications of FDDI are its use as a backbone, interconnecting existing Ethernet and Token-Ring networks. FDDI can also be implemented to accomplish tasks currently being done on Ethernet or Token-Ring, but complete these tasks in much less time. However, there are many applications that have not been possible on the existing slower-speed LANs that will come to market as FDDI gains acceptance and the prices begin to decline. Dataquest believes that FDDI is poised for growth and market acceptance as continued life cycle price declines occur.

AppleTalk, ArcNet, and Proprietary

The "Others" category will begin to decline as potential LAN users focus on widely accepted, open architecture networking solutions. However, a continued market for these networking solutions will be companies that already have an installed base of AppleTalk, ArcNet, or proprietary solutions and want to add additional users without having to convert to a new network.

DATAQUEST CONCLUSIONS

Ethernet and Token-Ring have become the LAN solutions of choice, with FDDI coming in as the high-performance LAN. As PC connectivity increases, the LAN market vendors are presented with the potential to grow their market share. However, Dataquest believes that over the next few years, stiff competition will exist between these access methods and the companies within each of these LAN solutions as this potential is realized.

As can be seen from the forecast, Ethernet and Token-Ring are growing at a similar rate, but Ethernet is forecast to remain the market leader for the next few years. FDDI is forecast to ramp up quickly as the need for higher transmission rates increase and the price of the solution continues to decline.

Anna L. Cahill

Dataquest
a company of The Dun & Bradstreet Corporation

Research Newsletter

SAMONITOR: TODAY'S PC INDUSTRY—A VICTIM OF CIRCUMSTANCES

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 BUSINESS CLIMATE

Even the most cynical economic forecasters now believe that the U.S. economy has begun to recover. Indeed, the U.S. Department of Commerce's estimate of real GNP growth in the second quarter was 0.4 percent. GNP shrank 2.8 percent in the first quarter and 1.6 percent in the fourth quarter of 1990.

Most economists dolefully expect the expansion to be moderately paced compared with previous recoveries. (Typically, the economy has grown 4 to 6 percent in the first two years of recovery.) However, a recovery that is moderate by historical standards is appropriate and solid by today's standards, given the dynamics of the recession and the economy's low underlying or potential long-term trend growth.

To place the recent recession and nascent recovery into proper perspective, it is important to remember two points:

- *Shallow recessions are followed by weak recoveries.* Real GNP has declined only 1.1 percent through the second quarter. By comparison, real GNP declined an average of 2.3 percent in the eight previous postwar recessions.
- *Today's growth potential is much lower than it was earlier in the post-WWII period:* 2.2 percent versus about 4 percent, respectively. This situation exists because productivity growth has slowed significantly in the last 20 years, as has labor force growth.

The implication is that a 1.1 percent decline in real GNP would have left the economy 5.1 percent below trend during the '50s and '60s, but only 3.3 percent below trend given today's sluggish potential. The upshot is that because the uphill climb in the expected recovery will be much shorter than was historically typical, the rate of ascent is appropriately less steep. If full recovery takes three years, then average growth of 3.3 percent per year (2.2 percent trend plus 1.1 percent catch-up) would be about right. Growth greater than this would risk reigniting the fires of inflation.

EQUIPMENT MARKETS

Dataquest's July survey of major OEM semiconductor procurement managers indicates expectations of short-term production. Overall six-month systems sales are expected to grow 9.0 percent, down slightly from 9.8 percent in June. Data processing OEMs' expected six-month growth is up a bit to 10.0 percent, compared with 9.2 percent in June. Six-month growth expectations ranged from 20 percent growth in computers to zero in automotive electronics.

Computers and office equipment orders growth for the three months ended in May was 2.9 percent *below* year-earlier orders, compared with negative 4.9 percent growth in April (see Figure 1). Shipments growth for the same period was 1.9 percent below year-earlier shipments, compared with negative 2.1 percent growth in April. Year-to-date orders and shipments growth are negative 1.3 and negative 2.0 percent, respectively. Inventories are at 8.5 weeks in May, down 0.7 weeks from May 1990 levels, a good sign that marginal orders are being filled from inventory, not incremental production.

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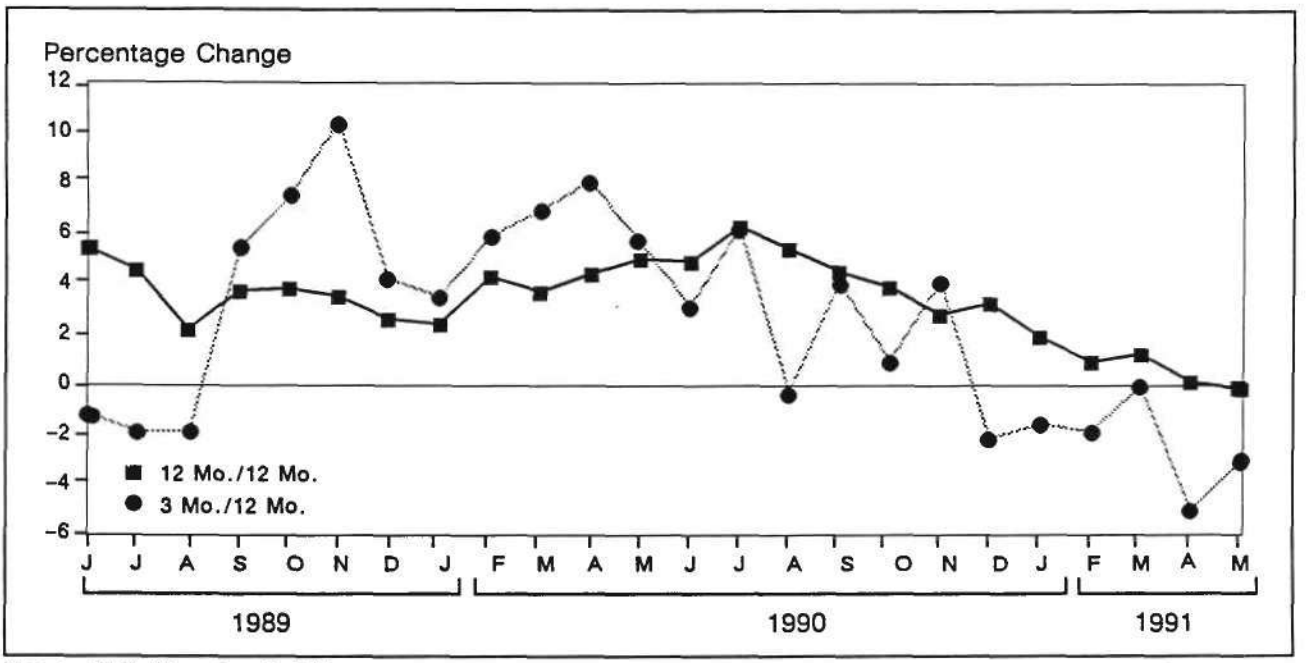
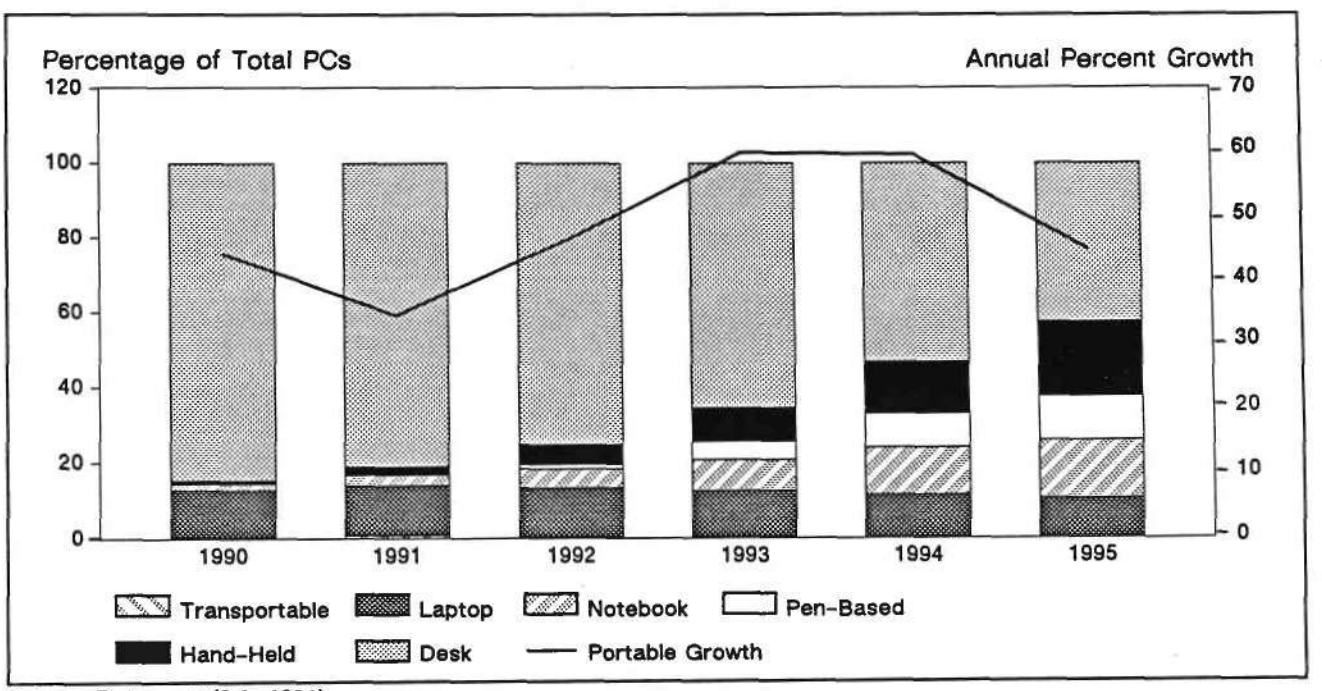
FIGURE 1
U.S. Computers and Office Equipment Orders Growth (1989-1991)



Source: U.S. Department of Commerce

FIGURE 2
PC Market Dynamics Worldwide Units



Source: Dataquest (July 1991)

The U.S. economic recession has hit computer manufacturers especially hard this time for the following reasons:

- *Two-thirds of desktops have computers on them.* After 30 years of innovation and booming sales, there are inevitably fewer opportunities for investment.
- Computers' share of U.S. capital investment more than doubled, from less than 3 percent in 1977 to about 7 percent in the mid-1980s, but has remained unchanged since then..
- Previously, new products—*without close substitutes*—enabled the computer industry to increase its share of capital spending faster than overall investment fell.

The last point is illustrated in Figure 2. Product innovation is alive and well in the PC business: Worldwide unit growth of portable PCs (defined as transportable, laptop, notebook, pen-based, and hand-held computers) is expected to be a respectable 34.6 percent in 1991. However, portables also are expected to account for only 18.9 percent of total PCs shipped in 1991. Furthermore, notebook, pen-based, and hand-held units, the fastest-growing portion of the portable market, account for only 4.9 percent of total PCs in 1991. By 1995, these three package types are expected to account for 47.1 percent of all PCs shipped.

The point is that chance circumstance made the timing of the introduction of these portable systems coincide with the economy's downturn, and thus their unit volumes are insufficient for their superlative growth to offset the decline in overall capital spending.

Communications equipment orders growth for the three months ended in May was 5 percent below year-earlier orders, compared with 1 percent growth in April. Inventories were at 6.6 weeks in May, down 0.4 weeks from year-earlier levels.

Orders growth for the three months ended in May was 21.3 percent below year-earlier orders for search and navigation equipment, versus negative 11.7 percent in April; 7.4 percent below year-earlier orders for measuring and controlling devices, versus negative 5.6 percent in April; and 6.6 percent above year-earlier orders for medical instruments, versus 2.4 percent in April.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

With emerging PC products in the high-growth/low-volume introductory phase of their life cycles, combined with relative market saturation by more mature technologies, systems manufacturers have had to cut prices to gain market share. Even as business' overall capital equipment spending resumes expansion during the remainder of 1991, systems manufacturers and their chip suppliers will be faced with a tough row to hoe. Only those chip manufacturers that have the right chip at the right place and at the right time and are the *most price competitive* are going to share in what little hard-to-get growth remains through the rest of 1991.

Terrance A. Birkholz

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Research *Bulletin*

SAMONITOR: 1991—THE YEAR TO WRITE OFF

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 BUSINESS CLIMATE

Signs of an economic recovery continue to mount, but the signals are mixed, as follows:

- U.S. real GNP growth in the second quarter was estimated to be a 0.4 percent seasonally adjusted annualized rate (preliminary).
- U.S. personal income and personal spending were both up 0.5 percent in June.
- The Conference Board's consumer confidence index remained essentially unchanged from June to July, reflecting households' persistent pessimism.
- The DOC's index of leading economic indicators climbed 0.5 percent in June, the fifth consecutive monthly increase, but factory orders fell by 1.4 percent across the board in June after a two-month run of greater than 2 percent increases.
- The National Association of Purchasing Management's index rose to 51.8 percent in July from 50.9 percent in June, the sixth increase in a row. (A reading over 50 percent generally indicates growth.) Much of the increase stemmed from production, a sign that the recovery in manufacturing is taking hold, and employment increases may soon follow.
- The U.S. unemployment rate fell to 6.8 percent in July from 7.0 percent in June.
- New-car sales were down 8.2 percent in July and down 9.4 percent in early August from year-earlier levels.
- Retail sales were up 0.5 percent in July, the third consecutive monthly gain.
- Housing starts rose 3.7 percent in July.
- Industrial production rose 0.5 percent in July, as industrial capacity utilization rose 0.2 percentage points to 79.7 percent.

The Dun and Bradstreet Corporation expects zero growth in U.S. real GNP in 1991, with positive growth in the second half offsetting the negative 1.7 percent average growth in the first half.

This is small consolation for electronics manufacturers, however, because real business fixed investment in capital equipment—of which computers represent 7 percent—is expected to lag overall economic growth. After falling a seasonally adjusted annualized rate of 18.4 and 1.6 percent in the first and second quarters, respectively, real business equipment investment is expected to grow 4.3 and 3.7 percent in the third and fourth quarters, respectively. For 1991 overall, real business equipment investment is expected to decline 2.5 percent from the 1990 level.

EQUIPMENT MARKETS

According to Dataquest's August survey of major OEM semiconductor procurement managers, expectations of short-term production remain relatively optimistic: Overall six-month systems sales are expected to grow 9.8 percent, up slightly from 9.0 percent in July. Data processing OEMs' expected six-month growth is down to 8.7 percent compared with 10.0 percent in July. Six-month growth expectations ranged from 4 to 20 percent growth.

Computers and office equipment orders growth for the three months ended in June was 0.1 percent *above* year-earlier orders compared with negative 2.9 percent growth in May (see Figure 1). Shipments growth for the same period was 1.6 percent below year-earlier shipments compared with negative 1.9 percent growth in May. This provides a good news-bad news situation: July was the second month of improvement in orders

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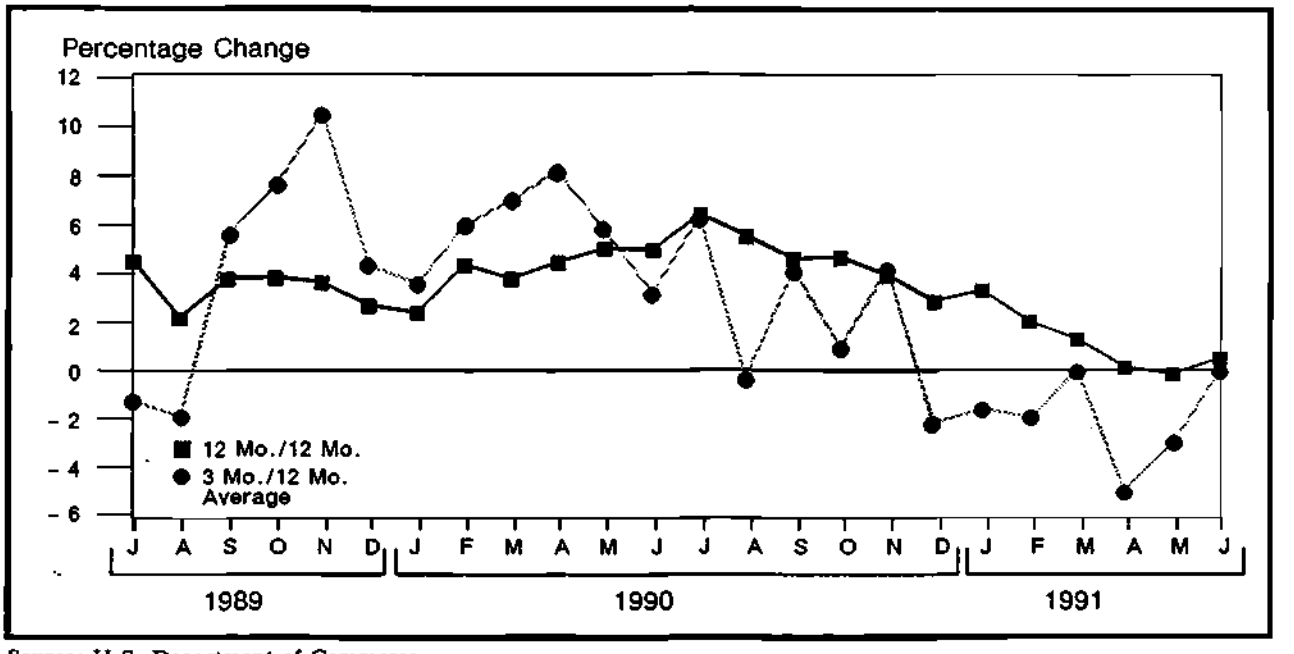
FIGURE 1
U.S. Computers and Office Equipment



Source: U.S. Department of Commerce

growth—granted, the rate is still negative, but it has become less negative in the last two months. Unfortunately, July was also the sixth consecutive month of negative shipments growth. June year-to-date orders and shipments growth are 0.1 and negative 2.0 percent, respectively. Inventories were at 7.5 weeks in June, down 0.9 weeks from June 1990 levels (see Figure 2).

Communications equipment orders growth for the three months ended in June was 10.3 percent below year-earlier orders compared with 5.0 percent decline in May. Inventories are at 6.0 weeks in June, down 0.4 weeks from year-earlier levels.

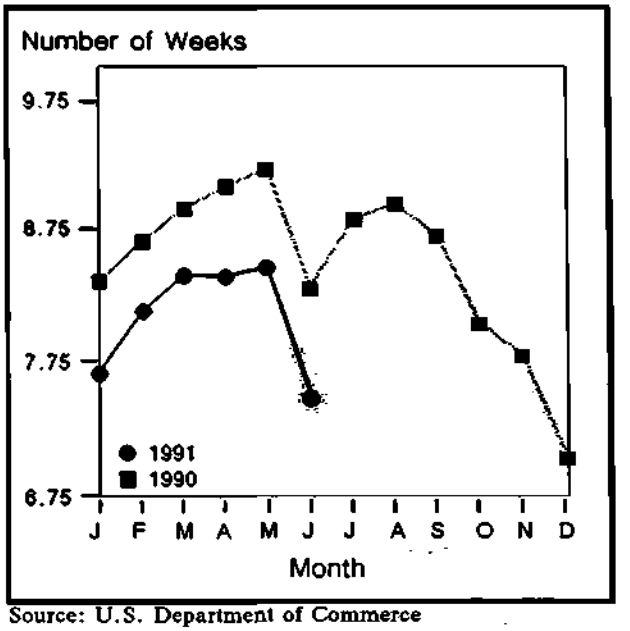
Orders growth for the three months ended in June was 10.6 percent below year-earlier orders for search and navigation equipment versus negative 21.7 percent in May, 5.0 percent below year-earlier orders for measuring and controlling devices versus negative 6.8 percent in May, and 3.7 percent above year-earlier orders for medical instruments versus 6.6 percent in May.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

While the signals portending an overall economic recovery, although mixed, continue to mount, the signals of recovery in the capital investment community remain a faint glimmer. Recovery in equipment investment—meaning spending on data processing equipment and, therefore, also semiconductors—will lag the overall expansion for the remainder of 1991. As for the pace of the electronics business recovery, Dataquest further expects growth to be relatively moderate compared with previous recoveries. The likelihood of a return to the hardware-buying binge days of the last decade is nowhere to be seen.

Terrance A. Birkholz

FIGURE 2
U.S. Computers and Office Equipment
Inventory-to-Shipments Ratio (Weeks)



Source: U.S. Department of Commerce

Semiconductor Application Markets Newsletters 1990

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1990 SAM Newsletter Index

The enclosed SAM *Newsletter Index* is a quick reference guide to the 1990 SAM newsletters. The newsletters' month and year follow each title listing in the index. Please refer to the quarter tab to locate a specific newsletter. This index is updated quarterly.

SEMICONDUCTOR USER AND APPLICATIONS CONFERENCE—1990

Dataquest's Semiconductor User and Applications Conference was held in San Francisco, California, on February 12 and 13, 1990. Eleven of the top 15 North American users (those that purchased more than $7 billion worth of semiconductors in 1989) were represented, along with delegates from 13 of the top 15 worldwide semiconductor suppliers.

- 1990 Semiconductor User Survey Focus Changes from Availability to Supplier Performance (1990-7) Mar. 1990
- True or False: User-Supplier Relationships to Change in the 1990s? (1990-8) Mar. 1990

STRATEGIC AND TECHNICAL TRENDS

OEM Monthly

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

- Cache Memory Balances System Performance and Cost (1990-1) Jan. 1990
- Peace Dividend—Western Chips in Soviet PCs (1990-3) Feb. 1990
- Chip Sets Make Telecom Multiplexing Easy (1990-9) Mar. 1990
- Snags Snarl ISDN, Dataquest Forecast Bleak (1990-13) Apr. 1990
- Technology's Path from the Lab to the Living Room (1990-15) May 1990
- Flat-Panel Color Displays: Light, Bright, and in Sight (1990-21) Jun. 1990

Additional Strategic And Technical Trends

- The US Consumer Cellular Scenario (1990-17) May 1990
- Risk and Opportunity in Eastern Europe: The View From Finland (1990-20) May 1990

SYSTEM SEMICONDUCTOR CONTENT TRENDS

Dataquest has a good knowledge of the semiconductor content of various types of electronic equipment, based on tearing down actual pieces of equipment on an ongoing basis, examining block diagrams in technical product literature, and conversing with knowledgeable industry sources (including members of our own staff, who have many years of industry experience). This

procedure allows us to accurately predict changes in semiconductor consumption based on changes in electronic equipment production.

- Smart Drive Electronics: If You've Seen One . . . (1990-4) Feb. 1990
- Rigid Drives Learn Self-Control (1990-10) Mar. 1990
- GSM In Europe—Cellular Turns Digital (1990-16) May 1990
- Portable PCs: What Comes in Small Packages? (1990-19) May 1990

TACTICAL AND ECONOMIC TRENDS

SAMonitor

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.

- Chip Industry Recovery on Schedule (1990-2) Jan. 1990
- Modest Recovery Stays on Track (1990-6) Feb. 1990
- Computer Orders and Shipments Improve . . . *Modestly* (1990-11) Mar. 1990
- "He Who Hesitates, Loses" (1990-14) Apr. 1990
- Systems Outlook Remains Upbeat (1990-18) May 1990
- All Systems Are "Go" (1990-22) Jun. 1990

Additional Tactical and Economic Trends

- First Quarter Electronics Equipment Update: Industry Catches Its Breath for the Long Haul (1990-12) Apr. 1990

OTHER NEWSLETTERS

Dataquest's Central Research Group publishes economic forecasts and analyses of major industry events. A copy of each newsletter is provided to every client of a Components Group (CG) service. If you subscribe to more than one Dataquest service, you may have decided to put your copy of these newsletters in a binder other than this one.

- Preliminary 1989 Worldwide Semiconductor Market Share Estimates: NEC and Toshiba Neck and Neck (CD 1990-1, Jan. 1990)
- DRAM! Foiled Again! U.S. Memories Nixed (CD 1990-2, Jan. 1990)
- First Quarter 1990 Worldwide Semiconductor Industry Outlook: Stabilization Is Around the Corner (CD 1990-3, Feb. 1990)
- A Preview of the 1990s (Corporate Research Newsletters)
- Recent Trends in Start-Up Activity (CD 1990-4, Apr. 1990)
- A New Decade—Where Does Opportunity Lie? (Corporate Research Newsletters, 1990)

- Worldwide Semiconductor Industry Outlook, Second Quarter 1990: Out of the Trough (CG 1990-5, Apr. 1990)
- Economic Outlook: In Like a Lamb, Out Like a Lion (CRG Newsletters, 1990)
- Capital Equipment Spending: Some 1990 Recession Protection (Corporate Research Newsletters, 1990)
- Final 1989 Worldwide Semiconductor Market Shares (CG 1990-6, May 1990)
- Semiconductor Consumption Trends in Worldwide Application Markets (CG 1990-7, Jun. 1990)
- Dataquest's 1989 Electronics Industry Market Shares (Central Research Newsletters, Jun. 1990)
- Second Quarter 1990 Worldwide Semiconductor Industry Outlook: The Corner Is Turned amid Mixed Signals (CG 1990-8, June 1990)

January-March

The following is a list of newsletters in this section:

- **OEM Monthly: January 1990 Cache Memory Balances System Performance and Cost** (1990-1)—*OEM Monthly* provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions. Technology absorption is a major challenge facing semiconductor users today. Dataquest recommends that semiconductor suppliers understand all of the relationships between their components and their customers' systems to provide total solutions that might include specialty memories, advanced packaging, and on-chip cache.
- **SAMonitor: Chip Industry Recovery on Schedule** (1990-2)—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. Dataquest believes that the North American semiconductor market is on schedule for a peak in growth in the second quarter of 1990.
- **OEM Monthly: February 1990 Peace Dividend—Western Chips in Soviet PCs** (1990-3)—Last year, the United States (via COCOM) relaxed its rules regarding the sale of certain products to non-COCOM members. The Soviet goal of installing 28 million PCs during the 1990s means a chip usage of $5.2 billion (the average semiconductor content of a 286-based PC is $185). Dataquest recommends that semiconductor suppliers that want to participate in this market should sell their existing chips to the Soviet Union through distributors and to PC manufacturers in the West.
- **Smart Drive Electronics: If You've Seen One . . .** (1990-4)—When it comes to embedded controller design, rigid disk drive manufacturers face a tough challenge: they must differentiate their product without sacrificing profit margins. This newsletter provides a detailed look at the semiconductor content of several recently announced 3.5-inch rigid disk drives. The models examined here were selected not only as representative of current embedded control implementations, but also as illustrative of the ongoing trends that face controller designers today.
- **SAMonitor: Modest Recovery Stays on Track** (1990-6)*—Dataquest believes that the North American semiconductor market will continue to recover, albeit at a modest pace. We maintain that as the market expands this year, chip manufacturers can be expected to fight tooth and nail for every bit of market share. Manufacturers that view the world digitally—that is, feast or famine—are most likely to conclude that we are in the midst of a famine.
- **1990 Semiconductor User Survey Focus Changes from Availability to Supplier Performance** (1990-7)—Results of the Fifth Annual Dataquest Semiconductor User Survey were presented at Dataquest's User and Applications Group Conference held in San Francisco, California, on February 12 and 13. This newsletter summarizes the presentation and highlights the key findings of this survey. Dataquest believes that the overall change of theme from availability issues to supplier performance underlines the efforts to reduce overall costs from every angle.

*The number 5 (e.g., 1990-5) has been omitted

- **True or False: User/Supplier Relationships to Change in the 1990s?** (1990-8)—Is *strategic partnering* the solution to reducing the wild swings that have occurred in the semiconductor industry during the past 25 years? Buyers and sellers had a chance to find out at Dataquest's annual conference for semiconductor users and suppliers, held again this year in San Francisco, California. This newsletter summarizes the conference by discussing the changes affecting the semiconductor industry today, ways in which Dataquest clients can seize opportunities while hedging the downside, industry forecasts for the 1990s, and Dataquest's second annual "Semiconductor Supplier of the Year" award.
- **OEM Monthly: March 1990 Chip Sets Make Telecom Multiplexing Easy** (1990-9)—The installed base of T-1, T-3, and fractional T-1 lines in the United States is increasing steadily, and an estimated $190 million worth of semiconductors will be consumed worldwide in 1990 in the electronics used for these multiplexing circuits. Dataquest concludes that telecom chip sets represent the fusion of an emerging need (i.e., digital multiplexing) with an evolving technology (i.e., cell-based ASSPs). We recommend that semiconductor suppliers that want to take advantage of this opportunity acquire telecom system expertise by either hiring telecom engineers or partnering with system suppliers.
- **System Semiconductor Content Trends: Rigid Drives Learn Self-Control** (1990-10)—The rigid disk drive (RDD) controller market offers high-volume opportunities for low-cost manufacturers of precision analog and mixed-mode ASIC devices and a growing market for memory devices. ASIC, microcontroller, and other digital logic manufacturers, on the other hand, face a less certain market, with opportunities tempered by severe price competition. This newsletter provides a quantitative analysis of the rigid drive market at the component level and examines the critical issues facing semiconductor suppliers seeking to meet the needs of the rigid disk drive market.
- **SAMonitor: Computer Orders and Shipments Improve . . . *Modestly*** (1990-11)—Recent expansion in North American equipment markets portends commensurate growth in semiconductor *unit* shipments. But recent downward price pressure—particularly with respect to DRAM prices—has biased overall expansion in the *value* of the market. Dataquest recommends that equipment and semiconductor manufacturers pay close attention to equipment orders and shipments growth rates and to the *non*memory portion of the semiconductor market in order to formulate an unbiased expectation of business activity for the rest of 1990.

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Research *Bulletin*

SAMONITOR: COMPUTER ORDERS AND SHIPMENTS IMPROVE...*MODESTLY*

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THE EQUIPMENT MARKETS

Computers and Office Equipment

The computer market showed some signs of *modest* improvement in January. Shipments growth for the three-month period that ended in January

Figure 1
Computers and Office Equipment

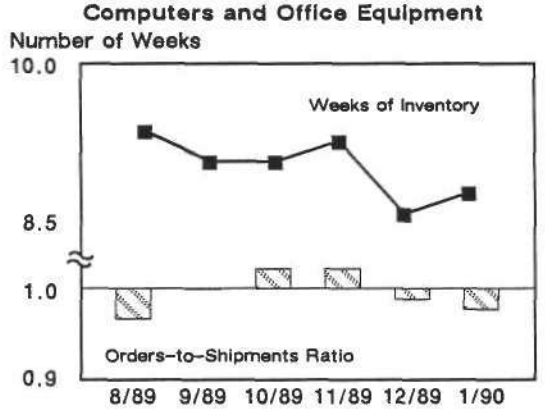

Figure 2
Communications Equipment

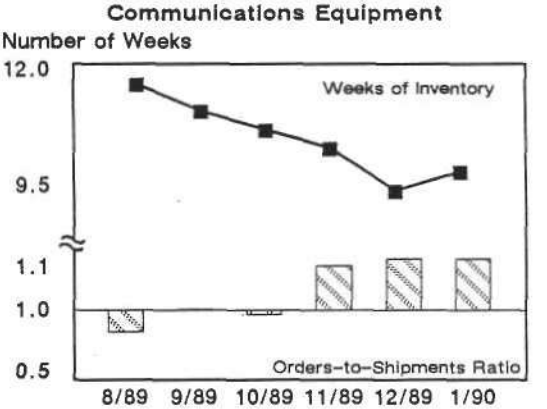

Figure 3
U.S. Instruments

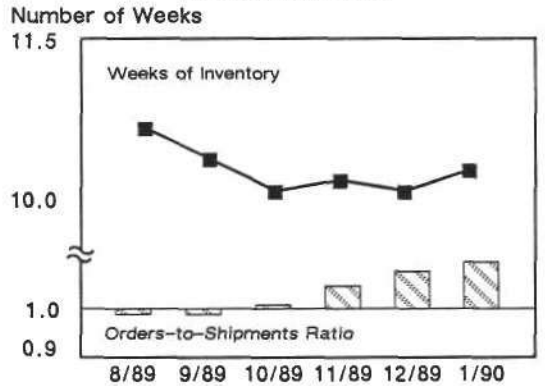

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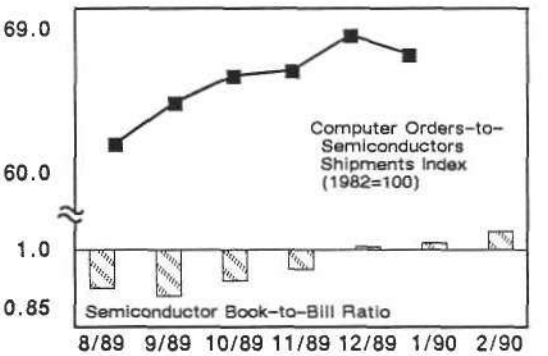
Figure 4
Semiconductors and Computers



Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
March 1990

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were 4.7 percent above year-earlier levels, compared with 1.8 percent in December. *This is good news: It may mean the end of the year-long deceleration in trend growth that shipments experienced during 1989. Furthermore, December shipments growth has been revised upward from a previously reported negative 0.3.* January orders growth was 4.5 percent above year-earlier orders, compared with 4.4 percent in December. The orders-to-shipments ratio (Figure 1) fell slightly from 0.99 in December to 0.98 in January. Although this is the second consecutive month that the ratio has been below parity, such a slight decrease is probably merely a random dip. Inventories edged up slightly to 8.8 weeks in January from 8.6 weeks in December, but they should be no problem as long as levels don't continue to rise in coming months. For the time being, the quickening pace in recent months' orders growth has halted the decline in shipments growth. Dataquest expects shipments growth to continue at a modest pace during the coming months.

Communications Equipment

Communications market business conditions continue to improve. The orders-to-shipments ratio (Figure 2) remained at 1.15 in January. Orders growth for the three-month period ending in January was 17.5 percent above year-earlier levels, compared with 17.2 percent in December. Shipments growth for the same period was 6.4 percent above year-earlier levels, compared with 6.5 percent in December. Inventory levels edged up slightly to 9.8 weeks in January from 9.4 weeks in December, at least partly in response to improved business conditions. With orders growth rates running more than twice the shipments growth rates and a minimal amount of finished goods in manufacturers' inventories, Dataquest expects orders growth to stabilize during the next several months and shipments growth to accelerate, narrowing the growth-rate gap.

Instruments

The instruments market is marked by continued improvement also. The orders-to-shipments ratio (Figure 3) moved up again in January to 1.10 from 1.08 in December. Orders growth for the three-month period ending in January was 10.1 percent above year-earlier levels, compared with 7.7 percent in December. Shipments growth for the same period was 6.7 percent above year-earlier levels, compared with 6.6 in December. Inventories edged up slightly from 10.1 weeks to 10.3 weeks in January. As in the communications market, with orders growth outpacing shipments growth and inventories remaining well managed, we expect shipments growth to pick up in the coming months and orders growth to moderate.

SEMICONDUCTOR DEMAND

The U.S. semiconductor market book-to-bill ratio increased to 1.05 in February from January's 1.03 (see Figure 4). The ratio's increase, however, is a result of the *value* of billings falling *faster* than bookings: U.S. market bookings (three-month moving average) fell 1.0 percent in February to $1,202.2 million, while February average billings fell 4.2 percent to $1,143.4 million. This shrinkage probably is due to the recent decline in DRAM ASPs rather than to changes in unit volume. Indeed, Dataquest's estimate of the weighted average of U.S. semiconductor prices fell 7.2 percent in February, continuing a trend that began last year. The weighted-average price rose 1.8 percent during the first week in March, however, reflecting recent stabilization in DRAM prices. The next few months' book-to-bill ratio could get a boost if prices remain stable, which is likely, and unit volumes continue to increase.

For the three-month period ending in January, average computer orders fell 2.4 percent from December and average semiconductor shipments for the same period declined 4.3 percent. As a result, the computer-orders-to-semiconductor-shipments index, a leading indicator of chip orders and shipments, fell slightly to 67.5 in January from 68.7 in December (see Figure 4). More important, however, is the fact that the index has been rising since March 1989, so February's decrease is probably of minor consequence. Dataquest expects the index to continue on its upward trend during the coming months, in turn indicating continued expansion in the chip market.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Recent expansion in North American equipment markets portends commensurate growth in semiconductor *unit* shipments. But recent downward price pressure—particularly with respect to DRAM prices—has biased overall expansion in the *value* of the market. (In 1989, MOS memories accounted for 34 percent of total North American semiconductor consumption, thus explaining a sizable portion of its total variability.) In light of this, Dataquest recommends that equipment and semiconductor manufacturers pay close attention to equipment orders and shipments growth rates and to the *non*memory portion of the semiconductor market in order to formulate an unbiased expectation of business activity for the rest of 1990.

Terrance Birkholz

Dataquest
a company of The Dun & Bradstreet Corporation

Research *Bulletin*

OEM MONTHLY: MARCH 1990
CHIP SETS MAKE TELECOM MULTIPLEXING EASY

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

THE RECENT GROWTH OF DIGITAL MULTIPLEXING

The installed base of T-1, T-3, and fractional T-1 lines in the United States is increasing steadily (see Table 1). T-1 lines, which were introduced in 1962, carry 24 voice frequency (VF) channels in a digitally multiplexed fashion on a single cable. In the 1970s, T-3 lines were introduced to carry 672 VF channels—the equivalent of 28 T-1 lines—on a single cable. Finally in 1988, fractional T-1 lines were introduced; these lines enable users to access and pay for only the used part of a T-1 line.

Buyers of the telecom equipment used for multiplexed lines include telephone companies, Fortune 2500 firms, and government agencies. Control and cost drive the purchase. Many large organizations, for example, want their own telephone systems and will buy T-1 equipment to link their separate facilities. Also, a company may want a T-1 service even when it doesn't need all 24 channels because the T-1 line often is priced at only six times the price of a VF line.

Table 1
Estimated Installed Base of Multiplexed Lines in the United States

Year	T-1	T-3	Fractional T-1
1988	29,800	700	150
1989	50,000	1,500	300
1990	80,000	2,500	600
1991	115,000	3,600	2,200
1992	150,000	5,000	6,000
1993	185,000	7,000	12,000

Source: Dataquest March 1990

THE OPPORTUNITY FOR MULTIPLEXING CIRCUITS

Channel banks were the equipment traditionally used to multiplex 24 VF channels into a T-1 line. Today, various telecom equipment can be bought with T-1 ports built in. These include PBXs, central office switches, digital cross-connects, digital subscriber loops, LAN bridges, automatic call distributors, and test equipment.

M13 multiplexers are used when 28 T-1 lines must be multiplexed into a T-3 line. In the future, the proposed Synchronous Optical Network (SONet) will be able to carry as many as 32,256 VF channels—the equivalent of 1,344 T-1 lines or 48 T-3 lines—on a pair of optical cables.

An estimated $190 million worth of semiconductors will be consumed worldwide in 1990 in the electronics used for these multiplexing circuits (see Figure 1).

THE TIME IS RIGHT FOR CIRCUIT INTEGRATION

Multiplexing circuits in production today use discrete, logic, and linear components to build the function blocks needed (e.g., framers, elastic stores, data link transceivers, alarms, and signaling extractors). Chip sets to implement these functions on only half a dozen or so ICs are being developed now by such suppliers as AT&T, Crystal, Dallas, Level One, Mitel, Rockwell, Transwitch, Vitesse, and VLSI/PMC. The multiplexing circuits can be reduced in size by 50 percent or more with these chip sets.

Telecom chip sets are application-specific standard products (ASSPs), and the most recently designed parts often use cells. High-density technology now is surpassing the 200,000 usable gates needed on an ASSP to make this approach feasible (120,000 usable gates achieved in 1989 and 300,000 usable gates expected in 1991).

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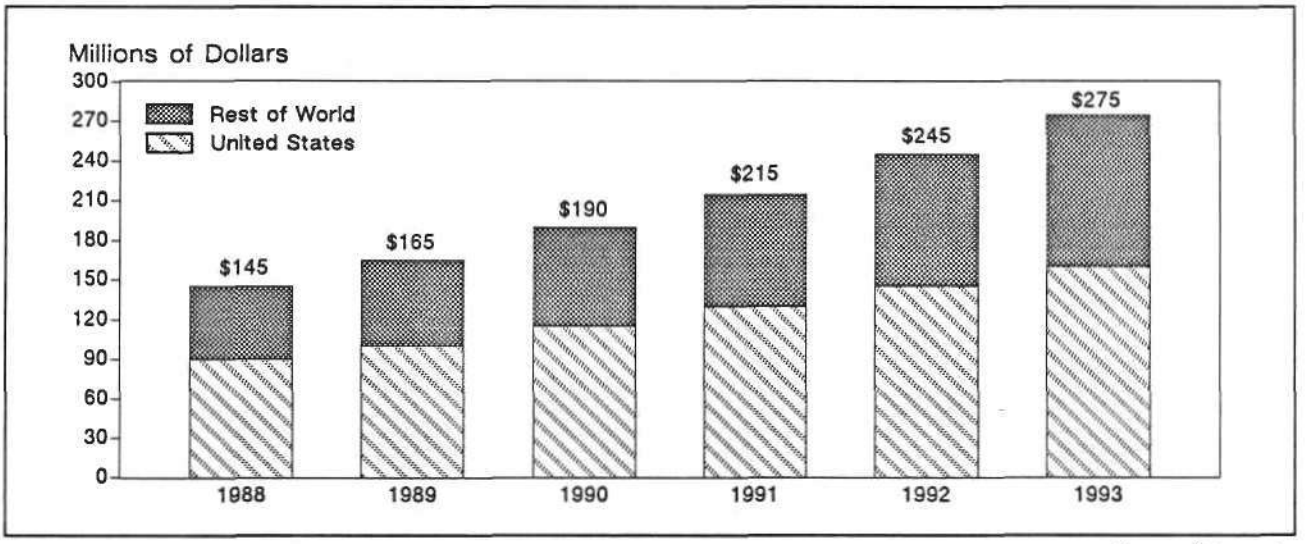
Figure 1
Estimated Semiconductor Use in Multiplexing Circuits (Millions of Dollars)



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Source: Dataquest
March 1990

This ASSP approach allows a substantial reduction in the time required for a new version of an IC when a customer wants something just slightly different from a standard device. With a cell-based design, for example, a supplier could ship new parts within six months after project go-ahead, rather than the three years usually required for a noncelled design.

DATAQUEST CONCLUSIONS AND RECOMMENDATION

Dataquest concludes that telecom chip sets represent the fusion of an emerging need (i.e., digital multiplexing) with an evolving technology (i.e., cell-based ASSPs). We believe that these chip sets also will have a major impact on telecom equipment in the 1990s. With chip sets available to all manufacturers, for example, we expect telecom equipment to become easier and less expensive to design. In turn, this development should allow equipment prices to decline and demand to grow.

[We note, however, that although the telecom scenario looks similar to the impact that chip sets had on PCs in the 1980s, the telecom industry is still regulated by public utility commissions (as in the United States, for example). We expect the "telecom revolution" of the 1990s to proceed at a much slower pace than the "PC revolution" did in the 1980s, as a result of this regulated market condition.]

To take advantage of this telecom opportunity, Dataquest recommends that semiconductor suppliers acquire telecom system expertise. Except for companies that manufacture both telecom semiconductors and systems (e.g., AT&T, Ericsson, Mitel, NEC, Northern Telecom, and Siemens), most "systemless" chip companies will have to acquire this expertise by either hiring telecom engineers or partnering with system suppliers.

We believe that a good model here is the agreement between VLSI Technology and Pacific Microelectronics Centre (PMC). In this relationship, PMC (which is a design center staffed by former telecom engineers) designs the telecom cells and VLSI manufactures the chips.

Roger Steciak

Dataquest
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Research Newsletter

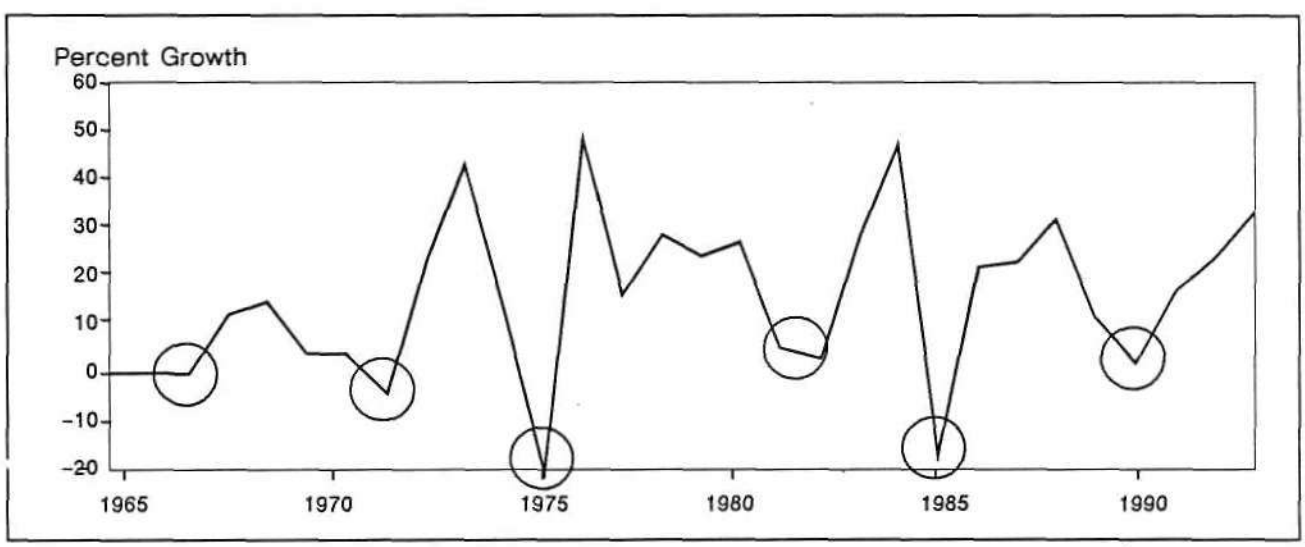
TRUE OR FALSE: USER-SUPPLIER RELATIONSHIPS TO CHANGE IN THE 1990s?

Strategic partnering was proposed in the early 1980s to describe how semiconductor customers and suppliers should conduct business with each other. But when the industry had a severe downturn in 1985, suppliers scrambled after every deal, and prices fell through the floor. When the industry finally had a mild boom in 1988, buyers chased after every available part, DRAM shortages developed, and spot-market lead times and prices went through the roof. Then in 1989, DRAMs became plentiful again and prices fell to record lows.

Is *strategic partnering* the solution to reducing the wild swings (see Figure 1) that have occurred in the semiconductor industry during the past 25 years? Buyers and sellers had a chance to find out at Dataquest's annual conference for semiconductor users and suppliers, held again this year in San Francisco, California. The more than 180 attendees to the two-day February conference included buyers (45 percent), sellers (40 percent), and persons from government agencies, investment firms, and the trade press (15 percent). Eleven of the top 15 North American users (e.g., those that purchased more than $7 billion of semiconductors in 1989) were represented, along with delegates from 13 of the top 15 worldwide semiconductor suppliers.

This newsletter summarizes the conference by discussing the changes affecting the semiconductor

FIGURE 1
Estimated Worldwide Semiconductor Industry Revenue (Would Closer User-Supplier Relationships Reduce the Swings?)



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Source: Dataquest
March 1990

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industry today, ways in which Dataquest clients can seize opportunities while hedging the downside, industry forecasts for the 1990s, and Dataquest's second annual "Semiconductor Supplier of the Year" award.

CHANGES AFFECTING THE INDUSTRY TODAY

The worldwide electronics industry continues to evolve, and developments in microelectronics show no signs of slowing down. Regions and technology are the two major areas of change affecting the industry today.

Regions

A supplier with headquarters located in one world region must deal effectively with customers located in different world regions. "(Having) resident experts in foreign countries is the key to success," explained Linn Nelson, executive vice president and cofounder of Barnel International. "To be global means to act local," echoed Kevin McGarity, senior vice president and manager of worldwide marketing for Texas Instruments' Semiconductor Group.

Distributors will either decline or prosper in the 1990s as the electronics industry becomes more global in scope. It all depends on whether or not distribution channels can adapt to changing needs such as VLSI/ULSI and customer-specific products. "Distribution must skate to where the puck will be," urged Charles Clough, president and chief executive officer of Wyle Laboratories, "if U.S. distributors are to increase the competitiveness of American equipment manufacturers and maximize the marketing efficiency of American semiconductor manufacturers."

What should a U.S. or Asian semiconductor supplier do to be competitive in the European Community? "Learn how to communicate," replied Jean-Pierre Melia, member of the board of Fiat Semelco and purchasing director of its Magneti Marelli France division. True buyer-supplier partnerships are important for risk sharing, forecasting, and long-term commitment, with technical cooperation preserving mutual interest during booms and crises. "The European electronics industry *believes* in 1992, European industry *is* restructuring now, and new opportunities *exist* beyond 1992," predicted London-based Jim Eastlake, senior industry analyst for Dataquest's European Semiconductor Industry Service.

Technology

The high R&D food chain of specification through design is collapsing as semiconductor companies focus on implementing systems with application-specific standard products (ASSPs). "System and semiconductor companies are coming together," stated John Rizzo, vice president of marketing for Momenta Corporation.

During 1989, 1Mb DRAMs went from shortages in the first half, to oversupply and multitier pricing in the third quarter, to production cutbacks and severe price erosion in the fourth quarter. The 4Mb DRAM is expected to have an unusually difficult market introduction in 1990. "The rules for memory ICs have not changed; each cycle is just different," concluded Fred Jones, associate director of Dataquest's Semiconductor Industry Service and manager of the Memory segment.

ASICs are integrated circuits that are dedicated to a single user. One type of ASIC, the MOS gate array, will have an increase in usage of 25 percent between 1984 and 1994. "ASICs allow a shorter time to market for a greater total product revenue," reported Jerry Banks, senior industry analyst for Dataquest's Semiconductor Industry Service. Mixed-mode ASICs, which combine both digital and analog circuits on the same IC, allow a reduction in the number of ICs in the equipment and reduce the problems of interconnection between ICs while optimizing circuit operation. "Users must learn about mixed-signal ASICs and suppliers must learn to specialize in markets and applications for this segment of ASICs to maximize its potential," advised Gary Grandbois, senior industry analyst for Dataquest's Semiconductor Industry Service.

SEIZING OPPORTUNITIES WHILE HEDGING THE DOWNSIDE

Change brings uncertainty, which creates risk. The industry can hedge risk by specializing in a segment of the electronics manufacturing cycle, forming closer user-supplier relationships, and exploring the possibility of a futures market for key electronic components.

Specializing

Greater product complexity and new market and product needs have led to specialized markets and products, which in turn have led to innovations such as fabless semiconductor companies.

Executives now have a greater choice in organizing an enterprise to serve a market, and customers benefit from the better service. "Semiconductor companies in 1990 are based on either technology, specialized products and technology, or design," summarized Michael Canning, vice president of manufacturing for fabless Cirrus Logic.

Relationships

What's in store for the 1990s is the sharing of problems to develop joint solutions users and suppliers need to form partnerships for R&D, applications, design, process, and applications success. "Do what the customer wants when he wants it done," recommended Charles Thompson, senior vice president and director of world marketing for Motorola's Semiconductor Products Sector.

Japanese semiconductor companies assimilate the local culture and business practices when they form a subsidiary in a foreign country because their customers demand it. "U.S. equipment manufacturers want to be treated the same all over the world and at the same time treated as a Japanese equipment manufacturer would be treated in Japan," revealed Robert Brown, senior vice president of semiconductor operations for Toshiba America Electronic Components. "Global service issues include early access to new technology, technical assistance, logistic support, local manufacturing, flexibility, and quality products."

The automotive industry is sometimes cited as a role model for the electronics industry because of close relationships between the users and suppliers of automotive assemblies. "Improved supplier responsiveness is (a) win/win (situation)," proclaimed Gene Richter, executive director of corporate procurement for Hewlett-Packard. Mr. Richter's newness to data processing electronics—he has been in this field for 18 months—enables him to evaluate the issues of the day with the objective eye of an outsider. Based on more than a decade of experience in the industrial and automotive sectors (with Black and Decker and Ford Motor Company), he challenged suppliers to pay more attention to fundamentals (e.g., planning, communicating, measuring, and follow-up) and to upgrade sales organizations (e.g., more resources, more training, more clout, and more global in scope).

Users today expect minimal inventory, guaranteed lead times, and a reduced vendor base. Sole-sourced components, however, still make users nervous unless they have formed a mutually dependent partnership with a supplier. A supplier, in turn, can use this opportunity to provide a total cost and value analysis for the user. To keep sole-source suppliers honest, Frank Gill, senior vice president of sales for Intel, reminded the audience that "a socket may be sole-sourced, but the electronic function is not."

Multichip modules are packages with two or more VLSI die, which make it possible to build higher-performance systems. Many technical and business challenges still face this new but promising idea. "Relationships between single IC suppliers, system houses, and strong package suppliers are required," recommended Dr. William Steingrandt, director of product development and marketing for Alcoa Electronic Packaging.

Futures

DRAM price volatility, coupled with its commodity nature, suggests futures as a familiar risk-management tool for modern business. "A DRAM is a small sliver of highly refined sand," explained Hoon Won, chief executive officer of Memory Clearing Corporation, "and can be traded like any other commodity." If the DRAM futures market does become a reality in upcoming months, it would be regulated by the Commodity Futures Trading Commission.

INDUSTRY FORECASTS FOR THE 1990s

Every year at this conference, Dataquest forecasts markets, applications, and prices for the upcoming year and the next five years. Dataquest and The Dun & Bradstreet Corporation presented these latest forecasts.

