European Semiconductor Application Markets Newsletters

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Research *Newsletter*

FIRST BUBBLES, NOW FLASH—SOLID STATE vs RIGID DISKS

INTRODUCTION

Over the past couple of years flash memory ICs have appeared which are nonvolatile, rewritable and substantially less costly than other solid-state memories such as battery-backed SRAM. Coinciding with flash's emergence was the formation of the Personal Computer Memory Card International Association (PCMCIA) and its joint release of a comprehensive solid-state memory card standard with the Japanese Electronics Industry Association (JEIDA).

Today the PC is the dominant source of demand for rigid disk drives and, not since the bubble memory fiasco of the mid-1970s have rigid disk manufacturers had so much cause to dust their crystal balls. In this newsletter we look at the critical strengths of each technology and assess how they will shape the future for PC mass storage.

Flash is an electrically rewriteable, nonvolatile form of semiconductor memory that is significantly cheaper than EEPROMs. Flash's distinction from EEPROM is that either a block or its entire contents must be erased before it can be electrically reprogammed. There are two classes of flash: the simpler and cheaper resembles a UV EPROM and is based on a single transistor per cell and needs split +5V and +12V supply rails; the other is more similar to an EEPROM and requires two transistors per cell, but can run off a single 5V supply. Currently, nearly 90 percent of the European flash market is in the split-rail version.

COST

Cost per performance is the most decisive issue in any comparison between rival technologies. Figure 1 shows costs per megabit for two rigid disk sizes: 15MB and 150MB. These are compared with the average raw (as opposed to packaged) memory card costs for flash ICs. We have to look much further out than our normal five-year horizon to find a crossover between the two. And so, for the purposes of this appraisal, we assume that the learning curves of both technologies for the latter half of the decade will resemble their respective curves today.

As the figure shows, today's cost improvements in rotating magnetic media are benefiting higher-capacity drives more than smaller ones. Small drives have a greater proportion of their total cost dedicated to slow price-declining overheads such as interface circuitry, electromechanics and casing. Consequently it is the small drives that will succumb first to the solid-state alternative, although on a raw cost-per-bit basis, even a 15MB rigid drive may not be undercut on price this century.

WRITEABILITY

There is a finite limit to how many times a flash memory cell can be written to before becoming unusable. This is the other major reason why flash EPROMs may not displace the *existing* rigid disk drive market for some while. Today that limit is around 10,000 to 100,000 times, and should increase in future products. By comparison, there is no practical limit to how frequently one may write to individual sectors in a rigid drive.

Although mass storage drives are buffered to reduce unnecessary writes it is impossible to guarantee that for any application a 10,000 or 100,000 write limit would not be exceeded. In fact, many applications do exist (such as real-time control systems) where frequent repetitive writes are made.

WHAT FUTURE RIGID?

Although rotating magnetic technology with large-capacity may have little to fear from solid state in the near future, optical drives may

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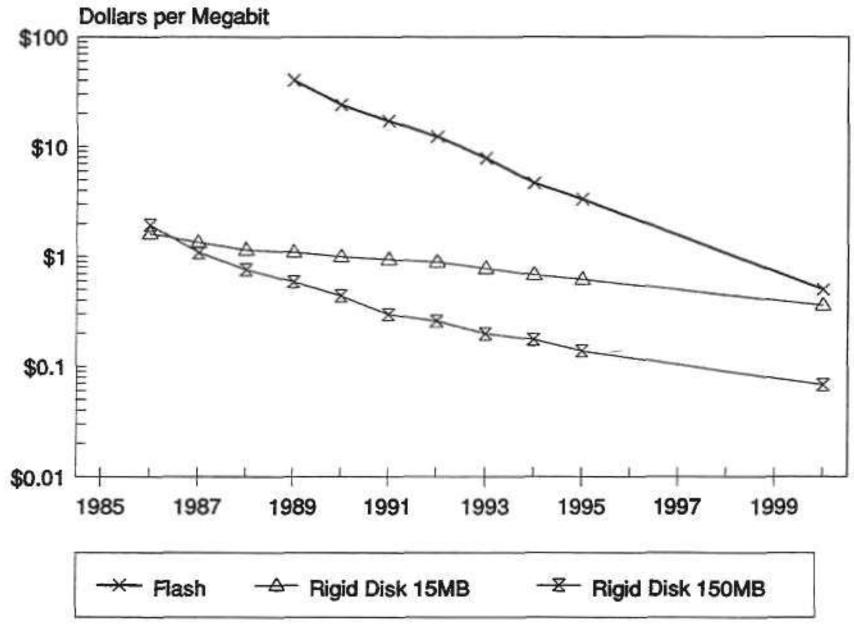
FIGURE 1

Solid State vs Rigid Disk Storage, Price Projections (Ex-Factory)



Source: Dataquest (December 1991)

represent a far greater hazard. Versions of 3.5 and 5.25 inches, from companies like IBM, Ricoh and Sony, are available today with capacities as high as 600MB. With access times today of around 35ms, magneto-optical is beginning to approach rigid disk speeds.

As for flash, writeability on magneto-optical drives is potentially a problem—although the limit for magneto-optical is much higher. Sony, for example, guarantees sectors on its disks for up to 1 million writes. However, with proper handling and storage away from ultraviolet light, writeability above this limit is not a problem.

Currently magneto-optical's cost (roughly $1 per megabit) is substantially higher than for conventional rigid disks, but this cost may fall rapidly as competition develops.

WHAT FUTURE FLASH?

Flash's differentiating features lie in its short access times and low power consumption. In these respects, flash leaves all rigid drives (magnetic or otherwise) and "flopticals" far behind. Many hand-held applications are emerging for which flash memories in small doses (more than 4MB) are the only solution. Examples are power-critical personal organizers or stylus-driven notepads that do not need the mass-storage capability of a normal PC. However, flash's need for dual +5V and +12V rails for large memory sizes breaks with the general trend in portable applications towards 3.3V and, consequently, they must provide DC-to-DC conversion if flash is to be accommodated.

Not all flash applications will be portable. One important application today is for desktop PC flash BIOS ROMs. It is often preferable to update a ROM electrically from a floppy disk than to unscrew a cover and replace it.

For removable memory sizes larger than a few megabytes flash will face strong competition from the new floptical disk manufacturers like Brier, Insite and Procom. Floptical drives use the same magnetic media as conventional floppy disks, but contain additional optically read track markers that allow their track densities to be increased. The first flopticals appearing on the market have capacites of around 20MB.

Flash will benefit, and enable the production of, many portable applications such as digital electronic cameras. And it is a rare camera, indeed, that has taken 10,000 pictures!

Jonathan Drazin

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Research Newsletter

COLORFUL COMMUNICATIONS

Sharp Electronics Corporation has launched its first color copier/facsimile, the FO-9000. Sharp does not use the term multifunctional, but this product is positioned as a full-color facsimile and copier machine offering photographic-quality reproduction. It is priced at $31,995 but as it is necessary to have a color facsimile at the receiving end in order to transmit in color, the buy-in investment would be almost $64,000.

PRODUCT OVERVIEW

Facsimile

Although several unique capabilities are introduced on this system, perhaps the most efficient capability is the connectivity to Group 3 facsimile. Because the FO-9000 operates over the public switched telephone network (PSTN) and because an automatic switch resides in the modem, the FO-9000 can share the same telephone line with an existing Group 3 facsimile machine.

Sharp has designed its Auto Color/G3 Fax switch to answer each call and direct it either to the FO-9000 if a color transmission tone is detected or to a G3 system if a regular fax tone is indicated. This capability eliminates the need and cost of installing an additional telephone line. Implementation, however, may not work well if transmissions from either the FO-9000 or the G3 system become high enough to involve contention. But in most instances redialling capabilities and features that allow transmission from memory would alleviate potential contention issues.

The Auto Color/G3 Fax is capable of determining whether either a color or ordinary G3 Fax is at the receiving end. In the United States, the facsimile industry is accustomed to dealing with compatibility standards and has greatly benefited from their establishment. To date, Comité Consultatif International de Télégraphie et Téléphonie (CCITT) standards for color facsimile have not been set. Therefore, as a pioneering effort in color facsimile in the US market, standard plug-in capability to existing Group 3 units would appear to be a good strategy. Table 1 gives full European specifications.

Color Highlights

Approximately 130 color-image pages can be accommodated by the unit's 130MB hard disk.

TABLE 1
FO-9000 Facsimile Specifications

Specification	Description
Machine Type:	Desktop
Line Connection:	Public switched telephone network
Modem Speed:	14.4, 12.0, 9.6, 7.2, 4.8, 2.4 bit/s
Scanning Method:	Flatbed CCD
Auto-dialing Functions:	100 stations
Automatic Redial:	2, 4, 8 times at 5-, 10-, 20-minute intervals
Confidential Transmission:	Standard
Confidential Receive:	Standard
CCITT Error Correction Mode:	Standard
Image Memory:	130MB
Paper Quantity:	50 sheets
Voice Request:	Standard
Activity Reports:	Standard
Resolution:	Scanner 400 dots per inch (dpi) Color printer 200 dpi G3 printer 200 dpi

Source: Sharp Corporation, Osaka, Japan

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Images can be scanned in separately and positioned and sized to fit on a page. This facility not only keeps transmission costs in check, but it also allows for additional control relative to print settings at the receiving/printing location. A standard A4 color image can be transmitted at approximately three minutes per page. Printing speed for the same image also would be approximately three minutes per page. Three print resolutions are available—superfine, fine and standard.

The FO-9000 uses full-color RGB scanning at 400 × 200 dpi and a printing process called sublimation dye transfer to produce color copies of photographs with near-continuous tone. This dye transfer process, a method close to thermal transfer, allows Sharp to vary the density of each impression in 64 levels to achieve the quality the company requires.

Color Copier

Sharp is also marketing this unit as a color copier in the United States and believes that some purchases will be based primarily on the system's color copying capability because of its high-quality end product. The system offers a zoom feature, which provides a reduction to 25 percent and enlargement up to 200 percent in 1 percent increments. Also available are nine preset ratios.

An interesting feature is the receive recopy. Although it must be pre-selected, it allows images to remain in the memory after initial printing. Additional copies can be made directly from the received image without loss in quality. As an option, Sharp will offer a slide and transparency scanner for copying or transmission from 35 mm slides, turning monochromes into prints. Transparencies can replace the specially treated paper for use with overhead projectors.

Competition

Sharp states that the company's intention is not business graphics but the color communication of high-quality photographs. Although there may be some overlap, training and marketing efforts will be geared towards those markets that could traditionally benefit from high-quality proofs of photographs on a quick turnaround. Sharp believes that those areas, initially, will be for the advertising and publishing industries.

Sharp could find many applications already being handled by desktop publishing systems. These systems and corresponding standards are in use today and allow for the creation, manipulation, and commercial printing of business graphics as well as color photographs. The particular configuration and cost of a desktop publishing system would be dependent on the application, but a wide range is possible.

In desktop publishing the application and use of the final product are determining features. For example, if the end product is to be a color brochure for mass distribution, it would most likely be sent to a service bureau with press equipment to handle the necessary and complex process of color separation. If, however, the end product is for proof (when 100 percent color accuracy is not necessary and reproduction is limited) a system such as Sharp's FO-9000 may be the most appropriate solution.

Compression and Standards

Sharp is using Area Vector Quantization (AVQ), a data compression and expansion system developed in conjunction with Kokusai Denshin Denwa Co. Ltd. (KDD). Using this system, data can be compressed to one-tenth of its original size before transmission, which minimizes distortion. This degree of compression requires the use of European technology in the form of two T800 transputers.

As a result of a joint committee of the International Standards Organization (ISO) and the CCITT, two international groups have established compression standards. Joint Photographic Expert Group (JPEG) is an international standard for still-picture compression (as opposed to motion, MPEG) used in applications involving desktop publishing, graphic arts, newspaper wire-photo transmission and medical systems. Joint Bi-Level Imaging Group (J-BIG) primarily deals with the compression of bi-level images such as black-and-white photographs or text. These standards involve source compression algorithms that eliminate or reformat certain repetitive data. This means that a code is employed which stands for repetitive data rather than actually repeating the data. The result is compressed data that will be stored or transmitted.

The compression scheme used by JPEG is labelled "lossy," meaning that data are lost (the elimination of repetitive data). Data are first reformatted and then quantized before elimination. The compression scheme used by J-BIG is considered "lossless" (as are the current standards for facsimile), meaning that the data are reformatted or reorganized, and therefore compressed, but no data are eliminated because they are not quantized. (The two standards result in different schemes primarily because continuous tones, as in color photographs, have separate needs.)

Both schemes are based on discrete cosine transform, a mathematical transformation used to reorganize the pixel information into a more compact form and generate a series of numbers that represent a pixel's value. After coding has taken place, these numbers are divided by a mathematical coefficient that makes them easier to send.

DATAQUEST ANALYSIS

Anyone who has viewed the result of the Sharp prototypes would be impressed. Sharp has met its objective in designing a product that transmits and reproduces quality color photographs. Its FO-9000 was first exhibited in Europe at the CeBIT Fair in Hannover, Germany, March 1991. Although the product has not yet been launched, it is expected to appear first on the German market at a price of approximately DM 55,000. The unit was also shown at the Which Computer? show in the United Kingdom in April this year, and the retail price was estimated at £12,000. In contrast to the United States, no indication is given that the product will be positioned as a color copier. It is not expected to be available until late this year anywhere in Europe.

Sharp believes that the FO-9000 will fit into niche markets. The company is signing up selected high-end NOMDA dealers and will target applications found in advertising and publishing for example, as opposed to applications related to general business graphics. With the high price tag, potential users' needs will be highly visible and extremely well defined. Sharp will have to be satisfied with very low placement numbers; this will be an interesting transition for a company whose facsimile business exploded through its distribution channels and for whom its presence in the high-end facsimile market is not well known.

Dataquest believes that Sharp will need to be more responsive to existing compression standards. The company is asking for a hefty financial investment for a product that is nonstandard today. It is generally believed that the JPEG standards will be adopted by CCITT for facsimile. Such an adoption could be very problematic for Sharp. A nonstandard product in today's office environment is very risky and can take its toll on the supplier. Dataquest believes that NOMDA dealers will face lengthy sales cycles more often than not, as well as issues of customization and interface capability that can become obstacles to success.

Dataquest estimates that during 1990 for Western Europe, placements totalled 14,170 units with an estimated installed base of 30,460. Most of the units placed so far have not yet reached the general office. These units have been primarily in copyshop environments and centralized reproduction centers within companies.

The indication of slow migration into the office is not a good sign for the color facsimile. To date, acceptance of the color copier in the market has been cautious. Dataquest believes that adding color-facsimile capability onto color-copier capability will not significantly increase market acceptance.

The FO-9000 is too expensive today, both in terms of equipment and supplies, to significantly attack the general office market at this time. Early indications are that such a device will find itself in a few specific markets with limited, but intense, competition and will be more application-specific than was initially expected.

Although Sharp is marketing the FO-9000 as a copier as well as a facsimile machine, Dataquest believes that copier placements will be limited. In order for a color copier to have widespread acceptance, both the purchase price and cost per copy must be low. Compared with a xerographic color copier, the purchase price of $31,995 and the cost per copy of almost $3 are both high. However, the FO-9000 does have superior copy quality to xerographic machines, almost on a par with photographic machines. Therefore, in those limited situations where supreme copy quality is essential and where users may be accustomed to paying these prices, this unit may be successful.

The FO-9000 is going to be difficult to sell. Sharp may be the initiator in the process for user adoption of color facsimile; a process from which the next entrant could possibly benefit by offering a standard product with slightly less quality but at a lower price. However, it may be that the niche application of the color facsimile will act as a catalyst, helping Group 4 facsimile machines to find their place in the market.

(This article was originally published by Dataquest's Document Management, Copiers service.)

Mike Williams
Ruth Ann Gardner

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Research Newsletter

IN-CAR NAVIGATION SYSTEMS: THE EUROPEAN WAY FORWARD

SUMMARY

Largely due to the lack of a standard and the enormous investment that will be required to provide an infrastructure for in-car navigation, Dataquest expects slow take-up during the next three years. This year we estimate that 4,000 units of various systems will be manufactured in Europe, rising to 57,000 units by 1994. Currently, this represents an estimated semiconductor demand of only $790,000 increasing to $5.2 million by 1994. However, our longer-term estimates indicate that this will be a strategically important market which, by the end of the decade, should drive a semiconductor market worth approximately $400 million.

INTRODUCTION

Navigation systems will play an increasingly important role in European transportation and communication networks. Automatic traffic control, automatic tolling systems, and even automatic policing of roads will all be implemented via these systems. Electronic road-communication networks will form the basis for efficient use of modern transport.

Road Transport Informatics (RTI) in Europe was initiated by the European Commission (EC). RTI is the term used to describe the development of intelligent highways and vehicle-to-vehicle communication in Europe. Other parallel systems include the Intelligent Vehicles and Highways Systems (IVHS) program in the United States, and the Japanese program, Info-Mobility. Applications for navigation systems cover military, marine, automotive, civil/military aerospace, pedestrian and geographic survey markets. The real application areas span from complex military global positioning systems to simple, handheld location and direction finding systems for pedestrians. Many of these products were originally developed for high-level applications such as military warfare (marine and airborne) and international strategic and tactical security organizations. However, as the political climate between East and West improves, these military markets are fast declining. Consequently, most manufacturers in this segment are evaluating ways of diversifying, and in particular, opportunities in the automotive segment have become the major area for technology migration.

This newsletter presents the main aspects of navigation as they relate to the automotive segment and gives an analysis of the mass-market product areas for semiconductor vendors.

Current costs of system hardware range from $500, for a map-based navigation system, to billions of dollars for the infrastructures required to support real-time public traffic and road management systems. Much research has been undertaken to develop a system of computerized road traffic networks. Under the auspices of the European Commission alone, total spending committed to research and development in RTI exceeds $2 billion. Independently of the EC, a few private companies and local government authorities in Europe have also invested in R&D and developed their own trial systems. The objective of these projects is to employ a range of technologies and concepts to improve driver safety through better traffic management, and also to reduce the amount of environmental damage caused by cars.

Even today, many more areas need to be researched before the EC is ready to approve and outline the standards needed for full implementation of a pan-European RTI system (see Table 1). Underlying these objectives is the realization that in most major cities, building new roads is no longer an adequate answer to congestion.

Until recently, RTI has been regarded as an engineering fantasy, with the concept of "intelligent" highways poorly grasped by the public.

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However, recent technological advances have led to the development of systems that will form an economic basis for RTI's infrastructure. In Europe, the development of a pan-European GSM (see ESAM newsletter 1991-6, "Multimedia: No Longer a Dream but a Vision") telephone network is one such important foundation for the communications network required. CD-ROM-based maps are also a key enabling technology and one which European system manufacturers such as Bosch (Travelpilot), Daimler-Benz (Routen-Rechner) and Philips (CARIN) have as an advantage.

There are four main categories of navigation communications systems:

- Satellite-based and radio-communications–based systems
- Autonomous route-guidance systems
- Advanced vehicle-control systems
- Advanced traffic-management system incorporating all the above types of system

In seeking a solution to pan-European traffic management and navigation, research activity has evolved around satellite-based communication systems and land-based monitoring and communications systems. Many of the major existing navigation systems are based on satellite networks such as those run by Loran-C, Inmarsat, and Navstar, which all perform global positioning. Other systems use either terrestrial radio beacons, receivers or dead-reckoning CD-ROM map-based systems which sense wheel or steering-column movement. Typically, a fully autonomous system would be based on CD-ROM technology where navigation data is stored as a map.

An illustration of the European RTI systems development plan is presented in Table 1 which shows how we expect to see RTI evolve into cars. Each phase shows parallel system development for tolling, maps, communications and car electronic systems that will be affected.

Real-time navigation systems need to communicate traffic and road conditions instantly to drivers and the emergency services and, consequently, have to be linked into a regularly updated computer-controlled center. CARMINAT is an example of a demonstrator project integrating the use of radio data systems (RDS) and the CD-ROM route-guidance CARMINAT system developed by Philips. It is the development of this area of navigation that has aroused interest across the telecommunications engineering industry and raised questions about its feasibility, and to what extent the benefits of this technology can be expanded. The EC has the task of addressing some of these issues, for example, the framework of the systems of cellular radio for traffic efficiency and safety (SOCRATES) program is to investigate the use of dedicated channels within a pan-European GSM network for information broadcast to vehicles.

RESEARCH AND DEVELOPMENT COSTS

An overview of key RTI trial projects in Europe is presented in Table 2, which also gives the trial dates and sponsors for each project.

TABLE 1
European RTI Systems Development Plan

Phases	Tolling	Maps	Communications	Car Systems
Phase 1 (1987–1991)	Automatic vehicle identity	Route-guidance systems	Radio-based, satellite, infrared traffic monitors	Engine-control systems (fuel emissions)
Phase 2 (1992–1994)	Automatic tolling	Route and comms. guidance	Collision-avoidance sensors	Cruise-control systems development
Phase 3 (1994–1997)	Roadside tolls transponders	Enhanced visibility	Car-to-car communications	Active braking systems
Phase 4 (1977 onwards)	Full road tolls infrastructure	Services, e.g. hotels, cinemas, clubs	Vehicle/obstacle detection	Active acceleration/ deceleration systems
Phase 5 (2010 onwards)		Intelligent road transport informatics		

Source: Dataquest (December 1991)

TABLE 2
RTI Trial Projects in Europe

Project	Duration	Sponsors
PROMETHEUS[1]		
Start	1986	
R&D	1989 to 1995	EUREKA
DRIVE I		
Pilot study	1985	Commission of the
Tests	1989 to 1991	European Community
DRIVE II		
Demonstration	1992 to 1994	Commission of the European Community
Trafficmaster		
Deployed	1990	General Logistics plc
LISB[2]		
Concept	1985	Siemens, Bosch,
Deployed	1989	Federal Govt. of Germany,
City Govt.	1991	Berlin Senate
Autoguide		
Demonstration	1987	GEC plc
Travelpilot		
Germany	1989	
Netherlands	1990	Bosch, ETAK

[1] PROMETHEUS = Program for European traffic with highest efficiency and unprecedented safety
[2] LISB = Leit und Information System Berlin
Source: Dataquest (December 1991)

The EC has initiated a number of wide-ranging but interrelated R&D programs of which dedicated road infrastructure for vehicle safety in Europe (DRIVE)—an offshoot of the EUREKA program—is the core. The objectives of DRIVE are as follows:

- Improve road safety
- Maximize and further develop new technology for road transport efficiency
- Contribute to environmental improvements

DRIVE envisages a common European road transport environment in which drivers are informed about road and traffic conditions, and "intelligent" vehicles communicate and cooperate with the road infrastructure itself. It is administered through the EC and is coordinated through an office in Brussels with all other EC-related projects. DRIVE projects will be implemented in two phases: DRIVE I (1989 to 1991) and DRIVE II (1992 to 1994) with, so far, a total of $450 million committed. In particular, DRIVE will cover EC involvement with technical standards. The EC actively encourages private companies with innovative products to participate in DRIVE's precompetitive research.

PROMETHEUS, derived from the EUREKA project, started in 1987 and has $700 million in precompetitive research funding. Participants of PROMETHEUS are mainly car manufacturers and electronics companies active in the European transportation industry. It is organized by the following subprograms:

- **PRO-CAR.** Vehicle monitoring and intelligent driver aids: sensors, signal processing, actuators, vehicle operation, general architecture, man-machine interfaces and vehicle safety and dependability (BMW, Fiat, Peugeot, Saab)
- **PRO-NET.** Communications network between vehicles, systems engineering, and emergency warnings (Daimler-Benz, Renault, Saab, Volkswagen)

- PRO-ROAD. Communication between the vehicle and roadside infrastructure and traffic control systems: information processing, data acquisition, infrastructure-based systems, on-board elements (Volvo, Daimler-Benz, and Renault)
- PRO-CHIP. Microelectronic development for information systems
- PRO-ART. Clarifying the requirements for, and the development of, artificial intelligence
- PRO-COM. Defining the structure, architecture and standards of communications systems
- PRO-GEN. Analysing traffic scenarios and developing simulation models for traffic control based on European road/route networks

AUTOMOTIVE NAVIGATION SYSTEM TRIALS

Other areas of research include automatic vehicle identification (AVI) whose research is now well advanced. AVI involves the use of infrared signals to transmit information held by a special tag attached to a vehicle to a central information processing center via a roadside transponder. The type of information held by the tag may include exhaust emission levels, and vehicle identification. AVI also holds the key to electronic policing of road users and tolling, and might also prevent unauthorized use of roads (for example, during rush-hour traffic or on private roads).

In the United Kingdom, a consortium has been formed by Cambridgeshire County Council (CCC) to develop a congestion monitoring and metering system (including Ford of Europe, GEC-Plessey Semiconductors, GEC Card Technology, Saab/Scania Combitech, Pilkington Glass and CSEE Division Communication et Informatique). The consortium has now developed an intelligent car-tagging and tolling system that uses microwave links between roadside units and vehicle-mounted transponder units. The CCC project aims to encourage road users to spread the timing of their journeys and avoid making unnecessary journeys at peak times. This is achieved by giving drivers more information on the time taken to travel to the city center at any time of the day, and by charging drivers for the use of streets at times of congestion.

A similar project has been in operation in Germany where the German government and Senate of Berlin have implemented the LISB concept on a trial basis. The LISB project is based on the use of the Siemens Ali-Scout navigation system. Also, in France, the Cofiroute highway lying south of Paris, has two toll booths, and the ESCOTA (Esterel Côte d'Azur) near Nice has nine lanes equipped with roadside transponder/receivers.

Results of DRIVE will be integrated in a pool containing a cross-section of road vehicles under two projects called common European demonstrators (CEDs) incorporating the following features:

- Vision enhancement
- Proper vehicle operation
- Collision avoidance
- Autonomous and infrastructure-supported route guidance
- Public information services
- Commercial fleet management

DRIVE: FIRST TRIALS

The first CED starts in 1992 and will develop an autonomous cruise control that will maintain a safe distance between the vehicle in which it is installed and those ahead of it. This will interface the system into the engine-control unit to reduce speed whenever slower moving vehicles are detected.

The second CED will start after 1994 and will link emergency services and public information databases (via cellular telephone networks) to alert vehicles approaching from behind to prevent secondary accidents. This secondary development will provide the infrastructure for added-value enhancements of a third phase of "value-added" database-oriented services (1997 onwards) such as local restaurant guides, petrol stations and theater or cinema information based on the location of the vehicle.

MAJOR EXISTING IN-CAR NAVIGATION SYSTEMS

Satellite global positioning systems (GPS) give automotive, aerospace, military and marine users the opportunity to locate on a map the distribution and positions of their vehicles. Emergency services, such as the police, fire and ambulance services can all benefit from the vehicle-tracking system and database facility. Other features of key importance are traffic information, route guidance and messaging (voice/text). Local governments also have an economic interest in the development of automotive navigation because they will be responsible for road traffic management, traffic congestion and the design and planning of road networks. Some level of financial subsidy is therefore usually available through local government funding.

The rate of penetration of car navigation systems into private and commercial use will be strongly determined by price. Dataquest believes that in-car navigation systems will need to fall to levels comparable with other major in-car systems such as entertainment systems (between $500 and $1,000) and must provide a full range of features before a mass market will develop.

The following list gives some of the key systems for in-car navigation developments which have formed part of the PROMETHEUS project, and are commercially available today:

- Robert Bosch Travelpilot
- General Logistics Trafficmaster
- Siemens Ali-Scout (Euro-Scout)
- Autoguide
- Philips: Carin system (CD-ROM route guidance)
- Blaupunkt (Bosch): EVA (route guidance)
- Daimler-Benz: Routen-Rechner (route guidance)
- GM Delco, Plessey: PACE
- Renault: Atlas (traffic information)
- Siemens: Pilot and Autoscout products
- SEL Alcatel: Globus

Some of the above systems have become commercially available. A typical example is RDS which allows for in-car radio cassette players to automatically identify and tune into radio stations that broadcast traffic information. RDS is now very widely available with many car manufacturers (Ford, Peugeot, Mercedes-Benz, GM-Opel, Rover, Renault) which offer cars fitted with RDS as standard. Initially, the most likely customers for these products will be:

- Car rental companies
- Courier/delivery companies
- Public utility organizations (police and fire service, and water/gas utility companies)

Conclusion

The present market for automotive navigation systems is currently very sluggish with less than 0.01 percent penetration in Europe. Despite this, we expect these systems to proliferate over the next few years. During the next three to four years, the first users of these systems will be confined mainly to drivers of emergency vehicles, and others with a critical need for electronic maps. Other early adopters will be car hire companies, which need to provide electronic maps for some of their customers (particularly those from abroad) and roadside-assistance vehicle-recovery companies.

We expect the DRIVE program to dictate the nature of any new products. Future development will emphasize secondary users such as local government town planners and law enforcement to the automotive industry itself (in the form of diagnostics) in the later stages. Future developments of navigation systems will offer more value-added features such as information directory services giving the motorist some local information on cinemas, restaurants and social events.

Environmental (green) issues will also influence the rate of penetration of electronics into vehicles and may indirectly hasten political moves towards implementing navigation. With pan-European emission control regulations in force, roadside transponders may have the capability of reading an engine's control unit, recording the level of pollutants emitted (although this is a controversial measure because identification systems are unpopular in many European countries).

The market will continue to bounce along the bottom until standards appear to define what features will constitute an integrated system. We estimate production of in-car navigation systems in Europe to be currently 4,000 units per annum, rising to 57,000 by 1994. The corresponding semiconductor market is estimated at $0.79 million and $5.20 million respectively. These estimates are based on a conservative extrapolation of trial systems in use and the potential available market. However, by the end of the decade we expect semiconductor consumption for in-car navigation systems to reach $400 million.

So far, the majority of European car manufacturers have announced some plans for the introduction of navigation systems. These include BMW, Ford, General Motors, Mercedes-Benz, and Renault. Of these we expect BMW and Mercedes-Benz to be the first to offer this feature.

Mike Williams

Appendix

Here we outline the top four products and the relevant electronic applications that will affect the semiconductor markets in Europe.

Robert Bosch Travelpilot

This is a route-guidance system incorporating dead reckoning: it comprises a VDU monitor for driver information display, a CD player for reading maps stored on disk, four-wheel sensors to record distance travelled, an electronic compass and an electronic control unit. The current cost is approximately $3,200 for the complete system.

Although Travelpilot is generally available in Germany (it is currently being used mainly by paramedic ambulance services like St. John's Ambulance, haulage transport and delivery companies), its UK introduction has suffered a two-year delay since its launch at the NEC Birmingham autoshow in 1989. This delay has been due partly to a change in emphasis towards accommodating the former east Germany. Robert Bosch is expected to introduce a second-generation system with VDU improvements over the current LED monitor to a high-resolution color LCD.

In the United Kingdom, Bosch is installing a few units on test vehicles for evaluation and has an agreement with a major car rental company to supply and install Travelpilot as soon as the product becomes available locally.

General Logistics Trafficmaster

This is a traffic information system based on a computer base-station network which transmits information via a system akin to radio-paging technology. Trafficmaster was launched in the United Kingdom in 1990 by an independent supplier, General Logistics. The system unit is available in three configurations: a desktop unit, a car unit and a mobile desktop/in-car unit. The actual system commonly consists of a VDU monitor, with an internal or external ariel and power-supply unit. All the electronics are built into the VDU, which has facilities for messaging. The current system costs around $2,400 and includes a four-year air-time lease.

Trafficmaster covers the Greater London circular motorway (M25) and all motorways leading from London up to a 56-km radius. Traffic information is processed from electronic infrared road sensors at approximately 3-km intervals linked to a central computer-controlled station. The road sensors are placed beneath motorway bridges above the fast lanes and report vehicle speeds of under 45 km/h. Any build up of traffic is also transmitted as blocks representing 3-km queues.

Siemens Ali-Scout (Euro-Scout)

Ali-Scout (more recently renamed Euro-Scout) is a three-in-one system featuring advanced traffic information, route guidance and navigation. The hardware configuration includes an LCD monitor, a keyboard, an on-board computer linked to an electronic compass, and an infrared transmitter/receiver for processing data to be sent/received via transmitters attached to traffic lights in the city. Ali-Scout also offers voice messaging as an added option. It is being used by the LISB project.

Autoguide

Parallel to the projects mentioned above was a joint effort in the United Kingdom between the RAC and the then GEC Marconi plc (now GEC-Plessey) to develop a more sophisticated system combining both traffic information and route guidance. This system failed to gain acceptance largely because the retail price was rather high starting at around $10,500. Prototypes became available in 1987, but a marketing effort was not part of this program. The autoguide system uses infrared beacons and roadside transponders to provide a dynamic route-guidance system combined with traffic information. A very limited trial is being undertaken on the route from central London to Heathrow airport. The trial is planned to be extended in the very near future.

Table 3 shows the electronic subsystems that form part of these four main systems.

TABLE 3
System Features and Subsystems

Feature	Ali-Scout	Autoguide	Trafficmaster	Travelpilot
CD-ROM Map	No	No	No	Yes
Wheel Sensors	Yes	Yes	No	Yes
Gyroscopes	Yes	Yes	No	Yes
GPS Satellites	NA	Yes	No	No
Radio Beacons	Yes	Yes	Yes	Yes
Vehicle Locator	NA	Yes	No	Yes
VDU Monitor	Yes	Yes	Yes	Yes
Eliminates Congestion	Yes	Yes	Yes	No
Antenna	Yes	Yes	Yes	Yes
Cost of System	NA	$10,500	$500	$3,250
Service Charge	Yes	NA	Yes	No
Messaging or Paging	Yes	Yes	Yes	Yes

NA = Not Available
Source: Dataquest (December 1991)

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Research Newsletter

HIGHLIGHTS OF TELECOM 91

This newsletter reports on the main highlights of the Geneva Telecom 91 Exhibition October 7 to 15. It represents the views of Dataquest's telecoms analysts, all of whom were present at the Exhibition.

After 10 hectic days, Telecom 91 (from October 7 to 15) ended last week at the Geneva Exhibition and Convention Centre, PALEXPO. Held under the general theme, "An interconnected world: improving the quality of life for all," the exhibition brought together the leaders of the worldwide telecoms industry in the public and private sector, including decision makers, system/service providers, user groups, and the representatives of governments, operating agencies and regulatory bodies, as well as academics and consultants. Many participated in the five symposia which centered on the new developments and the main problems of telecommunications today, seen from the vantage point of their own particular concern or field of activity: political, technical, regulatory, or economic. There was also a unique focus on the special requirements of the disabled.

The Telecom show, held every four years in Geneva, is sponsored by the International Telecommunications Union (ITU), the UN organization responsible for the regulation and planning of telecoms worldwide, for the establishment of equipment and systems operating standards, and the allocation of satellite and radio frequencies. ITU representatives are drawn from 164 countries around the globe, as well as three newcomers—the Baltic states of Lithuania, Latvia and Estonia. The ITU has confirmed that Telecom 95 will again take place at PALEXPO, Geneva from October 3 to 11, 1995. Incidentally, Dataquest will continue to be numbered among the exhibitors, for the third time in succession. See Table 1 for a summary of Telecom 91 statistics.

TABLE 1
Telecom 91 Statistics

Admissions: 337,336* representing 132,351 visitors with the following breakdown:

- 101,998 visitors purchased a ticket
- 23,945 visitors who were invited by exhibitors
- 1,000 VIPs
- 1,794 accredited media representatives
- 4,163 FORUM registrations across the board representing 3,633 participants who also took the opportunity to visit the exhibition
- 28,479 staff for 849 exhibitors from 36 countries
- 87,260 m^2 net of exhibition plus 4,600 m^2 in open air
- 164 countries represented by 97 ministers from 77 countriesand 85 Directors/generals from 74 countries as well as business and industry leaders and other personalities (exhibition, FORUM or visitors)

Telecom 87 Comparison

Admissions: 263,726 representing 55,000 visitors

* An admission represents an entry as opposed to a visitor.
Source: ITU

MAIN TRENDS

PTOs

Three powerful interwoven forces are changing the face of European PTOs:

- Privatization
- Deregulation
- Globalization

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The Policy and Regulatory Forums offered insight into how deregulation influenced the PTOs' performance, making them more competitive, and more oriented to producing profits instead of developing new technologies which are not market-driven.

A completely new relationship is forming between the public_service operator and the customer," says Dr. Herbert Ungerer, Head of Division, Directorate Telecommunications Policies, DGXIII, Commission of the European Communities (Ungerer wrote the 1987 Green Paper). The PTOs are in a state of flux: to remain competitive they are consolidating their relationships with other carriers and expanding their offering to include innovative new services, such as the provision of seamless services across Europe.

At the onset of the 1990s, the competitive framework is still being defined—even in the most liberalized country in Europe, the United Kingdom. To date, only mobile communications and to some extent, value-added network services (VANS) are areas open to genuine competition in the near term. It is a subject for debate raising complex regulatory issues, as to whether competition will be a viable alternative in the local loop (see Dataquest's recent report entitled *Cable TV and Telecoms: Competition and Choice for Europe?*).

To support this open competitive marketplace, there are many institutions and mechanisms at global, regional and bilateral levels, including the GATT, the CEC, and bilateral trade agreements. As emphasized at the Regulatory Forum, speed and flexibility are very important, and adapting to constant change is regarded as critical. Direct government involvement in telecommunications provisioning is decreasing significantly. The rapid advancement in technology has placed an increasing emphasis on pan-European standards. The European standards institute, ETSI, is working overtime to develop these standards through transparent processes, with heavy participation from all sectors of the telecoms industry. The Comité Consultatif International de Télégraphie et Téléphonie (CCITT) will also have to shape up in the new mood of reform. Dr. Theodor Irmer, Director of CCITT, said that the CCITT must become more responsive to market needs and abandon its technology-driven approach. However, with the focus on global competition it is becoming increasingly difficult for standards organizations to reach agreements.

Technology

The key development since 1987 is digitization and the rapid advancement of new technologies such as mobile communications and internetworking. "The potential for true worldwide access to telecommunications and extensive connectivity among information systems is at hand," says Dr. Pekka Tarjanne, Secretary-General of the ITU. "[Mobile communications] is the thing which will make future networks completely different from those of today," said Dr. Ungerer. "There'll be more change in the next 10 years than there has been in the past 100, and that will mainly come from mobility in its widest sense."

Fiber optics is also changing the face of telecoms. "In 1987, no one predicted there would be such rapid commercialization of synchronous optical network transmission technology," says Irving Ebert, Assistant Vice-President for advanced systems and services with Bell Northern Research (BNR) in the United Kingdom. Now broadband has leapfrogged narrowband and the potential seems enormous. This new technology is driven by the market itself, through the progression in leased circuits toward larger bandwidths, through the linking of local area networks and wide area networks, and through a potential coexistence with cable television.

Looking Ahead

Regulation will play an increasingly important role in the years to come. One-stop shopping will no longer be a buzzword—the telecoms administrations will increasingly use one another's infrastructures as part of the one-stop deal.

Mobile communications, fiber-in-the-loop, narrowband and broadband ISDN, intelligent networks, intelligent customer premise equipment, distributed computing and VSATs will achieve more impact on the marketplace by 1995. The use of video will also become more prevalent in the latter part of the decade, specifically videotelephony in the short term, and videoconferencing in the medium to long term.

DATAQUEST ANALYSTS' VIEWPOINTS

In the remainder of this newsletter each Dataquest telecoms analyst gives his/her personal view of Telecom 91.

Networking—WANs

Modems

V.32 bis is the latest development in the modem market and is doing very well for a brand new market segment. In the United Kingdom, for example, some 5,000 products were sold in 1990. The V.32 bis market will be dominated in the short term by manufacturers using DSP data pumps, who have been able to quickly upgrade them to the 14.4-Kbit/s V.32 bis standard (see ESAM Newsletter, 1991-15 "Modems in Europe: Semiconductor Markets and Issues").

Muxes and X.25

The multiplexer market is characterized by a number of products which are getting a bit long in the tooth. To offset this, time-division multiplexers (TDM) vendors have been implementing ADPCM voice in an effort to bridge the voice/data gap, improving their network management capabilities, and adding new interfaces. Hybrid TDMs with features such as frame relay are growing up, and in the long term TDM products will become access devices to faster networks based on asynchronous transfer mode (ATM) technology. The X.25 packet switching market has now established a very firm hold in both the private and public data network market in Europe, although the preference for private versus public systems varies from country to country. Both the multiplexer and X.25 markets are going to be influenced strongly by the introduction of new technologies, such as frame relay and ATM. One interesting product was on the Craycom stand, where a demonstration of 4.8-Kbit/s low bit-rate voice proved to show very reasonable quality, allowing the voice at the other end to be easily recognized.

Frame Relay

Frame relay is the definition for a protocol that allows data to be exchanged end-to-end between users, similar to X.25 but without the same degree of overheads from which X.25 packet switching systems suffer. Frame relay interfaces are therefore being added to traditional TDM multiplexers and X.25 nodal processors as well as LAN internetworking products to provide a link capability ideally suited for low bit-error-rate links, such as optical fiber systems. At Telecom 91, Telecom Finland had a successful demonstration.

There is a Frame Relay Forum established to help iron out the standards and ensure interoperability between equipment from different vendors, and this Forum is one example of a growing number of forums that are being created. The CCITT has announced that it is reviewing its procedures for establishing standards, but meanwhile, the OSI/NMS Forum, the Frame Relay Forum, and now the ATM Forum, announced at Telecom 91, show that a group of like-minded manufacturers are able to get together and formulate standards rather more quickly than are standards institutions. The pressure upon manufacturers to implement global standards rather than proprietary solutions has never been more intense, and the forums are a response to this pressure. As a result, at Telecom 91 frame relay has been hyped more than it deserves.

ISDN

The market for ISDN terminal adapters for pure data applications is small but beginning to run in France and Germany, and starting to get off the ground this year in the United Kingdom. The standards are still not finalized, and the introduction of a new technology takes time for:

- Users to become familiar with it
- Manufacturers to implement standards in the form of actual product
- Five-year network plans to start afresh

This analyst believes that the hype associated with ISDN is over, the products are beginning to become available, the carriers are beginning to provide the interface, and we can therefore foresee slow growth if the applications are attractive (see ESAM Newsletter, 1990-23 "ISDN IC Market in Europe: Part 3, Long-Term Outlook").

ATM for B-ISDN

If Telecom 87 was the year of preannounced ISDN, then Telecom 91 is certainly the year of preannounced ATM broadband switch technology. ATM is the path that networking will take in the 1990s. In 1987 everyone was talking about ISDN being able to "transport voice, data and video," but no-one quite knew how. ATM, or as it is also known, cell relay, permits information to be transmitted in a fixed-size packet called a cell across the ATM network. A data stream is chopped into packets and transmitted as cells. A voice call is digitized and treated in the same way. A video link is digitized and treated in exactly the same way, although with more cells allocated to it.

By varying the number of cells allocated according to bandwidth demand and user priority, and by using a cell-slotting technique whereby cells are reserved for real time or other high-priority channels, the high-speed cell relay pipe is the first real and standard implementation of that elusive dream; to pass voice and data and video over the same pipe. Cells can be switched much more quickly using hardware rather than software, because cells are fixed in size. This is the key advantage of cell relay over frame relay systems.

ATM switches and ATM multiplexers will be moving all types of information across pan-European and perhaps even global networks by the latter half of this decade. They will be interconnecting local area and metropolitan area networks, as well as conventional TDM and packet switch networks, with the latter becoming access networks to ATM broadband systems. Siemens had a prototype ATM switch in a couple of cubicles at Telecom 91—locked away behind glass doors!

Richard Mitchell, Networking—WANs

Networking—LANs

Wireless LANs

In terms of LAN products there was nothing significantly new at Geneva, but one new technology which received a tremendous amount of attention was that of wireless LANs. Olivetti Sixtel SpA, the telecommunications subsidiary of Olivetti Systems and Networks of Italy, had on display DECT (Europe's first Digital European Cordless Telecommunications) LAN and Motorola was displaying its 180-GHz Altair product.

While the wireless LAN solutions have great potential in Europe, considerable confusion exists over the spectral frequency allocations at which they will operate. This is due to the heterogeneous nature of Europe, with each country historically allocating different frequencies for radio-based products. ETSI is currently working through different groups on harmonizing spectral frequencies across Europe. However, this process will be long and time-consuming. In the meantime, it appears there will not be one single frequency at which wireless LANs can operate. Here are the frequencies most likely to be adopted in Europe:

- 1.88 to 1.90 GHz (DECT-based products)
- 2.4 GHz
- 17.1 to 17.3 GHz
- 61.0 to 61.5 GHz

Clearly, because of the considerable effort that has been invested in DECT, and its original provision to handle voice and data, DECT will be the first wireless LAN standard which will gain approval across Europe. The 1.88 to 1.90 GHz band is expected to be cleared for use by DECT systems across all countries by mid-1992.

Motorola has obtained concessions from the Spanish and German governments to operate its Altair system at 18 GHz, and is already actively selling into these countries. Other countries may follow, but they will be watching the activity of ETSI closely before making any decision. To operate in all countries across Europe, Motorola will have to conform to one of the above standards, most likely in the region of 17 GHz.

David Taylor, Networking—LANs

Voice Communications—Systems Applications

Geneva has in the past been a significant forum for the initial presentation of major new technologies: Telecom 91 has been no exception. Four years ago, image technology in the form of videoconferencing and slow-scan TV systems were on display. This was complemented at the terminal end of the market by the first Group 4 facsimile machines and early prototypes of videotelephones, using basic rate ISDN access. Multivendor internetworking and ISDN were strong themes. These same themes have carried through the intervening years. What has changed dramatically is the emphasis within the industry, in terms of the regulatory environment dominating market entry, the level of product maturity, the fortunes of the major competitors and user expectations.

ISDN

ISDN still hovers awaiting its fabled boom time. Although the infrastructure for basic rate and primary rate access has progressed, the rate of ISDN implementation and take-up by end-user businesses has been disappointingly slow. In terms of direct impact on the various switching equipment markets around Europe, Dataquest believes that the significance of ISDN infrastructure development will not be felt (with a few exceptions) as a direct impact on the various switching equipment markets in Europe until 1993.

With little to choose between the core switching products being displayed, the need for differentiation (and indeed survival) in the private switching industry is now all about the installed base and the development of added-value service revenues and add-on equipment markets. In the context of value-added terminal devices, the battle for PBX-based terminal devices supporting data applications via the PBX has well and truly been lost in favor of PC LANs. These increasingly dominate the text/data applications requirements of the office. It is clear, then, that the role of ISDN terminals is limited. The direct impact for PBX manufacturers has been to refocus back onto voice applications and proprietary digital featurephones as opposed to ISDN S-Bus digital terminals.

In the context of value-added service, the ability of a supplier to provide a quality system support service to the marketplace has, in itself, become a major differentiator for would-be system suppliers. There is an ever-increasing focus on how to gain added-value revenues from systems interaction. Because the core switching markets are much more competitive, the focus of providing product tailored to niche market needs has become vital. This in turn affects the techniques of distribution.

The emphasis on added system functionalities and effective communications management is leading directly to the development of a computer-supported telephony (CST) applications market. The focus is not on the physical integration but on the interaction between voice and data subsystems to satisfy the application needs of the end-user business. Early market niches which related to this focus include the now rapidly developing automatic call distribution (ACD) market. At Telecom 91, the focus on CST was indeed a feature of a number of stands, notably Siemens, but perhaps it was most significantly represented at the Japanese pavilion as an integral part of Japan's general thrust toward multimedia or mixed-media communications.

Highlights

So what were the significant issues to be gleaned from Geneva?

Video-Technology was again on display, including high-resolution TV and full-motion videotelephones. Still-image capture and transmission systems were on display, notably from Philips. Image technology has continued to improve in terms of full motion and color image quality. However, video-technology to the desk is still too expensive for significant volumes to be achieved, and the exact technique of delivery and bandwidth requirements remains a contentious issue. The approach from Philips with a product based on providing PC-based, still-image capture, editing and transmission may satisfy actual needs for real image/database applications (see ESAM Newsletter 1991-11, "Watching the Videophone Ripen—Time to Climb the Tree?").

Distributed Voice/Data Networking seemed to be a focus of the Japanese pavilion, with high-rate multimedia transmissions and ATM switching technology on display. Because of the growing dominance of the use of packet transmissions in both LANs and in WANs, the emerging focus on distributed PBX architectures and the potential for packetized voice products is growing. One critical pointer to the possible future for emerging architectures was shown in the presence of voice/data WANs in the Japanese pavilion, notably from Hitachi. Here the approach is to provide interfacing options for PBXs and LANs, including high-quality, full-motion video, connecting via a switching and transmission hub based on ATM technology. Just prior to Geneva, Alcatel joined the ranks of the major telecoms manufacturers in Europe with a commitment to approaching ATM as thepossible wide area networking standard. By Telecom 95, we may find that many networking issues (such as how to achieve network management, with dynamic allocation of bandwidth according to requirement within major corporate networks) may begin to be encompassed within a very different WAN framework—that of ATM.

Terry Wright, Systems Applications, Voice Communications

Voice Communications—Telephone Terminal Devices

The major areas of interest currently dominating the telephone terminals side of the telecoms industry, in the business sector at least, are those of digital cordless telephony, videotelephony and future trends in feature telephony.

Digital Cordless

Although all the major manufacturers of telephones in Europe were represented at Telecom 91, there were disappointingly few genuinely new products on display. Despite growing interest in the potential for digital cordless telephony and the cordless PBX, only Ericsson, GPT, Northern Telecom and Philips had products on show, and Motorola was showing its new and slimline SilverLink 2000 CAI-based digital cordless handsets which may become the widely used handset for PBXs implementing CT2-based systems.

On show at the Philips stand was its new digital cordless application used in conjunction with the Sopho-S15/S25/S35 small-system series. The application demonstrated the interworking between a wired digital telephone terminal and digital cordless handset to allow for greater flexibility within the office environment.

One of the interesting issues surrounding digital cordless systems for the office is whether the system implementation allows for handoff between base stations and whether the interface between the base station and the PBX is analog or digital. Apart from the potential of handoff, the use of digital interfacing determines whether the handset is able to carry additional features, such as those users are already accustomed to on office featurephones. The product implementations from GPT and Northern Telecom, both of which support the CT2/CAI standard and are scheduled for general launch in the UK market, differ in this critical aspect. The Northern Telecom system uses a digital interface and includes a central processing unit which enables handoff. The GPT 2030 system has no such handoff facility and uses analog interfacing to connect the base station to the PBX.

Feature

In terms of feature telephones, the trend towards more enhanced PBX features with special proprietary telephone combinations was again reflected at Geneva, although once again there was little new to be seen. Various ISDN feature telephones were also on display including some Japanese models. In terms of feature telephony among the Japanese manufacturers currently active in Europe, Panasonic enjoys the largest market share. On show at the Panasonic stand was its new model ISDN telephone (only available in Japan for the time being). As a further example of the trend towards intelligent telephone combinations targeted at both the business and consumer markets, Alcatel's 2592 featurephone was on display comprising an integrated screen and open-out keyboard.

Helen Graham, Terminal Analysis,
Voice Communications

Image Communications

Twist in Fax

Telecom 91 brought two new twists of facsimile technology, plus several evolutionary products, that might show market trends. The two new twists were:

- Touch-screen public fax
- Display facsimile

The evolutionary products included:

- Group 4 variations
- Color facsimile
- Credit card fax modem

Toshiba and Panasonic both showed display facsimiles where the image comes onto liquid crystal display (LCD) rather than paper. The Toshiba version is currently on sale in Japan, while the Panasonic was shown in its preliminary form. They both had a similar form factor with an LCD screen angled towards the user, a small footprint and a telephone handset. The Toshiba included both a thermal printer, hand-held scanner and an answerphone interface, while the Panasonic had attachments for a scanner and printer. Both companies see the hand-held scanner as a must in these sorts of devices to cope with books, newspapers and other odd-size pieces of paper.

The choice of scanner indicates where these two companies see the display fax products going into the home as personal fax terminals. Indeed, one application suggested in Japan is for children to exchange homework with each other. In Europe the home facsimile market is more price-sensitive, and with these devices costing considerably more than the cheapest facsimile (the cheapest Toshiba is ¥149,000 or $1,064), it will be hard to justify the purchase.

Video

Telecom 91 was a showcase for several impressive demonstrations on videophones and videoconferencing systems. The largest of these exhibits was in the Japanese pavilion, where NTT linked the videophones of the major Japanese telecoms companies. These could be connected to each other for 10-minute intervals, every half-hour and using standard ISDN rather than broadband. Dataquest believes that manufacturers see video products for ISDN as the "must-have" product that will raise ISDN to significance.

Returning to the products, one of the most interesting videoconferencing/phone products was a half-hidden prototype on the PictureTel (Peabody, USA) stand. This was a Macintosh computer complete with a camera, NuBus CODEC board and software to allow live video conversation to occur in a window. The demonstration was made more impressive by the 112-Kbit/s link provided by MCI to its Boston offices, where one could pose questions to the vice-president of marketing.

Two aspects of the product were interesting. Firstly the projected cost of the Macintosh system is $5,000, which even if you include a Macintosh or IBM-compatible computer (a similar board will also be available for IBM-compatibles), makes a system around $8,000. The usual cost of the videophones was around $15,000 to $20,000, well over the cost of the PictureTel plus the use of a personal computer. Secondly, the quality of the link with Boston was noticeably better than the demonstrations shown of most of the other videophones. The probable reason for this is the use of proprietary techniques rather than the CCITT H.261 standard. This was one of the few phones that did not feel like a slow-motion picture when you moved a limb—not to say that it was perfect, just better.

Compression Labs Inc. (CLI), the major US competitor to PictureTel, showed off its Rembrandt II/VP videoconferencing; the major feature being the ability to grow in bandwidth from 56/64 Kbit/s through to 2,048 Mbit/s with a single CODEC using a programmable video processor chip. CLI claims this to be the first in the world which is able to run even high-resolution algorithms at 30 frames per second—you can even add new features via a software cartridge. The Rembrandt comes in four ways termed "applications" in CLI's literature with the third and fourth applications providing near broadcast-quality images using proprietary algorithms and sufficient bandwidth.

Jeffrey Goldberg, Image Communications

Public Network Equipment and Services

For all major companies active in the public telecoms arena, both suppliers and operators, Geneva presented the opportunity to invest huge amounts in advertising systems and capabilities. As might be expected, the focus was very much on what will be (or might be) rather than what actually is. Broadband appeared as the buzzword of the exhibition. However, many of the exhibits clearly demonstrated that commercially available systems are still some way off.

SDH

Of the "new" technologies on show, perhaps the two most important were SDH and ATM. SDH has come a long way since Telecom 87, and from some of the exhibits (and also the field trials which are now happening) it was clear that SDH will "happen" commercially sooner rather than later. SDH provides an example of technology for which there is an existing demand—and market growth will very closely follow system availability. It is not dependent upon new applications, although there are new applications which will help to fuel further market growth. PKI (Philips) in particular appears to be leading the field.

ATM

ATM was demonstrated by several companies, including Alcatel, Fujitsu and Siemens. Unlike SDH, there is some debate as to how soon it will make a significant impact upon the market. While field trials may be in place, and Geneva showed that demonstration systems were available, even some of the suppliers themselves admitted that commercially available systems would not start to be released until 1994 to 1995. Certainly, more issues have yet to be resolved for ATM than for SDH, and in terms of time scales SDH presents a much shorter-term opportunity.

John Dinsdale,
Public Network Equipment and Services

Personal Communications

The educated layman with an interest in mobile communications will have come away from Telecom 91 with mixed feelings regarding the degree of progress achieved in the past four years.

GSM

As expected, there was a strong emphasis on new mobile technologies, with manufacturers and operators alike previewing their GSM products and services to a willing audience. Seven manufacturers actually demonstrated their own full GSM transportable and mobile prototype terminals: Alcatel, Ericsson, Motorola, Nokia, Orbitel, Panasonic and Siemens. Demonstrations ran over the networks set up by France Telecom and the Swiss PTT, around the Geneva area, and using local extensions, connected through leased lines to other operators' GSM systems—such as that on the Nokia stand, which temporarily extended the Telecom Finland network into Switzerland. Dataquest tested a number of units and found the quality of the connection, when it could be achieved, to be variable although certainly acceptable in most cases. A number of manufacturers suggested that the conditions in which their equipment was being tested were not conducive to optimum performance.

Unfortunately, a preview is all that could be available. Delays in the specification process have left little lead time for suppliers to produce working equipment to the still uncertain standard. Network operators which claim to have satisfied the spirit, if not the letter, of the Memorandum of Understanding (MoU), by launching pilot trials, are currently working on debugging their systems. Rohde & Schwarz, the German manufacturer with an exclusive contract to develop GSM test equipment, has been working closely with handset manufacturers to validate its products. Deliveries were made to designated test centers in August, but software problems continue to delay progress. This equipment is required to establish Interim Type Approval (ITA) for manufacturers' handset offerings.

Since Telecom 91, the number of tests required has been reduced from 266 to 160. This should, in turn, shorten testing throughput time, and some manufacturers are now hoping to have ITA by early December. Several operators have claimed that they are ready to launch services as soon as terminals are delivered.

Ericsson and AT&T were both able to announce contracts to supply Mannesmann Mobilfunk with digital microwave equipment for the D2 network in Germany. AT&T took the opportunity to declare its interest in becoming a true GSM equipment supplier; it hopes to have completed the necessary modifications to its 5ESS switch by the end of 1992.

DCS 1800

Telecom 91 also gave a platform for Ericsson to announce its selection as the prime supplier for the DCS 1800 network being built jointly for Unitel and Mercury Personal Communications in the United Kingdom. The initial contract is valued at over £100 million.

Ericsson's Scandinavian rival, Nokia, was the only company showing what purported to be PCN equipment. The object in question was a base station-style cabinet with a DCS 1800 badge, which it will supply to the third UK PCN operator, Microtel. Nokia's claim to have stolen a march on its competitors, and to be three to six months ahead in DCS 1800 development, would obviously have been more impressive had it been able to demonstrate the system in action with a working handset.

The fact that most manufacturers were not overtly discussing their approach to DCS 1800 is in itself interesting. The consensus industry opinion was that DCS 1800 infrastructure will cost roughly as much per channel as GSM.

Digital Cordless Telephony

While Northern Telecom and GPT both unveiled their cordless PBX products, based on CT2/CAI technology, Motorola made good use of the show to establish itself as the leading contender for terminal supply. Its equipment featured prominently on the French pavilion, where France Telecom was attracting a lot of attention with its renamed "Bi-Bop" (nee Pointel) service. Following the delayed launch of its technical pilot service in September, the operator is aggressively targeting a commercial launch in Strasbourg next March, and a rollout to all major cities through to 1995. A major difference between French plans and the UK experience is that the operator plans to introduce a degree of "two-way" calling, by allowing subscribers to temporarily register on a specific base station.

PTT Telecom of the Netherlands also helped to reduce the damage done by the recent suspension of all active UK telepoint operations, with plans to launch its own "Greenpoint" service next February. The Dutch service is currently planned to be one-way only, as in the United Kingdom—although, like France Telecom, the PTT anticipates that the combination of telepoint and paging will prove an attractive option to users.

Given the current degree of scepticism among many European PTT signatories of the CT2 MoU, the announcement from PTT Telecom might be seen as quite a surprising development. This is especially so, since it had been a keen supporter of the TDMA approach championed by Ericsson Business Mobile Networks BV, and had chosen at 1.8 GHz, as the DECT standard. PTT Netherlands' announcement, however, that it was also considering DECT-based services, and might switch over when equipment becomes available, is an indication that CT2 technology has a limited amount of time in which to prove its viability. One ironic aspect of the Dutch announcement was that, although there were a number of Motorola Silverlink 2000 CAI units on the PTT stand, these were reserved for use by Telecom executives, and would only accept incomingcalls.

Dancall, the pioneering Danish cellular supplier, attracted a lot of attention with its prototype DECT equipment, based on National Semiconductor's chip set. Elsewhere in the show, DECT-based voice equipment was not in evidence.

Dean Eyers, Personal Communications

(This newsletter was reproduced from Dataquest's Telecommunications Europe service.)

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Research Newsletter

EUROPEAN CONSUMER ELECTRONIC GOODS PRODUCTION

SUMMARY

Brown goods can broadly be divided into video products and audio products. Video products account for the majority of the units manufactured in Europe, with color televisions, video cassette recorders (VCRs) and camcorders accounting for 85 percent of total brown goods manufactured in Europe. Surprisingly, the number of units made by Far Eastern manufacturers is only 42 percent of the total number of video units made, although nearly 60 percent of the manufacturing facilities in Europe are Far Eastern–owned companies.

This newsletter is a summary of the results obtained from an extensive survey of consumer electronics production in Europe. It gives estimates for the unit production of the main manufacturing locations in Europe, and estimates the percentage of those products which contain European-procured semiconductors. A full report, containing all individual manufacturing locations, quantities manufactured, and trends in future consumer electronics production, with semiconductor contents of the equipment will be available in early 1992.

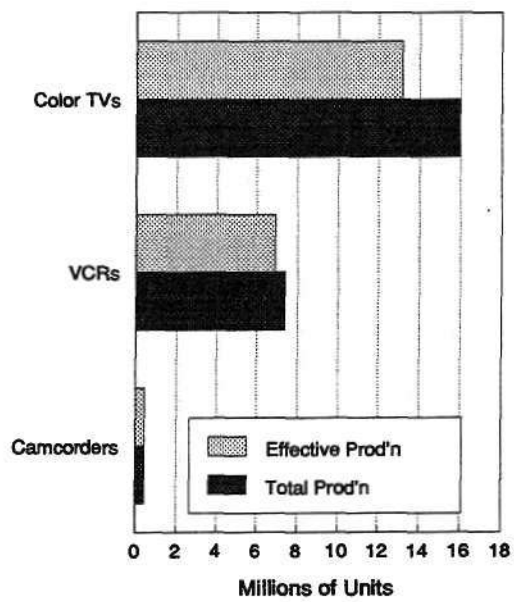
VIDEO EQUIPMENT

Dataquest found 21 manufacturers of color televisions in Europe, spread across 35 manufacturing locations. These locations manufactured an estimated 16 million color television sets in 1990, and are expected to manufacture 17.8 million in 1991. A growing percentage of the semiconductors used in the manufacture of these sets are procured in Europe. We estimate that 82 percent of the televisions manufactured in Europe have some, or all, of their semiconductors procured locally. The estimated share of video equipment units which use locally procured semiconductors (effective production), and the unit production volumes of the different video products for 1990 are shown in Figure 1.

We found 14 manufacturers of video recorders in Europe, spread across 16 manufacturing locations. These locations manufactured an estimated 7.4 million video recorders in 1990, and are expected to manufacture 8.2 million video recorders in 1991. Of the 16 manufacturing locations, 13 procure their semiconductor in Europe, although 94 percent of the video recorders include some European semiconductor components.

The top 10 video equipment manufacturers in Europe are shown in Table 1 (at the end of the newsletter), and Table 2 shows the manufacturing locations and the video products made in these locations.

FIGURE 1
Video Equipment 1990 Unit Shipments (Thousands of Units)



Source: Dataquest (November 1991)

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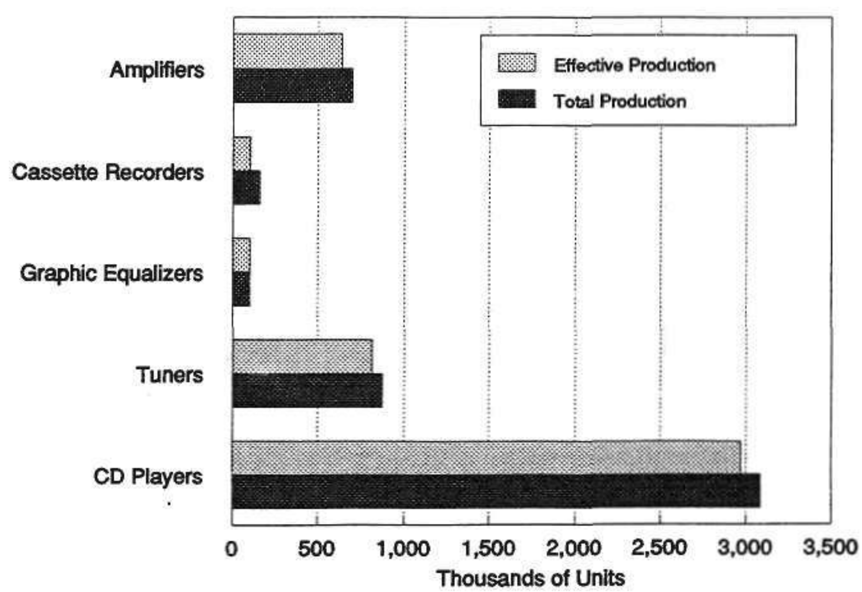
The television consumption market in Europe is effectively saturated, with almost 95 percent of households owning one TV set, and 30 percent owning more than one. Most new sets are sold as a replacement for an existing set. When economies enter recession consumer goods sales, particularly video and audio equipment, tend to suffer due to reduced disposable income among consumers. However, the introduction of satellite television into Europe, and the availability of new features such as stereo TV transmissions have provided some stimulus to consumption. The Olympic games in Barcelona next year are also expected to boost demand for televisions and VCRs.

AUDIO EQUIPMENT

Significantly fewer manufacturers of audio equipment exist in Europe in comparison with color television or video recorder manufacturers. Unit shipments and plant locations of these manufacturers are shown in Table 3. These companies made an estimated 4.9 million units in 1990 and the number is expected to rise to 5.6 million in 1991. The number of units with European procured semiconductors is higher for audio equipment than for video equipment, with an average of 94 percent of the audio units made estimated to contain some European-procured semiconductor components. The majority of the audio units made in Europe are CD players, with 96 percent made in Europe containing some locally procured semiconductor components. The estimated share of audio equipment units using locally procured semiconductors, and the unit production volumes of the different audio products for 1990 are shown in Figure 2.

The audio equipment market is also a saturated one, and products are generally bought on a replacement basis, as with color televisions. Some new products such as CD players provide new growth to the market, although this also is considered a mature market. The development of digital audio is expected to provide the next impetus in this area, as Philips and Sony introduce new digital audio products. Sony has developed the Mini-disc, a smaller (and recordable) version of the compact disc; and Philips is introducing its digital compact cassette (DCC). The DCC allows the user to play older analog cassettes as well as the new digital format, and it is because of this that the DCC is expected to succeed where the older digital audio tape (DAT) was less successful. Both companies have agreed to cooperate on the sales of prerecorded music in both formats.

FIGURE 2
Audio Equipment 1990 Unit Shipments
(Thousands of Units)



Source: Dataquest (November 1991)

REGIONAL ANALYSIS

The regional share of the total number of video and audio units manufactured in Europe by product is given in Table 4. This shows that manufacture of consumer equipment takes place mostly in the Rest of Europe (principally Spain, Austria and Turkey), Germany and the United Kingdom. Together these three regions account for 82 percent of the units of consumer equipment made in Europe. The main reason for this is the high percentage of color televisions, VCRs and CD players. Colour televisions account for 56 percent of units manufactured in Europe, with the majority of these made in the Rest of Europe region. VCRs represent 26 percent of units made, and CD players 11 percent. Again, the Rest of Europe region has strong representations in both of these areas. Efforts by the local governments of Spain, Turkey and Austria to attract foreign investment in manufacturing plants has resulted in several manufacturers building their facilities in these countries, in order to take advantage of the low-cost labor and attractive incentives offered.

Germany is the second-largest region in terms of units manufactured. Several manufacturers have large factories sited there, including a majority of the Japanese manufacturers.

The United Kingdom also has a large share of Europe's television manufacture, and is a net exporter of color TVs. The United Kingdom also has a large share of VCR manufacture; its government has for a long time adopted a policy of attracting foreign investment, particularly Japanese.

The importance of Far Eastern investment in Europe is becoming vital to the success of the consumer manufacturing industry. There are an estimated 47 video equipment manufacturing locations in Europe, and nearly 60 percent of these are Far Eastern. Interestingly, these manufacturers account for only 42 percent of Europe's manufacture of video equipment. This is because the plants built by Far Eastern manufacturers are relatively small, with only three Far Eastern–owned plants producing more than 500,000 units a year. This compares to five European-owned plants with an output of over 500,000 units, and three of these produce over 1 million units.

Mike Glennon
Mike Williams

Table 1
Top 10 European Video Equipment Manufacturers 1990
(Thousand of Units)

Company	Color Televisions	VCRs	Camcorders	Total Units
Philips	2,800	1,800	-	4,600
Grundig	2,899	700	-	3,599
Thomson	1,700	1,000	-	2,700
Sony	1,580	-	250	1,830
Matsushita	650	730	200	1,580
Nokia	1,050	-	-	1,050
Hitachi	400	600	-	1,000
Sanyo	625	288	-	913
Toshiba	550	300	-	850
Mitsubishi	350	450	-	800
Others	3,373	1,520	0	
Total Units 1990	15,977	7,388	450	
Total Units 1991	17,841	8,187	550	

Source: Dataquest (November 1991)

Table 2
Video Equipment Manufacturing Locations

Company	Town	Country	Color TVs	VCRs	Camcorders
Aiwa	Newport	Wales		✓	
Bang & Olufsen	Struer	Denmark	✓		
Daewoo	Antrim	Northern Ireland		✓	
Ferguson	Gosport	England	✓		
Funai Electrics	Shoeburyness	England		✓	
Goldstar	Worms	Germany	✓	✓	
Grundig	Vienna	Austria	✓		
Grundig	Kreuzwald	France	✓		
Grundig	Barcelona	Spain	✓		
Grundig	NA	Turkey	✓		
Grundig	Nürnberg	Germany	✓	✓	
Hitachi	Landsberg	Germany		✓	
Hitachi	Aberdare	Wales	✓	✓	
JVC	East Kilbride	Scotland	✓		
Luxor	Motala	Sweden	✓		
Matsushita	Cardiff	Wales	✓		

(Continued)

TABLE 2 (Continued)
Video Equipment Manufacturing Locations

Company	Town	Country	Color TVs	VCRs	Camcorders
Matsushita	Peine	Germany		✓	✓
Matsushita	Gerona	Spain		✓	
Mitsubishi	Livingston	Scotland		✓	
Mitsubishi	Haddington	England	✓		
Mivar	Milan	Italy	✓		
Nokia	Salo	Finland	✓		
Nokia	Bochum	Germany	✓		
Oceanic SA	Chartres	France	✓		
Philips	Vienna	Austria	✓	✓	
Philips	Bruges	Belgium	✓		
Samsung	Estoril	Portugal	✓		
Samsung	Budapest	Hungary	✓		
Samsung	Billingham	England		✓	
Samsung	Izmir	Turkey	✓		
Sanyo	Nördlingen	Germany		✓	
Sanyo	Lowestoft	England	✓		
Sanyo	Tudela	Spain	✓		
Seleco	NA	Malta	✓		
Seleco	Pordenone	Italy	✓	✓	
Sharp	NA	Spain	✓	✓	
Sony	Barcelona	Spain	✓		
Sony	Bridgend	Wales	✓		
Sony	Fellbach	Germany	✓		
Sony	Ribeauville	France			✓
Tatung	Telford	England	✓		
Thomson	Angier	France	✓		
Thomson	Cedosa	Spain	✓		
Thomson	Hannover	Germany	✓		
Thomson	Berlin	Germany		✓	
Toshiba	Mönchengladbach	Germany		✓	
Toshiba	Plymouth	England	✓		

NA = Not Available
Source: Dataquest (November 1991)

TABLE 3
European Audio Equipment Manufacture
Plant Locations and Unit Shipments

Company	Town	Country	Amplifiers	Cassette Recorders	Graphic Equalizers	Tuners	CD Players
Bang & Olufson	Struer	Denmark	60	55	-	60	60
JVC	Villers-la-Montagne	France	100	100	100	100	50
Matsushita	Longwy	France	250	-	-	250	-
Matsushita	Peine	Germany	-	-	-	-	250
Matsushita	Gerona	Spain	20	-	-	20	-
Mitsubishi	Madrid	Spain	-	-	-	-	2,400
Nippon	Nattetal	Germany	270	-	-	270	270
Pioneer	Erpe	Belgium	-	-	-	172	-
Sharp	Wrexham	Wales	-	-	-	-	55
Total 1990			700	155	100	872	3,085
Total 1991			902	205	150	940	3,354

Source: Dataquest (November 1991)

TABLE 4
1990 Regional Share
(Percent of Total Units)

Region	Amplifier	Cassette Recorder	Graphic Equalizer	Tuner	CD Player	Color TV	Video Recorder	Cam-Corder	Total Units	Total (%)
Benelux	0.0%	0.0%	0.0%	19.7%	0.0%	6.3%	0.0%	0.0%	1,172	4.1%
France	50.0%	64.5%	100.0%	40.1%	1.6%	8.4%	0.0%	55.6%	2,541	8.8%
Italy	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	1.2%	0.0%	810	2.8%
Scandinavia	8.6%	35.5%	0.0%	6.9%	1.9%	2.9%	0.0%	0.0%	695	2.4%
UK and Eire	0.0%	0.0%	0.0%	0.0%	1.8%	25.9%	22.7%	0.0%	5,874	20.4%
Germany	38.6%	0.0%	0.0%	31.0%	16.9%	16.7%	50.3%	44.4%	7,653	26.6%
Rest of Europe	2.9%	0.0%	0.0%	2.3%	77.8%	35.3%	25.7%	0.0%	9,982	34.7%
Total Percent	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%
Total Units (K)	700	155	100	872	3,085	15,977	7,388	450	28,727	

Source: Dataquest (November 1991)

ADDENDUM—COMPANY NOTES

Aiwa: One facility in Wales which recently opened. Products to be manufactured there are mainly audio separates and VCRs. Aiwa is a subsidiary of Sony, which has a majority stake.

Bang & Olufsen: Manufacturer of high-end hi-fi components and color televisions at its one facility in Struer, Denmark. Bang & Olufsen recently formed a joint company with Ericsson to manufacture telecoms products.

Ferguson: One manufacturing facility in Gosport, England making color televisions and satellite television products. Ferguson is now owned by Thomson, and Thomson plans to close this facility in 1992, transferring production to other Thomson factories in Europe.

Grundig: Five factories in Europe: Turkey, Spain, France, Germany, and Austria. Most of these manufacture color televisions, with the German factory also making VCRs and car radios.

JVC: Two factories in Europe: one in the United Kingdom manufacturing color TVs, and one in France manufacturing a full range of audio equipment, including car-stereo equipment. JVC is owned by Matsushita, but operates as a separate company with its own plants and brand names.

Luxor: Part of the ITT-Nokia group, together with Nokia, Salora and Oceanic. It has a single facility in Sweden making color televisions and satellite products.

Matsushita: Trades under the Panasonic and Technics brand names as well as Matsushita, and also owns JVC. It has three factories in Europe. The plant in the United Kingdom manufactures color televisions only; the plant in Spain makes some audio equipment and VCRs; the plant in Germany makes CD players and VCRs. The German plant is also one of only two in Europe manufacturing camcorders. Matsushita also plans to open a hi-fi line at the German facility in 1992. The company has held close links with Philips for many decades, and Philips has a 20 percent share.

Mitsubishi: Two plants in Scotland; one manufacturing VCRs and the other manufacturing color TVs. A facility also exists in Germany which makes CD players. We believe this to be the largest manufacturing plant of CD players in Europe. Mitsubishi has also built a plant to make mobile phones in France is expected to make 3,000 to 5,000 units per month.

Mivar: One facility in Milan, Italy for manufacturing color televisions. Mivar will open a new factory for color TV manufacture in 1994. We estimate that Mivar makes over 60 percent of Italy's color TV production.

NEC: No longer manufactures consumer equipment at its facility in Telford, England. This site is now used for the manufacture of printers and mobile phones.

Nokia: Finland's largest manufacturer of consumer goods, having two factories in Europe. It also own's Oceanic, Luxor and Salora. The factory in Finland makes color televisions, but 85 percent of Nokia's television production comes from its factory in Germany.

Oceanic: Part of the Nokia group, Oceanic manufactures color televisions at its only factory in France. This factory also makes monitors for data processing and industrial use.

Philips: Estimated to be Europe's largest manufacturer of color televisions and video recorders. It has six factories spread across Europe, manufacturing a wide range of consumer goods. Philips also plans to open a plant in Hungary to make video recorders, although this is not planned to perform the complete manufacture.

Pioneer: One facility in Belgium manufacturing tuners and car radios. Production of audio tuners has now stopped at this factory and has been transferred to the UK factory.

Samsung: Four factories in Europe making color televisions and video recorders. One of these facilities is in Turkey, and is a joint venture with Ortadogo in which Samsung has an 80 percent stake. The Turkish factory manufactures color televisions only.

Seleco: Two facilities in Europe. The plant in Italy makes color televisions and is Italy's only manufacturing facility for video recorders. Seleco also has a factory in Malta making small-screen color televisions.

Sony: Three facilities in Europe making color televisions exclusively, and one in France manufacturing camcorders. This is one of only two camcorder factories in Europe. Sony is building a new facility which will double the capacity of the television plant in the United Kingdom; the existing plant also manufactures picture tubes for color television. Sony has also introduced a new facility in Barcelona, Spain and this will manufacture color televisions. Sony is also a majority shareholder of Aiwa.

Thomson: One of Europe's major manufacturers of color televisions, with facilities in France, Spain and Germany. Thomson also has a joint venture with JVC in Berlin, which manufactures VCRs and trades under the name of J2T. The products manufactured in this facility sell under the brand names of Telefunken and Normende. J2T has a facility in France that manufactures some of the mechanics for these video recorders. The Berlin plant is expected to close in the near future.

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Research Newsletter

PC PRODUCTION IN EUROPE: 1990 AND FORECAST

SUMMARY

Dataquest estimates that in 1990 local manufacture of PCs in Europe accounted for 65 percent (4.86 million units) of the 7.42 million PCs sold locally. This represented a unit production growth of 31.3 percent over 1989, compared with an end-use market unit growth of 17.9 percent.

From a semiconductor marketing perspective, not all PC manufacturers procure electronic components in Europe. Many subcontract the manufacture of motherboards to outside Europe, while others buy from specialist suppliers mainly in the Far East. With these adjustments taken into account, the proportion of the market "effectively produced" in Europe is somewhat lower at 50.2 percent (3.72 million units) for 1990. Compared with 1989 this represented a significantly lower unit growth of 9.5 percent.

This newsletter presents the results of Dataquest's 1991 survey of personal computer (PC) production in Western Europe. This is the most comprehensive study conducted by Dataquest on PC manufacturing to date. (A much more detailed analysis covering all PC component consumption and a full set of all PC manufacturers will be published later as a separate report.)

TOP THREE: 60 PERCENT OF THE MARKET

IBM continues to far outstrip other PC manufacturers in Europe with an estimated 1.3 million PCs produced last year (see Tables 1 to 3). Despite declining margins, both Olivetti and Apple experienced strong production growth last year.

Consolidation among producers has occurred to such an extent that, combined, these top three producers account for an estimated 60.7 percent of total motherboard semiconductor procurement in Europe.

Within the last two years a number of acquisitions and mergers have taken place; Siemens/Nixdorf, Bull/ZDS and ICL/Nokia Data are all examples of this trend, with the demise of SMT-Goupil a warning to those that remain.

1991: YEAR OF THE 80386

The disparity between the relative proportions of what is effectively produced in Europe and what is consumed is shown in Figure 1. European manufacturing is weighted to high-end 80386 PCs, leaving the 8086/88 variants to be imported.

The 1990 survey also shows the decline of the 80286 in favor of the 80386, which more than doubled its sales from 1989, now accounting for 41 percent of all PCs made. This year we estimate that it will represent almost half (49.2 percent) of PCs made.

EUROPE: OVERLY BEHIND ON LAPTOPS

The transition to PC portability has not, so far, been accompanied by local production to the same extent as with desktops. During 1990, combined European laptop and notebook production came to 276,000 units, or 38 percent of 725,000 laptops and notebooks sold. But, in terms of effective production, this proportion is believed to be even lower.

Laptops and notebooks remain largely sourced from the Far East due, in part, to the lack of PCB assembly equipment in Europe able to handle the high-density package type that they require.

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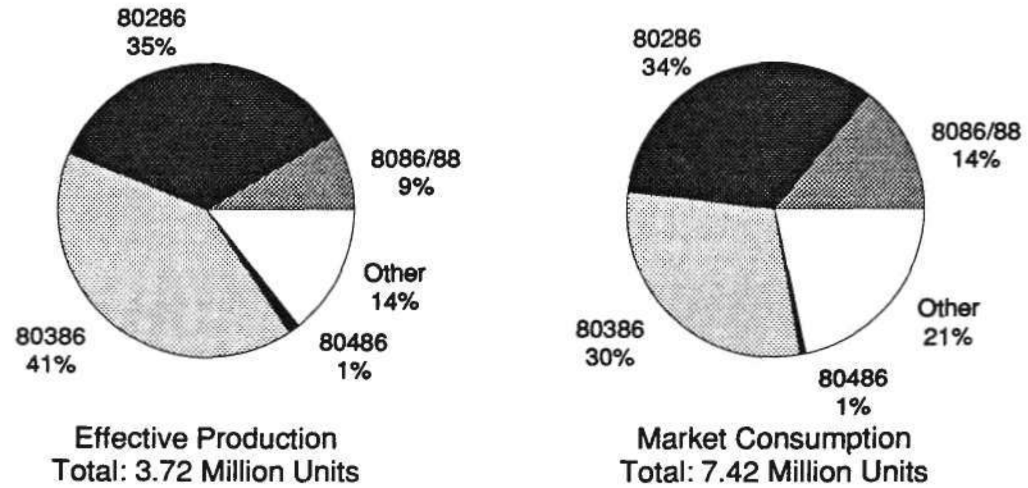
FIGURE 1

European 1990 PC Production and Market by Microprocessor Type



Source: Dataquest (August 1991)

FURTHER CONCENTRATION IN THE UNITED KINGDOM AND IRELAND

Since last year's survey, regional concentration of PC manufacture in the United Kingdom and Ireland further intensified during 1990. Intel's decision to site in Ireland and Apple's strong output during 1990 were key contributing factors. We estimate that UK/Eire's share of the effective production of PCs in Europe rose to 57.9 percent during 1990, and remains weighted heavily in favor of 80386- and 68xxx-based PCs (see Table 4).

Overall, production levels in Germany are estimated to have actually fallen during 1990 despite the inclusion of a number of German manufacturers (Itos, Magix, Peacock and Vobis) not surveyed last year.

DATAQUEST ANALYSIS

Our expectations of last year for strong production growth, fuelled by a unified Europe and its resulting pull towards local manufacture, have need of further qualification this year.

First, while total unit production during 1990 did indeed grow faster (31.3 percent over 1989) than the underlying market (17.9 percent), effective production grew only at a meager 9.5 percent. This is partly due to the fact that many major new facilities (Compaq, Dell, Tandon, Toshiba) have not yet made the transition to PCB manufacturing, although in some cases it has been planned. This is not hard to explain given that many local manufacturers cite situations in which motherboards can be imported from the Far East at lower prices than could be reached by producing them economically in Europe.

It is an inescapable fact that, overall, the manufacturers who do procure semiconductors locally are facing the greatest financial adversity in what is now a highly competitive and price-sensitive market.

Secondly, the PC market has surprised most forecasters with the almost reckless haste with which it is entering maturity. Moreover, this slowing of the total market is not being halted by repackaging PCs in smaller boxes and calling them "laptops" or "notebooks." This year (1991), Dataquest expects unit end-market growth to fall to the lowest level yet in Europe of 12.1 percent, or 8.3 million units.

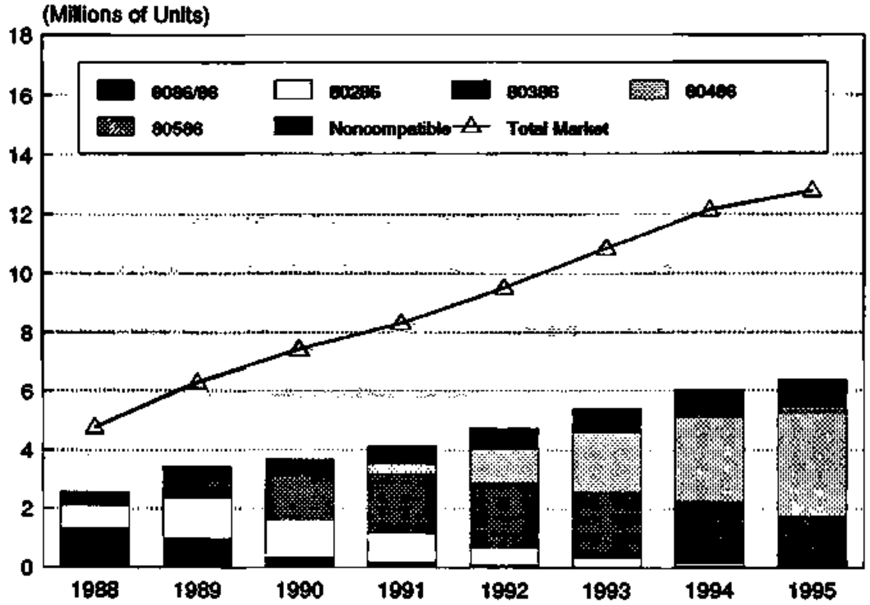
PRODUCTION FORECAST

Dataquest estimates that effective PC unit production will rise to 4.17 million units this year, a growth of 12.0 percent over 1990.

Our long-term forecast for production (see Figure 2 for a split by processor type) gives a compound annual unit growth rate of 11.4 percent for effective PC production in Europe between 1991 and 1995. This is based on the assumption

FIGURE 2

European Effective PC Production Forecast by Microprocessor Type



Source: Dataquest (August 1991)

that the proportion of PCs effectively produced in Europe compared with the end-user market will stay at the 1990 level of 50.2 percent during the forecast period. The poor growth (9.5 percent) observed in effective production during 1990 may seem hard to accept, but we believe that this will be largely offset in 1991 by European manufacturers' growing concentration on the less commodity-oriented segments in the high end, as clearly evidenced from the 1990 survey.

COMPANY NOTES

- Acer commenced production in January this year in the facilities of the PC company Kangaroo, which it acquired 18 months ago. The plant has a capacity of 350 units per day, with manufacturing levels currently estimated at 100 per day of 80386SX-based systems sold under its own name. Motherboards are imported from its parent company in Taiwan. Acer also acquired the UNIX systems manufacturer, Altos, last July. The company is considering whether to locate design facilities in Europe, as it has already done in the United States.
- Acorn is a subsidiary of the Olivetti Group and currently subcontracts all motherboard manufacture in the United Kingdom. Acorn specializes on personal computers for educational use; its production is listed separately from Olivetti.
- Active Book Company is currently negotiating to subcontract production of its notebook PC.
- Altec is the largest PC manufacturer in Greece, accounting for an estimated 30 percent of local PC production. Motherboards are imported from Taiwan and Hong Kong.
- Amstrad expects to move subcontracted production of all high-end PCs away from GPT (UK) to the Far East by the end of this year.
- APD has been producing PCs since 1981 and specializes in multiuser systems. Its main markets are Spain and South America.
- Apple's current factory is being expanded from 9,000 to 19,000 m^2 by October 1991.
- Apricot was acquired by Mitsubishi in May 1990.
- Asem entered the PC market in 1983 with a range of Apple II–compatible machines and, one year later, entered the IBM PC–compatible market.
- Bull acquired Zenith Data Systems (ZDS) in December 1989. It has since rationalized production to plants in France, Angers for PCB

assembly, and Villeneuve d'Ascq (VDA) for PC assembly and testing, closing down the ZDS facility in Ireland. Laptops are not made in Europe.

- **Commodore** assembles IBM PC compatibles in Germany, although the Amiga 500 PC and C64 range are imported from its factory in Hong Kong. Commodore is currently expanding the Braunschweig facility and building a new plant in the Philippines that will act as an overflow facility for the Hong Kong plant.
- **Compaq** is believed to source the laptop from Citizen (Japan). Desktops are assembled in Europe with motherboards imported from Compaq (Singapore). The company acquired the Wang (Stirling, Scotland) factory in 1989 for making repairs and fitting spare parts.
- **Dell Computer** recently acquired the former Atari plant.
- **Elonex** of Santa Clara (United States) transferred production of its new-generation 80386 and 80486 PCs to Europe from Taiwan earlier this year. Production is being subcontracted to Avex Electronics Ltd (East Kilbride, Scotland) with final configuration taking place at Elonex's plant in London. Elonex expects annual production levels to be around 100,000 units.
- **Forum International** was acquired by SMT-Goupil (which has subsequently gone into liquidation) and Archives SA in October 1990.
- **G2** is moving out of its current premises to a new factory in Maarssen, Netherlands.
- **Goldstar** started PC assembly and production at its Luton (England) facility at the end of last year. Plans are to move to full PCB assembly in the near future.
- **Hewlett-Packard** last year moved its worldwide PC headquarters from Sunnyvale, California to Grenôble, France.
- **ICL** is 80 percent owned by Fujitsu, and has announced that it is to market a complete range of Intel 80486-based PCs. These will be manufactured together with the company's existing 80286 range at its Ashton-Under-Lyne facility in England. Currently, manufacture of the 80286 is subcontracted to Acer, which will continue to supply ICL with motherboards for the foreseeable future and manufacture ICL's 386SX range.

  Last May ICL announced the agreed acquisition of Nokia Data from Nokia Corp. (Finland) for $400 million. When the transaction is complete Nokia Corp. will hold a 5 percent ordinary shareholding in ICL.
- **IN2/Léanord** was acquired by Siemens in early 1989.
- **Intel** has announced that it will phase out its computer manufacturing operations in Singapore by early 1992 in a move to bring production closer to its major markets. Production is being transferred to Intel's three other systems plants, including the new Leixlip facility. Intel recently reached an OEM agreement with Digital to supply 80486-based PCs.
- **Itos Computer**, formerly ComputerTecknik Muller (CTM) until March 1990, was acquired from Alcatel SEL in 1989. It commenced PC production in July 1990, and is believed to subcontract motherboard production.
- **Magix** was founded in 1983 and has been manufacturing PCs for six years. It currently purchases motherboards and assembles in two factories (Munich and Lübeck) in Germany. A new manufacturing and PCB assembly plant is currently under construction near Lisbon (Portugual), and is scheduled to commence manufacturing within six months.
- **NCR** discontinued PC production for Siemens, although it still manufactures motherboards and OEM systems for third parties.
- **NEC** currently has no plans to start manufacturing in Europe.
- **Nokia Data Systems AB** was acquired by ICL from its Finnish parent, Nokia Corp., for $400 million late in May 1991. Formerly Nokia acquired Ericsson's Data Division in January 1988. It currently has three manufacturing facilities, one of which (Brakne-Hoby, Sweden) is being closed down.
- **Normerel** was acquired by SMT in December 1989 when it took 65 percent of Normerel's holding company. However, the two companies were not integrated and, when SMT became insolvent in July 1991, Normerel was unaffected and has been able to find new partners, to be announced shortly.

- Olivetti Group has two internal PC manufacturing divisions: Olivetti Office and Olivetti Systems and Networks.

  It acquired the PC desktop and laptop subsidiary Triumph-Adler (Nürnberg, Germany) in 1986, and its production is included in the Olivetti Group. Triumph-Adler formed an OEM agreement last March to supply Digital with 80386-based notebooks and laptops (in addition to an earlier 1989 agreement to OEM desktop PCs). Olivetti also holds a 79.8 percent stake in the educational computer company Acorn, whose production is estimated separately. Olivetti Group has recently opened a PC factory in Mexico to supply the European market.

- Opus recently consolidated its manufacturing operations to its Redhill (England) location, and disposed of its Gainsborough (England) plant to Tiny Computers. PCB assembly is subcontracted to the Far East.

- Philips recently moved its PC operations out of its Information Systems division into its Consumer division last March. Philips' Information Systems division is to be sold to Digital next October, pending authorization by the European Commission. Philips' Consumer division currently does not manufacture in Europe; instead it imports complete systems from Philips in Canada and Taiwan. Philips has also announced that it plans to commence PC production in Tilburg (Netherlands) for the first time in the second half of this year. Currently, systems are shipped to Tilburg where they are configured prior to distribution.

- Research Machines currently subcontracts all desktop production to subcontractors in the United Kingdom and has a new factory under construction.

- Siemens-Nixdorf Information Systems (SNI) was formed by the merger of Siemens' computer division and Nixdorf in January 1990. Siemens had formerly acquired Léanord (France) in early 1989.

- SMT-Goupil has ceased manufacture and gone into liquidation.

- Sunnytech commenced PC production in 1990 and merged with Panatec in September 1989. PCs are sold under the Panatec brand name.

- Tandon commenced production in April 1989.

- Toshiba commenced production in April 1990. Despite earlier plans, local procurement has not yet started but is expected to commence in the near future.

- Triumph-Adler—see Olivetti Group.

- Tulip is planning to double its present capacity with construction of a new plant.

- Unibit purchases all motherboards from specialist suppliers.

- Unisys performs a combination of in-house PCB assembly for its 80386SX range and sources from Acer, Mitsubishi and Goldstar.

- Victor was acquired by Tandy in mid-1989 from the Swedish company Datatronics. Tandy has since announced that it will open a European manufacturing and repair facility in East Kilbride, Scotland in conjunction with its European subsidiary Victor Technologies. The new 5,500 m^2 facility, to be known as Tandy-Victor Scotland Ltd, will initially employ 130 people, rising to 250 when it reaches full production. The new plant will start production of Victor's M-Series systems before the end of the year and produce 400 units per day. Surface mount PCB assembly is not planned for the short term and Race Computers (Wales) will continue to supply motherboards.

- Vobis has been assembling desktop PCs since early 1989 using purchased motherboards. Laptops are sourced from Taiwan.

- Wang closed its Stirling, Scotland plant in September 1989 and has moved all production to Limerick.

- Zenith Data Systems—see Bull.

Jonathan Drazin
Andrew Norwood

TABLE 1
1990 Top 15 European PC Manufacturers by Microprocessor Type
(Percentage Breakdown and Millions of Units)

Manufacturer	8086/88	80286	80386SX/L	80386DX	80486	68000	68020	68030	Other	Total (M)
IBM	8%	31%	33%	27%	1%	0%	0%	0%	0%	1.30
Olivetti Group	14%	59%	20%	6%	1%	0%	0%	0%	0%	0.51
Apple	0%	0%	0%	0%	0%	49%	2%	49%	0%	0.45
Compaq	5%	33%	31%	29%	1%	0%	0%	0%	0%	0.41
Bull (including ZDS)	14%	49%	15%	22%	0%	0%	0%	0%	0%	0.22
Tandon	2%	60%	24%	12%	2%	0%	0%	0%	0%	0.20
Commodore	47%	45%	1%	7%	0%	0%	0%	0%	0%	0.18
Siemens-Nixdorf	0%	57%	28%	14%	1%	0%	0%	0%	0%	0.15
Victor	19%	48%	17%	15%	1%	0%	0%	0%	0%	0.13
Hewlett-Packard	0%	32%	39%	26%	3%	0%	0%	0%	0%	0.12
Toshiba	33%	43%	8%	15%	0%	0%	0%	0%	0%	0.12
Tulip Computers	16%	54%	23%	6%	1%	0%	0%	0%	0%	0.10
Acorn	0%	0%	0%	0%	0%	0%	0%	0%	100%	0.07
Schneider	33%	47%	15%	5%	0%	0%	0%	0%	0%	0.07
SMT-Goupil	4%	33%	43%	20%	0%	0%	0%	0%	0%	0.06
Others	11.3%	36.3%	27.8%	20.3%	3.0%	0.6%	0.0%	0.6%	0.2%	0.79
1990 Total Units (M)	0.50	1.78	1.14	0.89	0.01	0.22	0.00	0.22	0.020	4.86
1990 Split by Processor	10.4%	36.6%	23.4%	17.6%	1.2%	4.6%	0.2%	4.6%	1.5%	100.0%
1989 Total Units (M)	0.90	1.60	0.81	0.81	0.00	0.44	0.44	0.44	0.44	3.70
1989 Split by Processor	23.0%	43.0%	22%	22%	0.0%	12%	12%	12%	12%	100.0%

Source: Dataquest (August 1991)

TABLE 2
1990 Top 15 European PC Manufacturers by Format Type
(Percentage Breakdown and Millions of Units)

Manufacture	Desktop	Laptop	Notebook	Total (M)
IBM	100.0%	0.0%	0.0%	1.30
Olivetti Group	97.1%	2.9%	0.0%	0.51
Apple	95.3%	4.7%	0.0%	0.45
Compaq	100.0%	0.0%	0.0%	0.41
Bull (including ZDS)	100.0%	0.0%	0.0%	0.22
Tandon	92.8%	7.2%	0.0%	0.20
Commodore	98.7%	0.0%	1.3%	0.18
Siemens-Nixdorf	92.5%	7.5%	0.0%	0.15
Victor	85.7%	13.4%	0.9%	0.13
Hewlett-Packard	100.0%	0.0%	0.0%	0.12
Toshiba	0.0%	81.0%	19.0%	0.12
Tulip Computers	100.0%	0.0%	0.0%	0.10
Acorn	100.0%	0.0%	0.0%	0.07
Schneider	92.3%	7.7%	0.0%	0.07
SMT-Goupil	78.3%	21.7%	0.0%	0.06
Others	92.8%	4.8%	2.3%	0.79
1990 Total Units (M)	4.58	0.23	0.04	4.86
1990 Split by Format	94.3%	4.7%	0.9%	100.0%

Source: Dataquest (August 1991)

Table 3
Major 1990 European PC Manufacturers by Location and Activity

Company	City	Country	Full Assembly	Partial Assembly	Sub-Contract	Import/ Purchase
Acorn	Cambridge	England			✓	
AEG-Olympia	Wilhelmshaven	Germany				✓
Altec	Athens	Greece				✓
Amstrad	Brentwood	England			✓	
APD	Aranavez (near Madrid)	Spain			✓	
Apple	Cork	Ireland	✓		✓	
Apricot	Glenrothes	Scotland			✓	
ASEM	Buia	Italy	✓			
Bull (including ZDS)	Villeneuve d'Ascq	France		✓		
	Angers	France	✓			
Commodore	Braunschweig	Germany				✓
Compaq	Erskine	Scotland				✓
Donatec	Ivry Sur Seine	France				✓
Epson	Telford	England				✓
Goldstar	Luton	England				✓
Hewlett-Packard	Grenôble	France	✓		✓	
IBM	Greenock	Scotland	✓	✓	✓	
Intel Ireland	Leixlip, Co. Kildare	Ireland	✓			
Investrónica	Madrid	Spain				
Itos	Konstanz	Germany			✓	
Magix	Munich	Germany				✓
	Lübeck	Germany				✓
NCR	Augsburg	Germany	✓			
Nokia Data	Brakne-Hoby	Sweden	✓			
	Espoo (near Helsinki)	Finland	✓			
	Lohja (near Helsinki)	Finland	✓			
Normerel	Granville	France	✓			
Olivetti Group	Ivrea	Italy	✓			
	Scarmagno	Italy	✓			
Olivetti Group (Triumph-Adler)	Nürnberg	Germany	✓			
Opus	Redhill	England	✓		✓	✓
Peacock Computers	Wünnenberg-Haaren	Germany				✓
Psion	London	England			✓	
Research Machines	Oxford	England			✓	

(Continued)

TABLE 3 (Continued)
Major 1990 European PC Manufacturers by Location and Activity

Company	City	Country	Full Assembly	Partial Assembly	Sub-Contract	Import/ Purchase
Schneider	Turckheim	Germany			✓	
Siemens-Nixdorf	Augsburg	Germany	✓			
	Dresden	Germany	✓			
Siemens-Nixdorf (Léanord)	Haubourden	France	✓			
SMT-Goupil	Lyon/Granville	France			✓	
Sunny Tech	Breukelen	Netherlands				✓
Tandon	Vienna	Austria				✓
Tiki Data	Oslo	Norway		✓		
Toshiba	Regensberg	Germany				✓
Tulip Computers	's-Hertogenbosch	Netherlands			✓	
Unibit	Rome	Italy				✓
Unisys	Barentin	France	✓			
Victor	High Wycombe	England			✓	
Viglen	Alperton	England		✓		✓
Vobis	Aachen	Germany				✓
Wang	Limerick	Ireland				✓

Source: Dataquest (August 1991)

TABLE 4
Effective 1990 PC Production by Region
(Percent of Total European Effective Production and Millions of Units)

	8086/88	80286	80386	80486	68xxx	Total Other	Total Percent	Units (M)
Benelux	0.4%	1.4%	0.7%	0.0%	0.0%	0.0%	2.6%	0.09
France	0.9%	4.7%	6.1%	0.1%	0.0%	0.0%	11.9%	0.44
Italy	2.0%	8.5%	4.0%	0.1%	0.0%	0.0%	14.6%	0.54
Scandinavia	0.0%	0.0%	1.5%	0.0%	0.0%	0.0%	1.5%	0.06
UK and Ireland	4.3%	14.2%	24.6%	0.9%	12.1%	1.9%	57.9%	2.16
West Germany	2.5%	5.3%	3.0%	0.1%	0.0%	0.0%	11.0%	0.41
Rest of Europe	0.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.6%	0.02
Total Percent	10.5%	34.4%	39.9%	1.2%	12.1%	1.9%	100.0%	
Total Units (M)	0.39	1.28	1.49	0.05	0.45	0.07	3.73	

Note: Effective production counts only that proportion of PC production where semiconductor procurement is believed to have occurred in Europe.
Source: Dataquest (August 1991)

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Research Newsletter

PROFIT THROUGH THE SILICON CYCLE TENTH EUROPEAN SEMICONDUCTOR INDUSTRY CONFERENCE

SUMMARY

Dataquest's tenth annual European Semiconductor Industry Conference was held in Marbella, Spain from May 29 to 31. The theme of the conference, "Profit Through the Silicon Cycle: the Next Ten Years," focused on the increasingly global nature of semiconductor companies, and the growth of Far Eastern vendors in the European market, mainly at the expense of North American vendors. Future success may depend on exploiting hidden assets, such as intellectual property rights (IPR), training, organization and technology investments.

Speakers at the conference discussed the current situation in the European semiconductor scene and forecasts for the future, as well as the importance of customer–vendor relationships in the 1990s. One of the two concurrent panel sessions particularly covered the issue of managing the hidden assets for profit.

SPEAKER HIGHLIGHTS

This newsletter gives brief synopses of presentations by invited speakers in the following extracts.

Successful Supplier Relationships and Enterprise Selling

Raiyo Schroff
Senior Consultant, Esprit Ltd.

Companies commonly lack two important perceptions: that the people who design products need to get involved in selling them; and that the people who interface with the customer are the ones who put the company's vision into practice. Where company perceptions are deficient, training is a means of changing the way people think about their job. But training is useless if people return to their company after training only to find that they cannot put into practice what they have been taught because their manager has not himself been on the course. Changes can only come about if companies explain what they want and why; if they set achievable goals and provide the procedures and tools to achieve them; if they collect feedback and maintain enthusiasm for the change.

Spain's Premier Technology Park: Andalucía

Felipe Romera
Managing Director, Andalucía Technology Park

Foreign companies investing in Andalucía, southern Spain benefit in two ways: a big local market and significant financial inducements. Spain has a gross national profit (GNP) of ECU 345 billion (8 percent of the European Community); Andalucía has a GNP of ECU 44.6 billion (13 percent of Spain); Málaga Province has a GNP of ECU 8.3 bilion. Investment in inward electronics manufacturing is represented by Alcatel, Fujitsu and Siemens/Matsushita. Established in the Andalucía Technology Park are Hughes Microelectronics, Telefónica, RWTUV and Esamat. Regional subsidies are available up to 30 percent of the investment, and companies in the Park are additionally entitled to subsidies of 30 percent of the investment; maximum subsidies allowed are 50 percent. There are agreements with local banks to provide low interest rate loans. Joint-venture arrangements with local firms are available.

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The Electronics Industry in Spain

Manuel Lazaro
General Sub-Director of Information and Communication Technologies
Ministry of Industry, Spanish Government

Boosting Spain's electronics industry is a priority of the Spanish government. Last year the government approved a plan for the electronics industry, the "Plan Electrónica e Informático Nacional." For three to four years the Spanish electronics industry has been growing faster than the European industry. The problems it faces are a large trade deficit (a $15 billion market with local $8 billion production) and a shortage of qualified people. The National Plan is designed to improve that, concentrating particularly on wideband communications, HDTV and microelectronics. In the microelectronics area grants, subsidies and low-rate loans are available for work in ASIC design, smart power ICs, IC sensors, gallium arsenide ICs, hybrids and discretes (mainly diodes and transistors), and to promote involvement in European projects such as displays. The government has allocated a Pta 6 billion budget for the program. Subsidies are typically 20 percent of a project's cost plus 35 percent in soft loans. But in some cases, like ASICs, the loans could amount to 50 percent of the project's cost.

Grasping ASSPs and Making Money

Doug Dunn
Managing Director, GEC Plessey Semiconductors (GPS)

The semiconductor industry walks a tightrope between taking all the business on the table and taking acceptable profit margins. If more companies walked away from unprofitable business—as GPS does—then overall profit margins in the industry would improve. It is to be hoped that a more responsible attitude to pricing will be taken. GPS has been profitable for 11 successive years (averaging 11 percent before interest and tax). That has not been achieved by spending unlimited amounts of capital but by "using intellect and creativity to take to customers unique products which they require." The basis for GPS' future profitable growth is to continue making application-specific standard products (ASSPs) based increasingly on the use of multichip modules, particularly involving mixed technologies. Personal and satellite communications were key areas for GPS. The changes the industry was going to see in the 1990s would make the 1980s seem like a peaceful decade indeed.

Smart Cards

Marc Lassus
President and CEO, Gemplus Card International

Last year over 100 million smart cards were used worldwide, and in 1995 a billion will be used, worth close to $2 billion. Every card uses either a secured memory chip or a microcomputer chip and so, added to the number of chips used in card readers, it represents a significant chip market and is an application in which Europe is leading the world. New uses are emerging in banking ($1 billion a year lost in the United States from cash-machine fraud), ID, secure access (people and computers), encrypted TV ($500 million a year lost in the United States and Europe through nonauthorized viewing of subscription services), vending, health, mobile phones (to convert a nondedicated phone line to the user's line), car parks, medical (expected to be the largest user), and company cards. Moreover, according to the Electrical Industry Association of Japan, $1 of smart card sales generates $14 of associated sales hardware, software and services.

Multimedia: Virtually a Reality Today

Dr. Andy Hopper
Director, Olivetti Research Ltd.

One of the "killer applications" for multimedia could be video mail—the audio/video recording of a personal message on a PC and transmission to another PC for playback. Olivetti Research Labs are working on 100-Mbit/s LANs for this and other applications for multimedia systems. A multimedia workstation system could include a camera-on-a-chip ("the whole screen of a workstation could be lined with them if they are cheap enough"), a TV tuner, a CD-ROM player, a DAT bank, a bespoke compressor, a supercompressor, ISDN bridge, and audio/video file server. Networking could be via broadband ISDN. Applications could include being able to call up on your PC an audio/visual clip of anyone in your company so you get a personal feel for them.

Multichip Modules: a Vehicle for Industry Integration

Dr. Michael F. Ehman
Director, Alcoa Electronic Packaging Inc.

Multichip modules answer three of the industry's current problems:

- The problem of air-cooling chips dissipating up to $80W/cm^2$
- The "tremendous" and "unending" increase in I/Os
- The pitch on bond pads which could reach the limit for wiring at 110 µm

For the systems designer the module is a boon giving him a ruggedized single component. However, there are considerable problems for the assembler in design where "a whole new set of CAD tools are required which take into account the partitioning of the system" and which provide electrical and thermal simulation. Furthermore, "testability is a critical issue especially where the dies come from different vendors." Mixed technology testing—linear/digital, GaAs/Si, multiple power levels—needs improving as well as diagnostic and fault testing. Typical reasons for failure are where IC specifications do not match IC performance. Reworks cause customer dissatisfaction. The rewards in space reduction, speed increases and cost reduction will make the technology development worth it.

Zetex—Making the World of Difference

Bob Conway
Managing Director, Zetex plc
Paper delivered by Terry Roeves, Quality and Marketing Director, Zetex

Too much of the European electronics industry is tied up in large companies. Without a new breed of technological and industrial adventurers, European inertia and anti-entrepreneurial bureaucracy will stifle the "rich ingenuity" of Europe's scientists and technologists. Europe has got to show itself capable of fostering all kinds of electronics companies—start-ups, medium-size MBOs, as well as large multinationals and the large should "encourage, support and partner," while the small should feed the large with "concepts, applications and enlightened human material."

Semiconductor Start-Up Company Strategy for Profitability in the 1990s

David L. Angel
President, Information Storage Devices, Inc. (ISD)

Success is no longer assured in Silicon Valley. Well-financed, technology-rich start-ups fail. Now the term "distinctive competence" is used to describe the requirement to survive. It means distinctive innovation rather than incremental improvement offering significant value added to the customer and a sustainable competitive advantage to a start-up company. ISD has, for the first time, made a silicon device that can store analog signals without conversion. Moreover, it is nonvolatile storage. That was its distinctive innovation and its sustainable competitive advantage derived from it keeping quiet about what it was doing until it had developed its product to the point of shipping it to the market. In this way it achieved a lead on any potential competitors of at least two years. Furthermore, it has made 164 patent claims to protect its technology and has made the products very hard to copy. The chips have analog, digital, high-voltage, EEPROM, CMOS and bipolar technologies all on one chip; few companies have competence in all those technologies. Test is critically important and is all done in-house. All these things make it difficult for potential competitors. Two other rules for start-ups are: spend as little as possible—ISD got its products developed and shipping to the market for $2.2 million; Intel didn't start out as a microprocessor comany, but took business opportunities as they arose.

Action Against Unfair Trade in Semiconductors

Dr. Raimund Raith
Administrator, Commission of the European Communities

The task of the EC has been twofold:

- To safeguard the legitimate interests of the DRAM-making industry
- Not to unduly harm the user industry

It was clear that an ad valorem duty would not be satisfactory and the Japanese offered price undertakings. Eurobit, representing the user industries, was opposed to antidumping measures because they wanted access to DRAMs as cheaply as possible. The EC had to get Eurobit to change its mind and the argument used was that in world terms both the makers and the users were relatively weak and only by cooperating together could they survive. Eurobit was persuaded and measures were taken to fix a minimum price every quarter based on the weighted average cost of production of the cheapest device type in each density plus a modest margin of profit. "This was one of the, unfortunately rare, cases where a Community industry was able to recover in a very positive way as a result of antidumping policies." Now, one EC company has 25 percent of the Community's 1M DRAM market and another has 4 to 5 percent. Before the antidumping measures were taken, EC companies had zero market share, so EC users were not hurt.

Procurement Trends in the '90s

Ewan Davidson
Manager Purchasing, Production Materials
Alcatel NV

Procurement performance will become a key element in the success of a company. Alcatel's policy is where possible to use standard components and where possible to use standard design tools. It expected suppliers to get involved early in a product's design cycles, to be able to adjust quantities at short notice, to give early notice of bottlenecks, supply problems and lead times; to be so reliable that incoming inspection could be eliminated; to hold wafer stocks if needs be to support a product through its lifetime; to reduce internal order and manufacturing cycle time; to ensure IPRs are protected; to make new technologies available when forecast; to provide a worldwide order management system; and to standardize on packing, bar-coding, lot-size and marking.

PANEL SESSION 1: Managing the Hidden Assets for Profit

Dave Manners
Editor, *Electronics Weekly*

The means of IPR protection are: patent, copyright and trademark. The reasons for the multiplicity of recent lawsuits over IPR are: GATT-enforced recognition of IPRs in trading partners, more sophisticated laws and law enforcement, negative cashflow in the US chip industry. The motives of litigants are: to help them to win in the market (Intel), to make money (Texas Instruments), to extend IPR libraries (industry norm).

Ray Reusser
Manager, Intellectual Property, AT&T

To achieve registration a patent has to be new and useful, to be original to the inventor, not to be abandoned, and not obvious to one skilled in the art. AT&T has 18,000 patents, 9,000 in foreign countries. Licensing patents is a cheap way to access R&D.

Hideharu Egawa
Senior Vice President, Director of the Board
Toshiba Corporation

Toshiba recognizes intellectual property and uses patents and copyrights to protect its business, but it will not use them as a tool to earn money. The semiconductor industry is a combination of thousands of technologies. If everyone chased patent rights and charged royalties at two or three times the production costs then it would cause confusion in the semiconductor industry and damage to its customers.

Keith Chapple
Managing Director, Intel UK

The capital spending by the top 10 companies amounts to $6 billion a year. The risks are huge and the industry has to out-innovate the competition and derive top value from its products and protect that capability using all the legal means available to it. Intel concluded that the semconductor industry had to get more aggressive in exploiting its intellectual property or die.

Jerry Sanders III
Chairman and CEO, Advanced Micro Devices (AMD)

Between 1979 and 1990, the only company to gain market share was Intel and the only reason was the 386. Intel succeeded by limiting the competition. The more competition the lower the margin. Intel has not challenged AMD on patent grounds but on copyright grounds. It is preposterous for Intel to say you are entitled to use the copyrights but not entitled to sell the products based on them. We condemn aggressive tactics which are meant to be exclusionary and contrary to public policy.

In subsequent discussion it was agreed that new entrants to the business could be a threat to the industry's profitability—Dr. Egawa mentioned steel and chemical companies in Japan getting into the semiconductor business. Mr. Sanders agreed asking "Why should a ball-bearing factory in Japan want to get into this business?" These companies had nothing to offer the industry. In many cases the use of intellectual property by new companies was "nothing more than theft," said Mr. Sanders who had negotiated a dozen patent licenses to start in business when he founded AMD. He looked forward to the day when only by owning both process capability and patent capability could someone be able to operate in the semiconductor business. Nonetheless he thought that it would be wrong if the manufacturers of tools charged high levels of royalties. He would like to see widespread licensing of tools but aggressive protection of IC IPRs. AMD had 500 patents and protected its own IPR by suing Samsung and Cypress in respect of patent infringement on the 22V10 PLD. It had licensed Atmel to make the chip.

"Glocalization"

Pat Weber
Executive Vice President, President Semiconductor Group, Texas Instruments
Paper delivered by Roberto Schisano, Assistant Manager Worldwide MOS Memory Division, Texas Instruments

Texas Instruments (TI) is establishing a worldwide network of submicron CMOS processing which will bring manufacturing close to its customers in all the main electronics producing areas of the world: in Europe, it is adding a plant at Avezzano, Italy to its existing factory in Freising, Germany; in Asia it is building a joint-venture factory at Taipei, Taiwan with Acer; in Japan it will add a joint-venture plant being set up with Kobe Steel to its existing factory at Miho. In the United States it has submicron plants at Lubbock and Dallas. The Acer and Kobe joint ventures have had substantial contributions to their cost of construction from the joint-venture partners, and in the case of Avezzano substantial subsidy from the Italian government. Customers have agreed to pay in advance for products from those factories to ensure deliveries and prices. So customers can source locally with confidence in the flexibility that a global network provides. Processes around the world are standardized and TI has one of the largest communications networks with 100 percent of the workforce having PCs allowing global exchange of information. TI has pioneered a new era of cooperation with governments (e.g. Avezzano), with customers (e.g. advance payment for contracted supplies) and with competitors (e.g. technology exchange with Hitachi on the 16M DRAM.

After the Monopoly: a New Era of Innovation

Jerry Sanders III
Chairman and CEO, Advanced Micro Devices

Between 1979 and 1990 National Semiconductor lost nearly 70 percent market share, TI lost 60 percent, AMD lost 20 percent, and Motorola lost 18 percent. The only company to grow its market share was Intel because of the 386. The monopoly was of great benefit to Intel but not to the world. "Learning-curve pricing was a thing of the past with the 386 monopoly." Intel manipulated the PC market for five years first by indicating there would be second sourcing and then by going solo and keeping the price up. Moreover "Intel didn't use submicron technology, it didn't improve the 386." With the end of the monopoly and the stimulus of competition from AMD there was going to be more innovation from Intel. The PC market was soon going to be revolutionized. "DRAM pricing curves will be applied to PCs." Fifty percent margins of DRAMs were a thing of the past. The 386 would be a $12 to $20 part inside five years: "the microprocessor for the masses."

Changes in the Characteristics of the Japanese Semiconductor Market and User Needs

Tatsuo Tanaka
Senior Executive Vice President, INSEC

Japan has been increasing its purchase of foreign chips but has suffered problems. A survey of the users of foreign chips in Japan found that 64 percent of respondents reported that their production lines had been disrupted by delays in deliveries of foreign chips. Half those surveyed said that such delays had occurred more than three times in the period covered by the survey. According to a case study submitted to Insec by Japanese users, foreign suppliers have lower technical-support capability than Japanese firms and take twice as long to perform failure analysis. Foreign suppliers failed to specify standards and reliability and quality evaluation rules at the time of contract but "bring them out only after any trouble or dispute arises." The quality of foreign chips is seen as lower than Japanese-made chips with a higher frequency of defects in foreign chips. Although 97 percent of Japanese chip users would like foreign firms to have design centers in Japan, only 40 percent of them do. There were signs that better relationships between Japanese users and foreign suppliers were possible in the future.

New Products for Home and Office

Dr. Peter Draheim
Director, Product Division Semiconductors
Philips International BV

Two trends are driving the evolution of electronic markets: the merger of applications, and portability. The merger of applications has been driven by DSP—digital audio-signal processing, digital videosignal processing, digital data processing and digital information and data exchange are the driving forces towards putting new functions on TVs, telephones, PCs and cars. Portability requires long up-time for personal products; lower voltages and lower power leading to smaller and fewer batteries are the routes to that. Voltages will decline from the industry standard 5V. Operating voltages for ICs below 2V are essential. Components manufacturers must look to supporting applications involving the mix of video, audio, speech and telephony with data/video/disc/audio processors and peripherals. Philips has a Taipei development center for multimedia products. Multimedia hardware is being used 32 percent for industrial presentations, 28 percent for desktop publishing, 19 percent for education and training, 11 percent for CAD, 7 percent for medical imaging, and 3 percent for remote inspection and quality control.

Consistency, Predictability and Commitment

Jack Gifford
Chairman, President and CEO
Maxim Integrated Products, Inc.

The causes of profitability are consistency, predictability and commitment. Consistency involves: establishing a brand identity which does not vary (Maxim now has 208 proprietary chips out of 420); pricing fairly; delivering accurately; maintaining high quality; keeping key employees (Maxim has lost only seven professionals in eight years); sticking to a market area; maintaining high productivity ($170,000 sales per employee at Maxim); avoiding expense ("Everyone has to confront me to buy something"). Predictability involves: continual new product development; meeting specs ("a religion at Maxim"); maintaining yields; managing uncertainty; following the corporate plan; and maintaining a clear vision. It is important to look for the technologies required and take action to get them. Commitment involves: believing in Maxim's 13 Principles ("There's no room for nonbelievers"). The result of maintaining these standards is 23 percent return on equity, 50 percent gross margins, 21 percent operating profits and 90 percent per year growth in the share price since the IPO in February 1988.

Semiconductor Manufacturing Strategy and Capital Investment in the 1990s

Kazuo Kimbara
Executive Managing Director, Hitachi, Ltd.

Maintaining the technological pace is becoming increasingly demanding. Test is becoming increasingly difficult and pin counts have increased 2.5 times in 10 years: "By the year 2000 we will probably see 1,000 pin devices." Production technology is becoming increasingly complex with both process steps and the number of masks increasing. One result of this is the increasing time-lag between announcement of products and their mass production. For instance between announcing the 1M DRAM and reaching 1 million pieces a month production levels, there was a lag of 2.5 years; for the 4M there was a lag of 3 years; for the 16M it will be 4 years; for the 64M, 5 years. The investment efficiency ratio calculated by dividing one year's increased shipments by the previous year's investment volume shows a decline of one-third from 1980 to 1990. "If this continues chip makers cannot survive." The best way out of this problem is cooperation between companies. That would also help solve the problems of the imminent shortage of engineers and trade friction. Joint ventures are suitable for production factories and global cooperation for R&D.

Profits Are Possible

Steve Poole
European General Manager, Intel Corporation

Not many companies achieve consistent profitability but Intel has made profits of $248 million, $453 million and $605 million (1990) in the last three years. "Either we're lucky or a malignant monopoly, or we cheated our customers—or all three." Intel followed a policy of responsible sole sourcing. Multisourcing does not guarantee low prices or security of supply—look at the DRAM market—and many will remember nine-month lead times on low-power Schottky. "We ramped 386 production as fast as money would let us" and the 386 learning curve matched, proportionately, the DRAM learning curve with a price reduction every quarter for five years. The 386 has been developed going from 16 to 33 MHz, with the SX introduced at the bottom end and the 486 at the top end. With a capital spend of $1.6 billion this year, Intel needed a guarantee of steady revenue and sole sourcing is essential for that. "Sole sourcing is a trend for our maturing industry."

Costs and Risks in the Next Ten Years

Jürgen Knorr
Senior Vice President and President of Semiconductor Group, Siemens Corporation

The semiconductor industry is becoming polarized towards on the one side broad-based companies and on the other specialist niche market companies. The former will be responsible for technology development, the latter will be driven by intellectual creativity. If it is true that you have to spend $1 of investment to return $1 in sales, then in order to keep pace with the growth in the market, each of the broad-based companies will need to spend $10 billion over the next 10 years to stay in the business. The number of masks for memories and the number of metal layers for logic is increasing, so pushing up costs. Siemens would like to generate enough cash to make a return on its investment to create a market for future generations. Learning curve pricing is not a good thing. In 1970 both the steel and car industries peremptorily increased prices substantially. "That has to happen in ICs."

Semiconductor Strategic Alliances and Investment Trends in the '90s

Hideharu Egawa
Senior Vice President and Director of the Board, Toshiba Corporation

Although engineers are always optimistic about future technology development, it is becoming increasingly difficult to keep up with it in the semiconductor industry. Process steps increase by 1.3 times each generation and die sizes by 1.5 times; the cost per bit of DRAM reduces by 0.5 times per generation and the investment required per unit area of silicon is increasing. A big problem is the increase in the investment required when set against the decrease in the efficiency of the equipment. Japan has a further problem which is a decrease in the number of engineering students from 1991 onwards. Intercompany alliances are the best way to solve these problems, and the most successful alliances are in R&D, such as SGS-Thomson/Toshiba in CMOS logic, Hitachi/TI for 16M DRAM, IBM/Siemens for 64M DRAM, and VTI/Hitachi for standard cell. Intercompany alliances work better than R&D consortia such as Sematech, JESSI and the VLSI Project in Japan. Although the latter was generally regarded as successful, in reality it was not successful except in that it made company presidents aware that the semiconductor business is very important. "That is no longer necessary." In fact the Japanese companies in the VLSI Project developed their technology separately and didn't share it. By contrast, intercompany collaborations work: in manufacturing—LSI Logic/Kawasaki Steel, TI/Kobe Steel, Hitachi/Goldstar, NMB/Intel, and Toshiba/Chips and Technologies; in technology/product collaboration—Sun/Fujitsu, NEC/MIPS, and Motorola/Toshiba. These collaborations are good for systems companies offering reliable chip supplies without a big investment.

The '90s: Progressing into the Marketing Phase of Microelectronics

Pasquale Pistorio
President, SGS-Thomson Microelectronics

After the technology phase and the manufacturing phase of the semiconductor industry's evolution comes the marketing phase, in which as well as having world-class technology and a world-class manufacturing machine you also have Six Sigma quality "as the norm" and close working partnerships with customers. "Zero-defect products and zero-defect services." Niche companies can avoid these requirements but for everyone else "it's the price you pay to play." Even if we set up joint ventures with the Japanese, would the product flow be two-way? "Without reciprocity in the markets it's just creeping technological colonization." Europe has to have at least one indigenous semiconductor company capable of being a top 10 world player. No one in Europe has the scale although they have the technology and the organization.

Mike Williams

Dataquest
a company of The Dun & Bradstreet Corporation

Research Newsletter

WATCHING THE VIDEOPHONE RIPEN—TIME TO CLIMB THE TREE?

SUMMARY

Over the next few years, imaging applications are expected to benefit from a resurgence not witnessed in scale since the ascendancy of color television in Europe during the late 1960s and 1970s. Advances in digital signal processing and data compression are driving this revolution. Progress on standards and reductions in semiconductor costs lead us to conclude that circumstances will shortly be as promising for the development of videophones as they were for mobile phones and facsimile machines ten years ago.

Many manufacturers (including several that are European) are expected to market videophones towards the end of this and the beginning of next year. The first models will be based on programmable digital signal processor (DSP) ICs, with dedicated ICs appearing as the new standards stabilize.

Initial videophone prices are estimated to be $8,000 in 1992, with a number of manufacturers and semiconductor vendors indicating that low-end videophone prices could fall to as low as $500 per unit in the mid-1990s. From the precedents set in other emerging telecommunications applications, our forecasts for the European market indicate that videophone sales will reach 92,000 units by 1995—driving a semiconductor market worth $23 million at today's prices. By the end of the decade we expect sales to have risen to 1.9 million units, and to a semiconductor demand of $190 million.

INTRODUCTION

Today, few major electronic applications have escaped a transformation from limited business or industrial use to mass-consumer adoption. Consumerization of the voice telephone occurred within a few years of Alexander Graham Bell's invention of the telephone in 1876. However, despite demonstrations originating from as early as the mid-1960s (for example AT&T's Picturephone prototype exhibited at the 1964 World Fair), the videophone is still waiting for a mass market.

This newsletter identifies the key factors that have delayed the videophone's market development to date and explains why we expect the situation to change. We discuss current activities in Europe and present market estimates for sales of both the equipment and the semiconductors they will consume.

JUMPING THE MAJOR HURDLE: BANDWIDTH

Limited bandwidth is the main reason why a videophone market does not exist today. The maximum bandwidth that can be transmitted as an analog signal down an ordinary twisted-pair telephone line is about 5 kHz. This is adequate for transmission of speech but is far too small for motion video. By comparison, a normal television picture requires about 6 MHz of bandwidth.

Image Compression

Although moving images are greedy in bandwidth, large amounts of repetition are present in these signals. Adjacent frames in a video sequence are normally very similar, even for rapidly moving subjects. In the case of conventional television, the whole of each frame is transmitted, whether or not the frames are alike. This is wasteful, but by digitizing the video signal, it is possible to detect and transmit only those parts of a moving image that are changing; this is known as *inter*-frame compression.

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Other ways exist of eliminating repetition within a single frame (*intra*-frame compression). The most common employs a technique called discrete cosine transformation (DCT), where blocks of normally 8 × 8 pixels are coded in a representation where only a few pixels need to be transmitted.

CCITT H.261

Clearly, if data compression is to form the basis for video-communication, these algorithms must be precisely defined and standardized (because even minor incompatibilities between implementations by different manufacturers could render interworking impossible). Consequently, the need for tightly defined standards for video-communications is far more compelling than for voice.

The CCITT made its first attempt in 1984 to establish an international standard for video-communication, the H.120 standard. This required a relatively large 2,048 Kbit/s of bandwidth, making equipment that conformed to H.120 expensive to operate and unsuitable for low-cost videophone use. Over the same period, rapid advances were made with proprietary video compression algorithms, particularly from the US companies, Compression Labs Incorporated (CLI) and PictureTel. These led to reductions in bandwidth to 768 Kbit/s and, more lately, 384 Kbit/s. Significant improvements to picture quality were also obtained, the result being that proprietary systems were adopted in preference to H.120, limiting its uptake to mainly PTT-administered video-teleconferencing services in Europe.

By 1987, it was clear that a new standard would be needed to improve on H.120; the CCITT began developing a standard that would permit video-conferencing using integer multiples of 384 Kbit/s bandwidth. In the following year, the CCITT adjusted its plans further to permit even lower minimum bandwidths leading to the H.261 standard, based on an integer multiple of 64 Kbit/s (56 Kbit/s in the United States). For the first time, this has set the scene for the emergence of true videophone applications.

In December 1990, the CCITT Study Group XV recommended five standards for adoption. In terms of systems complexity and semiconductor content, H.261 is by far the most significant, although it should be noted that other standards also play important roles (see Table 1) in defining a working system. Standard H.261 defines six basic image compression and decompression functions.

TABLE 1
CCITT Standards Recommendations: Video-Conferencing and Video-Telephony

Standard	Function	Status
AV.231	Conferencing multipoint control	In development
AV.254	16 Kbit/s audio compression	In development
G.711	64 Kbit/s audio PCM	Adopted
G.722	48, 56 and 64 Kbit/s ADPCM audio	Adopted
H.221	Communications framing	Complete
H.230	Control and indication signals	Complete
H.242	Call setup and disconnect	Complete
H.261	Video-coding and compression	Complete
H.320	Narrow bandwidth systems	Complete
*	Video encryption	In development
*	Still-frame graphics coding	Starting

* Name as yet undecided
Source: Dataquest (July 1991)

Each can be translated directly into a semiconductor IC, and are as follows:

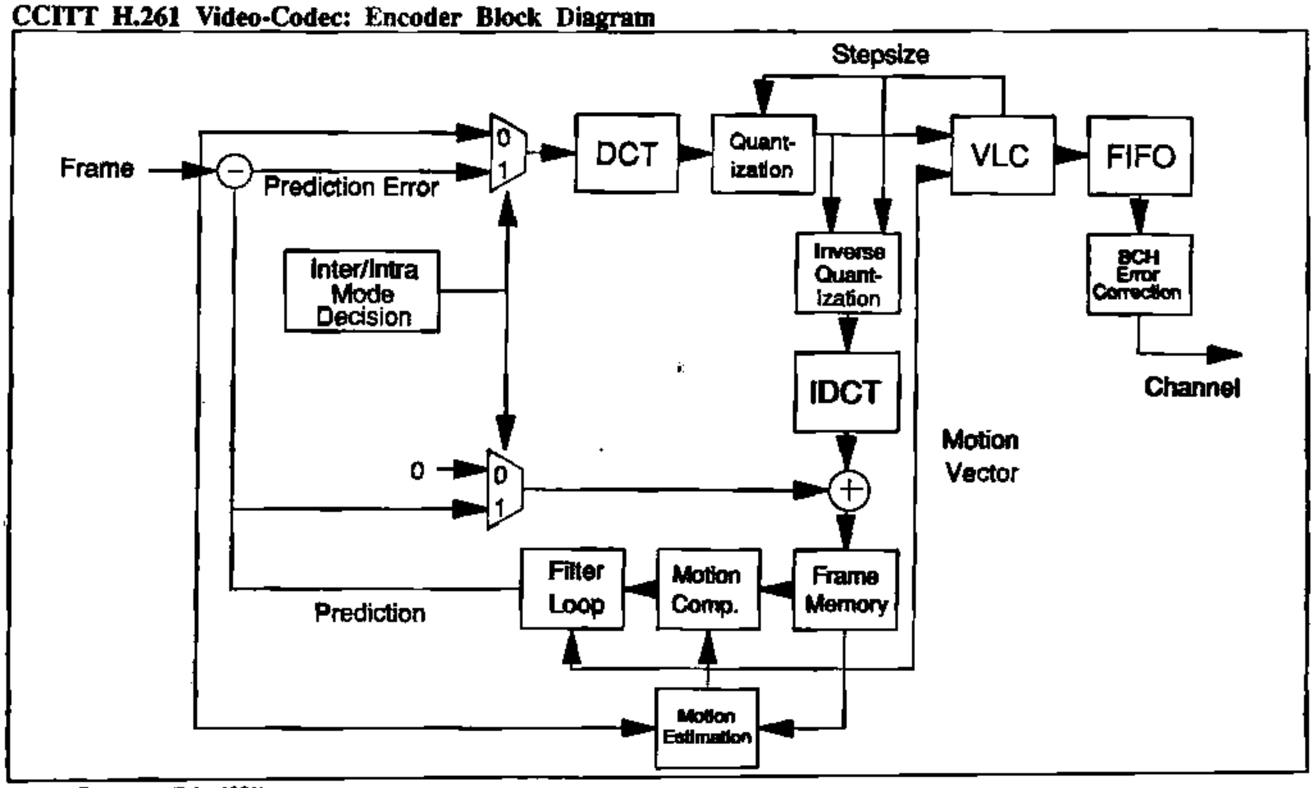
- **Discrete cosine transformation** is the procedure which subdivides a frame into blocks of 8 × 8 pixels and converts them into values that represent spatial frequencies.
- **Motion estimation and compensation** is the process by which adjacent frames are compared to identify moving patterns. These movements are transmitted as displacements of pixel blocks between frames, as opposed to fully reconstructing each block in each frame.
- **Quantization** is the technique used to represent the DCT values as a small number of discrete integer values. This minimizes the amount of data that must be transmitted to describe them.
- **Loop filtering** is a simple, low-pass digital filtration process used to remove unwanted edge artefacts that are a by-product of inter-frame compression.
- **Variable length coding/decoding (VLC)** are the processes that convert the quantized DCT coefficients to or from a serial bit stream.
- **BCH error correction** is a procedure which encodes the VLC bit stream in the transmit path to permit detection and correction of errors in the receive path.