Markets

The U.S. economy is going global in the 1990s because of structural changes taking place in the international economy. "Real GNP for the U.S. economy is expected to grow only 2.4 percent in 1990 and 3.4 percent in 1991," summarized Joseph Duncan, vice president, corporate economist, and chief statistician for The Dun & Bradstreet Corporation.

The U.S. equipment industry is healthy with an orders-to-shipments ratio at parity or greater and an equipment inventory that is being well managed. "Worldwide electronic equipment production is expected to grow 5.4 percent in 1990, 7.3 percent

in 1991, and 8.6 percent in 1992," predicted Terrance Birkholz, research analyst for Dataquest's Semiconductor User and Applications Group.

Although equipment production increases each year at a steady 5 to 10 percent, semiconductor production swings between negative 20 and positive 50 percent (see Figure 1). "The semiconductor industry pauses every five years to catch its breath," concluded Hal Feeney, group vice president and director of Dataquest's Components Group. The industry is projected to grow at a compound annual growth rate (CAGR) of 18 percent between 1990 and 1994 (see Figure 2).

In every region of the world, offshore semiconductor manufacturers are becoming local producers. "The next five years will continue the trends of new sources and regions. There will be adequate capacity," predicted George Burns, industry analyst for Dataquest's Semiconductor Equipment and Materials Service. Because of the effects of trade policies and subsidies, however, the possibility of overcapacity in 1995 looms on the horizon.

Costs, not availability, are the overall key issues among users this year. "Top user issues in 1990 include on-time delivery, pricing, and cost control," summarized Mark Giudici, product manager and senior industry analyst for Dataquest's Semiconductor User and Applications Group. Overall, respondents to Dataquest's annual purchasing survey plan to have a 9.6 percent semiconductor purchasing growth in 1990, with medium-size semiconductor companies the most optimistic about growth. However, "survey respondents expect 1990 growth to be at almost half that of 1989," reported Carolyn Doles, industry analyst for Dataquest's Central Research Group, which supports the Components Group.

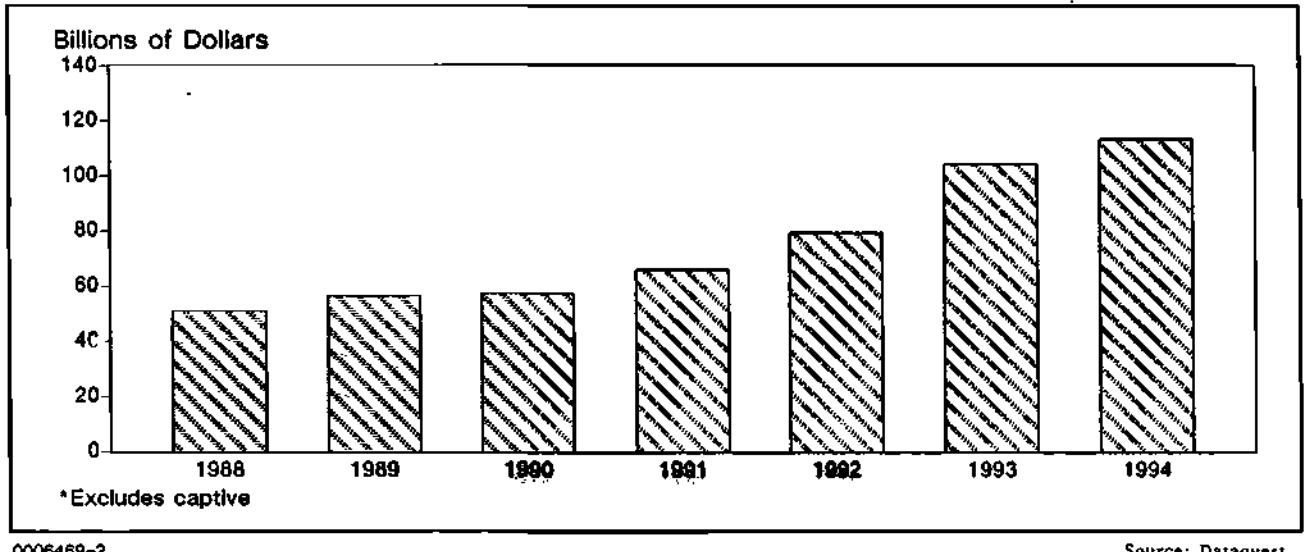
Applications

Multimedia PCs are expected to have a major impact on semiconductor demand by 1994. Between now and then, however, semiconductor companies have to keep their lines filled with wafers if they want to remain in business. "Market drivers for 1990 include 386-based PCs, workstations, rigid drives, LANs, laser printers, and facsimile machines," explained Kevin Landis, industry analyst for Dataquest's Semiconductor User and Applications Group.

Prices

The sticker shock of higher-priced, sole-sourced ICs is mitigated by high value. "Develop pricing and procurement strategies based on the system cost impact and keep close to manufacturers' activities and production plans," advised Greg Sheppard, senior industry analyst in Dataquest's Semiconductor User and Applications Group. Microprocessor, memory, and ASIC prices are expected to continue to decline in 1990 and 1991. (The estimated worldwide 1Mb DRAM

FIGURE 2
Worldwide Semiconductor Industry Revenue Forecast*



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Source: Dataquest
March 1990

pricing for 1987 to 1990 by quarter is presented in Figure 3.) "The crossover from 1Mb DRAMs to 4Mb DRAMs is expected to occur as early as the fourth quarter of 1990," predicted Ron Bohn, industry analyst for Dataquest's Semiconductor User and Applications Group.

SEMICONDUCTOR SUPPLIER OF THE YEAR AWARD

For the second consecutive year, Motorola's Semiconductor Products Sector was the recipient of Dataquest's annual "Semiconductor Supplier of the Year" award. Charles Thompson, senior vice president and director of marketing for Motorola's Semiconductor Products Sector, accepted the award from Gene Norrett, corporate vice president and general manager of Dataquest's Technology Information Division and Hal Feeney, group vice president and director of Dataquest's Components Group (see Figure 4).

The award is based on an annual Dataquest survey of more than 800 procurement site personnel representing the top 200 U.S. electronics companies that use semiconductors. Those surveyed were asked to rate semiconductor suppliers in the following five areas: quality, on-time delivery, pricing, technical support, and customer service. Motorola received the highest overall rating, with Texas Instruments ranking second, National Semiconductor third, Hamilton-Avnet fourth, and Intel fifth.

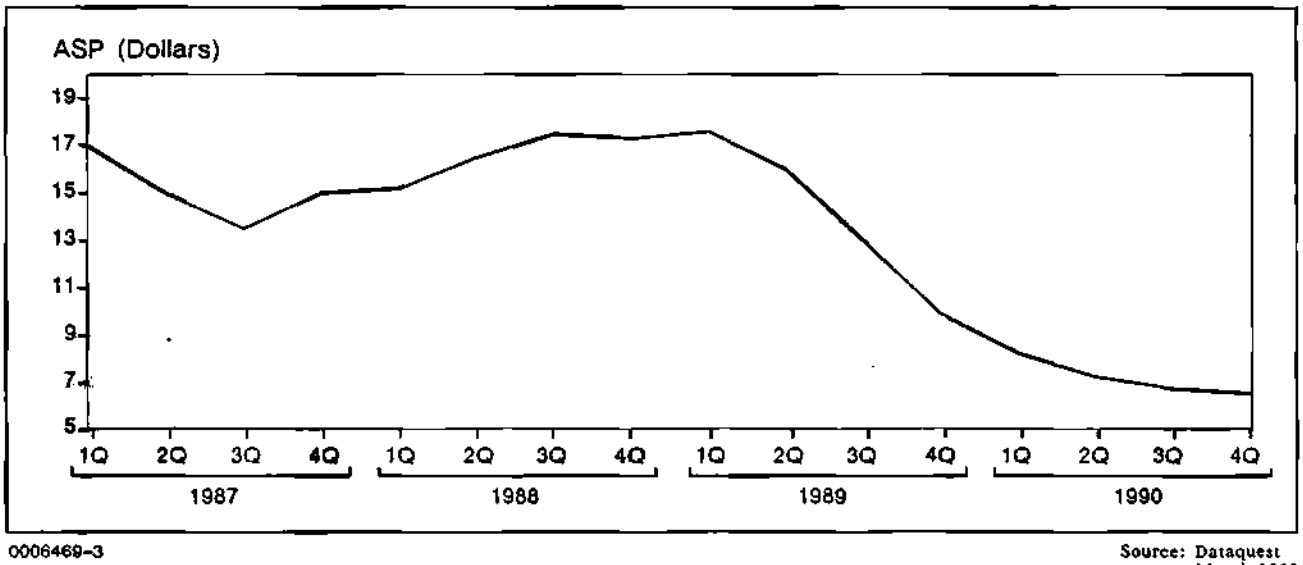
DATAQUEST ANALYSIS

Conclusions

Dataquest concludes that user-supplier relationships will indeed change for the better in the 1990s. We believe that the adversary attitudes of users and suppliers helped cause the wild swings experienced by the industry in the past 25 years (see Figure 1). Practices reflecting such attitudes as "they got us last time, so we'll get them this time" must give way to partnerlike cooperation because the fates of users and suppliers are becoming more tightly linked than ever before.

The conference did provide a forum to discuss changes that currently are under way in world regions and semiconductor technology, as well as how these changes are likely to affect users and suppliers. For example, the stakes in microelectronics are rising, with state-of-the-art fabs expected to cost as much as $1 billion by the year 2000. No supplier would ever make such an investment without first establishing that markets exist for the production, because the cost of an error is just too great—that is why users must share their technology and purchasing needs with suppliers. Likewise, no user would ever jeopardize its equipment business by depending on components that are inappropriate or unavailable for its needs—that is why suppliers must share their technology and capacity plans with users.

FIGURE 3
Estimated Worldwide 1Mb DRAM Pricing Quarterly: 1987-1990



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Source: Dataquest March 1990

FIGURE 4
Second Annual Semiconductor Supplier of the Year Award
(left to right) Gene Norrett, Charles Thompson, Hal Feeney

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Source: Dataquest
March 1990

Recommendations

Dataquest recommends that clients watch component market developments closely if they want to stay ahead. For that purpose, Dataquest publishes monthly reports such as the following:

- *Market Watch*—A bulletin released after the SIA book-to-bill *Flash Report* to give deeper insight into the monthly trends in the semiconductor market and an analysis of what is expected during the following six months
- *OEM Monthly*—To provide insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions
- *Procurement Pulse*—An update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers
- *SAMonitor*—An update that closely monitors changes in key electronic equipment markets

We also recommend that field and factory personnel have a basic understanding of electronics since this technology has become pervasive. For example, if a company has people who define CMOS (pronounced "SEA-moss") as green plants that grow on rocks at the beach rather than a semiconductor technology that offers high density and low power consumption, that company may consider implementing a training course at its facility.

Roger Steciak

Dataquest
a company of The Dun & Bradstreet Corporation

Research Newsletter

1990 SEMICONDUCTOR USER SURVEY FOCUS CHANGES FROM AVAILABILITY TO SUPPLIER PERFORMANCE

SUMMARY

Results of the Fifth Annual Dataquest Semiconductor User Survey were presented at Dataquest's Semiconductor User and Applications Conference held in San Francisco, California, on February 12 and 13. The three key findings were as follows:

- Respondents expect to increase their 1990 semiconductor purchases by 9.6 percent.
- Medium-size semiconductor users are the most optimistic about growth opportunities in 1990.
- The top three issues are on-time delivery, price, and cost control.

This newsletter summarizes the presentation and highlights the key findings of this survey.

METHODOLOGY

As in the past, Dataquest used the *Electronic Business* Top 200 company listings as a basis for the survey. We removed the sample companies that made or distributed semiconductors or software to ensure that we dealt with potential semiconductor users. This reduction brought our sample down to 188 companies. From this base, we surveyed by telephone 882 procurement sites of these companies and received 324 responses (37 percent). As seen in Figure 1, the majority (53.7 percent) of the respondents were from the Pacific and Northeast regions because of the larger concentration of technology manufacturing in those areas.

Table 1 shows the total respondent breakdown by application segment.

The military/areospace segment had the highest percentage in terms of response, partly because of the higher average selling prices (ASPs) relative to commercially priced semiconductors. The purchasing power of the 1989 sample represented 26.4 percent of total U.S. merchant shipments and is forecast to rise to 28.8 percent of the U.S. total in 1990.

SEMICONDUCTOR USER OUTLOOK

User Expectations

More than one-half (51.5 percent) of the respondents expect to have higher system sales in 1990. This figure, combined with 33.6 percent of those expecting flat sales, adds to a healthy total of 85.1 percent of the respondents that expect steady-to-increased sales this year. Mirroring this optimism in system sales, the respondents expect to purchase 9.6 percent more semiconductors in 1990 than in 1989. Relative to the past forecasts, this less-than-10 percent increase is historically conservative. Compared with semiconductor supplier forecasts that we have seen, this is an optimistic forecast in an otherwise flat market. Since the survey was taken, many large system companies have announced lower growth expectations, but our monthly survey data to date still show steady growth outlooks from the purchasing managers and mixed outlooks from the supplier community.

The brightest outlook for procurement growth is coming from midsize data processing and military/aerospace companies. The data processing respondents foresee higher growth opportunities in the high-end PC/workstation market and positive growth in the high-density storage and add-on memory board sectors of the industry. Countering common wisdom, midsize military/aerospace companies expect to see higher-than-average purchases

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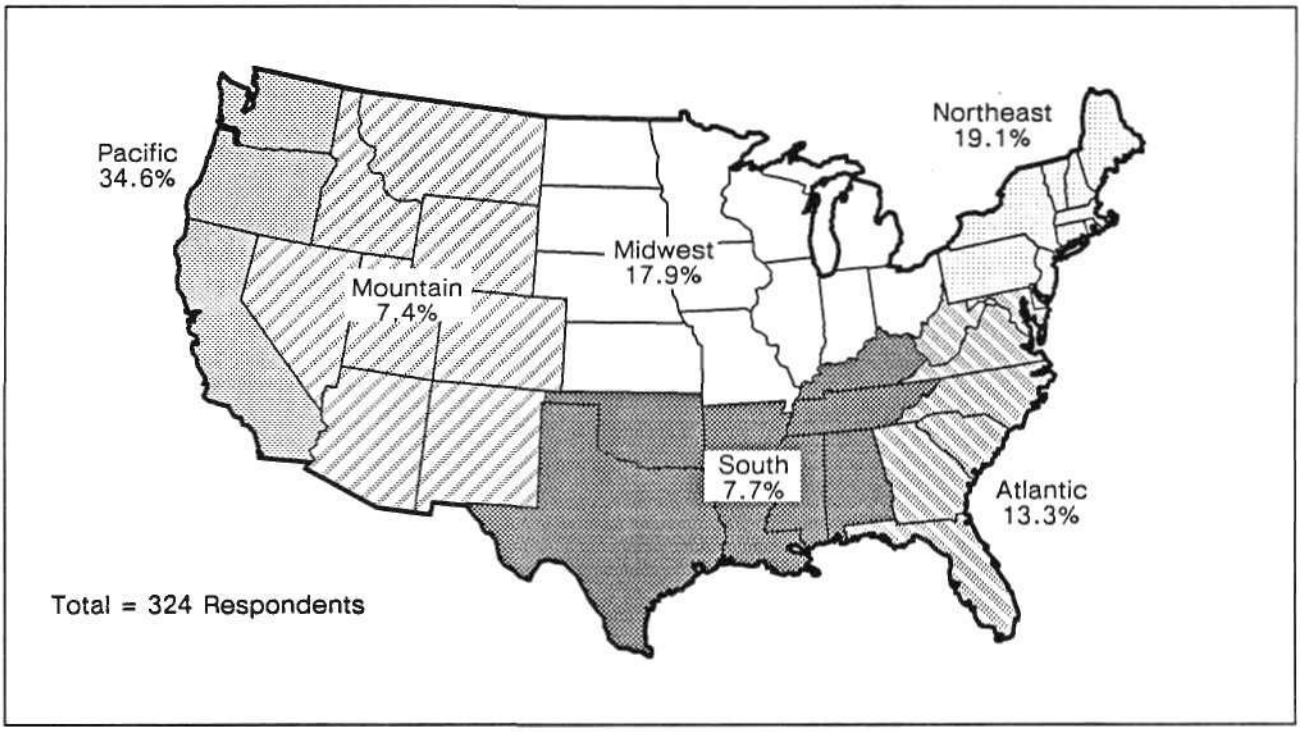
FIGURE 1
Procurement Survey Audience



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Source: Dataquest
March 1990

TABLE 1
1989 Survey Respondents' Purchasing Dollars

Military/Aerospace	35.6%
Industrial	23.9
Communications	17.9
Data Processing	12.8
Consumer	8.1
Transportation	1.7
Total	100.0%

Source: Dataquest
March 1990

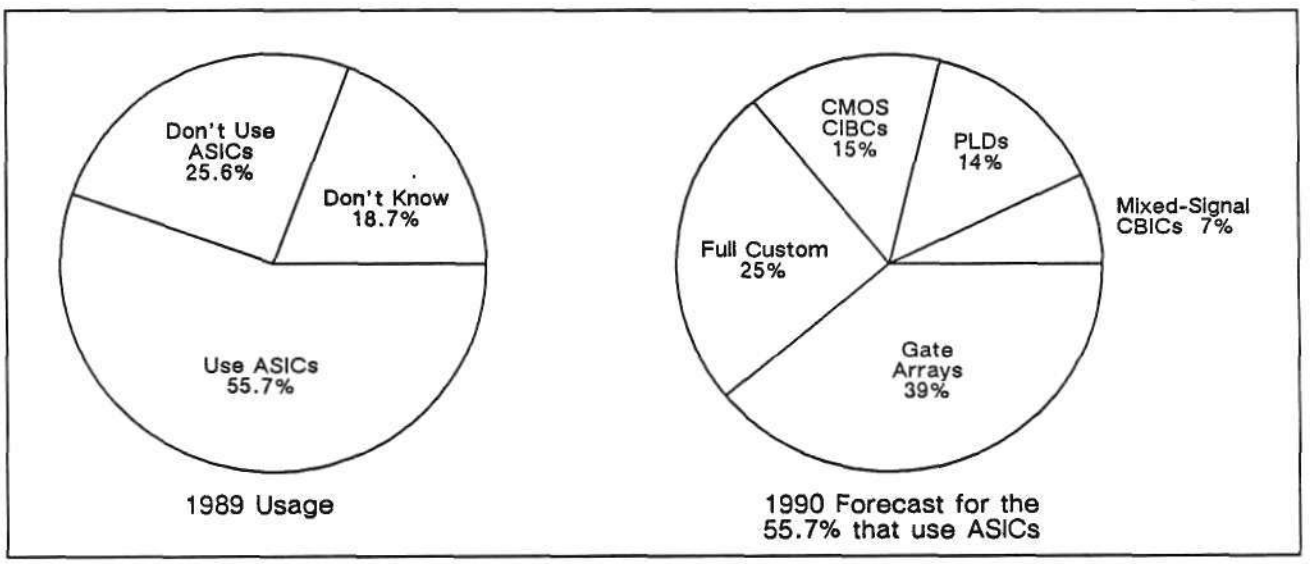
this year due to the clear status of many key programs. Last year, these programs had uncertain futures because of budget cuts. The programs that remain are comparatively secure and will receive a higher portion of funding than in 1989. More than one-half (55.7 percent) of the respondents used ASIC devices last year. A potentially larger marketing opportunity still remains for ASIC suppliers because 44.3 percent of the respondents either don't know if they use ASICs or simply don't use them at this time. The 1989 expenditure and forecast for 1990 are shown in Figure 2.

User Plans

The U.S. supply base for this year's respondents gained market share in 1989 at the expense of Japanese suppliers as a result of the improved availability of DRAMs relative to 1988. The 17.4 percent Japanese market share for the sample now reflects pre-1988 levels of market support. The trend toward manufacturing sites to offshore locations has abated, and 84.5 percent of the respondents plan not to move at all. Those that have facilities overseas now are beginning to use them to supply the local markets in addition to their traditional use as a source of low-cost production.

Last year's plans to reduce inventory levels have occurred, as seen in Figure 3. More than three-fourths (81 percent) of the respondents plan on either reducing or stabilizing their inventory levels this year. The respondent-targeted inventory

FIGURE 2
ASIC Usage



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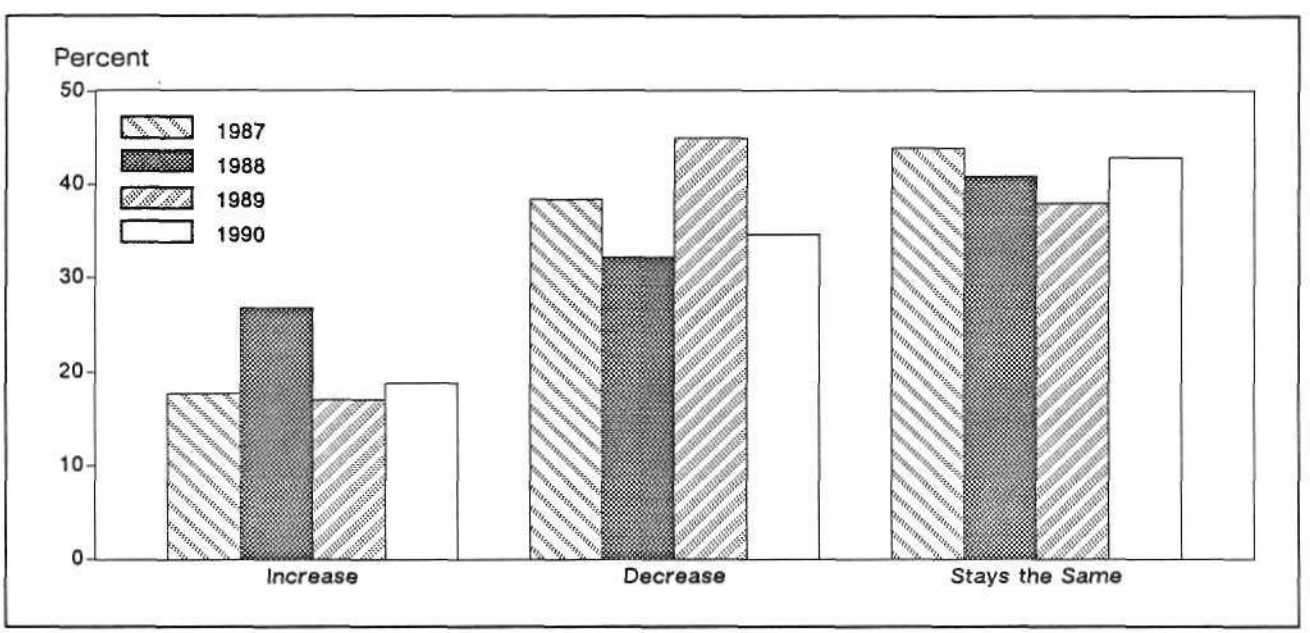
Source: Dataquest March 1990

FIGURE 3
Expected Change in Target Inventory Levels (Percent of Total Respondents)



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Source: Dataquest March 1990

level averaged out to 47 days. This relatively high target level is partly due to the inclusion of the military inventory requirement to have, on average, 180 days of inventory on hand. Our monthly survey reflects a target level for February of 19 days, which is more representative of the overall commercial market.

Top User Issues—The Focus Now Is on Supplier Performance

The biggest change in this year's survey was noting the shift of key issues away from product-related to supplier-related problems (see Table 2). For instance, the fifth-ranked problem for both 1988 and 1989 was memory. This year, memory availability was not even ranked as a top 20 issue! Focus has shifted to how well a given supplier performs on its commitments in terms of delivery, price, and meeting forecast needs. The number three issue, cost control, is the subtheme this year with all of the issues revolving around it. All semiconductor suppliers should take note that now, more than ever, meeting customer needs will be *the* determining factor in supplier loyalty this year. As mentioned in the Dataquest newsletter entitled "True or False: User-Supplier Relationships to Change in the 1990s," that chronicled the conference, Motorola again won the Semiconductor Supplier of the Year Award as voted by this year's respondents. In the buyers' eyes, Motorola met these needs by being perceived as the best in overall delivery, price, quality, technical support, and customer service. Next year's winner would be wise to address this new list of issues.

DATAQUEST CONCLUSIONS

This year's survey confirmed many trends that Dataquest had previously noted and also provided new insights as to what the user community is planning for 1990. The relatively conservative procurement estimates for this year reflect the uncertain outlook for system sales, yet most of the respondents were optimistic about the end markets at the time of the survey. Current surveys still show a steady undercurrent of semiconductor sales that is keeping low growth forecasts on track. It is important to note that the most growth in semiconductor procurement will be coming from

TABLE 2
User Issues

1990 Ranking		1989 Ranking	1988 Ranking
1	On-time delivery	3	3
2	Pricing	2	2
3	Cost control	7	4
4	Availability	1	1
5	JIT/inventory control	6	9
6	Quality/reliability	4	6
7	New products/obsolescence	8	8
8	Reducing vendor base	—	7
9	Forecasting	—	—
10	Government regulation	—	—

Source: Dataquest
March 1990

midsize companies, primarily in the data processing and military/aerospace industries. These two markets have the largest potential for higher sales for the following reasons:

- New products in the workstation and high-end PC markets as well as for more powerful peripherals
- Completed military budget cuts, resulting in steady procurement plans for surviving programs

Dataquest believes that the overall change of theme from availability issues to supplier performance underlines the efforts to reduce overall costs from every angle. Those companies that excel in supporting their customers will differentiate themselves and grow accordingly.

Mark Giudici
Carolyn Doles

Dataquest
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Research *Bulletin*

SAMONITOR: MODEST RECOVERY STAYS ON TRACK

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

The computer market took a turn for the worse in December. As shown in Figure 1, the orders-to-shipments ratio fell from 1.02 in

Figure 1
Computers and Office Equipment

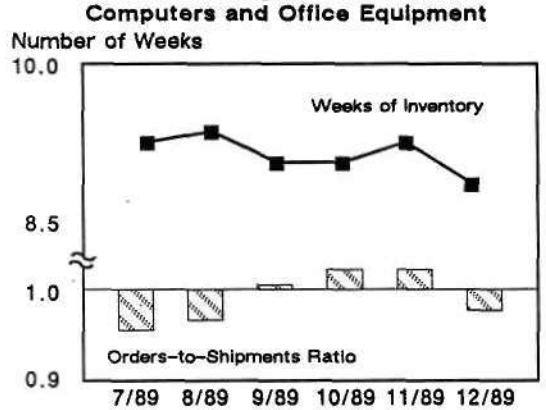

Figure 2
Communications Equipment

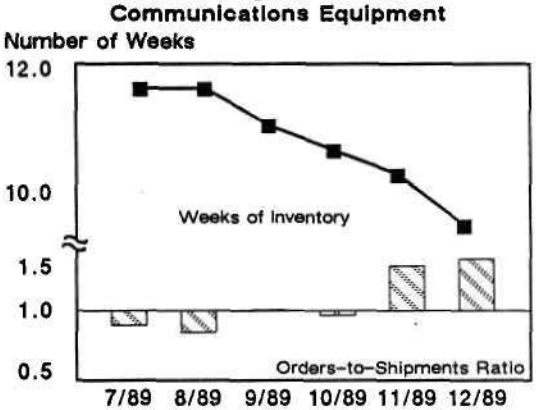

Figure 3
U.S. Instruments

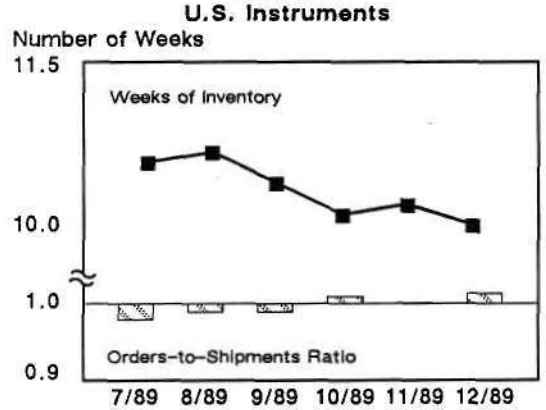

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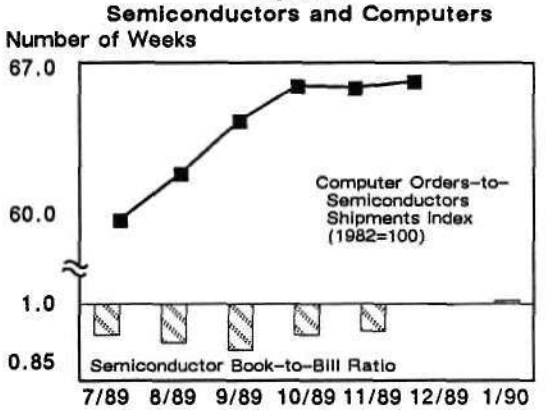
Figure 4
Semiconductors and Computers



Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
January 1990

SAM Newsletters 1990: January-March 1990-6

0006356

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

November to 0.98 in December. *This is the first month since August that the ratio has fallen below parity and the first month since June that the ratio has fallen from the previous month.* Orders growth for the three-month period ending in December was only 1.7 percent above year-earlier orders, whereas November growth was 11.1 percent. This abrupt change comes on the heels of an accelerating orders-growth trend that began last September. In retrospect, however, given the unusual strength since September, a correction in orders growth was probably due. Shipments growth for the three-month period ending in December was 0.3 percent below year-earlier shipments. *This is the first month of negative shipments growth since mid-1987.* If there is a silver lining, it is that manufacturers continue to keep a tight rein on their equipment inventories: Inventory fell to 8.9 weeks in December from 9.3 weeks in November. Despite December's lackluster showing, recent months' rebound in orders growth should help reverse the slowing growth trend in shipments and help bolster the market in the coming months.

Communications Equipment

Indicators show that business conditions in the communications market continue to improve. As shown in Figure 2, the orders-to-shipments ratio continues the upward trend that began last May, reaching 1.15 in December. Orders growth for the three-month period ending in December was 16.9 percent above year-earlier orders compared with 15.9 percent in November. In December, manufacturers further tightened inventories down to 9.5 weeks. Despite a sluggish economy, recent activity signals little change in the coming months.

Instruments

The orders-to-shipments ratio (see Figure 3) has been above parity since October and on a positive trend since April. But the road to improved business has been a bumpy one for the instruments market. Orders growth for the three-month period ending in December decelerated for the second consecutive month—to 2.0 percent from year-earlier orders—down from 6.3 percent in November and from the recent peak of 7.9 percent in October. Furthermore, three-month-ended shipments growth also slowed during the same period from 8.5 percent in November to 7.2 percent in December. Like the other equipment markets, inventories are well managed and fell slightly in December to 10.0 weeks. Dataquest does not believe that the recent activity portends continued slowing growth. Instead, orders growth probably is being buffeted by recent sluggishness in overall economic activity and business' cautious capital spending.

SEMICONDUCTOR DEMAND

Dataquest estimates that the U.S. semiconductor market book-to-bill ratio increased to 1.01 in January from December's 1.00, indicating that chip recovery is proceeding at a modest pace (see Figure 4).

For the three-month period ending in December, average computer orders fell 2.5 percent from November, while average semiconductor shipments for the same period declined 2.9 percent. As a result, the computer-orders-to-semiconductor-shipments index, a leading indicator of chip orders and shipments, remained relatively stationary at 66.4 in December (see Figure 4). As we said in last month's *SAMonitor,* Dataquest believes that this standstill is only temporary: Except for an insignificant decrease in July, the index has risen continuously since March, indicating that an improvement in the overall semiconductor market climate was due. Furthermore, Dataquest's estimate of the chip book-to-bill ratio confirms that the semiconductor market has passed its cyclical trough during the summer.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest believes that the North American semiconductor market will continue to recover, albeit at a modest pace. Furthermore, most of the market fundamentals of a sustained recovery are in place: Systems orders growth and shipments growth (save computers) is positive; system inventories are lean; and U.S. capital spending growth—a proxy of the business' demand for electronic systems—is forecast to accelerate from 3.5 percent in 1989 to 4.0 percent in 1990.

As reported last month, we maintain that North American chip shipments growth will be positive in 1990, but probably will be only fractionally ahead of 1989 shipments. Therefore, as the market expands this year, chip manufacturers can be expected to fight tooth and nail for every bit of market share. Manufacturers that view the world digitally—that is, either feast or famine—are most likely to think that we are in the midst of a famine. Bet on it that these companies are likely to be the ones that will miss this year's opportunities.

Terrance A. Birkholz

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Research Newsletter

SMART DRIVE ELECTRONICS: IF YOU'VE SEEN ONE . . .

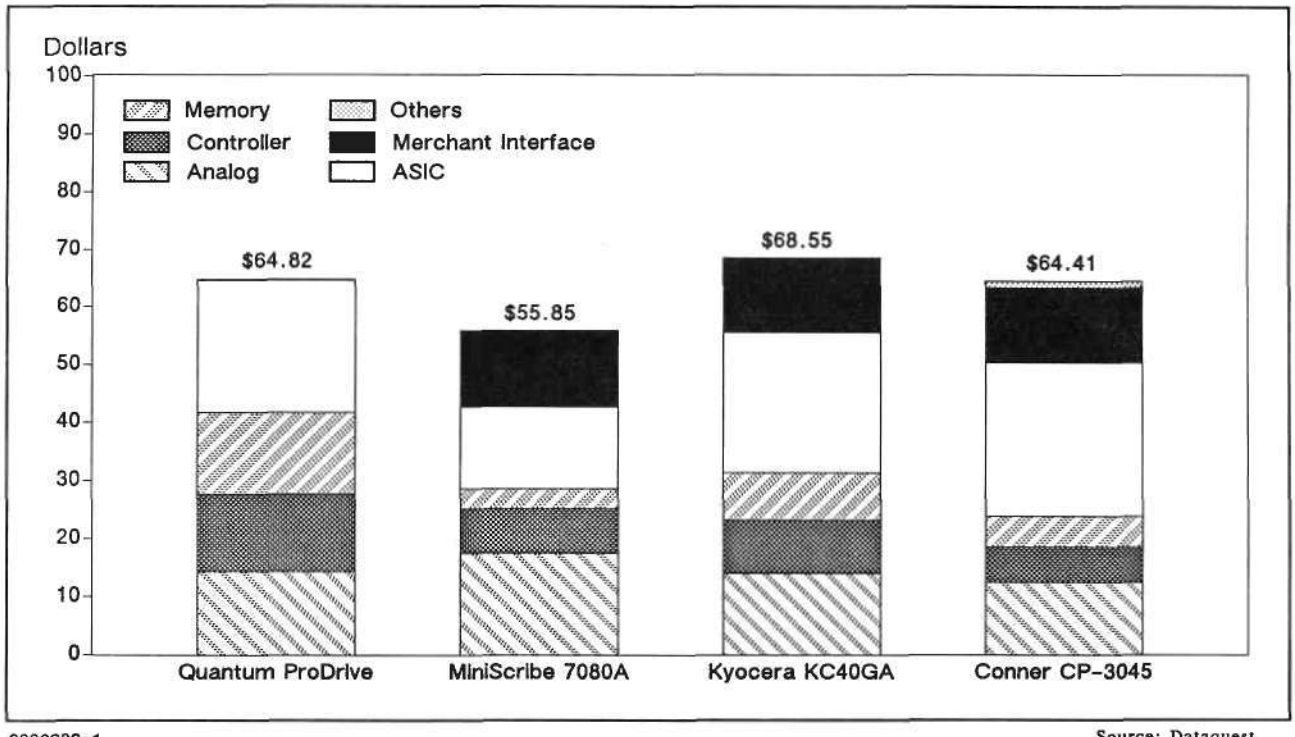
SUMMARY

When it comes to embedded controller design, rigid disk drive manufacturers face a tough challenge: to differentiate their product without sacrificing profit margins. This newsletter provides a detailed look at the semiconductor content of several recently announced 3.5-inch rigid disk drives. The models examined here were selected not only as representative of current embedded control implementations, but also as illustrative of the ongoing trends and constraints that face controller designers today.

INTRODUCTION/OVERVIEW

Figure 1 shows the estimated component cost of the Quantum ProDrive 80S, the MiniScribe 7080A, the Conner Peripherals CP-3045, and the Kyocera KC40GA. The pricing data contained in this analysis are based on Dataquest's Semiconductor User Information Service (SUIS) pricing study, assuming a 100,000-piece contract buy. Because manufacturers 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.

FIGURE 1
System Component Cost Breakout



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Source: Dataquest
February 1990

SAM Newsletters 1990: January-March 1990-4

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DESIGN CONSTRAINTS AND THEIR IMPLICATIONS

Cost, performance, interface, and form factor issues are placing severe constraints on the controller design equation, causing manufacturers to converge on what is essentially the same embedded controller solution. With product differentiation and the attendant gross margins becoming harder and harder to achieve, drive manufacturers face the prospect of losing the ability to set themselves apart through controller design and IC selection.

The next step in this analysis will sound all too familiar to chip industry veterans: Standardization leads to price erosion. As is often the case, the tremendous size of this industry is proving to be a double-edged sword for semiconductor suppliers, with a steady stream of new suppliers bringing pin-compatible products to market. As a result of this strong price pressure, Dataquest forecasts slowing growth for this application market. A detailed analysis of this market and our five-year forecast by semiconductor type will be provided in upcoming SAM newsletter number 1990-5, entitled "System Semiconductor Content Trends: Rigid Drives Learn Self-Control."

Table 1 compares the system specifications of these drives. Both AT and SCSI interface drives have been included, as these are by far the most common interface standards among intelligent drives today (vendors typically offer both versions). Aside from switching interface chips, there is virtually no difference in the semiconductor content of the respective versions of a given drive design. AT and SCSI interface devices are available on the merchant market at approximately the same price.

DRIVE DISCUSSION

The Quantum ProDrive 80S

Quantum is probably the best example of a drive manufacturer trying to achieve differentiation through chip selection. By using proprietary interface and buffer controller ASICs, Quantum is able to implement a unique design solution while keeping component costs under control. (There are indications that current pricing on merchant interface and buffer controller devices is slightly *higher* than the corresponding cost for certain in-house design solutions.) The current trend toward declining merchant ASPs threatens this cost edge, however.

In addition to using proprietary ASICs, Quantum also seeks differentiation through its own patented head positioning technique. Although this

TABLE 1
Drive Comparison

	Quantum ProDrive 80	MiniScribe 7080A	Conner CP-3045	Kyocera KC40GA
Interface	SCSI	AT	SCSI	AT
Platters	3	2	1	1
Surface Capacity (MB/s)	14.0	20.2	21.4	20.3
Drive Capacity (MB)	84.0	80.7	42.8	40.5
Access Time (msec)	19	19	25	28
Head Positioning	Servo	Servo	Servo	Stepper
Cache (KB)	64	-	-	-
Buffer (KB)	8	8	8	32
1:1 Interleave	Yes	Yes	Yes	Yes
TPI	1,000	1,387	N/A	1,309
BPI (Maximum)	22,050	30,625	N/A	29,589
RLL	2, 7	1, 7	2, 7	1, 7
Areal Density (Mb per sq. in.)	22.05	42.48	43.00	38.73

N/A = Not Available

Source: Dataquest February 1990

gives Quantum some unique benefits, it also increases controller requirements—the ProDrive has the most sophisticated, and expensive, microcontroller of any of these drives.

Table 2 shows the semiconductor content of the ProDrive 80S.

Although the ProDrive appears to have a substantially higher semiconductor cost, it is worth noting that this cost figure is skewed by the inclusion of three cache DRAMs. This cache is largely responsible for the ProDrive's fast access time and higher component cost. None of the other drives examined feature a data cache.

The ProDrive also illustrates the cost/technology trade-offs related to media technology. The ProDrive has the lowest level of head-media technology (areal density), which reduces the cost per platter, but this savings must be balanced against the cost of the additional platter required.

The MiniScribe 7080A

Never mind that MiniScribe's books look like the accounting version of the old "shell game"; the 7080A is a competitive product with a viable controller design. Like the ProDrive, the 7080A achieves faster access times through the use of a servo loop to control head positioning. Unlike the ProDrive, the 7080A takes advantage of much higher media technology (nearly double the areal

TABLE 2
Semiconductor Content—Quantum ProDrive 80S

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comments
Controller Card						
Data Path	Si Systems	32P541-CH	1	Pulse detector	$ 3.26	Read data processor
	Si Systems	32D5321-CH	1	Data separator	6.07	Data synchronizer/ ENDEC
Controller	NEC	D78312G	1	8-bit MCU	10.25	64-pin spider-leg DIP
	Hitachi	HA13441	1	Driver	3.05	Spindle motor driver
Memory	NEC	D27C256AC-20	1	OTP EPROM	2.03	256K, 200ns
	Fujitsu	81464-10	3	DRAM	8.58	64Kx4, 100ns
	Sharp	LH5164LN-10	1	SRAM	3.34	8Kx8, 100ns
ASICs	Plus	N/M	1	SCSI interface	12.00	68-pin PLCC
	Quantum	N/M	1	Buffer controller	11.00	68 pin PLCC
Std Logic	Mitsubishi	LS365A	1	Buffer	0.19	
Analog	SGS-Thomson	L2722	1	Op amp	0.22	Dual-power op amp
		C324G	1	Quad op amp	0.45	
		C339G	1	Quad comparator	0.22	
		3771	1	Op amp	0.22	8-pin DIP (M93)
		HCT08	1	DAC	0.45	14-pin DIP
Drive						
	Si Systems	32R 501-6CH	1	R/W preamp	2.75	28-pin PLCC
		C324G	2	Quad comparator	0.44	
	National	LM78L	1	Voltage regulator	0.30	8-pin DIP
Total:			21		$64.82	

N/M = Not Meaningful

Source: Dataquest February 1990

density of the ProDrive) to squeeze 80 megabytes onto two platters rather than three.

This aggressive technology strategy, although initially risky, has its rewards. By committing to a higher density and then pushing that technology to improve yields and costs, MiniScribe elects to push down a more advanced technology learning curve.

From a control electronics standpoint, the biggest difference between these drives lies not so much in the basic controller design itself but in the selection of proprietary versus standard ICs. Table 3 shows the semiconductor content of the 7080A.

MiniScribe's lack of interest in differentiating through chip selection is evident in the observation that, with the exception of two ASICs, all of the ICs in the 7080A are off-the-shelf merchant products.

The Kyocera KC40GA

Unlike the other drives, the KC40GA uses a stepper motor for head positioning which leads to a significantly higher access time. To offset this performance degradation, KC40GA offers a larger (32 KB) data buffer.

As a relative newcomer to this business, a general lack of product differentiation works to Kyocera's favor as it reduces the customer loyalties and switching costs that otherwise would form formidable barriers to entry. Volume manufacturing cost, not differentiation, is the key criterion in this design. Table 4 shows the semiconductor content of the KC40GA.

In implementing this design, Kyocera seems to be minimizing cost *in the long term*. This is

TABLE 3
Semiconductor Content—MiniScribe 7080A

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comments
Controller Card						
Data Path	SSI	32D536-CH	1	Data synchronizer	$ 6.07	28-pin PLCC
	N/A	N/A	1	Pulse detector	3.26	28-pin PLCC
Controller	Motorola	68HC11	1	Controller	6.15	
	Philips	TDA 514 OT	1	Motor driver	1.45	Spindle motor controller
Memory	Sony	CXK58257M-12L	1	64K SRAM	3.50	8KB buffer
Interface	Cirrus	CL-SH260-15PC-D	1	AT I-face adapter	13.00	SCSI version uses Adaptec
ASICs	MiniScribe	N/M	1		3.50	28-pin PLCC
	NCR	N/M	1	N/A	10.50	68-pin PLCC
Analog	Motorola	LM324	1	Quad op amp	0.54	14-pin DIP
	SGS-Thomson	LM324 D1	1	Quad op amp	0.54	14-pin DIP
	National	LM258M	1	Dual op amp	0.44	8-pin DIP
	SGS-Thomson	L2726	1	Quad op amp	0.54	14-pin DIP
	Siliconix	DG211	1	Quad switch	0.99	16-pin DIP
	Maxim	AD7628KCWP	1	Dual 8-bit DAC	2.38	20-pin DIP
	RCA	ACT10 RCAH485	1	N/A	0.24	14-pin DIP
Drive						
	SSI	32R510AR-4CL	1	R/W preamp	2.75	4-channel, 24-pin S.O. DIP
Total:			16		$55.85	

N/A = Not Available
N/M = Not Meaningful

Source: Dataquest
February 1990

evident in the selection of a high-density ASIC, which can be quite expensive initially, in order to minimize component count and long-run high-volume production costs.

This long-term focus is evident in Kyocera's media density as well. With virtually the same areal density as MiniScribe, Kyocera takes a similar approach in minimizing the number of platters in the KC40GA and then pushing that technology to improve yields and cost.

The KC40GA also is interesting in that it points out one of the competitive weaknesses of lower density drives. With the same controller cost spread over fewer megabytes, lower-density drives eventually will have a higher cost per megabyte than drives with similar media costs and a greater number of platters.

Another way of looking at it is to consider that the primary cost difference between the KC40GA and the 7080A is MiniScribe's second platter. For the incremental cost of that second platter, the end user can have 40 additional megabytes!

The Conner Peripherals CP-3045

Conner Peripherals, well on its way to becoming the fastest-growing start-up ever, has made its mark by taking the lead in the small, lightweight product segment of the market. In a market where many of its competitors searched fruitlessly for effective product differentiation to protect their profit margins, Conner looked past the challenges associated with the smaller form factors and saw opportunity in the portable PC boom.

Conner also has benefited greatly by focusing on key OEM relationships such as Apple, Compaq, and Sun. Not surprisingly, we found a CP-3045 while dissecting a Macintosh Portable.

Table 5 shows the semiconductor content of the CP-3045.

Although the 3045 uses an Adaptec interface chip and a Cirrus buffer controller, it nevertheless has a very high ASIC content. This high content is partly explained by the lack of standard logic components in this design. In addition, the lack of any motor driver/control devices, along with the

TABLE 4
Semiconductor Content—Kyocera KC40GA Teardown

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comments
Controller Card						
Data Path	Si Systems	X3P544-CHX	1	Pulse detector	$ 3.26	Pulse detection
	Si Systems	32D535-CW	1	Data synchronizer	6.07	Data separator/ ENDEC
Controller	Motorola	MC68HC11AO	1	8-bit MCU	6.15	
	Hitachi	HA13426	1	Driver controller	3.05	Spindle motor controller/ driver
Memory	Sony	CXK58257M-10L	1	SRAM	8.12	256K, 100ns, low power
Interface	Cirrus	CL-SH260-15QC-D	1	AT I-Face Adapter	13.00	100-pin quad flatpack
ASICs	Sanyo	CMM-8716	1	ASIC	5.25	
	N/A	PBL3770A	2	ASIC	7.00	28-pin PLCC
	Fujitsu	N/M	1	ASIC	12.00	96-pin quad flatpack
Analog		5247	2	A/D	1.90	8-pin DIP
Drive	Sony	N/A	1	R/W preamp	2.75	R/W preamp
Total:			13		$68.54	

N/A = Not Available
N/M = Not Meaningful

Source: Dataquest
February 1990

unusually large number (11) of power transistors present, suggests that the motor control function has been implemented in a mixed-mode ASIC, using power transistors as motor drivers.

Given Conner's superior product positioning, there is little incentive to differentiate in controller hardware. Therefore, one might expect this drive to have a very generic look to its controller design; however, power and form factor considerations have pushed this design into this relatively nonstandard, highly integrated condition. Indeed, the high level of integration present in the 3045 should make the job of adapting this design to a 2.5-inch form factor much more manageable.

DATAQUEST CONCLUSIONS

Figure 2 shows the IC cost distributions of these drives by semiconductor type. In this figure, Dataquest classifies the R/W preamp, the pulse detector, and the data synchronizer as analog components.

When compared with other electronic equipment types, these drives have a rather high analog component content. This is not surprising, given that the motor control functions are analog in nature and that the data is stored magnetically, and therefore must be read in analog form.

The memory content of these drives is surprisingly high because of increasing use of buffer

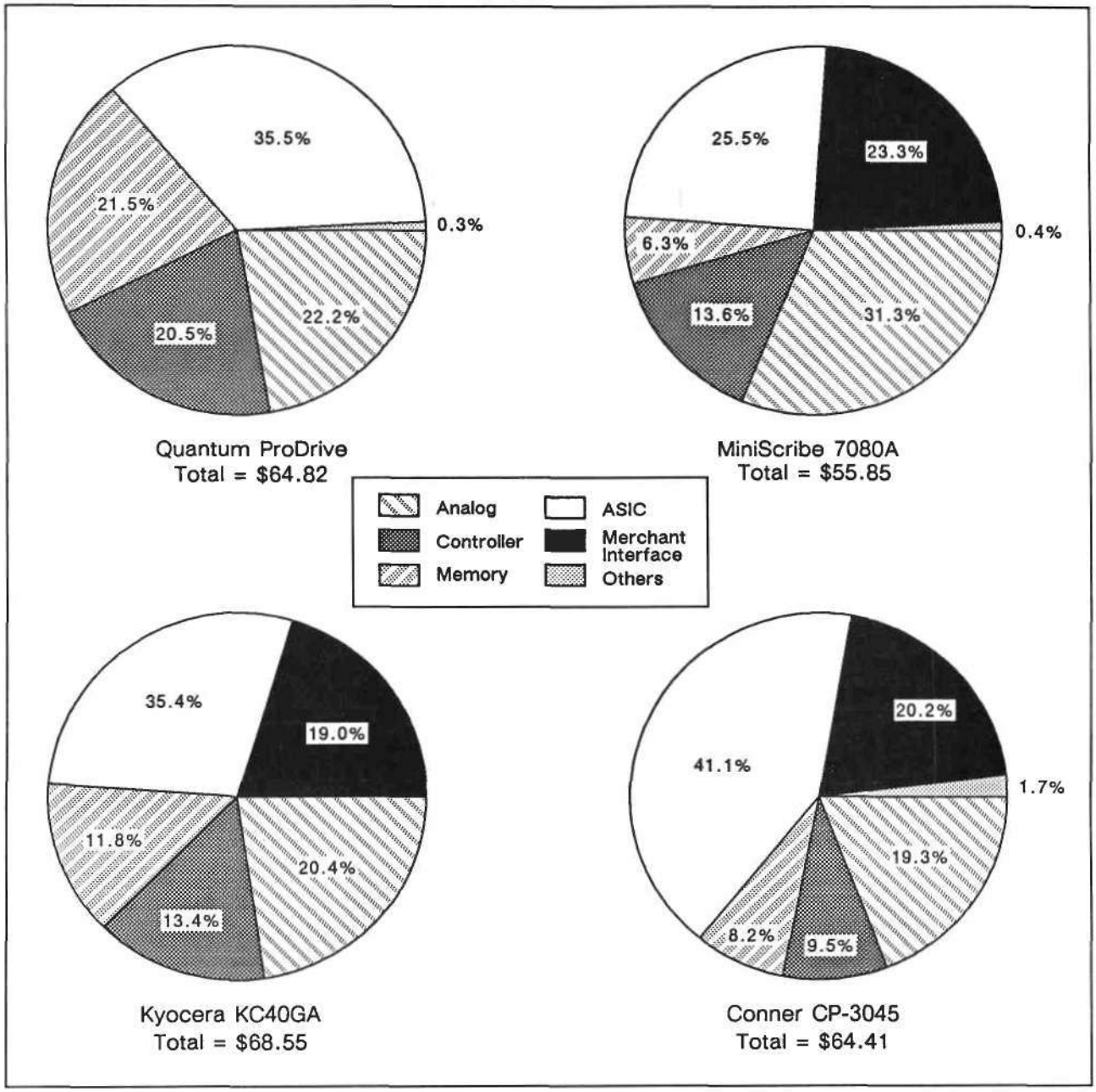
TABLE 5
Semiconductor Breakdown—Conner Peripherals CP-3045

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comments
Controller Card						
Data Path	Micro Linear	ML8464C-1CQ	1	Pulse detector	$ 6.07	28-pin PLCC
	N/A	N/A	1	Data separator	3.26	28-pin PLCC
Controller	Motorola	SC80566FN	1	Microcontroller	6.15	52-pin PLCC (ROM-less)
Memory	Atmel	AT27C256	1	OTP EPROM	1.95	256KB (32Kx8), 150ns
		SRM2264LM10	1	Buffer SRAM	3.34	100ns 8Kx8 (28-pin DIP)
Interface	Adaptec	AIC-610FL	1	SCSI interface	13.00	68-pin PLCC
	Motorola	61038-002	1	Standard cell	10.50	68-pin PLCC
ASSP	Cirrus Logic	SH110-00PC	1	Buffer controller	2.75	28-pin PLCC
ASICs	Motorola	S38AC004PK01	1	Gate array	6.25	44-pin PLCC
	Conner	GC27C	1	Mixed mode	6.95	44-pin PLCC
Analog	N/A	MOG3586A	1	N/A	0.35	16-pin DIP
Standard Logic	Fujitsu	74AC00	1	Quad 2-in NAND	0.23	14-pin advanced CMOS
	Fujitsu	74AC02	1	Quad 2-in NOR	0.23	14-pin advanced CMOS
	Fujitsu	74AC373	1	Octal 3-state	0.52	20-pin advanced CMOS transceiver
	Motorola	LS01D	1	Quad 2-in NAND	0.11	14-pin DIP
Drive						
	N/A	N/A	1	R/W preamp	2.75	
Total:			16		$64.41	

N/A = Not Available

Source: Dataquest February 1990

FIGURE 2
Semiconductor Cost Distributions



0006289-2

Source: Dataquest
February 1990

and cache memories. In addition, the high ASIC and application-specific standard product (ASSP) content can be attributed to the elimination of virtually all standard logic and interface chips.