Figure 1 shows how the CCITT H.261 functions fit together in an encoder: the portion of a video-codec that takes digitized raw frame data from a video camera and compresses and conditions it for transmission as a serial bit stream. Figure 2 shows the decoder portion of a video-codec: the reverse process of decoding and decompressing an input bit stream to reconstruct a digitized frame sequence.

SEMICONDUCTOR DEVELOPMENTS

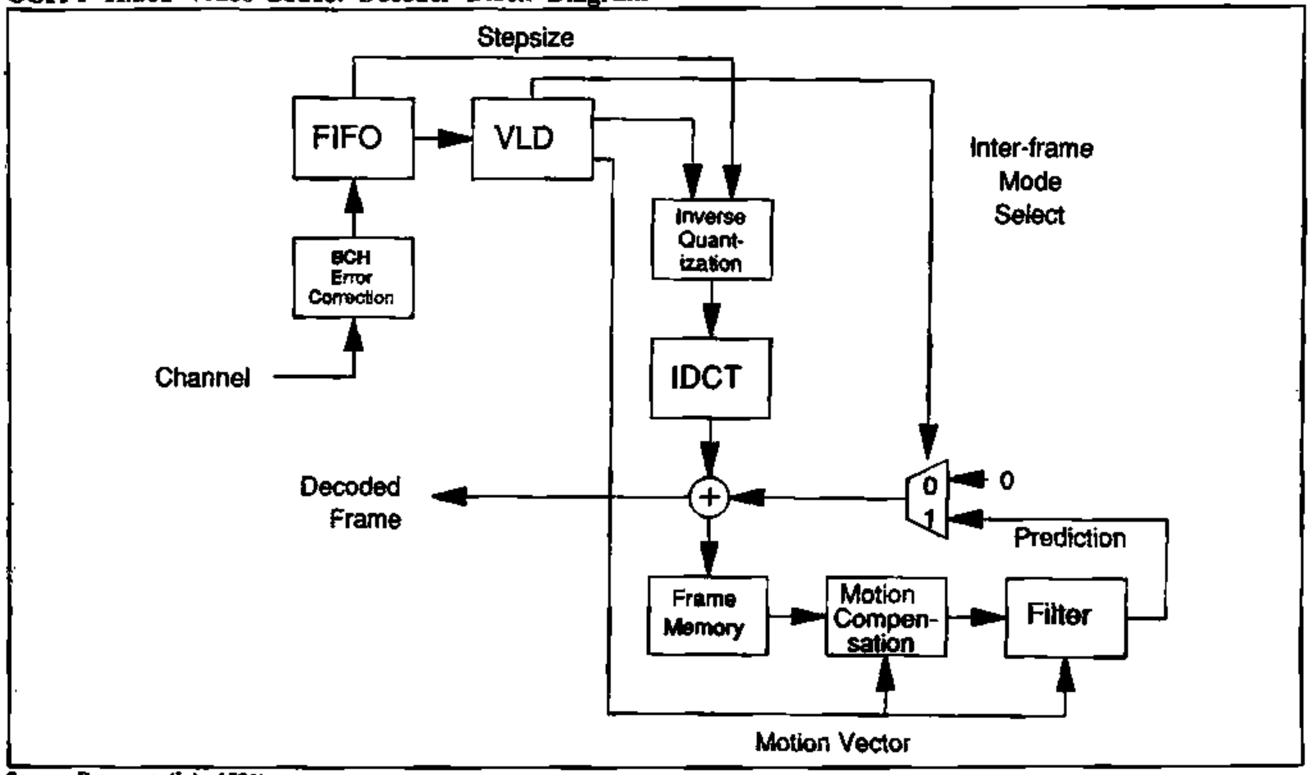
Currently, most H.261 designs implement all the functional blocks shown in Figures 1 and 2 using 16-bit programmable DSPs (such as Texas Instrument's 320C30, Analog Devices' 2101 or Motorola's 56001). Because of the inherent flexibility of programmable DSPs and some minor uncertainties that still remain over standards, these devices make ideal first platforms for videophone applications.

FIGURE 1
CCITT H.261 Video-Codec: Encoder Block Diagram



Source: Dataquest (July 1991)

FIGURE 2
CCITT H.261 Video-Codec: Decoder Block Diagram



Source: Dataquest (July 1991)

Hardwired ICs Replace Standard-Programmable Parts

Large degrees of computational parallelism exist in many of the H.261 functions (particularly for motion estimation, DCT and inverse DCT functions) where off-the-shelf DSPs are poorly suited on price/performance compared with dedicated silicon. Consequently, competition and price pressure will inevitably steer equipment manufacturers towards dedicated hardwired solutions.

The beginning of this transition is already apparent, with LSI Logic and SGS-Thomson offering ICs (dedicated to many of the functions indicated in Figures 1 and 2) to systems designers. LSI Logic offers 11 IC solutions addressing all the major computationally intensive H.261 encoding/decoding functions including DCT and inverse DCT (L64730), motion estimation (L64720), quantization (L64740) and inverse quantization, (L64751) and variable-length coding (L64750). SGS-Thomson offers DCT ICs (IMSA120/121, STV3200 and STV3208) and a motion-picture estimation (STV3220) IC. However, neither vendor's solutions are "total" as they both lack essential functions, such as micro and memory controllers needed to supervise the other H.261 blocks.

GEC-Plessey Semiconductor recently announced an H.261 chip set, with silicon expected from January 1992. Key elements in this set, the H.261 encoder/decoder (VP2611/VP2615) and multiplexer (VP2612) ICs, were designed by GPT Video Systems (Maidenhead, England) and Televerket (Farsta, Sweden) respectively under the European RACE HIVITS R&D program. Incidentally, other key IC contributors to HIVITS include PKI (Nürnburg, Germany), which is developing a color space conversion IC, and Matra Communications (Quimper, France), which will show a demonstrator system in the summer of 1992.

Many other semiconductor vendors currently offer, or are expected to introduce, semiconductor components specifically for video-conferencing or videophone applications. These include Brooktree, C-Cube, Hitachi, Intel (through its DVI multimedia processor technology), Mitsubishi, Motorola, Oki and TRW.

Significant demands for volatile memory are made by both the encoder and decoder. Greatest requirements are for frame storage (normally DRAM or VRAM) with 2 Mbits typically consumed in common intermediate formate (CIF) implementations (see later) per encoder and decoder function. Typically, 256-Kbit SRAM first-in, first-out (FIFOs) are also widely used to buffer the serial bit streams at the output from the encoder, and at the input to the decoder. Additional, but relatively less, volatile storage is required outside the video-codec for use with the microcontroller and audio circuits.

TELEPHONY vs CONFERENCING

From an end-user perspective the cost of a videophone has to be dramatically lower than the cost of a video-conferencing system. Telephones are person-to-person and, cost permitting, ideally sit on the user's desk. Consequently, the total cost of operating a videophone (transmission plus hardware) must compare favorably with alternative means of communication, such as voice telephony or personal travel.

Lowering the Cost of Call Charges

Later this year, the CCITT is expected to finalize on a low bit-rate (16 Kbit/s) audio-codec which, used in conjunction with an H.261 video-codec, will allow a videophone to establish a connection using the same 64 Kbit/s (or 56 Kbit/s in the United States) B-channel bandwidth conventionally used for a voice channel. Consequently, when systems with these codecs appear about 18 months from now, *transmission costs for video-telephony will fall to the same level as for a normal voice call.*

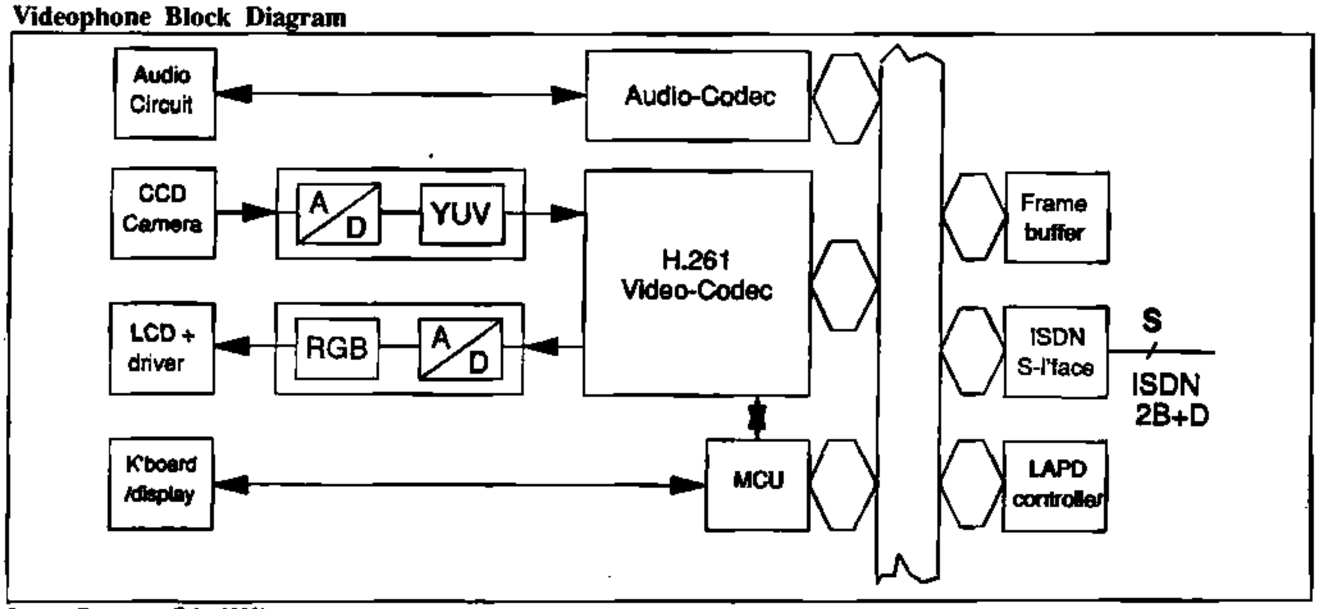
Until the CCITT 16-Kbit/s standard emerges, manufacturers are marketing either single B-channel videophones, using proprietary audio-codecs, or dual B-channel models using CCITT G.711 or G.722 codecs.

Cheaper Hardware

The CCITT has also taken measures to promote the appearance of low-cost terminals. As well as defining a standard display resolution for H.261, CIF of 288 lines by 352 pixels, it has also defined a low-resolution format Quarter CIF (QCIF) of 144 lines by 176 pixels—more suitable for low-cost, small-screen terminals such as videophones. Video-codec semiconductor implementations of QCIF are expected to be two to three times less costly than for CIF.

Other key functions in a videophone, besides the video and voice codecs, include an ISDN S-interface and camera and display circuitry to interface with the video-codec (see Figure 3). Video-conferencing systems, however, normally offer major additional features not needed by videophones, such as split screens, encryption, graphics frame stores and hub controllers to manage multiple incoming lines.

FIGURE 3
Videophone Block Diagram



Source: Dataquest (July 1991)

EUROPEAN MANUFACTURERS

Bundespost Telekom, the German PTT, is scheduled to launch a trial videophone service from September this year. It will be based on the H.261 image compression standard, the G.711 3.7-kHz audio-compression standard and the H.221 B-channel control protocol. The following three German-sited equipment suppliers were selected for the trial.

SEL-Alcatel (Stuttgart) has recently demonstrated a video-telephone system based on its own internally designed DSP IC, the cellular array processor (CAP-3) and submitted it to Bundespost Telekom for approval. SEL is currently evaluating other IC chip sets to form the basis of a second-generation post-trial system at low cost.

Besides the Budespost Telekom development, Alcatel has a number of video-telephone projects under way. A parallel development is under way in France between **CIT-Alcatel (Brittany), SAT (Paris)**, the switch and transmission manufacturer, and France Télécom's National Center for Telecommunication Studies (CNET). This is based on an ASIC-hardwired chip set developed with VLSI technology.

Other, albeit non-H.261 oriented, video-communication systems developed by Alcatel include broadband videophones, being developed by SEL, and "Viesonis," a wideband video-telephone developed by Opus-Alcatel (Paris) for connection to PABXs.

Philips Kommunikations Industrie, PKI, (Nürnburg) is marketing its "Teleview" videophone. This is a full CIF videophone using a CRT display, priced at around $30,000. PKI also manufactures and markets video-conferencing and video-telephony systems to the older H.120 standard. PKI's combined revenue for video-conferencing and video-telephony systems is estimated at around $8.4 million across about 150 systems.

AEG Olympia (Konstanz) will launch an H.261 videotelephone for use on the Bundespost's service at the end of this year. Its first model is software-implemented and based on ten Analog Devices 2101-programmable DSP ICs: nine of which to implement H.261 image compression, and one for the H.221 B-channel protocol. AEG Olympia is also developing a lower-cost second-generation system for consumer use, and is evaluating hardwired chip set solutions including the i750 DVI processor from Intel.

In addition to these German companies, there are several other potential European entrants.

GPT Video Systems (Maidenhead, England) has developed, independently, a desktop videophone for use with ISDN, and plans to start production in the summer of next year. It is based on Texas Instrument's TMS320C30/C25 DSPs, although GPT expects to migrate to hardwired processors for its next-generation systems. GPT also manufactures video-conferencing codecs in Beeston, England and has been marketing 384- and 2,048-Kbit/s systems compatible with the H.261 standard since July of last year. Development of these existing systems was in conjunction with British Telecom (BT), which markets GPT's video systems exclusively in the United Kingdom.

British Telecom's Research Laboratories (Martlesham, England) exhibited an H.261 videophone prototype at its Innovations '91 exhibition last April. This is a QCIF product based on Texas Instrument's C30 DSP ICs. Currently, BT has no firm plans to manufacture and market complete end systems, although it is considering marketing video-codec units to systems integrators, possibly including PC vendors. BT has recently announced a collaboration agreement with Motorola for video-codec units employed in video-teleconferencing.

GEC-Marconi Defence (Stanmore, England) has been subcontracted by a number of major OEMs to develop a domestic video-telephone for launch in late 1992 to 1993. Currently it is unable to disclose details, but the fact that narrowband ISDN, upon which H.261 is based, is unlikely to achieve significant levels of domestic penetration until the end of this decade suggests that such a model would need to be capable of transmission across analog lines. This implies data rates of around 9.6 to 14.4 Kbit/s and, hence, image qualities that are substantially lower than are achievable from H.261 on basic-rate ISDN. Other companies believed to be developing analog videophones include AT&T and CLI in the United States.

Matra Communication (Quimper, France) is expected to launch a CRT-based H.261-compatible video-telephone, "Visages," at the Geneva ITU Exhibition in October. This is believed to have QCIF resolution and to be implemented using five Motorola 56001 DSP ICs. Matra Communication is also involved in the development of a consumer LCD-based video-telephone with France Télécom and one undisclosed US company, to enter production in late 1993.

Thomson Consumer Electronics (Paris, France) is working with France Télécom to produce a consumer video-telephone in the $500 price range for launch in around 1993 or 1994. Key participants in this program are SGS-Thomson in collaboration with Thomson's main research laboratory LER (Rennes, France).

Other European companies include Vistacom (Helsinki, Finland), Aethra Telecomunicazioni/CSELT-SIP (Ancona, Italy) and Tanberg (Sweden).

MARKET ANALYSIS

Beyond an order from the Bundespost Telekom for 500 videophones for its trial later this year, there are no significant sales of videophones today. Currently, most offerings are prototypes and demonstrators based on costly off-the-shelf DSP implementations. Currently, no volume production of videophones exists—only plans.

We expect plans to materialize into significant videophone sales from early 1993. By this time, reasonably priced units are likely to be available from many companies, particularly from the European firms already mentioned. There will also be strong non-European participation in videophones, in particular from CLI and PictureTel (United States), Hitachi, Mitsubishi, NEC and Oki (Japan).

ISDN: Standardization Is Crucial

Although some videophones will be used on private networks, greater demand is expected for connection to public networks, just as normal voice telephones are connected today. Consequently, the rate of ISDN's continued deployment across Europe will have a strong bearing on the videophone's future prospects. In terms of ISDN coverage and availability, this does not appear to present a problem. Most European countries are expected to offer 100 percent ISDN availability by 1993. (The Netherlands is the only major exception, with full coverage not planned until 1995.)

However, ISDN's rate of development remains crucial in other ways, particularly on standards issues and where it affects terminal compatibility. For the most part, these are the same factors that have limited the adoption of other ISDN applications (see ESAM Newsletter 1990-23 "ISDN IC Market in Europe, Part 3: The Long-Term Outlook").

Market Evolution: Similar to Facsimile

Dataquest expects the videophone market to evolve from the video-conferencing business currently experiencing strong growth: with hardware revenues estimated at $65 million in Europe this year, up 67 percent over 1990. As large corporate users increasingly adopt video-conferencing systems, the demand for videophones will grow also. Many small office sites that cannot justify a full video-conferencing system may buy videophones instead.

Videophones will start as a shared resource—in much the same way that, for example, facsimile machines were in the early 1980s. As prices decline, we expect the videophone to continue to follow much the same path that facsimiles are following today: towards consumerization and one machine per desk.

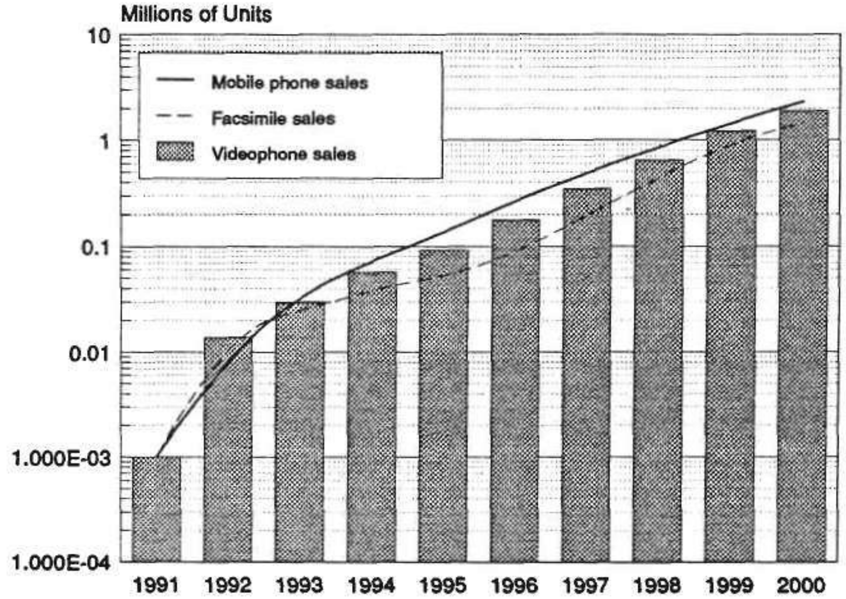
Market Assumptions

We have modelled the development of the videophone market on precedents already set in Europe by two other new telecommunication applications: facsimile machines and mobile phones. This is justifiable to the extent that both shared at their introductions similar *market characteristics* to those expected for videophones. These are as follows:

- Both have experienced similar levels of price erosion to that already foreseen for videophones over the next years. By 1995, we expect videophones to be available at domestic consumer prices: approximately $500 for desktop QCIF LCD videophones.
- In common with the videophone, both offer unique end-user utilities not available from other applications. Prior to the mobile phone, there was no (economic) way subscribers could telephone while travelling; and prior to the Group III facsimile machine, there was no universal and affordable way to communicate paper documents. Congruent arguments can and are being made for the potential utilities offered by videophones.

Forecasts according to both the facsimile and mobile phone scenarios are shown individually in Figure 4. They are derived from the points in their life cycles when respective average selling prices per unit in real terms (corrected for inflation) coincide with the average price we expect for

FIGURE 4
Estimated European Videophones Market Based on Two Market Models



Source: Dataquest (July 1991)

videophones in 1992: $8,000. This equates 1992 for the timing of the videophone market to 1981 in the market development of both facsimile machines and mobile phones (marking the commencement of cellular services in Europe). Using an average across both models, we expect videphone sales to approach 100,000 units per annum in Europe by 1995, passing the million mark in 1999.

Essential Differences from Facsimile or Mobile

Close inspection of the differences in market structure between the videophones and mobile phones or facsimile machines may suggest that, if anything, these forecasts depict a conservative outlook for the videophone market, for the following reasons:

- Office voice traffic greatly exceeds mobile or facsimile traffic. Furthermore, the potential number of *business* end users of videophones is believed to be greater than for either application in the sense that every normal voice phone user is, at the right price, also a potential videophone user.
- From an end user's perspective, videophones are likely to experience a greater demand for "one per desk" and personalization than has occurred for facsimile machines, which can be more easily shared among a workgroup.
- The cost of ownership of a videophone will be substantially lower than for a mobile phone, because no additional infrastructure is required to support it. Videophone charges will be about the same as a normal phone call, much lower than for mobile phones.

SEMICONDUCTOR CONSUMPTION

Not surprisingly, the potential videophone manufacturers are keeping their developments very close to their chests, and it is not possible at the present time to derive an accurate cost breakdown for semiconductor content. For the purposes of estimation, we have assumed a 10 percent I/O ratio, which is consistent with our knowledge of prices supplied to us by vendors for the hardwired parts that perform the functions in Figures 1 and 2.

By value, virtually all the component content of a videophone will be either CMOS logic or display, with low-end QCIF videophones expected to use LCDs. Both classes of component sit on steep learning curves and, as competition develops to supply H.261 parts, we expect videophone prices to follow a steeper decline than has already occurred with either mobile phones or facsimile machines. The component values of the latter are significantly influenced by the slowly declining price of parts, such as RF modules and stepper motors.

TABLE 2
Estimated European Videophone Market and Semiconductor Consumption

	1992	1993	1994	1995	1996	1997	1998	1999	2000	CAGR 1992-1995	CAGR 1995-2000
Videophone Sales (Millions of Units)	0.01	0.03	0.057	0.092	0.18	0.35	0.64	1.22	1.90	109%	83%
Average Selling Price ($)	8,000	5,000	3,500	2,500	2,000	1,600	1,300	1,100	1,000	-32%	-13%
Semiconductor Content ($)	800	500	350	250	200	160	130	110	100	-32%	-13%
I/O Ratio	10%	10%	10%	10%	10%	10%	10%	10%	10%	NA	NA
Semiconductor Consumption ($M)	8	15	20	23	36	55	84	134	190	42%	52%

NA = Not Applicable
Source: Dataquest (July 1991)

Our estimates for the European market carry forward to a semiconductor forecast of 43 percent compound annual growth rate (CAGR) in consumption, from $11 million in 1992 to $190 million in the year 2000. Table 2 gives real projections, not adjusted for inflation.

We further assume that local manufacturing of videophones will equal end-user sales. This is reasonable in the short term because, as already mentioned, there is very considerable European activity in videophone development—probably equivalent in scale to developments in Japan and certainly exceeding those in the United States. However, as the videophone market transits from early adoption to maturity towards the end of this decade, that picture will change. It is highly probable that Far Eastern interests will take on the same proportions to those already experienced with facsimile machines and, to a lesser extent, mobile phones.

CONCLUSIONS

The most important parameter, from a forcaster's viewpoint, is in judging *when* the videophone market will commence. For reasons of standardization, manufacturers' development activity and ISDN's readiness, we believe that the market will commence in earnest from 1992.

Our analysis clearly indicates that the videophone market does have some way to go before it can be taken in perspective with the whole semiconductor market. Four years from now (1995), we estimate videophone semiconductor consumption will reach $23 million, accounting for only 0.1 percent of total semiconductor demand ($20.8 billion) in Europe, increasing to 0.25 percent by the year 2000.

However, from semiconductor vendors' viewpoints, there are many reasons besides high market growth why videophones must warrant more than a small percentage of their attention. The greatest has to do with the potential for new spin-off business in closely related applications.

There are 21 million business PCs installed in Europe alone, many of which could become platforms for videophone features through the addition of an add-on card to interface the PC to an ISDN-compatible PBX. Further, the IC functionalities in many other new imaging applications, although conforming to other standards, share much in common with H.261. In particular, the JPEG and MPEG standards developed for still- and moving-image compression define functions that are virtually identical to those used in H.261.

Before deciding to enter the videophone IC business, semiconductor vendors should be aware of other imaging applications, such as desktop publishing, TV broadcasting and multimedia. Marketing ICs for these additional applications will accelerate vendors faster down the videophone experience curve than if they were involved in videophones only. While the videophone market remains small, this wider presence will be the only way vendors can reduce their risks and, at the same time, make reasonable revenues. In the longer term, when Far Eastern and worldwide competition has fully unfolded, a general excellence across other imaging applications will be essential to maintain margins and survive.

Jonathan Drazin

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Research Newsletter

EUROPEAN PC PRODUCTION UPDATE

The ESAM group is currently surveying personal computer (PC) production in Europe for 1990—and manufacturers' estimates for this and next year. Full results will be published during August. As a result of research already undertaken, several major recent developments have been noted, and these are shown below.

- **Tandy** has announced that it is to open a European manufacturing and repair facility in East Kilbride, Scotland, along with its European subsidiary **Victor Technologies**. The new 7,900 m^2 facility, to be known as Tandy-Victor Scotland Ltd, will initially employ 130 people, rising to 250 when it is at full production.

  The plant will start production of Victor's M-Series systems before the end of the year, and produce 400 units per day. No surface mount manufacture is planned for the near future, and **Race Computers** in Wales will continue to supply the motherboards.

- **ICL**, 80 percent owned by **Fujitsu**, has announced that it is to supply a complete range of Intel 80486-based PCs, which are being manufactured along with the company's 286 range at Ashton-under-Lyne, England. These machines were previously manufactured by Acer; Acer will continue to supply ICL with motherboards for the foreseeable future, and will continue to manufacture its 386SX range of PCs.

  ICL claims that PCs currently account for 15 percent, or £250 million, of its revenue and that by the end of 1991, 60 percent of its PCs will be manufactured within Europe. In May, ICL took over **Nokia Data** from its Finnish parent Nokia Corp. for $400 million. This will be made up by $50 million in cash and the balance in preference shares. When the transaction is complete Nokia Corp. will hold a 5 percent ordinary shareholding in ICL.

- **Intel** has announced that it is to phase out its computer manufacturing operations in Singapore by early 1992. The company says that "to remain globally competitive, we have to control our overall manufacturing costs by manufacturing at plants closer to our major markets." Products being manufactured at the Singapore plant will be transferred to Intel's three other systems plants, which include Leixlip in Ireland.

- **Goldstar**, the South Korean computer and electronics systems manufacturer, has started PC assembly and production at its facility in Luton, England. The company commenced assembly at the end of 1990 and plans to extend this process to include full manufacturing. The company supplies 286- and 386-based personal computers for the European market.

  Goldstar plans to commence full manufacturing and local sourcing of semiconductor components in the near future, although a date has not been announced. The main product portfolio for the European market consists of desktop machines offered with mono, color VGA, and color EGA monitors.

- Meanwhile, not all is looking good in the PC world: **SMT-Goupil**, the independent French PC manufacturer, has been forced to start bankruptcy proceedings after **Siemens-Nixdorf** decided not to acquire this troubled company. The French government, through the new prime minister Mme. Cresson, is now trying to persuade **Olivetti** to take a stake in Goupil. Negotiations are likely to go on for some time.

- **Amstrad** has said that it expects to move production of its high-end PCs out of the United

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Kingdom to the Far East by the end of the year. Most of Amstrad's production is already subcontracted to the Far East. At the moment Amstrad subcontracts the UK production to GPT in Kirkcaldy, Scotland. Amstrad says the reason for this move is that economies of scale now make it more cost-efficient to produce these PCs in the Far East, and also said that this decision is for the short to medium term, and that they might move production back to GPT or another European subcontractor in the future.

Andrew Norwood

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Research Newsletter

ICL AND NOKIA DATA JOIN FORCES

EXECUTIVE SUMMARY

On May 29, ICL plc and Nokia Corporation announced the merger of their information systems activities in Europe. The combination of ICL and Nokia Data will produce a $4 billion company with more than $3.5 billion of business based in Europe. The major manufacturing and development for the combined company will also be based in Europe. The transaction, to be completed pending Finnish government and EC approval on September 30, totals £230 million in a combination of £50 million cash and £180 million preference shares. This bulletin provides an overview of the merger, with analysis of its benefits to the companies involved.

OVERVIEW OF THE MERGER

Historical Background

This merger had originally been considered in the summer of 1988, but STC, the previous owner of ICL, was not interested in a third-party ownership due to a shareholders' agreement. Nokia had been discussing further options with Groupe Bull, building on existing marketing agreements, but this did not materialize. This current transaction required approval from the ICL board of directors and the major shareholders, Fujitsu and Northern Telecom. With this transaction, Nokia receives a place on the ICL board, as well as a 5 percent ordinary shareholding in ICL plc at the time of the flotation. A flotation of 49 percent of ICL will occur in the next two to five years when a sustainable share price of £2.25 is obtained. This was agreed upon by Fujitsu when it acquired 80 percent of ICL from STC last year.

The Merger and Its Advantages

As stated by Peter Bonfield, Chairman and Chief Executive of ICL, the merger is good for everyone except the competitors. Table 1 shows the current size and product segments of the two companies.

The merger gives ICL a stronger distribution channel and market position in the Scandinavian market, as well as adding strength to its PC product line to round out its current systems offering. It also creates a synergy between ICL's strategic

TABLE 1
How the Companies Compare

	ICL plc	Nokia Data
1990 Revenue (£M)	£1,612	£698
Number of Employees	21,000	7,000
Major Computer Segment	Midrange, mainframes	PC, PC LAN, workstations
Distribution Method	Direct	Direct
1990 European Product Revenue ($M)		
Personal Computers (EPCIS)	$276	$509
Other Computer Systems (ECIS)	$896	$47

Source: Dataquest (July 1991)

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directions in vertical markets and Nokia Data's strengths in financial services, local/central government, retail and retail distribution. Nokia Data also shares ICL's commitment to open systems, as well as a similar method of distribution. The merger will allow ICL to expand its manufacturing capacity for personal computers, currently in Taiwan, to the Nokia Data facilities in Finland.

DATAQUEST ANALYSIS

Dataquest believes this merger again emphasizes a key question facing European computer manufacturers, on whether to combine forces or to join with stronger US or Japanese vendors for survival. This merger will cause increasing concern about the growing Japanese influence in the European computer industry, given the current ownership and distribution ties between European and Japanese vendors, such as Groupe Bull and NEC, or Apricot and Mitsubishi Electric.

Everyone involved has gained from the merger. For Fujitsu, this agreement signals a move to gain distribution channels for the desktop portion of the business through acquisition. ICL gains a broader product line with a substantial installed base, as well as enhanced distribution in Scandinavia. Nokia Data receives a high-end product line as well as support, and Nokia receives the resulting financial benefits. Compatibility of product line is not an issue for the two merged companies, and synergies in ergonomics and open systems should make this merger beneficial to users in the long term.

As was said at the announcement, the merger will be good for everyone except the other European competitors.

Alea M. Fairchild
Mike Williams

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Research Newsletter

EUROPEAN SEMICONDUCTOR MARKET REGIONAL ANALYSIS

SUMMARY

Dataquest's final market share estimate reveals that, in 1990, the European semiconductor market grew by 9.3 percent compared with 1989, reaching $10,661 million. When exchange rate variations are taken into account, true local currency growth in Europe was actually minus 6.1 percent with the market expressed in European Currency Units (ECU).

This newsletter presents Dataquest's European regional semiconductor market forecast for 1991. It also provides an analysis of European regional growth in 1990. Currency variations often obscure real growth trends when analysing the European market. In order to clarify the true market trends in Europe this newsletter includes three tables that show the regional markets in their own local currencies—francs, pounds, lira, etc. (Table 1), in ECU (Table 2), and also in dollars (Table 3).

The growth patterns of the individual European regions depended on their markets' relative dependence on the major applications segments of electronic data processing (EDP), communications, industrial, consumer, military and transportation. The European EDP application segment declined considerably last year due to falling memory prices and reduced PC manufacture. The communications segment was very strong; manufacture of central exchange switch equipment for export markets lead to high semiconductor demand. The industrial segment declined slightly due to weakening economic conditions and falling prices. Demand for TVs and VCRs provided for healthy growth in the consumer segment. The military segment declined as nations continued to adjust to the changing world order. Finally, the transportation segment grew further from a relatively small base as the electronic content of cars continued to increase.

Analysis of the seven regional markets that Dataquest tracks in Western Europe reveals that all the regional markets declined last year in local currencies. The least affected of the European markets was Germany which declined by only 1.2 percent in deutsche marks. The German market benefited from strong demand from its substantial consumer and telecoms manufacturing base. This meant that Germany remains Europe's biggest market. The German semiconductor market is estimated to be worth DM 4,984 million or $3,077 million, making it 12.7 percent bigger than its nearest rival, UK/Eire, which is estimated to be worth $2,730 million (or £1,529 million). The UK/Eire market is heavily dependent on computer manufacturers and was impacted by a steep decline in memory prices. This was coupled with a weak economy in the United Kingdom.

The weakest region was Scandinavia which declined by 7.0 percent in Swedish krona. Scandinavia was impacted by weak economic conditions. Factors such as the high level of taxation in Sweden continue to force OEMs to move manufacturing outside the region.

The outlook for 1991 is more positive. Dataquest expects some degree of recovery in all the regional markets. The strongest of the major markets will be Germany, which will grow by 11.3 percent in deutsche marks, 2.8 percent above the European market average growth of 9.8 percent when the market is expressed in ECU (see Table 2), continued strong demand from telecoms equipment manufacturers being the key factor. Scandinavia will again show the lowest growth at 4.7 percent in Swedish krona because of continued economic difficulties.

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TABLE 1
European Semiconductor Market Regional Growth Analysis
(European Local Currencies)

Country	Currency	1989	1990	1991	1990/89	1991/90
Benelux	F M	1,075	1,018	1,070	-5.3%	5.1%
France	FF M	8,857	8,330	8,771	-5.9%	5.3%
Italy	L M	1,486,235	1,411,100	1,521,166	-5.1%	7.8%
Scandinavia	SKr M	4,399	4,091	4,283	-7.0%	4.7%
UK/Eire	£M	1,595	1,529	1,657	-4.1%	8.4%
West Germany	DM M	5,044	4,984	5,547	-1.2%	11.3%
Rest of Europe	Pta M	94,959	91,161	103,924	-4.0%	14.0%
Total Europe	ECU M	8,926	8,383	9,206	-6.1%	9.8%

Source: Dataquest (May 1991)

TABLE 2
European Semiconductor Market Regional Growth Analysis
(Millions of ECU)

Country	1989	1990	1991	1990/89	1991/90
Benelux	464	440	466	-5.2%	6.0%
France	1,268	1,204	1,266	-5.1%	5.1%
Italy	990	927	997	-6.4%	7.6%
Scandinavia	624	543	565	-12.9%	4.0%
UK/Eire	2,392	2,147	2,372	-10.2%	10.5%
West Germany	2,455	2,419	2,725	-1.5%	12.6%
Rest of Europe	733	703	815	-4.1%	15.9%
Total Europe (ECU)	8,926	8,383	9,206	-6.1%	9.8%

Source: Dataquest (May 1991)

TABLE 3
European Semiconductor Market Regional Growth Analysis
(Millions of US Dollars)

Country	1989	1990	1991	1990/89	1991/90
Benelux	507	559	621	10.3%	11.1%
France	1,386	1,531	1,688	10.5%	10.2%
Italy	1,082	1,179	1,330	8.9%	12.8%
Scandinavia	682	691	753	1.3%	9.0%
UK/Eire	2,614	2,730	3,163	4.5%	15.8%
West Germany	2,683	3,077	3,633	14.7%	18.1%
Rest of Europe	801	893	1,086	11.5%	21.6%
Total Europe ($)	9,755	10,661	12,274	9.3%	15.1%

Source: Dataquest (May 1991)

CURRENCY FLUCTUATIONS AND REGIONAL GROWTHS

In 1990 the European semiconductor market appeared to grow by 9.3 percent when the market size is expressed in dollars. However, during 1990 the value of the dollar dropped dramatically versus all the European national currencies, from Swedish krona to Italian lira. Thus the US dollar is not the best currency to measure the European market. The ideal solution is to choose a common European currency that the 19 countries in Western Europe could refer to as a fixed reference. The nearest Europe comes to this is the European Currency Unit or ECU. However, in choosing the ECU we must remember that during 1990 all the 19 European currencies, independent of each other, changed in value with respect to the ECU. This even includes European Community countries whose currencies participate in the European Exchange Rate Mechanism (ERM) itself.

In order to highlight these currency fluctuations Table 4 shows the difference in percentage market growth between a market expressed in, say, francs, and the same market in dollars and ECU. So, for example, Table 1 shows that the French semiconductor market declined by 5.9 percent in 1990 when expressed in francs. Using Table 4, however, we see that we must add 16.4 percent to this in order to find the dollar growth of the French market, and only 0.8 percent to find the ECU growth rate. Thus, in conclusion we use the ECU to express average market growth rates in each of the seven regional markets.

REGIONAL ANALYSIS

Benelux

The Benelux semiconductor market was estimated to be F 1,018 million in 1990. This represented a decline of 5.3 percent over 1989. The three countries which make up the region have relatively little manufacturing base of data processing equipment. This has tended to mean the region has grown below the European average for the past 10 years. The most important OEMs with regard to semiconductor purchasing are involved in telecoms and consumer equipment manufacture. However, while these companies have strong purchasing power centered in Belgium and the Netherlands, the semiconductors their companies buy tend to be consumed in factories outside the region.

Dataquest's outlook for Benelux in 1991 is again for below-average growth. Table 1 shows a 5.1 percent growth rate for the region. Table 2 shows that this is 3.8 percent below the European market average growth rate of 9.8 percent in ECU. Critical factors behind achieving this growth are the continued success of Alcatel Bell's System 12 digital telephone exchange, and Philips' successful business restructuring.

France

Table 1 shows that the French semiconductor market declined by 5.9 percent in 1990. A decline in the European EDP total available market (TAM) has been singled out as a primary negative factor in the European semiconductor market in 1990. However, Table 5 reveals that the French semiconductor market has a relatively low dependence on EDP

TABLE 4
European Market Growth Rate Variances versus the Dollar and the ECU

	Dollar		ECU	
Country	1990	1991	1990	1991
Benelux	15.6%	6.0%	0.1%	0.9%
France	16.4%	4.9%	0.8%	-0.2%
Italy	14.0%	5.0%	-1.3%	-0.2%
Scandinavia	8.3%	4.3%	-5.9%	-0.7%
UK/Eire	8.6%	7.4%	-6.1%	2.1%
West Germany	15.9%	6.8%	-0.3%	1.3%
Rest of Europe	15.5%	7.6%	-0.1%	1.9%
Total Europe	15.4%	5.3%		

Source: Dataquest (May 1991)

Table 5
Preliminary 1990 French Semiconductor Market Split by Application
(Millions of Francs)

	EDP	Com.	Ind.	Con.	Mil.	Trn	Total
Value (FF M)	1,832	1,916	1,666	1,166	1,083	667	8,330
Percent (%)	22%	23%	20%	14%	13%	8%	100%

Source: Dataquest (May 1991)

manufacturers in comparison to UK/Eire and Italy for example. The table shows that communications and industrial are of almost equal importance in driving the French TAM. Now, communications has been singled out as one of the key growth segments in 1990, so one might conclude that the French market should have been stronger than it was. As already noted, switches were the key application driving semiconductor demand in communications last year. Alcatel, the main telecoms manufacturer in France, makes most of its switches in Europe in Germany (Alcatel-SEL) and Belgium (Alcatel-BTMC). So, while the French communications market grew last year, it grew below the European average.

The French company, Thomson, is one of the leading consumer companies in Europe. However, it manufactures the majority of its TVs, VCRs and other consumer equipment outside Europe, in the United States and the Far East. Indeed, Thomson is continuing to follow the policy of moving manufacture to regions of lower labor cost, particularly Singapore. This factor, combined with the fact that Thomson is undergoing a process of rationalizing its production, has had a negative impact on the French consumer TAM.

The outlook for France in 1991 is for below-average market growth of 5.3 percent in francs. Table 2 shows that, in ECU France will grow 4.9 percent below the European average. There are signs of economic slowdown creeping into the French economy; we see this leading to little growth in the French industrial segment. On the positive side, Bull is increasing capacity at its Villeneuve d'Asque plant in order to make Zenith PCs; this will be at the expense of production at Bull's Eire factory. We also expect Hewlett-Packard to increase its spending on semiconductors this year.

France has the biggest military semiconductor market in Europe. While the aftermath of the Gulf war may lead to some spares and repairs requirements, we still expect military segment sales to decline in line with a relaxation of East–West tension.

While the slowdown in new car sales in Europe is affecting Renault and Peugeot Citroën, the rapid increase in usage of electronic systems in cars should drive an increased TAM in the transportation segment. France has the second-largest transportation semiconductor market in Europe after Germany.

Italy

The Italian TAM is dominated by the EDP segment, as shown in Table 6. Olivetti is the main reason for this, though US multinationals, most notably IBM, have increased their manufacturing presence in Italy considerably in recent years. So, with the steep fall in memory prices last year and difficulties at Olivetti, the overall semiconductor market declined by 5.1 percent in lira.

The application segments that declined least in Italy last year were communications and transportation. Italtel and Telettra benefited from local PTT demand, though most of their orders fell in the first half of the year, and high inventories became a

Table 6
Preliminary 1990 Italian Semiconductor Market Split by Application
(Billions of Lira)

	EDP	Com.	Ind.	Con.	Mil.	Trn	Total
Value (L B)	523	282	268	169	56	113	1,411
Percent (%)	37%	20%	19%	12%	4%	8%	100%

Source: Dataquest (May 1991)

problem in the second half of the year. In transportation, unit demand was down though component value increased. The net result was a flat TAM.

The Italian market growth last year represented an extreme example of the European quarterly billing pattern that has characterized the overall European market in recent years. All the growth occurred in the first two quarters. Sales in the second half of 1990 declined on the first half. This was due to a tight inventory management policy exercised by some Italian companies, whereby they aim to finish the year with very little inventory.

The outlook for 1991 is for Italy to grow by 7.8 percent in lira. Table 2 shows that this is 2.2 percent below the European average in ECU. IBM, which makes AS/400 mainframes and PC motherboards will be adding production of its workstations during 1991. Also, Hewlett-Packard will be starting to produce laser printers this year. However, a slowing in the overall growth of the European PC market, combined with the general business difficulties that Olivetti is in, should lead to lower semiconductor orders from Olivetti.

We expect the communications segment to show reasonable growth this year. Demand for exchanges from the Italian PTT should continue, and the inventory problems that affected the second half of 1990 have eased. However, the slump in new car sales will affect semiconductor demand in the transportation segment.

Italy's consumer segment is composed mainly of white goods manufacturers. As most European economies appear to be slowing in 1991, this will mean reduced demand for their products. Thus we expect little growth in this segment.

Scandinavia

The Scandinavian semiconductor market was the weakest of the European regions last year, declining by 7.0 percent in Swedish krona. Sweden is about 60 percent of the Scandinavian market and Ericsson represents 60 percent of the Swedish TAM. So, the region's TAM is dominated by Sweden and Ericsson.

While Ericsson's business in doing very well both in exchanges and mobile communications, the company is moving more and more production away from Sweden. The socialist government has imposed high taxes in order to support the high social benefits it provides, resulting in a very high cost of manufacturing in Sweden. Thus, Ericsson and other Swedish manufacturers are tending to move their production out of the country.

The next-largest OEM in Scandinavia is Nokia of Finland. In the region Nokia makes PCs (both in Finland and Sweden), communications equipment such as modems and PBXs (in Finland), and consumer TVs (through Solora in Finland and Luxor in Sweden). (Nokia also makes TVs under the ITT-Nokia label in Germany.)

Semiconductor spend in PCs was down due to memory price erosion. Sales to the communications segment were flat. But semiconductor consumption in TVs increased. As noted in the summary, demand from TV and VCR manufacturers was strong last year, with Nokia being one of the main beneficiaries.

The other center of expertise in Scandinavia is in industrial control and power management. Asea Brown Boveri uses specialized high-power discretes in motor control and power management systems. However, this represents quite a small amount of semiconductors in value terms.

The outlook for 1991 is for below-average growth of 4.7 percent in krona. Table 2 shows that Sweden will grow 5.8 percent below the European average in ECU. The Swedish economy is in a particularly weak state. While Ericsson's business is still healthy, we expect the trend to move manufacturing outside of the region will continue.

UK/Eire

As Table 7 shows, the UK/Eire semiconductor market is dominated by the EDP segment. Much of this comprises US multinational computer companies such as IBM, Digital Equipment, Apple and Western Digital. With this in mind, it is surprising that the UK/Eire market declined by only 4.1 percent in 1990 when expressed in pounds sterling.

Preventing a deeper recession were the following key factors:

- Increased demand from Far Eastern office equipment, automotive and consumer manufacturers. This has come about through an influx of these companies in the past three years. However, Dataquest notes that these companies' semiconductor purchases were not visible to all suppliers; it was Japanese semiconductor companies which benefited most from this.
- Strong demand from satellite equipment manufacturers.

TABLE 7
Preliminary 1990 UK/Eire Semiconductor Market Split by Application
(Millions of Pounds)

	EDP	Com.	Ind.	Con.	Mil.	Trn	Total
Value (£M)	551	291	306	229	76	76	1,547
Percent (%)	36%	19%	20%	15%	5%	5%	100%

Source: Dataquest (May 1991)

In addition to the decline in memory prices, there were other negative factors:

- A weak communications segment impacted by inventory problems at GEC Plessey Telecommunications (GPT).
- A UK economy that was in recession by the end of 1990. This impacted the industrial/distribution segment, with many small companies going out of business.
- Poor demand from mobile communications equipment manufacturers, with inventory problems among the cellular equipment manufacturers.
- Demand from PC manufacturers was lower than in previous years.

The transportation segment grew above the European average last year. A combination of the revitalized Rover Group and the presence of Nissan enabled the segment to grow despite a big slump in new car sales in the United Kingdom. However, the UK/Eire automotive market is still the smallest of the four leading countries, in Europe (Germany, France, Italy and UK/Eire).

The outlook for 1991 is for the region to grow by 8.4 percent in pounds sterling, 0.7 percent above the European average in ECU. While memory prices have firmed and may even increase slightly over 1991, the PC market in Europe is slowing. This will mean semiconductor demand from the EDP segment will recover, but show modest growth.

The UK economy has begun the year in recession. It will take till the end of 1991 before we see significant improvement, which will impact government and consumer spending.

The communications segment should show reasonable growth this year due to the resolution of inventory problems that have troubled it for 18 months.

Germany

The first important point to note about the reunified Germany is that the semiconductor TAM of east Germany was small before reunification—Dataquest estimates $189 million. After reunification it has greatly reduced, because most electronics manufacturing in east Germany has ceased.

The west German semiconductor market did benefit from reunification in 1990. This was visible in the strong demand for semiconductors from the communications and consumer segments. East Germans were quick to spend their new deutsche marks on electronic consumer goods from west Germany. Also, German telecom manufacturers were well-positioned to win lucrative contracts to rebuild the east German communications infrastructure.

Table 8 indicates the relative size and importance of the communications and consumer segments in Germany. Together they represent 44 percent of the German semiconductor market. This served to reduce the impact of a decline in the EDP segment. Growth in the transportation segment was slower in 1990 than in previous years—the German

TABLE 8
Preliminary 1990 German Semiconductor Market Split by Application
(Millions of Deutsche Marks)

	EDP	Com.	Ind.	Con.	Mil.	Trn	Total
Value (DMM)	1,296	1,097	947	1,096	50	498	4,984
Percent (%)	26%	22%	19%	22%	1%	10%	100%

Source: Dataquest (May 1991)

transportation semiconductor TAM is the biggest in Europe. The German transportation industry is a strong exporter; a combination of the weakness in the US economy, and to some extent the UK economy, combined with a weak dollar led to lower German car production.

We expect the German semiconductor market to grow by 11.3 percent in deutsche marks in 1991, 3.0 percent above the European average in ECU. This will make it the strongest of the major semiconductor markets in Europe again this year. Government investment in east Germany and Germany's favorable position with respect to other Eastern European countries will continue to create healthy markets for German industry in 1991. However, by the end of 1991 we expect to see some signs of serious overheating in the German economy, as a result of the large sums of German government money that have been poured into reunification in the past 10 months.

Early signs in 1991 indicate that demand from telecoms manufacturers remains strong. The first quarter of 1991 grew by some 14 percent in deutsche marks over the same quarter in 1990.

Rest of Europe

Dataquest includes the following countries in Rest of Europe: Spain, Portugal, Austria, Switzerland, Turkey, Greece and Malta.

While there is growing equipment and subassembly manufacture in these countries, there tends to be little purchasing power associated with it. This is particularly true in Spain and Portugal where companies such as Olivetti, Philips, IBM, Siemens, Samsung, Sony, and Fujitsu make a variety of telecoms, EDP and consumer goods. However, the purchasing decisions are taken elsewhere in Europe. As a whole the region declined by some 4 percent when measured in Spanish pesetas in 1990. Healthy demand from consumer factories in the various countries that make up the region failed to offset the negative impact of the decline in the EDP TAM.

In 1991 we see Spain, Portugal and Austria leading the region out of recession. Austria benefits from its neutral position with respect to Eastern European countries, and represents a useful trading post to do business with countries such as Hungary and Poland. Spain and Portugal continue to attract foreign investment in manufacturing plants. With a recovery in the EDP sector we expect to see positive growth.

Dataquest Conclusion

In 1991 the European semiconductor market will recover from the 1990 slump, showing a 9.8 percent growth in ECU. However, Europe will still be dogged by slow economic conditions. The economic recession that affected the United Kingdom and some Scandinavian countries during 1990 will tend to be reflected through the rest of Europe to a lesser extent in 1991. As semiconductor memory prices firm, the EDP segment will recover. Thus regions whose markets are heavily dependent on EDP manufacturers will strengthen—most notably Italy and UK/Eire. However, two of Europe's own EDP companies, Olivetti and Bull, will still be engaged in restructuring, which will affect the semiconductor market in Italy and France.

The consumer segment is expected to be flat in 1991, because demand for TVs and VCRs will be less than in 1990. However, there is every indication that the healthy demand from telephone exchange manufacturers is set to continue in 1991. Siemens Telecom, Ericsson and Alcatel are key manufacturers; their success in export markets has led to strong semiconductor demand. The transportation segment will reflect the slower economic conditions; we expect new car sales to be weak, and this will affect the growth of semiconductor consumption. Military will remain depressed through 1991, though the Gulf war will force many countries to reconsider their military budget cuts. The industrial segment will reflect the various national economies; overall, we expect semiconductor consumption from the industrial segment to grow by only a few percentage points.

With these applications factors in mind, Germany will continue to grow above the European average at 11.3 percent in deutsche marks or 12.6 percent in ECU. While Bull will increase production in France, we expect France will grow below the European average at 5.3 percent in francs or 5.1 percent in ECU. UK/Eire will show an 8.4 percent growth in pounds sterling, and growth above the European average in ECU at 10.5 percent. Improvement in memory prices will help the region, but a slowing European PC market will impact the spend of some of its leading semiconductor procurers. These factors also apply to Italy, which will grow at 7.8 percent in lira, or 7.6 percent in ECU, held back by a troubled Olivetti. Scandinavia will remain the weakest regional market in Europe, despite the continued success of Ericsson.

Jim Eastlake

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Research Newsletter

CAN JAPAN FINALLY TAKE OVER THE RDD MARKET?

OVERVIEW

During recent visits to Japan, a familiar question was asked again: "Will Japanese hard disk makers now be able to take over the market as they did with floppy disk drives?" In the 1980s, there were compelling reasons that such domination was impossible, but new technologies and changing market conditions require a reexamination of these issues.

Japanese corporations are investing huge amounts of capital in development of small-diameter disk drives. Disk drive manufacturers in the United States dominate the Japanese laptop market; these companies appear to be on the verge of losing their dominance. Japanese companies such as Alps Electric Corporation, JVC Corporation, Sony Corporation, and Toshiba Corporation are well on the way to full production of 1.8- or 2.5-inch-diameter disk drives to meet the technical specifications and production needs of laptop and notebook computer makers.

In an era when the United States exports $30 billion in products to Japan and consumes $90 billion of Japanese products, it is not inconceivable that such a trade imbalance could occur with hard disk drives. The effect on the US storage industry of such a loss would be staggering. This newsletter examines the history of Japanese competitive rigid disk drive (RDD) offerings and provides a Dataquest perspective on their future.

HISTORICAL ASPECTS

Hitachi Ltd. is second only to IBM in computer storage revenue but has yet to gain a substantial market share in any segment other than the IBM plug-compatible market (PCM). NEC Corporation is the dominant producer of small-diameter disk drives in Japan but has little worldwide market except for its captive uses in NEC computers. Fujitsu Ltd. won good worldwide market presence in the resale market but has never owned even 10 percent of the market in any of the industry segments. A review of the history of the RDD market is necessary in order to understand these problems.

Success on the High End

The 14-inch RDD market segment is at present dedicated to mainframe users, but back in the middle 1970s these monsters were the only hard disks available. Century Data Corporation, Control Data Corporation, IBM Corporation, and Memorex Corporation supplied drives with capacities under 10MB (now available in a 2.5-inch form factor).

NEC was the first Japanese entrant into the 14-inch drive business, a year or two behind the others. However, there was no significant Japanese presence in this market until Fujitsu began shipments of the Eagle series of 14-inch drives in 1982. Fujitsu, Hitachi, and NEC gained strength over the years and now are producing leading-edge drives long after the likes of Ampex Corporation, BASF, Century, IBIS, and Tecstor have left the business.

Today, the IBM PCM market is controlled by Japanese suppliers either directly or through their OEM buyers. The success of these companies is a result of considerable capital investment in this big-ticket market.

Such companies must follow IBM's technological lead at every turn in order to be compatible; this is not an inexpensive task. Most of these companies devised new technologies of their own and have been tracking IBM with smaller-diameter drives for several years. This market is expected to be taken over by arrays of small-disk drives by the middle of this decade. The Japanese companies are already hard at work on such products.

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8-Inch Market: The Strongest Japanese Position

The computer industry could hardly contain its excitement in 1979 when it was learned that a "small," 12MB, 8-inch-diameter disk drive was under development by several Silicon Valley companies. Shugart Associates and International Memories Incorporated (IMI) were the first to ship, followed by IBM, Micropolis Corporation, and Quantum Corporation.

Fujitsu and Hitachi joined the competition in late 1980, with Mitsubishi, NEC, and Toshiba following in 1981. By the middle of 1981, the ranks of US suppliers had grown to include Control Data and Memorex, both with a two-year technological lead over Toshiba. Throughout the life of the 8-inch drives, the Japanese players kept up with the recording-density race for which IBM set the pace.

By the middle of 1986, the Japanese vendors held a clear advantage in worldwide market share, with only Control Data and IBM holding a significant portion of the US market. Today, only Seagate Technology Company's 8-inch products appear to be keeping pace with Hitachi. (Seagate acquired the Control Data disk drive subsidiary called Imprimis Technology in 1989.)

Fujitsu and NEC also continue to develop and produce strong, new technology in this area. Hitachi was the first company to produce a drive with greater than 1,000MB of capacity and now holds the areal density lead, with a specification of 69.3 million bits per square inch.

5.25-Inch Market: The United States Wins One

Seagate was formed in 1979 to design and build 5.25-inch disk drives. In less than 10 years, Seagate has grown to a level of more than $2.5 billion in annual sales and owns more than 60 percent of the 5.25-inch rigid disk drive market. The first drive was Seagate ST506, 6.38MB product, first shipped in June 1980.

Fujitsu and Nippon Electric Company were the first Japanese producers of 5.25-inch drives, announcing a series of drives from 6.4MB to 25.5MB in July 1982. Mitsubishi was the next company to announce production of such drives with a March 1983 introduction of 6MB and 10MB products. NEC's entrance to this market was later in 1982. Hitachi wound up trailing Seagate's lead into the 5.25-inch drive market by four years.

Throughout the history of the 5.25-inch market, no single Japanese supplier has ever owned as much as 10 percent of the market. The US drive makers brought new meaning to the word innovation by regularly announcing new capacities, faster access times, and lower prices.

Personal computer builders found this innovation to be a differentiating feature that was often needed to compete against giants like IBM, so these manufacturers encouraged rapid technological advances from drive designers. The weakened US dollar and frantic technological evolution combined to make the hard disk market unprofitable for all companies except the active US manufacturers.

As the 5.25-inch market matures and loses ground to the popularity of 3.5-inch drives, only the high-capacity, high-performance products will remain in demand. The Japanese have done well in growing market share when technology and reliability are the differentiating aspects in the purchase decision (in the older, large-diameter business).

The move to increased Japanese market share began in 1990, when Fujitsu, Hitachi, and NEC combined to win 26 percent of the worldwide 5.25-inch unit market for drives over 200MB. This win was at the expense of US suppliers such as Hewlett-Packard, Maxtor Corporation, Micropolis, and Seagate. However, Seagate still owns almost 67 percent of the total 5.25-inch unit volume market.

Megabytes on the Lap

The growing popularity of laptop- and notebook-style computers caused the market for 3.5-inch-diameter disk drives to blossom beyond the industry's highest hopes. Rodime announced shipment of the first of these little drives in April 1983. The first products were 6MB and quickly grew to 12MB by the end of 1983.

The first announcement of production of 3.5-inch drives by a Japanese company came one year later from Nippon Peripherals. Alps Electric and Hitachi brought 12MB drives to market by February 1985. No fewer than 15 Japanese companies had delivered products by the end of 1988.

The US suppliers were slow to market, with these products but there was not much of a market until 1988. There has never been a strict requirement for 3.5-inch form factor products in most small computers. Even in 1989, when the 3.5-inch drives surpassed the 5.25-inch unit volumes, nearly 50 percent of all 3.5-inch drives were sold in 5.25-inch frames.

The slowness of this market and the exceptional strategy of Conner Peripherals, Inc., kept the Japanese out of competition for the OEM accounts. By the time the disk drive makers woke up, Conner owned most of the 3.5-inch OEM market.

Initially, Compaq Computer Corporation invested in Conner. At the same time, Compaq worked with Conner's designers to develop the industry standard in 3.5-inch disk drives.

Since its entry into the market with a 40MB drive in 1986, Conner has continued to nurture joint development efforts on its products, resulting in strong OEM relationships with companies like Digital Equipment Corporation, Grid, and Toshiba.

While Conner was busy signing contracts with the major laptop makers, IBM developed a strong set of captive 3.5-inch products for manufacture in its factory in Fujisawa, Japan. IBM requires second-sourcing of every part in its computers and expanded 3.5-inch drive manufacturing in Rochester, Minnesota, and Havant in the United Kingdom. At first, IBM bought large quantities of 3.5-inch drives from its old partner, Seagate, in order to supplement Fujisawa's production. Today, there is limited opportunity for OEM suppliers to sell 3.5-inch drives to IBM.

Another US company chose to manufacture 3.5-inch drives in Japan. Quantum has a contract with Matsushita Kotobuki Electric Ltd. to manufacture a large percentage of Quantum's 3.5-inch and all of its 2.5-inch drives. This relationship has proven to be profitable for both parties and allowed Quantum to offer reliable products at competitive prices. (Apple Computer Inc. and Sun Microsystems, Inc., are two of Quantum's prize customers.)

In 1990, it is estimated that Japan's combined total unit market share of 3.5-inch drives may have been as much as 18 percent. NEC's total production, including captive drives, was more than 8 percent of the world market. This is the first time that Japan's total unit production has exceeded 10 percent of the market, with no indication that this growth will stop.

There are now eight major Japanese producers of small disk drives and they are all known to be developing a new generation of drives that have diameters smaller than 3.5-inches. Alps, JVC, and Toshiba have already made formal announcements of 2.5-inch products, and several component vendors are busily sampling parts to Japanese companies for even smaller disk drives.

DATAQUEST PERSPECTIVE

Japan's increased market share in the small-diameter disk drive market is a result of its manufacturers' success in catching up in technology in order to meet the growing Japanese personal computer production needs. With US companies supplying most of the disk drives used in laptop computers, it was painfully clear where Japanese development resources must be placed.

There has never been any doubt that the Japanese manufacturing capabilities could turn out competitive, reliable disk drives, but Japanese companies did not understand the direction of market demand. Now that the laptop and notebook PC markets are driven by Asian companies, the low-power, small-form-factor drive requirements are clear. As a result, Japanese disk drive companies will become powerful competitors in this market.

The larger-diameter disk markets are dominated by the Japanese vendors, and the more mature a product segment becomes, the stronger the Japanese hold becomes. Domestic control over the commodity markets is key to the long-term success of US companies because high-volume, low-cost drive manufacturing is their only apparent advantage. If the next generation of tiny diameter drives is made by Asian companies, the hold of US companies on the disk drive industry is doomed.

Little can be done to reverse this trend. Purchase decisions in this decade will be based on functional compliance, reliability, price, and availability. Long-term warranties and a guaranteed assurance of product supply will command a premium in price. Preferred vendors will need to support these demands.

The weakness of the US dollar and the country's economic softness will continue to make foreign products more expensive on the US market, but it is unwise to base long-term strategies on these conditions. As in the past, consolidation of the disk drive industry is once again a strong probability, with only the richest large companies able to compete in the fast-paced market.

(This newsletter was originally published as part of a Computer Storage *Dataquest Perspective*).

Phil Devin
Mike Williams

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Research Newsletter

MULTIMEDIA: NO LONGER A DREAM, BUT A VISION

INTRODUCTION

Few buzz words are more successful than "multimedia" at grabbing attention. If the protagonists are to be taken at face value, multimedia's impact on publishing might even rival Gutenberg's invention of the printing press in 1456. However, in an industry where the half-life of buzz words is measured in months, multimedia must prove to potential users that it has something of *fundamental* value to offer.

This newsletter is organized in three sections. To begin, we present a brief history of how multimedia has evolved, identify its core technologies and explain why multimedia is expected to qualify for mass-market status in the 1990s.

The second section takes a short-term view of multimedia and assesses the impacts of three rapidly approaching digital multimedia technologies: DVI, CD-I and CDTV. We discuss their individual end uses and suggest possible scenarios for their development on the European market.

In its widest sense, multimedia is about improving the interface between people and machines, as is reflected in a wide variety of research in progress both commercially and academically. So finally, we take a broader view of what multimedia is, and identify other key applications that may make a significant impact on the electronics market towards the end of this century.

THE MEANING OF THE WORD

The meaning of multimedia varies according to who utters the word, and what their motives are. However, most agree that true multimedia systems combine all of the following media types:

Text	Graphics
Windows	Sound
Still images	Moving images

Storage and Chip Costs—Falling Hurdles

Until the late 1980s, sound and images placed impossible demands on digital storage. This situation changed with the advent of affordable CD-ROM drives. Until recently, the cost of providing the processor power needed greatly exceeded that used in the original host application. This has changed too and, over the past two to three years, multimedia PC cards have been available at prices less than, or comparable to, the PCs themselves. A similar situation is expected to unfold shortly for consumer TV-based multimedia systems (for example, CD-I and CDTV).

Sound and Image Compression—Key Technologies

Compression is a mathematical procedure by which image or sound data are modified so that just a small proportion needs to be transmitted or stored. Without compression, a single photograph of VGA resolution would require roughly 1MB of storage. A motion sequence at 25 frames per second would require a channel of 0.4 Gbit/s capacity to transmit, and a phenomenal 3GB of storage to capture a brief one-minute sequence.

Varying levels of compression can be achieved to ease storage and transmission requirements, with reduction factors of between 4 and 50 used commonly for still images and audio, rising to a factor as high as 200 for motion video. Consequently, compression plays a fundamental role in making multimedia possible.

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ANALOG MULTIMEDIA

Most multimedia systems sold today are "analog" in the sense that the video information comes from analog storage devices like videodisc players and VCRs. Most use a PC for a platform—Figure 1 gives a common configuration. An example is the UK company VideoLogic's DVA-4000 media control card (MCC) that is added to a PC to capture or deliver audiovisual signals to or from peripherals.

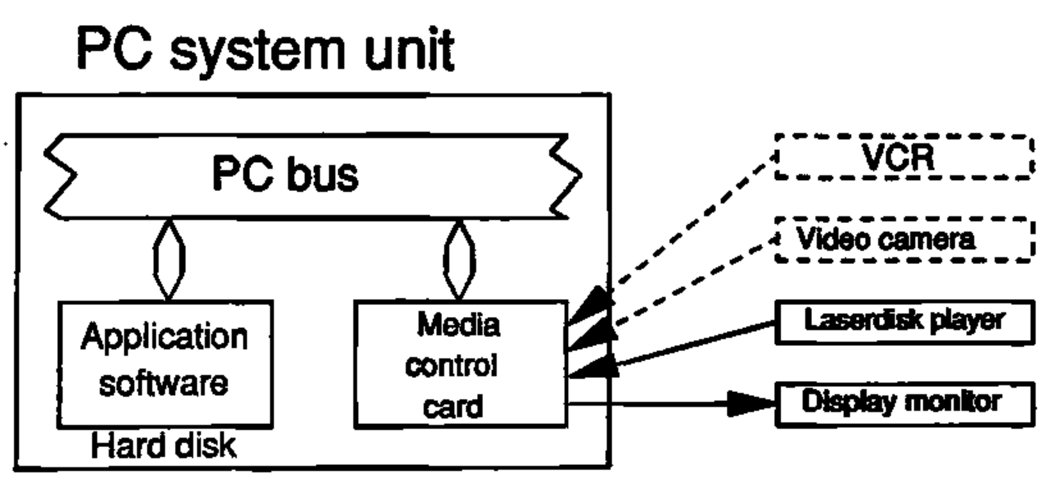
Analog systems offer a wide range of features including interactive video, frame sizing, windowing, and cut and paste. Although labelled as analog, *manipulation* of the video and audio signals within the MCC is performed digitally. Consequently, despite A/D and D/A conversion to capture video inputs and to output analog RGB signals to a monitor, most semiconductor content is DSP and video RAM.

Presently, analog multimedia systems serve niche applications, mainly in education, corporate training, and point-of-sale advertising. Dataquest estimates that total sales of analog PC-based multimedia is limited to a few tens of thousands of units in Europe, a very small proportion of total PC sales. Furthermore, there is a limited possibility for such systems to break from their existing niches to become volume products—in the way that, for example, LAN cards have today—for the following reasons:

- Analog multimedia software titles are delivered in two parts (see Figure 1): an analog audiovisual part (normally supplied on videodisc), and a program part (stored on hard disk). This is less convenient than for digital multimedia (discussed later), where the whole title resides on a single CD.
- The cost of authoring is high compared with digital multimedia, due to the fact that traditional studio mixing techniques are used to cut and splice analog video sequences. Videodisc formatting and mastering costs (typically $70,000) are also much higher than for CD-ROMs (around $3,000) used for digital multimedia.
- Videodiscs normally have a 12-inch (30-cm) diameter, meaning that the players cannot be integrated into a standard PC system unit in the same way that a CD-ROM drive can. Videodiscs also lack flexibility because they offer fixed video quality and a short 30-minutes-per-side playing time.
- Today's analog multimedia systems do not fulfill the requirements of users who need to author and mix their own material locally. Analog multimedia applications process motion video signals at sampling rates of around 100 Mbit/s, higher than can be stored on normal PC hard disks.

However, in analog multimedia's favor is the fact that these systems are very familiar to existing title developers and offer substantially higher video qualities than are presently available from the new

FIGURE 1
Configuration for a PC-Based Analog Multimedia System



Source: Dataquest (April 1991)

digital systems. Consequently, we expect analog multimedia systems to continue to thrive in niche segments where image quality outweighs the high cost of software development.

DIGITAL MULTIMEDIA

Digital multimedia systems differ from analog systems in that, apart from the initial capture of analog video signals from peripherals like videocameras and VCRs, all further manipulation, transmission and storage of video material is performed digitally. In addition, the program and video parts reside on the *same* medium, usually a CD-ROM (see Figure 2). Currently, three major digital multimedia technologies are beginning to emerge—DVI, CD-I and CDTV. These are described below.

DVI—Digital Video Interactive

The DVI system was demonstrated four years ago by the RCA David Sarnoff Laboratory, Princeton, USA. Intel has since acquired it, refined it, and brought it to market. Unlike CD-I, DVI is a set of component products, not a complete system. DVI's main semiconductor elements are two i750 processor ICs, a pixel processor and a display processor.

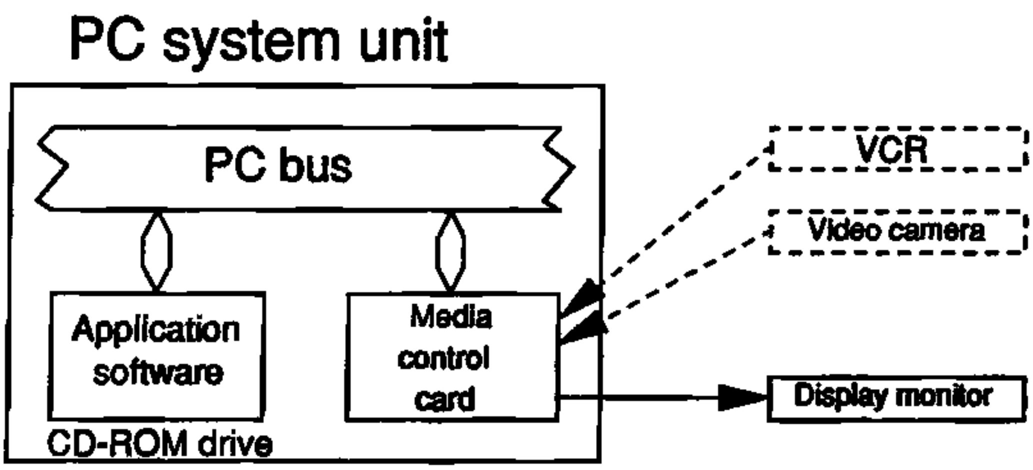
In addition to ICs, Intel also sells its Action Media software and boards to value-added resellers and systems integrators. It has two main boards, the first of which is a delivery board that performs DVI graphics manipulation and compression. This contains the i750 chipset and between 1MB and 2MB of video RAM. The second card is optional and used for video capture mainly by title developers and some end users; it contains largely flash conversion and filter circuitry.

Currently, the greatest interest in DVI comes from PC desktop and workstation OEMs (including AT&T, Compaq, IBM, Olivetti, Sun and Toshiba), which mainly see DVI as a way of differentiating their products in a crowded and maturing PC market. Over a longer term, DVI may appear alongside CD-I in consumer compact disc players, and in other applications such as electronic books and video-telephony (under development by IBM and PictureTel).

Although the i750 chip set has been commercially available for some time, DVI's uptake has so far been restricted to the same vertical markets as analog multimedia. This has been for the following reasons:

- Window features that permit multimedia titles to run alongside non-multimedia ones are essential for the uptake of general-purpose, PC-based multimedia. In this respect, Microsoft's Windows is expected to form the main delivery vehicle for windowed DVI on PCs. However, Windows is not presently compatible with DVI.
- The i750 chip set currently straddles two generations: the original "A" series and a new 1-μm "B" series—now available in samples. The i750B gives double performance at a substantially lower price (around $50 each this year).

FIGURE 2
Configuration for a PC-Based Digital Multimedia System



Source: Dataquest (April 1991)

Although the transition to "B" is a clear refinement, board designers and OEMs are likely to hold market promotion of their DVI products until the "B" parts become widely available.

- DVI titles that perform video capture (for example, video-mail) or manipulate image archives (for example, image databases) consume large amounts of storage. Two key elements, LAN and image database software, are not believed to be sufficiently advanced to accommodate network exchange and client-server storage of multimedia.

The above limitations are largely temporary. For example, a DVI-compatible version of Microsoft's Windows is expected later this year, although with an inevitable lag between its availability and that of the titles it hosts. Demonstration of networked DVI multimedia on Novell's NetWare is also expected soon.

Compared to analog multimedia solutions, DVI does offer significant improvements in usability. These are as follows:

- Low-cost software tools for DVI used to author applications software (for example, Intel's C-library, LUMENA, MEDIAscript and Authology) dramatically reduce the hardware and labor costs of title development, by a factor of between 2 and 5. This is important when one considers that title availability will be the key issue determining DVI's success.
- Although high-quality video compression is performed off-line, DVI has some real-time compression capability.
- Intel recently stated that from later this year it will supply software and microcode to give the existing i750-series ICs algorithm compatibility with the newly emerging Joint Picture Experts Group (JPEG) and Motion Picture Experts Group (MPEG) standards. JPEG and MPEG are the two main international multimedia standards groups, working under the auspices of both Comité Consultatif International de Télégraphie et Téléphonie (CCITT), and International Standards Organization (ISO).

The last two points are of special interest when considered in connection with videoconferencing and videotelephony—two of the most universally appealing applications. CCITT standards (H.261) have recently been set for these and, in the multimedia networks of the mid- and late-1990s, video material will need to be compressed to one family of standards.

CD-I—Compact Disc-Interactive

CD-I is a multimedia system based on the compact disc and targeted, initially, at the consumer and educational markets. CD-I was jointly developed by Philips and Sony, for which the technical specification is published as the "Green Book." CD-I is also being promoted by Matsushita, with Grundig, Fujitsu, Pioneer, Nintendo, Yamaha, Ricoh, Sharp and Sanyo also developing players.

The main application for CD-I is as an augmented CD player that functions both as an audio player and as a multimedia adjunct to a television. In addition, Philips has very recently announced that it will also market PC-based CD-I systems. CD-I's cost is designed to lie within the bounds of consumer affordability with, consequently, a lower performance compared to systems targeted at professional and business users.

CD-I players are based on the 68xxx microprocessor family and use a ROM-based operating system. The first CD-I players are based on Motorola's 16-bit 68070, with later versions expected to use 32-bit devices like the 68340. Memory requirements are 1MB of RAM and an additional 8KB of EEPROM scratchpad.

Although professional development systems have been on sale for some time, the launch of consumer CD-I products has been repeatedly postponed. This is partly due to the commercial necessity of achieving a critical mass of titles for launch, with the added possibility that launch is being affected by a wait for the full motion video decoder IC, presently under development by Philips and Motorola. Consumer CD-I is expected to be launched in the United States this year, to be followed next year with launches in Europe and Japan.

CDTV—Commodore Dynamic Total Vision

Commodore demonstrated CDTV last January at the Consumer Electronics show, Las Vegas, less than two years after development first commenced. CDTV is a CD-based unit expected to retail in Europe this month for around $1,200.

CDTV's semiconductor content closely resembles that in Commodore's Amiga computers, being based on the Motorola 68000 and complemented by three video-processing ASICs (from Commodore's MOS Technology subsidiary) and 1MB of RAM. The CD drive is manufactured by Matsushita. Later this year, Commodore intends to extend CDTV's multimedia features to its existing (and large) Amiga user base by selling CD-ROM drives worth $600 to be attached to high-end Amiga computers.

DATAQUEST ANALYSIS

Fundamental changes are taking place in technologies that deliver multimedia. Image compression and cheap CD-ROM storage have converged to form digital multimedia technologies such as DVI, CD-I and CDTV. Digital multimedia is more flexible than its analog counterpart, and will form the basis for a number of mass-market applications over the next two to three years. More specifically, we foresee mass-market status for two applications: consumer CD-based players, and desktop PC systems. These are discussed below.

Consumer Multimedia—Riding the Titles Wave

We are about to be swept along the first wave in a multimedia revolution, a titles wave. Here, one-way interactive replay is the key feature, where users can interact with several hundred prerecorded titles. We have previewed many title demonstrations, ranging from telephone directories, to training courses, to cartoon animation and games for children. Many convey degrees of interaction and familiarity completely unobtainable with conventional media devices like television and books.

However, from a forecaster's perspective, multimedia is new and has no real precedent. With this in mind, Table 1 gives one feasible outlook for European sales of consumer CD-based multimedia players, and the semiconductor revenue generated. We assume that consumer multimedia will experience the same rate of development that occurred after CD audio's launch in 1983, but with the following additional assumptions:

- Wide-scale market introduction will commence in Europe from 1993.
- At equivalent points in their respective life cycles, multimedia CD players will reach half

TABLE 1
Estimated West European Consumer TV-Based Multimedia Player Sales and Semiconductor Forecast

Consumer Players	1992	1993	1994	1995	1996	1997
Unit Shipments (M)	0.0	0.1	0.3	1.7	2.2	3.7
Growth (%)	NA	217%	208%	496%	27%	65%
Unit Installed Base (M)	0.0	0.1	0.4	2.3	4.4	8.0
Home Penetration (%)	0.0%	0.1%	0.3%	1.7%	3.5%	6.3%
Average Selling Price ($)	$1,200	$1,087	$984	$892	$808	$731
I/O Ratio (%)	10%	10%	10%	10%	10%	10%
Semiconductor Content ($)	$120	$109	$98	$89	$81	$73
Semiconductor Revenue ($M)	$4	$10	$29	$155	$179	$267
Growth (%)	NA	187%	179%	440%	15%	49%

NA = Not Applicable
Source: Dataquest (April 1991)

the penetration levels achieved for CD audio. Of Western European homes, 1 in 4 already have a CD audio player, and some resistance to the proposition of replacing it with another (of albeit greater functionality) is likely.

From a semiconductor perspective, not all the semiconductor consumption revenue in Table 1 will occur inside Europe. Many CD-I entrants will be Far Eastern, and are likely to satisfy most of the early European demand from plants in Japan. Furthermore, Commodore also assembles its CDTV player in Japan and has no immediate plans to start production in Europe.

PC-Based Multimedia—The Business Market

Similar uncertainties exist over multimedia's uptake in the business community, with business awareness, network compatibility and title availability seen as the key issues. The main factor affecting desktop multimedia's uptake is whether the generic multimedia titles presently being developed will do for DVI what, say, Lotus 1-2-3 or WordPerfect did for the PC.

Table 2 gives one view of the potential impact on semiconductor demand resulting from the emergence of the PC-based multimedia market. This is predicated on the assumption that 1 in 4 of Western Europe's projected 43 million desktop business users in 1996 will have multimedia capability.

Multimedia: Future Visions

Over the coming few years, multimedia will progress along traditional lines—as old media appearing on different platforms: namely video on PCs and text or graphics onto TVs. However, the longer-term outlook is different with radical, and possibly pervasive, ideas appearing from leading research laboratories including MIT's Media Lab, Xerox (Palo Alto) in the United States, and Olivetti in Cambridge, England.

Figure 3 shows the scene unfolding for multimedia on a wider stage, mapping its major applications against two constraints: complexity (the number of transistors employed), and bandwidth (the speed at which information must be processed and displayed).

Video-conferencing systems for PCs and workstations are already being extensively prototyped in Europe by Hewlett-Packard, IBM and Olivetti. High-definition television (HDTV) is multimedia's next display mechanism although, to begin with, this will be mainly for niche applications such as medical training and architectural design, not for mass-consumer use.

Video Walls—Paperless Offices Revived?

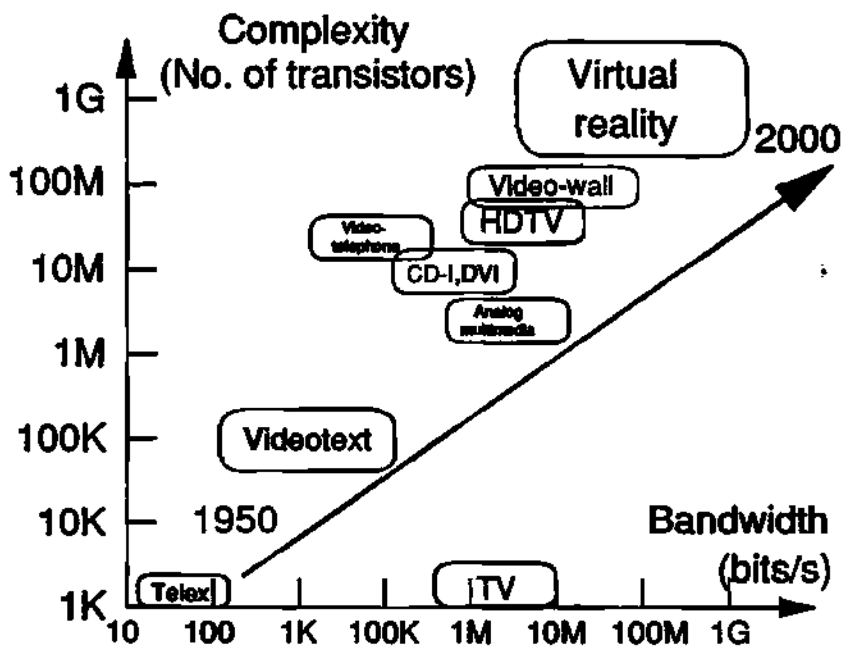
"Video walls" are another area of growing interest. Here, the wall replaces a desk. Documents may be covered, uncovered and piled on the wall in ways not physically possible on the desk. The wall

TABLE 2
PC-Based Multimedia Market Estimation and Semiconductor Forecast

PC-Based Multimedia	1991	1992	1993	1994	1995	1996
Unit Shipments (M)	0.0	0.0	0.1	0.7	3.1	6.8
Growth (%)	NA	1,748%	569%	445%	317%	123%
Desktop Installed Base (M)	21.8	26.5	31.1	35.5	39.5	43.0
Multimedia Penetration (%)	0.0%	0.1%	1.0%	2.5%	10.0%	25.0%
Semiconductor Content ($)	$200	$160	$120	$120	$120	$120
Semiconductor Revenue ($M)	$0	$3	$16	$88	$367	$817
Growth (%)	NA	1,379%	402%	445%	317%	123%

NA = Not Applicable
Source: Dataquest (April 1991)

FIGURE 3
Multimedia—Past Applications and Future Visions



Source: Dataquest (April 1991)

becomes a window through to the outside world, allowing one to contact, see and speak with others through it. However, the video wall (in some ways not too dissimilar from Windows 3 on a PC) remains a vision frustrated by the absence of affordable, large, high-resolution displays. This could change with the probable emergence of HDTV projection systems in the mid-1990s, being developed today by TV manufacturers like Barco, Thomson, Sharp and Sony.

Stepping Inside Virtual Reality

Multimedia's growth is part of a wider quest towards "virtually real" systems that satisfy every human sense. Visitors to a virtually real world wear goggles imparting color 3-D vision and headphones. As they turn their heads, they turn to see and hear each other in an imaginary computer-synthesized world. With the aid of position and touch-sensitive gloves, they may hold and manipulate objects that virtually exist, but not in reality.

Serious virtual reality systems already exist (Division, VPL Research, W Industries, and so on), and employ heavily concurrent computing architectures to calculate in excess of 3,000 polygons per second. Present uses include architectural design, flight simulation, neurosurgery, robot control and, not least, games.

Virtual reality is presently very new, very exciting, and very experimental. In some respects, virtual reality is where screen-based computer graphics was in the early 1970s. Less than a decade separated computer graphics in the laboratory from the same on the business desktop, and a similar situation is foreseeable for virtual reality too.

Conclusions—Waiting for the Cost Intercept

Analog multimedia systems have been around since the first introductions by Philips and MCA of analog videodisc players in 1978, achieving only niche sales over that time. Likewise, more than four years have passed since the first demonstrations of the digital CD-I and DVI technologies—without any clear sign today that either is taking off.

This may be sufficient evidence for some to conclude that multimedia is baloney and that the essence of learning and communication has little to do with presentation. Yet, at the same time, research and development activities in this area continue to escalate.

It is Dataquest's perception that, if the mass multimedia markets are to ride on the back of existing hosts like PCs and CD players, their semiconductor costs remain unacceptably high for them to take off today. PC-based DVI add-on boards presently have a $200 semiconductor content, greater than the average content of a whole PC motherboard ($175) last year. Even greater disparities exist between CD-I's content and that of a normal CD player.

From a semiconductor perspective, the intercept between cost and what is affordable in a mass market has clearly not arrived. However, as the cost of implementing digital multimedia on silicon continues to decline exponentially, the time for it to arrive is not far off.

Jonathan Drazin

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LOCAL CURRENCY METHODOLOGY

INTRODUCTION

As the European Community (EC) moves towards a system of closer monetary ties through the Exchange Rate Mechanism (ERM), Dataquest's European Semiconductor Group has changed its local currency forecast methodology. This will also tie in with company accounting procedures, as the use of a single currency measure in published balance sheets becomes more widely used. This newsletter summarizes the effect this has on our European semiconductor market history data in local currency terms.

METHODOLOGY

For the past 10 years all of Dataquest's European local currency forecasts have been prepared using Dataquest's own Semiconductor Industry Weighted Average (SIWA) currency. This unit was based on the semiconductor consumption of the major European countries (both EC and non-EC members), and used 1980 as the base year equal to 100. From 1991 onwards all local currency forecasts will be prepared using the European Currency Unit (ECU) as our measure of local currency, in place of the SIWA, which will no longer be calculated.

Table 1 shows the historical semiconductor consumption in Europe for all products and technologies in millions of US dollars, SIWA, and ECUs. Table 2 shows the corresponding growth rates for each of these currencies, and Figure 1 shows these growth rates in graphical form.

As Figure 1 shows, there is little deviation in the local currency growth rates when using either the SIWA or the ECU as the measure of local currency. However, the ECU growth rate tends to accentuate the peaks and troughs in the market.

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ESAM Newsletters 1991-5

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TABLE 1
Estimated European Semiconductor Consumption History
(US Dollars and Local Currency)

		1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Total Semiconductor	$M	3,018	3,686	3,041	3,167	3,370	4,805	4,720	5,532	6,355	8,491	9,755	10,693
	SIWA (M)	3,068	3,686	3,761	4,475	5,311	8,556	8,718	8,071	7,977	10,313	12,701	12,166
	ECU (M)	2,082	2,801	2,798	3,230	3,774	6,102	6,183	5,643	5,529	7,132	8,975	8,447
Total IC	$M	1,747	2,333	1,892	1,988	2,323	3,634	3,556	4,088	4,693	6,669	7,794	8,378
	SIWA (M)	1,776	2,333	2,340	2,809	3,661	6,471	6,568	5,964	5,891	8,100	10,148	9,532
	ECU (M)	1,205	1,773	1,741	2,028	2,602	4,615	4,658	4,170	4,083	5,602	7,170	6,619
Bipolar Digital	$M	390	510	454	434	483	724	709	782	725	772	640	562
	SIWA (M)	396	510	562	613	761	1,289	1,310	1,141	910	938	833	639
	ECU (M)	269	388	418	443	541	919	929	798	631	648	589	444
MOS Digital	$M	781	1,139	882	948	1,227	2,092	1,953	2,280	2,753	4,364	5,458	5,524
	SIWA (M)	794	1,139	1,091	1,340	1,934	3,725	3,607	3,326	3,456	5,301	7,106	6,285
	ECU (M)	539	866	811	967	1,374	2,657	2,558	2,326	2,395	3,666	5,021	4,364
MOS Memory	$M	367	543	426	469	581	995	750	822	838	1,797	2,548	2,283
	SIWA (M)	373	543	527	663	916	1,772	1,385	1,199	1,052	2,183	3,317	2,598
	ECU (M)	253	413	392	478	651	1,264	982	838	729	1,509	2,344	1,804
MOS Micro	$M	125	189	149	168	239	465	485	578	794	1,212	1,469	1,854
	SIWA (M)	127	189	184	237	377	828	896	843	997	1,472	1,913	2,109
	ECU (M)	86	144	137	171	268	591	635	590	691	1,018	1,351	1,465
MOS Logic	$M	289	407	307	311	407	632	718	880	1,121	1,355	1,441	1,387
	SIWA (M)	294	407	380	439	641	1,125	1,326	1,284	1,407	1,646	1,876	1,578
	ECU (M)	199	309	282	317	456	803	941	898	975	1,138	1,326	1,096

(Continued)

Table 1 (Continued)
Estimated European Semiconductor Consumption History
(US Dollars and Local Currency)

		1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Analog	$M	576	684	556	606	613	818	894	1,026	1,215	1,533	1,696	2,292
	SIWA (M)	586	684	688	856	966	1,457	1,651	1,497	1,525	1,862	2,208	2,608
	ECU (M)	397	520	512	618	687	1,039	1,171	1,047	1,057	1,288	1,560	1,811
Discrete	$M	1,138	1,192	995	1,011	866	963	954	1,153	1,384	1,516	1,594	1,915
	SIWA (M)	1,157	1,192	1,231	1,429	1,365	1,715	1,762	1,682	1,737	1,841	2,075	2,179
	ECU (M)	785	906	915	1,031	970	1,223	1,250	1,176	1,204	1,273	1,466	1,513
Optoelectronic	$M	133	161	154	168	181	208	210	291	278	306	367	400
	SIWA (M)	135	161	190	237	285	370	388	425	349	372	478	455
	ECU (M)	92	122	142	171	203	264	275	297	242	257	338	316
	SIWA/$	101.66	100	123.69	141.3	157.59	178.06	184.7	145.89	125.52	121.46	130.2	113.78
	ECU/$	0.69	0.76	0.92	1.02	1.12	1.27	1.31	1.02	0.87	0.84	0.92	0.79

Source: Dataquest (March 1991)

Table 2
Estimated European Semiconductor Consumption Growth Rates
(US Dollars and Local Currency)

		AGR 1980/1979	AGR 1981/1980	AGR 1982/1981	AGR 1983/1982	AGR 1984/1983	AGR 1985/1984	AGR 1986/1985	AGR 1987/1986	AGR 1988/1987	AGR 1989/1988	AGR 1990/1989
Total Semiconductor	$M	22.13%	-17.50%	4.14%	6.41%	42.58%	-1.77%	17.20%	14.88%	33.61%	14.89%	9.62%
	SIWA (M)	20.14%	2.05%	18.97%	18.68%	61.10%	1.89%	-7.42%	-1.16%	29.29%	23.15%	-4.21%
	ECU (M)	34.52%	-0.13%	15.46%	16.84%	61.68%	1.32%	-8.74%	-2.02%	29.00%	25.83%	-5.87%
Total IC	$M	33.54%	-18.90%	5.07%	16.85%	56.44%	-2.15%	14.96%	14.80%	42.11%	16.87%	7.49%
	SIWA (M)	31.36%	0.31%	20.03%	30.32%	76.76%	1.50%	-9.20%	-1.23%	37.51%	25.28%	-6.06%
	ECU (M)	47.09%	-1.83%	16.50%	28.31%	77.39%	0.94%	-10.49%	-2.08%	37.21%	28.00%	-7.70%
Bipolar Digital	$M	30.77%	-10.98%	-4.41%	11.29%	49.90%	-2.07%	10.30%	-7.29%	6.48%	-17.10%	-12.19%
	SIWA (M)	28.63%	10.11%	9.20%	24.12%	69.37%	1.58%	-12.88%	-20.23%	3.04%	-11.13%	-23.26%
	ECU (M)	44.04%	7.76%	5.99%	22.20%	69.97%	1.01%	-14.12%	-20.92%	2.81%	-9.20%	-24.60%
MOS Digital	$M	45.84%	-22.56%	7.48%	29.43%	70.50%	-6.64%	16.74%	20.75%	58.52%	25.07%	1.21%
	SIWA (M)	43.46%	-4.22%	22.79%	44.35%	92.64%	-3.16%	-7.79%	3.89%	53.39%	34.07%	-11.55%
	ECU (M)	60.63%	-6.26%	19.17%	42.12%	93.33%	-3.70%	-9.10%	2.99%	53.05%	36.98%	-13.09%
MOS Memory	$M	47.96%	-21.55%	10.09%	23.88%	71.26%	-24.62%	9.60%	1.95%	114.44%	41.79%	-10.40%
	SIWA (M)	45.54%	-2.96%	25.77%	38.16%	93.50%	-21.81%	-13.43%	-12.29%	107.50%	51.99%	-21.70%
	ECU (M)	62.97%	-5.03%	22.06%	36.03%	94.19%	-22.25%	-14.66%	-13.05%	107.04%	55.30%	-23.06%
MOS Micro	$M	51.20%	-21.16%	12.75%	42.26%	94.56%	4.30%	19.18%	37.37%	52.64%	21.20%	26.21%
	SIWA (M)	48.73%	-2.49%	28.80%	58.66%	119.83%	8.19%	-5.87%	18.19%	47.71%	29.93%	10.29%
	ECU (M)	66.54%	-4.57%	25.01%	56.21%	120.62%	7.59%	-7.21%	17.17%	47.38%	32.75%	8.37%
MOS Logic	$M	40.83%	-24.57%	1.30%	30.87%	55.28%	13.61%	22.56%	27.39%	20.87%	6.35%	-3.75%
	SIWA (M)	38.53%	-6.70%	15.73%	45.96%	75.45%	17.84%	-3.19%	9.60%	16.96%	14.00%	-15.89%
	ECU (M)	55.12%	-8.69%	12.31%	43.70%	76.08%	17.19%	-4.57%	8.65%	16.71%	16.48%	-17.35%

(Continued)

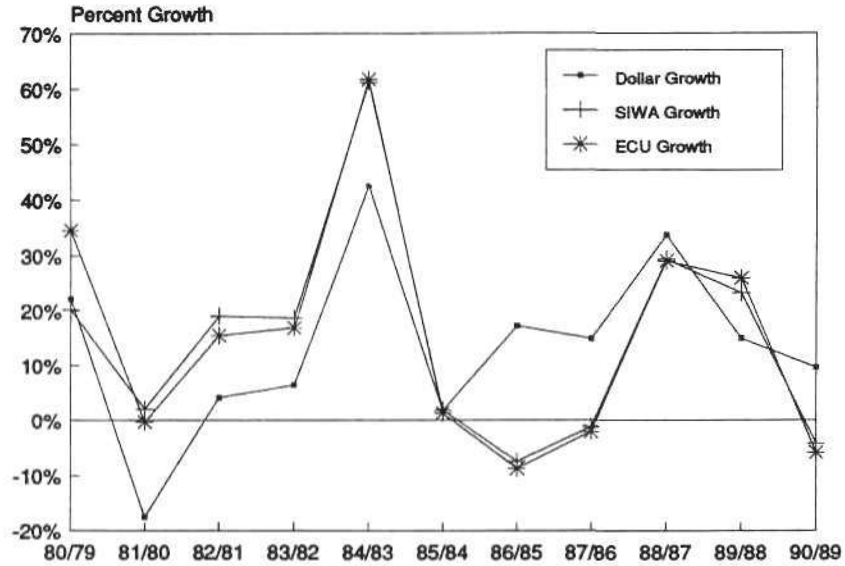
TABLE 2 (Continued)
Estimated European Semiconductor Consumption Growth Rates
(US Dollars and Local Currency)

		AGR 1980/1979	AGR 1981/1980	AGR 1982/1981	AGR 1983/1982	AGR 1984/1983	AGR 1985/1984	AGR 1986/1985	AGR 1987/1986	AGR 1988/1987	AGR 1989/1988	AGR 1990/1989
Analog	$M	18.75%	-18.71%	8.99%	1.16%	33.44%	9.29%	14.77%	18.42%	26.17%	10.63%	35.14%
	SIWA (M)	16.81%	0.54%	24.51%	12.82%	50.78%	13.37%	-9.35%	1.89%	22.09%	18.59%	18.10%
	ECU (M)	30.80%	-1.60%	20.84%	11.07%	51.31%	12.73%	-10.64%	1.01%	21.82%	21.17%	16.05%
Discrete	$M	4.75%	-16.53%	1.61%	-14.34%	11.20%	-0.93%	20.86%	20.03%	9.54%	5.15%	20.14%
	SIWA (M)	3.03%	3.25%	16.07%	-4.47%	25.65%	2.76%	-4.54%	3.27%	5.99%	12.71%	4.99%
	ECU (M)	15.37%	1.05%	12.65%	-5.94%	26.09%	2.19%	-5.90%	2.38%	5.76%	15.16%	3.16%
Optoelectronic	$M	21.05%	-4.35%	9.09%	7.74%	14.92%	0.96%	38.57%	-4.47%	10.07%	19.93%	8.99%
	SIWA (M)	19.08%	18.31%	24.62%	20.16%	29.84%	4.73%	9.45%	-17.81%	6.51%	28.56%	-4.75%
	ECU (M)	33.33%	15.79%	20.95%	18.30%	30.31%	4.14%	7.90%	-18.52%	6.28%	31.36%	-6.41%

Source: Dataquest (March 1991)

FIGURE 1

European Historical Growth Comparisons (Millions of Dollars and Local Currency)



Source: Dataquest (March 1991)

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EXCHANGE RATE NEWSLETTER

FINAL 1990

Dataquest's European exchange rate tables include data from all Western European countries, each of which has different and variable exchange rates against the US dollar. Where applicable, Dataquest's estimates are prepared in terms of local currencies before conversion (where necessary) to US dollars. Dataquest uses exchange rates taken from the *Wall Street Journal*, which are in turn taken from the Bankers Trust Co. All exchange rates previous to 1990 were sourced from the International Monetary Fund (IMF).

All forecasts are prepared using fixed exchange rates based on the last complete historical quarter (currently the fourth quarter of 1990). To maintain consistency across all its analyses, Dataquest makes ongoing adjustments to its forecasts for these currency changes during the year. As a result of this policy, forecast growth rates can become distorted when comparing dollar growth rates with European currency growths.

Effective exchange rates for the current year are calculated each month and are then used to assess the local currency's impact on US dollar forecasts. The purpose of this newsletter is to record these changes, and thus allow the reader to make any necessary adjustments when interpreting regional data. For each European region, Table 1 gives the local currency per US dollar for 1989, the third quarter of 1990, and the fourth quarter of 1990, together with the final estimate for the whole of 1990. Also shown, for reference purposes, are the same figures for the Japanese yen. As can be seen from this table, the Semiconductor Industry Weighted Average (SIWA) for all the European currencies for 1990 has increased 12.61 percent with respect to the US dollar, compared with 1989. This represents a 5.2 percent increase in the exchange rate from the third quarter of 1990 to the fourth quarter. Table 2 shows the 1990 quarterly values for the same regions.

Table 3 illustrates how to interpret the effect of the currency shifts on Dataquest's forecast numbers. For example, the table shows that the constant dollar forecast (based on final 1989 exchange rates) of $9,344 million for the 1990 total European semiconductor market becomes $10,693 million when adjusted for changes in European currencies. Table 4 shows this effect on Dataquest forecasts in European Currency Units (ECUs).

Table 5 shows the 1990 monthly values of local currency per US dollar for each Western European country and Japan. Included in the tables is the European Currency Unit. This unit, established in March 1979, is a weighted average of the currencies of all member countries of the European Community (EC). It is calculated by the IMF from each country's gross national product (GNP) and foreign trade.

Also included is the aforementioned SIWA. This unit is based on the semiconductor consumption of each European country featured here (EC and non-EC members), and uses the base year 1980 equal to 100 as a reference point. The SIWA is useful for interpreting the effect of European currency fluctuations against the US dollar, specifically for the European semiconductor industry.

Dataquest's European local currency forecasts and historical data have previously been recorded using the SIWA as a measure of local currency. Since September 1990 we have changed to using ECUs. As it is becoming increasingly common for companies to publish their annual reports in ECUs, all future local currency forecasts prepared by Dataquest will be published in ECUs. This change in policy has little effect on the local currency market growth rates, as can be seen by comparing Table 3 and Table 4.

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ESAM Newsletters 1991-4

0008348

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TABLE 1
European Currencies—1989 to 1990
(Local Currency per US Dollar)

Region	1989	3Q90	Percent Change 3Q90-4Q90	4Q90	1990	Percent Change 1989-90
Austria	13.24	11.21	6.00	10.54	11.36	14.17
Belgium	39.44	32.81	5.70	30.93	33.41	15.30
Denmark	7.32	6.08	5.50	5.74	6.18	15.54
Finland	4.30	3.75	4.30	3.59	3.82	11.16
France	6.39	5.34	5.40	5.05	5.44	14.84
Ireland	0.71	0.59	5.60	0.56	0.60	14.85
Italy	1,373.60	1,176.27	4.20	1,126.28	1,197.22	12.84
Luxembourg	39.44	32.81	5.70	30.93	33.41	15.30
Netherlands	2.12	1.80	5.90	1.69	1.82	14.15
Norway	6.91	6.15	4.90	5.85	6.25	9.53
Portugal	157.62	140.62	6.00	132.22	142.40	9.66
Spain	118.55	98.60	3.80	94.85	102.03	13.93
Sweden	6.45	5.86	4.50	5.60	5.92	8.15
Switzerland	1.64	1.33	5.00	1.27	1.39	15.40
United Kingdom	0.61	0.54	4.30	0.51	0.56	7.41
West Germany	1.88	1.59	6.10	1.50	1.62	14.10
ECU	0.92	0.77	5.30	0.73	0.79	14.19
SIWA (Base 1980 = 100)	130.20	111.06	5.20	105.26	113.78	12.61
Japan	138.07	145.07	10.00	130.50	144.71	(4.81)

Source: Dataquest (March 1991)

Table 2
European Currencies—1990 by Quarter
(Local Currency per US Dollar)

Region	1Q90	2Q90	3Q90	4Q90	Total Year 1990
Austria	11.90	11.80	11.21	10.54	11.36
Belgium	35.29	34.60	32.81	30.93	33.41
Denmark	6.52	6.39	6.08	5.74	6.18
Finland	3.99	3.96	3.75	3.59	3.82
France	5.74	5.64	5.34	5.05	5.44
Ireland	0.64	0.63	0.59	0.56	0.60
Italy	1,254.66	1,231.66	1,176.27	1,126.28	1,197.22
Luxembourg	35.29	34.60	32.81	30.93	33.41
Netherlands	1.91	1.89	1.80	1.69	1.82
Norway	6.53	6.49	6.15	5.85	6.25
Portugal	148.86	147.90	140.62	132.22	142.40
Spain	109.08	105.60	98.60	94.85	102.03
Sweden	6.15	6.08	5.86	5.60	5.92
Switzerland	1.51	1.44	1.33	1.27	1.39
United Kingdom	0.61	0.60	0.54	0.51	0.56
West Germany	1.69	1.68	1.59	1.50	1.62
ECU	0.83	0.82	0.77	0.73	0.79
SIWA (Base 1980 = 100)	120.18	118.61	111.06	105.26	113.78
Japan	147.92	155.35	145.07	130.50	144.71

Source: Dataquest (March 1991)

TABLE 3
Effect of Changes in European Currencies per US Dollar on Dataquest Forecasts—1989 versus 1990 (Millions of US Dollars)

	1989	1990	Percent Change 1989-1990
European Semiconductor Consumption (At constant 1989 exchange rates)	$9,755	$9,344	(4.2)
Weighted European Currency (Assumed) (Base 1980 = 100)	130.2	130.2	NM
Weighted European Currency (SIWA) (Latest Estimates)	130.2	113.78	12.6
Effective Consumption (At December YTD exchange rates)	$9,755	$10,693	9.6

NM = Not Meaningful
Source: Dataquest (March 1991)

TABLE 4
Effect of Changes in European Currencies per US Dollar on Dataquest Forecasts—1989 versus 1990 (Millions of ECUs)

	1989	1990	Percent Change 1989-1990
European Semiconductor Consumption (At constant 1989 exchange rates)	$9,755	$9,182	(5.9)
Weighted European Currency (Assumed) (Base 1980 = 100)	0.92	0.92	NM
Weighted European Currency (ECU) (Latest Estimates)	0.92	0.79	14.1
Effective Consumption (At December YTD exchange rates)	$9,755	$10,693	9.6

NM = Not Meaningful
Source: Dataquest (March 1991)

TABLE 5
European Currencies—1990 by Month
(Local Currency per US Dollar)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1990	1989	Percent Change 1989-90
Austria	11.90	11.80	12.00	11.86	11.71	11.84	11.55	11.05	11.04	10.73	10.43	10.46	11.36	13.24	14.2
Belgium	35.46	35.01	35.39	34.87	34.33	34.59	33.78	32.39	32.27	31.40	30.58	30.80	33.41	39.44	15.3
Denmark	6.56	6.46	6.53	6.43	6.34	6.41	6.24	6.00	5.99	5.82	5.68	5.73	6.18	7.32	15.5
Finland	4.00	3.95	4.02	3.99	3.92	3.96	3.84	3.70	3.70	3.62	3.55	3.59	3.82	4.30	11.2
France	5.76	5.69	5.76	5.66	5.60	5.66	5.50	5.27	5.25	5.11	4.99	5.05	5.44	6.39	14.8
Ireland	0.64	0.63	0.64	0.63	0.62	0.63	0.61	0.59	0.58	0.57	0.55	0.56	0.60	0.71	14.8
Italy	1,262.59	1,244.04	1,257.34	1,237.69	1,221.84	1,235.45	1,201.37	1,155.49	1,171.96	1,142.96	1,114.93	1,120.96	1,197.22	1,373.60	12.8
Luxembourg	35.46	35.01	35.39	34.87	34.33	34.59	33.78	32.39	32.27	31.40	30.58	30.80	33.41	39.44	15.3
Netherlands	1.91	1.89	1.92	1.90	1.87	1.89	1.85	1.77	1.77	1.72	1.67	1.68	1.82	2.12	14.2
Norway	6.54	6.46	6.58	6.54	6.45	6.47	6.30	6.08	6.06	5.92	5.79	5.83	6.25	6.91	9.5
Portugal	149.20	147.49	149.90	148.99	146.66	148.05	144.20	138.91	138.75	134.75	130.58	131.34	142.40	157.62	9.7
Spain	109.60	108.29	109.35	108.90	103.97	103.93	100.50	96.89	98.41	95.72	93.78	95.04	102.03	118.55	13.9
Sweden	6.17	6.11	6.18	6.11	6.05	6.09	5.95	5.78	5.86	5.64	5.55	5.60	5.92	6.45	8.2
Switzerland	1.52	1.49	1.51	1.49	1.42	1.42	1.39	1.31	1.30	1.28	1.25	1.27	1.39	1.64	15.4
United Kingdom	0.61	0.59	0.62	0.62	0.60	0.59	0.55	0.53	0.53	0.51	0.51	0.52	0.56	0.61	7.4
West Germany	1.69	1.68	1.71	1.69	1.66	1.68	1.64	1.57	1.57	1.52	1.48	1.49	1.62	1.88	14.1
ECU	0.83	0.82	0.84	0.83	0.81	0.82	0.79	0.76	0.76	0.74	0.72	0.73	0.79	0.92	14.2
SWA (Base 1980 = 100)	120.39	118.82	121.33	120.07	117.62	118.15	114.07	109.50	109.61	106.30	104.17	105.31	113.78	130.20	12.6
Japan	145.08	145.71	152.96	158.38	153.90	153.76	149.16	147.65	138.40	129.69	128.77	133.03	144.71	138.07	(4.8)

Source: Dataquest (March 1991)

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Research Newsletter

EUROPEAN COMPUTERS 1990—THE YEAR IN REVIEW

INTRODUCTION

Last year the European computer market was characterized by consolidations, tightening margins and financial difficulties. Most major vendors, including the largest European players, suffered from reorganizations and layoffs worldwide throughout the year. The workstation and midrange market segments, especially in the area of client or server technology, reflected a new focus within the computer industry. The growth of interest in the UNIX/open systems arena was also a barometer of change.

In this newsletter Dataquest provides the data for the 1990 European computer industry. We also outline the factors that will affect the success of European players throughout the 1990s. Individual country trends are reviewed within the light of the overall course of the market.

MARKET OVERVIEW

Dataquest estimates that the total market for European computer systems grew by approximately 6 percent in value in 1990 at a constant dollar rate (see Table 1). This figure includes sales of all computer systems but excludes personal computers. However, PC platforms used as multiuser systems and UNIX performance PCs, competing with workstations, are included. Total shipments for 1990 reached nearly $28.7 billion, with the fastest-growing product segment being the workstations including UNIX performance PCs.

This newsletter is organized according to Dataquest's architecture classes. The market is segmented into supercomputers, mainframes, midrange systems and workstations. Midrange systems are an

TABLE 1
Market Growth by Product Segment 1989 to 1990

Segment	1989 End-User Revenue ($M)	Growth* (%)	1990 End-User Revenue ($M)
Supercomputers	$417	15%	$480
Mainframes	$9,643	7%	$10,300
Midrange Systems	$13,674	1%	$13,505
MUPCs	$1,239	45%	$1,800
Workstations	$2,030	19%	$2,415
UNIX Performance PCs	$96	72%	$165
Subtotal	$27,099	6%	$28,665
Standard PCs	$13,880	13%	$15,684
Total	$40,979	8%	$44,349

* At 1989 constant dollar exchange rates
Source: Dataquest (February 1991)

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amalgamation of superminicomputers, minicomputers and microcomputers, the last-named of which includes multiuser PCs. Workstations include UNIX performance PCs.

Note: Exchange Rates

Dataquest has used 1989 exchange rates to compile the information contained within this newsletter. The 1990 rates were not finalized at the time of writing. As a guideline, Dataquest estimates that market values expressed in dollar end-user revenue at the 1990 dollar exchange rates would be approximately 15 percent higher than the figures in this report.

European Players

As they face economic uncertainty and the continuing encroachment of Japanese and US players into the European market, European vendors are implementing strategies to help maintain their positions. As a product of this, two companies, ICL and the Kienzle division of Mannesmann, lost their independence last year to Fujitsu and Digital respectively. In addition, Nixdorf was acquired by Siemens in an inter-European deal. Clearly, the worldwide market of the 1990s will only support a small number of vendors, including perhaps only two or three European players. The demise of many well-known industry names has even been discussed.

The ICL–Fujitsu deal represented the first major encroachment within Europe by a major Japanese systems company. The Mannesmann–Digital tie-up was particularly significant for two reasons:

- It was catalysed by Mannesmann's failure to acquire Nixdorf: Mannesmann had realized that its Kienzle division lacked the critical mass to remain independent within the highly competitive market of the 1990s and decided to look for partnerships with other players.
- This is probably the first major acquisition of a major European systems vendor by a US-based company.

Dataquest expects that the developing strategies of the European players will decide whether these companies can maintain significant market share in the computer industry.

Major Findings

Gross margins continue to be low and are still dropping, contributing to the losses reported by many of the manufacturers. Margins are particularly affected by three main factors:

- A continuing trend for users to buy PCs and low-end solutions, which are low-margin, commodity items
- A growing level of competition in traditionally high-margin areas such as mainframes
- The rapid increase in development of UNIX-based product lines by most of the major manufacturers

The last point needs further explanation: UNIX-based systems give the user more freedom to choose a vendor without being obligated to maintain vendor loyalty. This freedom heightens competition and forces vendors to be particularly competitive on price. Furthermore, they have to differentiate their products, which are built around standard components and environments, from those of their competitors. To achieve this, vendors have to dedicate significant resources to the development of additional functionalities and added value in general. As a consequence, they are obliged to focus large resources on research and development of open systems, while continuing to support their proprietary line of products. All of this adds millions of dollars to their costs.

COUNTRY OVERVIEW

Each European country was influenced to a greater or lesser extent by the factors that affected the major players. The major markets in Europe are summarized in Table 2.

Europe will continue to provide a significant portion (probably rising) of the computer industry's revenue in the 1990s. Many US and Japanese vendors are introducing new facilities for research and development or manufacturing in Europe. Whether the European vendors retain their market position in this light remains to be seen. Table 2 shows the relative growth of the IT industry in Europe by country.

In France, demand for high-end systems was strong, but the midrange segment was below expectations. The German market was primarily influenced by unification and the opening up of trade with Eastern Europe. It appears likely that growth in Germany will remain reasonably strong in 1991 as the process of unification proceeds. In Italy the market slowed down more than had been expected and grew in line with the rest of Europe. During the 1980s, growth in Italy usually exceeded the European norm, but is not expected to do so in 1991. This, in part, reflects the penetration of PCs into sectors traditionally dominated by minicomputers. Spain remains the fastest-growing major market where penetration of IT continues to catch up with the more developed areas of Europe. The UK market was heavily influenced by the economic recession in the country.

Although sales in the first quarter of 1990 held up above expectations, sales of midrange systems and mainframes combined are estimated to have declined slightly during the second half of the year as compared with the corresponding period of 1989.

COMPUTER MARKET SEGMENTATION

Supercomputers

This segment is led by Cray, which holds the leading market share. However, the traditional supercomputer (typified by Cray's systems) is under increasing threat from newer architectures such as departmental supercomputers (typified by systems from Convex) and research supercomputers (often parallel processors). Cray itself acknowledges this with the introduction of the lower-priced XMS system. Superworkstations are also starting to compete for similar budgets (but have been included in the workstation estimates, and not in the supercomputer estimates). In addition, the mainframe augmented by a vector processor has shown itself to be a viable alternative to the larger supercomputers in a number of cases. This environment is overwhelmingly dominated by IBM in Western Europe.

TABLE 2
Computer Market Growth of Major European Countries 1989 to 1990

Country	Market Growth ECIS Systems	Market Growth ECIS and EPCIS Systems*
France	6%	8%
Germany	7%	9%
Italy	6%	8%
Spain	8%	10%
United Kingdom	3%	5%
Total Europe	6%	8%

* End-user revenue from sales of all new PCs, workstations, midrange systems, mainframes and supercomputers
Source: Dataquest (February 1991)

TABLE 3
Value of Shipments for Supercomputers Western Europe 1990

Vendor	End-User Revenue ($M)	Growth 1989/1990* (%)	Market Share (%)
Cray	$235	4%	49%
IBM	$115	20%	24%
Convex	$80	43%	17%
Alliant	$16	0%	3%
Others	$34	47%	7%
Total	$480	15%	100%

* At 1989 constant dollar exchange rates
Source: Dataquest (February 1991)

The growth in the supercomputing segment in 1990 was oriented to the lower-priced architectures (departmental supercomputers and research supercomputers), which grew an estimated 35 percent over 1989. The mainframe-vector segment grew 20 percent while the traditional corporate supercomputer segment grew 5 percent. The overall segment grew 15 percent. These trends reflect a degree of saturation among potential users of corporate supercomputers, and investment by academia and some leading-edge users in novel architectures such as Transputer-based systems. The strength of the mainframe-vector segment reflects IBM's commitment to this solution and successful market development in academia and industry during the late 1980s. Table 3 shows revenue and market share for the leading supercomputers in 1990.

Mainframes

Even though many people in the industry predicted (on several occasions) the death of the mainframe to be in or even before the 1990s, the high-end computer market remained robust with an estimated growth of 7 percent. This is due to the central role the mainframe plays in the distributed computing environment, providing central power and storage capabilities, as well as to the critical role that it plays in the DP strategy of many companies. Its power and storage capability has continued to grow rapidly with the introduction of new high-end mainframes in 1990. Users are committed to mainframe systems to handle the "mission-critical" processing tasks and the protection of sensitive information. Development of new applications, however, is found to occur more and more on distributed platforms; RISC and CISC architectures under UNIX can be expected to be the key environments in these cases for the 1990s.

Last year, the healthy demand for mainframes was more evident in the case of the IBM-compatible environment, which gained share over competing environments. It should be noted that this reflects product life cycles as well as some decline in the installed base. Unisys and Bull both made significant product introductions in 1989 and enjoyed high growth; in 1990 they were not particularly successful with their high-end product lines (Unisys mainframes declined in excess of 10 percent, while Bull's GCOS 8 architecture showed little growth). On the credit side, Bull introduced a new high-end GCOS 7 system, the DPS 7000-700 Series, which has gained good market acceptance in terms of orders for 1991. ICL's mainframe sales stagnated in 1990, mainly due to the poor economic climate in the United Kingdom; however, upgrade business to the SX was good.

In the main, demand was strong for higher-end mainframes, and weak for lower-end systems, but growth was significant among the minor

Table 4
Value of Shipments for Mainframes Western Europe 1990

Vendor	End-User Revenue ($M)	Growth 1989/1990* (%)	Market Share (%)
IBM	$5,570	8%	54%
Siemens	$1,530	12%	15%
Bull	$690	2%	7%
ICL	$665	-1%	6%
Unisys	$545	-10%	5%
Amdahl	$455	4%	4%
Comparex	$275	10%	3%
HDS	$240	9%	2%
Olivetti	$130	40%	1%
Others	$200	21%	2%
Total	$10,300	7%	100%

* At 1989 constant dollar exchange rates
Source: Dataquest (February 1991)

players in the mainframe market. This was due to the successful introduction of new high-end products from Digital, Tandem and, at the end of the year, by Hewlett-Packard. Table 4 shows the revenue and market share for mainframes in 1990.

Midrange Systems

Midrange systems were the hardest hit in 1990, facing strong competition from workstations and PCs, pushing up from the low end, and mainframes, bearing down on them from the high end. As well as this, midrange UNIX systems are being acquired by users in place of proprietary systems. Typically, users are spending less on a UNIX system than they would do on a proprietary system, as the price/performance offered by UNIX systems exceeds that of proprietary systems. This is also affecting growth in the midrange market, and margins on UNIX systems are much lower.

The midrange market is estimated to have declined by 1 percent to reach a value of $13.5 billion. This market estimate does not include PC-based multiuser systems, but if it did the figure would grow by 2.6 percent to reach $15.3 billion.

Vendors are rapidly moving their product lines to emphasize UNIX systems most notably this year, as shown by Bull, ICL, Olivetti, Norsk Data, and IBM with the introduction of its RS/6000. Many other players have significantly increased their commitment to the UNIX environment. Vendors are finding it hard to make distinctions between their offerings, concentrating now on emphasizing applications solutions, system integration and service. They are also moving increasingly towards the integration of third-party products in their ranges in order to provide "total solutions" to their customers. Table 5 shows that all the major players faced sluggish demand in the midrange market in 1990.

IBM's AS/400 continued to grow, fuelled by upgrades at the high end while sales at the low end weakened. In the main, IBM's AS/400 systems are sold by IBM agents with vertical market expertise. The availability of a large number of these solutions has protected the AS/400 from competition with UNIX boxes to a degree. Nevertheless, growth in 1990 was below IBM's expectations and the outlook for 1991 is that the AS/400 is likely to be under increasing sales pressure, with IBM's own RS/6000 featuring among competing machines.

Digital's VAX and MicroVAX series have been sold in greater proportions to large accounts than have the AS/400 machines. Sales of the later systems have proved less robust against competition from UNIX than Digital had hoped, contributing to a decline in sales for Digital.

Bull had a good year with its UNIX systems, and 1991 promises to be better still. Growth in the UNIX ranges compensated for declining sales among the GCOS 6 family, and disappointing sales at the lower end of the DPS 7000 range.

Siemens-Nixdorf Informationssysteme (SNI) had a difficult year in the midrange area. This was certainly due in part to difficulties in combining the two companies. As anticipated, Nixdorf's proprietary 88xx ranges declined substantially; a long-term future in these architectures is clearly not foreseeable, and users are phasing out their expenditure on these systems. More surprisingly, UNIX sales (Targon from Nixdorf, MX from Siemens) were well below expectations.

A number of causes lie behind these results: increased competition in the UNIX market; over-reliance on the German market; a need to develop more channels of distribution; increased competition; and confusion caused by IBM's first real commitment to the UNIX world with the launch of the RS/6000. However, the most significant problems relate to the general uncertainty following the takeover of Nixdorf and issues resulting from the existence of the two product lines. Overall, these issues should be resolved in 1991.

Hewlett-Packard met with outstanding success in the UNIX minicomputer segment with its 9000-800S series. The company is challenging SNI for the top position in this market. The UNIX range now accounts for 50 percent of the company's midrange shipments in value terms in Europe, up from 34 percent in 1989. In the main, the proprietary systems have entered periods of slow decline.

Workstations

In 1990, a plethora of new announcements across the whole platform range and from all the major players injected even greater competition into the workstation market, especially at the entry-level end, but the market slowed down substantially. However price/performance gains should allow growth in 1991 to equal or exceed the 1990 figure. Table 6 shows 1990 workstation revenue and market share.

Table 5
Value of Shipments for Midrange Systems Western Europe 1990

Vendor	End-User Revenue ($M)	Growth 1989/1990* (%)	Market Share (%)
IBM	$3,470	5%	23%
Digital	$2,010	-5%	13%
Bull	$1,305	1%	9%
SNI	$940	-17%	6%
HP	$930	13%	6%
Unisys	$565	1%	4%
Others	$4,285	-3%	28%
Traditional Midrange Subtotal	$13,505	-1%	88%
Multiuser PCs**	$1,800	45%	12%
Total	$15,305	2.6%	100%

* At 1989 constant dollar exchange rates
** IBM-compatible PCs supporting multiple concurrent users (mainly UNIX- or Xenix-based)
Source: Dataquest (February 1991)

Table 6
Value of Shipments for Workstations Western Europe 1990

Vendor	End-User Revenue ($M)	Growth 1989/1990* (%)	Market Share (%)
HP	$800	10%	31%
Sun	$525	27%	20%
Digital	$520	5%	20%
IBM	$160	108%	6%
Intergraph	$160	20%	6%
SGI	$75	40%	3%
Cetia	$35	21%	1%
Others	$140	37%	5%
Traditional Workstation Class Subtotal	$2,415	19%	94%
PC Workstation Class**	$165	72%	6%
Total	$2,580	21%	100%

* At 1989 constant dollar exchange rates
** PC-based workstation competitors running UNIX.
Note: It should be noted that all workstation class systems are included in Table 5 with the exception of 30 percent of IBM's RS/6000 systems, which have been sold as multiuser UNIX systems supporting dumb terminals. These systems have been included under the midrange category.
Source: Dataquest (February 1991)

Sun

The low-price SLC and IPC from Sun, and the strong entry from NeXT, are bringing the workstation market into greater proximity to the PC market. At this low-price end, workstations are being treated as commodity items.

Conversely, at the high end, workstation manufacturers are beginning to realize that customers wish to protect their investment. Sun's announcement of the SPARC 2 included the possibility of field-upgradability from the SPARC 1. IBM announced field-upgradability for its high-end 530 and 540 users to the new 550 model late last year, like Sun demonstrating its commitment to provide customers with long-term investments.

Hewlett-Packard

Growth in the marketplace was hampered by delays with the Motorola 68040 chip, although HP's midyear introduction of the 9000 series 400 produced quite strong sales.

Digital Equipment

Digital's product line was further enhanced with high-end DECstation announcements, coupled with a comprehensive range of software for these ULTRIX boxes. However, the company faced the problem of supporting both its higher-price VMS VAXstations and the better price/performance DECstations.

IBM

IBM's release of its workstation, the RS/6000, has truly accelerated the movement of the workstation market from the technical arena into commercial acceptability. The performance ratings taken of the RS/6000 put it as a serious competitor to IBM's proprietary lines, especially the AS/400, which will add to the pressure on sales of this line.

Distribution

Third-party distribution channels have traditionally been focused on OEM relationships. More recently, complex and large-scale distribution channels are being formed by companies only recently aware that indirect sales through VARs could soon provide the majority of their revenue. The push for "shrink-wrapped" software is growing out of customer and reseller desire to make UNIX standard and easy. Standards bodies, such as X/Open and the two main UNIX groupings, UNIX International and Open Software Foundation, are addressing almost every area of system integration.

Summary

Overall, 1990 was a difficult year in the computer market, worldwide and in Europe. In addition, the prospects for 1991 are currently very uncertain and will be severely influenced by the economic outlook and events in the Middle East.

In 1990, computer manufacturers operated within a weakening economic environment. In the main, economies continued to perform poorly in the second half of 1990, and Europe has not escaped this trend. Within Europe, the United Kingdom has moved into a recession; this may occur in other countries in 1991. The effect of the economic slowdown has been felt by the computer industry, which tends to reflect changes in capital investment and the general economic climate.

(This newsletter was originally published by Dataquest's European Computer Industry Service).

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Research Newsletter

EUROPEAN SEMICONDUCTOR PROCUREMENT SURVEY 1990 TREND ANALYSIS

INTRODUCTION

This research newsletter analyses the results of Dataquest's annual European semiconductor procurement survey, conducted by the European Components Group. The survey serves two major purposes. Firstly, it indicates key trends in semiconductor procurement from the purchasing community, which is used as an input to modelling future semiconductor demand by product category. Secondly, it provides an insight into the buying habits of the purchasing community in different equipment sectors.

OVERVIEW—THE CUSTOMER IS STILL ALWAYS RIGHT

The issues most frequently cited by buyers are quality, on-time delivery and price. This newsletter shows that a huge gap remains between the requirements of the buying community and the performance of major vendors in meeting these requirements. Dataquest believes that as the new decade advances, service will become a major battleground; it will be used increasingly by buyers to differentiate between otherwise successful vendors. This, together with buyers' desire to reduce the number of vendors they use, will require vendors to carefully balance their future investment between R&D, manufacturing and customer service. Customer service includes electronic data interchange (EDI) for purchase orders, invoicing, and order acknowledgement, technical and application support, and logistic planning of purchases through to final, timely delivery at the specified quality and price.

SURVEY RESULTS

Data Processing—Europeans Need to Adapt Internationally

In our survey, all purchasing executives of the data processing segment indicated that purchasing of semiconductors in 1990 was reduced by a factor of at least 10 percent, compared with 1989. Their 1991 semiconductor spend is expected to recover to the 1989 level.

In the mainframe sector, more than 50 percent of the revenue from ICs purchased is accounted for by memory devices, followed by 21 percent ASICs and 20 percent microcomponents. Of the ASICs purchased, 50 percent are standard cells, 40 percent gate arrays and 10 percent programmable logic. Discrete devices comprise the smallest spend at 3 percent.

In the personal computer sector, 50 percent of revenue from ICs purchased is from memory devices, 25 percent from ASICs, followed by 20 percent from microcomponents. Of the ASICs purchased, 70 percent are gate arrays and 20 percent standard cells.

Dataquest found some major differences in the purchasing methods between certain computer manufacturers, namely: North American–owned multinationals and European-owned companies. While North American computer manufacturers hardly used any distribution suppliers, European computer manufacturers purchased up to 10 percent of their semiconductor supply from distributors. This suggests that European inventory control is inadequate, occasionally relying on the spot market for top-ups.

North American multinationals ran the tightest inventory, currently carrying 2 weeks stock with a goal to reduce to 1 week. Their European

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counterparts carry an inventory of 5 weeks with a long way to go for a desired goal of 1 week. One leading North American multinational in Ireland has a current inventory of 8 days with a goal to reduce it to 4 days. A sizeable European computer company is carrying 50 days of inventory, with a goal to reduce this in the long term, but does not expect it to change in 1991.

European computer companies' usage of ASICs is relatively low compared with the North American multinationals. Clearly, one area that European computer manufacturers need to address immediately is their purchasing strategies. In 1990, most multinational computer companies decreased their semiconductor spending, and some European companies increased their spending. This indicates that European companies either lack the bargaining power associated with volume purchases, or increase inventory after misreading price trends.

Buyers' overall concerns in the data processing sector are volatility of memory prices and the large number of vendors they currently do business with.

Communications—Consistent Growth

This was the most optimistic and buoyant of all the end-user segments surveyed. Purchasers in this segment increased their 1990 semiconductor spend by up to 10 percent. Most expect this to increase in 1991 by between 12 and 20 percent.

Currently, the switching market is the most dynamic sector. This is due to the success of major telecoms vendors in their export markets, some of which include Eastern Europe. Transmission is another strong area, consuming more discrete components than the switching sector; consumption of these areas are 25 percent and 10 percent, respectively. The switching sector uses a large percentage of ASIC devices (72 percent of total ICs used) of which 50 percent are gate arrays and 30 percent full-custom. This sector has a relatively low penetration rate for standard cells and programmable logic. In the transmission sector, of the ASICs purchased, 50 percent are standard cells and 40 percent gate arrays.

It is interesting to note that while vendors of semiconductor memory devices continue to focus on the highly volatile EDP market, buyers in the communications sector indicated that their third-largest purchase is memory devices. In the transmission sector, 30 percent of all ICs purchased are memory-based, while in switching, 16 percent are memory-based.

In the cellular communications sector, buyers expect a growth in semiconductor spend of 15 percent in 1991, compared with a growth of 18 percent in 1990. The survey shows that 33 percent of semiconductors purchased in this sector are discrete, with RF components being the most expensive items. The next-largest product group is ASICs at 20 percent of total expenditure, of which 60 percent are gate array, 30 percent are full-custom, and less than 5 percent are programmable logic.

The communications segment has come a long way in managing its inventory. Equipment manufacturers from this segment currently carry two to four weeks of inventory, with a goal of reducing this to between one and two weeks.

Users' major concerns in this segment are product obsolescence, the reduction of vendor base, increased quality and on-time delivery.

Industrial—A Mixed Bag of Surprises

Up to 50 percent of semiconductor consumption in the industrial segment is in discrete devices. Next in rank are commodity analog at 25 percent, followed by memory and logic devices accounting for another 25 percent collectively.

This segment has the lowest penetration of ASIC products. Most purchasers indicated that less than 10 percent of their spend was in ASICs, and 40 percent of this is programmable logic due to relatively short production runs.

Inventory levels vary considerably between companies. The highest level recorded was 10 weeks, with a plan to reduce this to 6 weeks. The lowest level was 4 weeks with a goal to reduce to 2 weeks.

This remains a good segment for semiconductor distributors, with up to 30 percent of purchases made via distribution channels, which is the highest percentage across all segments. The bad news is that many respondents indicated that they plan to reduce the number of distributors they trade with.

Overall, the industrial users who were surveyed increased their semiconductor purchasing by 8 percent in 1990. The majority of respondents indicated an expected or planned increase of 11 percent in 1991. The major concerns in this segment are the reduction of vendor base, implementation of EDI, pricing and inventory cost control.

Consumer—Linked to Local Economies

It was difficult to get an adequate snapshot of this segment due to a low response level to the survey. The inputs of the few that responded suggest that spending in this segment will decline by 10 percent in 1991, with 1990 being flat compared to 1989.

This segment still uses a large percentage of discrete devices, amounting to about 35 percent of total expenditure. Many consumer segment OEMs have offshore purchasing offices, mainly in the Far East, which may affect the potential of European IC demand. Between 10 and 15 percent of purchases are placed with local distributors.

Inventories are currently running at three weeks and are expected to remain the same in 1991. Major concerns in this sector are quality, packaging, price and on-time deliveries.