With controller designs settling into a predictable, almost standard implementation, component vendors face a tough challenge in sustaining healthy ASPs. This challenge is exacerbated by widespread second-sourcing within the semiconductor industry, which clearly enhances drive manufacturers' already considerable bargaining leverage.

Kevin Landis

Dataquest
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Research *Bulletin*

OEM MONTHLY: FEBRUARY 1990
PEACE DIVIDEND—WESTERN CHIPS IN SOVIET PCs

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

THE CHANCE FOR ANOTHER REGIONAL ELECTRONICS MARKET

Last year, the United States (via the Coordinating Committee for Multilateral Export Controls—COCOM) relaxed its rules regarding the sale of certain products to non-COCOM members. This change now allows the sale of 16-bit technology (e.g., Apple Macintosh, IBM AT) to the Soviet Union and represents an opportunity for Western PC and PC chipmakers to extend the market life of some of their more mature products.

The potential is tremendous because of the relatively small number of PCs in the Soviet Union. For example, the United States has 38 million PCs for its 245 million people (i.e., 1 PC for every 6 persons), while the Soviet Union is estimated to have fewer than 500,000 PCs for its population of 300 million people (i.e., 1 PC for every 600 persons). The Soviets expect to install 28 million PCs during the 1990s to reduce this difference.

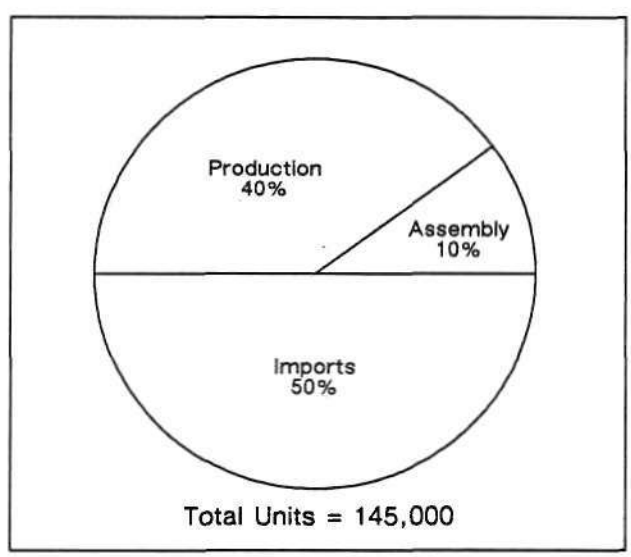
AN ESTIMATE OF THE SEMICONDUCTOR CONSUMPTION POTENTIAL

Imports of PCs to the Soviet Union supported an estimated 50 percent of the country's total PC consumption in 1988 (see Figure 1), while PCs produced from its own components supported an estimated 40 percent. PCs assembled from Western components supported the remaining 10 percent.

The Soviet Union expects to meet most of its PC needs during the 1990s with imports and units assembled locally from Western components. The reason for such dependence on foreign sources is the low quality of its own components. For example, a Soviet PC has a mean time between failure (MTBF) of 170 hours versus an MTBF of 2,000 hours for a Western PC.

The Soviet goal of installing 28 million PCs during the 1990s means a chip usage of $5.2 billion (the average semiconductor content of a 286-based PC is $185). While the mix between local assembly and foreign sourcing will depend on the path taken by the Soviet economy, the need to develop manufacturing industries and preserve foreign exchange is expected to favor assembly over purchase whenever possible.

FIGURE 1
Estimated 1988 Soviet PC Consumption



0006266-1

Source: Dataquest
February 1990

SAM Newsletters 1990: January-March 1990-3

0006266

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THE NEED FOR SUPPLIERS TO HAVE REALISTIC EXPECTATIONS

Doing business in the Soviet Union presents a chip supplier with many challenges. For example, the different monetary systems in the Soviet Union and Western countries still must be made compatible so that currency can flow more easily across borders. The centrally planned nature of the Soviet economy also demands government contacts and prolonged negotiations for doing business. A venture in the Soviet Union may require five or more years for payback.

In addition, the COCOM rule changes were motivated by changes in the international political climate. Should an unforeseen disaster occur between East and West in the coming years, the market for Western-made chips in the Soviet Union could disappear overnight. A chip supplier considering the Soviet market must keep this possibility in mind.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

A Soviet-market strategy is an investment with great uncertainty and a long-term payback—longer than most semiconductor suppliers can afford to make. On the other hand, the semiconductor components needed (80286 microprocessors and AT-clone chip sets) are two technology generations old and already have reached maturity. No new chip development is needed.

The only cost is marketing channel development. Dataquest recommends that semiconductor suppliers that want to participate in this market should sell their existing chips to the Soviet Union through distributors and to PC manufacturers in the West.

[For more in-depth analysis of the Soviet Union and its PC market, refer to Dataquest's 1988 report, *The USSR PC Market*. To purchase your copy, call the Dataquest Technology Products Group at 1-800-624-3282.]

Roger Steciak

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Research *Bulletin*

SAMONITOR: CHIP INDUSTRY RECOVERY ON SCHEDULE

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

Recent indicators suggest that the computers and office equipment market is entering a new stage of growth. New orders growth for the

Figure 1
Computers and Office Equipment

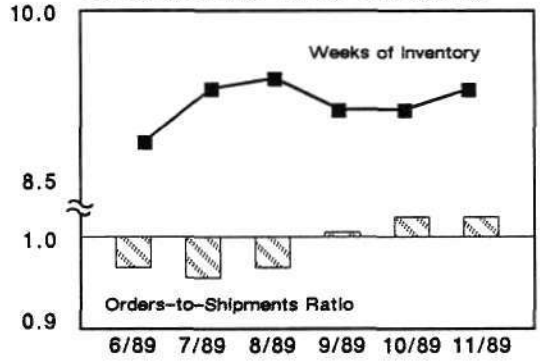


Figure 2
Communications Equipment

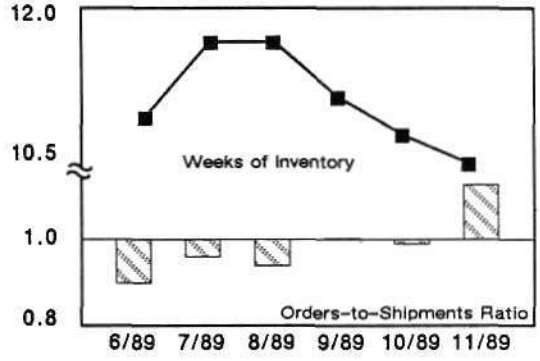


Figure 3
U.S. Instruments

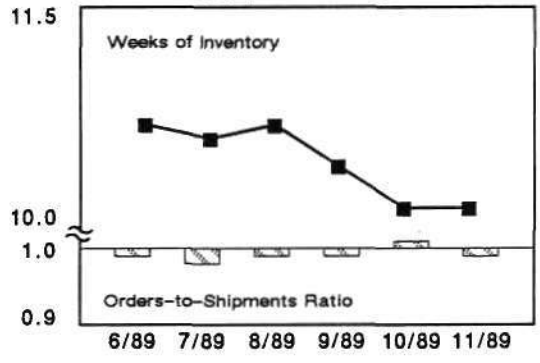
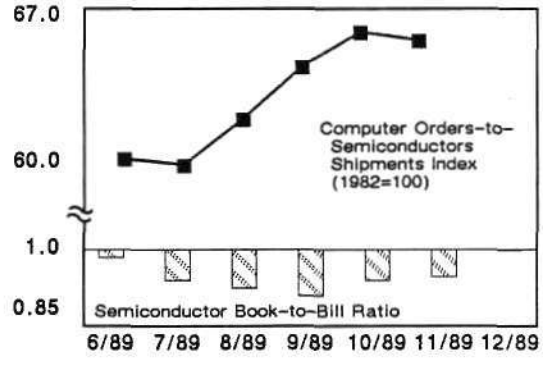


Figure 4
Semiconductors and Computers



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Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
January 1990

SAM Newsletters 1990: January-March 1990-2

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three-month period ended in November was 10.6 percent above year-earlier orders. *Not only is this the third consecutive month of positive orders growth, but it is also the second consecutive month of accelerating growth.* Shipments growth remains positive and continues to decelerate, *but at a slowing rate:* Shipments growth for the three-month period ended in November was 2.2 percent above year-earlier shipments, while October and September growth were 2.4 percent and 3.5 percent, respectively. The orders-to-shipments ratio (see Figure 1) remained steady in November at 1.01, while inventory levels rose slightly to 9.3 weeks in November. Dataquest believes that the recent pattern in orders and shipments growth indicates that this market is on schedule to enter a period of stable and sustained growth beginning in the first quarter of 1990. This growth should lead to a recovery in chip orders and shipments growth in the second quarter.

Communications Equipment

The communications market continues to improve. Orders and shipments growth for the three-month period ended in November accelerated from their respective October growth rates: Orders growth quickened to 15.5 percent from 8.9 percent, and the pace of shipments growth picked up to 7.5 percent from 7.2 percent. *This is the fastest three-month-ended orders and shipments growth since March and February 1988, respectively.* The orders-to-shipments ratio (see Figure 2) rose dramatically to 1.13 in November. *This is the highest the ratio has been since March 1986.* Manufacturers drew down their inventories to 10.4 weeks, their lowest level since December 1988. Dataquest believes that the market is in the midst of a period of improved growth that is likely to extend at least through early 1990.

Instruments

Instruments orders grew 6.1 percent for the three-month period ended in November, down slightly from the 7.9 percent growth in October, while shipments were up 9.4 percent. *This represents the third consecutive month of accelerating shipments growth since September.* The orders-to-shipments ratio (Figure 3) slipped back below parity in November to 0.99. However, in light of the positive situation in orders and shipments growth, the ratio's slippage is likely insignificant, and at this point can be dismissed as random noise. November inventory levels held constant at 10.1 weeks. The continuing upswing in orders and shipments growth, and lean inventory levels are laying a good foundation for stable future growth. Dataquest believes that orders and shipments growth will remain positive, but could likely be buffeted about in the coming months.

SEMICONDUCTOR DEMAND

The U.S. semiconductor market book-to-bill ratio increased to 1.00 in December from November's 0.93, indicating a recovery from the summer slowdown (see Figure 4).

For the three-month period ended in November, average computer orders rose 1.0 percent from October, while average semiconductor shipments for the same period advanced 1.7 percent over October. As a result, the computer-orders-to-semiconductor-shipments index (see Figure 4), a leading indicator of chip orders and shipments, fell slightly to 65.8 in November from 66.2 in October. Dataquest believes this is only a transitory aberration: Except for an insignificant decrease in July, the index has risen continuously since March, indicating that an improvement in the overall semiconductor market climate was due. The chip book-to-bill ratio confirms that the semiconductor market has passed its cyclical trough during the summer. Further, recent computers orders and shipments growth trends indicate that the chip market's recovery should be sustained for the next several months. Dataquest believes that the North American semiconductor market is on schedule for a peak in growth during the second quarter of 1990.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest believes that the North American semiconductor market has entered a new phase of growth. Improvement in system shipments and orders growth should provide the fuel to sustain improved chip market conditions through at least the first half of 1990.

Make no mistake that chip shipments growth will likely only be fractionally ahead of shipments in 1989. On the other hand, chip manufacturers that are unable to turn their operations "on a dime" will likely sacrifice any possible increment in market share attendant with the expected business upswing. True, these aren't the best of times; but they aren't the worst of times either. As the new year unfolds, manufacturers that stay forward-looking and do not become unduly preoccupied with the present (or recent past) misfortune stand the best chance of harvesting this year's limited crop.

Terrance Birkholz

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Research *Bulletin*

OEM MONTHLY: JANUARY 1990
CACHE MEMORY BALANCES SYSTEM PERFORMANCE AND COST

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

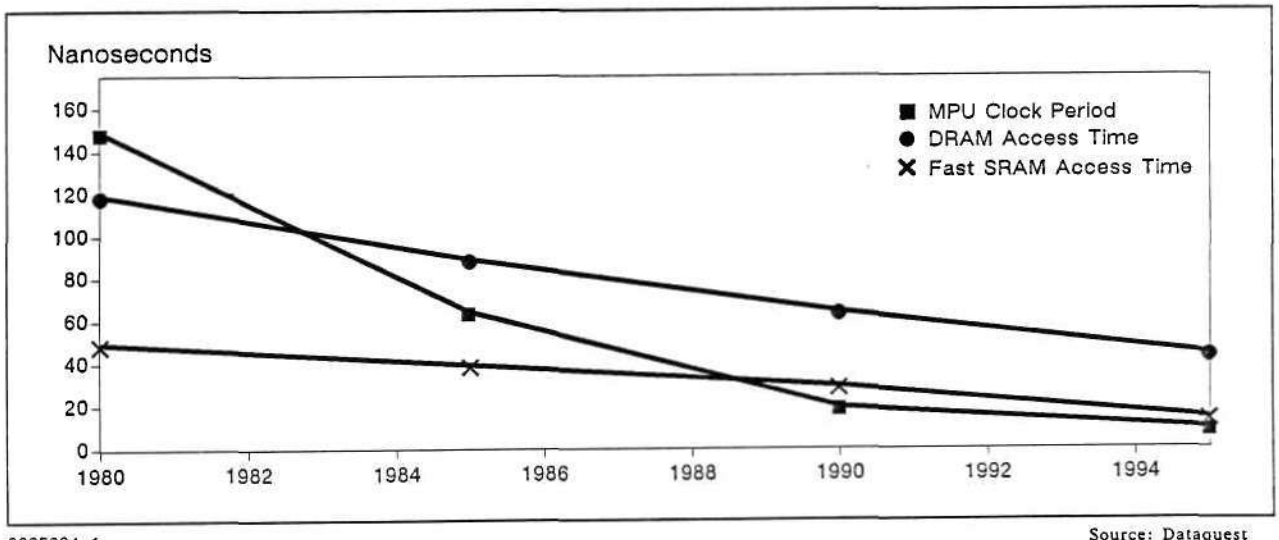
THE UNEVENNESS OF TECHNOLOGY EVOLUTION

Microprocessor clock periods declined 8:1 during the 1980s, while memory access times declined by only 2:1 (see Figure 1). As a result, today's advanced microprocessors are much faster than DRAMs. Because these faster microprocessors must idle much of the time while they wait for the slower DRAMs, the overall computer system is not able to take advantage of the microprocessors' higher speeds.

The "Correct Solution" Costs Too Much

A better memory for these faster systems is fast SRAM, because the microprocessor clock period would be more closely matched to the SRAM access time. However, SRAMs cost 10 to 20 millicents per bit, or 10 times the DRAM cost of 1 to 3 millicents per bit. Because PC memories

FIGURE 1
Advanced Microprocessor and Memory Trends



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Source: Dataquest
January 1990

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TABLE 1
Memory Alternatives for Advanced Systems

Component	System Use	Memory Size	Access Time	Cost	Verdict
DRAM	Main memory	4MB	100ns	$ 350	Too slow
Fast SRAM	Main memory	4MB	25ns	$3,500	Too costly
Fast SRAM	Cache memory	32KB	25ns	$ 100	Too small
DRAM/SRAM	Main/cache	4MB/32KB	100/25ns	$ 450	Compromise

Source: Dataquest
January 1990

must be at 4 megabytes or more to meet the storage needs of the UNIX or OS2 operating systems, memory cost must receive serious consideration.

Cache Memory Makes Higher Performance Affordable

The tradeoffs for various system memory alternatives are presented in Table 1. The architecture that provides a compromise between performance and cost includes a small amount of fast but expensive SRAMs (i.e., the cache memory) with a large amount of inexpensive but slow DRAMs (i.e., the main memory). Cache memories were first used in mainframes in the late 1960s and are being used today in high-performance systems ranging from workstations to supercomputers.

Cache memory architectures are sure to be used in high-end PCs in the 1990s. New CISC microprocessors such as the Intel 80486 and the Motorola 68040 include 8 kilobytes of cache memory. RISC microprocessor chip sets (e.g., BIT, Clipper, MIPS, and SPARC) also have architectural provisions for cache memories and cache memory controllers.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Technology absorption is a major challenge facing semiconductor users today. Faster microprocessors require architectural changes in the system (e.g., cache memory) to harness higher performance. Another system impact of faster ICs is the delay associated with data traveling between chips (discussed in *OEM Monthly* for October 1989, entitled "Interconnect—The Next Major Challenge for Electronics").

Dataquest recommends that semiconductor suppliers understand all of the relationships between their components and their customers' systems to provide total solutions that might include specialty memories, advanced packaging, and on-chip cache.

Roger Steciak

April—June

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

- **First Quarter Electronics Equipment Update: Industry Catches Its Breath for the Long Haul** (1990-12)—Dataquest expects North American electronic equipment production growth to be 5.8 percent in 1990, down slightly from 6.0 percent growth in 1989. This newsletter reviews the US economic outlook, the current situation, application market trends, and the long-term drivers. We conclude that the future belongs to those that choose to participate rather than spectate or gestate.
- **OEM Monthly—April 1990: Snags Snarl ISDN, Dataquest Forecast Bleak** (1990-13)—*OEM Monthly* provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions. The bulletin discusses the slowdown in ISDN lines, the impact on semiconductors, and the healthy long-term outlook. We recommend that semiconductor companies that are in this market for the long term maintain engineering contact with potential users.
- **SAMonitor: "He Who Hesitates, Loses"** (1990-14)—The *SAMonitor* is a monthly update that closely monitors changes in key electronic equipment markets. This bulletin points out that computer orders are 14.1 percent above year-earlier orders. We caution semiconductor manufacturers not to underestimate the strength of the coming expansion.
- **OEM Monthly—May 1990: Technology's Path from the Lab to the Living Room** (1990-15)—This bulletin discusses how world peace should energize leading-edge markets, discusses example technologies with commercial potential, and presents space-technology spinoffs and industry migration histories. We recommend that semiconductor suppliers monitor long-term system trends so that the appropriate semiconductor products can be developed in time to take advantage of potential high-growth opportunities.
- **GSM in Europe—Cellular Turns Digital** (1990-16)—The Groupe Speciale Mobile (GSM) pan-European digital cellular network is expected to be launched across Europe beginning in July 1991. This newsletter discusses the GSM system, its advantages over analog, the contents of the GSM telephone, the initial GSM price, the market for semiconductors, and future GSM generations. We conclude that during the next two years, vendors must strive to supply GSM telephone manufacturers with solutions that permit their GSM units to offer the same price/performance benefits as analog ones.
- **The US Consumer Cellular Scenario** (1990-17)—There are indications that cellular telephones are becoming a consumer product in the United States. This newsletter discusses the US consumer cellular scenario, the next five years for cellular in the United States, and how the US cellular scenario is just one "simulation." We recommend that suppliers that are not (or cannot become) high-volume, low-cost producers prepare to exit the market sometime during the next five years.
- **SAMonitor: Systems Outlook Remains Upbeat** (1990-18)—This bulletin points out that procurement managers' six-month system sales forecast for overall OEMs is 7.8 percent, while computer OEMs expect an 8.0 percent increase through October. We conclude that as the expansion matures and the fundamental determinants of growth solidify, variability in month-to-month business activity should lessen, thus adding to the expansion's durability.

- **Portable PCs: What Comes in Small Packages?** (1990-19)—This newsletter provides a detailed look at the semiconductor content of several recently announced portable personal computers. We conclude that the portable computer market is important for semiconductor manufacturers to follow—if not for its own dazzling potential, then for the excellent insights that today's portable PCs offer into future electronic content of mainstream desktop PCs.
- **Risk and Opportunity in Eastern Europe: The View from Finland** (1990-20)—Mikhail Gorbachev's June 1990 visit to Silicon Valley followed his earlier sweeps through Europe's high-tech centers. This newsletter discusses the benefits of entering these markets, the risks, and the view from Helsinki, Finland. We recommend that systems manufacturers establish a foothold presence in these regions now.
- **OEM Monthly—June 1990: Flat-Panel Color Displays: Light, Bright, and in Sight** (1990-21)—This bulletin discusses the portability offered by color LCDs and the turbulence ahead for flat-panel technology. We recommend that companies supplying semiconductors for displays form partnerships with display OEMs to stay current with technology trends.
- **SAMonitor: All Systems Are "Go"** (1990-22)—This bulletin points out that procurement managers' six-month system sales forecast for OEMs has risen for the fourth consecutive month, to 9.4 percent in May from 7.8 percent in April. We conclude that the systems market is recovering on schedule and is gathering steam.

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Research *Bulletin*

SAMONITOR: ALL SYSTEMS ARE "GO"

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

The computer market improved in April. Shipments growth for the three-month period ended in April was 5.8 percent above year-earlier

Figure 1
Computers and Office Equipment

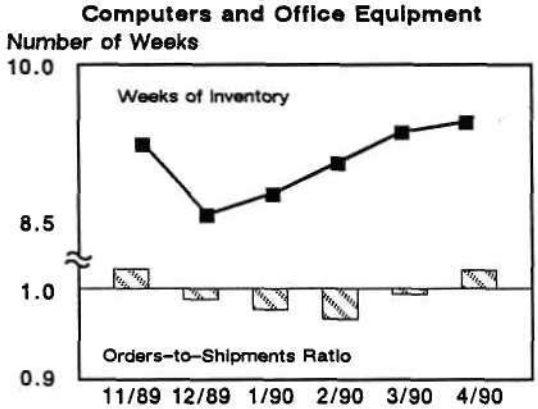


Figure 2
Communications Equipment

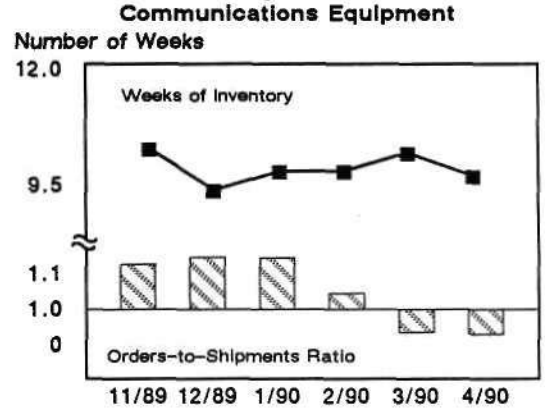


Figure 3
U.S. Instruments

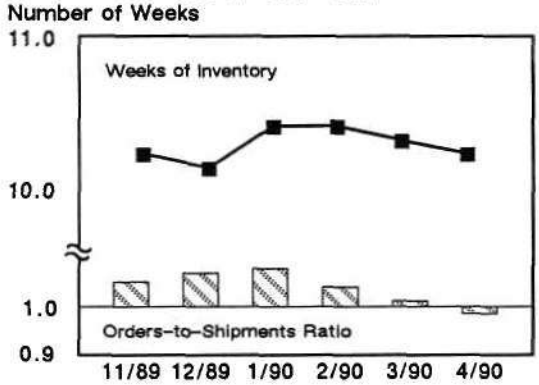
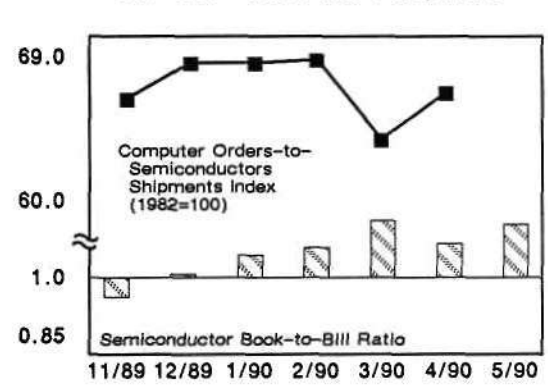


Figure 4
Semiconductors and Computers



Source: U.S. Department of Commerce, World Semiconductor Trade Statistics, Dataquest (June 1990)

SAM Newsletters 1990: April-June 1990-22

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shipments, compared with 6.9 percent in March. Although April is the first month of deceleration since growth reached its cyclical trough of 1.8 percent in December 1989, Dataquest believes that there is little cause for alarm: The first quarter's surge in shipments growth was in response to last year's fourth quarter surge in orders. We believe that the shipments surge has run its course and that the coming months will be marked by similar moderate growth as shipments growth stabilizes. Orders growth for the same period was 8.7 percent above year-earlier orders, compared with 7.3 percent in March. *Orders growth has accelerated continuously from 4.2 percent in January this year.* As a result of improved business conditions, the orders-to-shipments ratio (Figure 1) rose from parity in March to 1.02 in April. Inventories edged up slightly to 9.5 weeks in April from 9.4 weeks in March but are 0.2 weeks below last year's level, so excessive stocks are not a problem. During the next several months, Dataquest expects orders growth to stabilize around current rates and expects shipments growth to decelerate, then stabilize.

Communications Equipment

As forecast by Dataquest, orders growth rebounded in April. Orders growth for the three-month period ended in April was 5.4 percent above year-earlier orders, compared with 1.4 percent in March. Orders growth is likely to accelerate a few percentage points in the coming months as the market closes in on stability. Shipments growth for the same period remains brisk at 8.9 percent above year-earlier shipments, compared with 8.7 percent in March. The strength of recent shipments growth reflects the carryover from last year's strong fourth quarter sales. The decline in the orders-to-shipments ratio (Figure 2) from 0.94 in March to 0.93 in April belies the health of this market and reflects shipments' relative improvement in April over March when compared with orders' improvement. Inventories have begun their seasonal decline to 9.7 weeks in April and are 1.6 weeks below year-earlier levels as well. With a minimum of inventory slack in the market, Dataquest expects orders and shipments growth to accelerate and decelerate, respectively, toward roughly equal and stable rates in the coming months.

Instruments

Orders growth for the three-month period ended in April was 7.4 percent above year-earlier levels, compared with 9.1 percent in March. Shipments growth for the same period was 6.4 percent above year-earlier levels, compared with 5.8 percent in March. The decline in the orders-to-shipments ratio (Figure 3) masks the true expansion in the market and is more reflective of the 1.6 percent decline in April orders from March. Inventories continued to edge down from 10.3 weeks in March to 10.2 weeks in April; they are currently 0.8 weeks below year-earlier levels. Dataquest believes that recent shipments and orders activity reflects the market's correction to more sustainable growth rates. The coming months should be marked by relatively stable growth.

SEMICONDUCTOR DEMAND

US semiconductor market growth accelerated in May. US market bookings (three-month moving average) rose 5.3 percent in May to $1,379.6 million while May billings rose 2.9 percent to $1,205.6 million. As a result, the US semiconductor market book-to-bill ratio rose to 1.14 in May, from 1.09 in April (Figure 4). The strength of orders by computer manufacturers is helping to buoy the market despite softness in the DRAM area. As expected, computer orders' seasonal upturn occurred on schedule: The three-month period ended in April advanced 5.3 percent ahead of March. Also as expected, the computer-orders-to-semiconductor-shipments index, a leading indicator of chip orders and shipments, rose in April to 66.9 from 64.0 in March (Figure 4). April's upturn in the index signals continued expansion in the chip market as systems orders translate into chip sales.

Dataquest's monthly survey of major OEM semiconductor procurement managers supports this optimism: *Procurement managers' six-month system sales forecast for OEMs has risen for the fourth consecutive month, to 9.4 percent in May from 7.8 percent in April.*

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The systems-market recovery is on schedule and is gathering steam. Advancing system sales have spilled over to the semiconductor market, which had record bookings in May. The upcoming summer months, typically a slow period of the year for the chip business, will be the next short-term obstacle facing the semiconductor industry.

From a purely demand-side perspective, there are no indications in the electronics market that signal a slowdown in growth in the near term. The macroeconomic fundamentals of growth are in place: Businesses surveyed in April and May plan to increase capital spending 6.7 percent this year. Desired system inventories are close to actual inventories, thus minimizing the slack in the electronics-systems food chain. Recent past departures of orders and shipments growth from trend have been corrected and are now close to more stable, long run rates. As it stands now, "all systems are 'go'."

Terrance A. Birkholz

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Research *Bulletin*

OEM MONTHLY—JUNE 1990
FLAT-PANEL COLOR DISPLAYS: LIGHT, BRIGHT, AND IN SIGHT

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

COLOR LCDs OFFER PORTABILITY

Flat-panel color liquid crystal displays (LCDs) are expected to erode the market for color cathode-ray tubes (CRTs) over the next 10 years (see Table 1). Initial uses for color LCDs include personal color TVs and laptop and notebook PCs because small, light screens are needed.

Color LCD TVs have been on the market since 1986, and the first color LCD laptop (the NEC ProSpeed CSX) was introduced in 1989. We estimate that 10,000 of these laptops were sold worldwide in 1989, with 1990 shipments forecast to be 33,000 units.

The following challenges must be met before LCDs become a competitor to color CRTs:

- LCD cost must drop by an order of magnitude. The cost of a color LCD panel is in the $500 to $1,000 range, or approximately 10 times the cost of a color CRT display. We believe that parity will be reached by 1995 because of the investments being made in production facilities worldwide (e.g., more than $500 million in 1990).
- LCD size must triple. The largest color LCD today is 14 inches, whereas displays of 40 inches or more are desired for high-definition TV. Based on the R&D programs sponsored by the Ministry of International Trade and Industry in Japan, we believe that 40-inch color LCDs will be on the market soon after the year 2000.

Companies supplying color LCD panels include Alphasil, Alps Electric, Display Technology Corp (a joint venture between IBM and Toshiba), Hitachi, Hosiden Electronics, Matsushita, Mitsubishi, NEC, Oki, Philips, Sanyo, Seiko-Epson, Sharp, and Sony. Companies with color LCD control circuits include Chips & Technologies, Cirrus Logic, Vadem, and Yamaha.

TABLE 1
Estimated Worldwide Color LCD Displacement of CRTs (Millions of Units)

Equipment Display Type	1990	1995	2000
All Color Displays	75	100	150
All Color TVs	60	75	100
All Color PC Displays	15	25	50
All Color LCD Displays	2	15	90
Color LCD TVs	2	5	60
Color LCD PC Displays	0	10	30
Color LCD Market Share	3%	15%	60%

Source: Dataquest
June 1990

SAM Newsletters 1990: April-June 1990-21

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TECHNOLOGY TURBULENCE AHEAD

Display technology impacts the semiconductors used (see Figure 1). For example, the control electronics for CRTs use bipolar circuits, while those for LCDs use CMOS. Also, a CRT requires high-voltage circuits around it (e.g., a flyback transformer to produce the 20 kilovolts needed for its plate). The components for an LCD, on the other hand, are low-voltage VLSI circuits.

The electronics associated with an LCD eventually may be integrated into the display itself. Papers presented at the 1990 International Solid State Circuits Conference, for example, discussed breakthroughs at both the David Sarnoff and Xerox Palo Alto Research Centers. The ability to produce amplifiers and gates directly on a quartz substrate (to reduce cost) means that LCD makers—rather than chip suppliers—will provide these circuits. Because it usually takes several years for a discovery to move from the lab to the commercial mainstream, we believe that this integration will not happen until after the year 2000.

Furthermore, there is no guarantee that color LCDs will remain as the flat-panel technology of choice. Right now, LCDs are in the lead. A breakthrough, however, in an alternative (e.g., LEDs, gas plasma screens, electroluminescent screens, flat-screen CRTs) would alter the outlook.

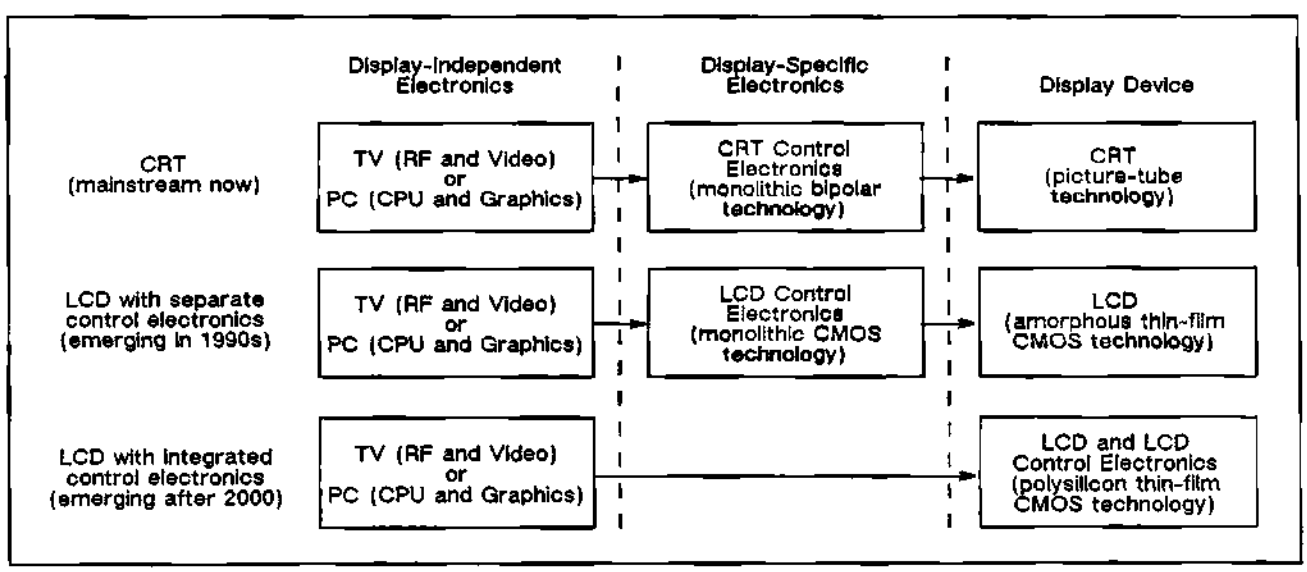
CONCLUSION/RECOMMENDATION

The flat-panel color display represents a user need (e.g., portability) in search of a solution. The semiconductors that will be used are linked tightly to developments in the end market.

Dataquest recommends that companies supplying semiconductors for displays should form partnerships with display OEMs to stay current with technology trends. In addition, suppliers need to realize that this market represents a commitment that goes far beyond the concern for next quarter's bookings.

Roger Steciak

FIGURE 1
Display Subsystem Evolution Scenario



0007023-1

Source: Dataquest June 1990

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Research Newsletter

RISK AND OPPORTUNITY IN EASTERN EUROPE: THE VIEW FROM FINLAND

SUMMARY

Mikhail Gorbachev's June 1990 visit to Silicon Valley will follow his earlier sweeps through Europe's high-tech centers. Systems manufacturers in Western Europe, North America, Japan, and Rest of World now confront a broad strategic decision: Should they target newly emerging markets in the USSR and Eastern Europe, and if so, what will be the time frame and business approach? Strategic planners at systems houses must carefully weigh the possible benefits of doing business in these new markets against an immediate set of hard risks (see Table 1).

During a recent business trip to London, Dublin, Paris, Brussels, Stockholm, and Helsinki we found Dataquest clients in Europe consistently stating that investment payback from these Eastern regions should occur over the long term—at the earliest. For companies committed to success in these emerging regions, Dataquest recommends a look at Finland as a safe and ultimately cost-effective stepping-stone to long-term market goals.

WHAT ARE THE BENEFITS OF ENTERING THESE MARKETS?

The prospective benefits of doing business in the USSR and Eastern Europe sound similar to the rationale for *entering* the China market. These benefits include the following:

- A huge consumer market "hungry" for the latest Western technology and consumer goods
- The availability of an enormous pool of low-cost labor for export or domestic market production
- Access to several specialized technologies (e.g., Soviet expertise in thin-film coatings)

A constant theme in the discussion of these benefits is that an early presence in these emerging

TABLE 1
Risk/Benefit Trade-Offs of Doing Business in the USSR and Eastern Europe

Prospective Benefits	Possible Risks
Early stake in emerging regional economic markets	Unfavorable or nonexistent currency exchange rate systems
Extended life cycle for mature systems (e.g., 80286 PCs)	Legal and political uncertainty (e.g., investment expropriation)
Potential low-cost manufacturing locales	Distant investment payback period
Access to several advanced technologies (e.g., thin-film coatings)	Continuing limitation on flow of technologies into these markets
	Stiff social and linguistic barriers

Source: Dataquest
May 1990

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regional economic markets should translate into a key long-range advantage in terms of market success. Indeed, some companies believe that failure to establish a presence now could mean a company's demise in global markets by the end of this decade.

Extended Life Cycle for Mature Systems

For electronic systems manufacturers, Dataquest already spots some relatively concrete opportunities and benefits for suppliers targeting the USSR and Eastern Europe. These countries represent newly emerging markets for data processing, telecommunications, and related systems. For example, Dataquest expects the installed base of personal computers in the USSR to grow from 150,000 during 1988 to 28 million by the mid-1990s. Demand will focus on lower-cost, user-friendly systems with a well-developed software base (e.g., 80286-based systems). In effect, the regional emerging markets could provide an opportunity for system manufacturers to sharply extend the life cycle of mature equipment.

U.S./USSR "Silicon Summit"

At the end of Mr. Gorbachev's visit to California's Silicon Valley, U.S. systems manufacturers will meet with the USSR's high-technology leaders. Dataquest expects North American companies such as Atari to use these meetings as a starting point for satisfying long-term Soviet demand for PCs and other systems. For example, at the time this article was written, Atari was negotiating to trade its PCs for 256K DRAMs produced at the Soviet state-owned fab in Zelenograd, USSR.

WHAT ARE THE RISKS OF ENTERING THESE MARKETS?

As discussed with clients in Europe, the risks of doing business in the USSR and Eastern Europe *also* sound similar to the reasons for *avoiding* the China market. They include the following:

- Unfavorable or nonexistent currency exchange rate systems
- Legal and political uncertainty (e.g., dramatic domestic political change)
- Lengthy investment payback periods
- Continuing and uneven U.S.-Western European limits on technology exports
- Daunting social, religious, and linguistic barriers to doing business

Unfavorable Exchange Rate Systems

There is an old saying that the only thing worse than an unfavorable exchange rate system is a *nonexistent* exchange rate system. At best, foreign manufacturers that enter these newly emerging markets confront primitive and unfavorable systems. At worst, the dysfunctional systems will force Western businesses into awkward, unfamiliar, and often disadvantageous countertrade arrangements (e.g., bartering PCs for beer, vodka, and raw materials).

Legal and Political Uncertainty

At best, legal systems in the USSR and Eastern Europe are rudimentary in comparison with Western systems. The Eastern legal systems could move into synchronization with international business law over time, but *only* in the absence of sharp domestic political change (as occurred in China during the past two years).

For example, the specter of the Russian military hung over Mikhail Gorbachev's shoulder during early May 1990 as the Soviet conflict with Lithuania, Estonia, and other Soviet Baltic republics continued. Indeed, Mr. Gorbachev's popularity seemed higher in Western Europe than in the USSR. Most European clients quietly supported U.S. President Bush's decision to not pressure Mr. Gorbachev about the Lithuania embargo, although they also expressed concern for the Soviet Baltic people.

The main point is that legal change in these regions will take time; nevertheless, virtually overnight, sudden domestic political change can completely alter the investment landscape.

Limits on Technology Exports

Systems manufacturers face continuing limits on systems technologies that may be sold into these new markets. The members of the European Community (EC) and the North Atlantic Treaty Organization (NATO) announce new embargo

relaxations each month; however, the process remains slow, cumbersome, and uneven in the eyes of many would-be exporters. Suppliers vigilantly honoring the law often hear reports—confirmed as well as unverified—that proscribed systems/technologies surreptitiously make their way into the Eastern markets or already are being manufactured quietly there. In either case, Western systems manufacturers confront the risk that the window of opportunity will be narrower than expected. In like fashion, uncertainty regarding technology controls makes long-term planning on system "technology road maps" and production schedules for these emerging markets quite speculative.

Distant Investment Payback Periods

The clear message from Dataquest's European clients as Europe moves toward 1992 is this: Any payback from investment in the USSR and Eastern Europe will not occur until after 1995 or perhaps early next century. Most European systems manufacturers are willing to allow a few global giants such as AT&T or Siemens to take the lead into these emerging markets. Many European companies are waiting to see if Western Europe reaches its economic-financial unification goals by 1992; if so, they may target their plans for the Eastern Bloc to commence two to five years later. Again, they expect the payback from investments in the USSR and Eastern Europe to occur much later this decade or during the next decade.

THE VIEW FROM HELSINKI, FINLAND

Regardless of the enormous risk and challenge, some systems manufacturers want to enter these new markets as soon as possible. Strategic planners at these companies should consider Finland as a base from which to begin the task.

In terms of geographic proximity, language, and business experience, Finland marks a safe entry point for Western companies interested in doing business in the USSR and the Baltic states *without* making a large, risky initial investment in those areas. For example, the Finnish language is most like the Estonian language, and Estonia is the one region where the Finns can be understood while speaking Finnish. The Finnish business community is also comfortable with doing business in English.

Finland has had a long and challenging history of relations with the USSR and the Baltic states. For example, since World War II, Finland often has been the USSR's leading trade partner among Western nations. Finnish companies do a good amount of business in these emerging regions, and Finnish banks are quite adept at handling the exchange rate/currency conversion and countertrade arrangements. Helsinki is considered an expensive city. However, establishing an office and facility there should prove less expensive in the long term than plunging directly into the USSR or Eastern Europe with costly physical investments.

Table 2 summarizes how Finland can help Western systems manufacturers minimize the risk of doing business in these new regions.

TABLE 2
How Finland Minimizes Business Risks in Eastern Europe

The Risk	The Finnish Alternative
Investment Payback Risk	Finnish physical investment is not vulnerable to government expropriation. Initial small modular Finnish investment can expand as USSR/Eastern European markets prove themselves and eventually allow for large-scale investment in these regions.
Exchange Rate Risk	Finnish banks and trading companies have long-time experience in Soviet-style countertrade.
Government Risk	Finnish facilities are not vulnerable to swings in the USSR and Eastern European legal/political/military structure.
Linguistic Barriers	Finnish staff can communicate in both Estonian and English.

Source: Dataquest
May 1990

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

A recent visit to leading European cities and high-technology centers reveals that the payback from investments in the Soviet Union and Eastern Europe should occur in the distant future at the earliest. Systems manufacturers that target these newly opening markets face a host of risks in terms of monetary exchange systems, technology controls, language, and government stability that signal caution on the part of strategic decision makers. Nevertheless, Dataquest does not advise companies to close their eyes to the prospect of doing business in these regions, especially in the glare of Mr. Gorbachev's anticipated visit to Silicon Valley during early June 1990 and the related U.S./USSR "Silicon Summit."

Balancing prospective return with current hard risk, Dataquest makes the following recommendations:

- Dataquest recommends that major systems manufacturers with deep pockets and a well-established position in Europe make direct investment in these regions during the next several years only if the company can endure a 10- to 15-year investment payback period or, in a worse case, withstand a complete loss of invested capital.
- For systems manufacturers of whatever scale that are firmly targeting the USSR and Eastern European markets—but are averse to risk—Dataquest recommends the establishment of facilities in Finland and/or the formation of alliances with Finnish banks and trading companies.
  - This route should serve as a cost-effective way of reducing investment exposure.
  - Should the markets develop, the presence in Finland can be expanded or used as a stepping-stone for larger direct investment in the emerging markets.
- Otherwise, Dataquest recommends that systems manufacturers establish a foothold presence in these regions now—for strategic information-gathering purposes on business customs, opportunities, and alliance candidates—by creating small "satellite" offices that can lay the foundation for future expansion within the next 5 to 10 years.

Ronald Bohn

Dataquest
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Research Newsletter

PORTABLE PCs: WHAT COMES IN SMALL PACKAGES?

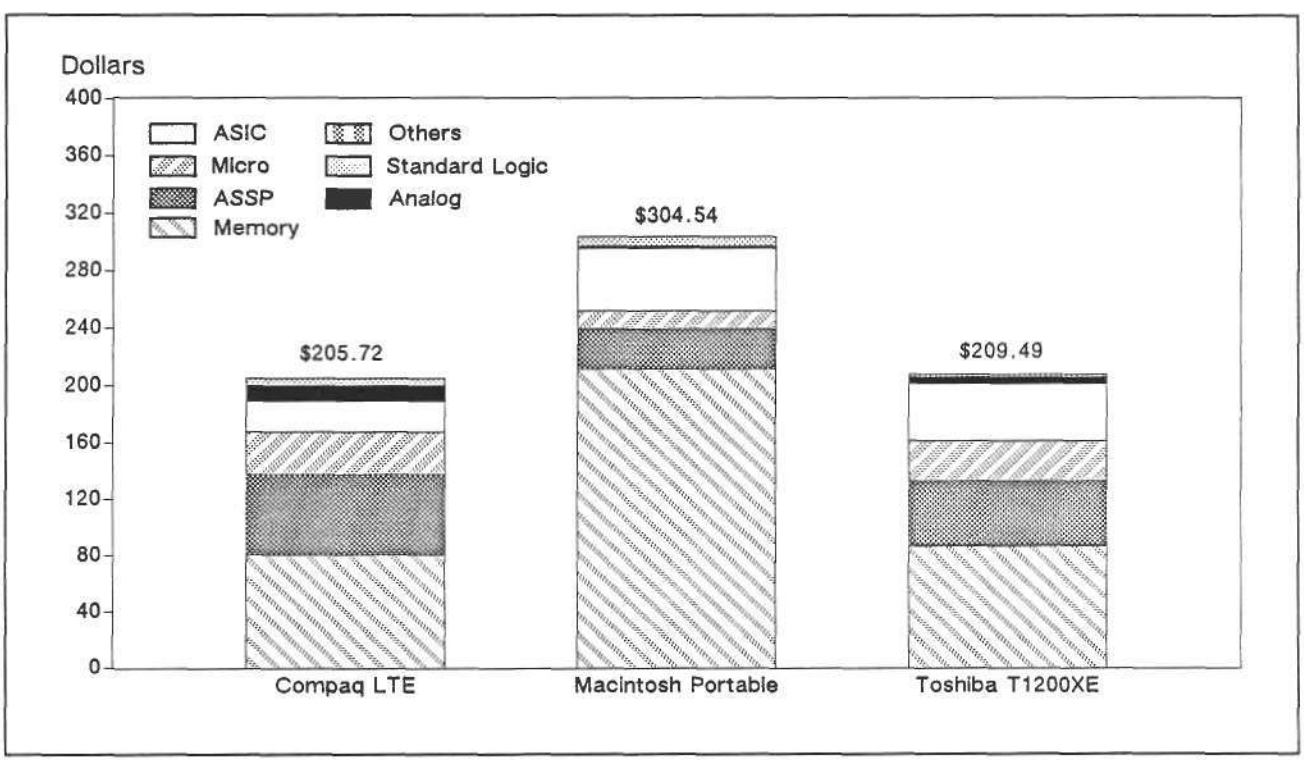
SUMMARY

This newsletter provides a detailed look at the semiconductor content of several recently announced portable personal computers. The models examined 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 costs of the Apple Macintosh Portable, the Compaq LTE, and the Toshiba T1200XE. The pricing data contained in this analysis are based on the Semiconductor User Information Service's (SUIS') pricing study, which assumes a 100,000-piece contract buy. Because manufacturers enjoy varying degrees of purchasing leverage and may secure greater

FIGURE 1
System Component Cost Breakout



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quantity discounts for certain components, these cost figures should be used for comparison purposes only.

SMALL PCS DRIVE A BIG MARKET

As the overall personal computer market slows from double- to single-digit growth, more manufacturers are looking to the "true portable" (laptop and notebook size) segment as the source of explosive growth within an otherwise slowing market. Successful portable design requires that both system designers and semiconductor suppliers reoptimize their products for the stringent power and space limitations required to satisfy consumer tastes. Fortunately, consumers have displayed a willingness to pay a hefty premium for portable PCs with relatively modest performance, provided that they are adequately compensated by acceptable size, weight, battery life, and display.

Table 1 compares the system specifications of the PCs shown in Figure 1. The approximate battery life represents Dataquest's best estimate, assuming typical use. System prices are manufacturers' current list prices.

Each of these products is significant for a different reason. As the industry pioneer, Apple Computer established a reputation as a company that was unafraid to be both daring and different, stressing the individual user experience above all else. But if the user community once looked to Apple for innovation, it is now looking increasingly in anticipation, waiting for Apple to take its cue from the leading edge of the DOS PC marketplace. This hesitancy is particularly evident in the portable segment, where Apple is only just entering with the Mac Portable.

Once a market follower, Compaq Computer has worked hard to recast itself in the innovator's role by being quick to market with the latest available technology. Compaq's latest notebook PC, the LTE, is perhaps the best example of this strategy to date. By using the best technology and manufacturing capabilities available—both internal and external—Compaq has been able to bring a true notebook PC to market sooner than most competitors thought possible.

One of the surprise stories of the 1980s was the Japanese computer industry's failure to wrest industry leadership from U.S.-based PC manufacturers. Hidden within that story, however, are the successes of certain Japanese companies in their own domestic market. Market dominance in Japan, along with a strong U.S. presence, make Toshiba the number one laptop vendor worldwide.

Japan's leadership in the manufacture of compact electronic devices such as minicameras and CD players raises some interesting questions in handicapping the race for leadership in the portable

TABLE 1
System Comparison

	Apple Mac Portable	Compaq LTE	Toshiba T1200XE
Intro Date	Sept. 1989	Oct. 1989	Feb. 1990
Dimensions (H x W x D)	4 x 15.25 x 14.83	1.9 x 11 x 8.5	2 x 12.2 x 11
Weight (Pounds)	13.7	6.2	7.9
Battery Life (Est.)	8.0 hrs.	3.5 hrs.	2.5 hrs.
Display	Active matrix	Backlit supertwist	Sidelit supertwist
Resolution	640 x 400	640 x 400	640 x 400
Graphics	NA	CGA	CGA
Floppy Drive (Inches)	3.5	3.5	3.5
Hard Disk	40MB	20MB	20MB
	3.5 in.	3.5 in.	2.5 in.
Processor	68C000	80C86	80C286
Clock Speed	16 MHz	9.54 MHz	12 MHz
Memory	1MB	640KB	1MB
List Price	$5,499	$2,999	$3,999

NA = Not available

Source: Dataquest
May 1990

PC area. Although the T1200XE just misses qualifying as a notebook under Dataquest's definition (which is a PC that weighs less than 7 pounds and is 2 x 12 x 12 inches, maximum, in size), it nevertheless is a strong flagship product and is being positioned directly against the LTE.

SYSTEMS DISCUSSION

The Mac Portable

The Mac Portable represents Apple's first attempt to leave the desktop, and it looks as if Apple is just testing the waters with this product. At nearly 14 pounds and approximately 900 cubic inches, this machine clearly has room to shrink, and does not appear to have the size and weight optimizations the market demands.

Power consumption is another matter, however. This design shows several significant steps to both reduce power consumption and boost battery life, but costly trade-offs have been made in each case. Apple's lead-acid battery adds tremendous size and weight, and the choice of SRAMs over DRAMs, although significantly reducing power requirements, dramatically increases both chip count and cost.

Table 2 shows the semiconductor content of the Mac Portable.

Apple's decision to pay a premium of approximately $130 (about a 70 percent increase in IC cost) for low-power SRAMs forces this machine to a higher price point, but the choice of microprocessors seems inconsistent. Putting a 68000 at the heart of this machine limits performance and makes the high price hard to justify.

With 8 ASICs and only 17 standard logic components, the Mac Portable shows good consolidation. After adjusting for the extra 24 memory devices necessitated by the use of SRAMs, the Mac's chip count actually is slightly less than that of its two, much smaller competitors.

Users *will* pay a premium for portables, but the poor market acceptance of the Mac Portable proves two things: first, that the consumer budget has *some* limits, and second, that consumers will demand more than just a handle for their portable price premium.

The Mac Portable represents a step in the right direction for Apple, but it is only a first step. We believe that Apple's best effort is yet to come.

The Compaq LTE

Although it is difficult to point to a single leader in a rapidly changing market such as notebook PCs, the LTE has clearly enhanced Compaq's position as one of the industry's prime innovative forces.

This innovation is at least partly a result of Compaq's open-mindedness. For example, Compaq uses merchant chip set components and subcontracts a great deal of the LTE's manufacture. The Apple and Toshiba machines, by comparison, both use proprietary ASICs and are manufactured in-house.

At 8.5 x 11.0 x 1.9 inches, this product is the one true notebook PC described in this newsletter (four LTEs will fit in a standard briefcase). To achieve this compact form factor, Compaq opted to eliminate the traditional motherboard, instead cramming all of the standard circuitry onto two narrow cards wedged between the disk drives.

Even considering both sides of each of these cards, the LTE uses approximately one-half the board area of the T1200XE and just over one-third of the area of the Mac Portable. Table 3 shows the semiconductor content of the LTE.

Given the LTE's compactness, the biggest surprise is the high chip count (71). This fact is attributable to the inclusion of the modem and memory cards and the high number of standard logic components (25). Compaq's use of so many standard logic components is most likely a reflection of time to market and ASIC design cycle constraints.

Although the LTE is certainly not the last word in notebook PCs, Compaq's careful weighing of weight, power, size, performance, value, and time-to-market trade-offs offers an excellent lesson in successful product development and positioning for this market.

The Toshiba T1200XE

As the lead product in the portfolio of one of Japan's strongest computer companies, the T1200XE is representative of the products with which many Japanese PC vendors hope to finally capture a large portion of the U.S. market. Although the T1200XE is just a little too large to qualify as a notebook PC under Dataquest's strict definition, this product has been positioned to compete with notebook PCs. (The recent, highly publicized Toshiba Challenge compared the T1200XE with the LTE286.)

Unlike the LTE, this product is built around a standard motherboard. Toshiba's decision to avoid a more costly and compact board has helped keep materials and manufacturing costs down; however, further shrinking of the T1200XE will be very difficult as long as this large motherboard is retained.

Table 4 shows the semiconductor content of the T1200XE.

The most striking aspect of this design is the high percentage of captive components used. In fact, the merchant chips in this design seem to fall into two categories: chips that Toshiba does not manufacture and chips with very low average selling prices (ASPs). The Toshiba ASICs could be either proprietary ASIC designs or an in-house chip set (Toshiba serves as second source/foundry for several PC logic ship set manufacturers).

In general, captive silicon is thought to offer the advantage of enhanced product differentiation through proprietary (and unclonable) technology. This generalization does not hold true in the DOS PC industry, however, where merchant chip set competition seems to provide the best solution.

Toshiba's high captive content is best viewed as a reflection of corporate philosophy rather than as a source of competitive advantage.

DATAQUEST CONCLUSIONS

Dataquest believes that the portable computer market is an important one for semiconductor manufacturers to follow—if not for its own dazzling potential, then for the excellent insights that today's portable PCs offer into the future electronic content of mainstream desktop PCs.

Figure 2 shows the IC cost distributions of these PCs by semiconductor type. The low analog and standard logic content figures are no surprise to anyone who follows desktop PC content trends. But these machines do seem to differ from their desktop counterparts in their low microcomponent content. We expect the microcomponent content of portables to increase as lower-power 32-bit processors work their way into these designs.

If the three most important elements in capturing PC design wins are price, price, and price, then semiconductor vendors will need to add integration and power considerations to the laptop equation (meaning power management as well as consumption). With so much opportunity tempered by so many headaches, it can safely be said that whichever company wins this business will certainly have earned it.

Kevin Landis

TABLE 2
Macintosh Portable Semiconductor Content

	Vendor	Part Number	Quantity	Description	Estimated Cost ($)	Package	Function/ Comment
Motherboard							
Microprocessor	Motorola	MC68HC000FN12F	1	CPU	9.95	68-pin PLCC	16-MHz system CPU
Microcontroller	Zilog	Z85C3008VSD	1	SCC	2.25	44-pin PLCC	Serial comm controller
ASIC	VLSI	VGT7737-6057	1	Gate array	7.50	84-pin PLCC	Video
	VLSI	VGT7737-6058	1	Gate array	7.50	84-pin PLCC	Misc. glue
	VLSI	VGT7737-6126	1	Gate array	7.50	84-pin PLCC	CPU glue
	VLSI	VC2982-0003	1	Cell-based IC	3.95	44-pin PLCC	SWIM
	VLSI	VC5007-0001	1	Cell-based IC	3.95	44-pin PLCC	ASC
	CMD	G65SC22PE-2	1	Mixed mode	4.15	44-pin PLCC	Video interface adapter
	NA	34250740-2	1	NA	3.95	50-pin PLCC	Keyboard controller
	NA	34250753-A	1	NA	5.45	60-pin PLCC	Power manager
ASSP	NCR	53C80	1	SCSI host adapter	3.25	44-pin PLCC	SCSI host adapter
Memory	Seiko SMOS	SRM20256LM10	32	256K PSRAM (100ns)	193.60	28-pin SOG	1MB main memory
	Sony	CXK58257M-70LA	1	256K SRAM (70ns)	9.97	28-pin SOG	Video buffer
	Toshiba	TC54100F-20	2	1Mb ROM (200ns)	8.28	32-pin SOG	BIOS
Analog	Linear Tech.	LTC1040CN	1	Dual comparator	0.14	18-pin SOG	1.5uW
	Linear Tech.	LT1054CN8	1	Voltage converter	0.13	8-pin SOG	
	Linear Tech.	LF412A	1	Dual op amp	0.19	8-pin SOG	
	PMI	OP20H	4	Low-power op amp	0.25	8-pin SOG	
Standard Logic	Pujitsu	74AC244	4	Octal driver	2.36	20-pin SOG	
	Pujitsu	74AC245	2	Octal bus transceiver	1.24	20-pin SOG	
	National	26LS32ACM	2	Quad 2-in. OR	0.50	16-pin SOG	
	AMD	AM26LS30JC	2	8-in. NAND	0.50	20-pin PLCC	
	Motorola	74AC153	1	Dual 4-in. MUX	0.40	16-pin SOG	
	Motorola	74HC133	1	13-in. NAND	0.15	16-pin SOG	
	Motorola	74AC02	1	Quad 2-in. NOR	0.22	14-pin SOG	
	Motorola	74AC157	1	Quad 2-in. MUX	0.41	16-pin SOG	
	National	74AC10	1	Triple 3-in. NAND	0.23	14-pin SOG	
	NA	NA	2	NA	0.50	18-pin PLCC	
		Total	70		278.47		
Display Card							
ASSP	Toshiba	T7778A	8	Column pixel driver	12.72	100-pin PLCC	
	Toshiba	T7900	6	Row pixel driver	12.30	92-pin PLCC	
Analog	NA	C324G	2	Quad op amp	0.44	14-pin DIP	
Standard Logic	NA	HC00	1	Quad 2-in. NAND	0.10	14-pin DIP	
	NA	HC04	3	Hex inverter	0.30	14-pin DIP	
	NA	HC74	1	Dual D flip-flop	0.12	14-pin DIP	
	NA	5291-810	1	NA	0.09	8-pin DIP	
		Total	22		26.07		
		Total IC Count	92		304.54		

NA = Not available

Source: Dataquest
May 1990

TABLE 3
Compaq LTE Semiconductor Content

	Vendor	Part Number	Quantity	Description	Estimated Cost ($)	Package	Function/ Comment
Board 1							
Microprocessor	Oki	M80C86A-10	1	CPU	4.75	44-pin PLCC	10-MHz system CPU
ASIC	Fujitsu	MB625154	1	Gate array or CBIC	4.75	44-pin QFP	
ASSP	Chips	F82C100	1	Systems logic chip	12.00	100-pin QFP	XT system controller
	Dallas	DS1285Q	1	RTC + RAM	4.05	28-pin PLCC	Real-time clock
Memory	NEC	424256-80M	4	1Mb DRAM	31.00	20-pin SOJ	256Kx4, 80ns
	Oki	M41464-10	4	256K DRAM	8.40	18-pin SOJ	64Kx4, 100ns
	Intel	N27C256	2	256K EPROM	4.50	32-pin PLCC	BIOS (socketed)
Standard Logic	Mitsubishi	74HC244	2	Octal driver	0.46	20-pin SOG	Noninverting 3-state
	Mitsubishi	74HC373-1	3	Octal latch	0.69	20-pin SOG	
	Mitsubishi	74HC245-1	1	Octal bus transceiver	0.24	20-pin SOG	
	Fujitsu	74ACT245	1	Octal bus transceiver	0.65	20-pin SOG	
	TI	74HC244A	1	Octal driver	0.23	20-pin SOG	
	TI	74HC14	1	Hex Schmitt trigger	0.10	14-pin SOG	
Analog	TI	TL555C	1	Timer	0.20	8-pin SOG	
		Total	24		72.02		
Board 2							
Microperipheral	National	NS16C450V	1	UART	4.75	44-pin PLCC	
	National	DP8473V	1	Floppy controller	6.75	52-pin PLCC	
	Mitsubishi	NM	1	Keyboard scanner	5.25	72-pin QFP	
ASIC	Fujitsu	NM	1	CMOS gate array	4.75	44-pin QFP	
	Fujitsu	NM	1	CMOS gate array	11.75	120-pin QFP	
ASSP	Chips	F82C425	1	CGA controller	9.50	100-pin QFP	Flat-panel controller
Memory	Sony	CXK5864BM-12L	3	64K SRAM	6.75	28-pin SOG	8Kx8, 120ns
Standard Logic	TI	TI848D/431AC	1	NA	0.10	8-pin SOG	
	TI	74HCT652	1	Octal bus transceiver	0.46	24-pin SOG	
	NA	3771/M21	1	NA	0.10	8-pin SOG	
	Signetics	74LS05D	1	Hex inverter	0.10	14-pin SOG	
	Mitsubishi	LS257A	2	Quad 2-in. MUX	0.74	16-pin SOG	
	Mitsubishi	74HC244	1	Octal driver	0.23	20-pin SOG	
	Mitsubishi	74HC04	1	Hex inverter	0.10	14-pin SOG	
	National	M912-DS34C87M	1	NA	0.13	16-pin SOG	
	National	74HC125M	1	Quad buffer	0.15	14-pin SOG	
Analog	Maxim	MAX241CWI	1	RS232 driver/receiver	1.85	28-pin SOG	
		Total	20		53.46		
Modem Board	Signetics	114238/930	2	NA	0.20	8-pin SOG	
	Fujitsu	109457-001	1	NA	0.15	24-pin SOG	
Standard Logic	TI	74HC174	2	Hex D flip-flop	0.18	14-pin SOG	
	NVP	74HC125D	1	Quad buffer	0.15	14-pin SOG	
Memory	Cypress	93C46K	1	NV RAM	0.10	8-pin SOG	
Microcontroller	Oki	M83C154-222	1	Microcontroller	4.25	44-pin PLCC	
	National	NS16C450V	1	UART	4.75	44-pin PLCC	
ASSP	SSI	73D215A-CH	1	Modem signal processor	9.90	44-pin PLCC	
ASSP (Analog)	SSI	73M214-IH	1	Modem front end	7.55	28-pin PLCC	2400-bps modem filter
		Total	11		27.23		
Memory Board	Toshiba	TC524256AJ-10	4	1Mb DRAM	29.36	20-pin SOJ	256Kx4, 80ns
Display Card	NA	358/848	2	Dual op amp	0.70	8-pin SOG	
	NA	F5049	1	Display driver	0.95	28-pin SOG	
	NA	NA	3	Row pixel driver	6.00		
	NA	NA	8	Column pixel driver	16.00		
		Total	14		23.65		
		Total IC Count	73		205.72		

NA = Not available
NM = Not meaningful

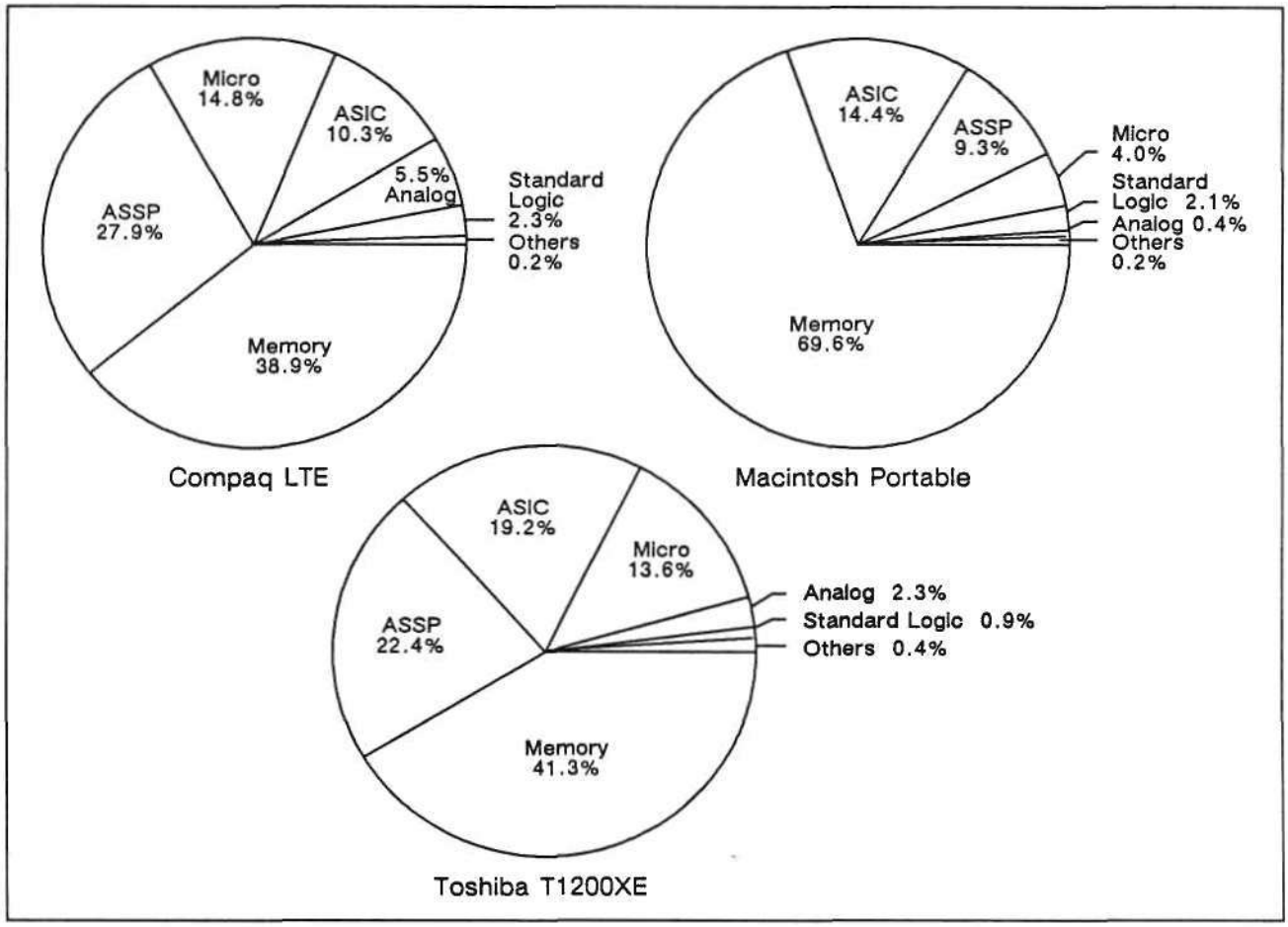
Source: Dataquest
May 1990

TABLE 4
Toshiba T1200XE Semiconductor Content

	Vendor	Part Number	Quantity	Description	Estimated Cost ($)	Package	Function/ Comment
Motherboard							
Microprocessor	Harris	CS80C286-12	1	Microprocessor	19.50	68-pin PLCC	12-MHz CMOS (socketed)
Microcontroller	Toshiba	80C49-6361	1	8-bit controller	2.65	44-pin QFP	Keyboard controller
	Toshiba	U42P531A	1	8-bit controller	3.52	44-pin QFP	Keyboard controller
ASSP	Motorola	MC146818AF	1	RTC	3.80	24-pin SOG	Real-time clock + RAM
	Toshiba	T9778A	1	Graphics controller	11.50	144-pin QFP	
Memory	Toshiba	TC514256AJL-80	8	80ns, 256Kx4 DRAM	62.00	20-pin SOG	1 MByte system memory
	Toshiba	TC55257AFL-12L	1	120ns, 256K SRAM	5.23	28-pin SOG	Display buffer
	Toshiba	TC55257BFL-10	1	100ns, 256K SRAM	5.90	28-pin SOG	Display buffer
	Toshiba	TC531000CF	1	1MB EPROM	6.66	28-pin SOG	Display BIOS (OTP)
	AMD	AM27C010-200DC	1	1MB EPROM	6.66	32-pin DIP	System BIOS (socketed)
ASIC	Toshiba	DC2286P175A	1	Gate array	16.64	208-pin QFP	System logic
	Toshiba	DC2262P863A	1	Gate array	6.00	100-pin QFP	Bus buffer
	Toshiba	DC2258P841A	1	Gate array	6.00	100-pin QFP	Bus buffer
	Toshiba	DC2261P476A	1	Gate array	8.00	100-pin QFP	Display support
	Toshiba	DC2259P173A	1	Gate array	3.52	44-pin QFP	Memory standby and refresh
Standard Logic	Motorola	74HC240	1	Octal bus driver	0.27	20-pin SOG	
	Motorola	74HC244	1	Octal driver	0.28	20-pin SOG	
	Motorola	74LS244	1	Octal driver	0.23	20-pin SOG	
	Motorola	74HC04A	1	Hex inverter	0.10	14-pin SOG	
	Hitachi	74HC157	2	Quad 2-in. data selector	0.16	16-pin SOG	
	Hitachi	74HC08	1	Quad 2-in. AND	0.24	14-pin SOG	
Analog	Motorola	MC145406/945EG	2	Line driver	0.80	16-pin SOG	RS-232 driver (12 volt)
	Toshiba	TC8568AM	1	NA	0.55	24-pin SOG	
	Toshiba	TB62007F	4	Octal driver	1.80	20-pin SOG	
	NA	NA	1	NA	0.09	8-pin SOG	
		Total	37		172.10		
Power Board							
Microcontroller	Toshiba	TMP47P860F	1	4-bit MCU	0.85	64-pin QFP	
	Toshiba	TMP90C840F	1	8-bit MCU	1.90	64-pin QFP	
Standard Logic	Toshiba	4049BF	1	Level shifter	0.15	16-pin SOG	
	Toshiba	DC2209P456A	1	NA	0.40	28-pin SOG	
	NEC	A1600/9003K7	2	NA	0.36	20-pin SOG	
Analog	National	LM358	1	Dual op amp	0.35	8-pin SOG	
	National	LP324M	1	Quad op amp	0.31	14-pin SOG	
		Total	8		4.32		
Display							
ASSP	Toshiba	T7778A	16	Column pixel driver	25.44	100-pin QFP	
	Toshiba	T7900	3	Row pixel driver	6.15	92-pin QFP	
Standard Logic	Toshiba	T40H163F	1	Counter	0.10	16-pin SOG	
	Toshiba	T40H047F	1	NA	0.10	16-pin SOG	
	Toshiba	T40H367F	1	Hex buffer	0.10	16-pin SOG	
	Toshiba	T40H240	1	Octal buffer	0.10	16-pin SOG	
Analog	Toshiba	LA5316	1	NA	0.35	20-pin SOG	
	Toshiba	TA75902F	1	NA	0.23	14-pin SOG	
	TI	TL1451A	1	Peripheral driver	0.50	16-pin SOG	
		Total	26		33.07		
		Total IC Count	71		209.49		

Source: Dataquest
May 1990

FIGURE 2
Semiconductor Cost Distributions, Base Configurations



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Source: Dataquest
May 1990

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Research *Bulletin*

SAMONITOR: SYSTEMS OUTLOOK REMAINS UPBEAT

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

The computer market continued to improve in March. Shipments growth for the three-month period ended in March was 6.3 percent above

Figure 1
Computers and Office Equipment

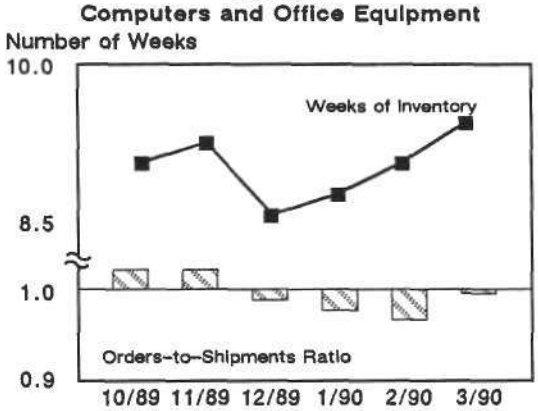


Figure 2
Communications Equipment

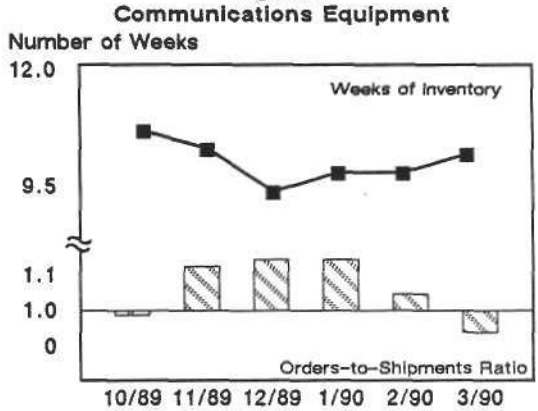


Figure 3
U.S. Instruments

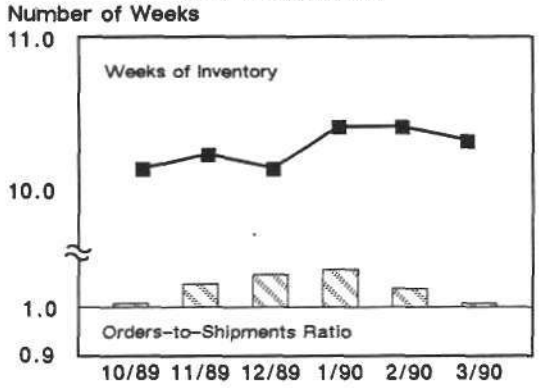
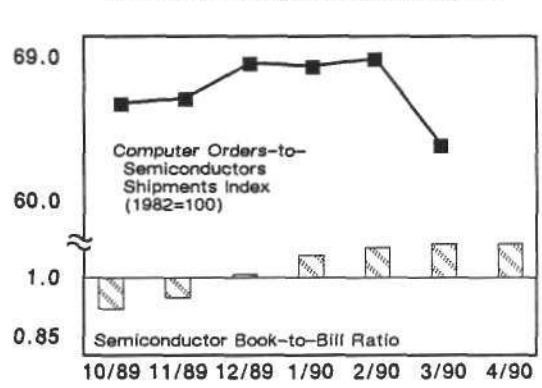


Figure 4
Semiconductors and Computers



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Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
May 1990

SAM Newsletters 1990: April-June 1990-18
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year-earlier shipments, compared with 6.8 percent in February. Orders growth for the same period was 6.8 percent above year-earlier orders, compared with 6.5 percent in February. Improved market conditions helped turn around the orders-to-shipments ratio, which rose to parity in March after falling for three consecutive months (Figure 1). Inventories continued their seasonal upward movement to 9.5 weeks in March, up from 9.0 weeks in February but still 0.5 weeks below last year's level. During the next several months, Dataquest expects orders growth to stabilize around current rates. However, shipments growth is expected to accelerate in response to the fourth quarter's run-up in orders growth. Growth in computer production already has been felt in the chip market. As production continues to expand, all signals indicate that the chip market should continue to follow suit.

Communications Equipment

As forecast by Dataquest, orders growth continued to decelerate in March. Orders growth for the three-month period ended in March was only 1.5 percent above year-earlier orders, compared with 10.3 percent in February. Given the unusual run-up in growth late last year, this recent slowdown is more likely to be the result of a return to normalcy from unsustainably high growth than the result of a fundamental change in business conditions. Shipments growth for the three-month period ended in March was 8.9 percent above year-earlier shipments, compared with 9.8 percent in February. As a result of the recent decline in orders growth, the orders-to-shipments ratio (Figure 2) fell for the second consecutive month to 0.94 in March, from 1.05 in February. March inventories were 10.2 weeks, continuing their seasonal upward movement, but nonetheless were 1.4 weeks below year-earlier levels. For the next few months, Dataquest expects orders growth rates to accelerate and then become more sustainable, in the 8 to 10 percent range, while shipments growth should remain relatively stable.

Instruments

Orders and shipments growth improved significantly in March. Orders growth for the three-month period ended in March was 9.1 percent above year-earlier levels, compared with 6.3 percent in February. Shipments growth for the same period was 5.8 percent above year-earlier levels, compared with 3.7 percent in February. Although the orders-to-shipments ratio (Figure 3) moved down in March to 1.01, from 1.04 in February, March orders and shipments growth acceleration indicates a healthy market. March inventories edged down slightly to 10.3 weeks, from 10.4 weeks in February; they are 0.7 weeks below year-earlier levels. Dataquest believes that recent shipments and orders activity reflects the continuation of a market correction to more sustainable growth rates. The coming months should be marked by relatively stable growth.

SEMICONDUCTOR DEMAND

The U.S. semiconductor market continued to expand in April, albeit at a meager pace. U.S. market bookings (three-month moving average) rose 1.0 percent in April to $1,279.3 million, while billings rose 0.8 percent in April to $1,172.0 billion. As a result, the U.S. semiconductor market book-to-bill ratio remained 1.09 in April, unchanged from March (Figure 4). Recent stability in DRAM prices and moderate expansion in non-DRAM chip areas likely have contributed to the ratio's recent activity.

As expected, the computer-orders-to-semiconductor-shipments index, a leading indicator of chip orders and shipments, fell significantly in March to 63.7, from 69.1 in February (Figure 4). Dataquest maintains that this decline is more a response to first quarter seasonality in computer orders—which typically trend downward during the first quarter and upward the remainder of the year—than an indication of a contracting market. Computer market fundamentals are sound. So far this year, three-month-ended computer orders have been ahead of last year and accelerating: 4.2 percent in January, 6.5 percent in February, and 6.8 percent in March. Dataquest expects the index to begin its upward trend in April, portending continued expansion in the chip market as the year unfolds.

Dataquest's monthly survey of major OEM semiconductor procurement managers supports this optimism: *Procurement managers' six-month system sales forecast for overall OEMs is 7.8 percent, while computer OEMs expect an 8.0 percent increase through October.*

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The outlook for U.S. electronic equipment production growth remains upbeat and shows no sign of running out of steam anytime soon. As the expansion matures and the fundamental determinants of growth solidify, variability in month-to-month business activity should lessen, thus adding to the expansion's durability. In turn, on a *unit basis*, the semiconductor market should continue to expand at a moderate rate. On the other hand, because of ASP variability, *revenue growth* is likely to stabilize and decline in selected products. Dataquest continues to advise semiconductor manufacturers not to underestimate the strength of the current expansion. History shows how easily and quickly market share can be lost because of undue pessimistic bias in forecast judgment.

Terrance A. Birkholz

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Research Newsletter

THE U.S. CONSUMER CELLULAR SCENARIO

SUMMARY

There are indications that cellular telephones are becoming a consumer product in the United States (see Table 1). If this scenario occurs as expected over the next five years, the dynamics experienced by suppliers to this market will change. Today's relatively mild competition in a business market will give way to the brutal competition of consumer electronics. Suppliers of components used in cellular telephones will not be immune from this shift because the dynamics of an equipment market always are felt by companies upstream in the electronics manufacturing chain.

The history of other consumer electronic products has been examined to provide a scenario of what might be in store for cellular. The consumer premise leads to the prediction that the value of the semiconductors used in the cellular telephones sold in the United States will decline from an estimated $54 million in 1990 to an estimated $45 million in 1995. This result would occur although the number of cellular telephones sold is likely to increase from an estimated 1.2 million units in 1990 to an estimated 3.0 million units in 1995.

We conclude that the cellular telephone will evolve into *the* "personal communicator" during the 1990s, based on our observations of the shifts that are under way in sales channels and product features. We also conclude that the present suppliers of components used in cellular telephones will have to make a decision about their ability to compete in this market in the long term because cellular is destined to become a consumer product with high unit sales and aggressive pricing. We recommend that suppliers that are not (or cannot become) high-volume, low-cost producers prepare to exit the market sometime during the next five years.

TABLE 1
A U.S. Consumer Cellular Market?

Indicator	Trend
Number of Users	Increased from 1.1 million in 1987 to an estimated 5.0 million in 1990 (66 percent CAGR)
Telephone Prices	Declined from $1,600 in 1984 to an estimated $550 in 1990 (negative 16 percent CAGR); some units less than $400
Sales Channels	Handsets now being sold at retail outlets such as Circuit City, Macy's, Radio Shack, and Sears
Monthly Rates	Several operators experimenting with pricing programs more appealing to consumer usage
Digital Cellular	Would triple network capacity at one-half the cost of a new system; would lead to 30 percent reduction in monthly rates; expected to begin in 1991
PCN Authorization	A long-term program to substantially increase network capacity; $50 to $75 handset prices likely

Source: Dataquest
May 1990

0006966
SAM Newsletters 1990: April-June 1990-17

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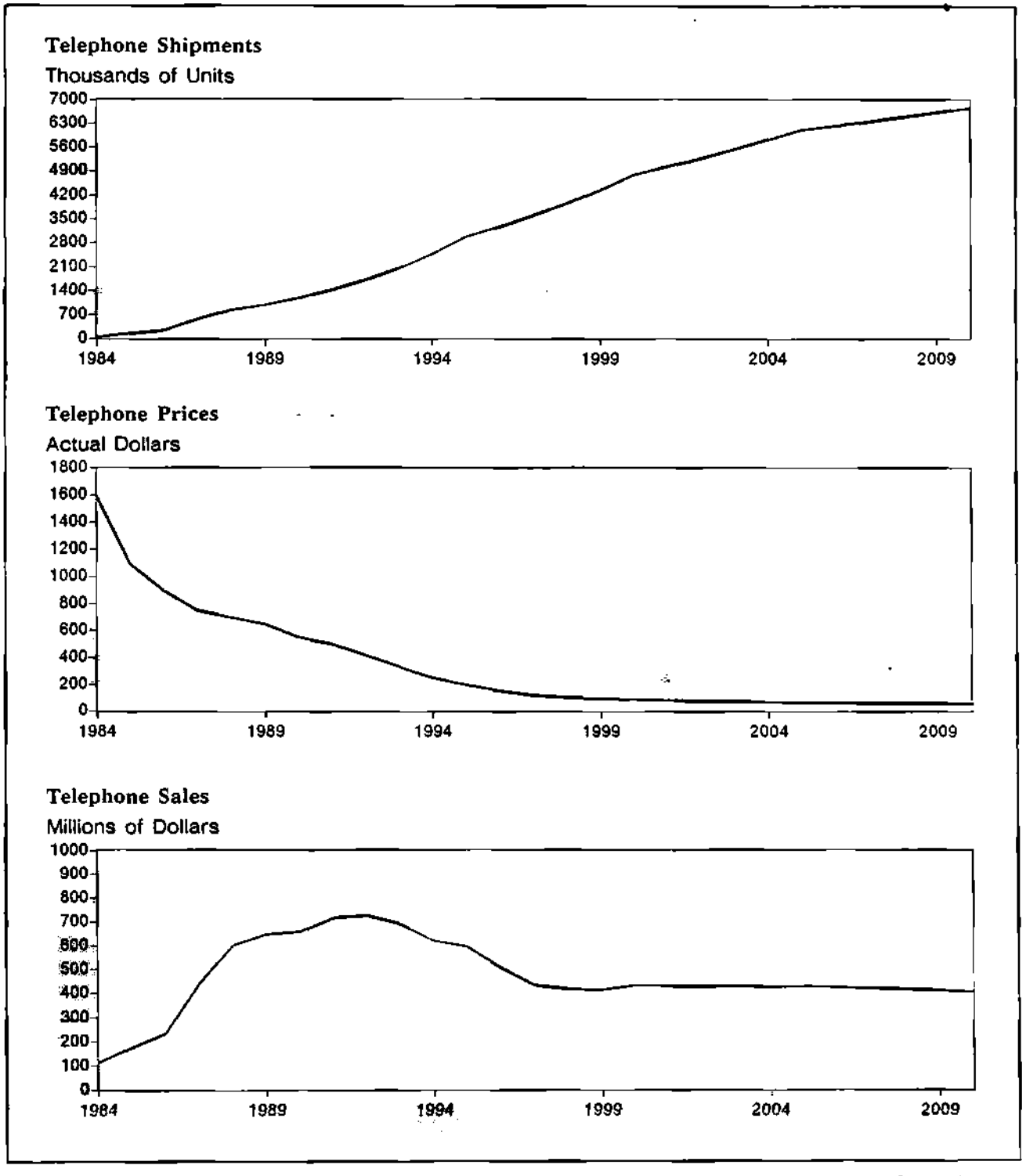
FIGURE 1
Actual and Estimated U.S. Consumer Cellular Scenario—Telephones



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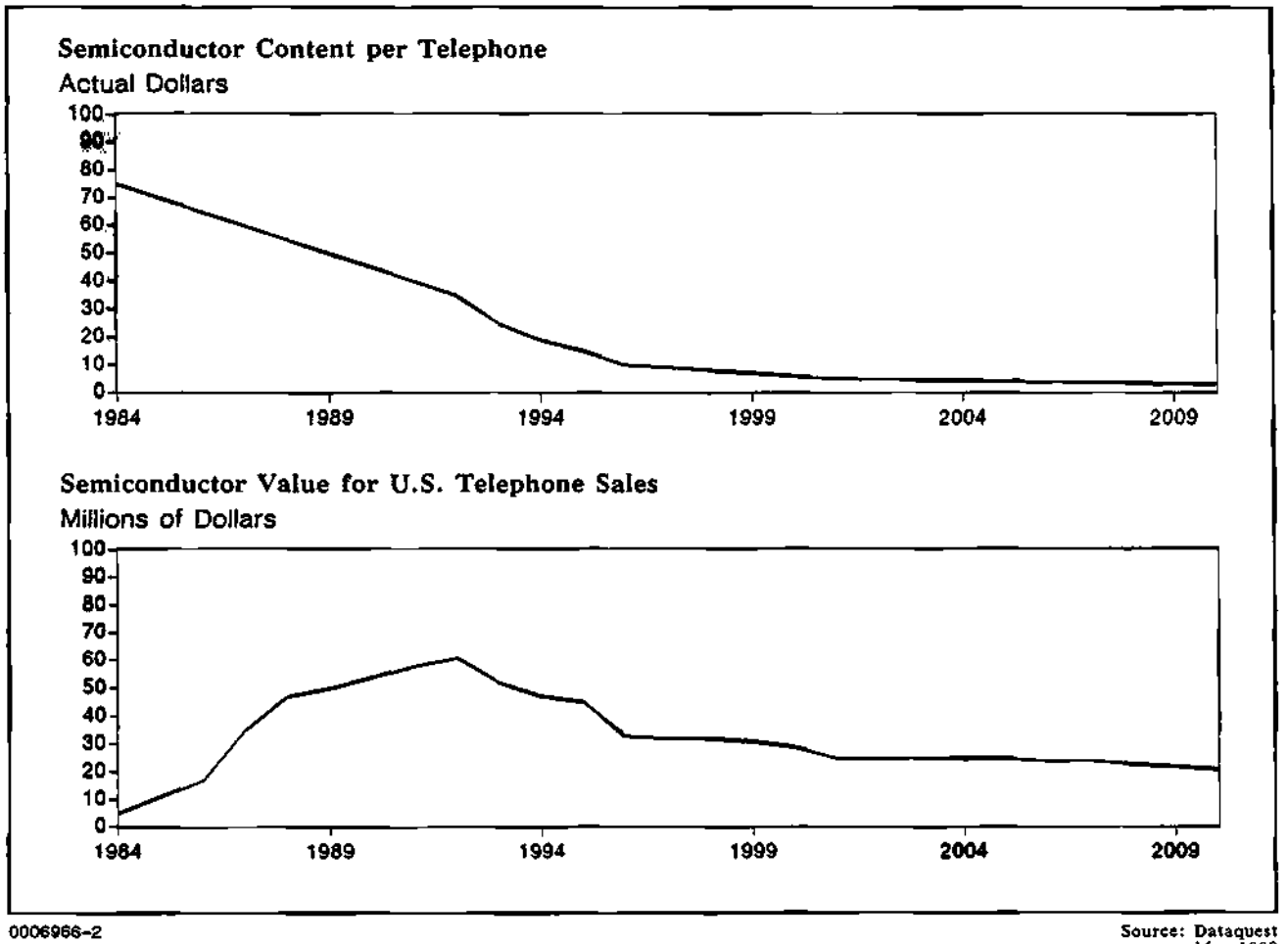
Source: Dataquest
May 1990

FIGURE 2
Actual and Estimated U.S. Consumer Cellular Scenario—Semiconductors



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Source: Dataquest
May 1990

THE U.S. CONSUMER CELLULAR SCENARIO SUMMARIZED

As cellular telephones become a consumer item, market revenue is expected to decline from an estimated peak of $725 million in 1992 to the $400 million level after 1995 because prices will decrease faster than unit shipments will increase (see Figures 1 and 2). The value of the semiconductors used in these phones also would decrease, from an estimated peak of $60 million in 1992 to $45 million in 1995.

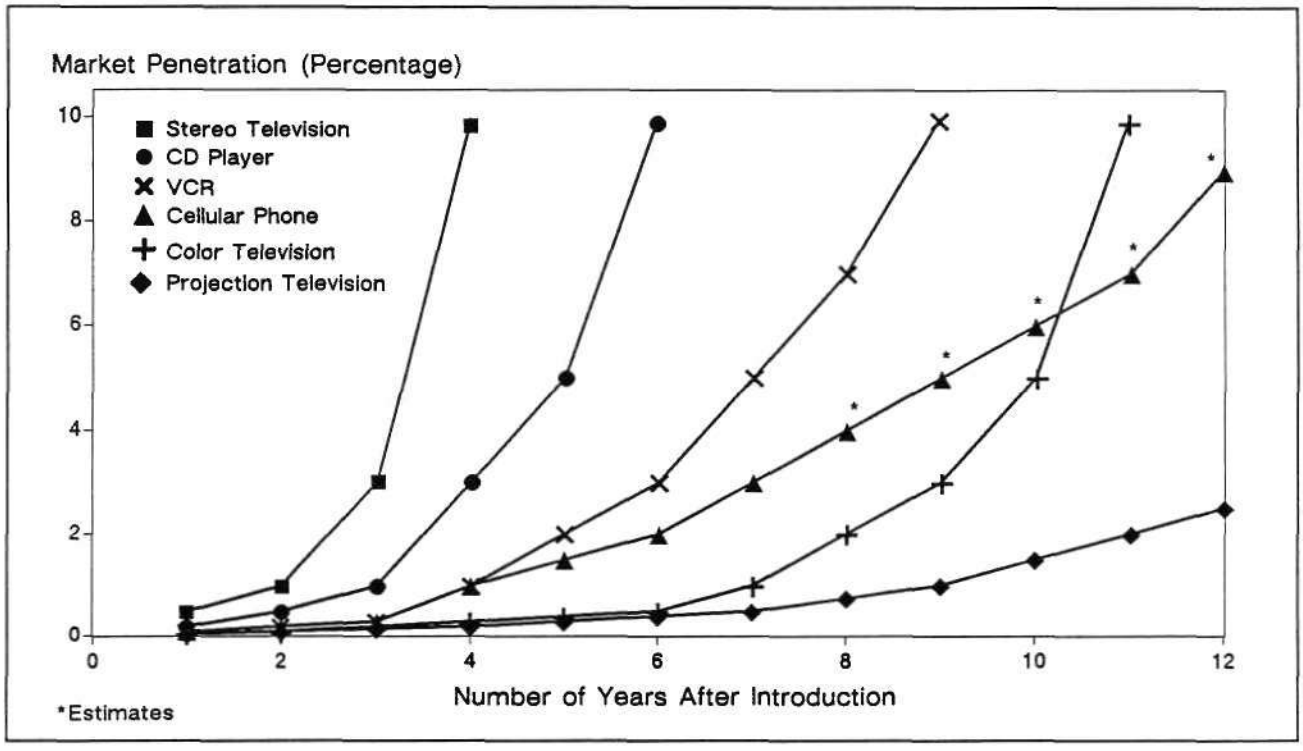
The long-term trend is for semiconductor consumption to continue to decrease. The cellular telephone is projected to have a price of $60 by the year 2010 (according to this scenario), with a $3 semiconductor content value and a total semiconductor consumption of $20 million for the units sold in the United States. Total revenue for the cellular telephones sold in the United States would remain at the $400 million level.

The Calculator, TV, and VCR Experiences

Hand-held calculators already have exhibited this kind of behavior. In the first seven years after their introduction, calculator prices declined from $180 to $55 (for a CAGR of negative 18 percent). Cellular telephone prices have declined at a CAGR of negative 16 percent during the first seven years after their introduction. Calculator shipments increased from 395,000 units to 26 million units (for a CAGR of 101 percent) during their first seven years. Cellular telephone shipments, on the other hand, increased from 72,000 units to 1.2 million units (for a CAGR of 60 percent) during the first seven years of their market life.

The cellular telephone is displaying a behavior similar to the VCR and color TV in its penetration of the market (see Figure 3). At introduction, these products had high prices and

FIGURE 3
Time to 10 Percent Penetration for Various Consumer Electronic Products



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Source: Dataquest
May 1990

were purchased only by a small group of early adopters. As consumers became more familiar with these products and prices declined, unit shipments increased. Although businesses were the early adopters of cellular, consumers are expected to account for most of the market after 1995.

The cellular telephone of the future will likely be enhanced with more features. For example, paging and voice-command dialing would complement its present conversation-carrying capability well. The mainstream user does not need much more than these items. Hence, the consumer scenario is based on the assumption that the cellular telephone (like the four-function calculator) will remain in its present form, with the incorporation of new technology resulting in the reduction of equipment prices. This dynamic is different from PCs, where the incorporation of new technology upgrades performance and maintains equipment prices.

The Case for an "Embedded Cellular" Market

Some fax machines and laptop PCs today are connected to the cellular network. The market for these items, however, is small because the high rates for cellular service limit the user base. As rates decline, users will find that the wireless nature of cellular is a benefit and will want cellular fax machines and cellular laptop modems for the convenience they offer. These types of products represent an embedded market for cellular components. Other potential embedded cellular applications include data entry terminals, smart cards, motor vehicles, and global positioning satellite (GPS) receivers. The potential market for cellular components in these kinds of products could exceed 10 million units per year (based on a share of the 15 million motor vehicles and 10 million PCs sold in the United States each year).

The embedding experience of calculators and digital watches (and the present embedding trend with CD players) provides a clue for what might happen to cellular. Almost all hand-held electronic gadgets today (e.g., currency converters, electronic diaries, and language translators) include a four-function calculator capability. Digital clocks exist in nonclock electronic products such as VCRs, PCs, car stereos, and TV sets. The $100 consumer price of CD players makes it practical to build them into car and personal stereos. The reduction

in cost of a cellular link because of high-volume consumer use means that low-cost cellular components will be available and affordable for other product applications that users do not usually think of as being "cellular." The embedded cellular market is likely to become more significant after the year 2000, when component prices are low and component suppliers are looking for new uses for their production.

THE NEXT FIVE YEARS FOR CELLULAR IN THE UNITED STATES

Shipments of digital cellular telephones are expected to begin in 1991 and should have a 40 percent market share in 1995 (see Figure 4). We expect digital cellular unit shipments in the early 1990s to be double the analog cellular shipments of the mid-1980s. Users are more familiar with cellular now, and network operators in congested areas (e.g., Los Angeles, New York) have no other way to expand their number of users.

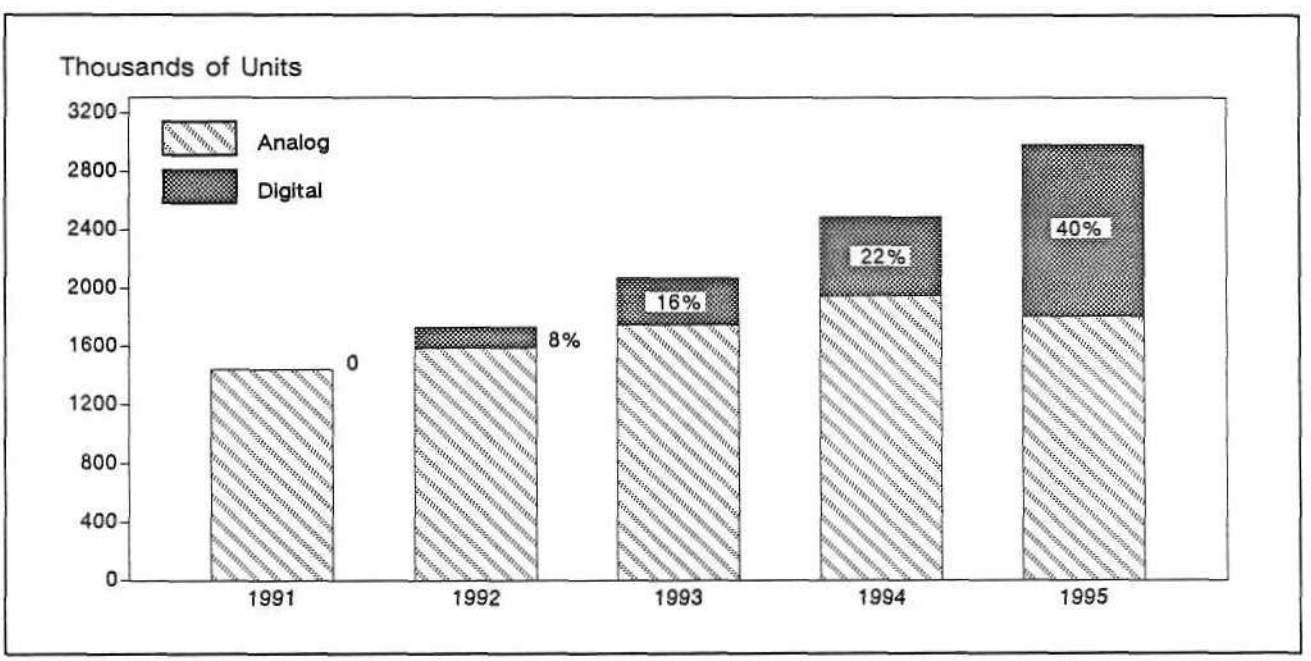
Consumer cellular is an emerging market that will change the landscape of electronics if it succeeds. As an emerging market, however, there is a great deal of uncertainty about the exact path that consumer cellular will take because there are many decisions to be made that can affect the outcome. For example, each cellular network operator in the United States has to decide when and how to migrate from analog to digital transmission. Although it is likely that all U.S. cellular networks will be digital by year 2000, the precise phase-in timing during the 1990s is not predictable right now.

Cellular Suppliers

Suppliers of cellular telephones in the United States include the following:

- Antel
- Alpine
- Audiovox
- Blaupunkt Bosch
- Clarion
- Ericsson GE
- Fujitsu
- Hitachi
- Kokusai
- Mitsubishi
- Motorola
- NEC
- Nokia-Mobira
- NovAtel
- Oki
- Panasonic
- Philips
- Shintom
- Sun Moon Star
- Tactel
- Tandy
- Technophone
- Toshiba
- Uniden

FIGURE 4
Estimated Digital Share of U.S. Cellular Market
(Thousands Of Units)



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Source: Dataquest
May 1990

THE CONSUMER CELLULAR SCENARIO: IT'S JUST ONE "SIMULATION"

The consumer cellular scenario is based on the assumption that cellular telephones will behave like other consumer electronic items in the marketplace as more consumers use them. The continuing popularity of cellular telephones is not guaranteed, however; other consumer electronic products (e.g., eight-track tape, quadraphonic sound) were great ideas that never caught on. Cellular telephones could remain primarily a business market, with consumers an important but secondary factor. If this scenario occurs, the rapid price declines and other potential applications (e.g., embedded cellular) may not happen for decades.

The consumer cellular scenario has the following *good points:*

- A worst-case description for the component supplier of what could happen (i.e., the market becomes much more competitive)
- A general description of the long-term trend of internetworked people and machines on a global basis

The consumer cellular scenario has the following *bad points:*

- No description of how government regulations could help or hinder market development
- No information on market timing (i.e., the scenario predicts by historical analogy rather than by an econometric model)

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest concludes that the cellular telephone will evolve into *the* "personal communicator" of the 1990s, based on our observations of the shifts under way in sales channels and product features. We also conclude that the present suppliers of components used in cellular telephones will have to make a decision about their ability to compete in this market in the long term because cellular is destined to become a consumer product with high unit sales and aggressive pricing.

We recommend that suppliers that are not (or cannot become) high-volume, low-cost producers prepare to exit the market sometime during the next five years.

Roger Steciak

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Research Newsletter

GSM IN EUROPE—CELLULAR TURNS DIGITAL

SUMMARY

The Groupe Speciale Mobile (GSM) pan-European digital cellular network is to be launched across Europe from July 1991. This newsletter examines how the market for GSM digital cellular telephones will develop in Europe over the next few years. In particular, we will look at the constituent parts of a GSM telephone, discuss what impact they will have on its selling price, and forecast the market for semiconductors that will result.

The semiconductor cost per first-generation GSM handset will exceed three times that used in current analog cellular handsets. Despite the increase, we argue that the average selling price of GSM handsets will not be sufficiently higher than for analog cellular so as to prejudice its market acceptance. Of this content, 60 percent will consist of CMOS logic, 30 percent of high-frequency bipolar/CMOS/BiCMOS linear technologies, and 10 percent of mixed analog-digital BiCMOS/CMOS technologies.

We forecast an aggressive rollout for GSM, with 276,000 units forecast to be shipped in 1991, rising almost linearly to nearly 2.5 million units by 1994. This will drive a semiconductor market worth $60 million in the first year, climbing to $421 million by 1994.

INTRODUCTION

GSM is to be adopted by 17 European countries from July 1991. The first services are likely to commence in West Germany, the United Kingdom, and Scandinavia. GSM initially focused on the radio transmission methods, or "air interface," used to communicate between mobiles and base stations. The GSM air interface is time-division multiple access (TDMA), made up of 123 channels of 200-kHz bandwidth, each with 8 speech slots per channel in two bands:

- 890- to 915-MHz (mobile receive)
- 935- to 960-MHz (mobile transmit)

Speech is compressed and encoded at 13 kbps, less than one-quarter of the 64-kbps rate commonly used for digital voice transmission.

Today, GSM defines all the major interfaces between the building blocks in the network, shown in Figure 1. Mobile stations (MS) communicate with a local base station system (BSS). Each BSS consists of a controller (BSC) and a number of transceiver stations (BTS). Connection between the base stations and the public-switched telephone network (PSTN) is made via mobile switching centers (MSC). Other blocks, not shown in Figure 1, are defined to provide for management and maintenance of the network.

GSM—ITS ADVANTAGES OVER ANALOG

GSM will offer significant improvements over existing analog cellular networks. The main benefits are as follows:

- Pan-European coverage will permit roaming across 17 countries and allow GSM to address *one* large potential market of 320 million people in Europe, far greater than those of either the United States or Japan.
- Greater spectrum efficiency compared to analog cellular, thereby reducing congestion in major cities. This will also result in improved *economic* efficiency compared to the analog cellular networks, with fewer base transceiver stations needed to support GSM subscribers.

SAM Newsletters 1990: April-June 1990-16

0006915

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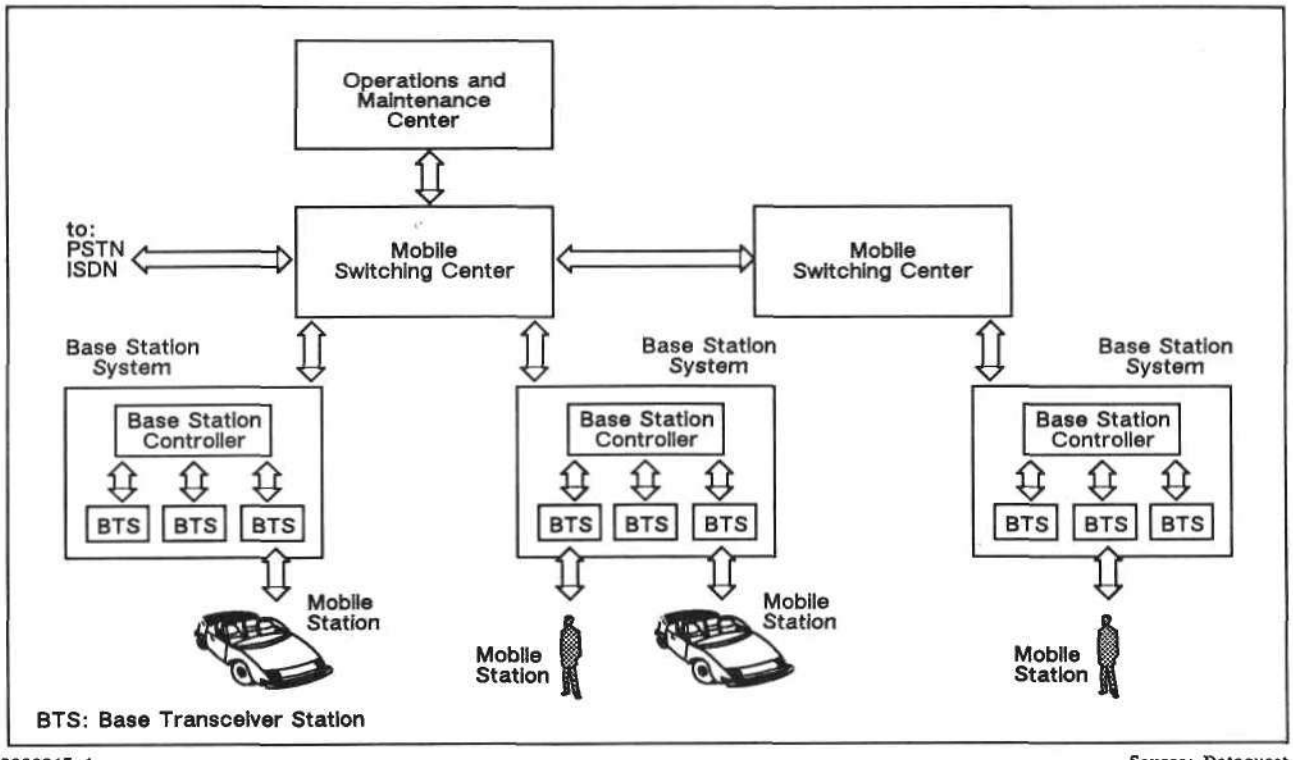
FIGURE 1
Main System Components in the GSM Digital Cellular Network



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Source: Dataquest May 1990

- GSM's digital air interface and digital infrastructure will bring greater service quality and greater functionality compared to analog cellular. Many of the annoying quirks associated with analog cellular telephony (poor speech quality, lack of security, low call reliability, and call fading) will be substantially eliminated.
- Communication within the GSM network will be based largely on CCITT Integrated Services Digital Network (ISDN) standards to minimize the degree of additional development required. This will allow for easy connection to the many public and private ISDNs that are expected to emerge throughout Europe and worldwide over the next few years.

In addition to compatibility with ISDN, GSM's main interfaces will be public domain and conform to layers 1–3 of the Open Systems Interconnection (OSI) model. OSI compatibility will allow GSM to carry complementary services to telephony, such as voice mail, facsimile, paging, messaging, and data communication.