Military—*Perestroika* Strikes a Blow

Of all the segments surveyed, the military segment was the most pessimistic. Some purchasers recorded as much as a 50 percent decrease in semiconductor spending for 1990, although some end users in France maintained their spend at the same level as 1989. Most purchasers expect 1991 to remain flat, or with a slight growth, depending partly on the outcome of the Gulf crisis which may drive up the replacement market.

A large percentage of military standard parts are procured through distribution channels—as much as 40 percent for sonar equipment and 20 percent for aerospace equipment. The general downturn in this segment is also affecting the purchasing organization of these companies. With recent cutbacks, many new purchasing executives have had to go through a learning curve, which disrupts traditionally long-established relationships between the manufacturer and the vendor.

Inventories are difficult to measure in this sector, but most respondents indicated a desire to reduce them by 30 percent. Major concerns include the reduction of vendor base, product obsolescence and the general health of the military equipment industry.

Automotive—Shining Light and Example for the Future

This segment currently carries the leanest inventory level in the industry, with typically two weeks of supply in stock. The goal for most automotive segment buyers is to reduce to one week. These buyers regard their vendors' current performance of just-in-time delivery, quality and pricing as insufficient to achieve this goal.

Trends in product consumption, across different automotive segment buyers, vary considerably due to the range of end products manufactured. In Germany, up to 25 percent of semiconductor consumption in this segment is in discrete components and 38 percent in ASICs, of which almost all are full-custom designs. Meanwhile, in Italy, only 17 percent of semiconductor spend is in discrete components, but on the other hand these users spend 66 percent in ASICs, of which 70 percent are cell-based designs. Microcontrollers account for 40 percent of semiconductor demand in Germany, while in Italy only 7 percent of the demand is in microcontrollers. Across the automotive segment there is relatively low demand for commodity analog or logic devices.

This segment increased its semiconductor purchase by 12 to 15 percent in 1990. Due to recessionary fears, buyers expect to increase their purchase by only 8 to 10 percent in 1991. Major concerns in the segment are on-time delivery, quality and price.

DATAQUEST PERSPECTIVE

One of the key issues this survey has brought to the fore is that OEMs, in most segments, wish to reduce the number of vendors with whom they do business. The motivation is to minimize unneccesary paperwork and maximize large-volume discounts. Buyers are generally becoming more strategic in their purchasing plans, thereby reducing short-term spot market and distribution purchases. The emphasis is on building up strong relationships with key vendors.

Table 1 summarizes the factors that will determine the success or failure of vendors in the 1990s. These include on-time delivery, quality, and pricing. It is clear that vendors must refocus on service as well as price in order to win their customers' loyalty. Many OEMs evaluating the total cost of ownership of a product realize that unit price is just the tip of an iceberg.

Bipin Parmar
Byron Harding

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TABLE 1
Summary of Respondents' Issues

Application Segment	Data Processing	Communications	Industrial	Consumer	Military	Automotive
Respondent's Expectations						
Growth 1989-1990	-10%	+10%	+8%	No Change	-30%	+12-15%
Growth 1990-1991	+10%	+12-20%	+11%	-10%	No Change	+8-10%
Present Inventory Level (Weeks)	1-7	2-4	4-10	3	Indefinite	2
Target Inventory Level (Weeks)	0.5-2	1-2	2-6	3	Indefinite	1
Procurement Issues						
1 = Weakest Issue						
10 = Strongest Issue						
ASICs	4	7	5	5	8	3
Availability	7	10	8	NA	4	2
Cost Control	5	6	6	NA	3	7
Fluctuating Exchange Rates	5	4	3	NA	2	4
Forecasting	7	6	8	NA	6	5
Inventory Control	5	6	7	5	7	7
Memories	6	6	7	5	6	2
Product Obsolescence	7	7	4	NA	5	3
Offshore Procurement	4	6	2	NA	1	2
On-Time Delivery	8	7	9	5	7	5
Pricing	8	8	9	5	9	9
Quality and Reliability	8	8	9	5	10	10
Reduce Vendor Base	6	7	9	5	9	4
Second Sourcing	4	6	6	NA	7	5
Surface Mounts	3	8	8	NA	1	4
Other Issues	NA	NA	9	NA	5	NA

NA = Not Available
These results reflect the views of respondents to the procurement survey and are not aggregated to reflect total market statistics.
Source: Dataquest (February 1991)

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Research *Newsletter*

ENGINE MANAGEMENT SYSTEMS IN EUROPE

SUMMARY

Dataquest estimates that in 1989 European engine management systems (EMS) semiconductor consumption was worth $286 million. During 1990, we estimate that $295 million worth of semiconductors were consumed by this one application, representing an annual growth rate of 3.2 percent. Last year's poor growth was due to a combination of depressed car sales and the maturity of penetration in top-range cars. However, with the considerable future potential of EMS to address many design problems besides fuel economy (for example, noise reduction, safety and reliability), we expect considerable growth in this area for the remainder of the 1990s.

The automotive electronics industry is steadily making the transition from being technology *driven* to becoming a technology *driver*. The nature of automotive design and development makes EMS a major cost overhead for the car manufacturer. In addition to the cost of hardware development, the vendor must bear the rapidly growing costs of software development. Rampant growth in automotive R&D costs has led to many joint ventures in all aspects of automotive technology, including production. These business relationships have also spread to include the semiconductor industry—such ventures were on the increase during 1990. This newsletter reviews some key alliances announced over the past 12 months.

INTRODUCTION

Fuel consumption first became a major issue for the motorist during the 1973 oil crisis. The oil shortage that followed forced engineers to review alternative ways of reducing this dependence on oil-related fuels. Electronics provides many solutions to help improve fuel efficiency. Recent legislation from the European Commission, which stipulated that there should be minimum levels of toxic fuel emissions and pollutants from motor vehicles, has further encouraged vehicle manufacturers to introduce electronic means of meeting these requirements.

An engine management system consists of electronic carburetor control or electronic fuel injection (EFI) combined with a programmed electronic ignition module (EIM) as shown in Figure 1. Thus the unit housing the electronic circuitry of these systems is commonly referred to as an electronic control unit (ECU). As the cost per electronic function declines, engine management systems will become an increasingly important means for the automotive manufacturer to differentiate its models from competing offerings.

EIMs are replacements for contact-breaker ignition systems. They commonly use hybrid technology to replace breaker points used for engine ignition timing, and give significantly better idle speed control than mechanical breaker points, thereby reducing exhaust emissions.

EFI normally incorporates a carburetor or fuel-injection control with an engine diagnostic or correction function. The ECU receives signals via sensors to control the function of electromechanical parts in the engine and fuel management. The three major types of EFI are for electronic carburetor control, single- or multipoint fuel-injection systems for petrol engines, and electronic control for diesel engines.

PRODUCTION

Table 1 lists the locations of EMS manufacturing companies, their products, and some of their key customer bases. The leading supplier country to the European marketplace is Germany, followed by France, Italy, and the United Kingdom. Not surprisingly, the geographic pattern of automotive

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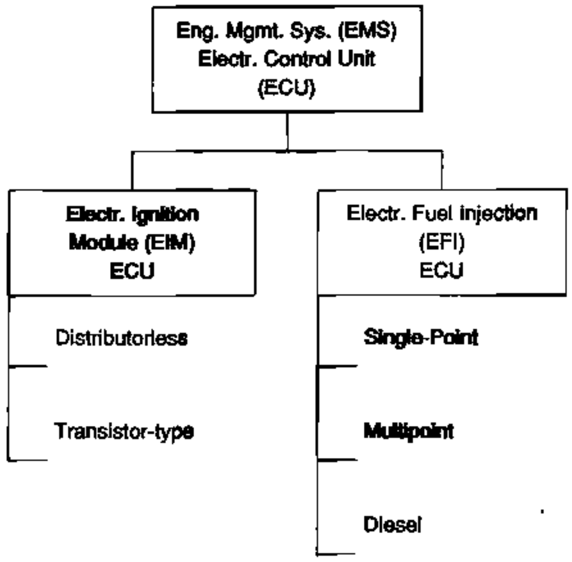
FIGURE 1
Engine Management System Family Tree



Source: Dataquest (February 1991)

equipment production tends to be consistent with national levels of car production.

Estimated unit volume production of systems by company is shown in Table 2. These estimates represent total unit production for engine control, fuel injection, and ignition control systems manufactured by each company. This past year has seen major announcements of new contracts won by EMS manufacturers. A number of manufacturers have also emerged on the scene, and Lucas among others has demonstrated a significant contribution to the EMS market.

Lucas commenced EMS supply to BMW last year (at the rate of 400,000 units per annum). Saab (a GM subsidiary) is also believed to be negotiating EMS supply from Lucas. In addition, Lucas has recently announced a $300 million investment to develop and produce EMS units for diesel engines.

The very high growth rates anticipated in the EMS market are attracting new entrants such as Lucas, Pierburg and Kraftfahrzeug-Elekronik (KEN) GmbH as well as established manufacturers such as Robert Bosch and Magneti-Marelli. After manufacturing and supplying low-margin electromechanical parts (starters, alternators, wiper motors and so on), Lucas has embarked upon an ambitious plan of related diversification with its launch into EMS products. Besides EMS, Lucas also manufactures antilock braking systems (ABS), is actively developing multiplex systems, and consequently has become a major semiconductor consumer in a relatively short time.

SEMICONDUCTOR CONTENT

Table 3 shows our estimates of semiconductor content gathered from industry sources. Table 4 gives an overview of car production in Europe, the percentage of EMS penetration by class of model, production, average semiconductor content per unit, and average selling prices for the forecast period 1984 to 1995. Our estimates for EMS consumption are founded on Dataquest's database and analysis of car production in Europe. The data is also supported by manufacturers' estimates of car production by engine type, which is given in Table 5. Although car sales in Europe have suffered in the last year and are forecast to decline further in 1991, continued EMS penetration is almost guaranteed following the release of European Commission regulations on car exhaust emissions.

Currently, Intel's 80C51 and Motorola's 68HC11 parts dominate the market with both vendors responding to the growing performance needs of EMS. They are offering new embedded CISC EE/EPROM products targeted specifically at the automotive segment. There is a general migration away from 8-bit technology to 16-bit configurations, with some players recently introducing 32-bit MCUs (for example, Motorola's 68332) to this segment.

TABLE 1
Manufacturers of Electronic Engine Systems within Europe

Supplier Company	EMS	EIM	EFI	Subcontr.	Plant Location	Major Customers
AB Electronics Automotive			✓	✓	Cardiff, Wales	Jaguar
Ford Electronics Division			✓		Cádiz, Spain	Ford's own
GM Delco Remy/AC Rochester			✓		Ande, France	GM Europe
Hitachi Automotive			✓		Munich, Germany	Volkswagen, Audi
Kraftfahrzeug-Elektronik (KEN) GmbH		✓	✓		Nürnberg, Germany	VW-Audi
Lucas	✓	✓	✓		Birmingham, England	Jaguar, BMW, Saab
Magneti-Marelli	✓	✓	✓		Cinsello, Italy	Fiat, PSA, Renault
Motometer (Diagnostic Systems)				✓	Leonberg, Germany	
Motorola AIEG				✓	Hitchin, England, and France	Rover, Ford
Pierburg GmbH			✓		Neuss, Germany	
Robert Bosch	✓	✓	✓		Stuttgart, Germany	Audi, BMW, Ford, GM, Mercedes-Benz, Porsche, Rolls Royce, Saab, Volkswagen
Saab Auto Engineering					Trollhatton, Sweden	Saab
Siemens Automotive Group (includes Siemens Bendix)	✓	✓	✓		Regensberg, Germany, and Toulouse, France	BMW, PSA Group, GM, Volkswagen
Telefunken		✓			Ingolstadt, Germany	
TRW (Automotive) Messmer GmbH			✓	✓	Radolfzell, Germany	
VDO Adolf Schindling			✓	✓	Schwalbach, Germany	Mercedes-Benz
Zytek Autmotive Ltd			✓	✓	Sutton Coldfield, England	Jaguar, Lotus

Note: EMS = Electronic management system: EFI, Carburetor (single- and multipoint) or diesel control, combined with ignition
EIM = Electronic ignition module
EFI = Electronic fuel injection, carburetor (single- and multipoint) or diesel control
Source: Dataquest (February 1991)

TABLE 2
Estimated Annual Production of Electronic Engine Systems in Europe (Millions of Units)

Supplier Company	1988	1989	1990
AB Electronics Automotive	0.20	0.25	0.30
Ford Electronics Division	0.40	0.46	0.50
GM Delco Remy/AC Rochester	0.50	0.55	0.60
Hitachi Automotive	0.00	0.00	0.10
Kraftfahrzeug Elektronik Nürnberg GmbH	Figures included in Siemens estimates		
Lucas	0.70	0.81	0.90
Magneti-Marelli	1.00	2.36	2.45
Motometer (Diagnostic Systems)	0.08	0.09	0.11
Motorola AIEG	0.50	0.55	0.65
Pierburg GmbH	0.15	0.17	0.20
Robert Bosch	3.30	3.80	4.20
Saab Auto Engineering	0.10	0.12	0.13
Siemens Automotive Group (includes Siemens Bendix)	0.65	0.75	0.85
Telefunken	0.10	0.15	0.20
TRW (Automotive) Messmer GmbH	0.20	0.23	0.25
VDO Adolf Schindling	0.20	0.25	0.30
Zytek Autmotive Ltd	0.05	0.06	0.07
Total	8.13	10.59	11.80

Note: Production volumes show total ECUs produced across all applications denoted in Table 1.
Source: Dataquest (February 1991)

TABLE 3
1990 Semiconductor Content Estimates for Electronic Control Modules

Module	($ per Unit)
EMS	$35
EIM (Ignition)	$15
ECU (Engine Control Unit)	
EFI—Multipoint	$30
EFI—Single-Point	$22
Average Semiconductor Content per Vehicle	$25

Source: Dataquest (February 1991)

CMOS is by far the most dominant technology for engine control applications because it is low cost and has low power consumption. CMOS technology advances are also paving the way for the next phase in automotive electronics—multiplexed wiring and advanced module-to-module communications.

The semiconductor vendor looking to supply the automotive market will need to qualify its parts according to very stringent requirements on quality. Key factors affecting qualification include:

- Ability to provide inventory for just-in-time delivery (in some cases *daily* deliveries are required)
- Parts-per-million defect levels below 100 (as low as 50 in some cases)
- Design-to-market times of less than 3 years
- Guaranteed working lifetimes of 5 to 10 years for zero-defect ICs
- Warranty provisions made by the semiconductor vendor

The inventory requirement is not exclusive to semiconductor vendors, but is one that virtually *all* suppliers to the automotive industry now have to meet. In terms of performance and reliability, the motor industry places heavy demands on the vendor. Harsh engine environments mean that many working devices must withstand temperatures of between minus 65°C and plus 150°C. Most currently available parts only cover a subset of this range: minus 45°C to plus 85°C. Longer working lifetimes of automotive equipment are required by the motor industry, but the semiconductor vendor has relatively little knowledge or control of how the motorist will use the equipment. Together, these requirements tend to imply higher development costs than for equivalent parts sold into other non-automotive applications.

BUSINESS ANNOUNCEMENTS

A number of key announcements have been made by semiconductor manufacturers and car equipment manufacturers over the past year relating to EMS. Some of the main ones are highlighted below:

- **Delco-Remy**, a General Motors (GM) subsidiary, revealed plans in 1989 to start building integrated coil electronics (ICE) in Portugal. ICE systems replace conventional electromechanical distributor systems. Capacity will eventually reach half a million per annum.
- **Ford** announced that it will invest $68 million in an engine control module plant in Cádiz, Spain with production scheduled to commence in 1991. These parts are mainly for European consumption by Ford's own car divisions.
- **Hitachi** and **Audi** have a joint-development program for engine controllers (specifically for the Audi Quattro models). Their controllers are already used in the 1990 model Audi 90 2.3-liter engine for ignition and multipoint fuel injection. Hitachi has also set up an automotive application research unit in Munich. This outfit operates independently of Hitachi's semiconductor group, and is currently staffed by three engineers from Japan.
- **Hughes Semiconductor** (a GM subsidiary), the parent company of **Delco Electronics**, has announced setting up an $80 million semiconductor plant at Málaga in Spain for 1991 to serve the European market. The new fab will employ 400 people.
- **Lucas** holds a master patent for digital engine mapping and has licensed a few Japanese and North American car component suppliers. Digital engine mapping is a technology for digitized ignition control and engine control allowing precise electronic gauging for engine movement, which will avoid engine knock.
- Last year, **Motorola** set up a microchip research, development, and technology center in Munich and announced a plan to look at emerging automotive applications; it plans to have eventually 9 to 13 engineers. Motorola is also talking to **Ford** as an outside EMS supplier to supplement Ford's own in-house products. Motorola also supplies the **VW-Audi** group with 68HC11 microcontrollers for Golf and Jetta engine controller units.
- **Motorola** and **Marelli** are to jointly develop and manufacture fuel-injection control modules. Between the two companies, production of these new systems is expected to be 2 million a year. About one-third of Magneti-Marelli's sales will go to its parent company, Fiat. The remainder will go to PSA, Renault, Ford, GM, Volkswagen, BMW, Volvo and Saab. Magneti-Marelli also owns Ufima the fuel-injection and dashboard-electronics supplier. Ufima has about a two-third share of the carburetor market in Europe. Strate-

gically this move is expected to give it a prime position on the market when European control standards on emissions come into force in 1992.

- Siemens Automotive Group is working on an electronic throttle designed around a Motorola 68HC11 with internal memory. This drive-by-wire system is expected to enter production in the 1993 to 1995 timeframe. Siemens also supplies BMW with ECUs (FENIX III, IV, V) containing 8-bit MCUs. In preparation for 1992, an agreement on a single-point, fuel-injection system has been signed with Pierburg GmbH. Pierburg will supply fuel-injection bodies and actuators for Siemens. Production is expected to commence in 1991.
- Toyota in Brussels, Belgium has adapted Motorola parts for high-end engine control. Toyota has a 16x part (MCU) developed by Motorola and has licensed Toshiba as second source. This part was designed explicitly for engine and transmission control. Fujitsu in Japan is already working through Nippondenso with Toyota on ABS and engine control.
- VDO is also believed to be working on electronic throttle systems for Mercedes and BMW luxury cars.

CONCLUSIONS

European Commission legislation will be the driving factor for rapid EMS penetration in the 1990s. Dataquest estimates that EMS penetration is currently at 34 percent across all car production in Europe. We expect to see nearly 95 percent penetration in cars assembled in Europe by the end of the decade as further penetration into mid- and low-range cars continues. Penetration of electronic fuel injection should grow at a faster rate, but this will depend on the cost ratio benefits of enhancing or replacing nonelectronic systems.

Economic pressures of the oil industry and political factors prevailing in the Middle East are also responsible for the growth in EMS. Over the last five years, we have seen steady growth in all fuel-injected engines, both diesel and petrol. Increased consumer awareness of the reduced threat that these engines pose to the environment, combined with higher performance and greater fuel efficiency, will continue to drive growth of this market into the next century.

We believe the 1990s will offer the opportunity of optimizing the true value and contribution of electronics to achieve integration between the person, the vehicle and the environment. Car design will increasingly focus on ride quality, handling properties, and powertrain optimization based on economy, emissions and driving performance. However, at the moment the harsh environment of the car engine and the level of reliability offered through existing sensor technology makes these objectives difficult to achieve. Electronic modules have now earned a reputation for reliability but sensor technology for input data will need to be improved to achieve higher credibility.

Penetration of electronics into the motor vehicle meets one obstacle: the rising costs of R&D, specifically the variable costs of elements of technology development, typically software engineering, which is open to management intervention.

In terms of product technology, we expect developments in semiconductors and improvements in sensor reliability to allow the complete integration of electronic engine control and ignition systems as one unit inside the engine. Memory requirement will increase as automotive control module databases of the future seek nonvolatile electrically erasable memory of a megabyte scale.

Mike Williams

TABLE 4
EMS Production and Semiconductor Forecast

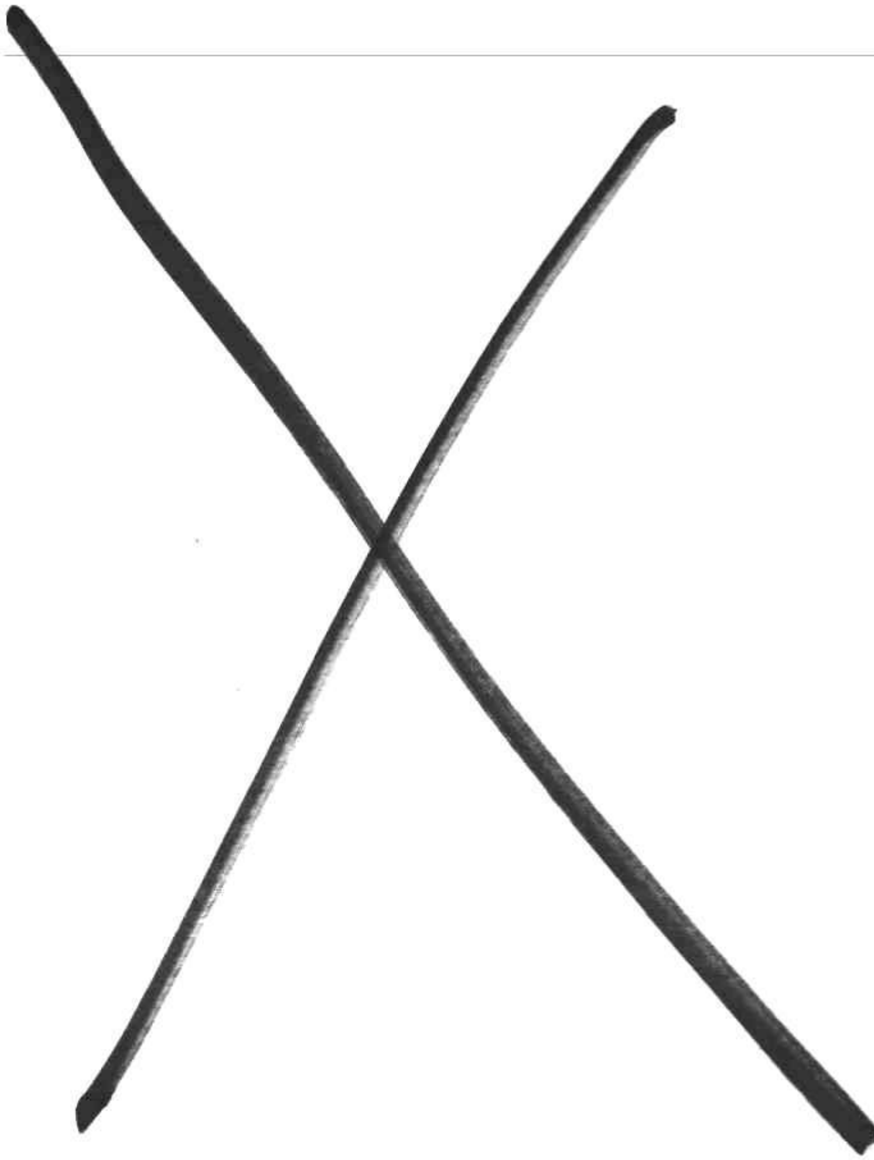
Overview	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total Car Production									
Top-range Cars (M)	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5
Midrange Cars (M)	6.6	7.1	7.3	7.9	8.1	8.2	8.2	8.3	8.4
Low-range Cars (M)	4.5	4.5	4.5	4.5	4.6	4.6	4.6	4.6	4.6
Total	12.4	13.0	13.2	13.9	14.2	14.2	14.3	14.4	14.5
Percentage EMS Penetration									
Top-range Penetration	89.3%	94.8%	96.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Midrange Penetration	32.8%	35.2%	35.5%	36.0%	38.0%	40.0%	48.0%	60.0%	70.0%
Low-range Penetration	4.1%	9.0%	9.5%	10.0%	12.5%	14.0%	16.0%	18.0%	25.0%
Total	28.4%	32.5%	33.2%	34.2%	36.2%	37.9%	43.1%	50.8%	58.9%
EMS Equipment Production									
EMS Consumption (Units M)	3.5	4.2	4.4	4.7	5.1	5.4	6.2	7.3	8.6
Revenue ($M ex-factory)	$2.6	$3.0	$3.0	$3.1	$3.3	$3.4	$3.8	$4.5	$5.1
Percentage Local Consumption	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
EMS Production (Units M)	6.0	8.1	10.6	11.8	13.0	14.0	15.8	16.7	17.8
Value ($M)	$4.4	$5.8	$7.2	$7.7	$8.4	$8.8	$9.8	$10.2	$10.6
ASP Breakdown ($)									
ASP for Top-range Cars	$800	$775	$750	$725	$720	$715	$710	$700	$695
ASP for Midrange Cars	$700	$675	$650	$625	$615	$600	$595	$590	$580
ASP for Low-range Cars	$700	$650	$625	$600	$595	$590	$580	$575	$550
Unit ASP ($)	$734	$704	$679	$653	$643	$630	$621	$611	$596
Weighted Average Semiconductor Content per Unit	$33	$30	$27	$25	$25	$25	$25	$25	$25
Semiconductor Consumption ($M)	$198	$244	$286	$295	$325	$350	$395	$418	$445

ASP = Average selling price
Source: Dataquest (February 1991)

TABLE 5
European Car Production by Fuel Type (Units)

Engine	1984	1985	1986	1987	1988
Diesel	1.6	1.9	2.0	2.0	1.8
Petrol	9.0	9.3	9.8	10.5	11.2
Total	10.6	11.1	11.7	12.4	13.0
Of Which:					
Fuel-Injection Engines (Unit Production)	3.4	4.0	4.4	5.0	5.5
Fuel-Injection as percentage of Total Production	32.3%	36.1%	37.9%	40.5%	42.0%
Annual Growth Rates of EFI	NA	16.9%	10.5%	13.6%	8.1%
Diesel Engines as Percentage of Total Production	15.0%	16.7%	16.9%	15.8%	14.0%
Direct/Indirect Injection (Units)	1.6	2.0	2.0	2.0	1.8
Percent Petrol Engines of Total Production	17.4%	19.5%	21.0%	24.8%	28.0%
Multi- and Single-Point Injection (Units)	1.8	2.2	2.5	3.0	3.7

NA = Not Applicable
Source: PRS



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Research Newsletter

THE HUNTERS AND THE HUNTED—RESTRUCTURING OF TELECOMS MARKET CONTINUES

INTRODUCTION

In October this year, Dataquest published a newsletter on the effective acquisition of Telettra by Alcatel (refer to ESAM newsletter 1990-22 "Alcatel Strengthens Its Number One Position"). In the newsletter, Dataquest analysed the logic behind the move, and commented on some of the factors behind the ongoing restructuring of the equipment supply industry for European public telecoms.

Just one month after the publication of that newsletter, Northern Telecom (NT) of Canada announced that it had made an agreed bid for the United Kingdom's STC, resulting in further consolidation of the industry. This newsletter expands upon the earlier one by analysing the market and describing some of the major market forces. It then goes on to consider the NT bid in order to better explain some of the issues facing telecoms companies. It concludes by considering what the future may hold for the remaining major suppliers.

MARKET ANALYSIS

The equipment supply market for European public telecoms is currently valued at an estimated $13 billion per annum. Although the market will continue to grow, it will be at a very slow rate; overall, it will remain relatively static.

This market comprises approximately 50 percent central office and 50 percent transmission. This needs further elaboration in order to clarify the nature of the market; we shall consider each of these two major segments in turn:

- Central Office—a fairly *coherent* market which consists of the sale of local and transit lines to national operating companies. Growth will continue in line shipments over the short term, but will decline in volume from 1993 onwards. Continued reduction in prices per line will result in an initially static market value that will start to reduce fairly sharply in 1993. This declining market value will be partially offset by the increasing sales of product upgrades—in other words, improving the features of existing systems without increasing the quantity of local lines.
- Transmission—this is a much more fragmented market than central office, with many more fairly discrete product segments. Transmission is defined as including cable-based systems, radio-based systems and telecoms cable. The market will experience growth over the next five years, but this tends to hide the fact that the various different product segments are at varying points in their life cycles and are each experiencing different growth rates.

COUNTRIES AND COMPETITORS

The market is summarized in Table 1, which shows the central office and transmission market values for each of the main European markets and their major suppliers (excluding licensees).

The most striking conclusion of the analysis is the domination of the market by the three main European suppliers—Alcatel, Siemens and Ericsson. These all have strong market positions in several European countries, in addition to very substantial sales outside of Europe.

The balance of major suppliers falls mainly into two categories: local companies with a strong national business (e.g. GPT); and international suppliers trying to penetrate the European market (e.g. AT&T).

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TABLE 1
European Public Telecoms Equipment Supply Market by Country and Supplier 1989

Country	Segment	Market Value ($B)	Major Suppliers
France	Central Office	0.7	Alcatel
	Transmission	1.2	Alcatel, SAT, Philips
Germany	Central Office	1.2	Siemens, Alcatel
	Transmission	1.4	Siemens, Alcatel, Bosch, Philips
Italy	Central Office	0.8	Italtel, Ericsson, Alcatel, Siemens
	Transmission	0.8	Alcatel, Ericsson, Pirelli, Siemens, Italtel
United Kingdom	Central Office	1.0	GPT, Ericsson, NT/STC, AT&T
	Transmission	1.0	STC, GPT, BICC, AT&T
Spain	Central Office	0.7	Alcatel, Ericsson, AT&T
	Transmission	0.5	Alcatel, Ericsson, AT&T
Rest of Europe	Central Office	2.2	Ericsson, Alcatel, Siemens, AT&T, NT
	Transmission	1.5	Alcatel, Siemens, Ericsson, Nokia, AT&T, NEC
Total	Central Office	6.6	Alcatel, Siemens, Ericsson
	Transmission	6.4	Alcatel, Siemens, Ericsson

Source: Dataquest (December 1990)

In the transmission area, in addition to the major suppliers listed, a number of niche suppliers are operating in specific product areas. Due to the fragmented nature of the market. Opportunities will continue to exist for such niche players within this market.

MARKET FORCES

The European public telecoms market is a complex one. However, four major factors are at play in shaping the market:

- Technology life cycles
- Liberalization and deregulation
- Customer demand
- Competition

Technology Life Cycles

Technological advances are being made at an ever-increasing pace. The availability of new technology results in a natural desire to implement the latest advances in commercially available systems. Therefore, the typical life cycle of the technology being deployed is decreasing. In public telecoms there are many examples of this. In the central office environment, Strowger automatic mechanical switching technology was deployed for well over 50 years. This was gradually superseded by crossbar switching technology during the early 1960s, and later, by electronic switching technology in the mid-1970s. During the 1980s electronic switching, in turn, was superseded by digital SPC switching, a market which is now approaching maturity.

In the field of transmission, availability of digital transmission techniques combined with single-mode optical fiber has led to the constant increase of bandwidths. Now, as one level of capacity becomes commercially available, so a higher capacity is being achieved in telecoms laboratories. Through the late 1970s and particularly through the 1980s, systems capacities rapidly increased from 2 Mbit/s to 565 Mbit/s. Today, 2.4-Gbit/s systems are being developed and will shortly be deployed within networks; 10-Gbit/s systems are already being considered.

To maintain competitive, state-of-the-art product lines, suppliers have to invest increasing amounts of money into research and development activities. Typical amounts invested in R&D now range from 10 to 15 percent of turnover, depending on the scale of turnover and the breadth of product range.

Liberalization and Deregulation

Historically, national networks for public telecoms have been run by government departments, with investment decisions centrally planned and controlled by governments. The telecoms networks were considered to be national assets which needed to be protected from outside influence. One result of this situation was that operating companies had very strong links with local equipment suppliers, from whom they sourced most of their major equipment requirements.

Now, however, markets are becoming increasingly subject to liberalization and deregulation (and sometimes privatization) by national governments. This has led to pressure being put on operating companies to behave more like purchasing companies in open, competitive markets. Pressure from EC initiatives will ensure that this trend continues.

One result of liberalization and deregulation is that national operating companies are becoming more and more reluctant to fund R&D programs. Although such funding does still happen, either explicitly or implicitly, the degree to which it happens has reduced dramatically, and in many countries all major R&D programs now have to be funded by private ventures.

Customer Demand

With time, customers are becoming more sophisticated in terms of their requirements for telecoms services. This is particularly true for large corporate customers who view telecoms networks as being vital in improving the overall efficiency and effectiveness of their operations.

Customers no longer accept only the basic services that have traditionally been offered by national operating companies. They are aware of technological advances and also of service offerings in other countries, so they demand, of their own local operating companies, new services and a better overall quality of service.

Competition

These three combined market forces inevitably lead to much greater competition—primarily in the equipment supply market but ultimately between the national operating companies.

Technological advances enable the improvement of networks and the offering of new services, and customers demand the best possible level of service. In a deregulated market, national operating companies have to respond to these demands and ensure that their networks (and, indeed, overall business) are capable of supporting modern requirements in a cost-effective manner. As they come under more financial pressure to achieve good returns on investment, they are passing the pressure on to their suppliers.

The major suppliers are faced with better opportunities in terms of new technologies and resulting products and systems, but have to recover their increasing research and development costs over shorter product life cycles. They therefore seek to expand their geographic market coverage in order to generate higher sales volumes, enabling them to keep the required R&D levels while maintaining their own objectives for return on investment.

With deregulation and the gradual lowering of trade barriers in Europe, increased competition is not only made possible but is actively promoted. The end result is that the major national suppliers can no longer continue to thrive on local business alone. While relatively small companies may be able to succeed through tight focus on niche-market opportunities, the major suppliers have to achieve growth through international expansion. However, while creating more competition abroad, they are at the same time faced with increased competition in their home markets.

Northern Telecom and STC

Against this background, NT recently made an agreed bid for STC. NT had a turnover in 1989 in excess of $6 billion, all of it generated from telecoms markets. It achieved phenomenal growth through the 1980s by being one of the first telecoms companies to introduce fully digital, central office switching systems. Based on its DMS switch, it made major inroads into the RBOC market in the United States, and succeeded in maintaining its market share through the late 1980s. An analysis of NT's 1989 sales is shown in Table 2.

The company is now, above all, a public telecoms equipment business, but with a strong subsidiary business in the private telecoms market. DMS is very much the flagship product; it and supporting technology form the core of its operations.

NT is laying the foundations for future products and systems with its main program, "FiberWorld" and new product announcements. With these it hopes to secure long-term business prospects.

The major issue facing the company is how to break out from the North American market. With 95 percent of its sales being generated in the United States and Canada, continued growth and profitability in the long term will have to be achieved by building successful businesses in other geographic markets. In order to help achieve some level of "internationalization," NT acquired a 27 percent stake in STC in 1987. This included the remaining 25 percent of STC still owned by ITT, which had historically owned all of it.

STC used to be the UK operating arm of ITT. When ITT merged with CGE's communications business to form Alcatel, STC was the one major European telecoms business which was excluded from the deal. As a part of its growth strategy, STC took over ICL in 1983 with a view to starting the much talked-about convergence of communications and computing technologies. By 1985, STC suffered a major financial crisis as a result of rapid growth, but it managed to survive and consolidate its business only after a boardroom coup and the injection of tough, new, senior executives.

Throughout the late 1980s, STC very successfully transformed its financial position and became a highly profitable organization. In order to continue successfully into the 1990s, however, it has to grow its international business substantially.

Since 1983, the original STC Telecoms and ICL have continued to be run as virtually separate companies, emphasizing that there was little real synergy between the two industries. Earlier this year STC finally announced it was to sell 80 percent of ICL to Fujitsu. The balance of STC consisted of telecoms (64 percent), and components and distribution (36 percent). These two divisions had a combined 1989 turnover of £991 million. An analysis of the core telecoms business is shown in Table 3.

With a world-leading submarine systems business, a good position in the emerging CT2/PCN markets, and 35 percent of sales being generated from outside the United Kingdom, the company appears to be very soundly based. However, the submarine system business is, by its very nature, rather erratic. The CT2/PCN markets will not start to generate cash for some years, and within transmission and miscellaneous telecoms, 75 percent of turnover was generated by just one customer, British Telecom.

STC has found it incredibly difficult to break away from its history as a UK subsidiary of a multinational company responsible for selling only into the UK market. Despite continuous efforts to build international business, STC remained highly dependent upon the BT market.

Table 2
NT Sales Analysis 1989

Product Area	Percent Share	Country	Percent Share
Central Office	54%	United States	59%
Transmission	10%	Canada	36%
Cable and Outside Plant	9%	Rest of World	5%
Business Communications	24%		
Other	3%		
Totals	100%		100%

Source: Dataquest (December 1990)

Table 3
STC Telecoms Sales Analysis 1989

Product Area	Percent Share	Country/Customer	Percent Share
Submarine Systems	29%	BT	50%
Transmission and Cable	34%	Other United Kingdom	15%
Other Telecoms	26%	Rest of World	35%
Non-Telecoms	11%		
Totals	100%		100%

Source: Dataquest (December 1990)

THE LOGIC BEHIND THE ACQUISITION

STC understood perfectly well the necessity to find some form of very close collaboration in order to secure its own future in telecoms. It was (and still is) working with a range of European companies, both in terms of joint product development and provision of European sales channels.

However, progress was (perhaps inevitably) very slow, with little or no impact on short-term revenues. With the sale of ICL, STC was faced with the choice of either using the cash to find a suitable acquisition, or realizing its own potential as an attractive acquisition target. Particularly with Alcatel's acquisition of Telettra, the former option became very limited. STC was approached by several companies with a view to taking over the remaining STC business; one of these was NT.

NT is fundamentally a public telecoms equipment company. Any major move, such as the acquisition of STC, must be aimed at strengthening its position in this market. Within public telecoms it has made some impact on minor European countries (Austria and Turkey), but with the exception of the United Kingdom, has failed to make any impact on the larger European markets. In the United Kingdom it has sold DMS switches to Mercury and also to BT for specialized applications. Its share of the European market is substantially less than 2 percent.

A primary objective, according to NT, is to use STC as a vehicle for increasing its presence in the European market, helping it to generate additional sales of its central office (and ultimately transmission) products. Clearly NT feels the need to achieve a substantially greater market share in the important European market, to help it fulfil its long-term growth objectives.

The most important factors behind the acquisition are:

- The existing relationship: STC is already a known quantity to NT.
- STC has a strong position in the UK market, and provides a good sales channel into BT.
- A substantial portion of the UK switching network will not start to be digitized until the second half of the 1990s, presenting an opportunity for NT's DMS.
- STC is a company with a strong position in the EC.
- It has been building relationships with continental European telecoms companies.
- STC has a strong technology base.
- It holds potential synergy from its respective R&D programs, particularly for synchronous transmission products.
- STC will improve NT's access into the UK private switching market.

A key issue behind all of this, is the fact that companies can only substantially penetrate the major European public telecoms markets by some form of joint venture, merger or acquisition with a local company. Only the acquisition option gives an immediate impact in terms of increasing business levels. It will not have escaped NT's attention that opportunities for the acquisition of suitable local companies are rapidly disappearing. STC presented one of the last few suitable targets.

WAS IT A GOOD MOVE?

In as much as NT has acquired a profitable company, and the acquisition will probably do STC more good than harm, it must be viewed as a good move. However, where is the real synergy in the move? And to what extent will STC help NT to achieve its European objectives? These questions need to be asked.

The following negative points must be raised against the undoubted positive points listed in the previous section:

- STC does *not* provide a sales channel into continental European markets.
- The potential availability of the UK central office market to NT is very limited—a share of one-third of 8 million lines, not commencing for perhaps 5 years.
- The so-called next-generation switching products are a very long-term proposition.
- NT will find it difficult to lever its FiberWorld products into European markets, even if a good sales channel is established.
- STC is developing products in collaboration with European companies, which are effectively competitive to FiberWorld.

In summary, short-term benefits are very limited and there is a big question mark over the extent to which STC will help NT to penetrate continental Europe, even in the medium to long term. NT now has a much stronger UK market position, and has the potential to rationalize transmission R&D programs and strengthen product offerings. Although NT paid a high price, it will shortly benefit from the cash generated by the sale of ICL stock to Fujitsu. Other elements of STC could also be sold off to generate further cash, without adversely impacting NT's objectives.

On balance, and given the restricted options for making a real impact on the European market, it may well prove to have been the correct strategy. However, NT needs to work hard to ensure that it gets maximum benefit from STC's assets, particularly if it wishes to use STC as a springboard into Europe—a strategy that NT itself has announced. NT/STC need to try to rapidly build upon the foundations laid by STC, while not disrupting the existing relationships.

DATAQUEST ANALYSIS

Trends in the supply market for public telecoms equipment are clear: continued industry restructuring being driven by irreversible market forces. While national protectionist activities will prolong the process, the inevitable end result is further reductions in the quantity of major suppliers that are left in the market. The only questions unanswered are how long the remaining companies will keep their independence? And at what stage will the restructuring stop?

In order to provide a partial answer to these questions, we need to look at all the active, major companies in the market (that is, those supplying a public telecoms product range that is relatively comprehensive). These can be grouped into three categories:

- Alcatel, Siemens and Ericsson
- Other European suppliers
- Non-European suppliers

The companies in the first group are all continuing to consolidate their positions, and actively dominate the European market. This will not change.

Basically it can be said that there must be a very large question mark over all companies which fall into the middle category. While niche marketing strategies can be successfully employed by relatively small companies that are visionary, flexible and capable of rapid reaction, this is not a strategy that has been made to work by larger companies. STC is an example of a company that has tried.

Larger companies are locked into a situation demanding that continued growth and market expansion is a necessary strategy to ensure long-term, independent survival and success. At the same time, the critical-mass threshold is getting higher and higher.

Looking ahead five years, it is difficult to envisage more than one of the companies from the "other European supplier" category still surviving and thriving with a comprehensive product range, with possibly room for one specialist telecoms cable supplier. It is probably fair to say that if there are more, then the EC has not succeeded in removing or reducing the trade barriers that it is trying to eradicate.

The continued presence (and possible financial success) of US and Japanese companies trying to penetrate the European market is very much dependent on how determined they are to build a presence and what level of investment they are prepared to make. Their combined share of the European market will undoubtedly grow.

Over the next five years, the market will continue to be characterized by suppliers being divided into the hunters and the hunted. Industry restructuring will stop there. Having said that, the scale of the task facing the hunters in maximizing benefits from their acquisition activities, should not be underestimated. Alcatel has taken a long time and a vast amount of senior management effort trying to rationalize its organization and product ranges since its formation in 1986. NT must work very hard to gain maximum benefit from its acquisition of STC.

Looking ahead ten years, the success of the remaining few suppliers may well depend on their skill in managing to best effect, diverse geographical organizations—consisting of a mixture of their own divisions and acquired or merged businesses.

John Dinsdale
Jonathan Drazin

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Research *Newsletter*

PC SEMICONDUCTOR CONSUMPTION IN EUROPE: JUST A TEMPORARY SETBACK!

SUMMARY

European semiconductor consumption into personal computers has shown an extraordinary growth in recent years with an estimated 60 percent compound annual growth rate (CAGR) for the 1986 to 1989 period.

However, this year we estimate consumption for PCs to be $667 million, an 11 percent *decline* from 1989. When a bad year is encountered after such a good run, the question on everyone's lips is: "Are we experiencing a blip—or is the party over?" In this newsletter, we argue that while growth of the end-user PC market in Europe is expected to slow, the prospects for future *semiconductor consumption* look good. The following major factors differentiate PC semiconductor consumption from its underlying end-user market growth:

- Declining DRAM prices are expected to be less steep next year and (probably) less steep in future years.
- Recent uptake of Windows 3 and other memory-intensive applications will increase memory content per PC.
- Solid-state memory cards will gradually replace magnetic floppy-disk media, starting with laptop applications; this will result in increased demand for flash memory, mask ROM, and DSP data-compression ICs.
- The addition of multimedia and cordless LAN features to PCs will bring significant additional semiconductor content.
- Europe has a net trade deficit in personal computers. Currently, only 60 percent of its consumption is produced within Europe. However, this proportion is increasing, so unit production growths will exceed end-user market growths.

Consequently, we regard the current situation as a blip, not a blow, for semiconductor vendors, and we forecast a 26 percent CAGR for PC semiconductor consumption in Europe over the period 1990 to 1994.

INTRODUCTION

Our forecast for the consumption of PC semiconductors in Europe is based on certain essential issues. We have looked at forecasts for the European PC end-user market, as prepared by Dataquest's European Personal Computer Industry Service (EPCIS). We have also considered the assessments of key PC-technology drivers and their impacts on the future PC market. Another contributory source is the survey of PC manufacturing locations in Europe, presented recently in our newsletter 1990-15 "PC Production in Europe, 1989—Preliminary Update," June 1990. And finally we analysed semiconductor content breakdowns of different PC models to determine average semiconductor contents.

PC SALES—SLOWING GROWTH

Dataquest estimates total European PC shipments for 1990 to be 7.2 million units, compared with 6.3 million units for 1989 (see Table 1). This corresponds to an annual growth of 13.8 percent over 1989, and is a sharp decline from 1989's

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TABLE 1
European PC Market Overview and Semiconductor Forecast

Personal Computers	1986	1987	1988	1989	1990	1991	1992	1993	1994	CAGR 1990-1994
Market Unit Shipments (M)	1.82	3.20	4.84	6.29	7.16	8.05	8.79	9.48	10.10	9.0%
Unit Growth	NA	76.1%	51.1%	30.0%	13.8%	12.4%	9.2%	7.8%	6.6%	NA
Average Selling Price ($)	$3,434	$3,333	$3,496	$3,592	$3,397	$3,526	$3,768	$3,911	$3,974	4.0%
European Market Revenue ($M)	$6,242	$10,669	$16,909	$22,589	$24,320	$28,367	$33,109	$37,056	$40,140	13.3%
Percent European Production	52%	54%	56%	59%	60%	62%	64%	65%	65%	2.0%
European Production ($M)	$3,246	$5,762	$9,469	$13,271	$14,592	$17,588	$21,190	$23,901	$26,091	15.6%
Production Growth	NA	77.5%	64.4%	40.2%	10.0%	20.5%	20.5%	12.8%	9.2%	NA
Percent Locally Purchased	80.0%	82.0%	84.4%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	NA
Effective European Production ($M)	$2,597	$4,724	$7,994	$12,212	$13,428	$16,184	$19,499	$21,993	$24,008	15.6%
I/O Ratio	7.0%	7.0%	8.8%	6.1%	5.2%	5.7%	6.2%	6.7%	7.0%	0.0%
Average Semiconductor Content ($)	$240	$233	$309	$220	$175	$201	$234	$262	$278	12.2%
European Consumption ($M)	$182	$331	$707	$749	$667	$922	$1,209	$1,474	$1,681	26.0%
Consumption Growth	0.0%	82.0%	113.8%	6.0%	-11.0%	38.2%	31.1%	21.9%	14.0%	NA

Note: Includes motherboard, monitor and keyboard only
NA = Not Applicable
Source: Dataquest (December 1990)

growth of 30.0 percent over 1988. Moreover, we expect PC unit growth rates to slow progressively through to 1994, giving a CAGR of 9.0 percent in unit sales between 1990 and 1994. We estimate that 1 in 4 white-collar workers now has a PC in Europe, and it is the business sector's progressive transition into saturation that is the most *fundamental* reason why growth must decline.

Despite a pattern of sobering end-user market growth, Dataquest does expect to see some islands of high growth in desktops, particularly in the home market, where penetration is still low (at 1 in 35 households). This will favor low-priced models, presently based largely on the 68000 (Commodore and Atari) and the 8086/88 (mainly Amstrad and Schneider) products. Strong demand for low-cost machines is also coming from Eastern Europe, including East Germany—in this instance mainly from businesses with limited budgets.

Figure 1 shows Dataquest's forecast for European unit sales by PC type. Shipments of the 80286-based desktops have peaked, but still outnumber the 80386-SX and DX-based products. The rate at which the 80286 declines further will depend largely on the outcome of the Intel versus AMD litigation on second sourcing of the 80386 products.

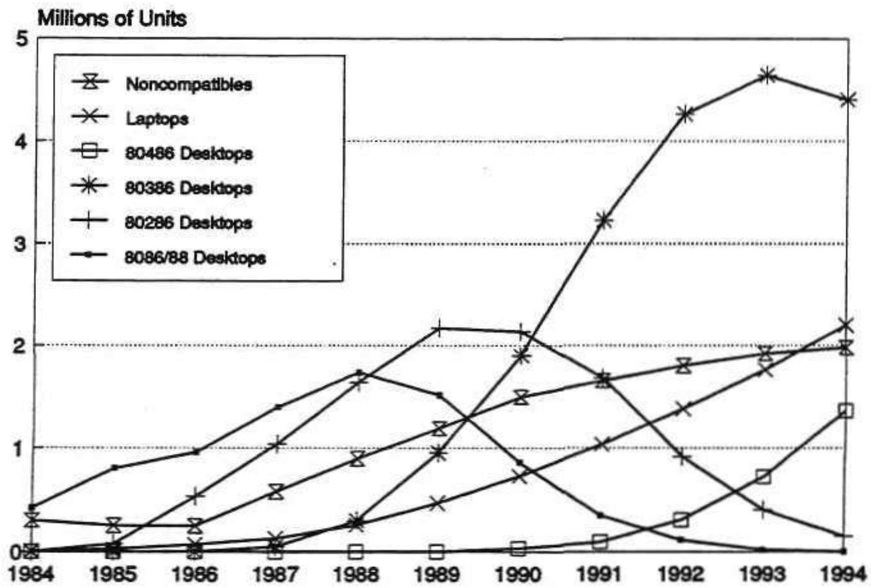
MADE IN EUROPE—THE TRENDS

We estimate that 60 percent of all PCs purchased in Europe in 1990 were made locally, although the proportion for which semiconductors are actually procured locally is slightly lower at 55 percent.

The following recent annoncements by major PC companies suggest that the ratio will continue to increase over the next two to three years:

- Amstrad will increase production through its European subcontractor, GPT.
- Compaq will start assembling PCBs locally in the near future.
- Toshiba will increase output and switch to local semiconductor procurement at its laptop plant in Regensburg, Germany.
- Dell will commence PC manufacturing in Ireland.
- Hewlett-Packard has transferred its worldwide PC headquarters from Roseville, California, to Grenoble, France.
- Acer, Goldstar, Kyocera, and NEC are all expected to launch PC production plans in Europe.

FIGURE 1
European PC Shipments by PC Platform



Source: Dataquest (December 1990)

Clearly, many PC vendors' plans still lie in the balance, with their final decisions influenced by many factors besides manufacture and supply. Inevitably, they will speculate on the future tone of the European Community's policies on local content, origin, preference and, not least, on the likely outcome of the General Agreement on Tariffs and Trade (GATT) talks.

TECHNOLOGY DRIVERS

Despite strong evidence of market saturation, the bulk of future PC demand in Europe will continue to come from the Western European business sector. Here, sales are increasingly determined by the rate at which the *existing* installed base is replaced.

Two main factors influence the replacement rate. The first is economic: prevailing interest rates and costs of capital, (but this is hard to predict and beyond the scope of this newsletter). The second influence: the rate at which new hardware functionality can induce users to trade up to newer models. To some degree, this is forseeable, because the prominent characteristics of the technology (displays, multimedia, radio techniques, etc.) that initiate these new functions are understood today. We discuss below the main impacts of the key technology drivers that will affect the PC markets.

Immediate Refinements—Display and Storage Techniques

The PC laptop market continues to be spurred by increasing availability of low-cost, high-resolution liquid crystal displays (LCDs). Other major refinements, such as color displays and solid-state memory cards, lie just around the corner.

Impact

- Desktop PC sales will erode in favor of laptop PC sales.
- Demand will shift towards low-power CMOS ICs with split-voltage supplies and adjustable clock speeds. This, in turn, will drive demand for battery-powered, switch-mode DC-DC converter ICs to provide split voltages.
- Rapid growth will occur in sales of flash and mask ROM memory cards likely, in turn, to generate an IC market for data compression DSPs that improve storage efficiencies on flash cards.
- PC notebook and palmtop markets will emerge.
- The LCD driver market will grow rapidly.

Tomorrow's Refinements—Multimedia

Low-cost, digital multimedia systems, as offered by Intel (DVI) or Philip (CD-I), will improve the PC user interface to far greater proportions than is possible with window management alone—or so the argument goes.

Undoubtedly, multimedia's flexibility will lure many new users not otherwise sufficiently attracted to using a PC. The most widely expected end-user segments are, teaching, training, guides, databases, diagnostic manuals, and entertainment.

Impact

- Desktop PC sales will be given a boost as the market widens to include new end-user segments.
- Competitive advantage will go to those semiconductor vendors strong in voice and image processing, DSP architectures, and flash D/A conversion.
- Multimedia semiconductors will go onto expansion cards, not motherboards, for the first few years. Procurement will resemble that of LAN cards and other PC peripherals, with demand coming from specialist manufacturers as opposed to PC manufacturers.

Wireless Mobility—A Long-Term Goal

Towards the end of this decade, a major boost to the PC market is expected to come from the addition of wireless networking capabilities.

The arrival of the Universal Mobile Telecommunications Service (UMTS) standard is currently being considered under the European RACE program. This should fully address the issues of mass wireless data communications by around 1998.

In the interim, the foundations are already being laid with the appearance of many digital wireless standards all capable, to a greater or lesser extent, of carrying data. They divide into two broad categories: proprietary data networking standards, such as Motorola's WIN and NCR's WaveLan; and pan-European digital telephony standards, such as CT2, DECT and GSM.

Wireless data communication, using standards such as GSM, should permit laptop PCs to exchange large data files at costs comparable to conventional modems today. Although cellular tariffs are higher, GSM's 32-Kbit/s rate is faster than any high-speed modem connected to the PSTN currently. Consequently, call periods should be shorter. DECT, with higher bit rates still, potentially offers even greater benefits.

Impact

- Impact in the PC market will take effect from 1993, and lag introduction of GSM for voice telephony by about two years.
- Growth will be most rapid for laptop PCs carried by their users across many environments: home; car; and main and secondary places of work.
- In most cases, wireless capability will *complement*, not replace, conventional cable-based LAN systems.
- A strong increase in semiconductor content is expected, favoring vendors with capabilities in packaging, codecs, DSP, high-frequency synthesizers, and PLLs.

PC CONTENT—LOW TODAY, RECOVERING TOMORROW

Volatile MOS memory prices have caused wild variations in PC semiconductor content. The DRAM price peak during 1988 drove PC semiconductor content to $309 per unit in that year. Dramatic increases in competition and price erosion in the PC chip market have been other crucial factors.

Table 2 gives our estimates for this year's PC semiconductor content and consumption by value (motherboard and monitor only). These are production-weighted averages across all PC model types. Even after major price erosion, MOS memory still represents 48 percent of the average content in a PC.

Despite the fact that semiconductor content has fluctuated markedly in recent years (see Table 1), end-user prices for PCs have remained flat, from $3,434 in 1986 to $3,397 in 1990. This is largely because semiconductor content is a relatively small proportion of total end-user price; we estimate that it will be 5.2 percent this year.

The long-term trend has been towards a decline in content, from an average $240 per unit in 1986, to $175 this year. Despite the recent downward trend in semiconductor content, many factors indicate an increase in coming years. These are explained below:

- The rate of price erosion for DRAMs has been far faster this year than the long-range trend of 26 percent annual decline in cost per bit. We expect 1991 prices to follow this trend more closely.
- Recent declines in DRAM price have prompted many PC users to gravitate towards host system software that is both memory-intensive and multiple-windowing, such as Microsoft's Windows 3. This is reflected by the fact that many 80386-based models are now being shipped with 2 Mbyte as standard.
- Similar moves towards increased memory are evident in applications software. For example, the current release (Version 3) of the popular Lotus 1-2-3 spreadsheet program has a minimum memory requirement of 1 Mbyte, and requires substantially more memory if overhead applications, such as LAN or windowing software, are to be used.
- Over a longer term (in the next three to five years) we expect to see a migration towards both windowing *and* multitasking operating systems, as is offered by OS/2, with a minimum practical memory requirement of around 3 Mbyte.
- As the popularity of LANs continues to grow, many PC manufacturers are expected to consider the inclusion of LAN functionality on the motherboard, as opposed to on expansion cards.

Consequently, we expect a recovery in the I/O ratio from today's 5.2 percent towards 7.0 percent in future years (see Table 1).

An important point to note is that much of the new semiconductor content associated with PCs will go off the motherboard (like memory cards, or add-on boards for multimedia or cordless LANs). This demand will come mainly from outside the circle of established PC manufacturers, and is in addition to the forecast in Table 1 (which covers motherboard, keyboard and monitor consumption only).

Table 2
Estimated 1990 PC Semiconductor Content by Microprocessor Type (US Dollars)

	8086/86	80286	80386	Non-compatibles	Average Content	Total Market ($M)	Percent Share
Total Semiconductor	$129	$133	$280	$105	$175	$667	100.0%
Total IC	$122	$123	$270	$100	$167	$636	95.3%
Bipolar Digital	$4	$1	$34	$8	$13	$50	7.5%
MOS	$116	$119	$223	$88	$148	$561	84.1%
Memory	$80	$73	$115	$50	$84	$320	48.0%
DRAM	74	58	115	46	77	292	43.8%
SRAM	0	0	0	0	0	0	0.0%
Other	6	16	0	4	7	28	4.1%
Micro	$14	$19	$73	$22	$36	$138	20.7%
MPU	6	12	60	16	27	104	15.5%
MCU	2	2	4	2	3	10	1.5%
MPR	6	6	9	4	7	25	3.7%
Logic	$22	$27	$35	$16	$27	$103	15.4%
ASIC	15	14	30	11	19	71	10.7%
Standard Logic	7	13	5	5	8	31	4.7%
Linear	$2	$3	$14	$4	$6	$24	3.6%
Discrete	$4	$8	$8	$4	$7	$25	3.7%
Transistors	1	1	1	1	1	4	0.5%
Diodes	1	3	3	2	3	10	1.4%
Other	3	3	3	2	3	12	1.7%
Optoelectronic	$2	$2	$2	$1	$2	$7	1.0%
LED Indicators	0	1	1	0	1	2	0.3%
Other	2	1	1	1	1	4	0.7%
Average Selling Price	$1,703	$2,971	$5,525	$2,082		$3,397	
Semiconductor I/O Ratio (Percent)	7.55%	4.47%	5.06%	5.04%		5.17%	
Effective Production (Millions of Units)	0.54	1.41	1.24	0.61		3.80	
Total Semiconductor TAM ($M)	$69.7	$187.3	$346.0	$64.4		$667.4	

Note: Includes motherboard, monitor and keyboard only
Source: Dataquest (December 1990)

DATAQUEST PERSPECTIVE

This has been a disappointing year for PC vendors, although times have been even harder for their semiconductor suppliers. We estimate 1990 semiconductor consumption for PCs in Europe to have been $667 million (motherboard and monitors only)—an 11 percent decline in revenue over 1989.

Of course, there is no escaping the fact that future PC semiconductor consumption will be closely linked to Europe's gradually slowing PC markets. However, for the reasons discussed above (rising semiconductor content, increased local production and procurement), growth rates of PC semiconductor consumption should exceed end-user market growth in Europe for some years.

To best address future business in this segment, semiconductor vendors are advised to focus on the new, key technologies that their customers will soon request. In particular, they should give special attention, now, to the development of DSP-oriented products (such as decoders for multimedia, data compressors for solid-state storage, and data codecs for wireless LANs). The other area of growing importance is the special needs of laptops, in particular for ICs with power control features (such as display drivers, variable clock rate, and switch-mode supply ICs).

CPU and memory are the only semiconductor aspects that the PC of the 1990s will share with the PC of the 1980s. In other respects, the PC will evolve this decade to a point when many vendors, to avoid confusion with its prehistoric antecedent, will be tempted to rename that ubiquitous term "personal computer" to "personal companion."

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Mike Williams

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Research Newsletter

ABS IN EUROPE—FEET OFF THE BRAKES

SUMMARY

The antilock braking systems (ABS) equipment market in Europe is estimated this year to be $963 million. Currently 9.5 percent of the 13.8 million cars produced in Europe contain ABS. Dataquest expects a rapid further penetration of this application in Europe over the next five years, as car manufacturers broaden the ranges of models offering this feature. We believe that by the mid-1990s the equipment revenue for ABS systems will have grown to $1,992 million, representing a 15.6 percent compound annual growth rate (CAGR) between 1990 and 1995. In terms of semiconductor consumption, we estimate that ABS production in Europe is driving an $81 million semiconductor market in 1990. This is forecast to more than double within the next five years, reaching $184 million by 1995. Two players, Bosch and ITT-Teves, currently account for 80 percent of ABS semiconductor demand in Europe.

This newsletter explains ABS technology, looks at the semiconductor content of ABS and forecasts its consumption by the European automotive industry.

INTRODUCTION

Antilock braking systems (ABS) are one of the most important safety systems in a car, giving safer braking in all road conditions.

An antilock braking system consists of a hydraulic module and an electronic control unit, which complement the conventional car braking system. ABS continuously monitors wheel speed and automatically releases brake pressure each time sensors detect wheel lock during braking. This gives greater steering control and stability. Effectively, the braking system does what an experienced motorist should do before the car begins to skid.

Lucas developed Girling, a mechanical system, in the 1970s—but the electronic developments of the 1980s have been the most significant and reliable basis for safer braking. Electronic ABS applications in cars first became popularly adopted by car manufacturers in 1986.

The imminent growth of ABS installations in Europe has been pioneered by two German car manufacturers, Mercedes-Benz and BMW, who already offer ABS as standard equipment on their top-range models.

Our discussions with a number of key car manufacturers in Europe lead us to believe that there will be a rapid uptake of ABS in midrange, and to a lesser extent, low-range cars over the next three to five years. The European manufacturers are following the Japanese approach of shifting value into electronic features such as ABS, as opposed to trim and body features such as upholstery and paintwork.

The prospect of legislation to extend ABS's mandatory use from articulated lorries and trailers to certain sizes and types of car is another major factor that will drive the growth of ABS in Europe. Already in the US State of California, legislation exists to enforce the inclusion of ABS into all cars sold from mid-1992. Similar legislation is looming in Europe and, within the next five years, we can expect to see near full penetration of ABS's applications in European car manufacturing.

INSIDE AN ABS

Typically, an antilock braking system has three major types of components: wheel speed sensors, an electronic control unit (ECU) and a hydraulic modulator/impulse ring. These components are attached to the car's conventional braking system, and are shown in Figure 1.

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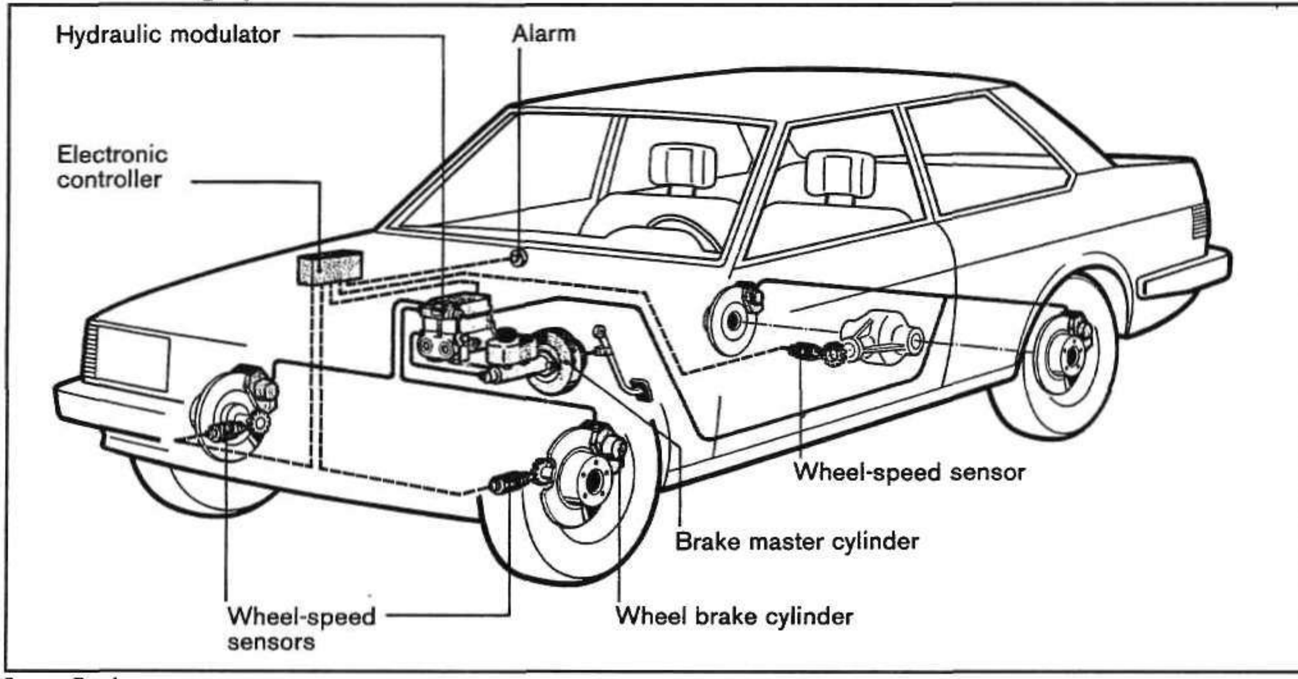
FIGURE 1
Antilock Braking System



Source: Bosch

Wheel Speed Sensors

The wheel speed sensors are attached to the chassis of the car, usually on the front steering knuckle and the rear axle body, while the impulse ring is fitted to the wheels, and in the case of a three-channel system (as illustrated) to the rear wheel axle. The sensors are connected to the ECU and positioned to monitor the rate of revolution for each impulse ring. When the brakes are applied, the controller computes tolerable wheel slip for optimum braking by eliminating wheel lock.

Electronic Control Unit (ECU)

The ECU processes signals and computes the permissible wheel slip for safe braking. It also regulates the pressures in the wheel brake cylinders by means of solenoid valves that convey pressure

TABLE 1
Semiconductor Content of a Typical ABS

Component Function	Technology	Units	Cost/Unit	Total Cost
Voltage Regulator	Bipolar (Analog)	1	$1.00	$1.00
Input Amplifier	Bipolar/BiCMOS	1	$2.00	$2.00
Microcontroller 1	MOS/ASIC	1	$5.00	$5.00
Microcontroller 2	MOS/ASIC	1	$5.00	$5.00
Valve Drivers 1-4	Bipolar/MOSFET	4	$0.50	$2.00
Valve Drivers 5-8	Bipolar/MOSFET	4	$0.50	$2.00
System Fault Diagnostics	MOS ASIC	1	$3.00	$3.00
Memory	EEPROM	1	$1.00	$1.00
Solenoid Valve Driver	Bipolar Power Darlington	3	$1.00	$3.00
Total Semiconductor Content:		17		$24.00

Source: Dataquest (July 1990)

information to it via an amplifier and A/D converter. Typically, the amplifiers and A/D converters reside on one bipolar or BiCMOS IC. The control outputs from the ECU to the hydraulic modulator are amplified by either discrete Darlington pairs or by power MOSFETs.

Hydraulic Modulator

The hydraulic modulator is the electromechanical interface to the braking system and is fitted to the car master brake cylinder. This unit consists of solenoid valves that are activated by the ECU.

Semiconductor Content

Table 1 shows the semiconductor content for a typical ABS system.

THE ABS PLAYERS

Table 2 lists the main ABS manufacturers in Europe by activity and location. Altogether, we estimate that these companies satisfy the bulk of ABS demand from car manufacturers in Europe, with imports of US and Japanese systems accounting for less than 5 percent of the total market.

Robert Bosch is the leading supplier of ABS systems both in Europe and worldwide. Bosch has manufacturing facilities in Anderson, South Carolina, USA and has a joint-venture company with Nippon-Denso developing ABS in Japan for cars and motorcycles. In Europe, ITT-Teves (West Germany), which also has a plant in Asheville, North Carolina, USA, and Lucas (UK) are also key ABS suppliers to the automotive industry.

One of the key issues facing semiconductor vendors and car manufacturers is to reduce the total cost of ABS by driving down the cost of the semiconductors they contain. Conceivably, this will happen through economies of scale as ABS continues to proliferate. The most popular type of ABS has been the ABS-2S supplied by Bosch which originally incorporated an ASIC chip but, for safety reasons, is now replaced by two microcontrollers. The second microcontroller is employed for standby purposes and acts as the diagnostic system monitor in case of system failure.

To gain an understanding of how ABS will evolve, ABS needs to be considered in conjunction with the other emerging electronic automotive applications. Inevitably, ABS will be integrated into other car systems. However, before integration,

TABLE 2
ABS Manufacturers in Europe by Location and Activity

Company	Location	Country	Status
BBA	Cleckheaton, W. Yorks.	UK	Developing ABS
Bendix France	Drancy	France	Car and truck antilock braking systems
Clayton Dewandre/Wabco Automotive Group	Rugby, Warwicks.	UK	Car antilock braking systems
Delco-Moraine	Gennevilliers Cedex	France	Developing antilock braking system: a new product, ABS-IV (with electronic motor instead of hydraulic unit) for GM
Fatec Fahrizeugtechnik GmbH	Alzenau/Unterfranken	WG	Developing antilock braking system
ITT-Teves	Frankfurt	WG	Car antilock braking systems (ATE ABS Mk IV)
Lucas	Kenfig Hill, Wales	UK	Car and truck antilock braking systems
	Koblenz	WG	Car and truck antilock braking systems
Magneti Marelli	Crescenzago	Italy	Developing antilock braking system (sold to Siemens/Bendix)
Motorola	Frankfurt	WG	Developing antilock braking system
Robert Bosch	Ansbach, Brodswindon	WG	Car antilock braking systems
TRW Messmer GmbH	Radolfzell	WG	Developing antilock braking system

Source: Dataquest (July 1990)

ABS will be connected to other car systems using "multiplexing" (the replacement of the existing wiring harness with a common communications bus). Some manufacturers (BMW and Mercedes) are already involved in multiplexing. The integration of ABS into other systems such as traction control, engine speed control, active suspensions, engine management and drive-by-wire concepts will follow.

At present, much of the semiconductor content in ABS systems consists of standard commercial, not military or high-reliability, parts. Further, there are no mandatory standards currently in place governing the use of semiconductors in automotive applications.

However, in Germany, the VDA (Association of the German Automobile Industry) is making provision for legislation. This draft legislation will mandate rigorous testing of automotive components, and their identification using serial numbers. Currently each car manufacturer has its own procedures for evaluating ABS reliability and quality testing.

Whereas, in most applications, semiconductor vendors are rarely liable for more than replacement of a defective part, the situation for semiconductors that go into ABS is likely to be very different, because the consequences of component failure are potentially catastrophic.

Automotive manufacturers are very wary of competitive espionage. Virtually all forms of car product development and prototyping occurs in highly secretive environments. Semiconductor vendors planning to do business with automotive manufacturers must be prepared to win the confidence of automotive manufacturers through close and exclusive cooperations.

Growing demand for lower-cost ABS has led to the development of hybrid ABS. The key features of hybrid ABS are their compactness and the lower entry-level costs. Hybrid ABS integrate together the controller unit and the hydraulic modulator, reducing system size, weight and cost. The introduction of hybrid ABS is permitting further penetration of ABS from high-end to midrange cars.

SAFETY—HEIGHTENED CONSUMER AWARENESS

A precedent already exists for EC legislation to require that ABS be fitted as standard in passenger cars in the same way that seat belts have become obligatory today. ABS is mandated in heavy-duty vehicles by EC legislation. This specifies for a given truck category what type of ABS equipment is required. ABS in trucks typically involve the use of hybrid systems which have the two major components described earlier. Trailers also have to be fitted with ABS units to meet EC requirements.

The factors driving increased penetration of ABS application in vehicles are largely a consequence of increased consumer awareness of the same safety issues that led to car seat belt regulations in Europe over the past 20 years. In North America, for example, GM and Ford have quietly announced plans to fit ABS as standard on virtually all cars by 1995. Similar plans are echoed in their operations here in Europe, and also by Mercedes and BMW. Car manufacturers in Europe are already beginning to standardize ABS in top-range cars—in preparation for mandatory regulations. Although such legislation is not yet fully defined for brake safety, the EC is currently working on a proposal to effect mandatory measures in this direction.

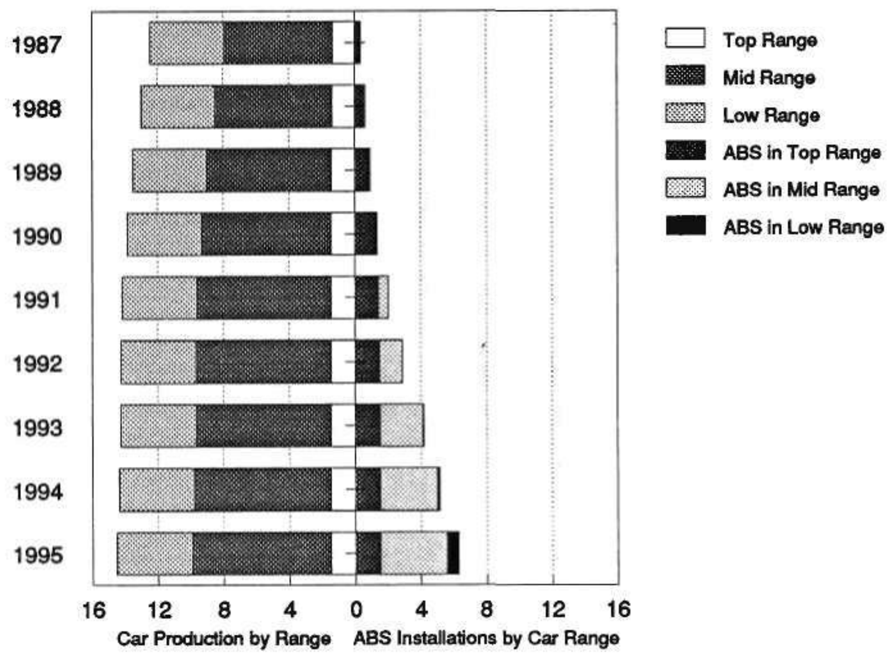
DATAQUEST ANALYSIS

ABS Proliferation

Table 3 shows ABS penetration in cars manufactured in Europe. Europe produces the largest number of cars in the world, estimated to be 13.8 million units in 1990. Of this total 10.5 percent fall in the top-range category, 56.8 percent are midrange and 32.7 percent low-range cars. Figure 2 shows European car production for 1987 to 1995 and ABS installations over that period.

We estimate that ABS has already achieved greater than 80.0 percent penetration into top-range cars. The next major opportunity for growth lies with its penetration of shipments into the midrange segment, which we currently estimate to have a penetration of only 1.2 percent (90,000 units). In anticipation of moves to reduce ABS cost, heightened consumer awareness on safety, and probable EC legislation, we believe that manufacturers will include ABS as standard (as opposed to optional) on most midrange models within the next two to four years. By 1995, ABS will become standard on all midrange cars, with some penetration into low-range cars. This leads us to a forecast of 6.25 million units sold in Europe in 1995 over the 1.32 million ABS units sold today.

FIGURE 2
ABS Production in Cars: History and Forecast
(Millions of Units)



Source: Dataquest (July 1990)

By 1995, we expect ABS will have achieved 100.0 percent, 48.0 percent and 15.1 percent penetration into top-, mid- and low-range cars respectively. This will represent a total ABS equipment market of $1.9 billion.

We forecast total ABS semiconductor consumption will rise to $184 million in 1995 from an estimated $59 million in 1989, representing 21.0 percent CAGR.

Conclusions

The key trend for ABS in Europe is clearly its strong growth in sales. Our analysis of the marketplace indicates that Europe is a net exporter of ABS to the United States and Japan. The main suppliers in Europe are Bosch, ITT-Teves and Lucas. Two players account for 80 percent of ABS semiconductor demand in Europe. Of the 1.95 million units produced in Europe during 1989, we estimate that Robert Bosch accounted for 55 percent and ITT-Teves nearly 25 percent. In addition to their European operations, both companies are expanding their production strongly in the United States and Japan.

Recent announcements from GM's Delco-Moraine subsidiary of a low-cost ($250) ABS based on electronic motors, instead of hydraulic units, is further indication that ABS is set for a rapid move into volume mid- to low-range cars.

However, the price erosion expected for complete ABS will not be matched by the same levels of erosion in the prices of semiconductors they contain. Several emerging factors—safety standards, fault tolerance, testability, serial numbering—could maintain costs at present-day levels for some years.

Mike Williams

TABLE 3
Estimated European ABS Production and Semiconductor Consumption Forecast

	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total Car Production									
Top-range cars (units M)	1.34	1.39	1.44	1.46	1.46	1.47	1.48	1.49	1.50
Midrange cars (units M)	6.58	7.10	7.55	7.87	8.17	8.20	8.21	8.31	8.44
Low-range cars (units M)	4.53	4.48	4.51	4.53	4.56	4.56	4.57	4.57	4.58
Total production	12.44	12.96	13.49	13.86	14.20	14.23	14.26	14.38	14.53
Percentage ABS Penetration									
Top-range penetration	24.00%	41.00%	58.00%	84.00%	95.00%	100.00%	100.00%	100.00%	100.00%
Midrange penetration	0.00%	0.09%	0.60%	1.20%	7.30%	17.00%	32.00%	41.80%	48.00%
Low-range penetration	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.80%	3.00%	15.10%
Total ABS penetration	2.6%	4.5%	6.5%	9.5%	14.0%	20.2%	29.0%	35.5%	43.0%
ABS Equipment Production									
ABS consumption (units M)	0.32	0.58	0.88	1.32	1.99	2.87	4.14	5.10	6.25
Dollar revenue ($M)	$283	$493	$680	$963	$1,202	$1,431	$1,690	$1,847	$1,992
% Local consumption	53.9%	55.6%	45.0%	46.2%	54.4%	68.4%	81.9%	84.2%	81.6%
ABS production (units M)	0.60	1.05	1.95	2.85	3.65	4.20	5.05	6.06	7.65
Dollar value ($M)	$525	$887	$1,512	$2,085	$2,208	$2,090	$2,063	$2,193	$2,439
ASP Breakdown									
ASP for top-range cars	$875	$850	$800	$765	$740	$700	$650	$600	$550
ASP for midrange cars	$360	$340	$325	$300	$290	$285	$275	$265	$250
ASP for low-range cars	$340	$315	$270	$250	$245	$235	$230	$225	$220
Unit ASP (US$ ex-factory)	$875	$844	$776	$732	$605	$498	$409	$362	$319
Semiconductor content	$35.0	$32.4	$30.0	$28.5	$26.6	$25.8	$25.4	$24.9	$24.0
Semiconductor consumption ($M)	$21	$34	$59	$81	$97	$108	$128	$151	$184

Source: Dataquest (July 1990)

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Research Newsletter

ISDN IC MARKET IN EUROPE, PART 3: THE LONG-TERM OUTLOOK

EXECUTIVE SUMMARY

European consumption this year of ISDN-dedicated ICs is estimated at $27.8 million, compared with Dataquest's prediction of $35 million two years ago. We forecast a 38 percent compound annual growth rate (CAGR) as the most likely outlook for the ISDN IC market over the period 1990 to 1995, yielding a total revenue of $140 million by the end of the period.

Recent ISDN IC demand has come predominantly from public infrastructure applications (switches, line cards and terminations) and has, so far, been independent of subscriber take-up. Consequently, the present market is dominated by revenues in U-interface and, to a lesser extent, S-interface ICs. This pattern will inevitably adjust in favor of the other ISDN functions as demand for terminal equipment begins to appear. By 1995, we expect unit demands for the major functions (U- and S-interfaces, link controllers, voice codecs and rate adapters) to become comparable.

The chief hurdles—full service coverage and pan-European compatibility of ISDN standards—are not scheduled to be overcome in Europe before 1992. In the interim, we expect major demand for ISDN semiconductors will result from non-ISDN applications such as pair gain.

A SERIES OF THREE NEWSLETTERS

This is the final newsletter of a three-part series that has looked at the market for narrow-band ISDN ICs in Europe. It presents the results of a survey of vendors' estimates for the current 1990 market, and shows a revised forecast for the period 1991 to 1995. Some estimates of the likely long-term scenario for narrow-band ISDN ICs in the year 2000 are also given.

Readers should refer to the first newsletter, "ISDN—The ICs and Their Applications, Part 1," 1989-1, for an explanation and glossary of ISDN concepts. The second newsletter, "ISDN—The Early Markets, Part 2," 1989-2, gives an explanation of the key factors affecting ISDN's uptake in Europe, although the forecasts it contained are now superseded by this newsletter.

INTRODUCTION

Dataquest's market forecast for the consumption of ISDN semiconductors is based on a "bottom up" model that sums subforecasts for each major application that consumes ISDN-dedicated ICs (Lotus 1-2-3 copies are available to ESAM subscribers at $300 each, and to non-subscribers at $1,000 each). The model is based upon the following critical issues and assumptions which are discussed in this newsletter:

- Semiconductor content by ISDN function, per major application
- PTT rollout plans for ISDN Basic and Primary Rate coverage across Europe
- ISDN price projections per function
- Levels of penetration per ISDN Basic and Primary Rate lines of the major ISDN applications
- Resolution of factors critical to ISDN's uptake: coverage; tariffs; standards; availability of applications; and market awareness

ISDN SEMICONDUCTORS

The market for ISDN semiconductor ICs depends crucially on the future demand from a handful of applications. Each function in Table 1 is sold today as a single IC. As revenue grows, we expect multiple functions to be combined onto a single IC. For example, the digital ISDN telephone,

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currently requiring four ISDN ICs, might be integrated into one. However, sales volumes are not nearly high enough for this to be considered today.

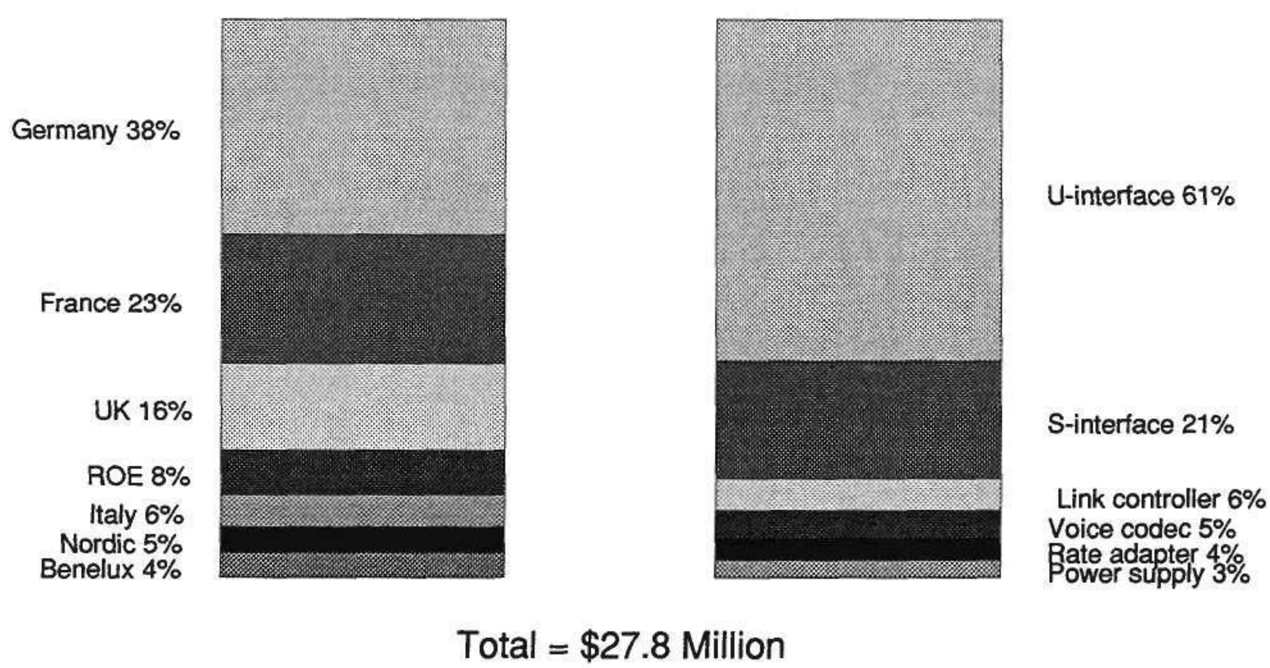
For Basic Rate communication with the public network, the U-interface function is most prevalent because it is a prerequisite to both line cards (Line Terminations) in the central office, and to terminations (Network Termination 1) in subscribers' premises. Its prevalence is compounded in revenue terms because it is the most costly to implement on silicon. For these reasons, the revenue of U-interface ICs in Europe, currently exceeds that of all other ISDN functions added together (see Figure 1).

Table 1
ISDN Function Content by Application—Key Assumptions

	ISDN Chip Type					
Application	U-interface	S-interface	Codec	Rate Adapter	Link Control	Power Supply
Facsimile (Group IV)		1			1	
Telephone		1	1		1	1
PC Card		1	1		1	
CO Line Card	1				0.25	
Pair Gain + Line Card	2		2		1	
Subscriber Termination (NT1)	1	1				
Intelligent Workstation		1	1	1	1	1

Source: Dataquest (November 1990)

Figure 1
European 1990 ISDN IC Revenue Estimated by Region and Function



Source: Dataquest (November 1990)

Many office environments are expected to use the S-interface to connect terminal equipment, with exceptions in cases where it is costly or impractical to install the 4-wire cable needed for the S-interface. In such instances, a low-cost proprietary U-interface is likely to be used.

Normally, the S-interface and attached terminals are powered by a local mains supply. However, in case of local power failure, the CCITT ISDN standards specify an emergency mode whereby designated terminals can draw power from the PSTN across the U-interface. A market is expected to develop for highly efficient ICs with switch-mode power that are dedicated to meeting these standards. Digital telephones will be the main applications for these ICs, particularly those connected directly to the NT1 termination in small offices and, eventually, private homes.

ISDN ROLLS OUT—FEW SUBSCRIBERS TODAY

True ISDN services have been launched in each of the main European countries: France, Germany and the United Kingdom. Substantial investment in public ISDN infrastructure has already commenced in each region. Table 2 shows our key assumptions regarding the installed base of Basic and Primary Rate ISDN lines in Western Europe.

Bundespost Telekom has recently installed 230,000 Basic Rate ISDN lines, with contracts for the switch and line card portions of the infrastructure going to Alcatel-SEL and Siemens. Orders for subscriber terminations have gone to Philips Kommunikations Industrie (PKI) and other smaller companies. However, prospects for a rapid succession of repeat orders from Bundespost Telekom are dimmed by the fact that, to date, little over 5,000 of these lines are currently in use (see Figure 2).

France Telecom's Numeris service was launched nearly two years ago. Again, uptake is limited, with only 3,000 Basic Rate lines currently in service. Further, the rate at which France Telecom can extend coverage beyond city islands is limited because, unlike its switches, only a small proportion of France's long-distance trunk network is digital. Consequently, despite France Telecom's proactive approach towards the marketing of ISDN, we do not expect particularly strong uptake in France over the 1990 to 1993 period.

British Telecom commenced trial of its true ISDN Basic Rate service earlier this year, and currently has only 200 lines accessed. Full-scale launch commences in January 1991. British Telecom's mature, long-distance digital network is expected to allow full, nationwide ISDN coverage by the end of next year. Over the 1991 to 1992 period, the service will be supported using 90,000 remote multiplexed lines supplied by STC Telecoms. Further ISDN spending will be placed with GPT and, later, Ericsson for Basic Rate line card extensions to their System-X and AXE-10 central office switches.

On a worldwide perspective, and in terms of ISDN lines *actually in service* (see Figure 2), Europe lags far behind the United States, where some 120,000 Basic Rate services are now in use. Europe's take-up of Basic Rate lines is also exceeded by Japan where more than 10,000 lines are in service. However, Europe currently has the largest number of Primary Rate lines in use.

Table 2
Assumptions for Basic and Primary Rate ISDN Line Installed Base in Europe (Thousands of Lines)

	Basic Rate		Primary Rate	
Region	1992	1995	1992	1995
France	300	350	8.0	20
Germany	310	470	14.0	21
Italy	100	260	4.0	10
United Kingdom	170	360	5.0	15
Rest of Europe	120	300	10.0	21
Total	1,000	1,740	41.0	87

Source: Dataquest (November 1990)

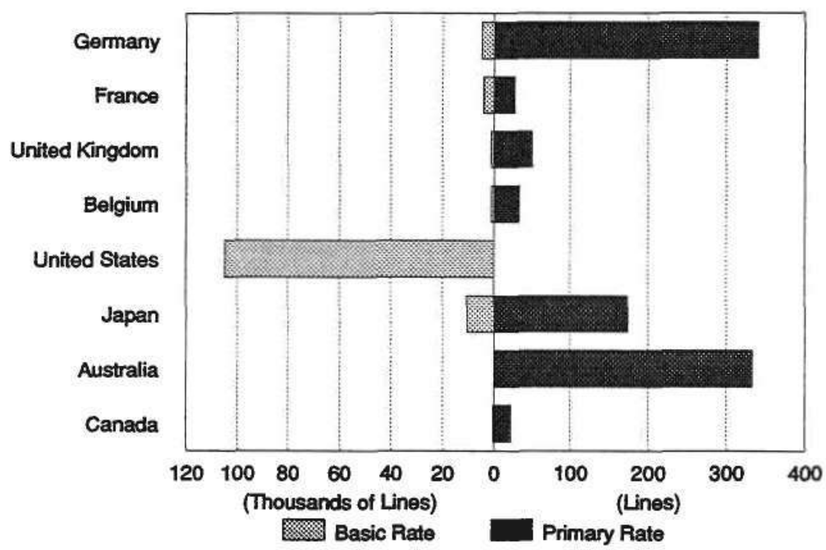
PRICE PROJECTIONS

We expect rapid price erosion over the first few years as volume markets for ISDN ICs unfold. To secure design-ins, many of the ISDN ICs presently on the market support multiple features and bus interfaces and, consequently, occupy larger die sizes than necessary. Prices will decline as volume, and hence, competition develops, quickened by rationalization of unnecessary features and shifts to smaller line geometrics. Table 3 shows the price assumptions that connect our unit forecasts to market revenue; they are not intended as forecasts of price *per se*.

ISDN—THE CRITICAL FACTORS

Discussions with experts in the ISDN community have led us to conclude that there is no one factor inhibiting ISDN's uptake in Europe. Unattractive ISDN tariffs are often cited as the most fundamental reason why ISDN is slow to emerge. But this obstacle cannot be the only factor, because there are clear cases where certain end-user segments (small offices and large decentralized organizations) could derive demonstrable cost advantages from adoption of ISDN today—although few, so far, have chosen to do so.

FIGURE 2
Public ISDN Lines in Service Worldwide
(As of End September 1990)



Source: Siemens, Dataquest (November 1990)

TABLE 3
ISDN IC Price Projections by Function—Key Assumptions
(More than 10,000 Contracts, Single Function per IC)

IC Function	1990	1992	1995
S-interface	\$6.00	\$4.55	\$3.00
U-interface	\$35.00	\$26.50	\$17.50
Rate Adapter (V.110/120)	\$8.50	\$6.40	\$4.25
Link Controller	\$6.00	\$4.55	\$3.00
Voice Codec	\$5.00	\$3.80	\$2.50
Power Supply	\$3.80	\$2.88	\$1.90

Source: Dataquest (November 1990)

We believe the following three factors (in order of priority) most limit ISDN's immediate uptake:

- **Limited geographical coverage.** Large decentralized organizations (e.g., chain stores, banks) are one of the most promising potential users of ISDN for communication. However, such users require complete coverage before they can adopt. Today, ISDN services are only available in small islands; full national coverage in the United Kingdom is not expected before the end of 1991, or in France and Germany before the end of 1992.
- **Low availability of applications.** Few companies have, so far, launched general-purpose ISDN applications suitable for use on a variety of computer platforms. We foresee that LAN-to-LAN bridges, which use the PSTN to link two or more office LANs, are one of the most promising applications. Many versions of these, usually in the form of PC adapter cards, have appeared already. However, their success is closely linked to the availability of one other application: the PABX-to-LAN interface, where progress towards standardization is slow.
- **Standards.** The PTTs' adherance to national protocols, which differ from the CCITT Blue Book recommendations, implies that terminal manufacturers must install costly, multipurpose, standard firmware into their ISDN products to allow them to work in each country. Standardization is also lacking in services that supplement voice communication (e.g., call forwarding, conferencing and identification), presently making it impractical to supply the same telephone keyboard layout in all European countries.

  The European Telecommunications Standards Institute (ETSI) plans to achieve full standardization of both public signalling and customer premise supplementary services by 1992. Although standards remain to be decided and adhered to at a European level, many PBX and terminal manufacturers already claim their equipment can interwork across different national ISDN services.

For the above reasons, we foresee 1992 as a transition year for ISDN, marking its transformation from a theoretical solution into a practical one.

VIDEO-TELEPHONY—A TRIGGER?

One common view exists that ISDN's adoption will be triggered by uniquely new applications that employ ISDN as the communications medium. Following the arrival of the new CCITT H.261 video-conferencing standard, the videophone might be regarded as a strong candidate.

The semiconductor content of videophones is currently very high, about $800 per unit. This is why the first-generation H.261 videophones cost over $25,000 each—and, of course, one needs two to communicate.

For videophones to sell in volumes comparable to normal telephones, they must sell at comparable prices, this implies a semiconductor content reduction of nearly 100 times. With such an enormous discrepancy between present prices and what is affordable, there is little precedent for videophones to become volume products until well *after* ISDN has achieved widespread adoption, in the late 1990s.

We expect video-teleconferencing systems to proliferate first; these will eventually pave the way for a videophone market. However, we believe that over the next two to three years video-teleconferencing's initial high prices will restrict it to a small number of large organizations.

Consequently, neither videophone nor video-conferencing can be expected to give ISDN line uptake a significant push for many years. Instead, we expect that ISDN compatibility will gradually diffuse its way into many key existing applications. Table 4 gives our assumptions for the rate at which this will proceed as a proportion of total shipments for three years: 1992, 1995 and 2000. (These penetrations are consistent with the ISDN line rollout figures given in Table 3.)

POTS AND PAIR GAIN—A CRUEL IRONY?

It is ironical that, in the near term, one of the greatest sources of demand for ISDN ICs will come not from ISDN applications but from the PTTs' expansions of their plain old telephone services. They are likely to achieve this in many cases through the use of "pair gain"—a term that describes the use of a single Basic Rate ISDN twisted-pair line to support two voice lines.

Pair gain is attractive because it makes more efficient use of the existing installed base of copper lines. Greater multiples of voice lines are being considered by using higher bit-rate U-interfaces than the 144 Kbit/s Basic Rate, and by using low

TABLE 4
ISDN Penetration into Total Unit Shipments (Percent)

	Year		
Equipment Type	1992	1995	2000
Facsimile	0.0%	3.0%	50.0%
Telephone, Residential	0.0%	1.0%	10.0%
Telephone, Business	0.6%	5.0%	30.0%
Personal Computers (PC Adapter Cards)	2.0%	20.0%	40.0%
CO Line Cards	1.0%	2.5%	20.0%
PBX Line Cards	0.3%	3.0%	20.0%

Source: Dataquest (November 1990)

bit-rate ADPCM codecs, but progress is currently hampered by cost, availability and power consumption. Pair gain may be one of the first applications where ISDN-dedicated ICs will appear—in this case a U-interface and a PCM voice codec integrated as one part.

Manufacturers of pair gain units in Europe include Alcatel–Telettra (Italy), ECI (Israel), and GPT, Landis & Gyr, Marconi, STC, and Telspec (all United Kingdom). In Western Europe, demand for pair gain is greatest in the United Kingdom, where British Telecom plans to purchase 150,000 units over the coming two to three years. Other moves towards pair gain are being considered in Germany and Switzerland. We may expect substantial demand for pair gain systems to originate from Eastern Europe where there will be massive pressures to boost subscriber densities as economically as possible.

MARKET ANALYSIS

Our vendor survey shows the European ISDN semiconductor market this year to be $27.8 million. In order of market share, the top three vendors are estimated to be Siemens Components, Mietec–Alcatel, and Mitel. Other major suppliers with revenues currently exceeding $1 million are AMD, National Semiconductor, and SGS-Thomson.

Present demand originates mainly from a small number of large orders for public lines. We estimate that more than a third of these went into last year's order from Bundespost Telekom for Basic Rates lines, resulting in major business for Mietec–Alcatel and Siemens Components.

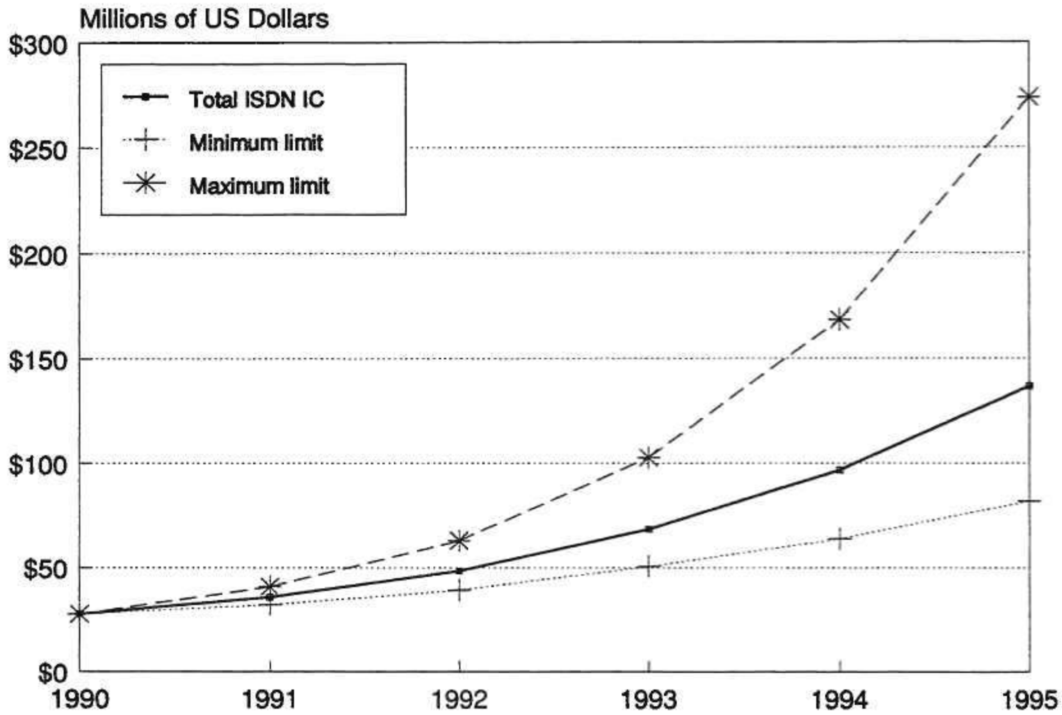
The present market is dominated by U-interface and S-interface IC shipments (see Figures 1 and 3). As subscriber interest in ISDN grows, we foresee that demand will shift towards customer premise equipment so that, by 1995, unit shipments of the major ISDN functions (excluding power supply ICs) will become comparable. However, in revenue terms, we expect the U-interface to continue to dominate, commanding 70 percent of the total market.

ISDN power supply ICs depend heavily on the market for digital telephones that can operate in emergency from line-fed power. The main source of demand for these telephones will be in the residential market, although this is not expected to develop until well after 1995.

The solid line in Figure 3 shows our estimates for ISDN uptake based on the PTT installed base estimates of Table 2. It shows a moderate 25 to 30 percent annual growth through to 1992, due largely to the fact that new orders for public infrastructure are unlikely to be forthcoming until better utilization of the existing ISDN installed base is achieved. Beyond 1992, the prospects look more positive, and we forecast a quickening of market growth to 40 percent CAGR for the 1992 to 1995 period.

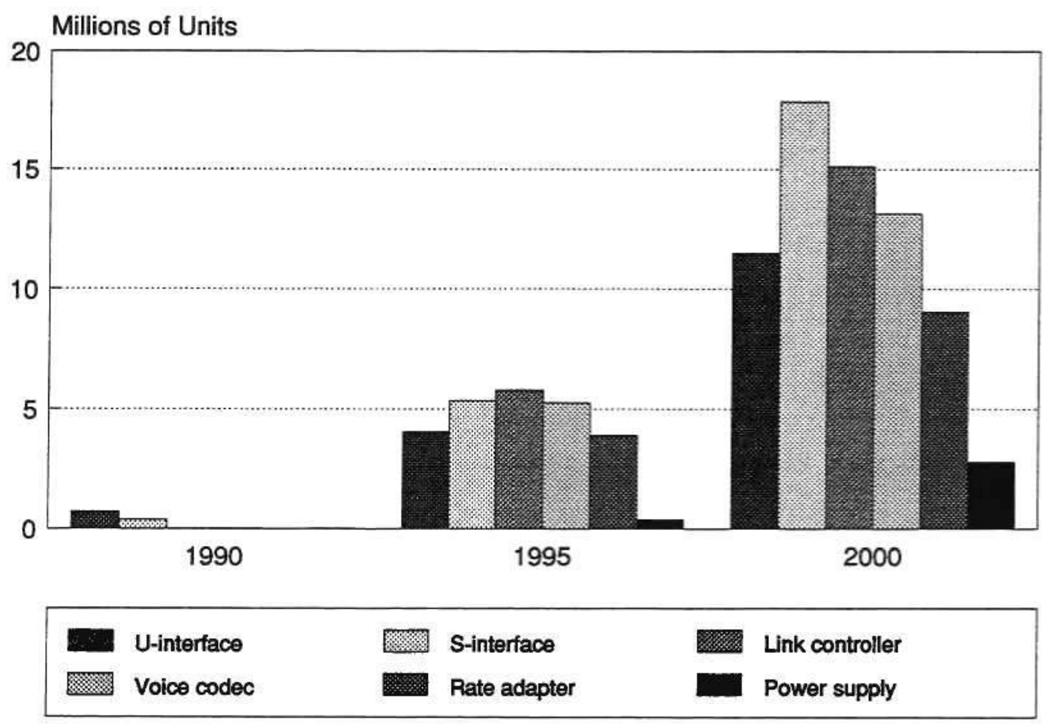
Knowledge of probable penetrations for ISDN equipment makes it possible to forecast the relative mix of ISDN functions, as depicted in Figure 4, with some confidence. However, accurate total ISDN forecasts are less straightforward, because they depend on the complicated interrelationships between the issues already discussed. By 1995, the most probable outlook for ISDN semiconductor consumption is $140 million. The maximum and minimum lines in Figure 3 give our view of the extreme limits to which the market could reach, between $80 and $280 million in 1995.

FIGURE 3
Total Forecast European ISDN Semiconductor Consumption



Source: Dataquest (November 1990)

FIGURE 4
European ISDN Unit Consumption Estimated by Function



Source: Dataquest (November 1990)

CONCLUSIONS

In terms of hardware cost per unit bandwidth, we already note that ISDN makes more cost-effective use of twisted-pair subscriber loops than conventional hardware such as analog telephones and modems. In particular, Basic Rate gives data rates (144 Kbit/s) unachievable using the fastest modems (18 Kbit/s) but at comparable prices.

The PTTs have made similar observations, but their current plans for ISDN are limited by their lack of coverage and how it fits into their portfolio of other services. However, it is clear that they will use ISDN internally as the most effective way of running their networks.

We expect pair gain to play an important role in drawing ISDN closer to the customers' premises—certainly more so than video-telephony. Pair gain offers a seamless transition from analog voice telephony to ISDN. Attracted by the opportunities to sell inexpensive, additional telephone lines, PTTs will prefer to fit Basic Rate line cards to their switches rather than lay more cable. While this is not a particularly encouraging sign for manufacturers of ISDN terminal equipment, it is clear consolation for vendors of ISDN semiconductors.

Jonathan Drazin

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Research Newsletter

PERSONAL COMMUNICATION NETWORKS—FACT OR FANTASY?

EXECUTIVE SUMMARY

Recent technological advances in digital-radio transmission (particularly in channel modulation, speech compression, and cell reuse) will shortly make it possible for people to carry wallet-size mobile communicators, which are light and inexpensive. This is the personal communication network (PCN) concept; where calls are made between people—not places.

PCNs could become a major new driver for semiconductor demand in the 1990s: they offer flexibility of communication to a whole population—as opposed to the limited subsegment of business users presently served by cellular telephony.

Today, the PCN concept is frustrated by the absence of PCN standards and high costs of handsets. This newsletter describes how rapid progress is being made on both fronts—possibly making Europe the first continent to enter the eras of Dan Dare, Dick Tracey and Captain Kirk.

INTRODUCTION

Currently in Europe, only 1 person in a 100 has a cellular telephone handset. It is widely expected that by the end of this decade the level of penetration will have risen to as high as 1 in 4 in some parts of Europe.

TABLE 1
Existing and Emerging European Cellular Telecommunications Standards

Standards	Countries of Use
Analog	
C-450	Portugal, West Germany
NMT-450	Belgium, Denmark, Finland, France, Luxembourg, Netherlands, Norway, Spain, Sweden
NMT-900	Denmark, Finland, Netherlands, Norway, Sweden, Switzerland
Radiocom 2000	France
RTMI (discontinued 1989)	Italy
RTMS	Italy
TACS-900	Austria, Ireland, United Kingdom
Digital	
GSM (commencing late 1991)	Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom
DCS 1800 (commencing late 1992)	United Kingdom, (others may follow)

Source: Dataquest (September 1990)

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Over the past decade, the development of mobile telecommunications standards in Europe has been rapid (see Table 1). However, today's networks for analog cellular telephones lack many of the qualities needed for mass mobile communication. The greatest limitation is that the networks fail to use radio spectrum efficiently enough for the needs of a whole population. Furthermore, many of these networks already experience problems serving subscribers in densely populated cities and urban areas.

PCN IN EUROPE: THE STORY SO FAR

In December 1989, the United Kingdom's Department of Trade and Industry (DTI) announced that it would award licenses to three consortia (Mercury, Microtel and Unitel) to build and operate PCNs alongside the analog TACS—and soon emerging digital Groupe Speciale Mobile (GSM)—services operated by Cellnet and Vodaphone. The DTI's objective in granting these licenses is to introduce mass-market competition for British Telecom, the main network operator in the United Kingdom.

All three UK consortia are scheduled to offer PCN services by the end of 1992 or early in 1993. At service launch they claim to be able to cover 25 percent of the UK population between them, rising to 75 percent by 1995. When granted, their licenses will stipulate that: by December 31, 1999, each operator must separately cover 90 percent of the UK population—amounting to a total infrastructure bill of about $5 billion. Special clauses have been built into their licenses to encourage this investment. These are as follows:

- The option to share infrastructure between the PCN operators
- The freedom to use their own microwave links to connect base-station sites with switching centers, and to bypass the normal BT/Mercury duopoly on such services
- The ability to sell services directly, via retail or service providers

Market projections from the three consortia suggest that, in total, there will be in excess of 10 million UK subscribers for PCN by the year 2000, a figure which, if true, may not be far short of the total number of subscribers for GSM across all Western Europe in the same year.

Earlier this year, the European Telecommunications Standards Institute (ETSI) based in southern France agreed to collaborate with the DTI-licensed consortia to develop a new PCN standard: Digital Cellular System 1800 (DCS 1800). In view of the short time to service launch, it was decided to base PCN on ETSI's new digital cellular GSM standard to commence service in cellular networks across Western Europe from the end of next year. Work on DCS 1800 is being untertaken by the same ETSI subcommittees that developed GSM, with the first stable version of DCS 1800 planned for January 1991. While this first release should lead to a marketable PCN network, subsequent refinements will be made when it has to cater for very dense voice traffic patterns and offer true ISDN compatibility.

Unlike for CT2 or GSM, no Memorandum of Understanding (MOU) exists between European states governing DCS 1800's adoption across Europe. Presently, DCS 1800 is being considered for adoption in Italy and Germany, with the probability that other countries will review its adoption at a later stage in DCS 1800's development. Work is also in progress in Europe on PCN standards that are not derivatives of the existing GSM and Digital European Cordless Telecommunications (DECT) air interfaces (particularly work on spread-spectrum techniques by AT&T and Alcatel). It is probable that several other candidates besides DCS 1800 will be considered by ETSI before a European consensus and MOU finally emerge on PCN.

DCS 1800 AND GSM—THE KEY DIFFERENCES

The advent of DCS 1800 has caused many arguments—particularly from cellular operators—that PCNs offer little beyond that which GSM is about to provide. Both types of network are likely to offer similar services to subscribers: smart card billing, call transfer, forwarding, conferencing and storage. So, what is DCS 1800's unique selling point? The answer lies in how it differs from GSM:

- Bandwidth allocation for DCS 1800 (in the United Kingdom) is three times greater than the EC allocation for GSM.
- The higher 1.8 GHz frequency band (compared to 900 MHz for GSM) allows for smaller cells to be used and greater reuse of spectrum.
- The DCS 1800 standard will permit infrastructure sharing using a new concept of "hosted" and "unhosted" cells that permit subscribers belonging to one operator to be temporarily connected to another when coverage is not available.

The above points, combined, form the basis of a mobile communications network with massively greater capacity than that available from the analog and digital cellular networks added together.

PCN IN THE UNITED STATES—MUCH INTEREST, BUT A LONG WAIT?

There is much interest in PCN in the United States: last June, the Federal Communications Commission (FCC) issued a Notice of Inquiry (NOI) calling for comment on development of a mass-market personal communication "service" (PCS). Already, some 22 experimental licenses have been requested for testing proposed services by companies including Millicom, Motorola, Nynex and BellSouth. Two to three years from now, the FCC is expected to announce its findings on PCS and declare its intentions for standards and spectrum allocation in a Notice of Proposed Rule Making (NPRM).

However, US spectrum allocation is a lengthy process. Several years are expected to elapse between the FCC's issue of the NPRM on PCS and its final ruling. In the case of the US analog cellular network (AMPS), five years passed before allocation was granted—this is largely why the new digital system (US Digital) uses the same frequencies as AMPS.

To overcome the frequency allocation problems in the United States, two companies—Millicom and Nynex—have proposed that the FCC use PCN services based on spread-spectrum techniques that employ a code division multiple access (CDMA) standard. Although CDMA uses a very wide bandwidth, it is spectrally efficient in the sense that there would be no need to clear spectrum because CDMA can be laid on top of other services. CDMA products, such as wireless LANs and very small aperture terminals, are already on sale in the United States and Europe. However, CDMA's feasibility for use in PCN environments (where received signal strengths are highly variable) is questionable. Consequently, widescale adoption of PCN services in the United States is not seriously expected for at least another five years—more than three years after DCS 1800 has entered service in the United Kingdom.

WHAT IMPACT FOR SEMICONDUCTORS?

The DCS 1800 standard is intended for use in cell diameters from about 50 meters to 1 kilometer—much smaller than the diameters used by GSM. Transmit powers (1W or 0.25W, depending on the power class) are also lower than for GSM, resulting in lighter, more compact handsets.

There will be no significant extra semiconductor cost from shifting the air interface to 1.8 GHz from 900 MHz for GSM. In fact, the overall semiconductor cost for DCS 1800 handsets will be lower than for GSM because no separate power-amplifier module is required. The move to smaller cell sizes also brings simplifications to the channel-equalizer and baseband codec ICs. Other functions, such as the GSM 13/6.5 kbit/s speech codec, are likely to remain unchanged.

Table 2 shows our estimates for the semiconductor content of a DCS 1800 handset in 1995. The total semiconductor content should be around $43, consisting of about four ICs. Chip-and-wire technology will allow the RF and IF stages (if any) to be mounted in a single, small package—we have already seen working prototypes from two European vendors. Simplifications to the channel modulator and equalizer circuits will allow them to be combined for PCN. The speech and controller ICs are likely to be used for GSM handsets (see ESAM newsletter 1990-5, "GSM in Europe—Cellular Turns Digital"), although possibly with minor modifications to the mask ROM codes in each.

Advances in cost reduction and compaction will leave the RF and IF stages accounting for less than a fifth of total semiconductor content. The remaining 80 percent by value consists of roughly 200,000 gates of CMOS. Consequently, we expect PCN handset semiconductor costs to fall roughly in line with high gate count CMOS for the remainder of the decade.

WHAT IS THE FUTURE FOR PCN?

So how will GSM and PCN coexist? In the first years of service, we expect the PCN operators to face a tough uphill battle. The fact that PCN uses smaller cells than GSM, makes the PCN cost of infrastructure per unit-area considerably higher. Further, up until the point when the GSM networks approach full capacity, there will be little to differentiate PCN from GSM. From this point onwards, service quality on the GSM networks will diminish, especially in the cities, clearing the way for PCN to take on new subscribers.

Although DCS 1800 is "mobile" (in the sense that it provides handover between cells and permits communication at speeds up to 125 km/h) we do not believe it will become a major rival to GSM for in-car mobile use. This is because PCN's coverage will first be limited to inner cities and later will expand to urban and rural areas. While coverage of major highways is envisaged, the operators are not likely to extend coverage to all rural roads for many years—if at all. Consequently, we foresee that GSM, not PCN, will become the chosen form of access for most automotive users.

We believe DCS 1800 in its present form has other limitations. Possibly the most severe of these is that time pressure (as a result of PCN's UK launch by 1992), has been one reason for ETSI selecting GSM, not DECT, to form the basis of DCS 1800. However, GSM is less spectrally efficient compared to DECT in small cells (for which DECT was designed). More fundamental is that, unlike DECT, neither GSM nor DCS 1800 can carry Basic Rate ISDN data traffic. This is not an issue today but by the mid-1990s, when both PCN *and* ISDN take off, this will become embarrassing. GSM and DSC 1800 are said to have problems in the short term too—one being that Group 3 facsimile machines cannot be connected to these networks.

DATAQUEST CONCLUSIONS

The implication of PCN for the semiconductor industry over the coming decade will be no less profound than the impact the personal computer had in the last decade. For Western semiconductor manufacturers the challenges will be particularly great. This is because personal communicators will have more in common with low-margin miniature consumer products like camcorders and Walkmans (into which they sell few parts) than they have with desktop PCs.

Dataquest is convinced that the PCN concept is set to commence across Europe within the next three to five years. What is less clear, is how Europe's first experience of PCN will fare in the United Kingdom. While DCS 1800 will lead to cheaper and more compact handsets (two vital conditions for mass adoption) than is possible with GSM, we are not convinced that it will have sufficient flexibility to ensure its adoption as the PCN standard for Europe. Much further work is needed to include DECT functionality into it before it will satisfy data users.

TABLE 2
Semiconductor Content Estimation for a DCS 1800PCN Handset in 1995

Component	Technology	Cost
Front-End IC	Chip-and-wire	$7.00
Filters	SAW	
Receive amplifier	Bipolar or GaAsFET	
Transmit amplifier	Bipolar	
Synthesizer/PLL	Bipolar	
Baseband conversion	CMOS	
Channel IC	Monolithic CMOS	$13.00
Channel Codec		
Channel equalizer		
Speech IC	Monolithic CMOS	$13.00
Speech Codec		
Mike/Speaker circuits		
Controller IC	Monolithic CMOS	$10.00
Keyboard/LCD controller		
Card controller		
Supplementary functions		
Memory		
Total Semiconductor Content:		$43.00

Source: Dataquest (September 1990)

We see stormy weather ahead for the PCN pioneers in the United Kingdom. They face strong competitors (Cellnet and Vodaphone) who, in the short term (1992 to 1994), have fully developed analog TACS networks with spare capacity—capable of carrying double the amount of subscribers than they have at present. Over the longer term (1993 to 1996) the same competitors will deploy GSM networks that are expected to at least triple their present capacities. Winning market share from these players will be an expensive exercise. Only when capacity runs short on GSM can PCN demonstrate clear leadership.

This is not to imply that PCN will be totally excluded from the UK market until the mid-1990s; niches will start to appear from the outset. These niches are likely to be in city areas: with professional users who value the quality of service that PCN will offer. Many of these will use PCN handsets in multiple environments: at home, while commuting, and around the office. But here, again, PCN will find itself pitted against two rival cordless technologies—CT2 and DECT.

Jonathan Drazin

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Research Newsletter

ALCATEL STRENGTHENS ITS NUMBER ONE POSITION

INTRODUCTION

Fiat of Italy and CGE of France have announced a far-reaching alliance, involving a share and business swap between the two companies, and also an agreement to form a group to explore a range of technologies of common interest to them. Undoubtedly it is the public telecommunications business which is at the heart of the agreement, and which has been the driving force behind the move.

Fiat has effectively sold Telettra to Alcatel.

Telettra will be merged with Alcatel's Italian subsidiary (FACE), although Fiat will hold a 25 percent share in the merged company. This further strengthens Alcatel's position as the largest European telecoms manufacturing company. Indeed, Alcatel was already the second-largest telecoms manufacturing company in the world, and this alliance could well move it above its other major rival, AT&T.

ALCATEL

Alcatel NV was formed in 1986 by the merger between CGE's communications business and ITT of the United States. It is 61.5 percent owned by CGE and 37 percent owned by ITT, with the balance being owned by Crédit Lyonnais. Alcatel is effectively a massive conglomerate of strong national subsidiaries, many of which have leading positions in their own markets. At least seven of its major European subsidiaries had 1989 turnovers well in excess of $500 million—and only three of these subsidiaries are based in France.

Its total turnover for 1989 was ECU 12.8 billion (approximately $14.1 billion), and its net income was ECU 478 million ($525 million).

Alcatel's business is above all else in telecoms manufacturing and marketing, and the company has a very comprehensive product range covering virtually all aspects of the telecoms market. Indeed, due to its history, one of its main issues and priorities has been to rationalize competing product lines to prevent duplication of effort and products, and to gain maximum benefit from its substantial scale. Alcatel's business is split as given in Table 1.

TABLE 1
Alcatel's Sales Analysis

Product Areas	Percent Share	Countries	Percent Share
Central Office	25%	France	29%
Transmission	14%	Germany	17%
Cables	28%	Italy	9%
Business Systems	21%	Spain	10%
Other	12%	Rest of Europe	17%
		Rest of World	18%
Total	100%		100%

Source: Dataquest (November 1990)

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TELETTRA

Telettra is 90 percent owned by Fiat, with the remaining 10 percent being held by Telefónica, the Spanish PTT. This shareholding reflects its business—basically an Italian company but with a major subsidiary in Spain. The Spanish subsidiary is itself 90 percent owned by Telettra, with the balance again owned by Telefónica.

Telettra's 1989 turnover was L 1.62 trillion ($1.2 billion), on which it earned a net income of L 200 billion ($150 million).

Telettra is a telecommunications company, with a small business in defense systems. Its transmission business constitutes by far the largest part of its turnover.

While having a strong position in the Italian and Spanish transmission markets, the major issue facing Telettra was how to consolidate and grow this business when faced with both much larger competitors, and the enormous problems encountered in trying to enter new markets. Telettra's business split is given in Table 2.

THE ITALIAN MARKET

The Italian market is, to say the least, very complicated. In contrast with the other major European markets, it has a complicated national telecommunications infrastructure, with several operating companies and a diverse supplier base. As an example, in the central office market, there are no less than five major suppliers supplying four different product ranges.

The estimated total Italian telecoms turnover of the major telecoms suppliers is shown in Table 3.

One key feature of the Italian market is the major influencing role of politics, individuals and central government. As an example, a merger between Italtel and Telettra had been long planned, but finally collapsed in 1987 due to disagreement over how the new company (Telit) would be managed and to what extent it would be free from central control or influence.

TABLE 2
Telettra's Sales Analysis

Product Areas	Percent Share	Countries	Percent Share
Transmission	63%	Italy	51%
Central Office	14%	Spain	29%
Other Telecoms	15%	Rest of Europe	6%
Defense	8%	Rest of World	14%
Total	100%		100%

Source: Dataquest (November 1990)

TABLE 3
Major Players in the Italian Telecoms Market

	1989 Turnover		
Company	Billion	$B	Primary Focus
Italtel	L 1,900	$1.4	Central office
Telettra	L 800	$0.6	Transmission
Alcatel	ECU 0.6	$0.7	Central office, cable, business systems
Siemens	L 500	$0.4	Central office, transmission
Ericsson	L 600	$0.4	Central office

Source: Dataquest (November 1990)

THE SPANISH MARKET

The Spanish market also has a fairly diverse supply industry, and in many ways represents the most open major market in Europe. Having said that, Alcatel is by far the largest supplier to the market. It also has great growth potential due to the relatively underdeveloped state of the network.

The estimated total Spanish telecoms turnover of the major telecoms suppliers is shown in Table 4.

Telefónica appears keen to promote further competition in Spain and a number of other major suppliers are successfully building a Spanish business—perhaps the most notable being AT&T.

THE LOGIC BEHIND THE MOVE

Quite simply, this move:

- Further strengthens Alcatel's position within the European telecoms industry
- Allows Fiat to focus more tightly on its core business, which is far removed from telecoms

In Italy, Alcatel and Telettra combined now have a dominant share of the transmission market in addition to Alcatel's strong position within the central office market. Together they are the equal of Italtel in turns of telecoms turnover within the country. In Spain, the combined company is by far and away the major player in the market, having well over 50 percent share of the central office market and approaching a 100 percent share of many areas within the transmission market.

While Alcatel has consolidated its position in these two major European markets, Telettra (and Fiat) has solved the problem of simply not being big enough in an industry that is increasingly characterized by large-scale suppliers. As a part of the Alcatel group it can now afford (or at least have access to) much larger R&D programs, and enable the benefits of rationalization and scale.

On its own Telettra could only have survived by an increased focus on "niche" markets or by entering into wide-ranging collaborations or joint ventures with other companies—a strategy demanding much high-level focus and attention. As it was owned by an automobile manufacturer and contributed considerably less than 5 percent of the total turnover of Fiat, it is highly questionable whether such a strategy would have worked. Fiat looked for a buyer, and has effectively sold Telettra for a very good price before the going got too tough.

For Alcatel, there must have been an added technology-based motivation behind the move. While it will not have been the prime reason, Telettra's advanced technology and products in digital cross-connect systems must have made it an even more attractive proposition. This key technology/product area will become ever more important within public telecoms over the next decade, and it represented the one obvious gap in Alcatel's otherwise comprehensive transmission product range. While there are, no doubt, many short-term issues to resolve, Alcatel has effectively plugged this gap.

DATAQUEST ANALYSIS

This alliance is further evidence, if any were needed, of the necessity for rationalization within the public telecoms industry in Europe. The telecoms market is now characterized by shortening product life cycles and resulting greater requirements for privately funded investment in R&D. The market is simply too small to support the large number of national suppliers which have historically existed. Every year, the number of medium-size suppliers is decreasing while the very few companies with larger telecoms turnover continue to grow even bigger. While there are still many opportunities for small companies, the middle ground is disappearing.

TABLE 4
Major Players in the Spanish Telecoms Market

	1989 Turnover		
Company	Billion	$B	Primary Focus
Alcatel	ECU 1.0	$1.1	Central office, transmission
Telettra	L 400	$0.3	Transmission
Ericsson	L 700	$0.5	Central office

Source: Dataquest (November 1990)

This has implications for the few remaining medium-size companies. As pointed out by STC after its recent sale of ICL stock to Fujitsu, one strategic option for enabling the longer-term success of the relatively smaller companies is the forming of a pan-European grouping of telecoms suppliers—but the options for finding appropriate partners has now narrowed even further. The acquisitive nature of the few remaining truly worldwide players is clearly not being halted by the collaborative plans of their smaller competitors.

The ongoing restructuring and rationalization of the industry also has implications for non-European companies keen to penetrate the market or grow their European public telecoms businesses. The target list for potential acquisitions or joint ventures is shrinking for them too. The opportunity to make a *really* major impact on the market is disappearing rapidly.

The interesting question now is how much longer the few remaining medium-size companies in this market will continue as "independent" companies.

As a footnote, it is also worthwhile commenting on the inability of the Italian government effectively to build a national champion in public telecoms. In the end, commercial and marketing pressures have won out over political intervention, and there must now be a very large question mark over the medium- to long-term survival of Italtel as an "independent" Italian company.

(This newsletter was originally published by Dataquest's European Telecommunications Industry Service.)

John Dinsdale
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Research Newsletter

WORKSTATIONS—RAMPING UP THE GROWTH

EXECUTIVE SUMMARY

From a recent Dataquest survey we estimate that 48,095 workstations were manufactured in Europe during 1989. This figure represents 54 percent of the total workstations (88,875 units) sold in this marketplace, and 17 percent of worldwide production. The results of our survey suggest that only 23.7 percent (21,045 units) of total workstation sales in Europe accounted for semiconductor sales on the European market.

The high growth of the end-user market, combined with local production, is expected to prompt a rapid rise in the general consumption of semiconductors for workstations. The European market for workstation semiconductors is expected to be $22.2 million this year, and we forecast that this will rise, with a 69 percent compound annual growth rate (CAGR), to $182.2 million in 1994.

WORKSTATION DEFINITION

Dataquest defines workstations as: any computer that is intended for multitask use by one operator, but this excludes 80x86-based machines that normally run MS-DOS or OS/2-type operating systems. Consequently, personal computers (see ESAM newsletter 1990-14 "PC Production in Europe, 1989—Preliminary Update") are excluded from this survey. Typically, most workstations use VMS (Digital), UNIX or UNIX-like operating systems such as DOMAIN (Apollo) or HP-UX (Hewlett-Packard).

EUROPEAN WORKSTATION PRODUCTION

Table 1 shows the main workstation manufacturers and production activity in Europe. Table 2 shows workstation production and shipments, and makes the distinction between total production and *effective* production; the latter counts only those units where semiconductors are procured in Europe. In total 48,095 units were produced during 1989—of which 43.8 percent were effectively produced. According to manufacturers' estimates, total production is set to nearly double to 70,850 units this year, with the proportion effectively produced dropping slightly to 40.7 percent. With many new plans announced to help ramp up production this year, the scenario for the years ahead looks very different.

In terms of semiconductor consumption, we estimate that Digital is the largest consumer, producing a total of 20,900 DECstations (RISC-based) and VAXstations (CISC-based) at its Ayr plant in Scotland last year. Second largest is Hewlett-Packard/Apollo, at its Böblingen plant in West Germany, with an estimated 17,900 unit production of CISC-based workstations. Third is Intergraph, which manufactured 4,950 RISC-based units in 1989.

Sun is scheduled to produce 9,000 units of Sun SPARC machines this year—accounting for 12.7 percent of total production in Europe—and it expects to more than double this figure next year. By mid-1991, it expects to be subcontracting the manufacture of printed circuit boards (PCBs) to ICL (Kidsgrove, UK). This is to keep all its workstation assembly operations in Linlithgow (which has capacity to produce 2,000 units per week). Bull HN is expected to announce plans later this year to launch a workstation product to be manufactured in Europe.

IBM

IBM has assembly facilities for its RISC-based RS-6000 workstation at its Santa Paloma plant in Italy. Although we estimate that some

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TABLE 1
Workstation Production Activity in Europe

Manufacturer	Subcontractor	Town	Country	Country of Origin	Board Assembly	Board Test	Workstation Assembly	Local Semiconductor Procurement
Acorn	AB Electronics	Cardiff	United Kingdom	United Kingdom	✔	✔	✔	✔
Cetia	Cetia	Toulon	France	France	✔	✔	✔	✔
Digital	Digital	Ayr	United Kingdom	United States	✔	✔	✔	(Spares Only)
HP/Apollo	HP/Apollo	Böblingen	West Germany	United States	✔	✔	✔	✔
IBM	IBM	San Paloma	Italy	United States	NA	NA	✔	(Captive Sales Only)
Impuls	Impuls	Vienna	Austria	Austria	✔	✔	✔	✔
Intergraph	Intergraph	Nijmegen	Netherlands	Netherlands		✔	✔	
Parsys	Thorn EMI Micrologic	Bedford	United Kingdom	United Kingdom	✔	✔	✔	✔
Silicon Graphics	Silicon Graphics	Neuchatel	Switzerland	United States		✔	✔	
Sun Microsystems	Sun Microsystems	Linlithgow	United Kingdom	United States	✔	✔	✔	(Commencing late 1990)

NA = Not Available
Source: Dataquest (October 1990)

TABLE 2
Workstation Unit Production Shipments in Europe

Manufacturer	1988 CISC Total	1988 RISC Total	1988 Total	1989 CISC Total	1989 RISC Total	1989 Total	1990 CISC Total	1990 RISC Total	1990 Total	1991 CISC Total	1991 RISC Total	1991 Total
Acorn	0	0	0	0	1,250	1,250	0	3,200	3,200	0	5,250	5,250
Cetia	970	0	970	1,800	0	1,800	1,800	200	2,000	2,000	600	2,600
Digital	18,750	0	18,750	20,500	400	20,900	23,500	2,700	26,200	19,700	6,600	26,300
HP/Apollo*	12,059	0	12,059	17,900	0	17,900	23,500	0	23,500	26,300	0	26,300
IBM*	NA	NA	NA	NA	NA	NA	NA	6,000	6,000	NA	NA	NA
Impuls	50	2	52	50	20	70	40	40	80	30	60	90
Intergraph*	0	4,500	4,500	0	4,950	4,950	0	5,500	5,500	0	6,100	6,100
Parsys	0	0	0	0	25	25	0	50	50	0	75	75
Silicon Graphics*	0	935	935	0	1,200	1,200	0	1,320	1,320	0	1,450	1,450
Sun Microsystems	0	0	0	0	0	0	0	9,000	9,000	0	29,750	29,750
Totals	31,829	5,437	37,266	40,250	7,845	48,095	48,840	28,010	76,850	48,030	49,885	97,915
Effective Production	13,079	2	13,081	19,750	1,295	21,045	25,340	3,490	28,830	28,330	35,735	64,065

* Estimated
NA = Not Available
Source: Dataquest (October 1990)

3,000 units of workstations were manufactured at the plant up until August 1990, we believe the plant has capacity to reach an estimated 15,000 units. Originally, IBM was expected to procure semiconductors locally for workstation production at Santa Paloma, but this has been postponed. Although we were unable to survey IBM, our belief is that IBM's semiconductor consumption is largely derived from its capative sales.

RISC AND CISC APPLICATIONS

Workstations based on CISC processors still dominate the market, accounting for 63.5 percent of total European workstations produced (see Table 3). Most of these have been designed around the 68000 series; very few 80x86-series processors have penetrated European manufacturing and it now appears that they are fading from this segment. The increasing availability of applications software for RISC UNIX-based platforms and the advent of Sun Microsystems' large manufacturing facilities in the United Kingdom means that the uptake of RISC workstation production is clearly underway. Other RISC processors in volume applications are: the Intergraph Clipper, SGS-Thomson's transputer series, Acorn's ARM processor, Intel's i860, and Motorola's 88000 part.