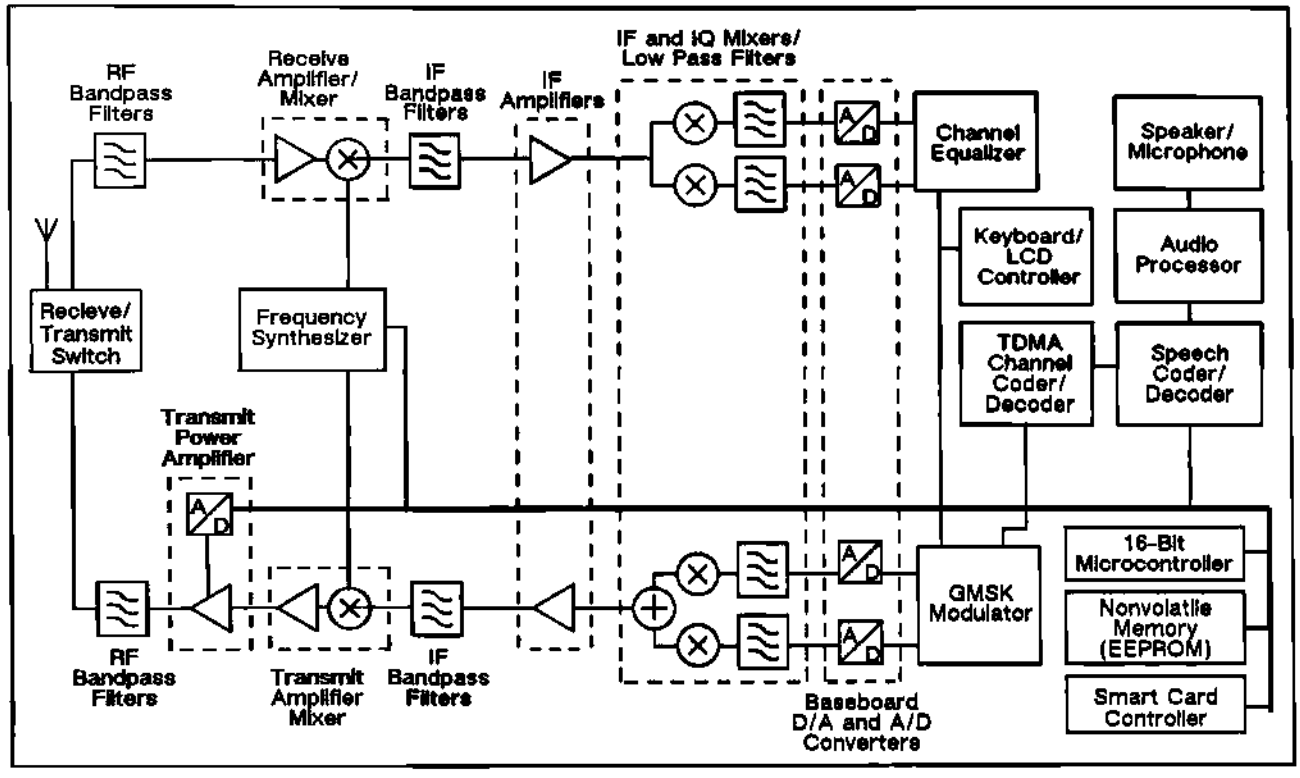
INSIDE THE GSM TELEPHONE

Demand for compact, hand-portable units is currently the strongest growth area in the analog cellular market. This represents a major challenge to designers of digital handsets, because these must be comparable in size and weight with analog handsets in order to be acceptable. In turn, this places tight criteria on the components employed for GSM, since they must both minimize power consumption to reduce battery size and occupy as few parts as possible.

Figure 2 is a block diagram for a GSM mobile telephone based on a single IF stage with quadrature processing at baseband. This is loosely based on developments being made by some manufacturers. Besides an 8-bit microprocessor, an LCD/keyboard, a smart card controller, and some memory, few standard parts will be employed in the first generation of handsets.

At the front end, the design objective of integrating both receive and transmit paths onto one piece of silicon is unlikely to be achieved for some years. The limitations are not complexity or

FIGURE 2
The GSM Digital Cellular Telephone



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Source: Dataquest
May 1990

yield but are instead the problems associated with power dissipation and interference between mixer stages. We expect two- to three-chip hybrids to be the most common solution initially. Packaging and screening will represent a major cost, making the RF front end an increasingly significant cost as greater levels of CMOS integration erode the back-end logic costs. Ultimately, the design approach will shift in favor of direct conversion from RF to baseband, removing the IF stages entirely and eliminating most of the bulky external filters currently employed.

The greatest complexities in design are represented by the channel equalizer, TDMA channel and speech decoder ICs. The equalizer—occupying more than 50,000 gates of semi-random logic on high-performance CMOS ASIC—synchronizes frame transmission with the base station and eliminates unwanted signals reflected from hills and buildings. The TDMA channel IC interleaves and recovers voice and control data across multiple frames to minimize bit errors caused by sporadic interference—similar to the method employed to read compact disks.

The need to maximize cell capacity requires use of efficient voice compression algorithms for GSM. The technique chosen is the Codebook Excited Linear Predictive (CELP) method originally developed by AT&T. CELP will initially use a bit rate of 13 kbps per voice channel. However, there is provision to provide for a 6.5-kbps option in the near future, with the effect of doubling the cell capacity from approximately 200 callers per cell, for 13-kbps codecs, to 400 callers per cell for 6.5-kbps.

The drive to reduce power consumption and battery weight will result in the use of techniques similar to those being applied to conserve power in the PC laptop market, namely dropping clock frequencies in dormant ICs and reducing the power rail on CMOS logic ICs from 6V to 3V. Innovations are also expected in battery technology following recent announcements of rechargeable titanium-nickel and lithium ion cells with two to four times the capacity of present cells.

TABLE 1
Estimated Component Content for a First-Generation GSM Class IV (2W) Handset

Function	Technology	Cost
Receive/transmit switch	SAW duplexer	$25.00
Transmit power amplifier	Bipolar/MOSFET discrete	$5.00
Transmit amplifier/mixer	Bipolar ASIC	$7.00
Frequency synthesizer	Bipolar ASIC	$15.00
Bandpass filters	SAW filters	$14.00
IF amplifier/mixer	Bipolar/BiCMOS	$8.00
Baseband converters	BiCMOS ASIC	$14.00
Channel equalizer	CMOS ASIC	$18.00
Modulator	CMOS ASIC	$14.00
Speech coder/decoder	CMOS ASIC	$18.00
Channel coder/decoder	CMOS ASIC	$14.00
Audio processor	CMOS/BiCMOS ASIC	$4.00
8-bit microcontroller	Standard CMOS IC	$8.00
LCD/keyboard controller	Standard CMOS IC	$4.50
Smart card controller	Standard CMOS IC	$6.00
Memory (256K)	Flash EPROM	$13.00
LCD display		$3.00
Total Semiconductor Content		$151.50
Total Nonsemiconductor Content		$39.00
Total Component Content		$190.50
Average Selling Price		$2,149.00
Semiconductor I/O Ratio		7.0%

Source: Dataquest
May 1990

WHAT PRICE GSM INITIALLY?

Table 1 shows the costs of the components shown in Figure 2 for a first-generation GSM Class IV (2W) hand portable. At the GSM launch in mid-1991, we forecast the total component value will be $190.50, of which 80 percent ($151.50) is semiconductor. By 1994, we expect the total component value to have declined to $151.50 with the greatest savings made by integration of the CMOS back-end logic.

Component contents will be similar in the higher transmit power Class I to III versions, with the exception of the RF power amplifier stage where more costly power discretes must be employed. Where compactness is not an issue, such as in fixed in-car mobiles, cheaper but bulkier ceramic filters are likely to be used in preference to surface acoustic wave (SAW) filters.

In terms of semiconductor consumption per unit, the GSM digital telephone is a big departure from the $50 content in analog telephones today. An obvious concern is what effect this triple increase in content will have on the selling price of GSM handsets? Will GSM be so unattractively priced compared to analog cellular that its uptake becomes adversely affected?

Despite the greater manufacturing costs, we predict that the GSM telephone will be priced only marginally (25 to 30 percent) higher than analog cellular handsets. For the following reasons, we expect the benefits of GSM perceived by subscribers, airtime resellers and network providers alike to more than offset this additional price:

- The other major manufacturing cost factors in a GSM handset will not rise pro rata with the triple increase in semiconductor content. The casing, cabling, antenna, battery, display and keyboard technology in first-generation GSM handsets will be substantially the same as for today's analog units.

- Competition for manufacture and supply of GSM telephones will be far greater than for analog cellular, resulting in lower ex-factory markups and distribution margins. The GSM telephone will be a pan-European product where, in many cases, subscribers will have the option not only to use the telephone anywhere in Europe but also to *purchase* it anywhere in Europe.
- GSM offers a higher marginal return on new network investment compared to analog because, per base station, it can accommodate a greater number of subscribers. Operators who discount handset prices to entice new subscribers onto their networks (such as Cellnet and Vodaphone in the United Kingdom) are likely to take this into account by discounting GSM handsets to a greater degree than for analog.
- It is clearly European Commission policy to liberalize the purchase and supply of telecommunications equipment within the Community. The open market of the United Kingdom has recently been joined by liberalization of mobile equipment in France, Spain, and West Germany, with Italy expected to follow shortly. Similar moves have occurred in the Scandinavian countries.

There is already evidence that the launch of GSM will coincide with a general liberalization of cellular airtime resale across Europe. As this market restructuring occurs, the $2,000 to $3,000 paid for handsets today in regions such as France, Scandinavia, and West Germany will reduce toward the U.K. prices of $300 to $1,500.

In West Germany—the greatest potential market for GSM telephones—the government is investigating ways to modify the Deutsche Bundespost Telekom's (DBT's) cellular service to allow it to compete fully with the new Mannesman consortium. It proposes to achieve this by introducing to DBT a new tier of resellers and dealers. There is a similar trend elsewhere in Europe with, in most cases, governments setting up two rival networks, one public and one private.

In the United Kingdom we expect Cellnet and Vodaphone, wary of the imminent threat from the four new licensed PCN operators, to invest heavily in GSM and move towards decreased cell sizes in urban areas, where PCN will be most active.

THE MARKET FOR THE SEMICONDUCTORS

Based upon our earlier assumptions, Figure 3 presents our forecasts for total semiconductor consumption by GSM handsets in Europe alongside our forecast for the total shipments of GSM handset units that this will drive.

We expect rollout of GSM to be aggressive with, assuming no major technical delays in service launch, 280,000 handsets shipped in the first year (1991). In 1994, we expect shipments of GSM handsets to have reached 2.4 million units, outnumbering shipments of analog units by five to one in the same year.

We forecast total semiconductor sales for GSM handsets in 1991 to be $60 million, rising sharply to $207 million by 1992, through to $421 million by 1994, representing a 190 percent CAGR over the 1991 to 1994 period. Of this revenue, we estimate that approximately 60 percent will consist of CMOS logic, 30 percent of high-frequency bipolar/CMOS/BiCMOS linear technologies, and 10 percent of mixed analog-digital BiCMOS/CMOS technologies.

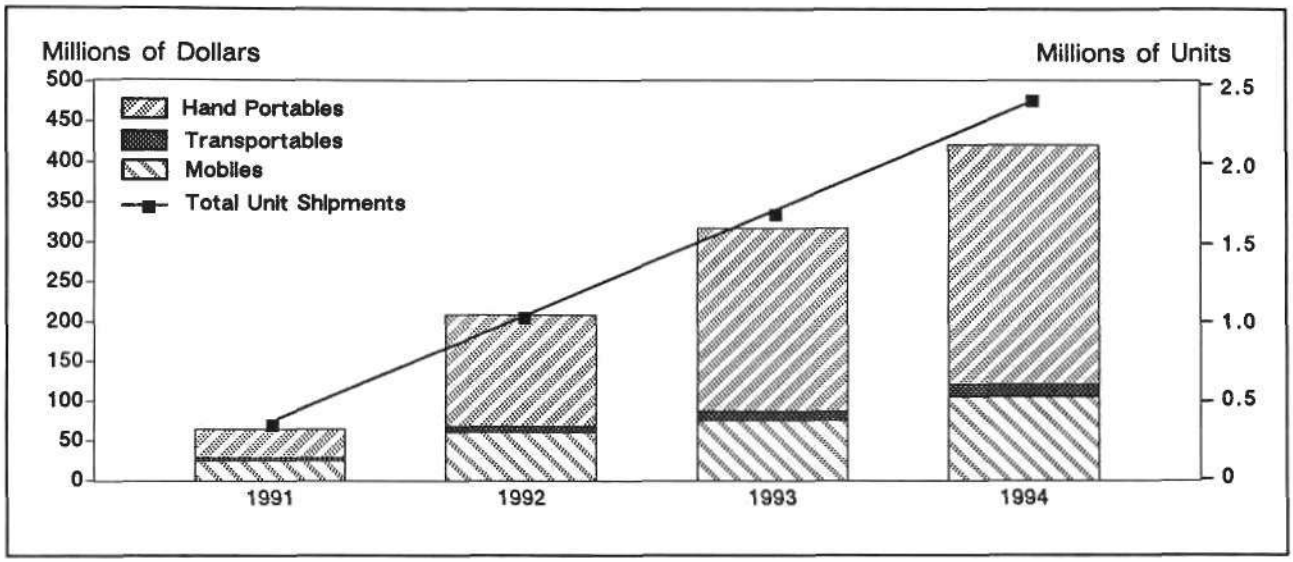
GSM—FUTURE GENERATIONS

Within the next five years, we expect GSM's open system compatibility to clearly differentiate it from analog cellular, in terms of both the features in the handset and the improved services that the operators will provide:

- Fast call setup times
- High-quality speech with DSP enhancement
- High-speed modem connection
- Integral pager/messaging
- Facsimile connection
- Call redirect
- Voice mail
- Caller blocking and identification

An important phase in GSM's evolution will start in the United Kingdom with the launch in 1993 of personal communications networks (PCNs). Other countries, such as France, West Germany, and the United States, also view PCN as a way to take GSM one stage further: turning wireless telephony into a true mass market. PCN will be based upon "pico-cells" of much smaller sizes

FIGURE 3
Forecast GSM Handset Shipments and Semiconductor Consumption by Handset Type



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Source: Dataquest
May 1990

compared to those to be used for GSM. The PCN solution for Europe will almost certainly be based on GSM standards to permit maximum sharing of electronic components between the two systems.

DATAQUEST CONCLUSIONS

No semiconductor vendor can afford to ignore the opportunities presented by the digital telephone market. GSM is just one of a rapidly developing set of other digital standards in Europe: CT2, DECT and PCN. Each translates into handsets suitable for specific types of end user but, while the standards differ, they share common needs for common ICs, particularly in the analog front end, the bandpass filters, and the microcontrollers.

Vendors with GSM design experience stand to benefit by applying their expertise to related standards in other markets. Similar moves to digital cellular telephony are being made in the United States, where the US Digital standard has recently been adopted by the American National Standards Institute (ANSI). US Digital will allow network operators to replace analog transceivers with digital ones, without the need to overhaul their existing network.

Our forecasts indicate that, with the development of GSM into a mass-consumer standard such as PCN, semiconductor demand from this application will begin to rival that from personal computers in size towards the end of the 1990s—with the added twist that many personal computers could themselves contain cordless modems based on GSM. However, over the next two to three years, vendors must strive to supply GSM telephone manufacturers with solutions that permit their GSM units to offer the same price/performance benefits as analog ones.

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Roger Steciak
Jonathan Drazin

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Research *Bulletin*

OEM MONTHLY—MAY 1990
TECHNOLOGY'S PATH FROM THE LAB TO THE LIVING ROOM

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

WORLD PEACE SHOULD ENERGIZE LEADING-EDGE MARKETS

Dataquest estimates that, because of relaxing world tensions, U.S. military electronics procurement will grow at a compound annual growth rate of only 2 percent over the next five years. This growth is actually a contraction after inflation, and the defense industry is worried.

Some military contractors (e.g., General Electric, Raytheon, and Rockwell) are diversified well already, while others (e.g., Hughes, Lockheed, and TRW) are trying to become less dependent on defense by finding more commercial uses for their technologies.

Dataquest believes that this "swords-to-plowshares" effort will accelerate the use of advanced technologies in the commercial products developed in the 1990s. We expect clever inventions that will improve society's standard of living.

EXAMPLE TECHNOLOGIES WITH COMMERCIAL POTENTIAL

Short-Term (Within Five Years) Examples

Embedded Control

The real-time processing used in smart weapons will make some products work better. For example, tighter mileage and emission standards will require the integration of automotive subsystems (e.g., electronic engine and transmission controls) that operate independently today. The need for higher performance will favor the use of 16- and 32-bit processors (rather than the 4- and 8-bit processors used now) in embedded applications.

Gallium Arsenide (GaAs)

The GaAs semiconductor technology used in military radars and other microwave systems has commercial uses as follows:

- Earth station receivers (e.g., direct broadcast satellite, global positioning satellite)
- Engine control sensors (e.g., Ford and Honda cars in 1991)
- High-speed communications (e.g., fiber-optic links)
- Supercomputer logic circuits (e.g., Convex C2, CRAY III)

Long-Term (Beyond Five Years) Examples

Neural Networks

The neural networks to be used for battlefield management and other pattern-recognition systems have potential embedded uses as follows:

- Image recognition (e.g., document scanners, machine vision)
- Natural language processing (e.g., translation telephones)
- Voice recognition (e.g., appliance controls, data entry)

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Optical Computing

The ultrafast optics-based computers being developed for military use would also have commercial uses as ultrafast computers. Companies with R&D programs include AT&T, IBM, Lockheed, and Rockwell.

SPACE TECHNOLOGY SPINOFFS AND INDUSTRY MIGRATION HISTORIES

NASA has had a program for the past 27 years to transfer space-level technology to earthbound applications. Incorporation of such technology in a product usually is not obvious; many times, even the product's designers are not aware of the process. Examples of electronics-using products either created or improved by space technology include cardiac pacemakers, cordless tools and appliances, heat pumps, medical scanners, and smart motors.

ICs and Digital Watches

Integrated circuit (IC) development was funded by both NASA and the U.S. Air Force in the 1960s to miniaturize electronics for the Apollo space mission and Minuteman missile. Digital watches are a by-product of these efforts. They also illustrate the path of diffusion that new technology takes as it enters society's mainstream.

Hughes was a major supplier of digital watch chips in the early 1970s because it had a CMOS line (military) that could be used to produce such chips. By the mid-1970s, several European and U.S. semiconductor companies with commercial product lines were making watch chips, and Hughes exited the business. The watch chip supply base then shifted to lower-cost producers in the Far East by the late 1970s and remains there today.

Global Positioning Satellites and GaAs

The global positioning satellite (GPS) is another example of a technology that has moved from military to commercial use and is expected to move to consumer use in the 1990s.

The exact location of a nuclear submarine must be known before an ICBM can be launched, and the U.S. military built GPS in the 1960s for this type of use on military vehicles. Commercial shipping vehicles (e.g., airplanes, trains, and trucks) began using GPS in the 1980s to monitor goods in transit.

We predict that GPS will be common on consumer vehicles by the end of this decade. Consumer uses for GPS include electronic navigation for the driver, vehicle location for emergency road service providers, and vehicle tracking to assist police in the recovery of stolen vehicles. Last month, Mazda announced a $4,200 GPS option for its cars sold in Japan.

GPS receiver prices are declining rapidly. A military version today costs $50,000, and a commercial version is $15,000. The portable GPS receiver made by Magellan lists for $3,750 and uses GaAs in the form of monolithic microwave ICs (MMICs). Sony is believed to have a hand-held GPS receiver in development that will carry a $700 price tag.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest believes that technology developed yesterday for an aerospace need will be reduced in cost for today's commercial need and further reduced in cost for tomorrow's use by consumers. Semiconductor demand is created when these technology-enabled electronic products find a market. The semiconductor components needed in them may change, however, just as soon as these systems incorporate the next generation of technology.

We recommend that semiconductor suppliers monitor long-term system trends so that the appropriate semiconductor products can be developed in time to take advantage of potential high-growth opportunities.

We believe that a good model to follow is Intel. The company earns almost 20 percent of its revenue from systems such as PC enhancement products, OEM PCs, and OEM workstations. In addition, Intel developed the i860 and i960 processor chips for the advanced parallel-architecture computing that is expected to find commercial uses in the 1990s in relational databases and economic modeling. With forward integration, Intel will understand its semiconductor markets even better.

Roger Steciak

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Research *Bulletin*

SAMONITOR: "HE WHO HESITATES, LOSES"

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

The computer market continued to improve in February. Shipments growth for the three-month period ended in February was 6.6 percent above

Figure 1
Computers and Office Equipment

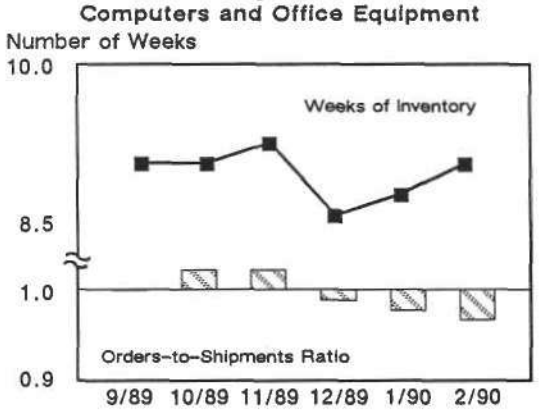


Figure 2
Communications Equipment

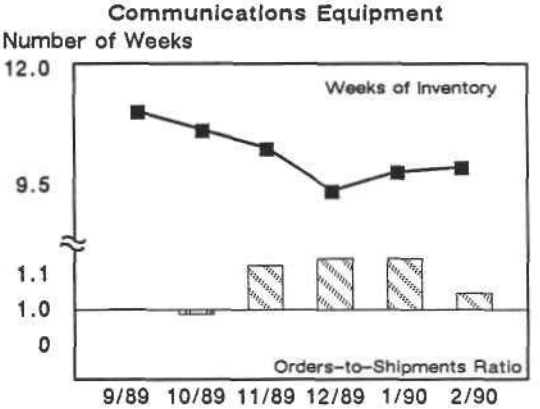


Figure 3
U.S. Instruments

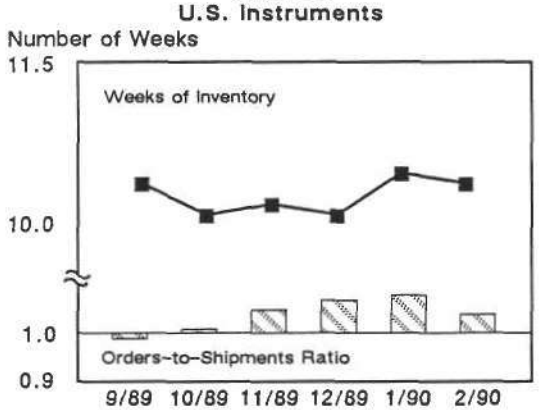
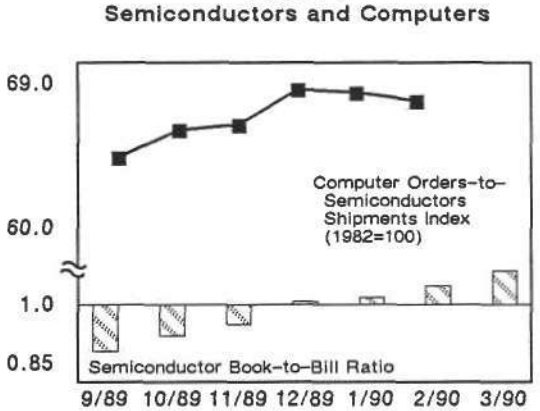


Figure 4
Semiconductors and Computers



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Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
April 1990

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year-earlier shipments, compared with 4.2 percent in January. Orders growth for the same period was 6.3 percent above year-earlier orders, compared with 4.2 percent in January. Furthermore, February shipments and orders were 9.5 percent and 14.1 percent, respectively, above year-earlier levels. *The year-long deceleration in trend growth that shipments experienced during 1989 appears to have turned the corner.* The orders-to-shipments ratio (Figure 1) fell for the third consecutive month and has been below parity for as many months. However, in view of the recent positive showing in growth, the ratio's decline can be dismissed as a temporary aberration of the data: Because of variations in growth rates, the dollar value of orders recently has overtaken the dollar value of shipments. Inventories edged up 0.3 weeks to 9.1 weeks in February; but they are probably close to target, given that they're nonetheless 0.4 weeks below last year's level. Dataquest sees nothing on the horizon that should reverse the current upswing in growth. This upswing will bode well for the chip industry, which should experience a similar demand-driven upturn soon, if it hasn't already.

Communications Equipment

As we projected in last month's *SAMonitor*, orders growth has slowed and the shipments growth pace has begun to accelerate. Orders growth for the three-month period ended in February was 11.1 percent above year-earlier orders, compared with 17.5 percent in January. February's decline in growth is more likely a return to slower, sustainable growth than an indication of a coming trend in further deceleration. Shipments growth for the three-month period ended in February was 10.5 percent above year-earlier shipments, compared with 6.4 percent in January. Most likely, the jump in shipments growth is due to a similar jump in orders growth during the fourth quarter of last year. Business conditions are positive, so February's 0.1 decline in the orders-to-shipments ratio (Figure 2) to 1.05 is probably only transitory and, like orders, a return to normalcy. Inventory levels edged up to 9.9 weeks; nevertheless, they are 1.10 weeks below year-earlier levels. During the next few months, Dataquest expects orders growth rates to stabilize in the 8.0 to 10.0 percent range, while shipments growth should remain relatively brisk and then subside to high single-digit rates.

Instruments

Growth remained healthy and positive in February but has decelerated since the vigorous showing in the fourth quarter. Orders growth for the three-month period ended in February was 6.1 percent above year-earlier levels, compared with 7.6 percent in January. Shipments growth for the same period was 3.6 percent above year-earlier levels, compared with 5.7 percent in January and 6.0 percent in December. The orders-to-shipments ratio (Figure 3) moved down to 1.04 in February, from 1.08 in January. Inventories edged down slightly to 10.4 weeks, about 0.4 weeks below year-earlier stocks. Dataquest believes that recent shipments and orders activity reflects a market correction to slower growth rather than a trend toward further deceleration. The coming months should be marked by relatively stable growth.

SEMICONDUCTOR DEMAND

The U.S. semiconductor market expanded in March, following a minor contraction in February. U.S. market bookings (three-month moving average) rose 5.4 percent in February to $1.267 billion, while February billings rose 1.7 percent to $1.163 billion. As a result, the U.S. semiconductor market book-to-bill ratio increased to 1.09 in March from February's 1.05 (Figure 4). *This ratio is the highest since July 1988, when it reached 1.10.* Recent stability in DRAM prices probably contributed to the ratio's boost in March.

The computer-orders-to-semiconductor-shipments index, a leading indicator of chip orders and shipments, fell slightly to 68.0 in February, from 68.5 in January (Figure 4). Dataquest believes that this decline is a result of first quarter seasonality in computer orders rather than an indication of a declining market: Monthly orders typically show a declining trend during the first quarter but a rising trend during the remainder of the year. For the three-month period ended in February, average computer orders fell 3.1 percent from January, while average semiconductor shipments for the same period declined 2.4 percent. *More important, though, is that computer orders are 14.1 percent above year-earlier orders.* Although seasonality may push the index down in March, Dataquest expects the computer orders, and therefore the index, to continue on an upward trend in the second quarter, portending continued expansion in the chip market as the year unfolds.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

U.S. electronic equipment production is in the midst of a nascent expansion that shows no sign of reversal any time soon. As the expansion matures, the fundamentals of growth should solidify and add to the expansion's durability and stability. In turn, the semiconductor market has begun to turn the corner, albeit modestly. Caution is natural—even warranted—when markets enter emerging stages of growth. But Dataquest also cautions semiconductor manufacturers not to underestimate the strength of the coming expansion. Indeed, to be caught by surprise could entail nothing less than the loss of future market share.

Terrance A. Birkholz

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Research *Bulletin*

OEM MONTHLY—APRIL 1990
SNAGS SNARL ISDN, DATAQUEST FORECAST BLEAK

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

THE SLOWDOWN IN ISDN LINES

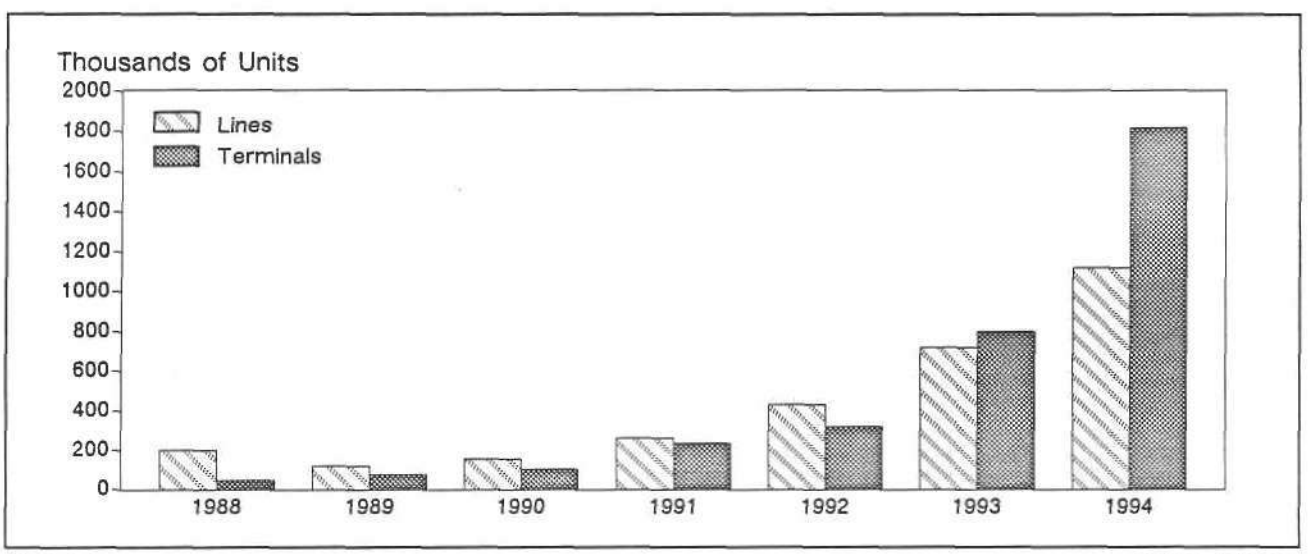
Dataquest's ISDN line shipments forecast for the United States dips in 1989 and 1990 (see Figure 1); these revised numbers are only one-half and one-fourth of our estimates of a year ago. Suppliers in 1988 overestimated the ability of the market to absorb shipments of ISDN lines, and existing inventories have to be reduced before ISDN line production is increased.

The glitch in this end market is expected to continue for the next two years. Internetworking standards must be defined before different makes of ISDN equipment can be connected. Additionally, passive bus software must be created so that each ISDN line will be able to handle up to eight terminals (e.g., telephones, PCs, fax machines). These two items are critical for ISDN to become widely accepted by users.

THE IMPACT ON SEMICONDUCTORS

Dataquest's ISDN semiconductor forecast for the United States also dips in 1989 and 1990 (see Figure 2); the revised long-term numbers are one-fourth of our estimates of a year ago. Chip prices are being discounted heavily in quotes for high volumes as suppliers compete for design wins at OEMs. For example, the new 2B1Q U-interface IC is being quoted at prices in the $50 range for volumes of 100,000 units or more, down 50 percent from the prices quoted a year ago. Both the

FIGURE 1
U.S. ISDN Equipment Consumption Forecast (Thousands of Units)



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Source: Dataquest
April 1990

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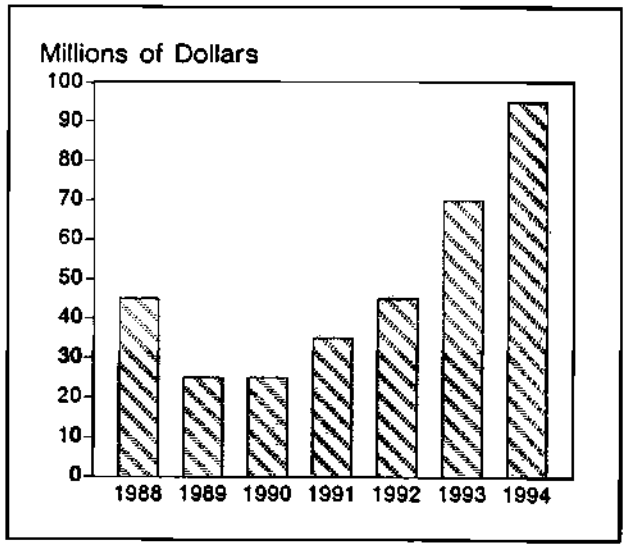
FIGURE 2
U.S. ISDN Semiconductor Consumption Forecast (Millions of Dollars)



0006710-2 Source: Dataquest April 1990

reduced line shipments by OEMs and the declining chip prices by suppliers are contributing to the bleak ISDN chip revenue expected though 1992.

HEALTHY LONG-TERM OUTLOOK

Despite low ISDN production right now, OEMs are continuing to design new ISDN products (see Table 1). These products include equipment for switching, computer hook-ups, network testing, and product development.

ISDN service plans have been announced by the eight largest telephone companies (i.e., seven RBOCs, GTE) and the three largest long-distance carriers (i.e., AT&T, MCI, Sprint). User groups also have been formed to help service providers and equipment suppliers define ISDN features.

U.S. users experimenting with ISDN include Allied Signal, American Express, the City of Colorado Springs, Hardee's, McDonald's, McDonnell Douglas, MIT, Rockwell, Tenneco, the U.S. Air Force, the U.S. Department of Energy, and USC. Other countries with ISDN plans include Australia, Belgium, Canada, France, West Germany, Japan, the Netherlands, and the United Kingdom.

Dataquest estimates that the IOM-2 IC bus architecture promoted by AMD and Siemens has a 67 percent design-in share. Chip suppliers with a major involvement in ISDN include the following:

- AMD
- AT&T
- Ericsson
- IMP
- Intel
- Level One
- Mitel
- Motorola
- National
- NEC
- Philips
- Rockwell
- SGS-Thomson
- Siemens
- TI

CONCLUSION/RECOMMENDATION

ISDN has the symptoms of a classic emerging market. Enthusiastic entry (as happened in 1988) is replaced by agonizing reappraisal (as is happening now) before the true market appears (as is expected in 1992).

Dataquest recommends that semiconductor companies that are in this market for the long term maintain engineering contact with potential users. In the age of the "system on a chip," even a minor change at the network level is likely to have some repercussions at the component level.

Roger Steciak

TABLE 1
A Sampling of ISDN OEMs

Supplier	Equipment	Supplier	Equipment
AG Communication	Switches	IBM	TAs
Alcatel	PBXs	Intecom/Wang	PBXs
Anritsu	Network testers	Navtel	Analyzers
AT&T	Switches	NCR	Interface boards
Concept Comm.	Video workstations	NEC	PBXs
Digital Equipment	Minicomputers	Northern Telecom	PBXs, switches
Eagle	Terminal equipment	Rockwell	ACDs
Fujitsu	PBXs	SEI Corp	Power supplies
General Datacomm	Multiplexers	Siemens	PBXs
Genrad	Protocol testers	Stratus Computer	Minicomputers
Hayes	ISDN PC cards	Teleos	ISDN development tools
Hitachi	PBXs	Vadis	ISDN PC cards

Source: Dataquest April 1990

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Research Newsletter

FIRST QUARTER ELECTRONICS EQUIPMENT UPDATE: INDUSTRY CATCHES ITS BREATH FOR THE LONG HAUL

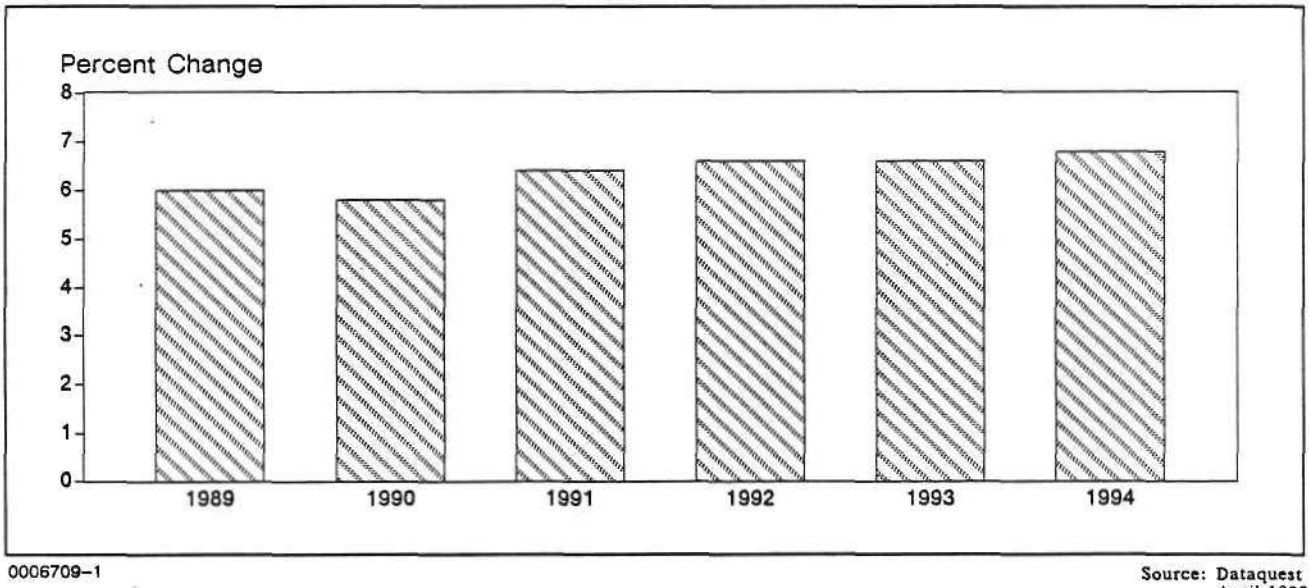
SUMMARY

Dataquest expects North American electronic equipment production growth to be 5.8 percent in 1990, down slightly from 6.0 percent growth in 1989. Beyond this point, we expect the pace to accelerate to 6.4 percent in 1991, to 6.6 percent growth in 1992 and 1993, and to 6.8 percent in 1994 (see Figure 1). In the short term, semiconductor consumption growth will be fueled by workstation production growth, personal computer and PC peripherals growth, and local area network (LAN) production. In the long term, semiconductor growth will be driven by the emergence of multimedia systems. Multimedia systems will spur development of new applications that in turn will necessitate increased processing capability as processing and control functions, traditionally held by the central processing unit (CPU), are off-loaded to smart or "intelligent" peripherals.

ECONOMIC OUTLOOK

Dataquest does not forecast a recession in the U.S. economy during the next two years. However, the U.S. economy has entered the 1990s with a period of slow growth, largely as a result of economic events in the latter part of 1989. While 1990 is likely to have real GNP growth of approximately 2.4 percent (down from 2.9 percent in 1989) and be the weakest year of the current seven-year-old expansion, the second half of the year should be

FIGURE 1
North American Electronic Equipment Production (Annual Percentage Growth)



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decidedly better than the first half. Growth is expected to accelerate to 3.4 percent in 1991.

Of particular interest to electronics and semiconductor manufacturers is the investment outlook. Business' planned equipment investment growth is expected to slow from 5.2 percent in 1989 to 4.8 percent in 1990 and to pick up to 9.1 percent in 1991. Equipment investment is interest-rate sensitive; with rates declining in 1989, the stage is set for firms to commit to new projects in 1990. Furthermore, investment growth in electronic equipment accelerates not only when interest rates decline but also when technological advances enhance productivity. Thus, the economy's relatively smooth near-term growth path should minimize the uncertainty usually associated with investing and thus provide a relatively hospitable environment for the electronics business.

THE CURRENT SITUATION

The computer market's year-long deceleration in shipments growth may be over. According to the Department of Commerce (DOC), shipments growth of computer and office equipment for the three-month period ending in February, the latest reported month, were 6.6 percent above year-earlier levels compared with 4.2 percent in January. Also, February orders growth was 6.3 percent above year-earlier orders compared with 4.2 percent in January.

The communications and instrument equipment markets' business conditions continue to improve. In the communications market, orders and shipments growth for the three-month period ending in February were 11.1 percent and 10.5 percent above year-earlier levels, respectively; in the instruments market, orders and shipments growth for the same period were 6.1 percent and 3.6 percent above year-earlier levels, respectively.

Manufacturers' inventories are close to desired levels. Thus, recent orders growth should continue to buoy both equipment and semiconductor shipments growth through the first half of 1990. Nonetheless, semiconductor growth will likely be modest this year.

APPLICATION MARKET TRENDS

As previously mentioned, Dataquest expects total North American equipment production to grow 5.8 percent in 1990 (see Table 1), down a bit from the 6.0 percent pace in 1989. Equipment market growth is marked by relative long-run stability (see Figure 1) and by a 1989 to 1994 forecast compound annual growth rate (CAGR) of 6.4 percent.

Growth among the application markets is unevenly distributed, as shown in Figure 2. However, the near-term, above-average growth opportunities have this in common: All are the result of the evolution toward decentralized desktop computing. Table 2 highlights some of the most important applications offering near-term, above-average growth.

1990 Market Drivers

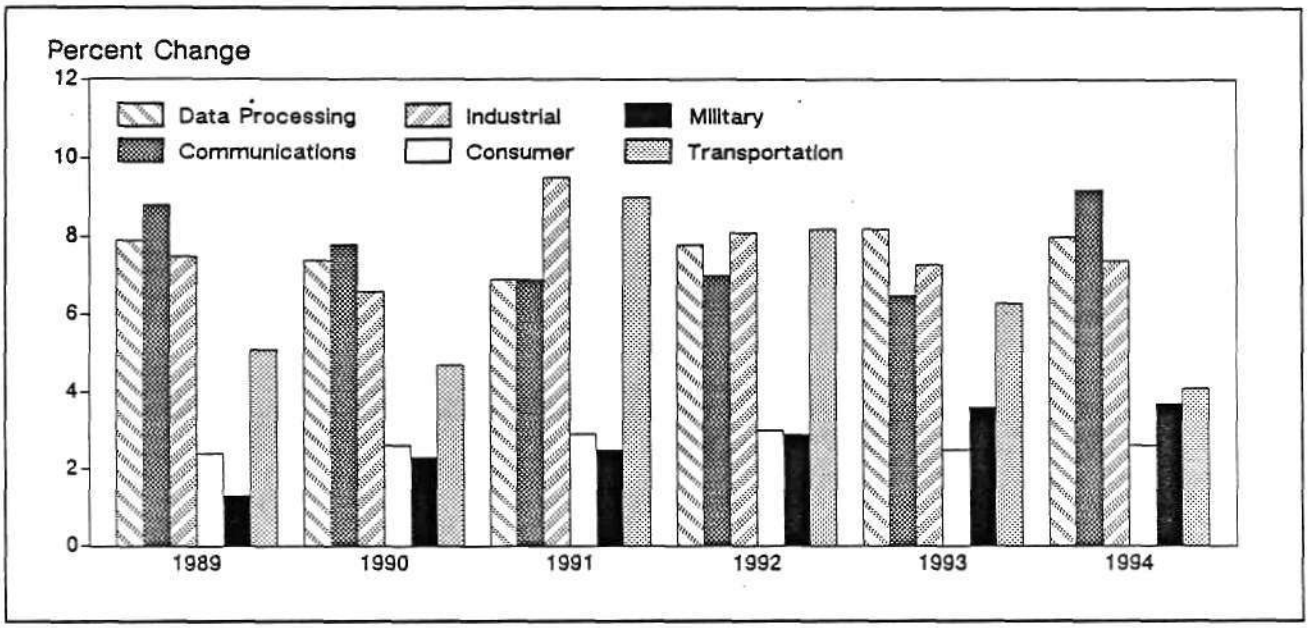
As previously mentioned, growth opportunities for semiconductor manufacturers are expected

TABLE 1
North American Electronic Equipment Forecast (Millions of Dollars)

	1989	1990	1991	1992	1993	1994	1989 to 1990	CAGR 1990 to 1994
Data Processing	$108,941	$116,997	$125,098	$134,872	$145,912	$157,549	7.4%	7.7%
Communications	29,915	32,239	34,459	36,861	39,244	42,865	7.8%	7.5%
Industrial	46,899	49,989	54,742	59,199	63,514	68,230	6.6%	7.8%
Consumer	20,457	20,986	21,598	22,239	22,789	23,372	2.6%	2.7%
Military	51,727	52,918	54,263	55,845	57,866	59,998	2.3%	3.0%
Transportation	11,292	11,828	12,897	13,952	14,836	15,449	4.7%	6.5%
Total	$269,231	$284,957	$303,057	$322,968	$344,161	$367,463	5.8%	6.4%

Source: Dataquest
April 1990

FIGURE 2
North American Electronic Equipment Production
by Application Market
(Annual Percentage Growth)



0006709-2

Source: Dataquest
April 1990

TABLE 2
North American Production Forecast: Selected Equipment (Millions of Dollars)

	1989	1990	1991	1992	1993	1994	CAGR 1989 to 1990	CAGR 1990 to 1994
PCs	20,775	22,513	24,714	28,164	31,385	34,270	8.4%	10.5%
Workstations	5,398	7,160	9,030	11,155	13,322	16,653	32.6%	25.3%
3.5-Inch RDD	2,990	4,209	5,156	6,033	7,195	7,696	40.8%	20.8%
Page Printers	4,560	5,450	6,395	7,400	8,545	9,865	19.5%	16.7%
LANs	3,774	4,959	6,084	7,020	7,857	9,828	31.4%	21.1%
Subtotal	37,497	44,291	51,379	59,772	68,304	78,312	18.1%	15.9%
All Other Equipment	231,734	240,666	251,678	263,196	275,857	289,151	3.9%	4.5%
Total	269,231	284,957	303,057	322,968	344,161	367,463	5.8%	6.4%

Source: Dataquest
April 1990

to be modest at best in 1990. However, given the large and increasing number of application markets in various stages of growth and decline, there are nearly always growth opportunities to be found.

In order to drive overall demand this year, a market must not only boast a strong growth rate but must offer a large dollar volume of growth. As such, several high-growth, high-visibility markets do not qualify. In most cases, they are still too small to have a substantial impact on the overall market.

The systems listed in Table 2 account for 43.2 percent of the net total dollar growth in North American equipment production in 1990; taken as a whole, they are expected to grow 18.2 percent over 1989. Although the value of these systems' production is expected to be only 15.5 percent of total production in 1990, these markets clearly generate substantial growth. Note that these markets are not the only ones that are growing; however, if it were not for these five markets, North American production growth would be only 3.9 percent this year.

Recent past and expected near-term future activity in these markets are discussed in the following paragraphs.

Personal Computers

PC production value in North America is forecast to grow 8.4 percent in 1990, down from 9.6 percent growth last year. The 80486-based systems are all the rage, but the 80386 systems are responsible for the most unit and semiconductor growth. Meanwhile, 80286 systems face a tough battle on two fronts—the transition from mainstream to entry-level PCs; and competition from 80386SX systems.

Given the recent declines in DRAM ASPs, some memory suppliers may be surprised to see this market growing at all. In fact, it is only by virtue of the relatively rich non-MOS memory chip content of the 386- and 486-based machines that any ray of hope shines for positive PC or semiconductor consumption growth in 1990.

The slowdown in unit sales growth—an inevitable result of increased saturation of the installed base into the workplace during the 1980s—means that the PC market will require a continuously changing mix of products to generate future growth.

Workstations

The value of North American workstation production should grow 32.6 percent in 1990, down from 38.4 percent growth last year. In contrast to the PC market, surging unit growth is expected to push workstations' semiconductor consumption. The outlook for the workstation market is so bright that it is the only computer market with an anticipated double-digit growth rate for 1990. However, as enticing as this growth may be, the workstation market is valued at approximately one-third that of the PC market. Relatively speaking, this market is a midsize one that is becoming a driver by virtue of its supernormal growth. In fact, by 1994, workstation production is still expected to be less than one-half that of PC production.

Rigid Disk Drives

The 1990 forecast for North American rigid disk drive production shows growth of 40.8 percent, which is down from 65.7 percent growth in 1989. Future growth is likely to be tempered by two factors. First, on a unit basis, rigid drive shipments have almost caught up with PC shipments, which means slower growth on the equipment side.

Second, semiconductor suppliers to this market are experiencing increasing average selling price (ASP) pressure due to increased second-sourcing and intensifying pressure from drive manufacturers that are themselves feeling increased price pressure.

Local Area Networks

North American LAN production value is forecast to grow 31.4 percent in 1990; this figure is down from 46.3 percent growth in 1989. Like the rigid disk drive market, the LAN market is experiencing ASP pressure. In light of the PC slowdown, the LAN forecast may at first appear to be aggressive. But by comparing new LAN connections with the LAN installed base and also with the installed base of PCs in the business environment, the forecast is realistic.

Page Printers

In North America, page printer production value is anticipated to grow 19.5 percent in 1990, up slightly from 18.2 percent growth last year. Laser printers account for approximately 90 percent of this market's value. Like any technologically ground-breaking product, the laser printer receives a great deal of media attention. But in terms of strategic significance, the attention is well deserved.

On the semiconductor side, the recent sharp decline in memory prices has reined in near-term semiconductor growth opportunities. But the continued proliferation of laser printers in the workplace portends a sustained period of future healthy growth.

Long-Term Drivers

Today, it is difficult to read anything about computing without encountering the topic of multimedia. Although much of multimedia is in the conceptual stage, and companies are vying for acceptance of their designs, it is generally agreed that we are moving swiftly toward image-based computing, which will require unprecedented amounts of compute power.

The advent of multimedia will significantly affect systems architectures, and, therefore, semiconductor requirements and demands. Now it appears that the growth in demand for processing power—as measured by a system's millions of instructions per second (mips)—is dominated by layering new functions upon existing functions rather than growth in existing functions. This trend is likely to have a profound impact on future semiconductor demand as well.

Some of the basic peripheral tasks significantly affected by the emergence of multimedia are shown in Table 3. The move toward image-based computing carries with it the requirements of capturing, encoding, storing, organizing, and generating those images. A good example is a laser printer, which now generates its own output image on demand.

These functions all are essentially peripheral to the primary tasks of the CPU. However, they require a compute capability equal to, and in some cases greater than, that of the CPU itself. Empowering peripherals and subsystems to carry out these functions will have a profound effect on the organization of the next generation of desktop computers.

Because these subsystems are made to perform tasks of ever-increasing sophistication, their hardware content begins to resemble that of an independent computer: What was once a configured system of a single computer with peripherals now is a configured system of computers (see Figure 3). The hierarchy of these systems allows them to function as a single integrated computing tool.

The implication is that while the desktop computer market is expected to remain relatively healthy during the next five years, the real explosive growth is to be found within peripherals (see Table 4). In each case, intelligent peripherals drive the rest of the market.

This dynamic is expected to hold true in the semiconductor market as well (see Table 5). Again, the demand for semiconductors derived from the PC market should be relatively healthy, while the demand for chips derived from the intelligent peripherals market should experience supernormal growth.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest sees underlying trends that should not go unnoticed by the semiconductor community. The first is the continuing increase in the pervasiveness of electronics into new application markets. The second is the layering concept, wherein the incremental growth in demand for processing power will derive from the layering of new functions upon existing functions.

The combined effect of these trends is to push noncomputer semiconductor growth up sharply. Additionally, the greatest growth opportunities within the computer and peripherals markets lies in the areas of smart peripherals and subsystems.

Make no mistake about it: It is no pipe dream; these market dynamics already are under way. The future belongs to those that choose to participate rather than spectate or gestate.