TABLE 3
European Workstation Production and Semiconductor Consumption Forecast

Microprocessor Type	1988	1989	1990	1991	1992	1993	1994
European Sales (Units)	61,250	88,875	134,157	189,857	263,779	353,347	460,265
CISC							
68000 series	31,779	40,200	48,800	48,000	NA	NA	NA
80x86 series	50	50	40	30	NA	NA	NA
Total CISC (Units)	31,829	40,250	48,840	48,030	46,161	44,754	43,392
RISC							
MIPS R2000/3000	935	1,600	4,020	8,050	NA	NA	NA
Intel i860	0	0	0	0	NA	NA	NA
Acorn ARM	0	1,250	3,200	5,250	NA	NA	NA
Sun SPARC	0	0	9,000	29,750	NA	NA	NA
Motorola 88000	0	0	200	600	NA	NA	NA
AMD 29000	0	0	0	0	NA	NA	NA
Inmos Transputer Series	2	45	90	135	NA	NA	NA
Intergraph Clipper	4,500	4,950	5,500	6,100	NA	NA	NA
Other RISC	0	0	6,000	0	NA	NA	NA
Total RISC (Units)	5,437	7,845	28,010	49,885	89,743	137,307	193,603
Total Unit Production	37,266	48,095	70,850	97,915	135,904	182,061	236,994
Effective Unit Production	13,081	21,045	28,830	64,065	108,723	172,958	236,971
Semiconductor Content per Unit ($)	$780.00	$740.00	$769.00	$769.00	$769.00	$769.00	$769.00
European Semiconductor Consumption ($M)	$10.20	$15.57	$22.17	$49.27	$83.61	$133.00	$182.23

NA = Not Available
Source: Dataquest (October 1990)

Over the next few years we believe that RISC-based workstations will continue to grow at a faster rate than CISC-based workstations. The higher price/performance advantage offered by RISC is strongly in demand from a growing number of technical and CAD/CAM/CAE users. In terms of unit production, we foresee a strong 72 percent CAGR for RISC-based production, and a declining 3 percent CAGR for CISC through to 1994.

This is already evidenced, we believe, by the fact that this year's sales of RISC machines closely match those of CISC. RISC has become successful mainly because support for RISC architectures has increased dramatically, and it is now clearly evident that RISC will play a central role in the workstation market. Dataquest forecasts that RISC could account for 80 percent of the total workstation market worldwide by 1994; last year it accounted for 43 percent.

EUROPEAN SALES

Workstation sales within Europe grew progressively over 1987 to 1989 from 32,275 units to 88,875 units respectively. Dataquest forecasts that the trend will continue this year, with a 51 percent growth in sales to an estimated 134,157 units.

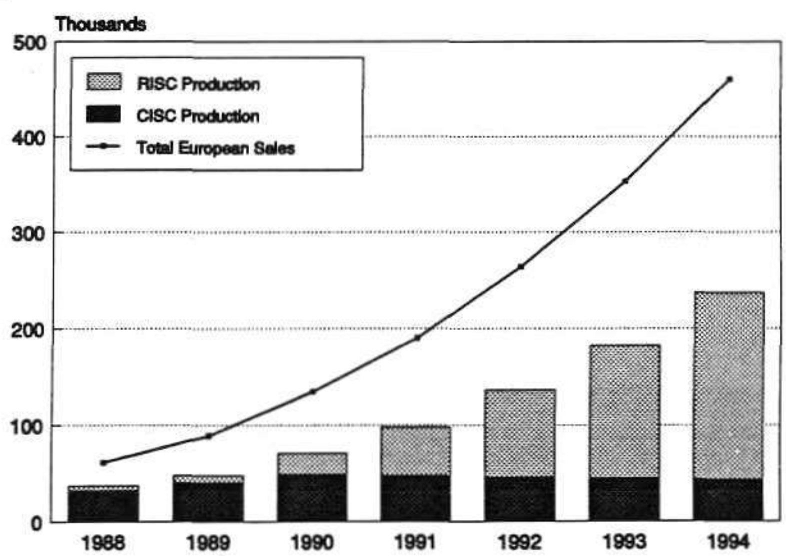
The US manufacturers indicated that they planned to increase production to meet all local demand in Europe. Currently, their target estimates for 1990 suggest that effectively 21.5 percent of units sold in Europe are produced in Europe. By 1994, we expect this proportion to have risen to above 50 percent (see Figure 1).

SEMICONDUCTOR FORECAST

To prepare estimates of the revenue from European consumption of workstation semiconductors, we have examined a typical motherboard for a midrange workstation to determine semiconductor content (see Table 4). MOS ICs represent some 82 percent of semiconductor content, with the remainder being predominantly bipolar TTL, ECL and PAL standard logic.

Our analyses of semiconductor content combined with production give a consumption forecast as seen in Table 3. While we do not forecast any growth in semiconductor content, we do forecast high growth in revenue of semiconductors in Europe (69 percent CAGR, 1990 to 1994), due to the rapid increases in effective production as discussed earlier. This year we estimate semiconductor consumption to be $22.2 million, rising to $182.2 million by 1994. In fact, the total consumption of semiconductors in workstations is expected to exceed the figures given in Table 4 as other PCBs—such as LAN, video, disk and driver

FIGURE 1
European Workstation Market and Production (Thousands of Units)



Source: Dataquest (October 1990)

cards—besides the motherboard, are needed to build a complete workstation system. In addition, peripheral units (for example, monitors, keyboards, hard disks, and so on) are not included in these estimates, consequently we believe that the total consumption for workstations exceeds Table 4 by a factor of between 1.5 and 3.

CONCLUSIONS

Today, few manufacturers procure semiconductors locally for workstation production. In our survey we discovered that, although some board tests do take place in Europe, most take place overseas.

Discussions with the manufacturers have revealed that they nearly all intend to ramp up their production markedly *and* procure locally. While many of their claims verge on the optimistic, there are clear, fundamental reasons why this might be achieved. Like PCs, the workstation market is becoming increasingly competitive; as price competition grows, so does the need to have local centers of production so that import duties can be bypassed. The need to manufacture close to their customers is another reason why these manufacturers are giving special attention to procurement in Europe.

However, this is not sufficient explanation for the transition towards local procurement among manufacturers. It may be that the unit volumes that these manufacturers are selling into Europe have not until now been high enough for them to justify investment in costly PCB assembly and test facilities. Another reason could be that recent activities by the European Commission—enforcing minimum local contents for some Japanese manufacturers of printers and photocopiers—have urged some of the workstation manufacturers to insure themselves now against further EC developments in other areas, such as PCs and workstations. However, we feel that this is unlikely as we do not foresee any "dumping" in this marketplace. It is more likely that preference rules—which give preference to suppliers with higher local content—could encourage more workstation vendors to start procuring locally.

Mike Williams
Jonathan Drazin

TABLE 4
Estimated 1990 Workstation Semiconductor Content for a Typical Midrange Workstation

	Value	Number of Parts	ASP per Part
Total Semiconductor	$769	228	$3.37
Total Integrated Circuit	$757	221	$3.42
Total Bipolar	$125	119	$1.05
Bipolar Memory	0	0	NA
Bipolar Logic	125	119	$1.05
Total MOS	$632	102	$6.19
MOS Memory	522	81	$6.45
MOS Micro	87	4	$21.73
MOS Logic	22	17	$1.31
Linear	$2	3	$0.62
Discrete	$10	4	$2.50
Optoelectronic	$0	0	NA

Note: CPU motherboard only; excludes monitor, power supply and peripheral drivers (e.g. LAN and disk controllers)
NA = Not Applicable
ASP = Average selling price
Source: Dataquest (October 1990)

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Research Newsletter

EUROPE—REDRAWING THE COMPETITIVE BORDERS EUROPEAN SEMICONDUCTOR INDUSTRY CONFERENCE

SUMMARY

Dataquest's ninth annual European Semiconductor Industry Conference was held in Geneva, Switzerland, from June 6 to 8. The theme of the conference, "Europe—Redrawing the Competitive Borders," focused on how economic, commercial, technological and political changes were affecting the semiconductor industry, its users and suppliers.

Along with discussions on the current situation in the European semiconductor scene and forecasts for the future, with reference to Eastern Europe, and developments in memory chips, the attendees had a choice of two concurrent panel sessions:

- "Made in Europe"—What does it mean?
- Has the ASIC market matured?

SPEAKER HIGHLIGHTS

This newsletter highlights the information presented at the conference by the invited speakers in the following extracts.

JESSI and the European Semiconductor Industry

Raimondo Paletto
President, JESSI Board

Whereas Sematech is aimed only at manufacturing science, JESSI covers the total "food chain" of electronics from research to applications. JESSI's budget of $4 billion over eight years is as much as all the other Eureka projects combined. The aim in process technology is to go from 0.8 µm to the 0.3 µm needed to make a 64-Mbit DRAM. In April an agreement was reached on industrial property rights which "ensures the success of JESSI." Spurred on by the IBM/Siemens alliance, all JESSI targets for memory chip development have been accelerated by one year (1994 for the 64-Mbit DRAM). These chips will give European companies access to a $70 billion plus market by 1995.

Mega-Technologies for the '90s

Dr. Horst Fischer
Vice President and Chief Operating Officer
Siemens Semiconductor Group

The world market share of the European electronics industry has been stagnant for ten years. The three "legs" on which the industry stands are proprietary architectures, efficient software and innovative chips. Europe can supply only half its chip consumption. Siemens is producing 4 million 1-Mbit DRAMs a month and is ramping the 4-Mbit. It can supply 20 percent of the European requirement for 1-Mbit and 5 percent of the requirement for 4-Mbit. First silicon of the 16-Mbit was developed in April and its production ramp will start in the second half of 1992. The 64-Mbit being developed with IBM is expected in 1994. The continual improvements in process technology are feeding through into Siemens' logic products.

Economic Overview

Dr. Yuri Levine
Senior Research Fellow, Institute of World Economy and International Relations, USSR

The drive towards market-oriented economies and political pluralism is both underway and irreversible in the Eastern bloc. By the end of 1990 legislation is expected in Russia and Eastern

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Europe to allow the purchase of real estate. A stock market has opened in Budapest. Legislation to set up a stock market has been adopted in Poland. Similar legislation is being enacted in Czechoslovakia and is being prepared in Russia. The transfer to market prices has happened in Hungary where government subsidies are nil, and in Poland where prices are rising steeply. Market prices are being introduced in Czechoslovakia where subsidies are diminishing, and in East Germany where prices are soaring while some subsidies remain. In Russia, large price subsidies are continuing but reform is expected. In the Eastern bloc as a whole, foreign capital does not play any substantial role as yet.

Technology for the Next Century

Manny Fernandez
President, Dataquest Incorporated

DRAM generations are coming closer together which will entail a revision of Moore's Law. Driving that will be the PC for which the market will more than double over the next four years to 239 million units in 1994 from the 1989 level of 94 million units. There are two possible pitfalls to this growth:

- Software, which is lagging behind the introduction of the hardware to such an extent that a whole silicon cycle could be wasted with new machines merely offering the capability to run old software faster.
- Marketing, which has to learn how to address a 240 million user market.

Pen and Paper—The New Revolution

Dr. Hermann Hauser
Chairman, Active Book Company

The 1990s will be the age of the book computer—the fourth wave in computing after mainframes, minicomputers and PCs. Dr. Hauser has invested $1 million of his own money in producing a notebook computer which is accessed via a stylus using handwriting rather than a keyboard. The machine simulates the working of a book with chapters, pages and an index, adding to it voice and animation. It will open up computing to computer illiterates. The first models are expected to be on the market in the first quarter of 1991 and will cost around £1,000.

East European Perspective

Mitja I. Tavčar
Vice President, Iskra Commerce

Iskra is a group of Yugoslavian manufacturing companies with combined sales of 1.4 billion ECU and exports of 350 million ECU in telecommunications, automation, electronics and components including semiconductors. Iskra's exports to COMECON have grown from 50 million ECU to 110 million ECU in the last 15 years. A huge but unquantifiable market for electrical and electronic products exists in Eastern Europe. Among the problems in opening it up are: CoCom regulations, poor distribution, the low profile of companies, the lack of hard currency, and the chaos caused by sudden decentralization after years of central planning. One way of trading is to swap manufactured Western goods for Eastern bloc components including semiconductors.

Trends in Consumer Electronics

Dr. Jean Caillot
Senior Vice President
Thomson Consumer Electronics

Semiconductors and consumer electronics depend on each other for survival. The Japanese built their semiconductor industry on the back of their consumer electronics industry; so must Europe. While the United States has mostly withdrawn from consumer electronics, Europe has two companies—Philips and Thomson—in the top six worldwide. A constraint to the success of European companies is the fact that the second largest consumer market—the Japanese market—is effectively closed to outsiders; for example, 77 percent of the big Japanese stores with 45 percent of the sales are controlled by the top nine electronics manufacturers (other stores are pressured into not taking foreign goods).

Multimedia—Converging Technology

Ray Burgess
Business Segment Director
Motorola European Semiconductor Group

Multimedia is the convergence of one or more of the characteristics of consumer electronics (still pictures, audio, motion video) with one or more of the characteristics of the computer (text, graphics, interactivity). In education it can provide interactive books and language learning. In entertainment it makes possible video games and simulated experience like armchair holidays. For training it can provide "How to ... " manuals, the "expert-in-the-corner," and situational simulation. For presentations it can help in point-of-sale promotions, conference addresses and visualization. Software will drive the market, which should reach $16.4 billion by 1994.

New Trends in Semiconductor Memories

Dr. Tsugio Makimoto
Director and General Manager, Semiconductor Design and Development Centre
Hitachi

The 1990s are the submicron decade when the world moves from the Mega to the Giga—from the 0.8 μm 1-Mbit DRAM in 1990 to the 0.1 μm 1-Gbit DRAM in the year 2000. MOS remains the technology driver. MOS memory is a quarter of the total semiconductor market and will increase to a third by 2000. On average, each person on the planet consumes 160 Kbits of MOS memory a year; in 2000 that will rise to 8 Mbits. Logic and memory are merging to the extent we will have to talk about "memory and logic" chips. Flash technology provides an approach to the ultimate memory chip, a high-density, cost-effective nonvolatile RAM. Gigabit technology should make possible portable translation machines—a powerful aid to world communication.

Semiconductors: Rationale for a Community Strategy

Gérald Santucci
Principal Administrator
European Commission—DG XIII

Is it justified to provide special support for the semiconductor industry? The semiconductor industry is becoming a crucial element in the world economy—its small size must not hide its broader significance—and its inescapable importance to the European economy means that EC policies must be adopted accordingly. Concern centers on the increasing domination of the market by Japanese producers. European producers have "at best a modest position" but EC efforts to maintain a European semiconductor industry will determine whether the EEC stays in the rest of the electronics industry. That is because it is unlikely that systems design and software will be sufficient to stay in the electronics industry because of the increasing integration of intelligence into the chips themselves. Although managed trade in semiconductors would lead to ossified trade, there is a case for forming a multilateral consultative forum on semiconductors, maybe with the OECD.

PANEL SESSION 1: "Made in Europe"—What does it mean?

Michael F. Phillips
Director, European Corporate Affairs
Motorola Inc.

The November 1989 report by the US National Advisory Committee on Semiconductors stated that semiconductors were a strategic industry for the United States as the foundation of the information age. So it is for Europe. A product is usually said to have the nationality of where it is made, but a chip can be diffused on one continent, assembled on another and put into equipment on a third. Where a product is made in two or more countries, it takes on the nationality of the country in which the last substantial process which is economically justified was performed. With chips that process is the diffusion stage, which is accepted by the EC as the "last substantial transformation."

Bruno Lamborghini
Vice President
Corporate Strategic Analysis and Planning
Olivetti Group

To be competitive the European electronics industry needs to get supplies of semiconductors at the right time and the right place. Europe has become too dependent on the Japanese for DRAMs and on the Americans for microprocessors—the most critical devices for computer manufacturers. Other areas like TV—particularly HDTV—printers and workstations need increasing quantities of DRAM. Olivetti has supported JESSI and antidumping actions but is concerned at the artificial price limitation measures, especially at the delicate stage of the introduction of a new device such as the 4-Mbit DRAM. Tariffs should not be used as a protectionist measure. The competitiveness of the European IC industry should come through the positive action of the manufacturers and not by creating an artificial market. We need alternative high-quality sources in a competitive environment.

Albert Maringer
Director Strategic Planning
Siemens AG

The undertaking extracted by the EC from the Japanese manufacturers on the pricing of DRAM was fair. The case took too long to settle, but it ended in a voluntary agreement. A monopoly in the supply situation is not and never will be in the interest of the European user industry. The reference price mechanism is in place for five years for existing and future products.

Sadru Nanji
Manager, Components Products Centre,
Purchasing Division, ICL

We need an electronics industry in Europe that is competitive against the world. Any action taken by the EC that makes us uncompetitive in the market is very serious. The 14 percent tariff is punitive and damaging—the United States has zero duty. But the Europeans have matured over the last two years and have tried to communicate and make all our positions clear.

Question from the Floor: Is the European semiconductor industry able to supply the 4-Mbit DRAM?

Maringer: it is too far-reaching to say we are leading the Far East—what we're trying to achieve is an open market. If there is no European supply then we are completely in the hands of others. If we say we're going to supply everything, that's nonsense.

Question: We are running into disaster. In a year or two there will only be Japanese suppliers of flat screens. It is almost too late.

Santucci: We have established a forum where representatives of the suppliers and users can meet to discuss common issues. Since 1988 tremendous work has been done in narrowing the gap between users and suppliers, which has to be the first thing. That's what happened with the DRAM. But this is wasted if the industry lacks the will—both from the suppliers and users.

Enrico Villa
Vice President of Government Affairs
SGS-Thomson Microelectronics

There are misconceptions about the ability of semiconductor vendors to become competitive. We should be competitive with the best in the world but it is not easy. Take the cost of money in Europe compared to Japan, and take the cost of R&D. But if companies leave commodity memory manufacturing, they have no chance of becoming competitive.

Question: How will the EC deal with possible oversupply by newly created fabs in Europe?

Santucci: There are two basic rules in the Community:

- There must be neutrality in the treatment of domestic and inward investment.
- There must not be a sectoral approach to investment.

Because of 1992, the European market has become attractive. We're not going to encourage or discourage inward investment. We can trust those deciding to invest Europe that they know what they're doing.

Maringer: The hype about 1992 forces inward investment on people who think there's a big market coming. But in electronics, 1992 is already here. Nothing will happen to change things between now and 1992. The market size won't change; there will still be the same number of people spending the same amount of money.

Question: How is the 14 percent tariff helping the indigenous semiconductor industry?

Maringer: The tariff has little effect on the final price of equipment (for instance, 0.6 percent on a TV, 1.7 percent on a PC) and there are many expectations from tariffs altogether. Tariffs help to manage the trade in semiconductors to stop Europe becoming dependent on imports.

PANEL SESSION 2: Has the ASIC market matured?

Jean-Pierre Liebaut
President and Chief Executive Officer
Mietec Alcatel

Maturity in the digital ASIC market, if not already achieved, is not far off. However the market for mixed-mode ASIC has not reached maturity. According to Dataquest the mixed-mode ASIC market will grow from $361 million in 1988 to $1,603 million in 1993.

Dieter Mezger
President, Europe
VLSI Technology Inc.

MOS ASIC has grown in line with the overall semiconductor market since 1985. MOS full-custom has been a static market, but MOS semi-custom has increased its share of the overall logic TAM from 7.2 percent in 1985 to 26.5 percent in 1989. Traditional ASIC products may be addressing mature markets, but ASIC technology for systems integration will be increasingly needed.

Jörgen Hjert
Manager Custom Circuit Design Centre
Ericsson Telecom AB

The ASIC market has not matured. Complexity will increase by a factor of 5 or 10 compared with today's chips, but the CAE tools are not powerful enough to cope with the available process technology. It is said that CAE tools a thousand times more effective are needed. Programmable logic will be used mainly for fast prototyping.

John C. East
President and Chief Executive Officer
Actel Corporation

This year there will be more design starts for field programmable gate arrays (FPGA) than there will be for conventional gate arrays. FPGA revenue will grow at a compound annual rate of 50 percent through 1994. By contrast bipolar gate array design starts have been, and are expected to stay, static through 1994, and MOS gate array design starts, which increased from around 8,000 worldwide in 1987 to nearly 10,000 in 1989, may increase to 12,000 in 1992 but thereafter are expected to be a static market.

Hisashi Izumi
Managing Director
Toshiba Electronics (UK) Ltd

A limited number of major suppliers with stable market shares dominate the market, with a handful of small companies supplying niches. The growth rate of the market is moderate, market penetration is high, there is little product differentiation and slow product evolution. The US market is more mature than the market in the UK and Japan. Europe has the potential to grow faster than the other two main trading blocks, becoming the largest semiconductor market in the world.

End of Panel Sessions

Global Procurement Strategies: A European Perspective

David Miller
Manager, Supply Management Group
Bull HN Information Systems Ltd

The 1990s are not like the 1960s—Europe is now becoming a major player in the computer and semiconductor industries. It has three companies in the top 12 computer firms worldwide, and two of the three fastest-growing semiconductor companies in the 1988 to 1990 timeframe. Bull intends to be in the top five by 1995. Having no semiconductor capability, Bull has to rely on semiconductor vendors and was disappointed last year when it was let down in memory supplies by vendors with whom Bull thought it had established close relationships. Europe has to establish a true pool of technology like the United States and Japan.

Europe's Silicon Supply—In Shape for the '90s

Hans-Jürgen Giffhorn
Executive Vice President, Marketing and Sales
Wacker-Chemitronic GmbH

Wacker is third out of the six companies (two German, four Japanese—the Americans are no longer in it) left in the silicon supply business. Profitability is poor. The silicon supply industry is worth $33 billion compared to the $60 billion of the semiconductor industry and the $733 billion worth of the equipment industry. The market is growing at 10 percent a year and the largest growth area is the rest of the world (Korea, Taiwan and Singapore), which is expected to grow at 19 percent per year between 1988 and 1993. Eight inch wafer processing is still rare. IBM is using 8-in. wafers in three locations. One other company is also using 8-in. Three Japanese companies start this autumn and Samsung starts shortly. (Since this presentation, Samsung has moved to using 8-in. wafers.)

Wafer Scale Integration

Peter Cavill
Chief Executive Officer
Anamartic Ltd

A high-volume market for intermediate storage—between semiconductor memory and magnetic media—is developing and Anamartic is shipping wafer product into it. Its current product is a 40-megabyte stack of wafers which sell at $45 per megabyte. Next year should see a 100-megabyte stack selling at $35 per megabyte and 1994 a 250-megabyte stack will offer $20 per megabyte intermediate memory. Applications include relational databases, network file servers, high-end UNIX machines and CAD/CAM workstations. In two years' time the company expects 16-Mbit flash EPROM technology to provide non-volatile storage; 16-Mbit technology will also allow Anamartic to put 2,000 transputers on a wafer providing 25,000 mips (if the yield is 50 percent) at a cost of $3,000, or 12 cents per mip.

Time to Redraw Europe's Semiconductor Borders

Philippe Geyres
Corporate Vice President, Strategic Planning
SGS-Thomson Microelectronics

Europe has woken up to the fact that it doesn't have to lose. It has 4 electronics companies in the world top 12, and 6 in the top 20. Europe is moving towards self-sufficiency in semiconductors and can internally source 80 percent of its needs. Before year-end it will have developed 16-Mbit DRAMs and EPROMs. JESSI will give Europe products which command access to a $70 billion market in 1996, and an equipment market 15 times bigger.

The Expertise in Integration

Michel Desbard
Managing Director
Matra MHS

Mid-size vendors can do a better job than giant companies when they have excellence in particular specialities. Matra MHS is making microprocessors, static RAMs and ASICs all on the same process, from the same wafer fab with the same methodology and the same people. No other manufacturer can say that. Of Matra's wafer starts 50 percent are for 1 μm processing compared with the 19 percent norm for Europe and the 9 percent norm for the USA. Taking European vendors only, Matra MHS is fourth in MOS ICs, third in gate arrays, fourth in micros, third in memories and second in SRAM.

Semiconductor Computing in Europe

Bernard Giroud
Vice President, Intel Corporation
President, Intel Europe

The decline of Europe is over. Although Europe currently has a $20 billion trade deficit in semiconductors, telecommunications and information technology, it is now looking for recognition as innovatory with strong business leaders and companies which compare with the leading US and Japanese companies. Europe needs access to the driving technologies in a secure fashion. A key one is semiconductor processing which JESSI is funding. Europe has not been strong in the computer business but its growth in PCs is such that the European market could outstrip the US market by the mid-1990s. The "new computer industry" is a very open, competitive and international business in which the key to success is continually identifying bottlenecks that impede the flow of technology from the technology engine (PC, workstation, etc.) to the end user, removing them, and going on to the next bottleneck.

Winning in the '90s

Jim Hubbard
Senior Vice President, Semiconductor Group
General Manager, Texas Instruments Europe

The electronic equipment market will be a $2 trillion market by the year 2000—close to being the world's largest market. At that time the semiconductor market will be worth $200 billion, but "it's not for the faint-hearted." The Far East is able to "productize" technology (that is, get new technology to market in the form of products) faster than the United States can. The West has to concentrate on reducing product development cycle times, support customers locally with globally available products ("local globalization"), and bring down the total cost of ownership of its products. This needs leadership which requires "human resources excellence." One way of achieving this is to improve the "communications yield" inside a company, by eliminating such destructive practices as preformed opinions, "rebuttal preoccupation" and unclear use of English.

FOOTNOTE

At the end of the conference, delegates were asked their opinion on holding the 10th annual European Semiconductor Industry Conference in Hungary. Opinion was mixed on this issue and, due to logistic reasons, an Eastern bloc conference in 1991 will not be possible. The conference is likely to be held in Spain or Portugal, but any suggestions you have will be welcome.

Mike Williams

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Research Newsletter

EXCHANGE RATE QUARTERLY NEWSLETTER

SECOND QUARTER 1990

Dataquest exchange rate tables involve data from many countries, each of which has different and variable exchange rates against the US dollar. As much as possible, Dataquest estimates are prepared in terms of local currencies before conversion (when necessary) to US dollars. Dataquest uses exchange rates taken from the *Wall Street Journal*, which in turn are taken from the Bankers Trust Co. All exchange rates previous to 1990 were sourced from the International Monetary Fund (IMF).

All forecasts are prepared assuming no changes in any exchange rate from the last complete historical year—in this case 1989. During the course of the current year, as local currency exchange rates vary, the appropriate US dollar value changes accordingly. To maintain consistency across all its analyses, Dataquest does not make ongoing adjustments to its forecasts for these currency changes during the current year. As a result of this policy, as the year progresses the forecast numbers could become distorted, in dollars, should the European currencies deviate substantially from the previous year's rate. This, however, is becoming increasingly less likely as more European currencies join the European Exchange Rate Mechanism (ERM), forcing member countries to prevent their currency fluctuating beyond a predetermined range.

Effective exchange rates for the current year are calculated each month and are then used to assess the local currency's impact on US dollar forecasts. The purpose of this newsletter is to record these changes, and thus allow the reader to make any necessary adjustments when interpreting regional data.

For each European region, Table 1 gives the local currency per US dollar for 1989, first quarter 1990, and second quarter 1990 together with the estimate for the whole of 1990. Also shown, for reference purposes, are the same figures for the Japanese yen. As can be seen from this table, the Semiconductor Industry Weighted Average (SIWA) for all the European currencies for 1990 has increased 8.8 percent with respect to the US dollar, compared with 1989. This represents a 1.3 percent increase in the exchange rate from first quarter 1990 to second quarter 1990. Table 2 shows the 1990 quarterly values for the same regions.

Table 3 illustrates how to interpret the effect of the currency shifts on Dataquest forecast numbers. For example, the table shows that the constant dollar forecast of $9,745 million for the 1990 total European semiconductor market becomes $10,682 million when adjusted for changes in European currencies.

Table 4 shows the 1990 monthly values of local currency per US dollar for each European region and Japan. Included in the tables is the European Currency Unit (ECU). This unit, established in March 1979, is a weighted average of the currencies of all member countries of the European Community (EC). It is calculated by the IMF from each country's gross national product (GNP) and foreign trade.

Also included is the aforementioned SIWA. This unit is based on the semiconductor consumption of each European country featured here (EC and non-EC members) and uses the base year 1980 equal to 100 as a reference point. The SIWA is useful for interpreting the effect of European currency fluctuations with respect to the US dollar, specifically for the European semiconductor industry.

James Heal

ESAM Newsletters 1990-17

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TABLE 1
European Currencies—1989 to 1990
(Local Currency per US Dollar)

Region	1989	Q1 1990	Percent Change 1Q90-2Q90	Q2 1990	1990#	Percent Change 1989-90
Austria	13.24	11.90	0.8	11.80	11.85	10.5
Belgium	39.44	35.29	2.0	34.60	34.77	11.9
Denmark	7.32	6.52	1.9	6.39	6.43	12.1
Finland	4.30	3.99	0.8	3.96	3.97	7.8
France	6.39	5.74	1.7	5.64	5.67	11.2
Ireland	0.71	0.64	1.8	0.63	0.63	11.1
Italy	1,373.6	1,254.7	1.8	1,231.7	1,239.3	9.8
Luxembourg	39.44	35.29	2.0	34.60	34.77	11.9
Netherlands	2.12	1.91	1.0	1.89	1.89	10.7
Norway	6.91	6.53	0.6	6.49	6.49	6.1
Portugal	157.62	148.86	0.6	147.90	148.22	6.0
Spain	118.55	109.08	3.2	105.60	105.64	10.9
Sweden	6.45	6.15	1.1	6.08	6.10	5.4
Switzerland	1.64	1.51	4.2	1.44	1.45	11.7
United Kingdom	0.61	0.61	0.4	0.60	0.60	2.1
West Germany	1.88	1.69	1.0	1.68	1.68	10.5
ECU	0.92	0.83	1.4	0.82	0.82	10.3
SIWA (Base 1980 = 100)	130.20	120.18	1.3	118.61	118.77	8.8
Japan	138.07	147.92	(5.0)	155.35	152.70	(10.6)

Final year estimate
Source: Dataquest (July 1990)

TABLE 2
European Currencies—1990 by Quarter
(Local Currency per US Dollar)

Region	Q1	Q2	Q3*	Q4*	Total Year 1990#
Austria	11.90	11.80	11.84	11.84	11.85
Belgium	35.29	34.60	34.59	34.59	34.77
Denmark	6.52	6.39	6.41	6.41	6.43
Finland	3.99	3.96	3.96	3.96	3.97
France	5.74	5.64	5.66	5.66	5.67
Ireland	0.64	0.63	0.63	0.63	0.63
Italy	1,254.7	1,231.7	1,235.5	1,235.5	1,239.3
Luxembourg	35.29	34.60	34.59	34.59	34.77
Netherlands	1.91	1.89	1.89	1.89	1.89
Norway	6.53	6.49	6.47	6.47	6.49
Portugal	148.86	147.90	148.05	148.05	148.22
Spain	109.08	105.60	103.93	103.93	105.64
Sweden	6.15	6.08	6.09	6.09	6.10
Switzerland	1.51	1.44	1.42	1.42	1.45
United Kingdom	0.61	0.60	0.59	0.59	0.60
West Germany	1.69	1.68	1.68	1.68	1.68
ECU	0.83	0.82	0.82	0.82	0.82
SIWA (Base 1980 = 100)	120.18	118.61	118.15	118.15	118.77
Japan	147.92	155.35	153.76	153.76	152.70

* Estimate
# Final year estimate
Source: Dataquest (July 1990)

TABLE 3
Effect of Changes in European Currencies per US Dollar on Dataquest Forecasts—1989 versus 1990
(Millions of US Dollars)

	1989	1990#	Percent Change 1989-1990
European Semiconductor Consumption (At Constant 1989 Exchange Rates)	$9,755	$9,745	(0.1)
Weighted European Currency (Assumed) (Base 1980 = 100)	130.2	130.2	NM
Weighted European Currency (Latest Estimates)	130.2	118.77	8.8
Effective Consumption (At June YTD Exchange Rates)	$9,755	$10,682	9.5

# Final year estimate
NM = Not meaningful
Source: Dataquest (July 1990)

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TABLE 4
European Currencies—1990 by Month
(Local Currency per US Dollar)

	Jan.	Feb.	Mar.	Apr.	May	June	July*	Aug.*	Sept.*	Oct.*	Nov.*	Dec.*	1990#	1989	Percent Change 1988-89
Austria	11.90	11.80	12.00	11.86	11.71	11.84	11.84	11.84	11.84	11.84	11.84	11.84	11.85	13.24	10.5
Belgium	35.46	35.01	35.39	34.87	34.33	34.59	34.59	34.59	34.59	34.59	34.59	34.59	34.77	39.44	11.9
Denmark	6.56	6.46	6.53	6.43	6.34	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.43	7.32	12.1
Finland	4.00	3.95	4.02	3.99	3.92	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.97	4.30	7.8
France	5.76	5.69	5.76	5.66	5.60	5.66	5.66	5.66	5.66	5.66	5.66	5.66	5.67	6.39	11.2
Ireland	0.64	0.63	0.64	0.63	0.62	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.71	11.1
Italy	1262.6	1244.0	1257.3	1237.7	1221.8	1235.5	1235.5	1235.5	1235.5	1235.5	1235.5	1235.5	1239.3	1373.6	9.8
Luxembourg	35.46	35.01	35.39	34.87	34.33	34.59	34.59	34.59	34.59	34.59	34.59	34.59	34.77	39.44	11.9
Netherlands	1.91	1.89	1.92	1.90	1.87	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	2.12	10.7
Norway	6.54	6.46	6.58	6.54	6.45	6.47	6.47	6.47	6.47	6.47	6.47	6.47	6.49	6.91	6.1
Portugal	149.20	147.49	149.90	148.99	146.66	148.05	148.05	148.05	148.05	148.05	148.05	148.05	148.22	157.62	6.0
Spain	109.60	108.29	109.35	108.90	103.97	103.93	103.93	103.93	103.93	103.93	103.93	103.93	105.64	118.55	10.9
Sweden	6.17	6.11	6.18	6.11	6.05	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.10	6.45	5.4
Switzerland	1.52	1.49	1.51	1.49	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.45	1.64	11.7
United Kingdom	0.61	0.59	0.62	0.62	0.60	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.60	0.61	2.1
West Germany	1.69	1.68	1.71	1.69	1.66	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.88	10.5
ECU	0.83	0.83	0.83	0.83	0.81	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.92	10.3
SIWA (Base 1980 = 100)	120.39	118.82	121.33	120.07	117.62	118.15	118.15	118.15	118.15	118.15	118.15	118.15	118.77	130.20	8.8
Japan	145.08	145.71	152.96	158.38	153.90	153.76	153.76	153.76	153.76	153.76	153.76	153.76	152.70	138.07	(10.6)

* Estimate
\# Final year estimate
Source: Dataquest (July 1990)

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Research Newsletter

PC PRODUCTION IN EUROPE, 1989—PRELIMINARY UPDATE

SUMMARY

In 1989, 58 percent (3.7 million units) of the 6.4 million personal computers (PCs) sold in Europe were also manufactured in Europe. Some PC manufacturers do not purchase semiconductors locally but, instead, import loaded printed circuit boards (PCBs) from outside Europe. Consequently, we estimate that only 53 percent of the PCs sold in Europe actually accounted for semiconductor sales on the European merchant market—3.4 million units.

This newsletter presents the results of Dataquest's survey of PC production in Europe for 1989, and forecasts future production trends. A second ESAM newsletter, to be published shortly, will give a detailed analysis of PC semiconductor content and a forecast for semiconductor consumption.

PC PRODUCTION IN EUROPE

IBM continued to represent the lion's share of PC production in 1989 with 1.2 million units, dwarfing Olivetti in second place with 470,000 units. Apple came in third place with 317,000 units. Tables 1 and 2 show PC production volumes and locations for the top 25 producers in Europe.

In estimating semiconductor consumption from these producers, the qualifications below need to be made to Table 1 to arrive at an "effective" production estimate that more accurately reflects PC semiconductor procurement in Europe.

- Compaq and Tandon are believed not to have procured semiconductors locally but, instead, imported PCBs from outside Europe.
- We estimate that only a small amount (41,000 units) of Amstrad's total 350,000 units of PC production was made in the United Kingdom. However, semiconductor procurements for both its United Kingdom and its Far Eastern subcontractors are believed to originate in Europe.
- We estimate that a small proportion (15 percent) of IBM's total semiconductor demand for PCs originated from captive supply.

In total, we estimate that 92 percent (3.4 million units) of the 3.7 million units produced in Europe during 1989 were *effectively produced* in Europe from the point of view of semiconductor consumption. This is a 23 percent growth in units over what we estimate was effectively produced in Europe during 1988: 2.8 million units.

PC PRODUCTION BY REGION

A regional breakdown of total unit production (Table 3) shows some interesting contrasts. Most striking is the fact that more than half (55 percent) of Europe's PC production was in the United Kingdom and Ireland. Production in the other two major regions, Italy and West Germany, trailed far behind with 14.5 percent and 13.6 percent of total production respectively.

Significant differences also appear in product emphasis between the regions. Of all 80386 PCs produced in Europe during 1989, 65 percent were produced in the United Kingdom. Its high level of PC production, particularly in 80386-based units, is the major cause of the United Kingdom's disproportionately high share of total MOS memory sales compared to its share of total semiconductor sales.

PRODUCTION FORECAST

Over the past couple of years, we have witnessed significant restructuring in European PC

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production with transfer of some facilities (Ericsson to Nokia Data, Apricot to Mitsubishi) and closure of others (Telenova, Thomson). Further rationalization is probable following the acquisition of Zenith's operations in Ireland by Bull and the likely merger of Nixdorf into Siemens.

However, the overall trend is one of increased investment, particularly in large production facilities. Examples are Tandon's new facility in Vienna (Austria), Compaq's facility in Erskine (United Kingdom), and Toshiba's new plant in Regensburg (West Germany) which commenced production last April. These may be joined by Intel in Ireland and, possibly, the Taiwanese PC and laptop manufacturer Acer.

We expect growth in PC production to match growth in PC unit sales to end users—this is a crucial assumption in our forecast. Given the relatively stable investment scene in Europe, in the run-up to 1992, we believe this assumption to be reasonable.

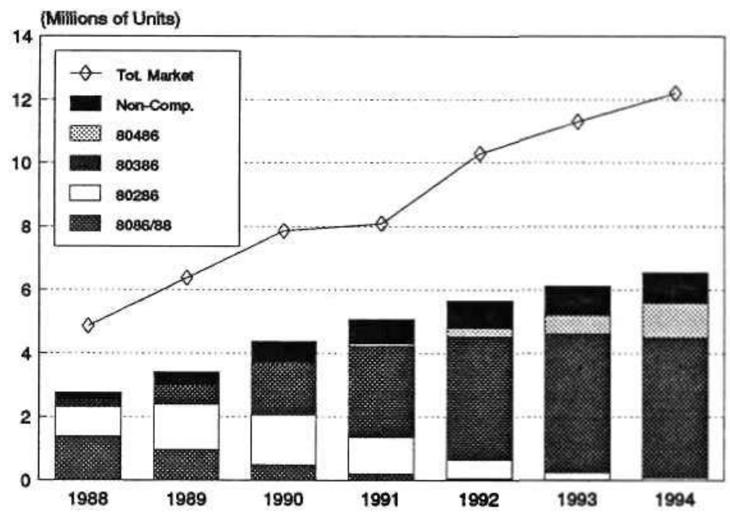
Figure 1 shows our forecast for PC production in relation to the total PC market in Europe. We forecast that effective PC production in Europe will have nearly doubled to 6.6 million units by 1994, from 3.4 million units in 1989. Our five-year forecast window almost fully encompasses the decline of the 80286; by 1994, its current popularity will have long diminished, due to its limited memory capability and the, by then, wide-scale availability of OS/2 applications.

Production of the other microprocessor types will also change dramatically to the extent that, by 1994, we predict that 4.4 million units produced will be based on the 80386 microprocessor—and 1.1 million PCs will be based on the 80486 microprocessor.

(This newsletter was produced in conjunction with Dataquest's European Personal Computer Industry Service.)

Jonathan Drazin

Figure 1
European Effective PC Production Forecast by Microprocessor Type



Source: Dataquest
June 1990

TABLE 1
PC Production in Europe in 1989, Top 25 Companies

Rank	Company	Total Units (M)	Units Breakdown (Percent) 8086/88	80286	80386	Non-Comp.*
1	IBM	1.200	23%	46%	31%	0%
2	Olivetti	0.470	35%	51%	14%	0%
3	Apple	0.317	0%	0%	0%	100%
4	Compaq	0.235	0%	38%	62%	0%
5	Commodore	0.180	65%	35%	0%	0%
6	Schneider	0.151	69%	24%	7%	0%
7	Hewlett-Packard	0.125	3%	67%	30%	0%
8	Bull	0.100	0%	83%	17%	0%
9	Tulip	0.092	53%	37%	10%	0%
10	Siemens	0.075	0%	84%	16%	0%
11	Nokia Data	0.075	0%	76%	24%	0%
12	Apricot	0.068	0%	35%	65%	0%
13	Zenith (Bull)	0.060	0%	78%	22%	0%
14	NCR	0.055	0%	74%	26%	0%
15	Investrónica	0.051	71%	27%	2%	0%
16	Nixdorf	0.050	NA	NA	NA	0%
17	Opus	0.042	32%	43%	25%	0%
18	Amstrad	0.041	89%	9%	2%	0%
19	Acorn	0.040	0%	0%	0%	100%
20	SMT Goupil	0.039	28%	52%	20%	0%
21	Tandon	0.036	0%	75%	25%	0%
22	RML	0.036	12%	75%	13%	0%
23	Wang	0.036	0%	75%	25%	0%
24	Epson	0.034	41%	53%	6%	0%
25	Normerel	0.027	16%	50%	34%	0%
	Others	0.078				
Total Production		3.70	23%	43%	22%	12%
Total Effective Production		3.40	28%	42%	18%	12%

Notes: "Effective production" counts only the proportion of PC production where semiconductor procurement is believed to have occurred in Europe.
Figures may not add to totals shown due to rounding.

*Non-IBM-compatible
NA = Not Available

Source: Dataquest
June 1990

Table 2
Top 25 PC Manufacturers in Europe, Production Locations

Rank	Company	Manufacturer/ Subcontractor	Town	Country
1	IBM	IBM	Greenock	United Kingdom
2	Olivetti	Olivetti	Scarmagno	Italy
		Olivetti	Barcelona	Spain
3	Apple	Apple	Cork	Ireland
4	Compaq	Compaq	Erskine	United Kingdom
5	Commodore	Commodore	Braunschweig	West Germany
6	Schneider	Schneider	Turckheim	West Germany
7	HP	HP	Grenoble	Switzerland
8	Bull	Bull	Villeneuve d'Asque	France
		Bull	Barcelona	Spain
9	Tulip	Tulip	's-Hertogenbosch	Netherlands
10	Siemens	Siemens	Augsburg	West Germany
11	Nokia Data	Nokia Data	Espoo	Finland
		Nokia Data	Lohja	Finland
		Nokia Data	Ronneby	Sweden
12	Apricot	Apricot	Glenrothes	United Kingdom
13	Zenith (Bull)	Zenith	Kells	Ireland
14	NCR	NCR	Augsburg	West Germany
15	Investrónica	Investrónica	Madrid	Spain
16	Nixdorf	Nixdorf	Berlin	West Germany
17	Opus	NA	NA	United Kingdom
18	Amstrad	GPT	Kirkcaldy	United Kingdom
19	Acorn	NA	NA	United Kingdom
20	SMT Goupil	Agde	Lyon	France
		Moulinex	Granville	France
21	Tandon	Tandon	Vienna	Austria
22	RML	RML	Oxford	United Kingdom
23	Wang	Wang	Sterling	United Kingdom
24	Epson	Epson	Telford	United Kingdom
25	Normerel	NA	Granville	France

NA = Not Available

Source: Dataquest
June 1990

TABLE 3
Regional Breakdown of Effective European PC Unit Production in 1989
(Millions of Units)

Region	8086/88	80286	80386	Non-Comp.	Total
Benelux	0.050	0.036	0.012	0.000	0.098
France	0.022	0.222	0.079	0.000	0.322
Italy	0.174	0.250	0.070	0.000	0.494
Scandinavia	0.000	0.058	0.019	0.000	0.077
UK/Ireland	0.449	0.648	0.404	0.391	1.891
West Germany	0.221	0.203	0.037	0.000	0.461
Rest of Europe	0.038	0.016	0.003	0.000	0.056
Total	0.954	1.433	0.622	0.391	3.400

Note: Figures may not add to totals shown due to rounding.

Source: Dataquest
June 1990

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Research *Newsletter*

REDRAWING THE APPLICATIONS BORDERS FOR THE 1990s

The following speech was presented on behalf of Dataquest's European Semiconductor Applications Markets (ESAM) service at the European Semiconductor Industry Conference in Geneva, on June 7, 1990.

The full text is reprinted here for the benefit of ESAM clients who could not attend the Conference. Copies of the slides are shown at the end of the newsletter.

Redrawing the Applications Borders
for the 1990s
European Semiconductor Industry Conference
June 7, 1990
Geneva, Switzerland

Jonathan P. V. Drazin
Industry Analyst
European Semiconductor Applications Markets
Service

SLIDE 1: AGENDA

The theme of our Conference this year is about redrawing the competitive borders. These borders may be geographical—or they may be borders that divide markets in other senses, such as the set of borders that divide one application from another. Will the border between the television and the personal computer disappear? ... And will new borders *appear* to form new territories like "personal communications land" which are splinters from the land of the "plain old telephone?"

I do not propose to answer these questions directly. However, I *do* propose to put some of the most promising applications emerging in Europe on the map and leave you, in true *perestroika* fashion, to put the borders where *you* want them to be!

I will look at the new GSM standards, and the pan-European digital cellular telephone. I will then turn to look at smart cards, and some of the many smart card applications now appearing. Finally, I shall end with a little insight on the common threads between the various applications and technology issues we will have covered.

SLIDE 2: SEMICONDUCTOR CONSUMPTION

But first, let us stand back to see how we expect the overall applications borders of Europe to change. This table is based on analysis of semiconductor demand across the top 90 existing electronics segments we cover in Europe. We have condensed these into the six main categories, and shown them for three points in time: 1986, today and four years from now.

The most dramatic transformation has come from electronic data processing applications, and it is easy to forget that back in 1986 its consumption was comparable to telecoms, consumer or industrial. This has been dramatically changed by strong computer hardware growth, OEMs switching to European production, and memory price inflation; so that, today, data processing is 35 percent of the semiconductor market.

The emergence of the personal computer has played a large part in this change over the last few years. Today, we estimate this one application accounts for 35 percent of all data processing semiconductor consumption—and both my colleague, Gregory Nelson and our guest speaker, Dr. Hermann Hauser, will look at the PC in much more detail shortly—and you can safely expect data processing will continue to remain a fertile environment for many new applications in the near future. One example is X.terminals ...

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SLIDE 3: X. TERMINALS

X.terminals are very intelligent graphics and text terminals, with window management. Typically, they are based on a Motorola 68020 microprocessor, a Texas Instruments graphics processor, a LAN controller and somewhere between 2 and 8 Mbytes of DRAM.

X.terminals are being offered by companies like Digital, IBM, NCR, Network Computing Devices (NCD) and many others. Their significance is that they rival traditional workstations in terms of the interface they present to the end user—but at a much lower price.

The key issue here is whether these low-cost terminals could reverse the trend of having computation centralized in one big mainframe to having it distributed across several workstations? Watch this application very closely over the next few years, not just for its own potential, but for the implications it may have on the workstation and, possibly, the PC markets.

Next, I would like to turn to a data processing application which *has* been with us for some years, but has yet to make a major impact on semiconductor demand in Europe.

SLIDE 4: LASER PRINTER

The laser printer is an exciting opportunity for future semiconductor sales in Europe ... for good reason.

First, there is massive pressure to provide faster page rates and computationally intensive features like PostScript—particularly at the low end of the laser printer market. In turn, this is driving semiconductor content up, favoring powerful 32-bit controllers, like those offered by National Semiconductor or Intel.

Second, only 20 percent of Europe's $3 billion laser printer market is satisfied by local production. However, strong competition and having to meet local content rules *may* encourage many Japanese manufacturers, already making dot matrix printers in Europe, to switch to making page printers as well.

This combination of a growing end-user market, growing content and the outlook of increased local production *may* lead to very *rapid* semiconductor growth in this area, from the relatively small $39 million consumed last year. I say "may" because the key factor here is local content and, as I am sure you all know, the European Commission's policies have been hotly contended at GATT. Any deviation from present policies will cause major revisions to future plans, not just for production of laser printers, but for a long list of other segments as well.

Next, I would like to turn to transportation which, if you recall from my first main slide, will match data processing in overall revenue growth over the next four years.

SLIDE 5: TRANSPORTATION

In most transportation applications, the main semiconductor issues are *cost* and *reliability*, because these components must compete with well established rival electromechanical systems.

However, whereas features like ABS, fuel-injection and engine control are, today, fast becoming standard, the cumulative replacement of electromechanical by electronic will have largely ended by the mid-1990s. Five years from now, the opportunities for car manufacturers to differentiate by adding refinements to these applications will have faded. New applications will be needed to fill this differentiation gap—and we expect the mid-1990s to herald the era of in-car navigation, traffic control, noise reduction and, of course, the digital cellular telephone.

For the semiconductor industry the issues will no longer be cost reduction and reliability but, instead, ones where it will be crucial to both *lead* and *follow*. To lead through innovation ... but to follow through close attention to developing standards from European programmes like Eureka, Esprit and Drive, which each contain many transportation projects scheduled to mature in the mid-1990s.

Recalling again my first slide, you see that while transportation takes second place in terms of long-term semiconductor growth, telecommunications will continue to rank second after data processing in absolute revenue.

SLIDE 6: TELECOMMUNICATIONS

The most dramatic trend here is the swing away from the production of public telecoms equipment (like switches, line cards and transmission systems) towards customer premise equipment (such as modems, local area networks, facsimile machines and cellular phones).

In the spirit of our theme, it is the applications borders which are being redrawn. The picture in 1986 was one where the premise telecom and public telecom segments were comparable in size. Today, we estimate that production in Europe of the many customer premise applications outnumber public telecoms equipment by nearly 2 to 1; and, as you see here, this gap will widen further in the coming years.

A clear understanding of emerging applications is crucial for predicting the future of today's mature ones. This is particularly so for telecoms, where all telecoms hardware, from phones to fax machines, seek to satisfy the same basic end-user need: namely, to communicate.

SLIDE 7: THE APPLICATIONS OVERLAP

In the Europe of the 1990s, where the X's are marked on this chart, battles will be fought and borders will be crossed. Some battles mark the end of border disputes started in the 1980s, like the decline of telex to new applications like facsimile.

But other battles are just around the corner. One such example sits in the middle of this map: namely, the inevitable collision between modems and ISDN terminal adaptors. Over the last year, ISDN adaptors have been launched by a large number of companies like IBM, Matra Communication, Siemens, Sagem and Systec. These adaptors mainly allow PC users to connect either to a PBX or to the public network.

However, in the move from modems to ISDNs, we see no stampedes—only a gentle but irreversible plod. Today, these adaptors and other ISDN hardware are confined largely to communication within the national borders of France or West Germany; there is still no common standard for international communication using ISDN.

The standards issues could be resolved in months, but ISDN's implementation across the whole of the public networks in Europe will take years to achieve. For these reasons, there is a lot of life in the modem yet, with double-digit growth in modem semiconductor demand continuing into 1992.

Turning to the top left corner of this diagram, we see other instances of the telecom overlap characteristic—between cordless, cellular and standard telephones.

SLIDE 8: CT2

Last year, we predicted there would be between 4 and 16 million cordless phones in use in Europe by 1995. We still hold to this forecast but, since that time, several major events have occurred ... or not occurred.

First, at the beginning of this year, the United Kingdom's Department of Trade and Industry, the prime mover behind CT2, licensed three consortia to build and operate a new type of network called PCN, the personal communications network. This will be largely based on the European cellular GSM standard, which I shall come to shortly. Second, CT2 products suitable for office use, as opposed to consumer or telepoint use, have yet to reach the market. Third, the CT2 Memorandum of Understanding between the European PTTs was not signed until spring this year, instead of last summer as originally planned.

So, what is the picture for CT2 now? Many argue that the greatest threat to CT2 is the imminence of superior systems like PCN or DECT. However, at a time when most of the PTTs are under threat themselves from cellular and other services, CT2 is widely regarded as the "PTT's friend" because the telepoint services it supports complement their existing wire-based telephone networks.

However, at CT2's present prices, no amount of investment in, or promotion of, telepoint services can guarantee its success. Few are going to pay in excess of $300 for a CT2 handset to do what they can already do from a public payphone ... unless the same handset can satisfy some other need as well. One such is the need for a roaming office telephone which, like the normal office worker, is not permanently tethered to the desk.

We shall have to wait a few more months to see whether CT2 technology can satisfy users in the office. If it does, then there is a far stronger probability that it will satisfy the same users *outside* the office—as subscribers to telepoint services. If it does not, then CT2 will leave a vacuum that will take the emerging DECT, GSM and PCN technologies at least two years to fill.

This leads me to the first of the two applications I want to mention today: namely, the new pan-European digital cellular telephone. First a few words of explanation: in Europe both the new digital cellular phone, and the network infrastructure that will support it, are based on the so-called "GSM" standards.

These networks are scheduled to enter service from the middle of next year. Looking round Europe, we see West Germany as the largest and most eager potential market for GSM. However, we also expect prompt take-up of GSM throughout the rest of Europe, even in countries like the United

Kingdom where analog services are already established.

We recently surveyed several R&D labs to determine what ICs will go into a GSM handset, and to uncover some of the more crucial technology constraints. These are some of our findings.

SLIDE 9: GSM COMPONENT BREAKDOWN

These two bar charts sum up how the components in a GSM handset split out by technology, and by function. The handset in question is a first-generation 2w hand-portable.

The left bar splits out only semiconductor components by their process type. The right bar identifies the main electronic components in the handset. The "others" block consists of a variety of electronic components, both semiconductor and non-semiconductor.

One striking point is that the total electronic content for GSM handsets will be about $190 when they are launched next year, of which 80 percent will be semiconductor.

From the semiconductor viewpoint, the GSM telephone has more in common with a laptop personal computer than it has with a normal telephone. Its large CMOS content includes, among other things, three big DSP ICs: the speech and channel CODECs, and a channel equalizer. *Each* of these has a computational capacity in the range 2 to 5 mips—somewhat *more* than your average laptop!

The other 20 percent of non-semiconductor is taken up mainly by costly SAW and ceramic filters.

Altogether, we expect the first digital cellular phones to have a semiconductor content about three times higher than that of a typical analog handset today.

SLIDE 10: GSM HANDSETS

Let us not forget the key design objectives for the handset manufacturers. They are aiming to sell compact, light, but affordable digital handsets—ideally, as small as the lightest 300 gram analog cellular handsets on the market today, This is what *their* customers want, and new mass-market derivatives of GSM, like PCN, will fail if this cannot be offered.

Besides component cost, the critical issues affecting IC designers are power consumption and bulk. The two are inextricably linked in that additional power means more battery ... which means more bulk.

Ironically, a major source of power dissipation in a GSM transportable is not through the antenna, but from the costly DSPs I mentioned earlier. There will be an enormous push to raise yield and conserve power from these ICs over the next few years.

Mastery of this CMOS logic will go ultimately to those mainline vendors with high-yielding submicron processes. I am thinking here of companies like Motorola, NEC and Texas Instruments.

The analog RF front end is another area where progress must be made. The challenges are a little different in the sense that the synthesizer, mixer and amplifier ICs are each quite small and do not present yield problems ... But power remains a big problem because, although these parts consume considerably less power than the DSPs I mentioned earlier, they remain on standby mode—when calls are not being made.

Besides power reduction, the other main drive is to reduce bulk and component cost by minimizing the number of IF stages, and discarding as many discrete filter components as possible.

You don't need powerful CAD suites, high yields and to be able to make big chips to be in this business. Instead, the crucial factors are a reasonably fast bipolar process, an inspired radio design group and strong capabilities in RF packaging, which is where vendors like Philips, Plessey, Siemens, SGS-Thomson and STC all excel.

SLIDE 11: GSM MARKET FACTORS

Picking up from what I said earlier about the comparatively high semiconductor content in these handsets, you might conclude that they will be expensive to buy, and have problems selling alongside today's analog handsets.

In fact, we expect the GSM telephone will carry only a marginal price premium over existing equipment. Two factors support this: first, the fact that any GSM handset will work anywhere in Europe will bring greater economies of scale. More significantly, this will give greater freedom for subscribers to buy equipment where they want, and at the most competitive price. Second, the powerful speech compression ICs used by GSM allow it to cram in more subscribers compared to analog systems, and this will eventually lead to lower call charges.

We predict an aggressive rollout for digital cellular in Europe, with 2.4 million telephones shipped in 1994, equivalent to a semiconductor market of nearly $300 million—although not all of this will be consumed in Europe.

Returning one moment to the laptop computer comparison, these GSM handset shipments are 40 percent higher than what we forecast for *laptop PC* sales in Europe in the same year. This comparison with the laptop market is not an entirely idle one, for cordless laptop modems may be one potential major spin-off for GSM semiconductor sales in the mid-1990s.

Every GSM handset will need a smart card inserted into it before it will work. Smart cards themselves will make very promising applications for semiconductor sales in Europe this decade.

But the smart card is not *one* application but *several* ... in fact, hundreds. However, we are fortunate in the belief that the bulk of the market over the next few years lies with just a handful of key applications.

First, a few words of explanation: there are two broad forms of smart card in use today. The first, the token card, is not a smart card in the strict sense of the word; it contains no microprocessor and only a small amount of memory ... and then there are true smart cards, like the French health card you see here, which contain microprocessor, memory and other logic—all on a single IC.

SLIDE 12: SMART CARDS

We estimate that $16.3 million of semiconductor sales went into smart cards or token cards in Europe last year, mainly into token cards for payphones in France.

So far, the majority of true smart card issues have gone to a handful of bank applications—like those of Carte Bancaire in France and Eurocheque in West Germany.

Three vendors hold the majority of semiconductor supply to this market. SGS-Thomson and Texas Instruments account for the bulk of ICs into token cards, with Motorola the leading supplier for ICs into smart cards.

SLIDE 13: SMART CARDS—KEY FACTORS

Strong recent support for token cards has come from the West German, Spanish, Finnish and Irish PTTs, with their decision to follow France in the use of token cards for payphones.

Pay TV has recently become a major new application for smart cards. This year we estimate that nearly 3 million smart cards will be issued for pay TV, with most of these being made in Scotland by a venture between New International and the smart card company, Gemplus, for viewers of Sky television. Sky will be followed by other smart card pay channels, including Canal Plus and the new D2-MAC channels.

However, by far the *greatest* demand for smart cards will come from the banks, who need the smart card concept to differentiate their services from their competition. When the time is right, there will be an avalanche of bank smart card issues across Europe. The first signs have already appeared in France, Norway, West Germany and here, in Switzerland, with the Migros banking and shopping card.

What will be the final trigger to this avalanche? Arguably the greatest determining factor will be the European Commission, which is presently formulating policies on the rights and roles of consumers in relation to the banks, retailers and national institutions like health and social security.

The Commission has two groups developing standards and policy for the whole Community, one working on card authentication and the other on standards. Both are known to be in favor of the smart card as a universal transaction device for the whole population, not just for consumer purchases ... but for *everything* from medical records to passports.

SLIDE 14: SMART CARDS—THE MARKET

Even when we restrict ourselves to the few applications I have mentioned, the prospects for IC sales into smart cards look very bright. The revenues you see here are for token and smart cards combined. For just the applications mentioned, we forecast total semiconductor consumption in Europe to reach $139 million—for some 200 million cards in 1994.

The trend will be towards secure and sophisticated multipurpose cards which will drive an increase of semiconductor content above the jelly-bean levels typical in the popular telephone token cards of today—so that by 1994, we expect IC content to have at least doubled from the 35 cents per card average today.

At this point, I would like to stand back to make some brief remarks about what all these applications have in common from the semiconductor viewpoint.

Slide 15: Closing Remarks

My first observation is that there are many emerging applications where custom IC design is a very large part of the total systems development cost. This is particularly true for the digital cellular telephone, where companies like Motorola and NEC must surely benefit from having their whole production effort under one roof.

These applications tend to be at the leading edge of what is technologically possible. High-definition television is another example, where the close involvement of companies like Philips, Thomson and Sony at every level of development, from semiconductors to systems, should give them each a strong advantage.

Vertical integration is certainly a key factor in determining the *rate* at which new applications will emerge. If the companies that developed CT2 handsets had the benefit of larger and better resources at the silicon level, I am sure CT2 would be a mass market today.

My second point is that it is important not to underestimate the benefit of hindsight when assessing the future for new applications. It is easy to forget that the application consuming the largest volume of semiconductors today, some 10 percent of the *total* market in Europe, is also the youngest.

The personal computer is the quintessence of why it is essential to watch emerging applications with care. In less than ten years, these boxes have upturned market shares, not only in the computer business but also in semiconductors, with their enormous demands for memory, microprocessors and chip sets.

Finally to my last point—on where to draw the application borders of the 1990s.

Slide 16: Redrawing the Borders

In redrawing the borders of the '90s, an appreciation of which technology has its fingers in which application will be *crucial*.

On this table, I have separated some basic technologies, shown along the top, from a number of major applications down the left. For good measure I have thrown in a few other promising technologies and standards in addition to GSM and smart cards. I have put crosses where each technology might have the potential to appear in each application.

When you sum up each column, you see that GSM does pretty well. So do smart cards for that matter—particularly when there are literally hundreds of applications for smart cards not written in.

There is a third, and vital, dimension on this graph for *you* to fill in when you get back to the office: how will your companies' individual strengths fit with these technologies and these applications?

At Dataquest we will, of course, be delighted to help and work with you to answer this question!

Ladies and Gentlemen, thank you.

Jonathan Drazin

Erratum

There have been two ESAM newsletters issued with the code 1990-10. Please change the code on the newsletter "Smart Cards in Europe—from Telephones to Consumers" to 1990-11.

AGENDA

- Overview
- Digital Cellular
- Smart Cards
- Conclusions

EUROPEAN SEMICONDUCTOR CONSUMPTION AND GROWTH

BY APPLICATION

	Percent Consumption 1986	Percent Consumption 1990	Percent Consumption 1994	Annual Growth 86-90	Annual Growth 90-94
EDP	20.2%	35.7%	40.5%	36.0%	24.5%
Telecoms	23.2%	19.1%	18.6%	12.2%	19.8%
Industrial	21.0%	17.7%	16.3%	13.0%	16.4%
Consumer	22.6%	15.5%	14.4%	7.3%	18.4%
Military	6.6%	5.0%	3.5%	9.4%	10.5%
Transportation	6.3%	7.0%	7.8%	21.2%	24.0%
Total	100.0%	100.0%	100.0%	17.9%	20.7%
Revenue ($B)	5.5	10.7	22.7		

Source: Dataquest

X. TERMINALS

- Same screen capabilities as workstations
- Lower cost
- What impact on the workstation market?
- A re-birth for centralized computing?

LASER PRINTERS

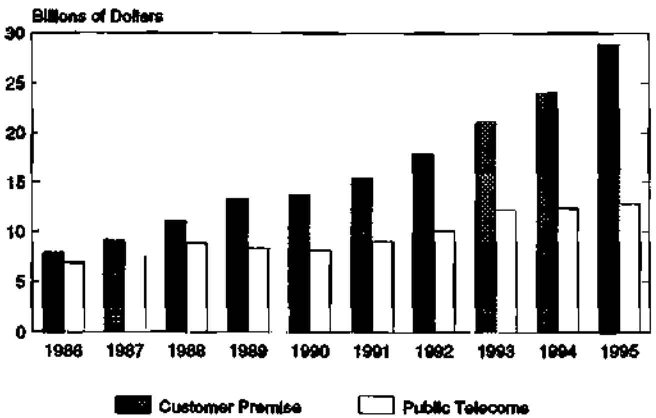
- Increasing semiconductor content
  - push to faster page rates
  - new features (e.g. PostScript)
- European production accounts for 20 percent of market
- Local Far Eastern producers to switch to laser printers
- Strong semiconductor growth

TRANSPORTATION

SEMICONDUCTOR ISSUES

- Today: Cost and Reliability
- Manufacturers will look to new applications for differentiation
  - in-car navigation
  - traffic control
  - noise reduction
- Tomorrow: Innovation and Standards

Estimated Customer Premise and Public Telecoms Equipment Production in Europe



Source: Dataquest

TELECOMS THE APPLICATIONS OVERLAP

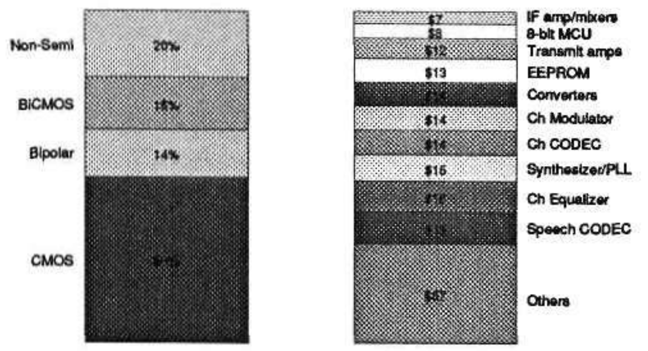
	STANDARD PHONES	CORDLESS PHONES	CELLULAR PHONES	MODEMS	ISDN TAs	LANs	TELEX	VIDEOTEX	FACSIMILE	
STANDARD PHONES	■	X	X							VOICE
CORDLESS PHONES	X	■	X							VOICE
CELLULAR PHONES	X	X	■							VOICE
MODEMS				■	X		X			DATA
ISDN TAs				X	■		X	X	X	DATA
LANs						■				DATA
TELEX				X	X		■	X	X	TEXT & IMAGE
VIDEOTEX					X		X	■	X	TEXT & IMAGE
FACSIMILE					X		X	X	■	TEXT & IMAGE

Source: Dataquest

CT2

- Strong preference by PTTs for telepoint
- Slow acceptance in U.K. - so far
- CT2 must satisfy office users
- Future rival technologies:
  - DECT
  - GSM
  - PCN

Electronic Component Breakdown
for 1st Generation Class IV GSM Handset by Technology and Type



Total Content = $190

Source: Dataquest

GSM HANDSETS

- High component cost
- Critical issues:
  - power consumption
  - bulk
- CMOS logic - big ICs, many challenges:
  - 50,000 gates per IC
  - <1 um, double level metal
  - 1cm x 1cm ⟶ yield critical
- RF front-end - small ICs
  - minimize IF stages and filters

GSM - MARKET FACTORS

- Reasonable handset prices:
  - scale economies
  - price competition
  - bandwidth efficiency ⟶ lower tariffs
- Aggressive rollout:
  - 2.4 million handsets shipped in 1994
  - $300 million semiconductor consumption
- Spin-offs...cordless modems for laptop PCs?