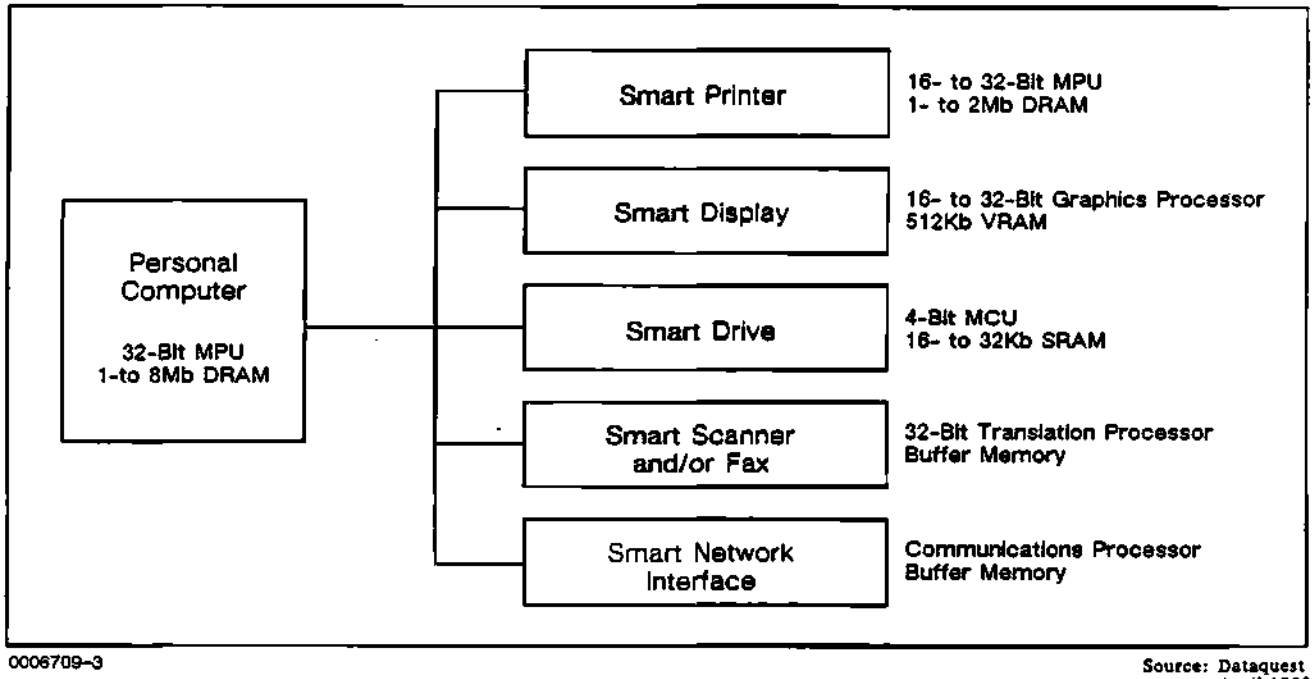
Terrance Birkholz

TABLE 3
Subsystem Implications

Peripherals	Requirements
Mass Storage	Search large image databases
Displays	Generate real-time images
Scanners/Fax	Convert bit-mapped images
Printers	Match laser printer features
Network Interface	High-speed data compression/network management
Front-End Voice Recognition	Implement AI software

Source: Dataquest
April 1990

FIGURE 3
Desktop Computing System Trend:
Decentralized Intelligence



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Source: Dataquest
April 1990

TABLE 4
Worldwide Selected Smart Peripheral Production Forecasts (Millions of Systems)

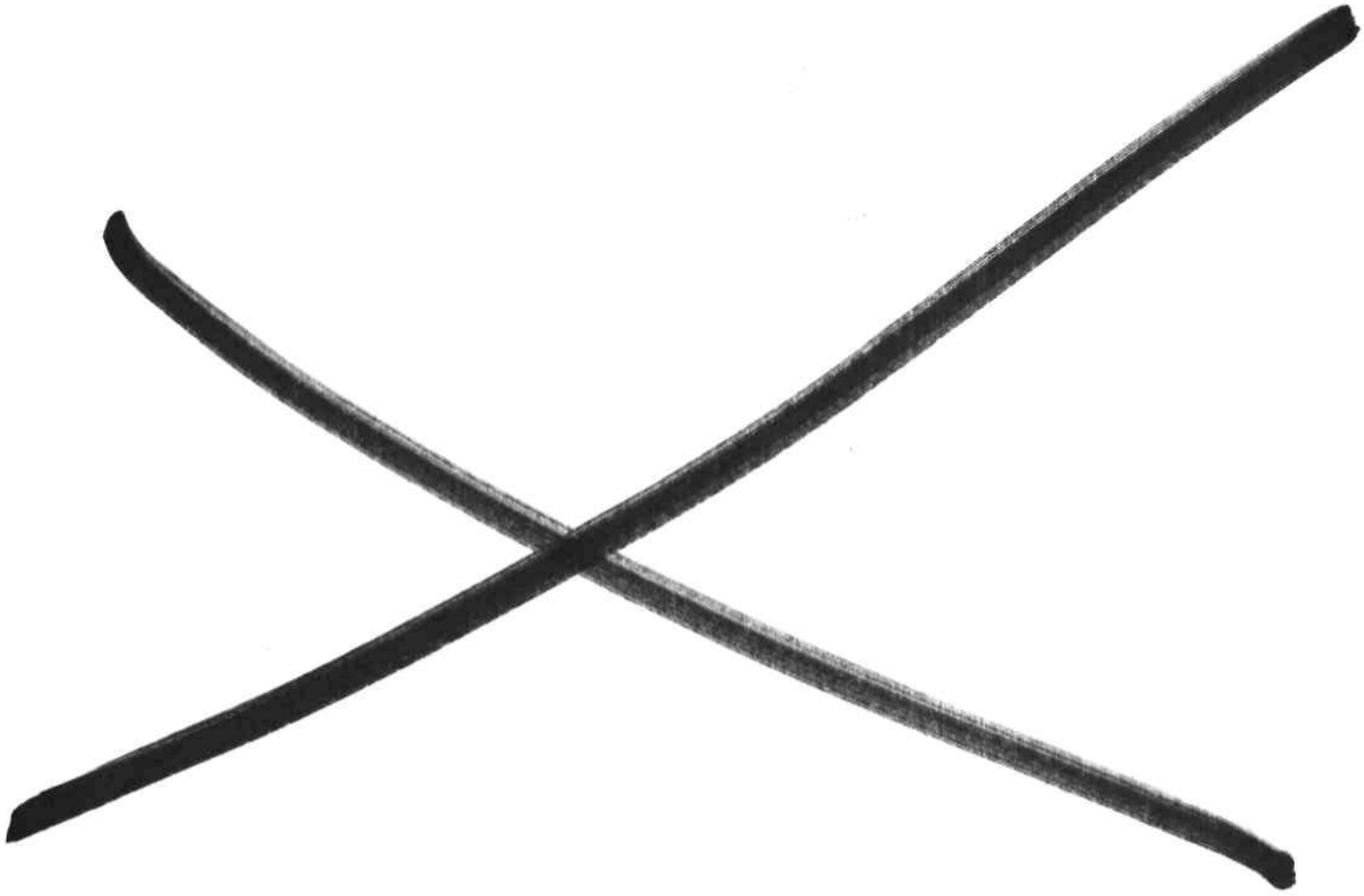
	1989	1994	CAGR
PCs/Workstations	21.4	34.8	10%
Processor-Based Graphics Subsystems	0.7	10.5	72%
Small Rigid Disk Drives	19.6	33.6	11%
Intelligent Drives	8.2	26.9	27%
Printers	16.8	21.9	5%
Laser Printers	2.2	5.6	21%

Source: Dataquest
April 1990

TABLE 5
Worldwide Selected Smart Peripheral Production Forecasts (Millions of Dollars)

	1989	1994	CAGR
Personal Computers	4,000	7,100	12%
Laser Printers	900	2,700	25%
Intelligent Drives	420	1,080	21%
Processor-Based Graphics	220	1,230	41%

Source: Dataquest
April 1990



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Research *Bulletin*

SAMONITOR: THE SKY IS *NOT* FALLING

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

Orders and shipments growth were mixed in July. Orders growth for the three-month period ended in July was 5.6 percent above year-earlier

Figure 1
Computers and Office Equipment

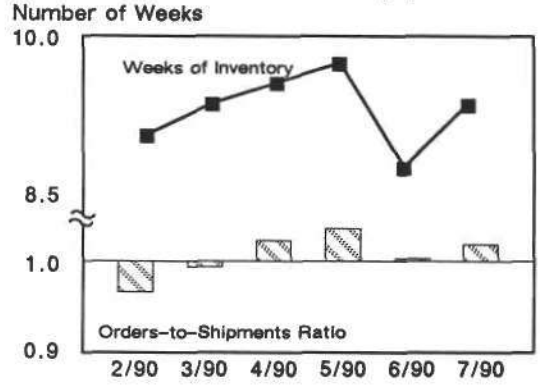


Figure 2
Communications Equipment

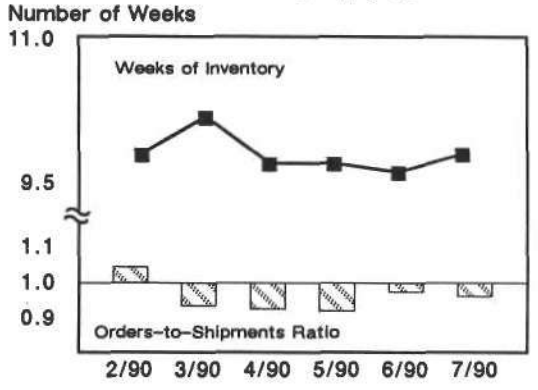


Figure 3
US Instruments

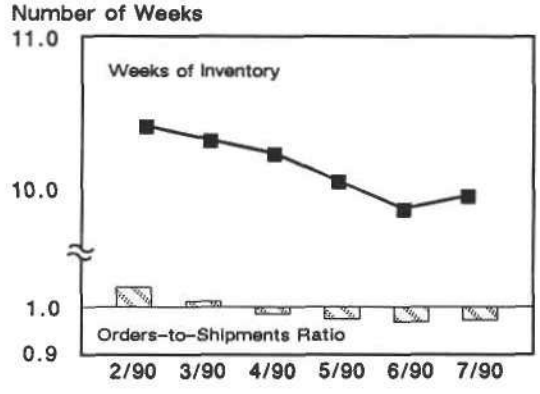
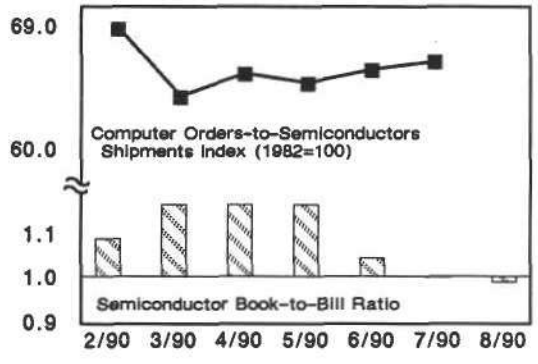


Figure 4
Semiconductors and Computers



Source: WSTS, US Department of Commerce, Dataquest (September 1990)

SAM Newsletters 1990: July-September 1990-30

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orders compared with 3.6 percent in June. Since January, there has been no discernible trend in orders growth; rather, growth cycled up in the first quarter, then down in the second quarter. Shipments growth for the same period *fell 0.6 percent below year-earlier shipments* compared with a 0.5 percent increase in June. July is the fourth consecutive month of decelerating shipments growth, down 7.5 percentage points from the previous cyclical peak of 6.9 percent in March, and the first month of negative growth since June 1987. The orders-to-shipments ratio (Figure 1) moved up to 1.02 in July from 1.00 in June, reflecting orders' good showing relative to shipments. Inventories rebounded in July to 9.4 weeks from 8.8 weeks in June but remain only 0.1 week above last year's level, indicating good control by manufacturers. Given the orders-shipments growth-rate gap and the well-managed inventory stocks, Dataquest expects shipments growth to rebound in the coming months, even if orders growth remains relatively stable for the remainder of the year (the most likely scenario).

Communications Equipment

As previously forecast by Dataquest, *orders growth for the three-month period ended in July decelerated to 7.6 percent, down from 13.8 percent in June, after accelerating continuously since March.* Shipments growth for the same period accelerated to 7.1 percent in July from 4.9 percent in June. Despite this expansion, the orders-to-shipments ratio (Figure 2) slipped from 0.98 in June to 0.96 in July—the fifth consecutive month that the ratio has been below parity. Inventories remain tightly controlled, edging up only 0.2 weeks in July to 9.8 weeks, 1.9 weeks below year-earlier levels. Given the unusually brisk orders growth during the third and fourth quarters in 1989, Dataquest expects the coming months to be marked by further deceleration in orders growth combined with mild acceleration in shipments growth, with both stabilizing in the 5 to 7 percent range by year end.

Instruments

Orders growth for the three-month period ended in July rebounded to 5.0 percent above year-earlier orders from 3.2 percent in June. Shipments growth for the same period slowed to 6.0 percent in July from 6.4 percent in June. Inventories moved up slightly, from 9.8 weeks in June to 9.9 weeks in July, and are currently 0.8 weeks below year-earlier levels. The orders-to-shipments ratio (Figure 3) remained unchanged at 0.97 in July and below parity for the fourth consecutive month. The ratio's recent downward movement reflects the simultaneous decrease in orders and increase in shipments and is more a correction toward stability than an indication of underlying market weakness. We expect orders and shipments growth to fluctuate in the 5 to 7 percent range in the next months.

SEMICONDUCTOR DEMAND

The US semiconductor market expanded in August. Bookings (three-month moving average) rose 0.9 percent in August to $1,199.5 million; billings rose 2.4 percent to $1,215.1 million. But the book-to-bill ratio fell below parity from 1.00 in July to 0.99 in August, due to billings' relatively stronger showing (Figure 4).

Although semiconductor demand has returned to pre-summer levels, our monthly survey of major OEM semiconductor procurement managers continues to support an outlook of slower, but nonetheless positive, short-term growth: Overall, six-month system sales are expected to grow 4.2 percent, down from 5.5 percent in August. *Data processing OEMs' expected six-month growth fell to 6.1 percent in September from 8.3 percent in August.*

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Contrary to popular belief, the sky is not falling, nor is it expected to do so anytime soon. True, the rate of economic growth has slowed over the past 12 months, but the US unemployment rate is 5.6 percent, lower than it has been for any year between 1974 and 1987, and factory capacity utilization is 83.0 percent, exceeded in only 6 of the past 20 years. Both of these measures reflect relatively tight labor and product markets. Further, the recent rise in oil prices resulting from the Middle East crisis is not likely to push the economy into recession. Real GNP and employment should continue to expand. Recent moderation in systems growth is more the result of the Fed's policy of reigning in aggregate demand to bring down inflation than insufficient demand unique to the systems markets.

Although it would be imprudent to completely ignore the increase in Middle East tensions, Dataquest advises systems manufacturers to tend their business with an eye more toward *pre*-crisis fundamentals and expectations than give undue weight to the recent turn of world events.

Terrance A. Birkholz

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Research *Bulletin*

OEM MONTHLY: SEPTEMBER 1990
DATA COMPRESSION LOOSENS MULTIMEDIA BOTTLENECKS

Among the more interesting aspects of any new technology are the challenges it poses for other technologies. Multimedia, actually a collection of technologies, is no exception. Because multimedia computing requires rapid manipulation, transmission, display, storage, and retrieval of high-resolution images, it faces enormous I/O challenges and storage-capacity limitations.

Semiconductor opportunities tend to be greatest when current performance levels seem to be holding the market back. Enter data compression devices. By relieving the I/O bottleneck and reducing storage requirements, high-performance compression devices can accelerate systems-level innovation at attractive prices.

Data compression techniques generally fall into two categories: lossless and lossy. While lossless data compression techniques guarantee complete data integrity, lossy data compression techniques allow for the loss of a small portion of the original information.

WHY WOULD ANYONE DO THAT?

One of the critical properties of a compression scheme is its compression ratio. The data integrity constraint limits today's lossless compression ratios to, at most, 5:1. Lossy techniques, by comparison, are able to achieve compression ratios as high as 30:1 today and should eventually surpass 100:1. These specifications are not "hard," however, as designers can trade error rate against compression ratio.

COMPRESSION APPLICATIONS

It is clear that these techniques excel at very different tasks. Lossless techniques are appropriate for applications in which data integrity is crucial (such as mass storage), whereas the high compression ratios offered by lossy techniques are crucial in high-speed image transmission.

So what is "image compression"? It is the practice of applying lossy techniques to images and is a market-oriented term coined by some perceptive individuals who realized that in product positioning, terms such as "lossy" almost never have a positive connotation.

COMPRESSION IMPLEMENTATIONS

"Can You Do It in 1/30th of a Second?"

Early compression implementations were implemented in software using standard microprocessors and/or DSP devices. As compression technology has advanced and mainstream applications have been identified, the need for high-performance optimized silicon has become apparent.

In order to achieve full-motion video performance levels, multimedia PCs will need to display at least 30 frames per second (fps). Enhancements to resolution, color levels, and/or shades of gray will be feasible only if the 30-fps requirement can be met through enhanced compression techniques. Table 1 lists some of the semiconductor manufacturers that currently offer products in this area.

POTENTIAL MARKETS

Table 2 lists several end-equipment markets as likely candidates for early adoption of compression devices. Because several of these are highly cost sensitive, we will assume initial adoption only in the high-performance segment of each market.

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DATAQUEST CONCLUSIONS

Data compression is still in its infancy. The rate at which this technology matures and pervades society depends on factors subject to a great deal of uncertainty, such as software and standards evolution. As compression moves into the mainstream, cost reduction will become an increasingly important issue. At the limit, very low-cost compression devices could, and probably will, find their way into nearly every compute and/or communications device, including TVs, video phones, and still and motion picture cameras. Under the right set of circumstances, unit volumes for compression devices could exceed 100 million devices by the end of the decade.

Kevin Landis

TABLE 1
Data Compression IC Vendors

Company	Type
C-Cube	Lossy (JPEG)
Inmos	Lossy (JPEG)
Intel	Lossy (DVI)
LSI Logic	Lossy (JPEG)
Infochip	Lossless
STAC	Lossless

Source: Dataquest (September 1990)

TABLE 2
Early Adopters of Data Compression

Product	Type	1992 Estimate (Thousands of Units)	Market Penetration
Multimedia PCs	Lossy	1,500	2%
Workstations	Lossy	95	10%
Scanners	Lossy	36	15%
Laser Printers	Lossy	320	5%
Digital Copiers	Lossy	80	2%
Fax Machines	Lossy	600	5%
Rigid Disk Drives	Lossless	3,100	10%
Rewritable Optical Drives	Lossless	7	20%
Tape Drives	Lossless	200	10%
High-Speed LANs	Lossless	680	5%

Source: Dataquest (September 1990)

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Research Newsletter

SYSTEM SEMICONDUCTOR CONTENT TRENDS: THE PC DWARFS OTHER MARKETS

SUMMARY

The personal computer (PC) market offers high-volume opportunities for manufacturers of both volatile and nonvolatile memory devices and a growing market for specialty memory, communications, and data compression devices. ASIC and microcontroller vendors, on the other hand, face a less certain market, with opportunities tempered by severe price competition and functional consolidation.

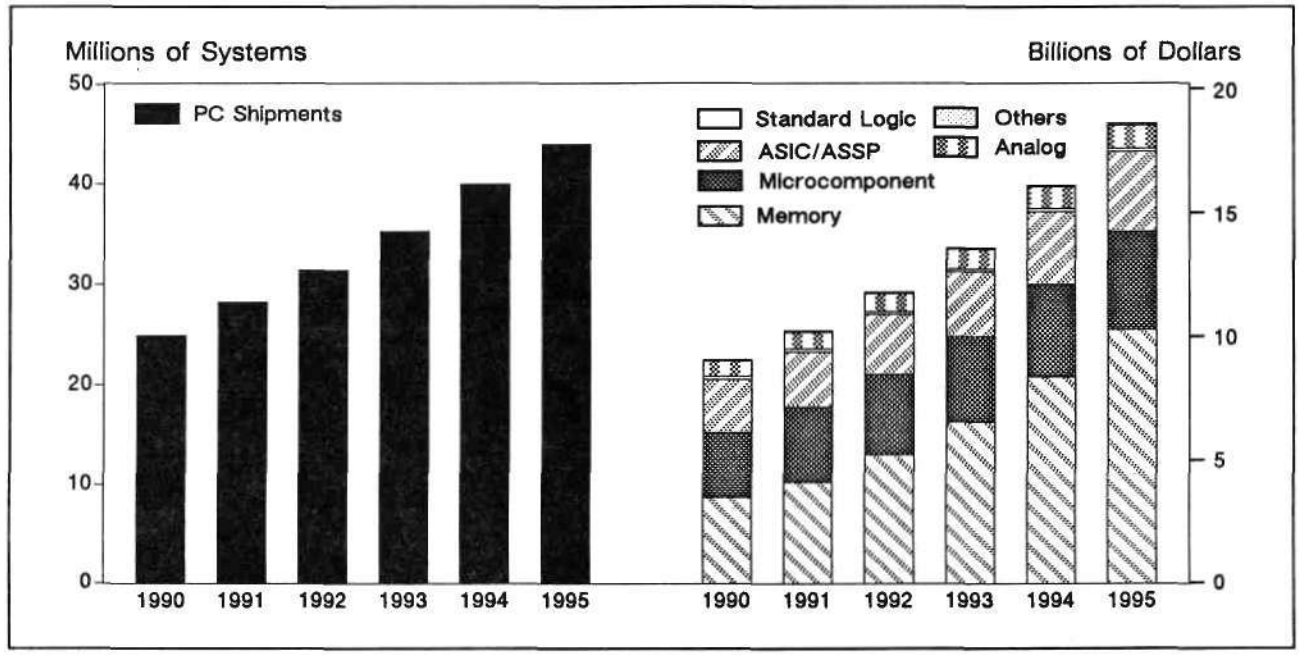
This newsletter provides a quantitative analysis of the PC market at the component level and will examine the critical issues facing semiconductor suppliers seeking to meet the needs of the market.

OVERVIEW

Dataquest expects worldwide shipments of PCs to grow from 24.9 million units in 1990 to 40.0 million units in 1994. Dataquest's forecast for the portable segments calls for a compound annual growth rate (CAGR) of 44.0 percent through 1994 compared with just 4.1 percent for the desktop segment.

Figure 1 shows Dataquest's estimate of the worldwide PC market and our estimate of the associated semiconductor demand.

FIGURE 1
Personal Computer Semiconductor Forecast



Source: Dataquest (September 1990)

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PCs: THE WORLD'S BIGGEST NICHE MARKET?

If the semiconductor industry has a single most important market, it is unquestionably the PC industry. PCs offer the irresistible lure of both rapid innovation and phenomenal unit volumes.

But these two enticements lead directly to the two toughest challenges facing suppliers to this industry: vicious price cutting and a high risk of obsolescence through functional consolidation. This competitive turbulence renders design wins temporary and market advantage fleeting.

COMPRESSION OF PRICE, FUNCTION, DATA

It seems as if the one-chip, $500 PC has been just around the corner for several years now. Fortunately for both PC and chip companies, it is not likely to arrive anytime soon. But if we are able to put more and more functionality onto a single chip, and if the cost of a given function consistently falls over time, how is it possible that system cost and chip count have not collapsed?

The answer can be found in the typical process of layering new functionality upon the old. By constantly adding new features and capabilities, systems and chip manufacturers alike are able to stimulate continuing demand for innovative products at healthy price points. In short, the layering of new features and functions offsets the compression (both in price and in form) of the established ones. These forces are also balanced against the consumer's desire (and ability to pay) for new features.

Figure 2 shows some examples of functions in various stages of absorption by the typical PC motherboard. Standard functions reside on the motherboard, where they are consolidated into fewer devices per function. Emerging functions tend to reside on add-in cards and are sold to early adopters at early-stage price points. Functions in transition are incorporated onto the motherboard once the issues of standards and widespread acceptance are sorted out.

IMPLEMENTATION

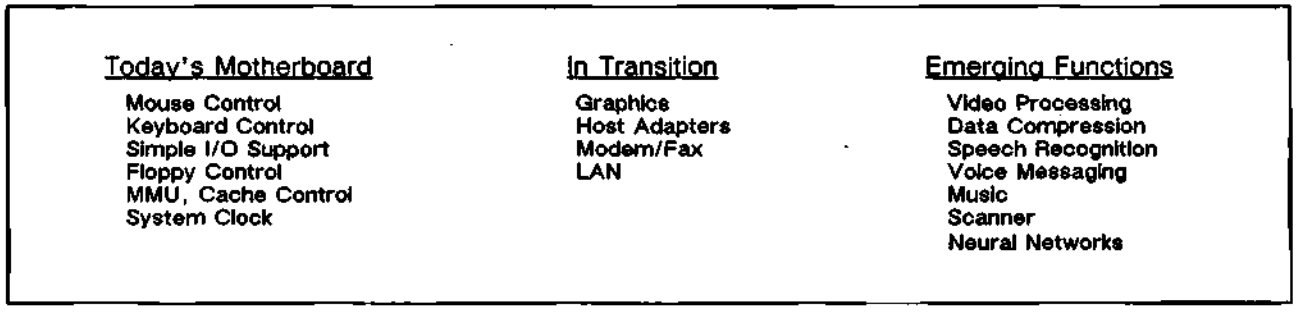
Although the "typical" PC is both a moving target and an average of various distinct classes of PCs, there is a great deal of commonality in the basic functions of most PCs. Figure 3 illustrates a typical PC block diagram.

Certain functional blocks, such as the microprocessor (MPU), are able to sustain a healthy price by increasing performance over time while others, such as main memory, sustain theirs through bit growth, offsetting declining cost per bit. For the most part, however, each function will experience declining unit ASPs in the short run, followed by eventual consolidation.

A good example of this is the cache controller market. As the percentage of PCs with cache memory increases, cache controllers are likely to experience healthy growth followed by plateauing as market saturation and increased competition cause ASPs to collapse. Eventually the cache control function will be integrated into another chip, and this will no longer be a distinct market at all.

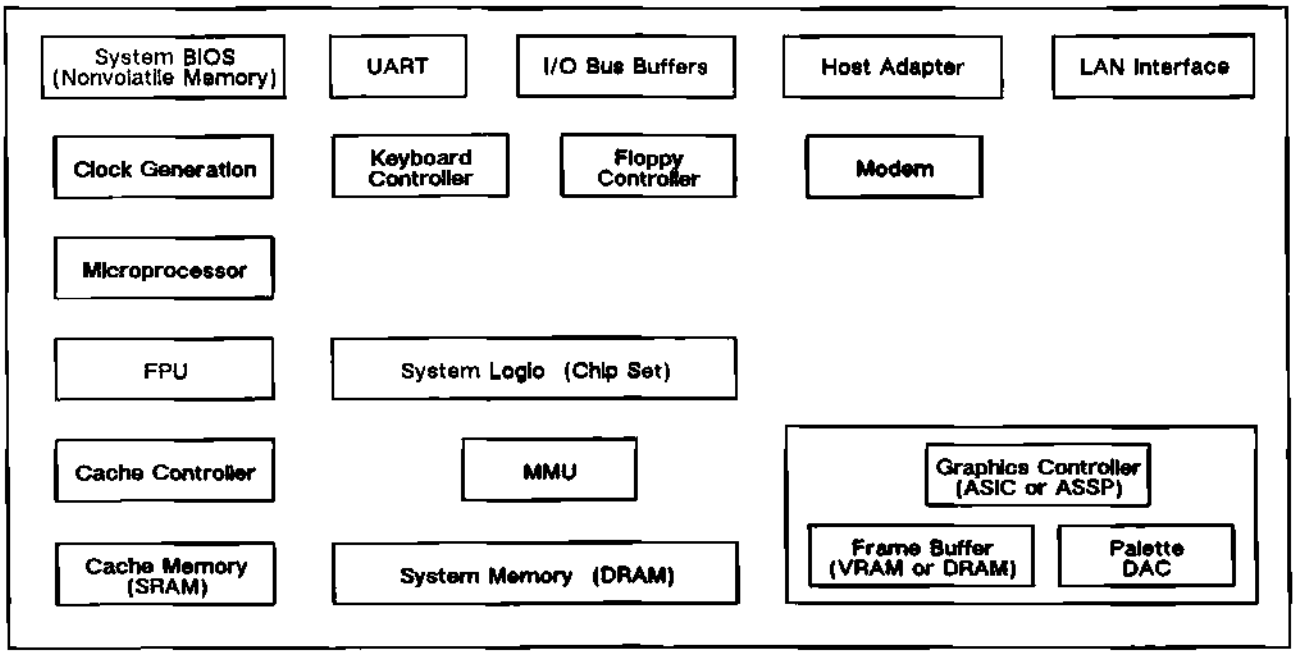
How then are semiconductor vendors (apart from system processor and memory suppliers) to

FIGURE 2
Functional Compression



Source: Dataquest (September 1990)

FIGURE 3
Typical Personal Computer Block Diagram



Source: Dataquest (September 1990)

TABLE 1
Worldwide PC Semiconductor Market

	1990	1995	CAGR 1990-1995
WW PC Production (Millions of Units)	24.9	44.0	12.0%
Total Semiconductor Demand ($M)	8,957	18,385	15.5%
Micro	2,616	3,914	8.4%
ASIC/ASSP	2,074	3,165	8.8%
Standard Logic	125	132	1.2%
Memory	3,483	10,191	24.0%
Analog	611	914	8.4%
Others	48	69	7.6%

Source: Dataquest (September 1990)

protect their market share? Clearly, most opportunities exist in the growth in emerging functions. Vendors taking the lead in developing enabling silicon will enjoy a substantial head start in what are typically some of the most profitable sockets on the board.

SEMICONDUCTOR CONTENT/ CONSUMPTION FORECAST

Table 1 summarizes Dataquest's estimated worldwide semiconductor market for PCs. We expect total semiconductor demand to increase from $8.96 billion in 1990 to $18.40 billion in 1994. Over the forecast period, CAGRs range from 24.0 percent for the memory category to 1.2 percent for standard logic, with an overall growth rate of 15.5 percent. Although not the highest growth area, the microcomponent market is expected to remain healthy with stable growth.

Table 2 summarizes Dataquest's estimation of semiconductor content trends for PCs on a unit basis. Three factors drive the shifts in semiconductor content. First, specialty microperipherals, such

TABLE 2
Semiconductor Content Forecast ($/PC)

	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-1995
Micro	100.00	105.00	107.10	101.75	97.32	93.22	88.95	(3.3%)
ASIC/ASSP	87.25	83.25	79.00	75.81	73.44	72.74	71.93	(2.9%)
Standard Logic	5.25	5.00	4.25	3.50	3.25	3.00	3.00	(9.7%)
Memory	172.30	139.77	144.59	164.10	183.52	206.25	231.61	10.6%
Analog	25.50	24.54	23.65	22.83	22.08	21.40	20.78	(3.3%)
Others	2.00	1.92	1.84	1.77	1.70	1.63	1.57	(4.0%)
Total	392.30	359.48	360.43	369.76	381.31	398.24	417.84	

Source: Dataquest (September 1990)

as floppy controllers, keyboard controllers, cache controllers, system logic, and graphics chip sets, are likely to feel strong price pressure.

Second, the system microprocessor will be able to defend a strong ASP by competing on the basis of performance, bringing peripheral logic functions on-chip, and controlling the evolution of the core of the system.

Finally, while main memory cost may fluctuate from year to year, the trend in per-system main memory cost should be only a gradual increase. Buffer and cache memories, on the other hand, are likely to rise dramatically as increased system complexity requires a wider distribution of processing power and memory.

DATAQUEST RECOMMENDATIONS

Several viable strategies exist for successful participation in this market. Selecting the appropriate one depends not only upon the relative advantages of the supplier, but also upon the portion of the design and the OEMs being targeted.

Among the viable strategies for this market are the following:

- *Survive by staying cheap*—Consolidation poses the greatest risk to devices with high ASPs. Standard logic vendors, as well as a few specialty microcontroller vendors, have discovered that a low-cost strategy can substantially lengthen their product life cycles.
- *Survive by specializing*—By becoming experts in specific functions, vendors can build sufficient systems-level complexity into their components to make them difficult to duplicate or incorporate into other devices. Examples of this include host adapters and LAN chips.
- *Survive by being hard to swallow*—Standard transceiver vendors continue to enjoy a healthy level of business in this market because they offer one important feature that cannot yet be cost-effectively integrated—drive. Analog and drive functions can continue to resist consolidation provided they also hold low ASPs.
- *Survive by swallowing other functions*—Chip set and processor vendors use this strategy to protect their ASPs. This could eventually pose a problem to chip set vendors once processor vendors have a large enough "transistor budget" to swallow the entire chip set. Palette DAC and graphics controller manufacturers will also face an interesting confrontation.

DATAQUEST CONCLUSIONS

The PC market offers the lure of astonishing unit volumes; however, these volumes have bred one of the most intensely competitive markets in existence. Semiconductor manufacturers competing in this market will find themselves continually challenged on all fronts.

This market offers a wide variety of ways in which to fail. Cost of manufacturing, time to market, obsolescence, and standards wars can all prove fatal. Competitors with weaknesses in any of these areas are at risk of being blindsided, but for strong companies with vision, the rewards speak for themselves.

Kevin Landis

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Research *Bulletin*

OEM MONTHLY—AUGUST 1990
DRAM APPLICATIONS EXPOLORED

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

DESKTOP DOMINATES

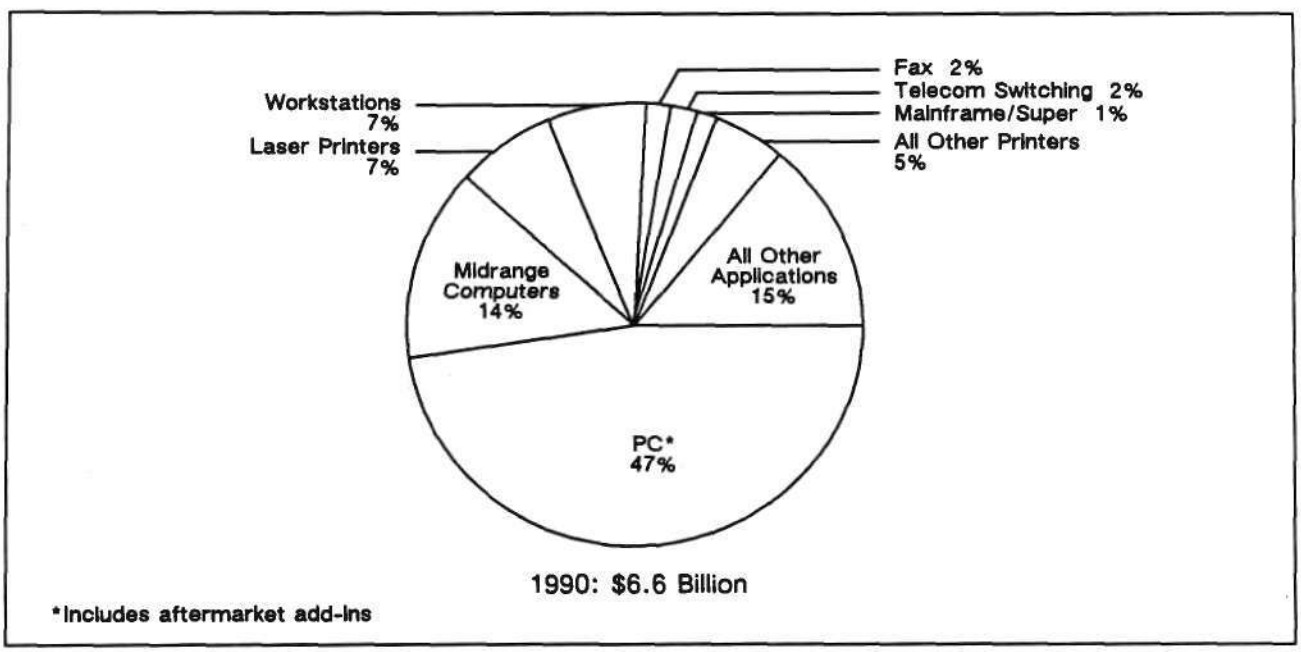
As shown in Figure 1, desktop applications for PCs, workstations, and their associated peripherals are expected to absorb nearly 60 percent of DRAM dollar shipments in 1990. Desktop consumption of DRAMs is being accelerated by many factors, including the following:

- Expanded memory requirements for software, including the growing popularity of multitasking and other system-level aids (e.g., Microsoft Windows, OS/2, and UNIX)
- The surge in networking and its resident software and data buffers
- A substantial aftermarket motherboard and add-in module business
- New applications such as laser-printer buffer memory

THE DRIVERS

Table 1 presents a listing of the primary computer applications of DRAMs, the average usage per system, and the leading OEMs that produce the equipment.

FIGURE 1
DRAM Worldwide Application Mix
Merchant Only—Dollar Basis



Source: Dataquest (August 1990)

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TABLE 1
Computer DRAM Usage Examined

Application	Average MB/System	Principal OEMs
PCs	2MB	IBM, Apple, Compaq
Midrange Computers	16MB	IBM, DEC, Unisys
Laser Printers	1MB	HP, Apple, IBM
Workstations	16MB	Sun, HP, DEC
Mainframe/Supercomputers	64MB	IBM, Fujitsu, Cray

Source: Dataquest (August 1990)

THE FUTURE

As 4Mb and then 16Mb DRAMs enter the marketplace and megabyte prices drop to less than $50 and almost to $40, new applications should unfold. The accompanying improvement of access times (better than 70ns) will start making DRAMs an attractive economic alternative to slow SRAMs. Emerging significant applications for DRAMs will include the following:

- Enhanced display subsystems for image-based processing
- Digital document processing
- Digital copiers
- Solid-state disk drives
- Car audio entertainment (for DSP)
- TV employing DSP (including HDTV)

In general, Dataquest expects continued growth in bits of DRAM per system as software functionality and user friendliness increase. We also expect the growing popularity of digital signal processing (DSP) techniques as applied to embedded control functions to uncover new "sockets" for DRAMs.

DATAQUEST CONCLUSIONS

Dataquest expects aggressive bit demand for DRAMs to continue into the foreseeable future. Desktop systems and accompanying peripherals will continue to be the principal near-term driver of DRAM bit growth. Rapidly growing PC markets in Europe, Japan, and the Asia/Pacific countries will provide substantial DRAM demand over the next three to five years. Upgrades and expanded software and networking functionality will drive PC DRAM growth in North America.

DRAM use by the new "digital-era" computer, office, and consumer products will start to become significant in the mid-1990s as they become price/performance competitive with existing solutions. We expect application-specific DRAMs (e.g., VRAMs) to become a more substantial opportunity as specific system design and economic constraints dictate.

Dataquest recommends that DRAM manufacturers thoroughly study the demand profile of volatile memory as derived from individual applications and match investment and production mixes accordingly.

Gregory Sheppard

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Research Newsletter

WILL ENABLING TECHNOLOGIES FRAGMENT THE PRINTER INDUSTRY?

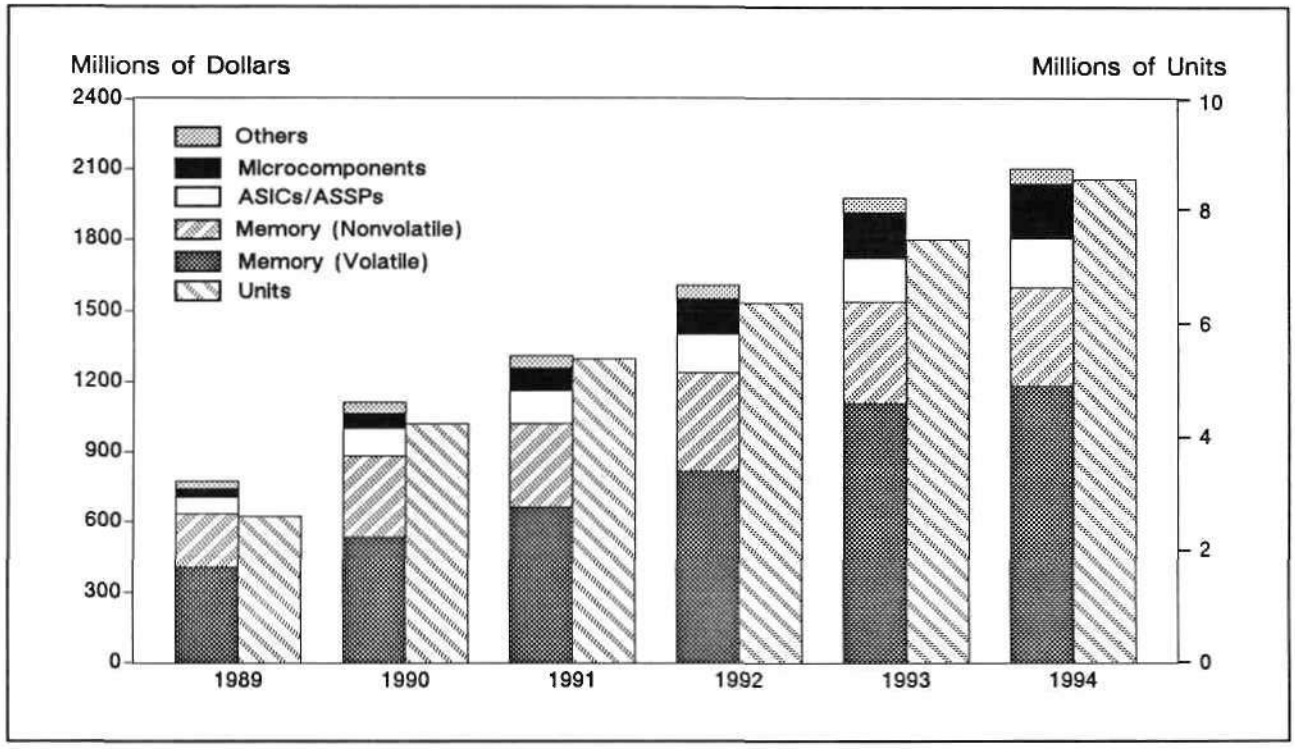
INTRODUCTION

Semiconductor suppliers looking at the page printer market most likely see a high-growth, can't-miss opportunity. But in order to fully capitalize on this opportunity, it is necessary to see beyond the industry's high growth rate and examine some fundamental industry transitions that are currently under way.

Transitions in controller architectures and in the breadth of the customer base are likely to strongly influence the kinds of opportunities available in this market. Semiconductor suppliers will need to understand both if they are to offer the right solution to the right group of customers.

This newsletter addresses the transitions facing this market and provides an update of Dataquest's Semiconductor Application Markets (SAM) forecast for laser printer semiconductor content. Figure 1 shows our current forecast.

FIGURE 1
Worldwide Page Printer Market



Source: Dataquest (August 1990)

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OVERVIEW

As one of today's hottest growth markets, the laser printer industry has been drawing new competitors like a magnet. These opportunists have targeted not only the printer market itself, but also the supplying industries such as print engines, semiconductors, and software.

One of the more interesting implications of this flood of participants is their combined effect on the competitive climate of the laser printer industry itself. There is little doubt that the evolution of these enabling industries will continue to reshape the rules of competition within the page printer industry.

Once again, those suppliers reaping the biggest gains are likely to effect the greatest change upon the target industry itself. To do so, they must fully understand the effects of their own catalytic actions.

PCs: THE HISTORICAL EXAMPLE

In 1984, the DOS PC market had an open standard but PC companies still had to design much of their own hardware, including systems logic and BIOS. This translated not only into some very real barriers to entry, but also into product differentiation issues as a lack of perceived compatibility proved fatal to several competitors.

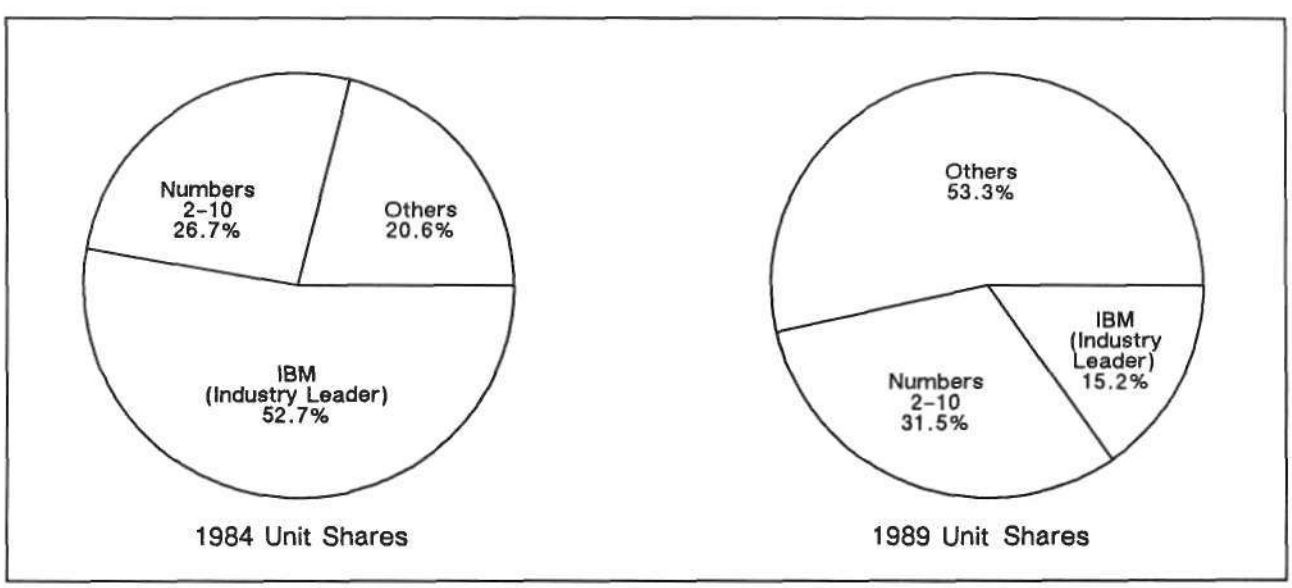
All of that changed, however, over the next few years, as supplying/enabling companies such as Chips & Technologies, Phoenix Technologies, and Western Digital developed key system building blocks to meet the standard. By making the PC "cloneable," these companies shattered most of the barriers to entry, empowering even the smallest start-up to build a PC product from readily available merchant components.

A partial listing of the PC system building blocks that became available on the merchant market is shown as follows:

- Microprocessors
- Chip sets
- Memory components
- BIOS
- DOS
- Power supplies
- Disk drives
- Monitors
- Keyboards
- Add-in cards

The results of this evolution are clear: today, barriers to entry and product differentiation have all but vanished, forcing PC manufacturers to compete on the basis of marketing and distribution channels rather than on the basis of technology. Figure 2 shows unit market shares for the various DOS PC vendors in 1984 and 1989.

FIGURE 2
DOS PC Market Shares
1984 and 1989 Unit Shares



Source: Dataquest (August 1990)

Clearly, low entry barriers and lack of product differentiation have caused this industry to become much more fragmented and competitive. Innovative enabling suppliers have had the profound effect of changing the basic nature of competition in the PC industry.

Those Who Cannot Learn from History...

Could the same thing happen to the laser printer industry? The answer depends on developments within the supplying industries as well as on the actions of leading laser printer manufacturers.

THE MARKET: DIVIDE OR CONSOLIDATE?

The Case for Fragmentation

The following shows a partial list of key printer components that are currently available on the merchant market:

- Microprocessors
- Chip sets/ASICs
- Memory components
- Font software
- Drivers
- Power supplies
- Print engines
- Case, etc.

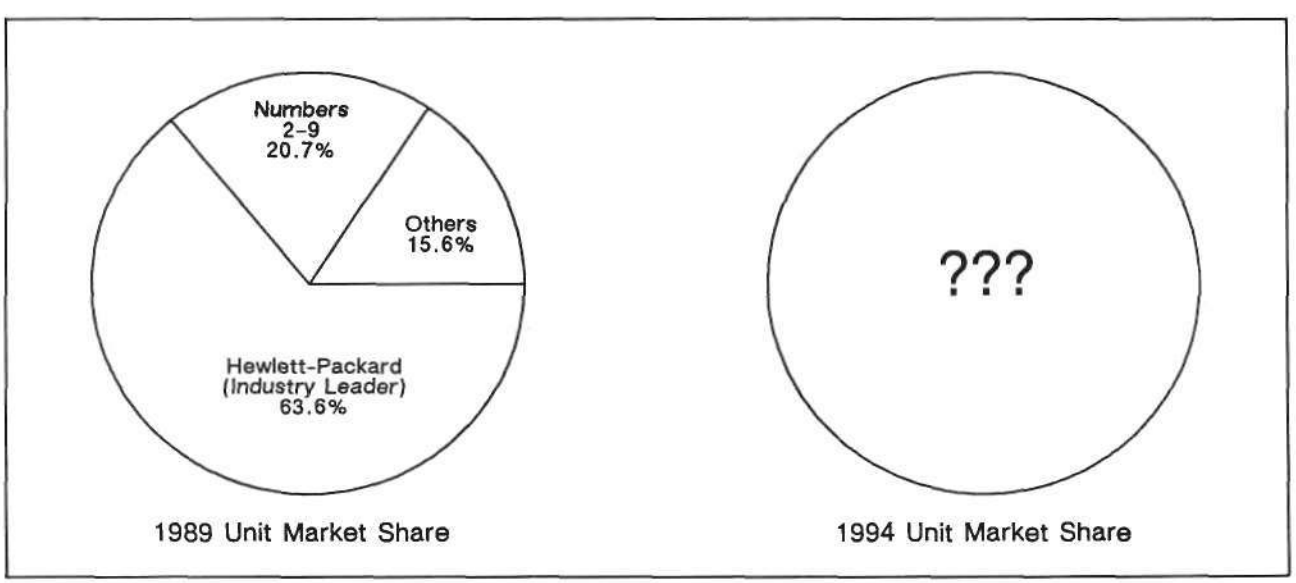
Of these components, the print engine and font software industries are undergoing the most rapid fundamental change, with new suppliers steadily streaming in (much as they did in the rigid drive, BIOS, OS, and applications software industries in the mid-1980s).

But this list tells only part of the story. Some of the best minds in the semiconductor business have been studying this industry for several years now, and their efforts have brought about several high-performance, printer-specific microprocessor products. In developing and marketing these products, companies such as AMD, Intel, National Semiconductor, and Weitek, to name just a few, have greatly simplified the task of designing the laser printer controller.

The combined effect of these supplying/enabling companies' efforts to cash in on this market has made it easier now to enter this business than at any time in the past. Figure 3 shows unit market shares for various page printer vendors in 1989.

A caveat: Low-entry barriers do not guarantee success to anyone—they just guarantee that many new players are likely to try their luck.

FIGURE 3
1989 Low-End Page Printers Unit Market Share



Source: Dataquest (August 1990)

The Case for Consolidation

No analogy is perfect, and the imperfections in this one point to some of the best arguments for consolidation. Chief among these arguments is the historical element. The dynamics of the PC industry's growth and transformation are well known by all, including Hewlett-Packard, the current laser printer industry leader. A case can be made that HP, by following a preemptive strategy, could lead this industry down a different path.

By asserting both price and technology leadership whenever possible, HP can maximize the following barriers to entry:

- Product differentiation/switching costs—HP can assert technology leadership by linking unique product features to proprietary technology, such as the page description language or the system ASICs. A "clone-proof" product would not only protect differentiation but also greatly increase competitors' product development costs.
- Capital requirements—To the extent that the merchant supplier industries are able to offer the essential laser printer building blocks, new printer companies will face minimal capital requirements. But by maintaining a high market share, HP indirectly weakens this supplier base.
- Economies of scale—experience curve—By asserting price leadership and pursuing a high-volume strategy, HP could drastically lower target price points. This might make life difficult for smaller competitors, unless their key suppliers also enjoy high volumes.
- Access to distribution channels—HP has built up tremendous dealer loyalties by providing the channel with a high volume of very profitable business. Successful entrants will need a viable channel strategy if they are to overcome this obstacle.
- In the final analysis, HP's ability to learn from IBM's experience may prove to be the most important factor of all.

Semiconductor Impact

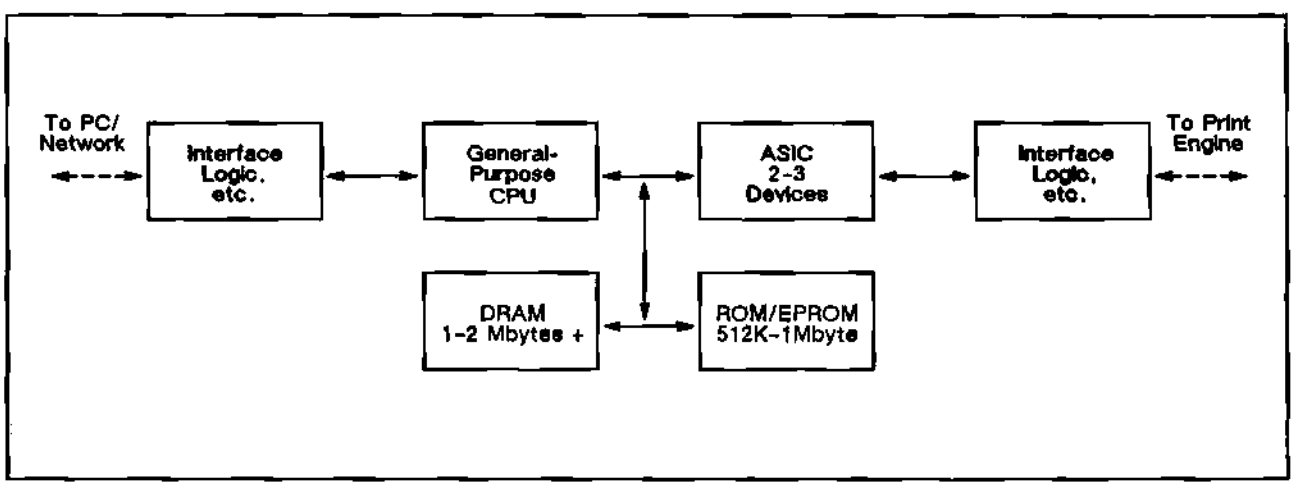
Why should semiconductor manufacturers care how this industry matures? Because the two aforementioned scenarios carry with them very different implications for the evolution of printer controller architectures and for the breadth of this customer base. Although the opportunities will be great in either case, the form of those opportunities and the appropriate strategies for capitalizing on them will differ sharply.

The Strategic Implications of Controller Design Choices

Up until last year, most low-end printer controllers closely resembled the basic design shown in Figure 4. Low unit volumes and rapidly evolving design requirements made the choice of the general-purpose microprocessor/ASIC combination a logical one.

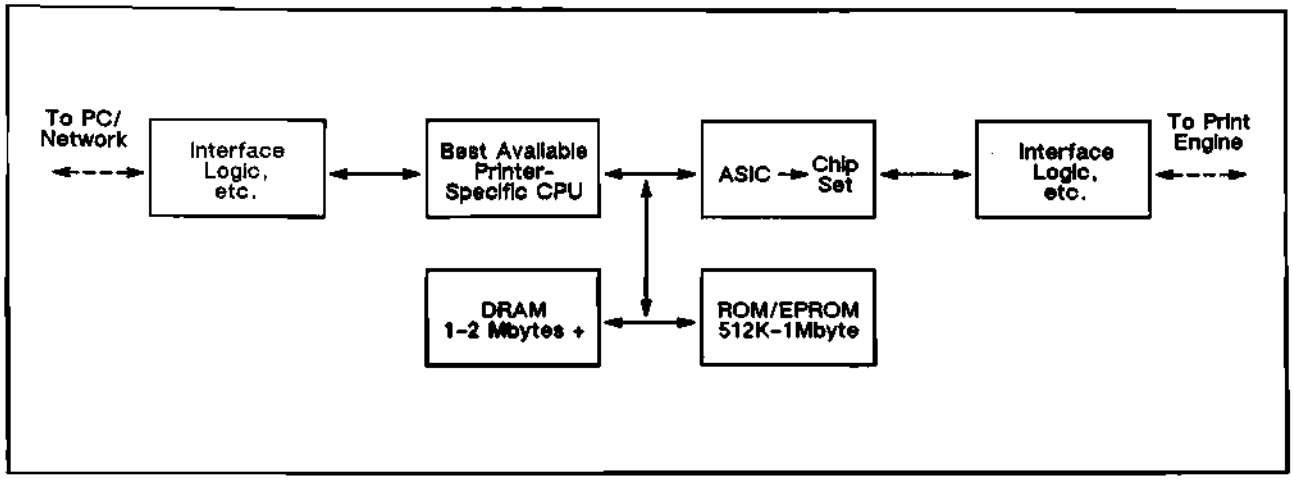
But a strong demand for higher performance, along with much greater volumes, has caused many

FIGURE 4
Current Low-End Controller Typical Implementation



Source: Dataquest (August 1990)

FIGURE 5
Merchant Market Solution



Source: Dataquest (August 1990)

to reconsider this approach. The answer to enhancing performance depends, interestingly, as much on the market position of the designer as it does on technical issues.

Laser Printer Architectures Diverge

Printer manufacturers can take either of two very different approaches toward performance enhancing design.

In Figure 5, the printer manufacturer elects to follow the "best available silicon" rule. In harnessing the competitive energies of the merchant semiconductor market, these vendors will become the beneficiary of hard-fought competition among some very talented companies. But they will have to look elsewhere for a competitive edge, because merchant silicon provides no product differentiation.

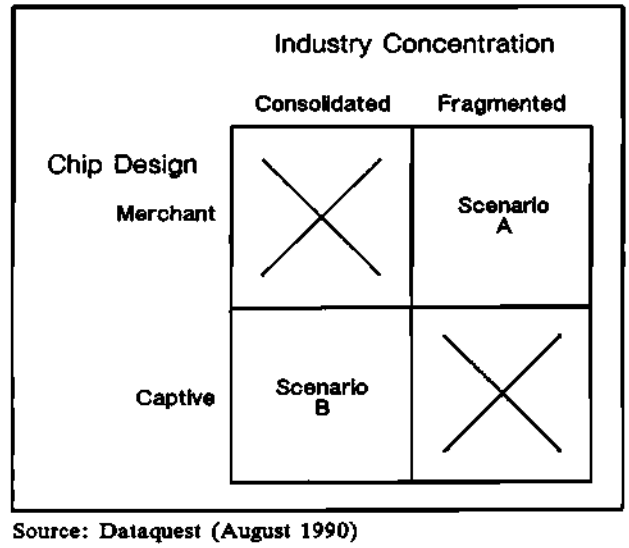
Another option is to maintain a competitive edge by enhancing performance through the use of proprietary ASICs. This approach protects product differentiation (cloning someone else's ASIC is impossible), and enhances entry barriers. On the other hand, if the merchant semiconductor industry is successful in providing a better solution, the investment in proprietary silicon will have been wasted, and the designer will face some awkward product transition issues.

Because each group of competitors designs with a different set of competitive technical issues in mind, we believe that a strong correlation exists between captive silicon designs and product differentiation. We further believe that this correlation applies to industry concentration as well. This relationship is shown in Figure 6.

THE FORECAST

Tables 1 and 2 show the semiconductor demand forecast associated with the worldwide laser printer market. Dataquest foresees a gradual transition from general-purpose to application-specific microcomponents and logic for this

FIGURE 6
Intertwining Issues: Design versus Industry Fragmentation



Source: Dataquest (August 1990)

TABLE 1
Semiconductor Content Forecast
(Dollars per Printer)

	1990	1994	CAGR 1990-1994
Total Semiconductor	260.52	245.75	(1.4%)
Microcomponents	15.35	27.50	15.7%
ASICs/ASSPs	27.15	24.05	(3.0%)
DRAMs	125.34	137.63	2.4%
N.V. Memory	81.92	49.15	(12.0%)
Standard Logic	4.59	2.40	(15.0%)
Analog	6.18	5.03	(5.0%)

Source: Dataquest (August 1990)

TABLE 2
Semiconductor Content Forecast
(Millions of Dollars)

	1990	1994	CAGR 1990-1994
Worldwide Unit Shipments (Thousands of Units)	4,259	8,548	19.0%
Total Semiconductor	1,110	2,101	17.3%
Microcomponents	65	235	37.7%
ASICs/ASSPs	116	206	15.5%
DRAMs	534	1,176	21.8%
N.V. Memories	349	420	4.8%
Standard Logic	20	20	1.2%
Analog	26	43	13.1%

Source: Dataquest (August 1990)

market. This transition is reflected in our forecast of strong growth in the microcomponents segment, along with a gradual shift from ASICs to chip sets.

This shift implies a transition to a more fragmented printer industry. Should the current industry leaders prove us wrong, then the industry would likely demand more ASICs and standard microprocessors at the expense of chip sets and application-specific microprocessors.

DATAQUEST CONCLUSIONS

Dataquest does not forecast market share, nor do we predict the fates of individual companies. To raise the issue of the possible fragmentation of the printer industry brings us a step away from such comments. In raising these issues we seek not to size up the prospects of certain printer manufacturers, but rather to highlight the technological interdependencies that exist between the semiconductor industry and its constituent electronic equipment industries.

Semiconductor companies possess the ability to serve a catalytic force in many instances. In order to take maximum advantage of this position, it is necessary for them to understand all of the effects of that change, not the least of which is the composition of the vendor base in the affected industry.

Kevin Landis

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Research *Bulletin*

SAMONITOR: ELECTRONICS INDUSTRY ENTERS PERIOD OF MODERATE GROWTH

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

Orders and shipments growth slowed down for the second and third consecutive months, respectively, in June. Orders growth for the

Figure 1
Computers and Office Equipment

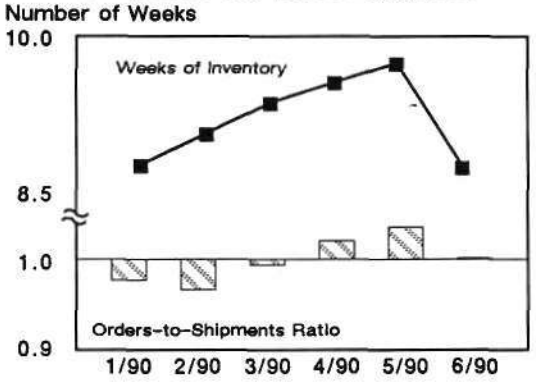


Figure 2
Communications Equipment

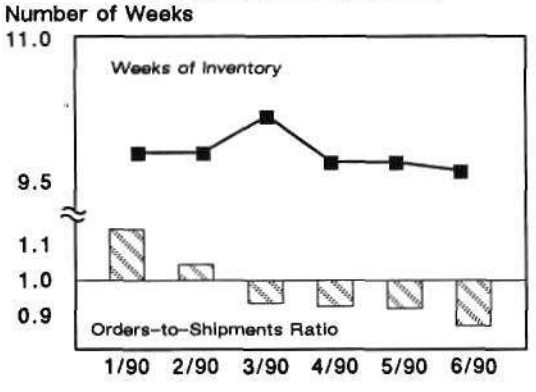


Figure 3
US Instruments

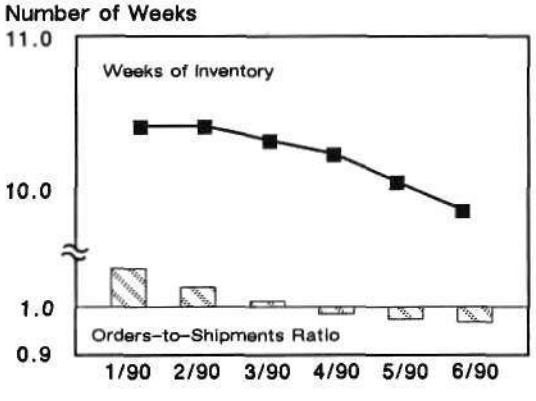
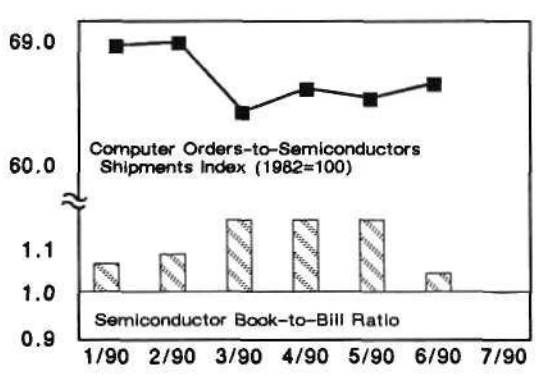


Figure 4
Semiconductors and Computers



Source: WSTS, U.S. Department of Commerce, Dataquest (August 1990)

SAM Newsletters 1990: July-September 1990-25

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three-month period ended in June was 3.3 percent above year-earlier orders compared with 5.6 percent in May. Shipments growth for the same period was only 0.2 percent above year-earlier shipments compared with 2.1 percent in May. This spring's deceleration in shipments represents the steepest three-month growth-rate descent—6.7 percentage points since March—since orders growth fell 7.3 points between July and October 1985. Less ominous, but still significant, is the recent deceleration in orders by 4.9 percentage points since April—the steepest two-month slowdown since orders growth fell 6.9 points from November 1989 through January 1990. After rising for three consecutive months, the orders-to-shipments ratio (Figure 1) fell to 1.00 in June from 1.03 in May, reflecting a slowdown in orders compared with shipments. As expected, inventories were due for a correction and fell a full week in June to 8.8 weeks—equal to last year's level—from 9.8 weeks in May. Orders and shipments growth may remain sluggish through the rest of the summer. Unless overall economic growth (capital spending in particular) improves this autumn—an increasingly unlikely scenario—Dataquest does not expect orders growth to improve much through the end of the year.

Communications Equipment

As forecast by Dataquest, *orders growth for the three-month period ended in June accelerated for the third consecutive month, to 12.3 percent above year-earlier orders,* compared with 12.1 percent in May. Shipments growth for that period decelerated for the second consecutive month to 4.8 percent in June from 5.4 percent in April. The orders-to-shipments ratio (Figure 2) advanced from 0.92 in May to 0.97 in June, reflecting a resurgence in orders. Inventories remain well managed, edging down 0.1 weeks in June to 9.6 weeks, 1.3 weeks below year-earlier levels. The rate of orders and shipments growth acceleration and deceleration has begun to slow, indicating a probable market movement into a period of dampened growth fluctuations in contrast to first-half growth marked by wide swings. Dataquest expects the coming months to see deceleration in orders growth and mild acceleration in shipments growth, both stabilizing in the 5 to 7 percent range.

Instruments

Orders growth for the three-month period ended in June slowed for the third consecutive month to 3.2 percent above year-earlier orders compared with 5.1 percent in May. Shipments growth for the three-month period ended in June also slowed, to 6.4 percent above year-earlier levels, compared with 7.2 percent in May. The orders-to-shipments ratio (Figure 3) declined for the fifth consecutive month, to 0.97 in June from 0.98 in May. As stated in last month's *SAMonitor,* the ratio's downward movement masks the market's real health. Inventories continued to edge down from 10.0 weeks in May to 9.8 weeks in June and currently 0.9 weeks below year-earlier levels, as manufacturers fill shipments from inventory in the absence of rising orders. We believe that the market is in the midst of a correction and will converge toward more stable growth in the next few months.

SEMICONDUCTOR DEMAND

The US semiconductor bookings (three-month moving average) fell 6.4 percent in July to $1,189.1 million, while July billings fell 1.4 percent to $1,187.1 million. As a result, the US semiconductor market book-to-bill ratio fell from 1.06 in June to parity in July (Figure 4). Dataquest cautions its clients not to read unwarranted pessimism into these numbers: Seasonality and 1Mb DRAM price declines continue to mask the market's underlying strength. Indeed, discrete components' book-to-bill—a relatively more stable indicator of underlying system demand—remained unchanged in July at 1.07 compared with June.

Our monthly major OEM semiconductor procurement manager survey supports the outlook of slower short-term growth: Overall, six-month system sales will grow 5.0 percent, down from 7.3 percent in July. *Data processing OEMs' expected six-month growth fell to 8.3 percent in August from 11.0 percent in July.*

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The moderation of systems growth that Dataquest expected has arrived. Continued—albeit sluggish—economic growth should provide a foundation for moderate systems-market expansion through year end. The most likely hazard to growth is an escalation of Mideast tensions supporting world oil prices at current levels for several months. Indeed, there can be no doubt that world business conditions have entered a heightened state of uncertainty—the bane of business, particularly investment. In this climate, we urge our clients to pay keen attention to their core businesses and to sharpen their competitive advantages in these areas. Eternal vigilance on competitiveness is the surest way to catch the next wave of growth.

Terrance A. Birkholz

Dataquest
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Research *Bulletin*

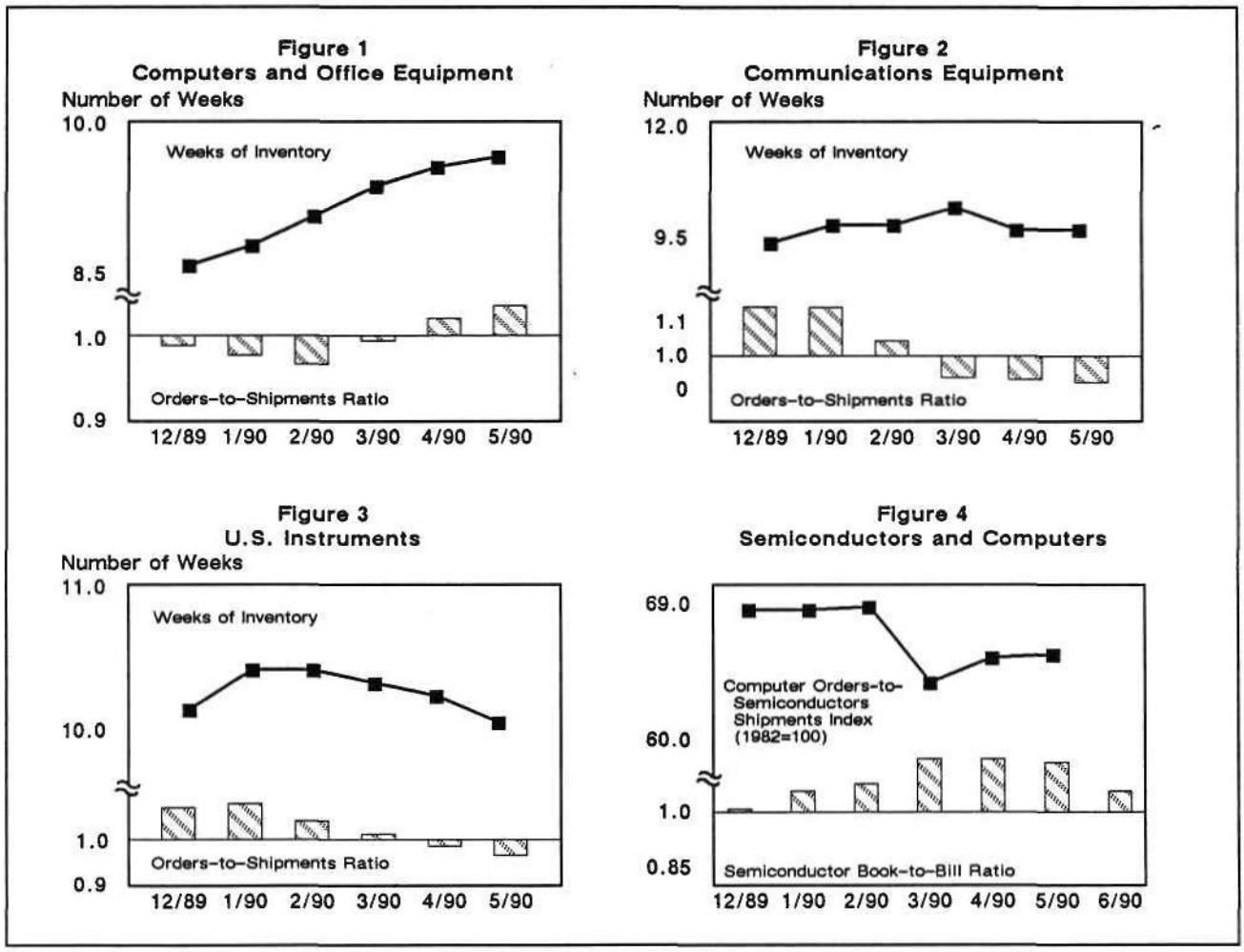
SAMONITOR: EQUIPMENT MARKETS SHOW SIGNS OF STABILITY

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

Shipments growth slowed down in May for the second consecutive month. Shipments growth for the three-month period ended in May was



Source: U.S. Department of Commerce, World Semiconductor Trade Statistics, Dataquest (July 1990)

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2.9 percent above year-earlier shipments, compared with 5.2 percent in April. Given the first quarter's surge in shipments growth, the slowdown is not wholly unexpected. Dataquest believes that it has run its course. Orders growth for the same period was 6.4 percent above year-earlier orders compared with 8.2 percent in April. Also in May, 6- and 12-month-ended orders growth were 6.4 percent and 5.4 percent, respectively, above year-earlier orders. The close proximity of these growth rates suggests that orders growth is also approaching stability. As a result of improved business conditions, the orders-to-shipments ratio (Figure 1) rose for the third consecutive month, to 1.03 in April. Inventories edged up slightly to 9.7 weeks in May from 9.6 weeks in April, 0.2 weeks above last year's level. The seasonal downturn in inventories is overdue; levels should begin to fall in June. Barring some unforeseen outside disturbance, Dataquest expects the coming months to be marked by stable orders and shipments growth, in the 3 to 6 percent and 5 to 7 percent range, respectively.

Communications Equipment

As forecast by Dataquest, orders growth continued to rebound in May. Orders growth for the three-month period ended in May was 12.1 percent above year-earlier orders compared with 6.1 percent in April. Shipments growth for the same period decelerated to 5.4 percent in May from 9.0 percent in April. The decline in the orders-to-shipments ratio (Figure 2) from 0.93 in April to 0.92 in May belies the health of this market and is more a reflection of a correction in orders growth from the extraordinary rates that occurred during the fourth quarter of 1989 and early in the first quarter of 1990. Inventories are exceptionally lean at 9.7 weeks, a full 1.5 weeks below year-earlier levels. Dataquest believes that the recent large oscillations in growth should dampen in the coming months, with shipments growth stabilizing in the 5 to 7 percent range and orders growth decelerating and settling down in the same region.

Instruments

Orders growth for the three-month period ended in May was 5.1 percent above year-earlier levels compared with 7.4 percent in April; shipments growth for the same period was 7.2 percent above year-earlier levels compared with 6.4 percent in April. The decline in the orders-to-shipments ratio (Figure 3) masks the real health of the market: Late last year, actual orders growth overshot sustainable orders growth; actual orders are now undershooting the trend to correct for this previous error. Inventories edged down from 10.2 weeks in April to 10.0 weeks in May and are currently 0.8 weeks below year-earlier levels. Dataquest believes that recent activity reflects the market's correction to more sustainable long-run growth rates. Stability should be realized in the next few months.

SEMICONDUCTOR DEMAND

In June, the US semiconductor market stepped back from the growth it had realized in recent months. US market bookings (three-month moving average) fell 8.0 percent in June to $1,270.4 million, while June billings fell 0.2 percent to $1,203.5 million. Furthermore, DRAM price pressure continues to depress the value of the market; June shipments are 8 percent below last year's level. As a result, the US semiconductor market book-to-bill ratio fell from 1.14 in May to 1.06 in June (Figure 4). Computer market growth shows no sign of abating in coming months, which should foster continued chip market growth.

Dataquest's monthly survey of major OEM semiconductor procurement managers supports our optimistic outlook: Overall, six-month system sales are expected to grow 7.3 percent, down from 9.5 percent in June. Among data processing OEMs, however, expected six-month growth has risen from 9.6 percent in June to 11.0 percent in July.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Production growth is beginning to show signs of moderating and stabilizing; witness the decelerating growth in computer shipments and the convergence of 3-, 6-, and 12-month-ended computer orders growth. Barring some unforeseen shock to the electronics industry and aggregate investment spending, we see little reason for moderate growth not to continue.

From a semiconductor manufacturer's perspective, this dynamic is good news: Better that the end-equipment markets should grow moderately, but stably, rather than swing wildly from high to low growth.

Terrance A. Birkholz

Dataquest
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Research *Bulletin*

OEM MONTHLY: JULY 1990
FUZZY LOGIC: AN OXYMORON FINDS EMBEDDED-CONTROL USES

OEM Monthly provides insight into application markets so that Dataquest clients can make better strategic and technical marketing decisions.

SYSTEMS USING FUZZY LOGIC

Fuzzy logic (see Table 1) has been discussed in the trade and popular press recently. Some products using fuzzy logic are in the stores right now (e.g., "picture-perfect" TVs), while others are not likely to be on the market for another ten years (e.g., cars with obstacle-avoidance systems that can park automatically). Fuzzy logic will be used in high-end models at first, so their success in the marketplace will determine how soon the technology is used in midrange and low-end models.

TABLE 1
Examples of Existing and Potential Fuzzy Logic Uses

Product	Application	Sponsor
Air conditioner	Temperature control	Mitsubishi
Automobile	Automatic transmission	Nissan, Subaru
	Collision avoidance	Mazda
	Suspension system	Nissan
Camcorder	Autofocus	Canon, Sanyo
Commuter train	Acceleration, braking	Hitachi
Elevator	Start and stop control	Hitachi, Mitsubishi, Toshiba
PC (palmtop)	Handwriting recognition	Sony
Refrigerator	Defrost control	Kenmore (Sears)
Robot	Arm movement	Hitachi
	Obstacle avoidance	Mazda
Shower system	Temperature control	Matsushita
Space station	Automatic docking	NASA
Television	Picture adjustment	Sony
Washing machine	Cycle selection	Hitachi, Matsushita

Source: Dataquest (July 1990)

SAM Newsletters 1990: July-September 1990-23
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By the year 2000, we expect the worldwide market for fuzzy logic semiconductors to be in the $2 billion range, or less than 1 percent of the $230 billion worldwide semiconductor market. More than 2.5 billion consumer electronics units (e.g., appliances, audio, video) are expected to be sold with a microcomponent content of $1.00 each.

TRENDS IN EMBEDDED CONTROL

Fuzzy logic is used in very sophisticated systems and represents the next step in the ongoing evolution of embedded control. Electronics began having embedded control functions earlier this century. Examples include radio automatic gain control (AGC) circuits and radar antenna servos, and these were done with analog techniques.

After the microcontroller was invented in the early 1970s, embedded control was implemented with digital techniques. Several new product features then became practical. Examples include remote-controlled television sets and VCRs, electronically tuned radios, antilock brakes, speed-dial telephones, and graphics printers.

Real-Time AI Is Coming

As the complexities of these digitally based embedded-control systems increase, their designs have to be partitioned into rule and inference sections. They become a subcategory of artificial intelligence (AI) known as "expert systems."

AI helped doctors to diagnose disease and geologists to find oil in the 1980s. AI systems usually have 1,000 to 10,000 rules and need several seconds to cycle through their programs. Embedded systems, however, must work in real time (i.e., cycle hundreds of times a second). Fuzzy logic (with typically only 10 percent of the rules of traditional AI) running on an AI coprocessor (with special instructions for doing inferences) can meet this speed requirement.

The Speed/Precision Trade-Off

Although fuzzy expert systems cycle faster than traditional systems, fewer rules also means less precision. This lower precision should not be a problem, however, because products using fuzzy logic will be designed well enough to keep users satisfied with their performance. With fewer rules, fuzzy logic also has a shorter time to market.

The future of fuzzy logic can be modeled from the history of floating point, which began as a software program and then migrated to a hardware processor. As ICs dropped in price and the need for graphics grew, the function was incorporated in the main processor (e.g., the Intel 80387 Floating Point Unit is included on the Intel 80486 system processor). It is likely that fuzzy logic will be in the main CPU by the year 2000.

As a type of mathematics, fuzzy logic is not without controversy. Proponents claim that fuzzy logic is an extension of the same set theory that underlies traditional logic. Critics, on the other hand, claim that fuzzy logic fails to meet a rigorous proof.

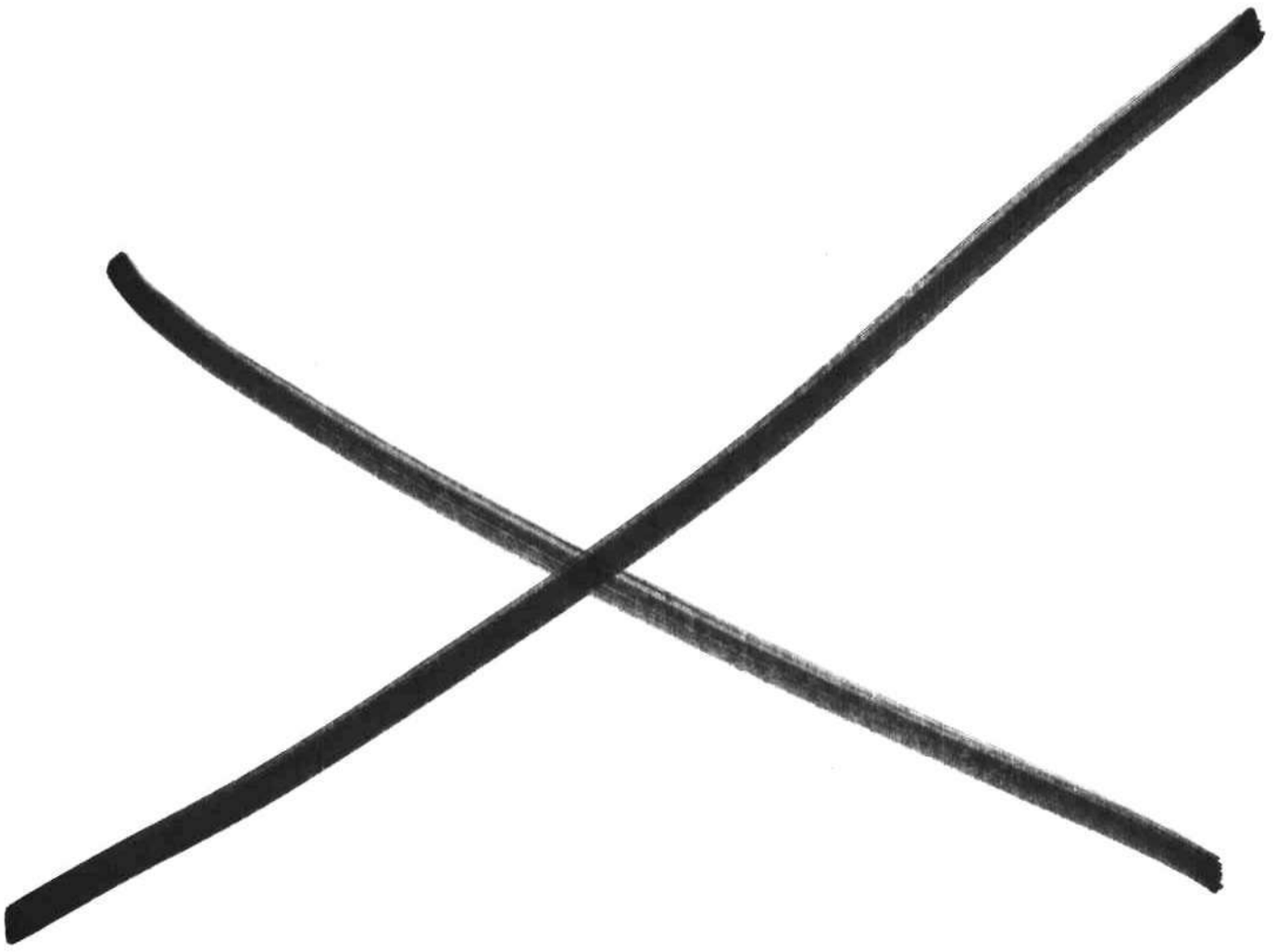
Nevertheless, fuzzy logic companies are offering products anyway. Companies providing boards and components include Apt Instruments, AT&T, Micro Devices, Mycom, Omron, and Togai InfraLogic.

DATAQUEST CONCLUSIONS/ RECOMMENDATION

Dataquest believes that fuzzy logic is a technology worth watching. As part of an embedded controller, fuzzy logic has the potential to create the next generation of "smart electronics" that possess seemingly magical features now seen only in science fiction. In addition, we believe that these products will become part of our standard of living within a decade.

For suppliers wanting to pursue this opportunity, we recommend that they first investigate the status of fuzzy-logic intellectual properties. In Japan alone, there are more than 2,000 fuzzy-logic-related patents. With 48 members in the Ministry of International Trade and Industry (MITI) Laboratory for International Fuzzy Engineering (LIFE), the number of patents is bound to increase in the coming years.

Roger Steciak



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Research *Bulletin*

SAMONITOR: SYSTEM MARKETS SLOW TO YEAR-END CLOSE

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

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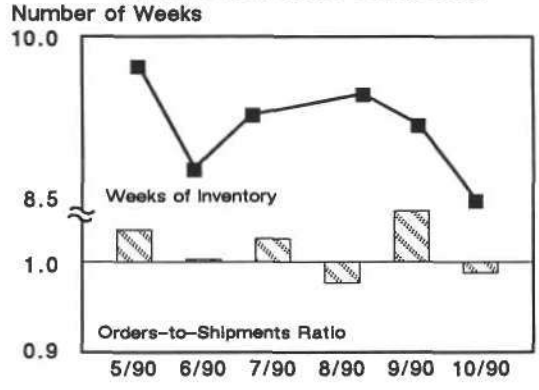


Figure 2
Communications Equipment

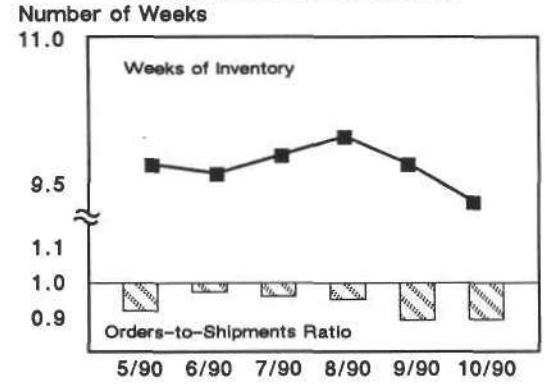


Figure 3
US Instruments

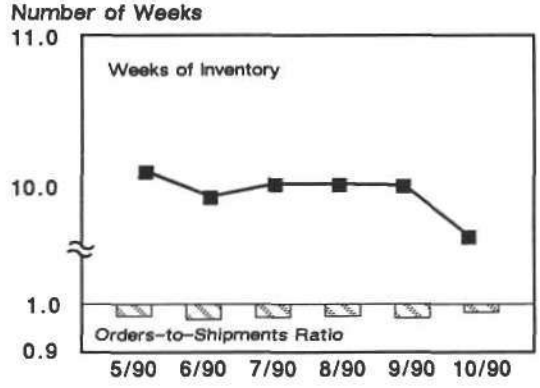
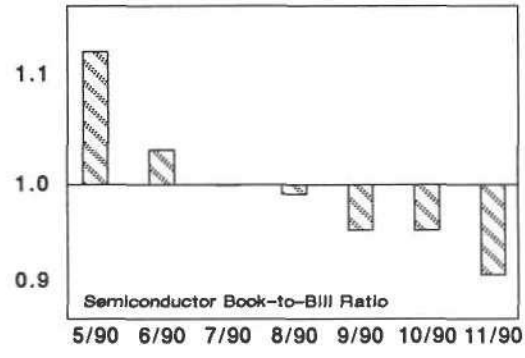


Figure 4
Semiconductors and Computers



Source: WSTS, US Department of Commerce, Dataquest (December 1990)

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NASM Newsletters 1990 1990-39

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September. Shipment growth for the same period rose sharply to 4.3 percent in October from negative 0.5 percent in September. The orders-to-shipments ratio (see Figure 1) fell to 0.99 in October from 1.05 in September, reflecting the meager 0.8 percent increase in October orders, dominated by the 7.2 percent increase in shipments. Inventories continued their seasonal downturn, moving down 0.7 week in October to 8.5 weeks, a healthy 0.6 week below last year's level. Computers and office equipment production growth continues to be hampered by the effects of waning growth trends in centralized data-processing systems, increasing saturation of traditional fully configured desktop business systems plus cutthroat price competition combined with a generally slow, macroeconomic-wide equipment investment environment.

Communications Equipment

Orders growth for the three-month period ended in October fell a negative 5.1 percent below year-earlier orders from negative 4.7 percent in September. Recent weakness in orders growth is more a result of exceptionally strong third and fourth quarter 1990 orders growth than a sudden collapse in market fundamentals. Shipments growth for the same period decelerated to 5.0 percent in October from 6.9 percent in September. The orders-to-shipments ratio (see Figure 2) was unchanged in October at 0.90 compared with September, reflecting order's shrinkage and shipment's deceleration. *September is the eighth consecutive month that the ratio has been below parity.* Inventories continued their second-half downturn, declining 0.3 week in October to 9.3 weeks, 1.4 weeks below year-earlier levels. In view of the unusually brisk orders growth during the second half of 1989 and the outlook of sluggish business investment spending through the first quarter of 1991, Dataquest forecasts orders growth in the 0 to 3 percent range in the coming months.

Instruments

Orders growth for the three-month period ended in October fell a negative 1.3 percent below year-earlier orders compared with a negative 0.2 percent decline in September. *This is the second consecutive month of negative orders growth.* Shipments growth for the same period slowed to 1.3 percent in October from 1.9 percent in September. The orders-to-shipments ratio (as shown in Figure 3) rose to 0.99 in October from 0.97. Inventories fell 0.4 week to 9.5 weeks in October and are currently 0.6 week below year-earlier levels. As in the communications sector, quick growth in the fourth quarter of 1989, and delayed business investment plans make it increasingly likely that *orders growth will*—at best—be flat through the first quarter of 1991.

SEMICONDUCTOR DEMAND

U.S. semiconductor bookings (three-month moving average) fell a negative 6.0 percent in November to $1,121.5 million, while billings fell a negative 1.5 percent to $1,241.5 million. As a result, the October book-to-bill ratio (see Figure 4) fell to 0.90 in October from 0.95 in September. October bookings were a negative 5.4 percent below year-earlier orders.

Dataquest's monthly survey of major OEM semiconductor procurement managers supports improvement in the systems market outlook: Overall, six-month system sales are expected to grow 4.0 percent, up from 3.1 percent in November. Data processing OEMs' expected six-month growth moved up to 6.5 percent compared with 6.0 percent in November. *This growth represents the first uptick in expectations for the last six months.*

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest and the Dun & Bradstreet Corporation maintain that the overall U.S. economy will avoid recession (strictly defined as two consecutive quarters of negative real GNP growth)—albeit narrowly. We expect fourth quarter 1990 growth and first quarter 1991 growth to be negative 0.4 percent and 0.8 percent, respectively. The investment outlook is more pessimistic. Real business equipment investment is expected to be negative 7.1 percent in the fourth quarter and negative 2.9 percent in the first quarter. The good news is that real GNP and equipment investment growth are expected to accelerate throughout 1991. Given this sluggish-to-moderate growth environment, semiconductor manufacturers can expect a commensurate improvement in the systems and silicon market in 1991.

This improvement should not be construed to mean that the chip and systems business is expected to be any less forgiving in 1991. Even as the business climate improves, profit margins are expected to be under a lot of pressure. In the distant past, technological competence was a *sufficient* condition for profitability; supernormal growth was the safety net that absolved companies from poor business practices. Not so in the future; as we move into the next stage of industry maturation, technological competence will become an increasingly minimal *necessary* condition for a company's corporate survival. The practice of basic, fundamentally sound corporate policy will be of increasing relative importance to earning competitive or superlative rates of return.

Terrance A. Birkholz

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Research *Bulletin*

DECEMBER PROCUREMENT PULSE: ENDING THE YEAR ON A POSITIVE NOTE

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This bulletin explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

A RISE IN SEMICONDUCTOR ORDERS PLANNED

Figure 1 illustrates how this month's survey respondents expect to increase semiconductor orders by 29.4 percent over last month's levels. Last month's expected 5.0 percent rise in orders was

Figure 1
Averaged Monthly Semiconductor Orders

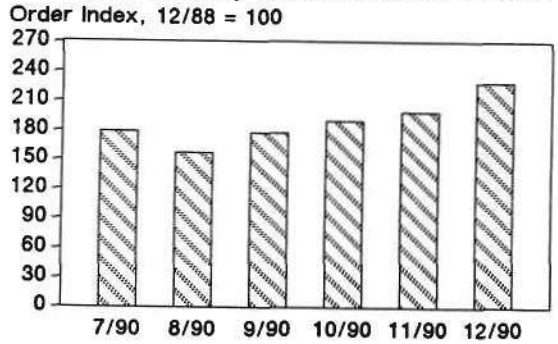

Figure 2
Averaged Semiconductor Lead Times

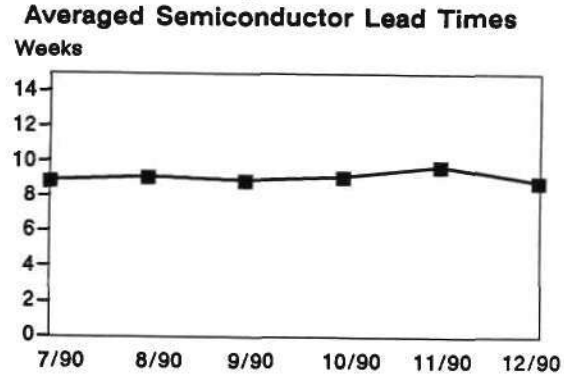

Figure 3
Actual vs. Target Inventory Levels (All OEMs)

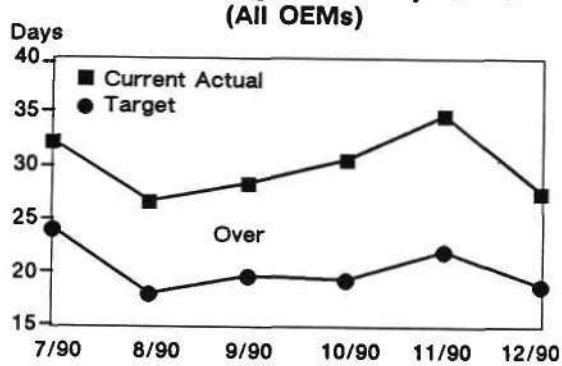

Figure 4
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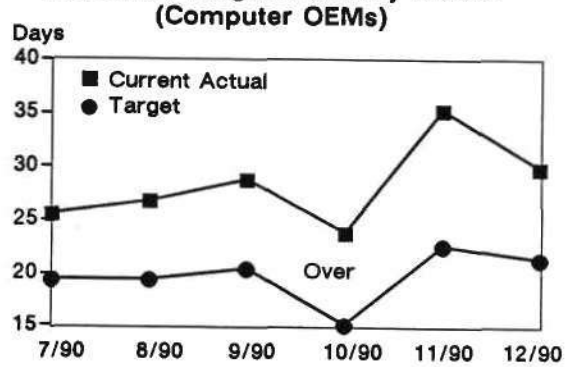

Source: Dataquest (December 1990)

NASM Newsletters 1990: October-December 1990-38

0009129

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tempered by a slight increase in inventories that, as shown later in this bulletin, has been corrected. The most recent buying optimism reflects an increase of confidence in system sales. For the first time in six months, buyers expect a slight rise in system sales from last month's overall 3.0 percent growth level to 4.1 percent. The computer system buyers' outlook also is up, to 6.7 percent from last month's 6.0 percent level. Although one month does not make a trend, this slight uptick in system sales expectations possibly signals a bottoming of the "low-growth" sales scenario of the past few months. Dataquest sees little indication that a large downturn in systems or semiconductor business will occur in the next six months.

LEAD TIMES REMAIN STEADY—DIP TO BELOW NINE WEEKS

This month's average lead time dipped to 8.9 weeks from last month's 9.8-week level, as shown in Figure 2. For the *fourth consecutive month, all survey respondents reported no problem products,* attesting that availability continues to be a nonissue. Although many products are available with sub-eight-week lead times, it appears that many users prefer a six-to-eight-week planning window that allows for adjustment to month-to-month system shipment variances. Overall pricing declined an average of 2.1 percent since last month. Dataquest continues to see no impediment to ready availability and lower pricing for all semiconductors for the next two quarters, because current capacity should be more than enough to meet demand levels for the next six months. Quality and obsolescence are the main concerns facing semiconductor users this month; both are areas in which suppliers may be able to stand out in this very competitive market.

SEMICONDUCTOR INVENTORY LEVELS ARE ADJUSTED DOWNWARD

Both targeted and actual inventory levels declined this month, reflecting the combination of corrections to last month's uptick and efforts to improve financial reports. As shown in Figures 3 and 4, the overall targeted and actual inventory levels declined to 19.0 and 27.7 days, respectively, compared with last month's comparable levels of 22.2 and 34.9 days. The computer segment's targeted and actual inventory levels dropped to 21.5 and 30.0 days, respectively, versus last month's comparable 22.8- and 35.5-day levels. As mentioned in last month's *Procurement Pulse,* these reductions in inventory were expected. Semiconductor billing levels are expected to rise by 8.1 percent this month after last month's negative 3.2 percent average, which effectively reduced inventories. The current average billing increase illustrates how semiconductor procurement is becoming more closely tied to the overall cycle of the electronics industry. Despite intentions to target inventory levels to about a 20-day average, it is becoming apparent that the actual average of 30 days (±3 days) is the norm.

DATAQUEST ANALYSIS AND RECOMMENDATIONS

The low-growth systems sales outlook and tightly controlled inventory level trend continues. Because no large volume "new" product is pulling demand, semiconductor capacity levels are able to exceed current needs. Availability, predictable pricing, and delivery performance have become the mainstay at current business levels. Many suppliers have noted improvements in forecast accuracy from users, which is helping keep overall inventory levels (for both users and suppliers) manageable. Dataquest continues to expect steady (but low) system and semiconductor demand for the next two quarters until the overall economy sorts itself out and the Middle East crisis is resolved.

Mark Giudici

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Research *Bulletin*

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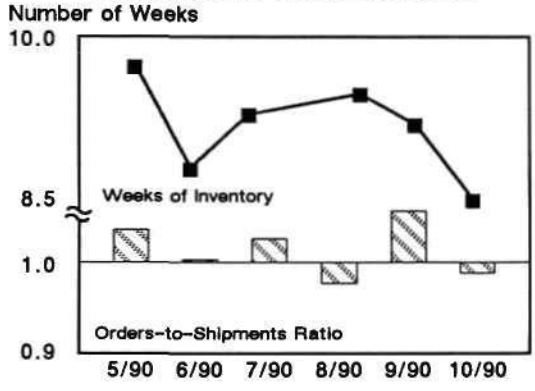

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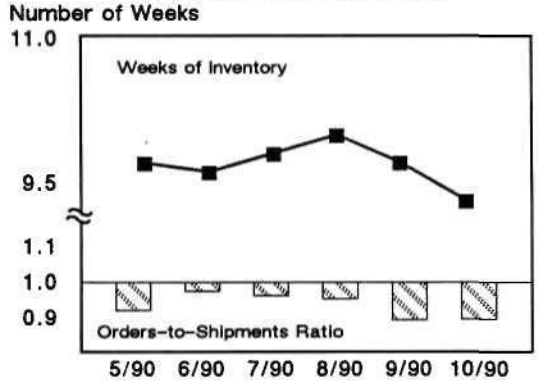

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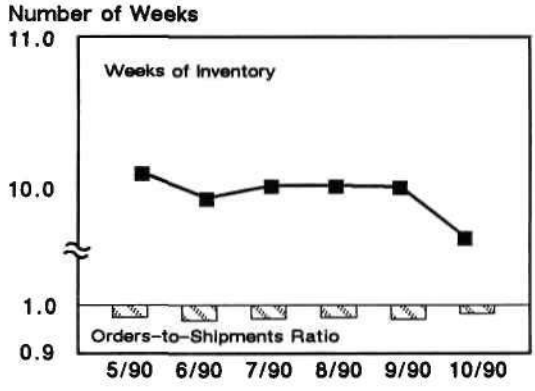

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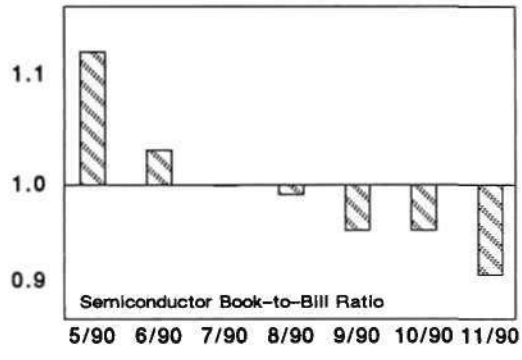

Source: WSTS, US Department of Commerce, Dataquest (December 1990)

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Terrance A. Birkholz

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Research Newsletter

ACCELERATORS QUICKEN MAC GRAPHICS

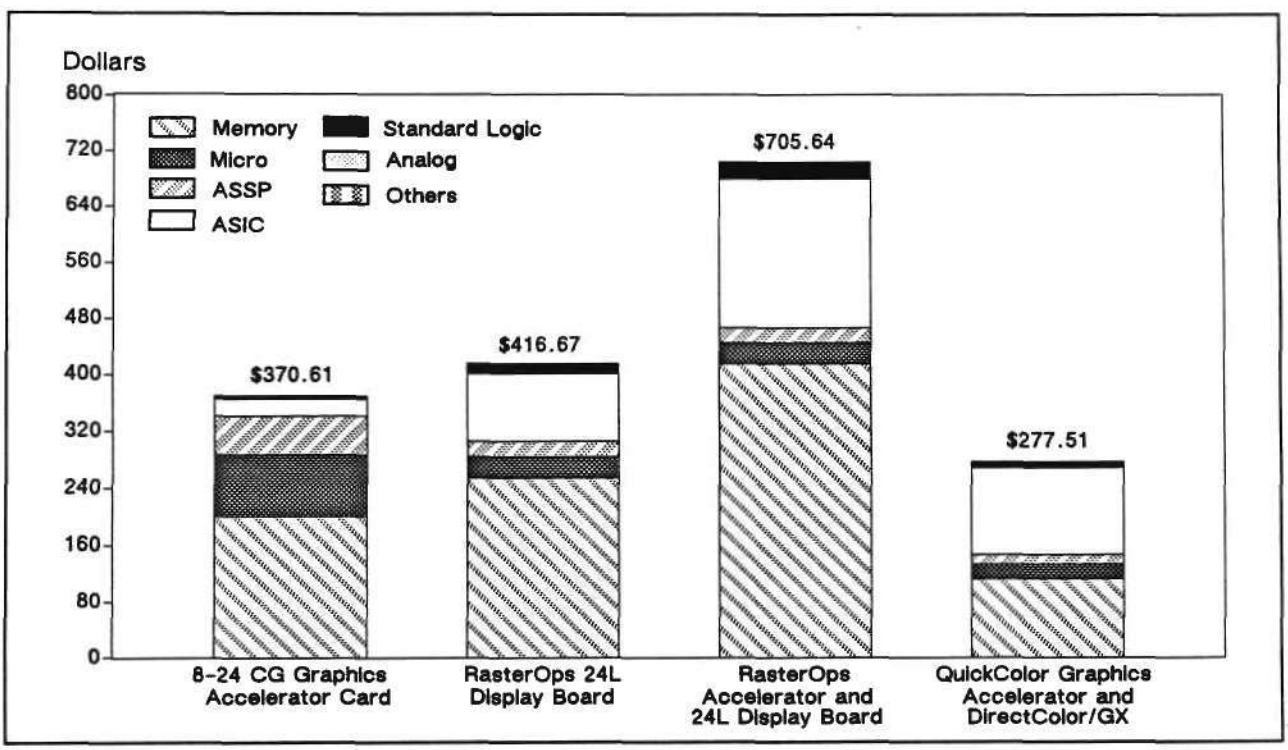
SUMMARY

This newsletter provides an overview of four Macintosh graphics accelerators currently offered by Apple and several third-party vendors. The models were selected as representative of current accelerator implementations and are examined by detailing the semiconductor content and associated costs. A discussion of the role that these products play in the industry and marketplace today also is included. Dataquest believes that these products represent an important and growing opportunity for semiconductor vendors.

INTRODUCTION/OVERVIEW

Figure 1 shows the estimated component cost of the Apple 8*24 graphics accelerator card, the Radius QuickColor graphics accelerator, the RasterOps 24L display card, and the SuperMac Spectrum/24 PDQ graphics accelerator card. The pricing data contained in this analysis are based on the Semiconductor User Information Service's (SUIS') pricing study, which assumes a 100,000-piece contract buy. Because manufacturers enjoy varying degrees of purchasing leverage and may secure greater quantity discounts for certain

FIGURE 1
Estimated Costs—Accelerator Cards



Source: Dataquest (December 1990)

SAM Newsletters 1990: October-December 1990-36

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components, these cost figures should be used for comparison purposes only.

32-Bit QuickDraw

Since the introduction of 32-Bit QuickDraw by Apple Computer in March 1989, end users of Macintosh color display systems have battled the problem of sacrificing drawing speed for high-quality, 24-bit color images. Radius, Inc., tried to solve this problem by introducing a graphics accelerator in July 1989 that accelerated certain routines of 32-Bit QuickDraw. SuperMac (October 1989) and RasterOps (April 1990) followed Radius with their own accelerators, which achieved similar results but with different design implementations. In March 1990, Apple introduced a graphics accelerator that accelerated all QuickDraw routines in 24-bit color, but only on the Apple 13-inch monitor.

QuickDraw is a series of algorithms designed for drawing and manipulating bit maps on the screen and translating mathematical descriptions of objects output by Macintosh applications into screen images. 32-Bit QuickDraw combines 24-bit true color (which offers a palette of 16.7 million colors) with 8 bits reserved for special effects. One problem encountered in using 32-Bit QuickDraw is the burden placed on the CPU by the increased number of pixels and greater pixel depth.

Graphics Accelerators Offer a Look at the Future

Graphics accelerators can enhance system performance by building into the accompanying software a faster algorithm that can be used to manipulate the pixels or a graphics coprocessor to speed image calculations. Display accelerators intercept QuickDraw calls that applications normally send to the CPU and route these calls to the accelerator's hardware. The purpose of the graphics accelerator is to off-load the processing work of the CPU in order to increase the complete system's ability to draw images quickly.

Today's early adopters tend to be end users whose applications push older technology past the limits of acceptable performance, such as prepress work in the publishing community or graphics art applications that require photorealism. Such applications not only require a greater number of colors but also tend to run on larger monitors, which substantially increases resolution and, therefore, compute requirements.

As common applications begin to require more advanced graphics capabilities, low-cost acceleration hardware is likely to migrate into the mainstream of desktop computing. Today's graphics accelerators can accomplish 24-bit true color and acceleration in one of two implementations: either on a single card containing both the graphics and acceleration functions or as a two-board set passing information through the NuBus.

PRODUCT DISCUSSION

The Apple Macintosh Display 8*24 GC

As owner of the QuickDraw source code, Apple is in the unique position of offering the only product that accelerates each and every QuickDraw command.

The 8*24 GC provides both acceleration and video functions on the same card. The decision to implement these functions together on a single card has some interesting cost, performance, and product positioning implications. Two-board solutions face the problem of passing information over the NuBus, which can become a bottleneck, while single-board solutions have no such constraint. The tight designs of the single-board solutions clearly offer some of the best performance available.

But if the single-board approach allows for higher performance, it also imposes some difficult marketing constraints. First, the design must favor integration over cost, forcing a higher price point. Second, the consumer faces an all-or-nothing buy decision. Not surprisingly, single-board solutions tend to be higher price/performance products.

These price/performance trade-offs are evident in the component content of the 8*24 GC. High-speed static RAM (SRAM) and expensive video RAM (VRAM) add considerable cost, but are necessary complements to the high-performance AM29000 and can be easily justified by the 8*24's superior performance. The use of proprietary ASICs also increases cost but allows Apple to fine-tune performance and offer advanced features such as convolution while consolidating the design.

When considering the price/performance trade-off, it is important to remember that there is no one "right" choice. The 8*24 GC is a good example of several component choices that are consistent not only with one another, but with the end-product positioning as well. Table 1 shows the semiconductor content of the Apple Macintosh Display 8*24 GC.

The SuperMac Spectrum/24 PDQ Graphics Accelerator Card

Easily the most versatile product of the group, the Spectrum/24 PDQ supports a variety of monitors while offering all of the video and acceleration feature s on a single card. The additional complexity imposed by multiple monitor support along with a high level of performance makes this one of the most sophisticated acceleration products available.

But this performance comes at a price. A sophisticated feature set implies a demanding, complex design, and the higher level of integration required to fit so much functionality on a single card means added cost. SuperMac's extensive use of ASICs may provide a proprietary edge in delivering this feature set, but a reliance on proprietary silicon also can increase product development and update times. The large number of ASICs on this board also leaves little room for other functions, such as bus mastering or GWorld support.

Another interesting aspect of this design is the lack of a processor, implying that much of the acceleration is performed by processing circuitry embedded in one or more of the ASICs. This suggests a higher cost for these ASICs. Table 2 shows the semiconductor content of the Spectrum/24 PDQ Graphics Accelerator card.

The Spectrum/24 PDQ provides a good example of third-party product positioning options. By taking an unbundled approach, SuperMac is able to differentiate this product in a manner that would be difficult for Apple to copy.

The Radius QuickColor Graphics Accelerator

The single-board solutions we have examined tend to trade price for performance in semiconductor selection. Such choices are consistent with high-performance product positioning. The QuickColor Graphics Accelerator, on the other hand, appears to have been engineered for a low-cost solution.

Because this product requires the use of a standard graphics card, we also have examined the Radius DirectColor/GX interface card. By dividing these functions onto separate cards, Radius is able to offer existing customers a relatively painless upgrade path (the additional board space provides greater flexibility in designing out cost, and certain customers are able to keep their old graphics card).

Semiconductor content analysis reveals several clever cost reduction decisions, which made this the lowest-cost design examined. For example, Radius' choice of the Acorn processor gives this design the lowest-cost graphics processor of the group, and the selection of standard dynamic RAMs (DRAMs) over more expensive VRAMs saves over $80.

The decision to use several Xilinx field-programmable gate arrays (FPGAs) gives back some of these savings, but probably pays off in greater design flexibility and time to market. This approach differs radically from that of SuperMac's ASIC approach. Table 3 shows the semiconductor content of both the QuickColor Graphics Accelerator and the DirectColor/GX Graphics Interface.

The RasterOps Accelerator

Because this product requires the use of a standard graphics card, we have examined the RasterOps 24L Display card as well. The design trade-offs for this product are similar to those of the Radius solution; however, the RasterOps solution features much more memory (a staggering 7MB of DRAM between the two boards). This extra memory provides for support of the GWorld off-screen buffer, and suggests that the RasterOps solution should be capable of handling much more information than do the other solutions.

Both the 24L and the Accelerator use quite a bit of standard logic as well as Altera and Actel FPGAs and PALs. This approach provides greater design flexibility and, in the case of the standard logic, is a way of trading board space for cost. Although the RasterOps clearly was designed with cost in mind (by using DRAMs rather than VRAMs and avoiding high-density ASICs), the use of extra memory and FPGAs indicates a willingness to trade up the price/performance curve provided that the costs are not prohibitive.

Table 4 shows the semiconductor content of the RasterOps Accelerator and the RasterOps 24L Display card.

Figure 2 shows the IC cost distributions of these products by semiconductor type. The large memory content figures should come as no surprise (these systems need to buffer large chunks of output information)—memory content tends to fall as DRAM prices decline and rise with screen resolution. The micro and ASIC content figures are also substantial and tend to move counter to one another as designers trade ASIC complexity for processing power.

DATAQUEST CONCLUSIONS

Graphics accelerators play an important role in today's Macintosh environment. Dataquest believes that role, however, currently is limited to high-end applications in which the end user is working with graphics-intensive documents and needs the additional speed that accelerators provide. For most end users, 8-bit unaccelerated color is adequate, and the additional cost of an accelerator usually outweighs the benefits of accelerating such applications as word processing and spreadsheets.

We do believe that accelerators should be viewed as a leading indicator, however, because they offer important clues about the mainstream graphics subsystems of the future. As end users become more sophisticated in the use of high-end applications, we expect to observe an increase in demand for faster graphics.

As is the case for many emerging high-end applications, today's market demands performance first, but it is important for semiconductor suppliers to realize that the full potential for this market will only be realized once system designers are able to offer low-cost solutions to the masses. If winning these sockets depends on performance, keeping them may depend on aggressive price reduction.

Kevin Landis
Katherine M. Bull

TABLE 1
Apple 8*24 GC Graphics Accelerator Card

	Vendor	Part Number	Quantity	Description	Estimated Cost	Package	Function/ Comment
Microprocessor	AMD	AM29000-30GC	1	RISC processor	85.00	169-pin PGA	Graphics processor
	National	DP8531V	1	SCC	2.25	28-pin PLCC	
ASSP	Brooktree	BT357S0010-A	1	Palette RAMDAC	54.25	68-pin PLCC	256x8 colors (110 MHz)
Memory	Motorola	MCM6295NJ25	8	16Kx4, 25ns SRAM	36.40	28-pin SOJ	Multiport video RAM
	Toshiba	TC524258AJ-10	16	256Kx4, 100ns VRAM	161.60	28-pin SOJ	
	AMD	AM27C512-205PC	1	64Kx8, 200ns EPROM	2.85	28-pin DIP	Socketed
ASIC	Toshiba	344S0091-A	1	Gate array	11.52	144-pin QFP	
	Toshiba	344S0090-03	1	Gate array	11.52	144-pin QFP	
	AMD	Pal16L8CNL	1	PAL	0.59	20-pin PLCC	
Standard Logic	National	74P543	4	Oct. trans.	0.92	24-pin SOG	
	National	74F399	8	Quad 2-in MUX	1.85	16-pin SOG	
	Motorola	F38	2	Quad 2-in NAND	0.22	14-pin SOG	
	TI	F245	4	Octal bus transceiver	0.94	20-pin SOG	
	Motorola	MC10H116P	1	Triple diff. line rec.	0.55	16-pin DIP	
	Motorola	MC10H174P	1	Dual 4-1 MUX	0.15	16-pin DIP	
		Total	2		370.61		

Source: Dataquest (December 1990)

TABLE 2
SuperMac Spectrum/24 PDQ Graphics Accelerator Card

	Vendor	Part Number	Quantity	Description	Estimated Cost	Package	Function/ Comment
Microprocessor							
ASSP	Brooktree	Bt458LPJ110	3	Palette RAMDAC	78.75	84-pin PLCC	256x24 colors (110 MHz)
	Brooktree	Bt438KC	1	Clock generator	7.00	20-pin DIP	
Memory	Toshiba	TC524258AZ-10	24	256Kx4, 100ns DRAM	252.00	28-pin ZIP	Multiport video RAM
	Micron	5C6408DJ-15	4	8Kx8, 15ns SRAM	23.86	28-pin SOJ	
	SGS Thompson	M27512FL	1	64Kx8 EPROM	2.85	28-pin DIP	Socketed
ASIC	NA	NM	10		79.80	84 pin PLCC	
Standard Logic	TI	AS646	8	Octal bus transceiver	6.12	24-pin SOG	
	Signetics	74F245D	6	Octal bus transceiver	1.40	20-pin SOG	
	Signetics	74F244D	1	Octal driver	0.23	20-pin SOG	
	Motorola	LS244	1	Octal driver	0.22	20-pin SOG	
	Motorola	F08	1	Quad 2-in. AND	0.10	14-pin SOG	
	Motorola	F151D	1	8-in. MUX	0.18	16-pin SOG	
	Motorola	F521	1	Octal comparator	0.28	20-pin SOG	
	NV Phillips	74HCT138D	1	1 of 8 decoder	0.17	16-pin SOG	
	Motorola	MC10H116P	1	Triple diff. line rec.	0.55	16-pin DIP	
		Total	64		453.51		

NA = Not available
NM = Not meaningful
Source: Dataquest (December 1990)

TABLE 3
Radius' Accelerator and Interface Boards

	Vendor	Part Number	Quantity	Description	Estimated Cost	Package	Function/ Comment
Accelerator Board: Radius QuickColor Graphics Accelerator							
Microprocessor	VLSI	VL86C010-12QC	1	RISC processor	21.00	84-pin PLCC	Graphics engine (Acorn)
Memory	Motorola	MCM6264WP70	8	8Kx8, 70ns SRAM	23.20	28-pin DIP	Frame buffer memory
	TI	TMS27C256-15JL	1	256K, 150ns EPROM	1.92	28-pin DIP	Code storage (socketed)
ASIC	National	GAL20V8A-12LNC	2	12ns GAL	7.60	24-pin DIP	Socketed
	Lattice	GAL20V8A-12LP	6	12ns GAL	22.80	24-pin DIP	Socketed
Standard Logic	TI	SN74ALS648NT	7	Octal bus transceiver	2.70	24-pin DIP	
	Signetics	74ALS573BN	4	Octal "D" latch	1.54	20-pin DIP	
	TI	SN74S38N	2	Quad 2-in. NAND	0.32	14-pin DIP	
	Signetics	74F109N	1	Dual J-K FF	0.14	16-pin DIP	
	RCA	CD74ACT02E	1	Quad 2-in NOR	0.22	14-pin DIP	
	Signetics	74F521N	1	Octal comparator	0.24	20-pin DIP	
Subtotal			34		81.69		
Interface Board: Radius DirectColor/GX Interface							
ASIC	National	GAL16V8A-15LNC	6	15ns GAL	6.42	20-pin DIP	
	Xilinx	XC2018-70PC68C	1	Logic cell array	19.00	68-pin PLCC	
	Xilinx	XC2018-70PC84C	3	Logic cell array	45.00	84-pin PLCC	
	Xilinx	XC3042-70PC84C	1	Logic cell array	21.00	84-pin PLCC	
ASSP	Dallas	DS1010-100	1	RTC	2.15	14-pin DIP	
	Brooktree	Bt473EPJ35	1	RAMDAC	11.67	68-pin PLCC	35MHz, 256x4 TrueColor
Memory	NEC	D42274V-10	8	256Kx4, 100ns DRAM	84.00	28-pin ZIP	Dual-port video RAM
	AMD	AM27C512-200DC	1	512K, 200ns EPROM	2.85	28-pin DIP	
Standard Logic	Motorola	F32	1	Quad 2-in. OR	0.10	14-pin SOG	
	Motorola	F08	1	Quad 2-in. AND	0.10	14-pin SOG	
	Motorola	F74D	2	Dual "D" FF	0.24	14-pin SOG	
	Motorola	F51	1	Dual AOI	0.11	14-pin SOG	
	Motorola	LS04D	1	Hex inverter	0.10	14-pin SOG	
	Signetics	74F244D	1	Octal 3-state driver	0.23	20-pin SOG	
	Signetics	74F377D	4	Octal "D" FF	0.92	20-pin SOG	
	TI	ALS520	1	Octal comparator	0.39	20-pin SOG	
	National	DM74ALS646WM	4	Octal bus transceiver	1.54		
Subtotal			38		195.82		
Total			72		277.51		

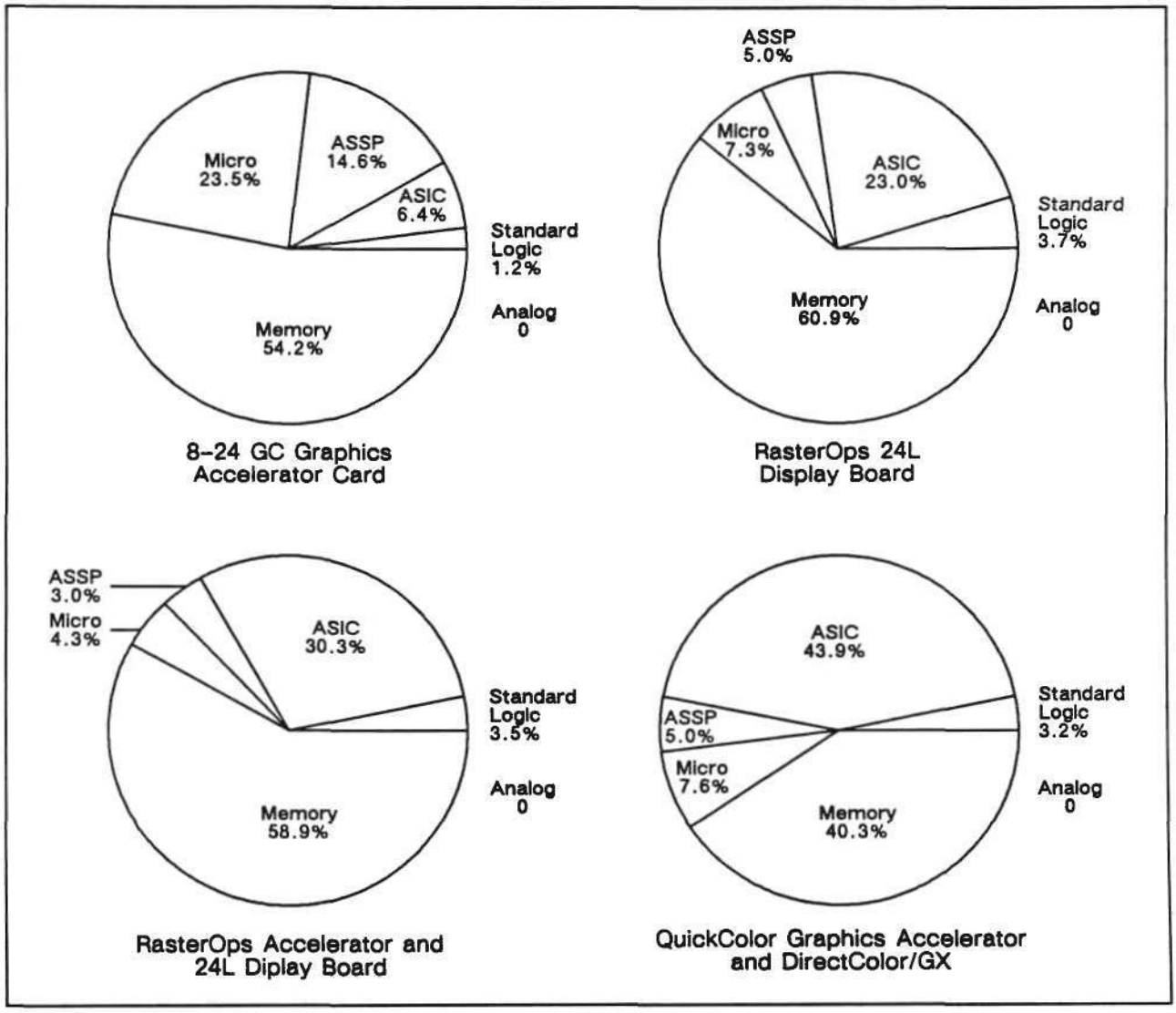
Source: Dataquest (December 1990)

TABLE 4
RasterOps Accelerator and 24L Display Board

	Vendor	Part Number	Quantity	Description	Estimated Cost	Package	Function/Comment
Accelerator							
Memory	Toshiba	TC514100J-10	32	1Mb, 100ns DRAM	161.60	20-pin SOJ	Off-screen memory buffer
ASIC	Actel	A1020A-PL84C	2	2,000-gate FPGA	41.00	84-pin PLCC	Socketed
	Altera	EPM5064JC-1	1	25ns EPLD	51.00	44-pin PLCC	Multiple array matrix
	AMD	PAL16R4BCN	2	PAL	1.18	20-pin DIP	
	AMD	PAL16R8BCN	2	PAL	1.18	20-pin DIP	
	Cypress	PALC22V10-25PC	2	PAL	7.70	24-pin DIP	
	Cypress	PALC22V10B-15WC	2	PAL	14.70	24-pin DIP	
	AMD	PAL16L8BCN	2	PAL	1.18	20-pin DIP	
Standard Logic	Signetics	74ALS153N	6	Dual 4-in. MUX	1.88	16-pin DIP	
	Signetics	74F11N	2	Triple 3-in. AND	0.20	16-pin DIP	
	TI	SN74ALS869NT	5	8-bit synch. counter	1.93	24-pin DIP	
	TI	SN74ALS573CN	2	Octal "D" latch	0.77	20-pin DIP	
	TI	SN74F74N	1	Dual "D" FF	0.12	14-pin DIP	
	TI	SN74F00N	1	Quad 2-in. AND	0.10		
	Signetics	74F86N	1	Quad XOR	0.12	14-pin DIP	
	Signetics	74F02N	1	Quad 2-in. NOR	0.10		
	Signetics	74F640N	4	Inv. octal bus trans.	0.94	20-pin DIP	
	Signetics	74F244N	4	Octal driver	0.94	20-pin DIP	
	Signetics	74F240N	2	Octal 3-state driver	0.47	20-pin DIP	
	National	DM74ALS520N	1	Octal comparator	0.39	20-pin DIP	
	TI	SN74F574N	1	Octal "D" FF	0.23	20-pin DIP	
	IDT	SA25TP	5	Quad 2-in. NAND	1.10	20-pin DIP	
Others	Dallas	DS1000M-50	1	Delay line	0.15	8-pin DIP	
		Total	82		288.97		
Board Display							
Microprocessor	TI	TMS34061FNL	1	Graphics processor	30.50	68-pin PLCC	
ASSP	Brooktree	Bt473KPJ80	1	Palette RAMDAC	21.00	68-pin PLCC	Triple 8-bit, 80 MHz
Memory	NEC	D42274V-10	24	256Kx4, 100ns DRAM	252.00	28-pin ZIP	Dual-port graphics buffer
	Signetics	27C256-20	1	32Kx8, 200ns EPROM	1.95	28-pin DIP	Window
ASIC	NA	NA	3	GA	15.30	68-pin PLCC	
	Altera	EPM5128JC-1	1		74.85	68-pin PLCC	
	Altera	EP610LC-25	1		5.50	28-pin PLCC	Socketed
Standard Logic	TI	74ACT640	10	Inv. octal bus trans.	6.20	20-pin SOG	
	TI	74ALS996	2	8-bit read-back latch	0.77	24-pin SOG	
	TI	AS153	1	Dual 4-in. MUX	0.44	16-pin SOG	
	TI	74ALS992	1	9-bit read-back latch	0.39	24-pin SOG	
	TI	74ALS842	3	10-bit read-back latch	1.16	24-pin SOG	
	National	DM74ALS563AWM	4	8-bit latch	1.54	20-pin SOG	
	Signetics	7407D	1	Hex. inverter	0.10	14-pin SOG	
	National	74ACT240	1	Octal 3-state driver	0.55	20-pin SOG	
	National	74ACT245	4	Octal bus transceiver	2.20	20-pin SOG	
	Signetics	74F32D	1	Quad 2-in. OR	0.11	14-pin SOG	
	Motorola	74F74	3	Dual "D" FF	0.12	14-pin SOG	
	National	DM74ALS520WM	1	Octal comparator	0.39	20-pin SOG	
	National	74ALS573BWM	2	Octal "D" FF	0.77	20-pin SOG	
	Signetics	74F08D	1	Quad 2-in. AND	0.10	14-pin SOG	
	National	74F175	1	Quad "D" FF	0.20	16-pin SOG	
	National	DM74ALS541WM	1	Octal buffer	0.39	20-pin SOG	
	Dallas	DS1000M-50	1	Delay line	0.15	8-pin DIP	
		Total	70		416.67		

NA = Not available
Source: Dataquest (December 1990)

FIGURE 2
IC Cost Distributions by Semiconductor Type



Source: Dataquest (December 1990)

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Research *Bulletin*

OEM MONTHLY: AUTOMOTIVE APPLICATIONS PROFILED

Automotive semiconductor applications continue to present an attractive market opportunity. Every model year, more standard electronics are embedded into each vehicle; optional electronic systems also proliferate. The automotive semiconductor business is potentially lucrative, but it is subject to the laws of economies of scale and is best characterized by its high volumes and low margins.

IMPORTANT APPLICATIONS

Key forces driving the standardization of embedded automotive electronics include legislation and insurance. Legislation as characterized by an updated Clear Air Act and Corporate Average Fuel Economy (CAFE) regulations, as well as the green movement in Europe, are driving many changes in the power-train control area.

The desire to reduce emissions and move CAFE averages to over 30 mpg, coupled with the Persian Gulf crisis, is helping stimulate more sophisticated engine and transmission control. Legislation also has created a market for airbag/seat belt controls in a very short time. Growth in installation rates of antilock braking systems (ABSs) and theft deterrence systems is being stimulated partly by the insurance industry as a means of reducing costs. Table 1 summarizes some larger and growing application areas in automotive electronics.

SEMICONDUCTOR CONTENT

Table 2 summarizes the semiconductor content of several key applications. Multipoint electronic fuel injection (EFI) and transmission control areas are the richest in content, running in the $30 range. Whenever MPUs are employed, they constitute about 20 percent of the semiconductor value while creating a need for many other semiconductors. Other semiconductors needed include semicustom logic, standard and custom analog, and discretes such as power transistors.

The use of semicustom microcontrollers with 8-, 16-, and 32-bit widths should continue to expand. The more stringent emission and CAFE laws are helping force designers to consider higher-performance MCUs to achieve difficult integrated control functions (e.g., engine and transmission combined). Digital and mixed-signal CMOS and BiCMOS ASICs should continue to be employed for various I/O and control applications around core CPUs. Entertainment and signal conditioning will drive analog need, and the abundance of

TABLE 1
Forecast Key Automotive Electronic System Installations in North America (Millions of Units)

	1990	1995
AM/FM Stereo/Cassette	5.9	7.0
Cruise Control*	8.1	10.0
Suspension Control	0.6	1.9
ABS (2- and 4-Wheel)	4.0	12.8
Electronic Instrument Clusters	7.9	9.1
Multipoint EFI	5.3	7.9
Transmission Control*	3.7	5.0
Airbag Control	2.4	10.0
Interval Wipers	9.9	13.0

*Can be coupled with engine management functions.
Source: Dataquest (December 1990)

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

TABLE 2
Semiconductor Content of Key Automotive Applications
1990

	Semiconductor Price per Unit	Percent MPU	Percent Logic	Percent Memory	Percent Analog	Percent Disc/Opto	Total
AM/FM Stereo/Cassette	18.30	20	2	0	52	26	100
Cruise Control*	11.10	22	48	0	10	20	100
Suspension Control	15.20	0	4	0	4	91	100
ABS (2- and 4-Wheel)	15.80	22	31	0	28	18	100
Instrument Clusters	10.40	11	21	2	48	18	100
Multipoint EFI	31.30	18	52	14	0	17	100
Transmission Control*	33.00	7	75	7	4	7	100
Airbag Control	16.80	20	40	1	31	9	100
Interval Wipers	4.20	0	9	0	74	17	100

*Can be coupled with engine management functions.
Source: Dataquest (December 1990)

TABLE 3
Automotive Semiconductor Applications
1990

	Percent of Semiconductor End Use	Percent of MPU End Use	Percent of Logic End Use	Percent of Memory End Use	Percent of Analog End Use	Percent of Disc/Opto End Use
Entertainment	14	13	1	<1	34	17
Vehicle Control	14	15	14	<1	10	18
Body Control	2	2	4	<1	4	4
Driver Information	16	9	21	11	19	9
Power Train	42	51	51	86	14	39
Safety/Convenience	13	9	9	3	19	13
Total	100	100	100	100	100	100

Source: Dataquest (December 1990)

actuators (e.g., fuel injection, ABS) and motors will drive power transistor and IC use.

The average semiconductor content per car and light truck in North America currently is $107. Most of these vehicles have $100 or less in content, whereas high-end, low-volume cars are expected to have $200 or more.

Table 3 shows the semiconductor usage distribution across general automotive electronic categories. The power-train area clearly is the largest for most of the digital and discrete categories. Of total automotive memory usage, 84 percent is for control-code (EPROMs) and scratch-pad (SRAMs) use in power-train applications. Of all analog consumption, 39 percent is for entertainment.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Many opportunities to penetrate automotive applications and automotive OEM accounts exist. The proliferation of new applications has, to some degree, opened the door for new semiconductor suppliers in a market best characterized as one of close relationships. Dataquest recommends, however, that interested suppliers develop a vertical marketing approach before targeting automotive OEMs. In this market, relationships, quality, service, and price generally come before product innovation when trying to win business.

Greg Sheppard

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Research Newsletter

ELECTRONIC DRUG DELIVERY SYSTEMS: A NICHE MARKET FOR SEMICONDUCTORS

INTRODUCTION

Rising health care expenditures and the push for cost containment will drive new electronic solutions in medical electronics. The purpose of this newsletter is to present one high-growth-potential niche market for semiconductors in medical electronics. In this newsletter, Dataquest looks at the following:

- PCA pumps
- Dataquest's estimated North American unit TAM
- Semiconductor content
- Market players
- Trends

PCA PUMPS—WHAT ARE THEY?

Patient-controlled analgesia (PCA) pumps constitute a drug delivery system that allows for the controlled, continuous infusion of morphine or other analgesics without constant medical supervision. Individual patient dosage levels are programmed into the pump via a keypad or dial system with operator feedback through LCD display or small printer. Medication then is administered on a continuous or basal/patient-controlled basis. This instrument allows patients to maintain a constant comfort level while avoiding the side effects of higher levels of sedation. The device provides hospitals with a reliable drug delivery system and reduces staffing costs. Moreover, PCA pumps have resulted in shorter hospital stays, leading to diminished expenditures for insurance carriers.

Use of this instrument can be divided into two major categories: postoperative and ambulatory care pain management. PCA pumps can be further broken down into syringe and peristaltic pumps. Syringe pumps are prevalent in hospital settings, whereas modified syringe and peristaltic pumps are used in an ambulatory environment. Because the control functions are analogous for all types of PCA pumps, the basic semiconductor requirements are the same.

Of the 22.5 million surgical procedures performed in the United States in 1988, Dataquest estimates that approximately 15 to 20 percent—or 3.3 million to 4.5 million cases—could have benefited from a PCA pump for postoperative pain management. Ambulatory care applications include patients with chronic debilitating pain as well as those with terminal conditions. Currently, only terminal cancer patients are approved for reimbursement under Medicare. Compensation undoubtedly will shift as the device is recognized for its distinct benefits in controlling health care expenditures as well as providing terminal ambulatory patients with a higher quality of life during the final stages of their illness.

NORTH AMERICAN PCA UNIT TAM DISCUSSION

In determining the market for PCA pumps, both distinct end markets—postoperative and ambulatory care—should be considered. Table 1 illustrates Dataquest's North American unit TAM estimate for PCA pumps. According to pump manufacturers, approximately 15 to 25 pumps could be shipped per hospital over a five-year period. In 1988, there were approximately 6,780 hospitals in the United States and 1,250 in Canada, representing a five-year unit TAM of between 120,450 and 200,750 units for the postoperative PCA sector. Of the nearly half-million terminal

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TABLE 1
North American Five-Year Unit TAM Estimate
PCA Pumps
Base Year: 1988

Postoperative Care PCAs	Banded Estimates
Estimated PCA Shipment per Hospital	15 - 25
Total U.S. Hospitals	6,780[1]
Total Canadian Hospitals	1,250[1]
North American Unit TAM Estimate	120,450 - 200,750
Ambulatory Care PCAs	
Terminal Cancer Patients	494,000[2]
Estimated Applicable Cases (%)	< 5
North American Unit TAM Estimate	9,880 - 24,700
Additional Pumps Required Due to Nonreturn	988 - 2,470
	10,868 - 27,170
Estimated Five-Year TAM	131,318 - 227,920
Estimated Time to Obsolescence	Five years

[1] American Hospital Association
[2] American Cancer Society
Source: Dataquest (December 1990)

cancer cases each year, industry sources cite an adoption rate for ambulatory PCA pumps of no more than 5 percent, or a five-year unit TAM of approximately 24,700. Ambulatory pumps have a greater than 90 percent return rate after use, indicating that about 2,470 pumps would require replacement. Dataquest believes that growth in the ambulatory care sector will trail that of postoperative care, relying on the availability of support and training for patients and FDA approval for employment with added drug therapies. *The ambulatory care sector, however, should provide the main impetus for growth and drive consumption of higher-density components in the future.*

Dataquest anticipates that the worldwide TAM for PCA pumps consists of developed nations in which a strong medical reimbursement infrastructure and an undersupply of health care workers exists. Applying corresponding assumptions to Japan would yield an estimated five-year unit TAM of 147,615 to 246,025 for postoperative pumps and 10,000 for ambulatory units. For Germany, the United Kingdom, and France, Dataquest estimates a collective five-year TAM of 90,300 units for postoperative and 6,000 units for ambulatory devices.

SEMICONDUCTOR CONTENT

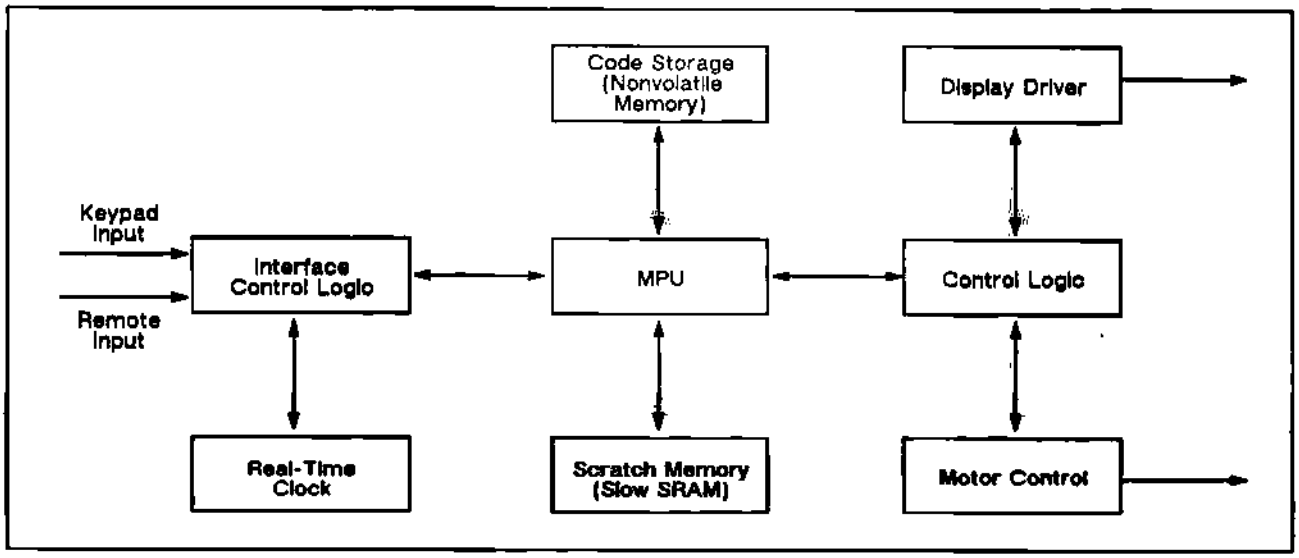
Figure 1 shows a typical PCA system block diagram.

Table 2 summarizes the semiconductor component content of a representative high-end postoperative PCA pump. This instrument contains 30 components with an estimated total semiconductor value of $26.49. Wholesale unit price for this pump is approximately $3,200 to $3,500.

Portable ambulatory pumps tend to use surface-mount technology for greater reliability, smaller footprint, and lower manufacturing cost. Postoperative pumps still employ standard dual in-line package (DIP) plastic packaging. Dataquest anticipates that these designs will abandon older packaging technologies as the price premium associated with surface mount gradually disappears.

FIGURE 1

PCA Pump Block Diagram



Source: Dataquest (December 1990)

TABLE 2
PCA Pump Component Content

Classification	Part Number	Quantity	Description	Vendor	Cost
Micro	Z83C30PS	1	CMOS microprocessor	Zilog	2.00
	MM80C95M	1	CMOS microcontroller	National Semiconductor	2.50
Memory	HM6116PL-2	1	16K CMOS slow SRAM	Hitachi	3.50
	AM2731LDC	3	32K EPROM	Advanced Micro Devices	4.80
Standard Logic	CD4069CN	2	Hex inverter	Harris	0.44
	HC139	2	Dual decoder	NA	0.30
	HD14688P	1	Real-time clock	Harris	4.50
	MM74HC244N	1	4-line digital demultiplexer	National Semiconductor	0.12
	CDP-HC1858-OP3	1	Select chip for LCD	Harris	3.00
	UNL2003A	1	7-channel latch driver	Sprague	0.55
	MM7474A	1	Dual flip-flop	National Semiconductor	0.17
	CD4724	2	8-bit latch	Harris	1.04
	MC14075	1	Triple 3-input OR	Motorola	0.24
	HFC40106EE	1	Quad 2-input NAND	SGS-Thomson	0.11
	74C174	2	Flip-flop	Motorola	0.50
	DM74LS7AN	2	Hexinverter	National Semiconductor	0.24
	MM74C244	1	Octal Driver	NA	0.25
	CD4081BPC	2	Quad 2-input AND	Harris	0.22
Analog	MC14C174	1	CMOS motor driver	Motorola	0.36
Opto	NA	3	LEDs	NA	1.65
					26.49

NA = Not available
Source: Dataquest (December 1990)

TABLE 3
Key North American Manufacturers of PCA Pumps

Company	Division/Subsidiary	Location[1]
Abbott Laboratories	Abbott PCA Pump Division	Abbott Park, IL
Baxter International	Baxter Pharmacy Division	Deerfield, IL[2]
C.R. Bard, Inc.	Bard MedSystems Division	North Reading, MA
Eli Lilly & Co.	IVAC Corporation	San Diego, CA
Pharmacia AB	Pharmacia Deltec, Inc.	St. Paul, MN

[1] [2]Manufacturing location unless otherwise indicated
Manufactured in Beverly, Massachusetts, by Strato Medical Corporation
Source: Dataquest (December 1990)

MARKET PLAYERS

Table 3 provides information about the five prominent North American PCA manufacturers.

TRENDS

Trends in TAM

Electronic infusion systems present a high potential growth market within medical electronics. Key factors forming increased demand for drug delivery systems include higher levels of PCA pump usage by terminal cancer patients and approval for usage in cases of severe arthritis or AIDS.

Factors affecting the cancer rate include the continued aging of the U.S. population and the higher incidence of cancer in this group. Arthritis represents a major nonterminal disease for potential treatment by PCA pump. According to the Arthritis Foundation, an estimated 2 million Americans suffer from rheumatoid arthritis, the type generally associated with serious pain.

According to the Center for Disease Control, the AIDS population in the United States in 1988 was 36,272. The center estimates that the number of new cases will increase by 159 percent by 1992. These patients also constitute a potential market for PCA instruments.

In short, the graying of the population and diseases related to aging, coupled with other terminal conditions, should provide strong growth in PCA demand. The key element for shipment growth lies with insurance carriers' acceptance for compensation in ambulatory cases. Dataquest further recognizes the potential for a market shift toward ambulatory pumps for postoperative care as these devices begin to offer more advanced features at competitive prices.

Trends in Semiconductor Consumption

As the instrument content analysis indicates, today's PCA pumps contain a sizable number of standard components, which allows the manufacturer to minimize component costs while maintaining margins. These standard devices pose a challenge for manufacturers because their product can easily be reverse-engineered. Dataquest foresees the greatest opportunities for ASIC suppliers, namely those of PLDs, to meet the need of OEMs in their next generation of pumps by providing a proprietary solution while supporting trends in product enhancements such as new safety features and shrinking of the product footprint.

DATAQUEST CONCLUSIONS

Although certain segments of the medical electronics market receive greater attention, *semiconductor vendors may be better served by focusing on high-volume equipment markets.* The highly competitive PCA pump arena is a good example of a niche market in which both manufacturer and semiconductor supplier could benefit by streamlining existing designs.

Rebecca E. Burr
Kevin Landis

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Research *Bulletin*

SAMONITOR: DON'T BATTEN DOWN THE HATCHES (YET)

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

Orders growth for the 3-month period ended in September was 4.3 percent above year-earlier orders compared with 0.3 percent in August.

Figure 1
Computers and Office Equipment

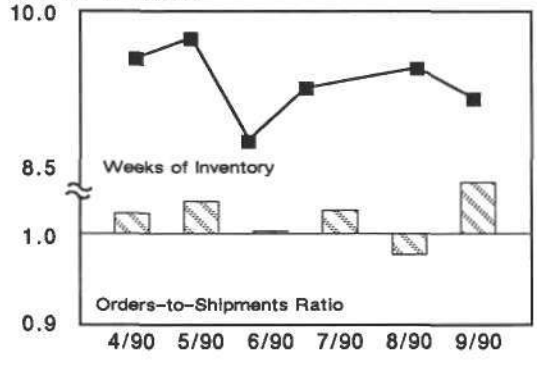


Figure 2
Communications Equipment

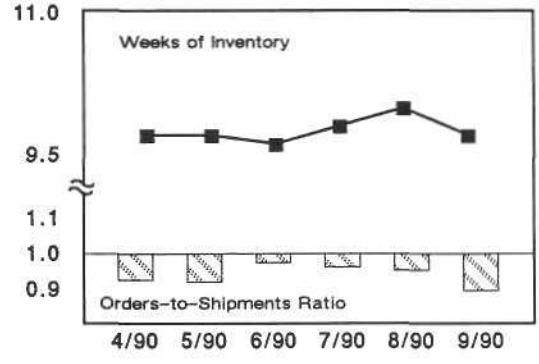


Figure 3
US Instruments

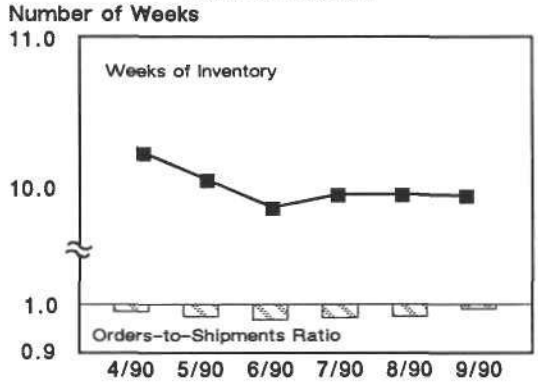
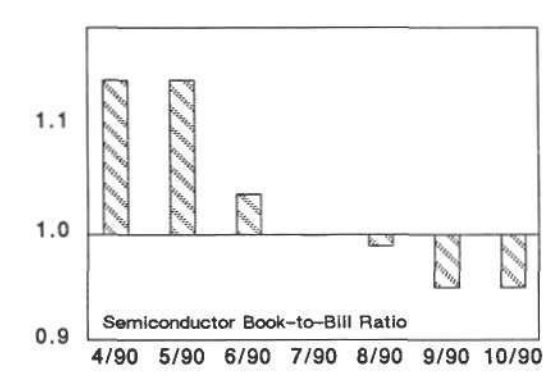


Figure 4
Semiconductors and Computers



Source: WSTS, US Department of Commerce, Dataquest (November 1990)

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SAM Newsletters 1990 1990-33

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Shipments growth *fell for the third consecutive month:* September 3-month-ended growth fell 0.3 percent below year-earlier shipments compared with a 0.4 percent decrease in both July and August. The orders-to-shipments ratio (Figure 1) rose to 1.050 in September from 0.098 in August, reflecting a 7.6 percent rebound in September orders from August. Inventories began their seasonal downturn on schedule, moving down 0.3 week in September to 9.2 weeks, 0.1 week above last year's level. This news is especially welcome given shipments' recent lackluster performance. The prospect of a Persian Gulf war and the adverse impact of tightening credit on what was already meager capital spending make it increasingly likely that *orders growth will remain flat for the rest of 1990 and spill over into the first quarter of 1991* compared with year-earlier orders.

Communications Equipment

Orders growth for the three-month period ended in September fell 4.5 percent from 7.9 percent in August. Month-to-month orders volatility arises from the relatively discontinuous flow of defense-related communications orders and therefore should not be construed as an indication of underlying business conditions fragility. Shipments growth for the same period accelerated insignificantly to 7.0 percent in September from 6.9 percent in August. The orders-to-shipments ratio (Figure 2) fell for the third consecutive month in September to 0.90 from 0.95 in August, reflecting the 4.1 percent drop in orders and the 2.0 percent rise in shipments from August to September. *September is the seventh consecutive month the ratio has been below parity.* Inventories remain tightly controlled, edging down 0.2 week in September to 9.7 weeks, 1.4 weeks below year-earlier levels. In view of the unusually brisk orders growth in the second half of 1989 and the sluggish equipment investment spending outlook through year-end, Dataquest forecasts orders growth in the 0 to 3 percent range. We expect orders growth to accelerate during 1991's first quarter as the business investment climate improves.

Instruments

Orders growth for the three-month period ended in September decelerated to 2.2 percent above year-earlier orders from 2.9 percent in August. *Excepting July, orders growth has slowed continuously from 9.1 percent in March.* Shipments growth for the same period slowed to 2.1 percent in September from 5.2 percent in August. In spite of this slowdown, the orders-to-shipments ratio (Figure 3) rose to 0.99 in September from 0.97 in August, reflecting a 2.0 percent increase in orders and a 0.6 percent decrease in shipments in September from August. Inventories remained unchanged in September at 9.9 weeks and currently are 0.5 week below year-earlier levels. As in the communications sector, quick growth in the fourth quarter of 1989 and delayed investment plans make it increasingly likely that *orders growth will further decelerate—and probably flatten—during the remainder of 1990* compared with year-earlier orders and will accelerate in the first half of 1991.

SEMICONDUCTOR DEMAND

US semiconductor bookings (three-month moving average) rose 0.4 percent in October to $1,193.6 million, while billings rose 0.7 percent to $1,260.5 million. As a result, the October book-to-bill ratio (Figure 4) remains unchanged from September at 0.95. Belying this apparent sluggishness, October bookings were 5.1 percent above year-earlier orders.

Dataquest's monthly survey of major OEM semiconductor procurement managers supports the increasingly pessimistic systems-market outlook: Overall, six-month system sales are expected to grow 3.0 percent, down from 3.4 percent in October. *However, data processing OEMs' expected six-month growth has remained almost unchanged at 6.0 percent in November compared with 5.9 percent in October.*

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Two factors continue to contribute to an outlook of slow—albeit positive—electronic systems growth in the next three to six months. First, the additional layer of uncertainty stemming from the Persian Gulf crisis has collided head-on with what was an already lackluster capital investment climate: Business' equipment investment spending growth is expected to fall 3.0 percent in the fourth quarter, down from 8.2 percent in the third quarter. Investment spending is, however, forecast to begin recovery in the first quarter of 1991 at 2.2 percent growth and to accelerate throughout 1991.

More specifically, though, *over two-thirds of last year's growth occurred in the final third of the year.* That performance will be tough to match—not to mention beat—but should not be misinterpreted as meaning that we are headed for "the crash of 1991."

Terrance A. Birkholz

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Research *Bulletin*

OEM MONTHLY—OCTOBER 1990
SMART CARDS: WHAT'S SO SMART ABOUT THEM?

INTRODUCTION

Fifteen years after the development of smart cards in France, the market in the United States continues to be very fragmented and diverse.

A smart card is the size of a credit card and has ICs embedded in it. Examples of emerging smart card applications range from security access cards and driver's licenses to banking and medical record cards. Confusion over standards and high initial costs of implementing a smart card solution have delayed market development. Dataquest believes that newer and intermediate-term applications will be the market initiators, leading to eventual economies of scale and standards setting.

IC CARDS DEFINED

Confusion exists on differences between memory cards and smart cards. The Personal Computer Memory Card International Association (PCMCIA) defines a memory card as using solid-state memory as disk-like storage for computers and data storage such as for font and game cards. Memory cards tend to be physically larger than smart cards and focus on data processing applications.

The smart card category includes several different types of function cards. Table 1 shows cards, definitions, and key applications specific to smart cards. "Enhanced" smart cards and smart cards are similar because both have a CPU with memory. However, enhanced smart cards have additional features such as LCD and a keypad.

A "semismart" card does not employ a CPU for the logic/encryption capability function for user verification. This verification function differentiates between smart and nonsmart cards.

WHO'S RESPONSIBLE?

Smart card manufacturers have expected financial applications to drive the market. However,

TABLE 1
Smart Card Technology and Applications

Type of Card	Definition	Key Applications	Current Price
Enhanced smart cards	Smart card with LCD & keypad	Financial, "all-in-one" cards	$60.00
Smart cards	CPU with memory (nonvolatile & RAM)	Financial, education, security/ authentication, medical records	$3.00-$12.00
Semismart cards	Memory with specialized control or encryption	Security/authentication, welfare/ social programs, driver's licenses	$3.00-$12.00
Nonsmart cards (Token, IC)	Memory	Pay TVs, pay phones, security access	$0.80-$8.00
Magnetic stripe/IF	Magnetic field	Currently used in many consumer applications	$0.30-$1.00

Source: Dataquest (November 1990)

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SAM Newsletters 1990-32

TABLE 2
Potential Application Markets

Potential Size of Market	Time Frame: Current/Soon (0-2 Years)	Intermediate Term (3-7 Years)	Long Term (>7 Years)
<1 Million	US Department of Agriculture Toll roads	Military "dog tags"	Entitlements (food stamps, social security)
1 Million-<10 Million	Security/authentication (building entrance, computers)	Education ("all-in-one" w/meal ticket, registration, library card) Medical records/payment records, state driver's license	—
>10 Million	—	Pay TV, pay phones	Financial industry, banking cards, credit/debit cards

Source: Dataquest (November 1990)

until card costs are reduced or their security capability outweighs the costs, smart cards will not be a feasible solution for the financial industry. A large potential market exists for smart card use in other applications (see Table 2), with the focus on consumer-type applications.

Participants interested in the smart card arena have two options. An active strategy is to invest heavily and be an initiator. A low-risk strategy is to keep up with the most current technology, remain in the R&D stage, and wait until the market develops further. For an active strategy to be viable, participants must focus on today's most conceivable applications. This strategy will enable the market to develop, the possible high volumes to be achieved, and the costs to decline.

CHICKEN/EGG SYNDROME?

The common problem of economies of scale exists in the smart card market. Currently, smart card volumes are low, resulting in high prices. However, many potentially large volume users cannot afford to pursue a smart card solution until prices decline, resulting in slower reduction in economies of scale.

We anticipate two ways that the smart card market will pull together to create one complete standard and sizable applications. One is for a standards-setting body similar to PCMCIA to emerge, creating comprehensive standards for all aspects of smart cards ranging from the cards themselves to the terminals. A second possibility is that high-volume application markets will develop, bringing smart cards into mainstream applications. This scenario then sets a de facto standard for future entrants.

ALIGNED FOR THE FUTURE

Successful market development also depends on properly integrated execution at four levels: IC manufacturer, card manufacturer, terminal manufacturer, and systems integrator. In the United States, companies (many of them start-ups) tend to focus on the one level where they are involved. This narrow focus leaves them vulnerable to the effects of poor execution at any other level. In Japan, however, pioneering companies tend to be vertically integrated and well financed, allowing them to invest heavily at one level to realize profits at another.

Substantial development in the smart card market relies on a completely integrated solution, from ICs to systems integration. For companies not vertically integrated, alliances will be crucial to their market success.

DATAQUEST RECOMMENDATIONS AND CONCLUSIONS

Dataquest believes that participants in the smart card market must align themselves vertically, which will be crucial to implementation of a complete smart card solution. We also believe that fragmentation will slow standards emergence, retarding market development initially. However, once economies of scale are reached, volume will increase and standards will be set.

The application markets for smart cards have been slow to emerge. However, continued focus on the variety of application possibilities for the near term will result in large market growth and cost reductions. The challenge lies in realizing smart cards' market potential.

Anna L. Cahill

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SAMONITOR: PERSIAN GULF CRISIS CASTS PALL OVER WEAKENING SYSTEMS MARKETS

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

Without exception, business conditions registered a poor showing in August. Orders growth for the three-month period ended in August was only

Figure 1
Computers and Office Equipment

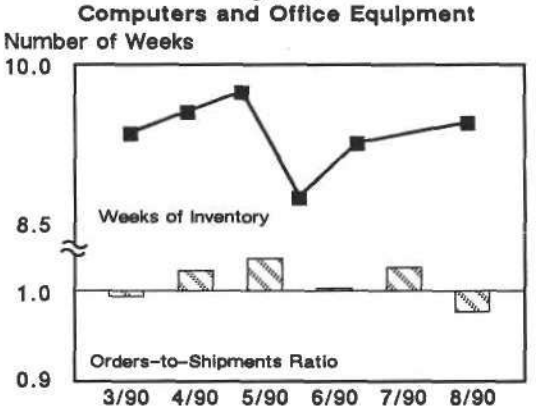
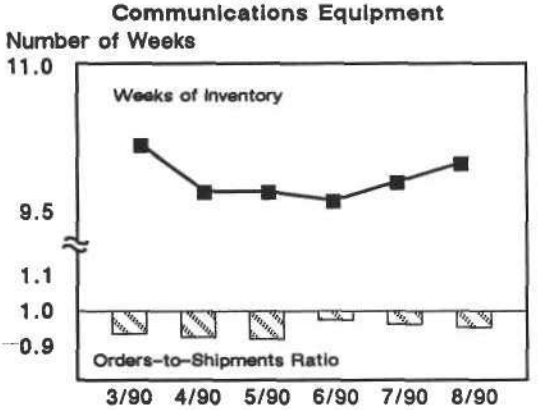


Figure 2
Communications Equipment



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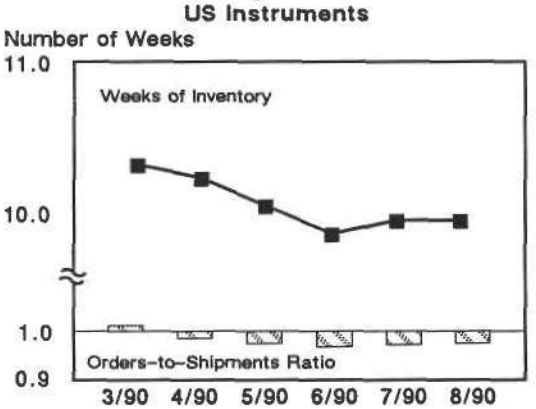

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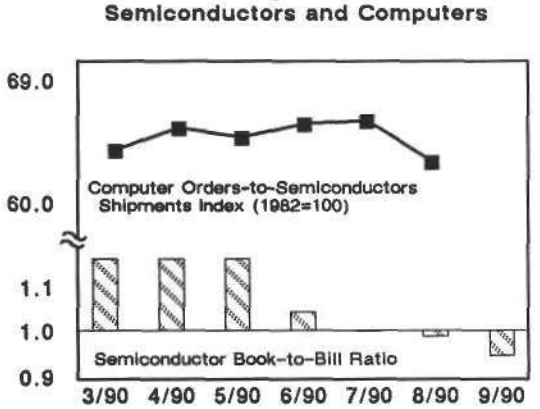
Semiconductors and Computers



Source: WSTS, US Department of Commerce, Dataquest (October 1990)

SAM Newsletters 1990: October-December 1990-31
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0.3 percent above year-earlier orders compared with 6.6 percent in July. Shipments growth for the same period fell 0.5 percent below year-earlier shipments compared with a 0.4 percent decrease in July. *August was the slowest orders-growth month in the last 12 months and is the second consecutive month of negative shipments growth.* The orders-to-shipments ratio (Figure 1) fell to 0.980 in August from 1.024 in July, reflecting the 3.7 percent drop in August orders from July's level. Fortunately, manufacturers have kept a tight reign on inventories. Inventories edged up only 0.1 week in August to 9.5 weeks, 0.1 week above last year's level. Strong growth in last year's fourth quarter, combined with rising tensions in the Persian Gulf and their adverse impact on what was already sluggish capital spending, make it increasingly likely that *orders growth will remain flat during the remainder of 1990* compared with year-earlier orders.

Communications Equipment

Orders and shipments growth began to show signs of stabilization in August. Orders growth for the three-month period ended in August accelerated slightly, to 8.0 percent from 7.6 percent in July. Shipments growth for the same period decelerated to 6.5 percent in August from 7.1 percent in July. The orders-to-shipments ratio (Figure 2) slipped for the second consecutive month, from 0.96 in July to 0.95 in August, reflecting the 1.2 percent drop in August orders from July. *August was the sixth consecutive month that the ratio has been below parity.* Inventories remain tightly controlled, edging up only 0.2 week in August to 10.0 weeks, 1.7 weeks below year-earlier levels. In view of the unusually brisk orders growth during the second half of 1989 and the sluggish equipment investment spending outlook through year-end, Dataquest forecasts that the upcoming months will be marked by deceleration in orders and shipments growth, with both stabilizing in the 3.0 to 5.0 percent range.

Instruments

Business conditions weakened across all indicators in August. Orders growth for the three-month period ended in August decelerated to 2.9 percent above year-earlier orders from 5.0 percent in July. Except for July, orders growth has slowed continuously from 9.1 percent in March. Shipments growth for the same period slowed to 5.2 percent in August from 6.0 percent in July. The orders-to-shipments ratio (Figure 3) remained unchanged at 0.97 in August and below parity for the fifth consecutive month, reflecting the 0.7 percent drop in August orders from July. Inventories remained unchanged in August at 9.9 weeks in July and are currently 0.8 week below year-earlier levels. Brisk growth in last year's fourth quarter and postponed investment plans make it increasingly likely that *orders growth will decelerate further—and probably flatten—during the remainder of 1990,* compared with year-earlier orders.

SEMICONDUCTOR DEMAND

The US semiconductor market bookings and billings were mixed in September. Bookings (three-month moving average) fell 0.9 percent in September to $1,188.5 million, while billings rose 3.0 percent to $1,251.3 million. As a result, the September book-to-bill ratio (Figure 4) slid to 0.95, down from 0.99 in August. Despite the erosion in DRAM ASPs, September bookings were 9.8 percent above year-earlier orders.

Dataquest's monthly survey of major OEM semiconductor procurement managers supports the increasingly pessimistic systems-market outlook. Overall, six-month system sales are expected to grow 3.4 percent, down from 4.2 percent in September. *Data processing OEMs' expected six-month growth has fallen to 5.9 percent in October from 6.1 percent in September.*

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Year-to-date and 12-month-ended electronic systems orders are 5.6 and 8.3 percent above year-earlier levels, respectively. Under ordinary circumstances, this growth would be regarded as respectable and sustainable, albeit modest.

Two factors, however, combine to contribute to *an outlook of significantly slower growth through year-end.* Generally, the ripples of uncertainty from the Persian Gulf crisis have collided head-on with what was an already lackluster capital investment climate. Business equipment investment spending growth is expected to decelerate significantly in 1990 to 0.5 percent, down from 5.2 percent in 1989, and to accelerate only 2.0 percent in 1991.

More specifically, 69.9 percent of growth in the value of 1989 systems orders occurred during the September through December period. In other words, *over two-thirds of last year's growth occurred in the final third of the year.* The corollary is simple: The toughest stretch of the year is yet to come!

Terrance A. Birkholz