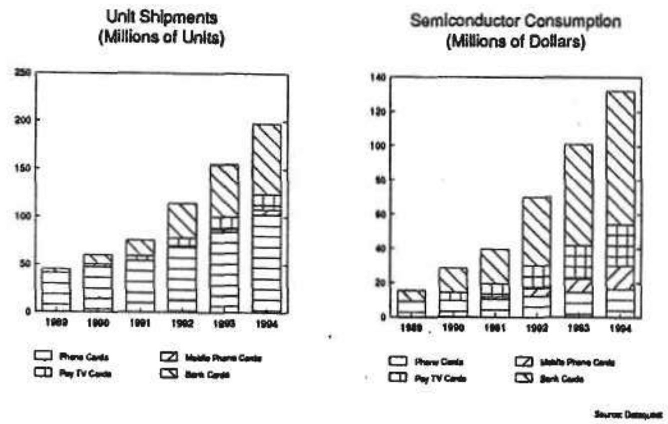
SMART CARDS

- Awaiting mass-adoption by banks
- $16.3 million semiconductor consumption in 1989
- Key vendors
  - Token: SGS-Thomson, Texas Instruments
  - Smart: Motorola, SGS-Thomson
- Emerging applications:
  - pay phones, mobile phones
  - pay TV
  - medical, passports, social security

SMART CARDS - KEY FACTORS

- Payphones - renewed PTT interest
- Pay TV - a new application:
  - 3 million smart cards for Sky TV this year
  - Canal Plus and D2-MAC demand will follow
- Bank cards:
  - smart cards permit differentiation
  - EC studies in progress
  - multi-applications - attractive to banks
- Smart cards - the universal transaction device

Smart and Token Cards - The Market



CLOSING REMARKS

- Complex new systems (GSM, HDTV) need vertical integration
- 1980s: The decade of the PC
- 1990s: The decade of ?
- Essential to separate out:
  - technology
  - standards
  - end-user needs

DRAWING THE APPLICATIONS BORDERS FOR THE 90s

VENDOR CAPABILITY — TECHNOLOGY & STANDARDS — KEY APPLICATIONS

KEY APPLICATIONS	FDDI	MULTI-MEDIA	GSM	SMART CARDS	HDTV	DECT	CT2	ISDN	SCORE
PCs	X	X	X	X	X	X		X	7
FAXES			X					X	2
PHONES			X	X		X	X	X	5
TVs		X		X	X				3
VCRs					X				1
PBXs			X			X	X	X	4
SCORE:	1	2	4	3	3	3	2	4	

Source: Dataquest

Dataquest
a company of The Dun & Bradstreet Corporation

Research Newsletter

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

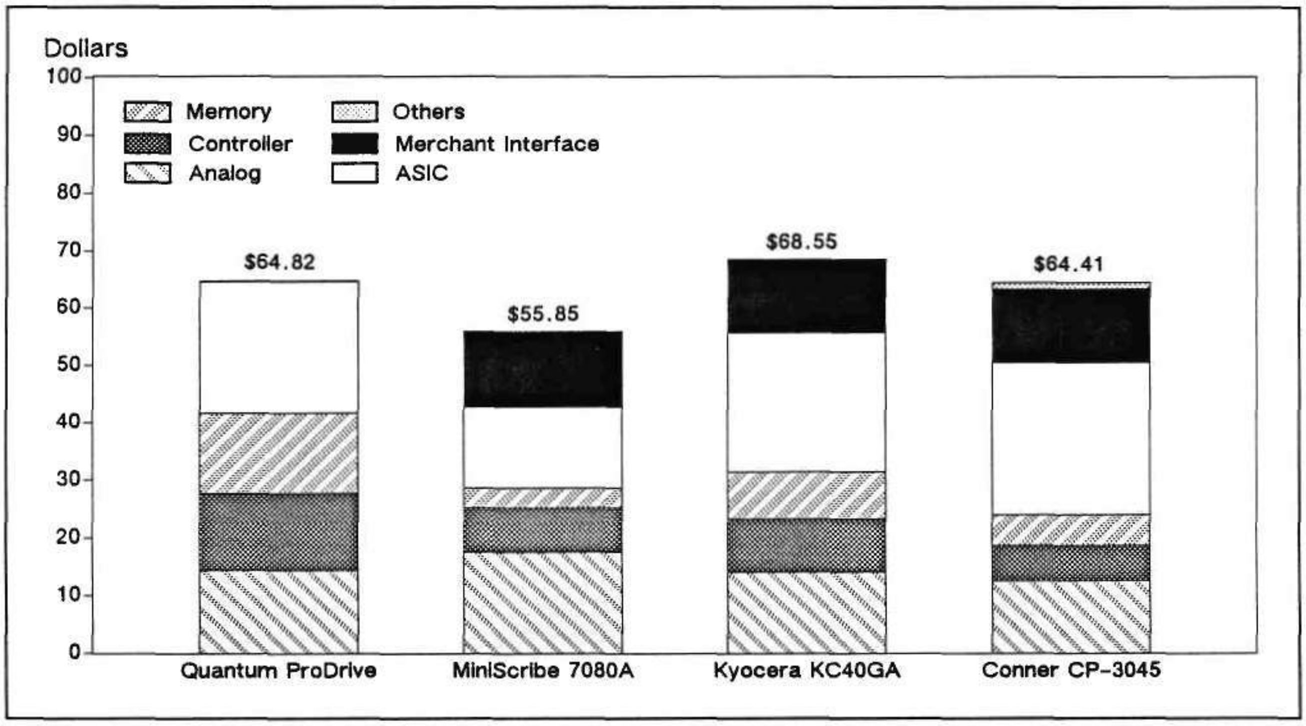
SUMMARY

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



Source: Dataquest (June 1990)

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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	NA	1,309
BPI (Maximum)	22,050	30,625	NA	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

NA = Not available

Source: Dataquest
June 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	NM	1	SCSI interface	12.00	68-pin PLCC
	Quantum	NM	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	

NM = Not meaningful

Source: Dataquest
June 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 (32KB) 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
	NA	NA	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	NM	1		3.50	28-pin PLCC
	NCR	NM	1	NA	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	NA	0.24	14-pin DIP
Drive						
	SSI	32R510AR-4CL	1	R/W preamp	2.75	4-channel, 24-pin SO DIP
Total			16		$55.85	

NA = Not available
NM = Not meaningful

Source: Dataquest
June 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	
	NA	PBL3770A	2	ASIC	7.00	28-pin PLCC
	Fujitsu	NM	1	ASIC	12.00	96-pin quad flatpack
Analog		5247	2	A/D	1.90	8-pin DIP
Drive	Sony	NA	1	R/W preamp	2.75	R/W preamp
Total			13		$68.54	

NA = Not available
NM = Not meaningful

Source: Dataquest
June 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

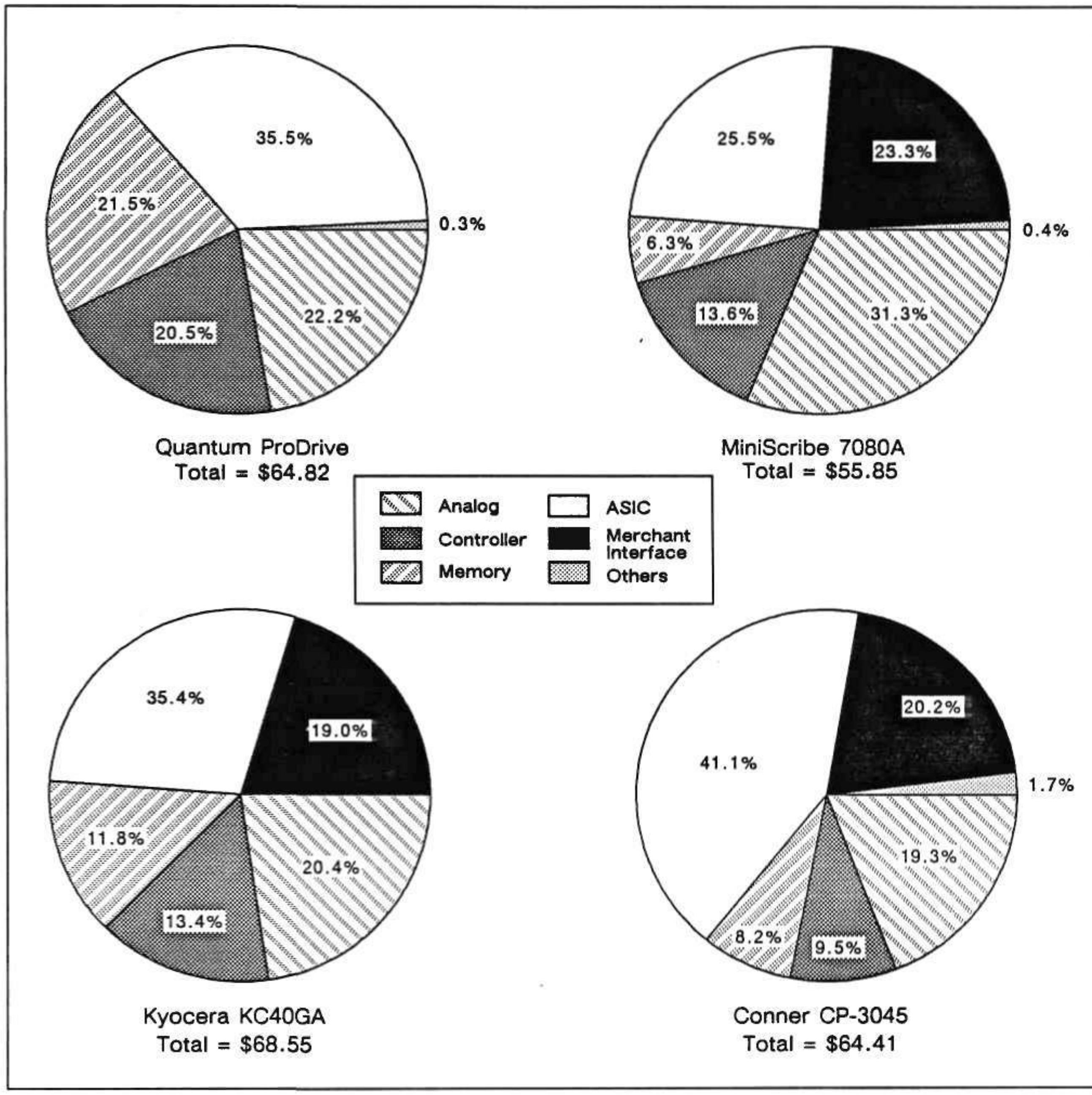
TABLE 5
Semiconductor Breakdown—Conner Peripherals CP-3045

	Vendor	Part Number	Quantity	Function	Estimated Cost	Comments
Controller Card						
Data Path	Microlinear	ML8464C-1CQ	1	Pulse detector	$ 6.07	28-pin PLCC
	NA	NA	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	NA	MOG3586A	1	NA	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						
	NA	NA	1	R/W preamp	2.75	
Total			16		$64.41	

NA = Not available

Source: Dataquest
June 1990

FIGURE 2
Semiconductor Cost Distributions



Source: Dataquest (June 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.

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Mike Williams
Kevin Landis

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Research Newsletter

SMART CARDS IN EUROPE—FROM TELEPHONES TO CONSUMERS

SUMMARY

Smart card technology has progressed to a stage where, while on cost grounds it cannot surpass the magnetic stripe card, it does offer powerful new functions that pave the way for the smart card to ultimately play many roles in most peoples' lives.

With a few exceptions, the smart card has failed so far to make major inroads into the existing mass-market banking and credit applications of Europe. Widescale adoption by the banks will not happen until *all* the issues concerning its adoption (authentication, reliability, cost, patent liability, etc.) have been fully addressed. We believe this to be one to two years away.

On a more positive note, smart card technology has already spawned many existing (pay telephone cards) and emerging mass-market applications (mobile telephone, pay TV and health cards). The fact that the smart card is so rich in applications, so early in its development, is a very positive indicator for its future.

Dataquest forecasts a strong 35 percent compound annual growth rate (CAGR) for total smart card issues in Europe: from 45 million units in 1989 to 199 million units in 1994. We foresee a swing away from simple prepaid telephone cards, widely in use today, to true smart cards for banking, TV and mobile telephone applications. Indeed, all segments will show healthy growth. As a consequence of increasing card sophistication, we expect smart card IC revenue growth to exceed unit growth: rising from $16.3 million in 1989 to $139 million in 1994, a 54 percent CAGR.

This newsletter explores some of the many applications, existing and new, to which smart card technology is being applied and assesses the prospects for semiconductor vendors to sell ICs into these markets.

SOME CARDS ARE SMARTER THAN OTHERS

The smart card is one of a number of existing and emerging card technologies. These technologies divide into two broad types: those that contain semiconductors, known as IC cards, and those that do not (see Table 1).

Table 1
The Card Technologies

Type of Card	Key Card Manufacturers	Cost per Card
IC Cards		
Memory Cards	Fujisoku, Macro, MIPS, Mitsubishi, Oki,	$20 to $1,000
Token Cards	Bull, Gemplus, Schlumberger, Sligos	80 cents to $8
Smart Cards	Bull, Citizen, Dai Nippon, Gemplus, Philips, Schlumberger, Sligos	$3 to $10
Smart Contactless	ADE/Valvo, AT&T, GEC	$15 to $30
Super Smart Cards	SCI, Toshiba	Over $50

Source: Dataquest
May 1990

ESAM Newsletters 1990-10

0006073

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Table 1
The Card Technologies (Continued)

Type of Card	Key Card Manufacturers	Cost per Card
Non-IC Cards		
Magnetic Stripe	(too numerous to include)	30 to 60 cents
Laser Optical	Canon, Drexler	$3 to $5
IR Optical	Landis & Gyr	80 cents

Of the non-IC cards, the most ubiquitous are magnetic stripe cards, extensively used for consumer credit and banking since the mid-1970s. More than 1.6 billion of these cards have been issued worldwide but, although cheap to use, they are susceptible to fraudulent copying and are less reliable than IC cards. Above all, magnetic stripe cards lack the flexibility to offer multiple services, or higher levels of service, that are needed for one application vendor to *differentiate* itself from another.

Of the cards that contain ICs, only those that contain a central processor unit (CPU) are commonly known as "smart cards." Consequently memory cards, widely used to hold games software, character fonts and as solid-state disks for laptops, do not qualify as smart cards. Tables 2 and 3 list the major IC card and reader manufacturers in Europe. In this newsletter, we look at the applications markets for "token" and "smart" cards only, with or without contacts. These are defined below.

Token Cards

We define as "token" those IC cards which do not contain a CPU but whose data flow to or from a card reader is more complex than a basic memory read or write. These cards are often referred to as "prepaid" cards.

Token cards presently account for the greatest proportion of the IC card market. Typically, they contain a fusible programmable logic array (PLA) with a small amount (16 to 256 bytes) of EPROM or EEPROM. Their main applications are as prepayment cards for public payphones, vending machines, car parks and movie theater admission. They offer little more functionality than a magnetic stripe card, except that they are less easily recopied and reused. Like most other IC cards, they are about 10 times more reliable than magnetic stripe ones.

Table 2
European IC Card Fabricaters

Country	Manufacturer
France	Adventure, Bull, Citizen, Gemplus, Grundig, Hello, IBSI Electronique, Logicam, Mustang Technologies, Ordicam, RTIC, Ruwa Bell, Schlumberger, Sligos, Télécash, Télématique Finance, TRT, Vak
Netherlands	Philips
United Kingdom	De La Rue, Fortronic, GEC Card Technology, McCorquodale, News Gem Ltd
West Germany	Datacard, GAO, Giesecke & Devrient, Maxell, Oldenbourg, ORGA, Rexroth Electronic, ADE/Valvo

Source: Dataquest
May 1990

Table 3
European IC Card Reader Manufacturers

Country	Manufacturer
Austria	Voest Alpine
France	A&S, ACS, Bull, Camp, Ceicom, CGE, CKD, CSEE, EIN, ESD, FAAS, Gemplus, Générale des Eaux, Gilbarco, Grundig, G3S-Infodif, Hello, Ingenico, ITT-Sealectro, Logicam, Matra, NSI, Ordicam, Radiotel, Recitel, Réseaumatique, RTIC, Sagem, Satam, Satelcom, Schlumberger, Secre, Sedri, Sepia, Sextant/Crouzet, SF2E, Silec, Sinfa, Smart Ingénière, SMT-Goupil, Sofrel, TBS, Télémedicartes, Transtel, TRT, Unidel, Vak
Netherlands	Philips
United Kingdom	De La Rue, Fortronic, GEC Card Technology, Zergo
Switzerland	Clairinter
West Germany	Bosch-Telenorma, GAO, Giesecke & Devrient, IBM, ORGA, Rexroth Electronic, Siemens

Source: Dataquest
May 1990

We estimate that Gemplus, Schlumberger and Silgos manufactured 41 million token cards in Europe in 1989. More than 95 percent of these were purchased by France Telecom for use as prepaid public telephone cards, using ICs supplied by SGS-Thomson and Texas Instruments.

The market for token cards is expected to grow strongly despite their limitations. The telephone card has spread recently to Finland, Ireland, Luxembourg, Norway and West Germany – with trials also underway in Spain. These countries lag France Telecom's early adoption but, five years from now, we expect comparable levels of penetration to be achieved in these, and possibly other, countries as in France today.

Smart Cards

Smart cards are so named because they include a CPU to perform complex data processing tasks. Most smart cards conform to the ISO 7816 standard, and usually contain a single IC with an 8-bit CPU based on the 6805, 8048 or S9 architectures.

The DES, RSA and other proprietary algorithms, needed for encryption and cardholder authentication, place the greatest demands on both the CPU and the memory. These algorithms require high-speed CPUs with large amounts of ROM and RAM. The need for greater computational speed will eventually result in the introduction of cards with 16-bit CPUs. IBM's recent adoption of Hitachi's H8-310 smart card IC for security access systems is one example.

The following types of memory are also included within the IC:

- Mask ROM (1 to 10 Kbytes) memory to store the operating system and application program.
- EEPROM or EPROM (1 to 8 Kbytes) memory to store personalized card data. This area is programmed by the card issuer, as opposed to the IC supplier, and is often used to hold security routines to complement the card's operating system. EEPROM is gaining increased popularity over EPROM because of its ability to be erased and re-written.
- Volatile SRAM (36 to 256 bytes) used as fast scratch memory to hold intermediate results of calculations.

Semiconductor cost is a critical factor for smart cards because the IC represents a high proportion (15 to 60 percent) of their total cost. A vendor that can supply an IC which closely matches an application's needs is at a strong advantage. The mainstream smart card IC vendors (Motorola and SGS-Thomson) offer ICs with multiple size mixes.

SMART CONTACTLESS CARDS

Most of the token and CPU-based smart cards in use today employ a set of 6 to 8 gold-flashed contacts to make connection between the card and the card reader. Initially there were several proprietary positions and protocols for these contacts, but now ISO standards exist to define these.

Two European companies, GEC and ADE (manufacture contracted to Valvo), have developed smart cards without contacts. These use an RF loop around the card perimeter to draw power and communicate with the card reader. In other respects they resemble normal smart cards.

Today, there are no ISO standards to define the communications protocol, or "air interface," between a contactless card and its reader – although work is in progress. Until these standards appear, we expect contactless cards to be restricted mainly to small niche applications where regular smart cards cannot perform, such as in inflammable, corrosive or dirty environments. Their extra cost over regular smart cards will also strongly limit their uptake.

SUPER SMART CARDS

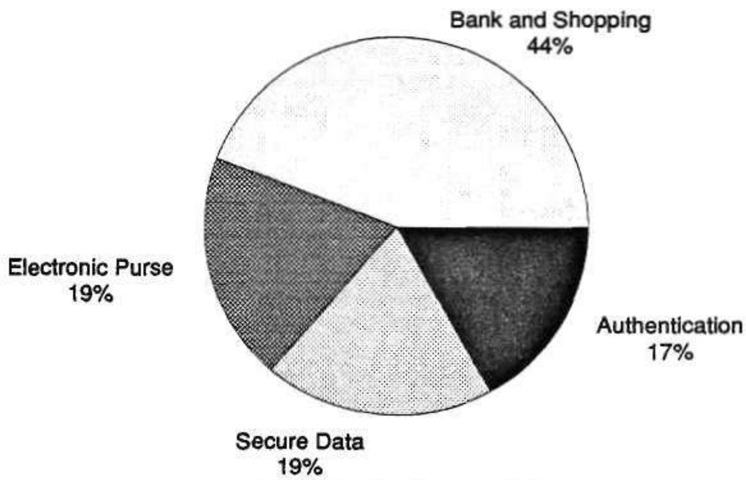
In view of the fact that the term "SuperSmart" is now a Visa International trademark, super smart cards might more appropriately be called "augmented smart" cards. They contain additional features such as a keyboard and LCD, and resemble slim calculators. Three trials are currently underway in Japan by Visa (using Toshiba's card), by Sumitomo Bank (Omron) and by Fuji Bank (Oki).

High component and assembly costs are expected to make these cards expensive compared to smart cards, even in mass production. For this reason, we expect them to remain a curiosity for some years. Trials by one global credit card company and two major Japanese banks is *not* an indication that these cards will receive early adoption by the European financial community, or for other smart card applications.

MANY DIVERSE APPLICATIONS

France accounts for about half of the 67 established smart card applications we have counted in Europe, with this total more than doubling if card trials and experiments are also included. Figure 1 divides out the established applications in Europe by type. These types are defined below.

FIGURE 1
Existing Smart Card
Applications in Europe Counted by Class



Source: Dataquest
May 1990

Electronic purse applications use token cards for prepayment. Examples are the payphone systems of France Telecom, Deutsche Bundespost and Televerket, numerous vending machine and car parking systems and Pathe's movie admission card.

Banking, shopping and credit applications use smart cards to perform PIN verification, authentication and, occasionally, to record transactions. Ultimately smart cards will replace magnetic stripe bank and credit cards. There have been many experiments, but only one has resulted in mass issue — Carte-Bancaire (16.5 million Bull and Philips smart cards) — and the Norwegian Bank card is commencing this year. The Eurocheque smart bank card, presently offered in Regensburg (West Germany), is another major and growing application.

Authentication covers a wide range of non-banking applications from pay TV, home shopping, PC security, to computer network and secure area access systems.

Pay TV became a major application following the scrambling of Sky's movie channel last February. This year, we expect about 50 percent of Sky's 1.3 million viewers (satellite and cable) to purchase prepaid viewing on disposable Gemplus smart cards every four months — 2 million cards. Large-scale card sales into the emerging French and West German D2-MAC Eurocrypt pay-per-view networks are less favorable since only one reusable smart card is issued per subscriber. There are no smart cards currently planned by BSB for its D-MAC channels.

Secure Data applications use smart cards as portable, secure data stores. The most promising applications, so far, are those taken up by the French medical insurance companies: Biocarte, Santal and Transvie. Many dental, pharmaceutical and hospital trials are also in progress. Other applications include industrial batch monitoring, electoral voting (Norway) and electronic lotteries (Loto, France).

Although potentially representing one of the largest markets, medical applications are characteristic in their need for high data capacities. Consequently, non-semiconductor laser card technologies with 2- to 3-Mbyte capacities may prove more suitable in the long term.

WHAT'S HOLDING UP THE SMART BANK CARD?

Replacement of the magnetic stripe credit or bank card is one of the greatest opportunities for the smart card. Overall, there has been scant uptake by the financial community because the savings from prevention of fraud are not sufficient justification alone for migration away from the magnetic stripe card.

We believe the two most significant European advances so far in smart card banking have occurred largely as a consequence of factors which are *atypical* for Europe as a whole:

- The recent decision by Carte Bancaire to expand its card issues to Paris and the rest of France should be viewed in the light of the fact that Carte Bancaire is a group of French banks which works in close harmony with the strategic initiatives in information technology advocated by the French government.
- The full-scale launch of the smart Norwegian Banking Card allows banks to perform secure off-line transaction processing, not previously possible using magnetic stripe cards. However, we believe the key economic factor behind this move is the abnormally high cost of fixed lines needed for on-line processing in Norway compared to the rest of Europe.

Waiting for Biometrics and Better Authentication

Easily forgotten and often uncovered by fraudsters, the personal identification number (PIN) is a less than ideal way to check identity. A "biometric" technique, that cross-matches a cardholder's characteristics with a metric stored in the card would be preferable. Possible metrics are written signature, finger prints, hand contours and face recognition. For use with existing smart card technology, the signature appears to be the most feasible. Dynamic signature verification trials by Midland Bank using the GEC contactless card are about to commence in the United Kingdom.

A smart card using biometric authentication would entail fitting biometric sensors to ATMs and POS terminals, at considerable cost. Consequently, the banks may be unlikely to opt for smart cards until they can all agree that one biometric is clearly superior to the others — not likely for some years.

The Sleeping Patents

Currently about 450 patents cover smart card technology in Europe. Bull, historically the leading innovator in smart cards, holds about half of these and administers them collectively. The others are owned by many different companies and private individuals. Consequently, a total assessment of patent liability by card manufacturers and issuers is difficult, and could become a major factor inhibiting the smart card's future generally.

Multiapplication Cards—The Snags

Recent smart card designs permit many different applications to reside on one card, with ISO standards passed to facilitate this. Potentially, this might make cards more affordable and reduce the number that have to be kept by cardholders. It would also allow the banks to sell services on behalf of other applications that reside on their cards (pay TV, for example).

There are two hurdles to overcome: first, no mechanism presently exists to prevent one application reading the memory space of another. To counter this limitation, each application is obliged to encrypt all data residing in it if security against being spied upon by another application is to be ensured. Second, there is value in having a brand logo printed on the card face, suggesting that many application vendors may be reluctant to share the same card with other vendors.

MOBILE TELEPHONES—A NEW CHAMPION

The GSM pan-European mobile telephone is set to become a champion for smart card market development, as was the payphone for the token card following France Telecom's adoption of it in 1983. (For an introduction to GSM, readers should refer to the ESAM newsletter "GSM in Europe —Cellular Turns Digital," March 1990.)

All GSM mobile phones will be fitted with smart card readers. Standard credit-card-sized cards will be used for in-car mobiles, with smaller plug-in modules intended for hand portables. Unlike today's cellular networks, call charges will be billed to the cards, not to the handsets. This opens the way to several smart cards being issued per handset.

Dataquest predicts a rapid uptake of GSM in Europe. In 1994, we forecast that 2.4 million handsets will be shipped into Europe. A reasonable assumption is that each handset will drive a demand for between one and two smart cards, leading to approximately 6 million GSM smart card issues and reissues in 1994.

THE MARKET

The smart card has not one market, but several. However, the emergence of just one mass application could dramatically transform the total market from what it is today. With much smart card technology, software and standardization already in place, such innovations can easily appear. With this qualification in mind we believe that, over the next five years, the bulk of the smart card IC market will lie with the following key applications:

- Payphone (prepaid and subscriber) cards
- Mobile telephone cards
- Banking and credit cards
- Pay TV cards
- Smart card readers and terminals (for the above applications only)

Inevitably, the emergence of other applications (particularly health, cordless telephone and transportation cards) will cause the total smart card consumption to exceed the total shipments of Figure 2.

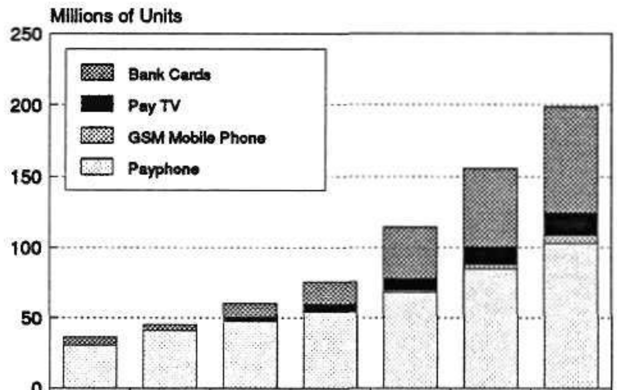
1989—The Year of the Payphone

We estimate that total token and smart card IC consumption (cards and terminals) amounted to $16.3 million in 1989 (Figure 3). ICs for payphone cards accounted for 57 percent ($9.3 million) of total semiconductor consumption, with smart bank cards taking most (38 percent, $6.3 million) of the remainder.

In 1989 we estimate that altogether 45 million IC cards were produced in Europe, of which 44.1 million were token cards consumed in the French market.

Telephone applications currently dominate. In units, the vast bulk of telephone cards were token cards with low IC value (25 cents). We estimate that smart cards for pay telephone applications accounted for only 250,000 units last year, but had a significantly higher semiconductor content ($1.40). Token cards offer limited services and, in principle, are susceptible to fraud — both factors will push payphone card demand from token to smart cards over the coming years.

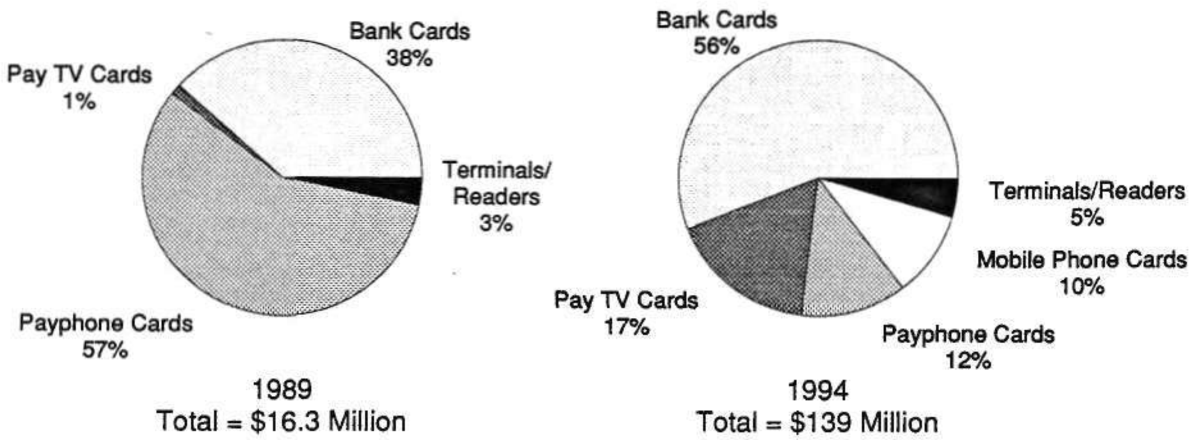
FIGURE 2
Estimated European Smart Card Production by Application Type



	1988	1989	1990	1991	1992	1993	1994
Bank Cards	6.1	3.9	10	16	36.5	56.2	74.24
Pay TV	0	0.1	2.8	4.8	8.3	12.6	16
GSM Mobile Phone	0	0	0	0.42	1.53	2.97	5.55
Payphone	30.25	41	47.6	54.41	68.1	85	103

Source: Dataquest
May 1990

FIGURE 3
Estimated European Smart Card IC Consumption Split by Application



Source: Dataquest
May 1990

1994—The Year of the Consumer

Two key European Commission (EC) studies are presently being conducted by CEN (the European standards body) and the European Payment Systems Council (EPSC) to evaluate the future roles between the consumers and retailers, bankers and other European institutions. It is known that these bodies are strongly in favor of the smart card as a universal transaction device for the consumer.

We forecast total production in Europe will rise to 199 million cards in 1994, showing a 35 percent CAGR in unit shipments since 1989. Interestingly, we predict that IC revenue growth will markedly outstrip unit growth over the same period: 54 percent CAGR, rising from $16.29 million in 1989 to $139 million in 1994. As applications appear that require smart card, as opposed to token card, ICs we expect the average semiconductor content to rise from an estimated 35 cents in 1989 to 67 cents by 1994.

The rapid emergence of banking, pay TV and mobile phone applications will cause today's scene to change dramatically, reducing payphone applications to 12 percent of total IC consumption, although nearly doubling its revenue. We expect IC revenue from banking smart cards to overtake payphone IC revenue this year (1990). In 1994, we expect them to account for IC revenue worth $78 million with 74 million cards shipped.

As pay satellite and cable TV find increasing acceptance in Europe, so will smart cards. Currently the main application is Sky TV, with others opening up as Canal+ moves to card-based decoders and D2-MAC EuroCrypt channels emerge in Europe. We forecast that 16 million pay TV smart cards will be issued in 1994, equivalent to an IC revenue of $24 million.

The number of smart card units shipped will in future depend on the extent to which multiple applications can share a single card. However, we expect IC revenue to be less sensitive to this outcome because the success of multiapplication cards would result in fewer cards — but more costly ICs.

CONCLUSIONS

The smart card IC will be one of the most critical products of the 1990s. The probability is that, by the end of this decade, at least one smart card will be used by every man, woman and child in Europe, for whatever purpose. In terms of uptake worldwide, smart card developments in the Far East at least parallel and probably exceed those in Europe.

The main implication for the European IC market is not the prospect of rapid growth, but that there will be an *irreversible* trend toward high-end smart cards containly increasingly sophisticated smart ICs. The ergonomics of a single powerful multiapplication smart card will eventually be compelling.

We expect to see many new entrants from the Far East in this market. The existing IC vendors must be prepared to put as much technology and investment into smart card ICs as they do into PCs and other main-line applications today because, one day, the smart card could become a PC.

Jonathan Drazin

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Research Newsletter

FLAT-PANEL DISPLAY: TRENDS AND DIRECTIONS

INTRODUCTION

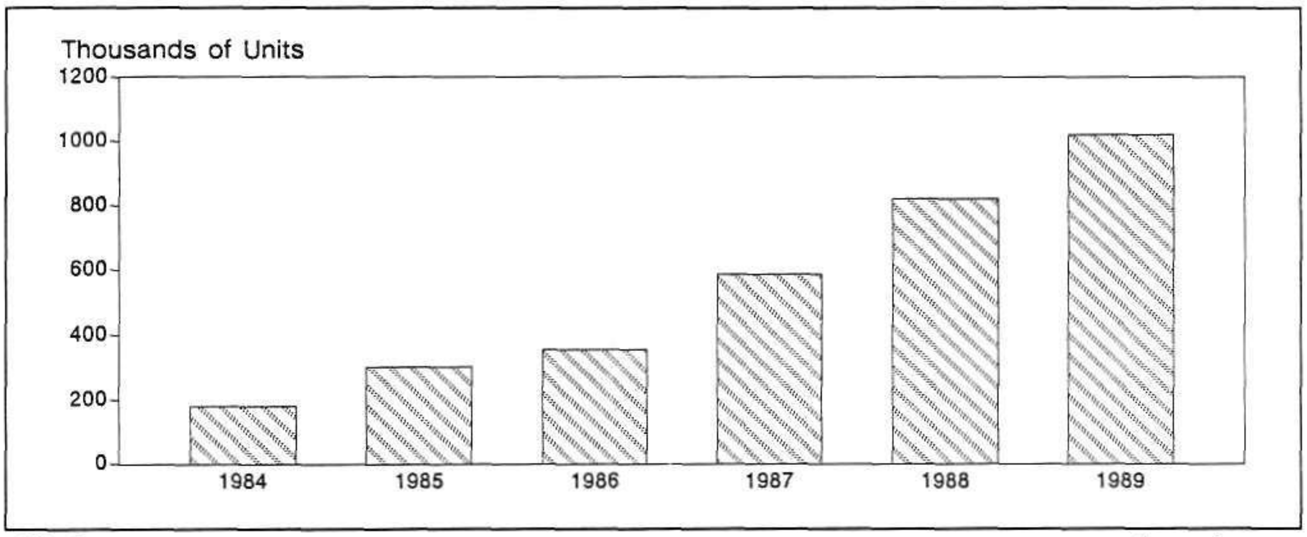
Display technology has witnessed exciting progress in the past decade. Although the traditional cathode-ray tube (CRT) display remains dominant in most applications, its future has never looked so doubtful. Replacing the vacuum tube CRT with some other "flat" technology has been anticipated ever since the vacuum tube triode was replaced by the solid-state transistor.

Ten years ago, liquid crystal display (LCD) development was driven by consumer electronics applications using small-area LCDs; few expected this technology to develop into a replacement for CRTs. Today, LCD technologies have emerged as the leading candidates to replace CRTs. Laptop computers are the current technological driving force for LCDs; however, LCD manufacturers also hope that their technology will play a major role in tomorrow's high-definition TVs (HDTVs). Screen manufacturers currently are demonstrating working prototypes of large-area color LCD displays at trade shows and are creating a frenzy of excitement. Market trends in laptop computers extrapolate to rapid growth with an even faster displacement of traditional machines being limited only by the lack of a high-contrast, reasonably priced, flat-panel display. Figure 1 shows the worldwide portable computer market.

LCD MARKET GROWS

Although many manufacturers have demonstrated impressive working models of color LCD displays, the major problems with bringing these

FIGURE 1
Worldwide Portable Computer Market



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Source: Dataquest
May 1990

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products to market are manufacturing in nature. Specifically, obtaining a high yield from large-area display production is a monumental problem that roughly parallels the challenges of producing the next generation of DRAM products. Whereas DRAMs involve placing a larger number of working transistors on a chip, thin-film display (TFT) LCDs must make their transistors work over a larger physical area of material that is fundamentally less uniform (i.e., nonsingle crystal). Corporate efforts toward solving DRAM and TFT LCD manufacturing problems are very similar; massive investments by major manufacturers are being augmented by strategic alliances and membership in various consortia.

Last August, IBM and Toshiba announced the establishment of a new joint venture company, Display Technology Corporation (DTC). At the press conference, one of the DTC company officers predicted that TFT display panels would completely take over CRT displays. At an Osaka, Japan, electronics trade show last October, DTC demonstrated its new product, an 11.2-inch diagonal color TFT LCD fabricated on amorphous silicon. The DTC display had a pixel count of 720 x 480 and an intensity of 120 cd/m^2 with a contrast ratio of between 20:1 and 40:1. At the same trade show, comparable color TFT LCDs were shown by Hitachi, Seiko-Epson, and others.

Many Japanese electronics companies have begun funneling large investments into their LCD production facilities. Sharp, a leading LCD manufacturer, announced plans to invest ¥140 billion ($970 million) in LCD production by 1994. The company currently has two factories under construction. As well as its joint venture with IBM, Toshiba will spend ¥3 billion ($21 million) to strengthen its existing LCD production facilities during 1990. Toshiba executives have been quite explicit in their expectations that LCDs will play a key role in future corporate product strategy. Current goals at Toshiba are to fabricate 10- to 14-inch color TFT panels with one megapixel of resolution to be produced concurrently with its 4-Mbit generation of DRAM products. Hitachi, Matsushita, Mitsubishi, and Seiko-Epson all announced intentions to invest heavily—approximately ¥10 billion to ¥30 billion ($70 million to $210 million) apiece—in LCD manufacturing capacities. In 1990 alone, total investment in LCD technology by major electronics companies should exceed ¥100 billion. Even a relatively small company, Alps Electric of Tokyo, is planning to build a ¥5 billion ($35 million) color LCD facility that should be operational this spring. Other Japanese players include Hoshiden Electronics, NEC, and Sanyo. Most companies have relatively lofty goals, taking direct aim at color panels with dimensions greater than 10 inches, employing TFT technology, and scheduling mass production in 1990 or by early 1991.

Japanese market projections forecast a ¥1 trillion LCD business by 1995. As a large contribution to this growth, industry observers forecast a tenfold increase in the laptop computer industry from its current level until the end of 1993. In the long term, HDTV is expected to be the next bonanza for the electronics industry, with many gambling that LCD will be the primary display technology for HDTV implementation. Present Japanese domestic CRT production is approximately ¥500 billion ($3.5 billion) per year.

JAPANESE GOVERNMENT CONSORTIA

Because LCD development clearly is resource intensive, private enterprise in the display arena is being complemented by several government-sponsored efforts in Japan. In 1989, the Japanese government established two consortia related to LCD research. Table 1 gives the background on these two recently formed consortia, which were assembled by the Japan Key Technology Center (Japan Key-TEC), the Ministry of International Trade and Industry's (MITI's) research organizer.

Giant Technology Corporation (GTC) has the charter to develop various fundamental technologies needed to realize a 1-square-meter (about 40 x 40 inches) color TFT LCD display, thereby attempting to leap over at least one generation of LCD displays. Participants include a diverse group of traditional electronics companies and printing, glass, and vacuum technology companies. At press time, the project appears to be progressing smoothly.

High Definition Television Engineering Corporation (HDTEC) is primarily studying HDTV technology. HDTEC currently is pursuing four objectives simultaneously; one objective is the improvement of projection-type LCD displays.

OTHER TECHNOLOGIES: DOWN WITH THE BLUES

Professor Akazaki and a team of semiconductor engineers at Japan's Nagoya University recently developed a high-intensity blue light-emitting diode

TABLE 1
Japanese Display Technology Consortia

	Giant Electronics Technology Corporation (GTC)
Established:	March 23, 1989
Objectives:	R&D of advanced technologies for large-area TFT circuitry
Project Term:	7 years
Budget:	¥13 billion ($90 million)
Participants:	Japan Key Technology Center (Japan Key-TEC), Asahi Glass, Casio, Chisso, Dainippon Printing, Fujitsu, Hitachi, Hoechst Japan, Japan Sheet Glass, Japan Synthetic Rubber, NEC, Sanyo, Sharp, Seiko-Epson, Semiconductor Energy Research, Thomson Japan, Toppan, Ulvac
	High Definition Television Engineering Corporation (HDTEC)
Established:	March 27, 1989
Objectives:	R&D of HDTV technologies such as computer graphics, high-speed digital information transfer systems, LCD projection type display, and evaluation of display quality
Project Term:	5 years
Budget:	¥3.5 billion ($24 million)
Participants:	Japan Key Technology Center (Japan Key-TEC), JR Research, Meitec, NEC, NHK, Seiko-Epson

Source: Dataquest
May 1990

(LED). Red and green LEDs have been available for some time, but blue LEDs have long eluded researchers, creating the primary barrier to the successful implementation of a flat-panel color display based on LED technology. It is likely that the first LED display products will be hybrids, i.e., discrete or small-scale devices bonded together that will not require the high manufacturing yield of monolithic devices. Because one-dimensional bonded LED arrays of page-size dimensions now are being used as imaging arrays in commercial high-resolution printers (in competition with laser printers), it is clear that this type of packaging already exists to some degree. LED displays should offer superior contrast, color, and viewing angle when compared with LCD displays. Sanyo already has made progress toward the development and commercialization of blue LEDs.

Although gas plasma and electroluminescent screens are not as well publicized as LCD displays, their contrast and response time are considered their traditional strong points. At the Osaka electronics show, Matsushita revealed a 17-inch color plasma display that it plans to sample-ship by the end of 1990. Matsushita's display had an output intensity specification of only 25 cd/m^2 at a 640 x 480 pixel resolution, but it possessed a contrast ratio of 150:1. The only other non-LCD products shown at this show were a fast 12-inch monochrome plasma display from Oki and a 10-inch monochrome electroluminescent screen from Sharp. As with displays based on LEDs, progress in the development of color electroluminescent screens has been hindered by the lack of a high-intensity blue phosphor.

DATAQUEST ANALYSIS

Dataquest believes that further erosion of the CRT market is inevitable. Although many technologies compete with the CRT in monochrome applications, the LCD is positioned to be the first to compete directly with the CRT in applications requiring color displays. The TFT LCD manufacturing learning curve will determine the price-time progression and thus define both how quickly laptop computers displace desktop machines and, more generally, how rapidly LCD panels penetrate traditional CRT markets. However, several competing technologies should not be discounted, including plasma discharge, electroluminescence, and LEDs, all of which probably will evolve to the level needed to create a usable color, flat-panel display. In the past decade, LCDs have benefited numerous advances such as the so-called super-twist technology and the advent of thin-film transistors on amorphous silicon. However, if a comparable innovation or breakthrough occurs in one of the less publicized technologies, such as those based on gas plasmas, electroluminescence, or even cold cathodes, it could once again change the complexion of the display market. We could conceivably see a renewed interest in such a technology in the same way that there has been resurgence of interest in bipolar transistors in the digital VLSI arena.

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Junko Matsubara

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Research *Newsletter*

EXCHANGE RATE QUARTERLY NEWSLETTER

FINAL 1989

Dataquest exchange rate tables involve data from many countries, each of which has different and variable exchange rates against the U.S. dollar. As much as possible, Dataquest estimates are prepared in terms of local currencies before conversion (when necessary) to U.S. dollars. Dataquest uses International Monetary Fund (IMF) average foreign exchange rates; but all exchange rates quoted after final 1989 will be sourced from the *Wall Street Journal* in line with standard Dun & Bradstreet practice.

All forecasts are prepared assuming no changes in any exchange rate from the last complete historical year—in this case, 1988. During the course of the current year, as local currency exchange rates vary, the appropriate U.S. dollar value changes accordingly. To maintain consistency across all its analyses, Dataquest does not make ongoing adjustments to its forecasts for these currency changes during the current year. As a result of this policy, as the year progresses the forecast numbers could become distorted, in dollars, should the European currencies deviate substantially from the previous year's rates.

Dataquest monitors the exchange rates on a weekly basis using IMF exchange rates, supported by *Financial Times* exchange rates when IMF data are not yet available. (*Financial Times* is the accepted U.K. newspaper giving daily updates.) Effective exchange rates for the current year are calculated each month. This information is then used to assess the local currency's impact on U.S. dollar forecasts.

The purpose of this newsletter, which will be updated quarterly, is to record these changes, and thus allow the reader to make any necessary adjustments when interpreting regional data. For each European region, Table 1 gives the local currency per U.S. dollar for 1988, third quarter 1989, and fourth quarter 1989 together with the final estimate for the whole of 1989. Also shown, for reference purposes, are the same figures for the Japanese yen. As can be seen from this table, the Semiconductor Industry Weighted Average (SIWA) for all the European currencies for 1989 has decreased 7.0 percent with respect to the U.S. dollar, compared with 1988. This represents an increase of 3.8 percent in the exchange rates from third quarter 1989 to fourth quarter 1989. Table 2 shows the 1989 quarterly values for the same regions.

Table 3 illustrates how to interpret the effect of the currency shifts on the Dataquest forecast numbers. For example, the table shows that the constant dollar forecast of $10,208 million for the 1989 total European semiconductor market becomes $9,537 million when adjusted for changes in European currencies.

Table 4 shows the 1989 monthly values of local currency per U.S. dollar for each European region and Japan.

Included in the tables is the European Currency Unit (ECU). This unit, established in March 1979, is a weighted average of the currencies of all member countries of the European Community (EC). It is calculated by the IMF from each country's gross national product (GNP) and foreign trade.

Also included is the aforementioned SIWA. This unit is based on the semiconductor consumption of each European country featured here (EC and non-EC members) and uses the base year 1980 equal to 100 as a reference point. The SIWA is useful for interpreting the effect of European currency fluctuations with respect to the U.S. dollar, specifically for the European semiconductor industry.

James Heal

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Table 1
European Currencies—1988 to 1989
(Local Currency per U.S. Dollar)

Region	1988	Q3 1989	Percent Change 3Q89-4Q89	Q4 1989	1989	Percent Change 1988-89
Austria	12.35	13.54	5.7	12.77	13.23	(7.1)
Belgium	36.77	40.27	5.5	38.06	39.40	(7.2)
Denmark	6.73	7.48	5.7	7.05	7.31	(8.6)
Finland	4.18	4.34	2.9	4.21	4.29	(2.7)
France	5.96	6.50	5.2	6.17	6.38	(7.0)
Ireland	0.66	0.72	5.1	0.68	0.71	(6.5)
Italy	1,301.60	1,386.60	3.7	1,335.43	1,372.09	(5.4)
Luxembourg	36.77	40.27	5.5	38.06	39.40	(7.2)
Netherlands	1.98	2.17	5.7	2.05	2.12	(7.1)
Norway	6.52	7.04	2.7	6.85	6.90	(5.9)
Portugal	143.96	161.27	3.0	156.38	157.46	(9.4)
Spain	116.49	120.60	4.0	115.76	118.38	(1.6)
Sweden	6.13	6.54	2.3	6.39	6.45	(5.2)
Switzerland	1.46	1.66	3.2	1.61	1.63	(12.0)
United Kingdom	0.56	0.63	(0.7)	0.63	0.61	(10.1)
West Germany	1.76	1.92	5.7	1.81	1.88	(6.8)
ECU	0.85	0.93	4.3	0.89	0.91	(7.1)
SIWA (Base 1980 = 100)	121.46	132.73	3.8	127.65	130.01	(7.0)
Japan	128.11	142.42	(0.5)	143.18	138.02	(7.7)

Source: IMF
Dataquest
March 1990

TABLE 2
European Currencies—1989 by Quarter
(Local Currency per U.S. Dollar)

Region	Q1	Q2	Q3	Q4	Total Year 1989
Austria	13.01	13.61	13.54	12.77	13.23
Belgium	38.75	40.53	40.27	38.06	39.40
Denmark	7.18	7.53	7.48	7.05	7.31
Finland	4.29	4.32	4.34	4.21	4.29
France	6.29	6.56	6.50	6.17	6.38
Ireland	0.69	0.72	0.72	0.68	0.71
Italy	1,357.30	1,409.03	1,386.60	1,335.43	1,372.09
Luxembourg	38.75	40.53	40.27	38.06	39.40
Netherlands	2.09	2.18	2.17	2.05	2.12
Norway	6.72	7.01	7.04	6.85	6.90
Portugal	152.01	160.18	161.27	156.38	157.46
Spain	115.52	121.63	120.60	115.76	118.38
Sweden	6.31	6.55	6.54	6.39	6.45
Switzerland	1.58	1.70	1.66	1.61	1.63
United Kingdom	0.57	0.62	0.63	0.63	0.61
West Germany	1.85	1.93	1.92	1.81	1.88
ECU	0.89	0.93	0.93	0.89	0.91
SIWA (Base 1980 = 100)	126.64	133.04	132.73	127.65	130.01
Japan	128.53	137.95	142.42	143.18	138.02

Source: IMF
Dataquest
March 1990

TABLE 3
Effect of Changes in European Currencies per U.S. Dollar on Dataquest Forecasts—1988 versus 1989
(Millions of U.S. Dollars)

	1988	1989	Percent Change 1988-1989
European Semiconductor Consumption (At Constant 1988 Exchange Rates)	$8,491	$10,208	20.2
Weighted European Currency (Assumed) (Base 1980 = 100)	121.46	121.46	N/M
Weighted European Currency (Latest Estimates)	121.46	130.01	(7.0)
Effective Consumption (At August YTD Exchange Rates)	$8,491	$9,537	12.3

N/M = Not Meaningful

Source: IMF
Dataquest
March 1990

TABLE 4
European Currencies—1989 by Month
(Local Currency per U.S. Dollar)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1989	1988	Percent Change 1988-89
Austria	12.87	13.03	13.12	13.16	13.72	13.94	13.33	13.55	13.75	13.15	12.88	12.27	13.23	12.35	(7.1)
Belgium	38.35	38.83	39.08	39.17	40.94	41.47	39.65	40.29	40.88	39.21	38.35	36.63	39.40	36.77	(7.2)
Denmark	7.08	7.20	7.27	7.28	7.59	7.72	7.36	7.49	7.59	7.28	7.11	6.77	7.31	6.73	(8.6)
Finland	4.24	4.34	4.30	4.19	4.34	4.43	4.27	4.34	4.41	4.27	4.25	4.12	4.29	4.18	(2.7)
France	6.25	6.31	6.32	6.33	6.62	6.72	6.42	6.50	6.59	6.33	6.22	5.95	6.38	5.96	(7.0)
Ireland	0.68	0.69	0.70	0.70	0.73	0.74	0.71	0.72	0.73	0.70	0.69	0.66	0.71	0.66	(6.5)
Italy	1,344.20	1,356.70	1,371.00	1,372.40	1,418.30	1,436.40	1,371.00	1,383.50	1,405.30	1,369.20	1,343.50	1,293.60	1,372.09	1,301.60	(5.4)
Luxembourg	38.35	38.83	39.08	39.17	40.94	41.47	39.65	40.29	40.88	39.21	38.35	36.63	39.40	36.77	(7.2)
Netherlands	2.07	2.09	2.10	2.11	2.20	2.23	2.14	2.17	2.20	2.11	2.06	1.97	2.12	1.98	(7.1)
Norway	6.66	6.72	6.79	6.79	7.05	7.19	6.95	7.04	7.12	6.94	6.90	6.70	6.90	6.52	(5.9)
Portugal	150.28	151.96	153.79	154.65	160.92	164.98	158.91	161.22	163.67	159.16	157.53	152.44	157.46	143.96	(9.4)
Spain	114.69	115.66	116.20	116.19	121.94	126.76	119.04	120.53	122.24	118.61	116.49	112.18	118.38	116.49	(1.6)
Sweden	6.26	6.31	6.37	6.36	6.59	6.69	6.47	6.54	6.60	6.45	6.42	6.29	6.45	6.13	(5.2)
Switzerland	1.56	1.57	1.60	1.65	1.73	1.71	1.63	1.66	1.69	1.63	1.62	1.57	1.63	1.46	(12.0)
United Kingdom	0.56	0.57	0.58	0.59	0.61	0.65	0.62	0.63	0.64	0.63	0.64	0.63	0.61	0.56	(10.1)
West Germany	1.83	1.85	1.86	1.87	1.95	1.98	1.89	1.93	1.95	1.87	1.83	1.74	1.88	1.76	(6.8)
ECU	0.88	0.88	0.89	0.90	0.93	0.95	0.91	0.93	0.94	0.91	0.89	0.86	0.91	0.85	(7.1)
SIWA (Base 1980 = 100)	125.34	126.68	127.89	128.42	133.86	136.83	130.77	132.72	134.69	130.28	128.73	123.96	130.01	121.46	(7.0)
Japan	127.96	127.60	130.02	131.97	138.01	143.86	141.11	141.11	145.05	141.93	143.52	144.10	138.02	128.11	(7.7)

Source: IMF
Dataquest
March 1990

Dataquest
a company of
The Dun & Bradstreet Corporation

Research Newsletter

AUTOMOTIVE ELECTRONICS IN EUROPE—THE REAL ISSUE IS COST

SUMMARY

Western Europe is the largest automotive producer in the world, accounting for 30 percent of world production.

Competition among manufacturers is fierce. There is a continuing battle to incorporate more and more electronic features for safety, performance and convenience. As a result, sophisticated electronic systems are spreading from luxury cars into high-volume midrange models, putting pressure on semiconductor manufacturers to quickly enhance their technology while at the same time increasing reliability and reducing cost.

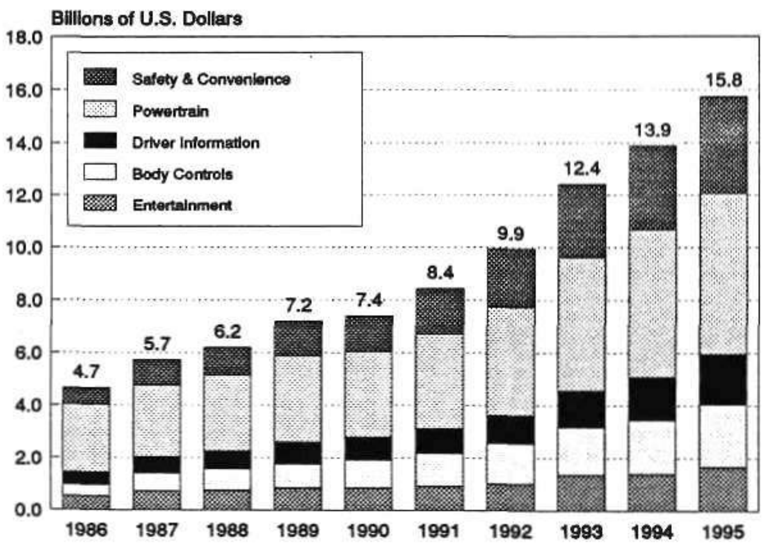
This newsletter gives an overview of the European transportation semiconductor markets, based on an analysis of transportation semiconductor vendors in Europe. The results of our study show that there are few technological barriers at the moment. The key issue remains reliability and cost.

OVERVIEW

Developments in ASICs, mixed analog and digital design, reliability and packaging have contributed to a steep rise in semiconductor content as a proportion of total vehicle value. The same developments are also responsible for driving down the cost of existing electronic systems.

Dataquest estimates that the transportation semiconductor total available market (TAM) in

FIGURE 1
Estimated European Transportation Electronic Equipment Forecast



Source: Dataquest
April 1990

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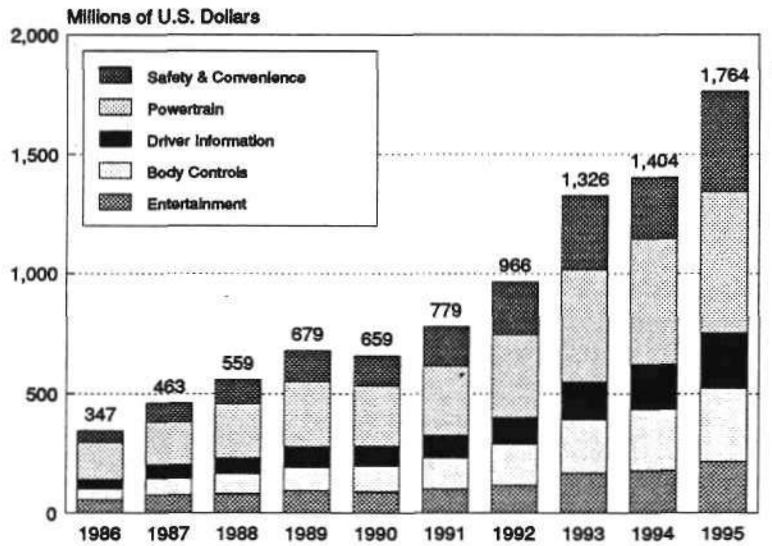
Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

FIGURE 2
Estimated European Transportation Semiconductor Consumption Forecast



Source: Dataquest
April 1990

Europe grew by 21.5 percent in U.S. dollars in 1989, compared to 1988. In 1989 the transportation electronic equipment market grew by 16.0 percent. This clearly indicates that currently, semiconductor consumption in transportation equipment is increasing.

We see the trend continuing over the next five years. Over the period 1991 to 1995, we forecast the transportation semiconductor TAM will grow at a compound annual growth rate (CAGR) of 22.7 percent, compared to a CAGR of 16.9 percent for the transportation electronic equipment market.

Figure 1 shows the total transportation database analysis of electronic equipment production in Europe, and Figure 2 illustrates estimated semiconductor consumption for transportation applications by equipment type.

Historically, safety and convenience, driver information, and body controls have grown above the average transportation electronic equipment CAGR of 17.5 percent (1986 to 1990). This trend is also reflected in the semiconductor TAM for the same segments, which indicates the increased volume of semiconductor usage in these three segments.

We estimate, in our forecast, strong growths for safety and convenience, and driver information applications. Body control applications will show growth above the average transportation semiconductor CAGR over the period 1991 to 1995.

These anticipated growths are due to the following factors:

- Developing technologies: antilock braking systems (ABS), power steering, multiplexing, radio data systems (RDS), in-car navigation, traffic control.
- European Commission (EC) research and development initiatives under Eureka and ESPRIT scheduled to mature in the mid-1990s:
  - Eurotrac: Pollution reduction systems
  - Europolis: Control systems to aid urban and interurban traffic, and metropolitan traffic information control and monitoring
  - Carmat 2000: New fabrication techniques for car body production
  - ERTIS: Transborder road information systems
  - Prometheus: Road traffic control and monitoring to minimize congestions
  - Cell Bus: Electric vehicle propulsion systems
  - Carminat: Driver information display systems
- Progressive tightening of European emission control legislation—full adoption of the "Luxembourg Agreement" (Ref: EC Directives 83/351, or the similar UN/ECE Regulation 15.04;

88/76; 88/436; 88/77; 89/458) to enforce strict rules about vehicle fuel emission levels across Europe by 1993.

- Further growth will come from the large-scale appearance of Japanese car manufacturing activity in Europe, possibly bringing with them their own semiconductor suppliers.

Entertainment

European semiconductor consumption for in-car entertainment systems, mainly car radios, is estimated to have grown at a 12.6 percent CAGR between 1986 and 1990. The emergence of RDS and its acceptance by the major broadcasters in Europe is already stimulating growth in this segment. RDS is becoming standard in an increasing number of radios supplied by Ford, Philips, Bosch (Blaupunkt) and General Motors (GM). France, West Germany and the United Kingdom are expected to give national support to this program.

Over the next five years, car entertainment applications will expand to include compact disc (CD) players and noise reduction systems such as the Lotus-developed "Adaptive Noise Control System," licensed to Blaupunkt. We forecast an increased growth for this segment of 21.2 percent CAGR for the period 1991 to 1995.

Body Controls

Multiplexing will connect all electrical vehicle subsystems such as lights, instrumentation, engine controls and ABS onto one common bus, and represents a radical development for the 1990s. Multiplexing will commence very shortly in Europe, with Mercedes and BMW expected to pioneer it later this year. Initially, it will appear in high-end cars because the cost per unit of introducing this new technology is still high. Successfully to change up to multiplexing, car manufacturers will need to cooperate closely with their suppliers. Many other manufacturers such as Austin Rover, Ford, GM, Honda, Nissan, Toyota and Volkswagen–Audi are known to be well advanced with their multiplexing plans.

We estimate a 25.0 percent CAGR in body control semiconductor consumption between 1986 and 1990, with a 23.5 percent CAGR forecast for 1991 to 1995.

Driver Information

Semiconductor consumption in the driver information systems segment includes dashboard, diagnostics, navigational computers and audio annunciation systems. Overall, these are estimated to have grown by 20.7 percent CAGR between 1986 and 1990. We expect the German, French, Italian and U.K. governments to progress furthest in this direction through their interests in the Prometheus project.

GEC-MEDL has just completed installation of "Autoguide" traffic sensor networks on major motorways in the United Kingdom, with a parallel program (ARIAM) in West Germany using Bosch-ANT systems. Similar developments are underway in France. With the infrastructure moving into place, the next phase will be for cars in these countries to be fitted with driver information units.

Dataquest forecasts a semiconductor consumption CAGR of 25.2 percent between 1991 and 1995 for this segment.

Powertrain

Powertrain is a more mature market for semiconductors. It covers electronic ignition, emission systems, fuel control, turbo/engine control, transmission control, and diagnostics or on-board computer systems. Many of these are today found in most midrange cars, but there is still room for further penetration.

We have seen a CAGR of 12.6 percent between 1986 and 1990, in terms of semiconductor consumption in powertrain. EC regulations will further tighten emission controls and pave the way for electronic engine control units made by Motorola, ITT, Bosch, Siemens and Marelli-Autronica. These units control fuel flow and ensure the most efficient injection of fuel. We forecast a 19.6 percent CAGR for semiconductor consumption in this area between 1991 and 1995.

A new electronic engine management unit, Modular Engine Management System (MEMS), has been introduced into Rover's latest 214Si saloon car. Based on an Intel 8096 microprocessor, the system has an 8-kilobyte memory and allows full diagnostics using Rover's own smart card based ROSCO (Rover Service Communications Protocol). Similar applications have also been developed by Ford, GM, Hyundai and Mazda.

Safety and Convenience

Car safety and convenience systems, mainly ABS and antiskid/antislip systems, are expected to create further semiconductor demand. On the safety front, other developments include the latest version of Bosch's ABS-2E system, which due to its lower cost can now be fitted into compact cars. The electronic controller is substantially reduced in size and attached directly to the hydraulic modulator for the first time. Consequently, it can be installed more easily and at lower cost.

Dataquest estimates a 26.6 percent CAGR for semiconductors in these areas, between 1991 and 1995, compared to a 25.7 percent CAGR in the last four years, 1986 to 1990.

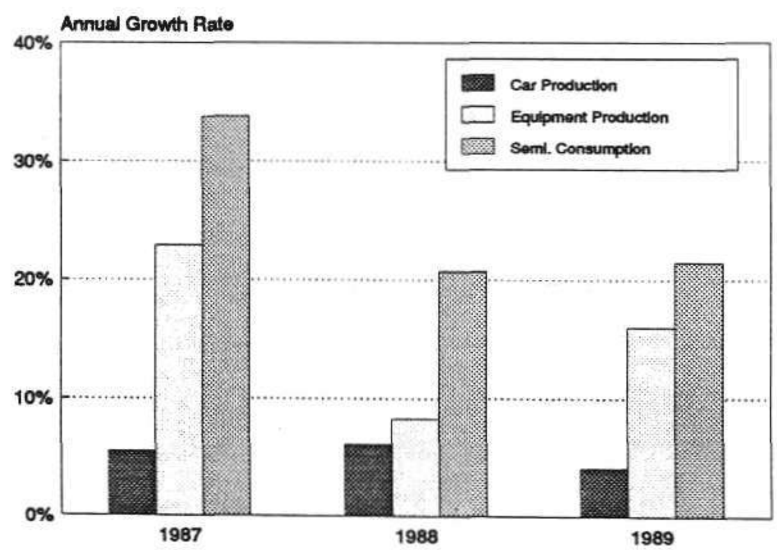
CONCLUSIONS

The transportation industry experienced rapid growth in the late 1980s and is set for continued growth this decade. Recent announcements by Fiat, Ford, GM, Mercedes-Benz, and Volkswagen to site production in Eastern Europe indicate that volume production of automobiles will continue to grow in Europe. Consequently growth in the automotive electronic equipment market is as favorable as ever. Figure 3 summarizes how transportation semiconductor consumption growth rates have consistently outperformed both car production revenue, and revenue for the electronic systems in cars.

Looking to the future, we predict technological developments in the semiconductor industry will form a basis for practical solutions for the car manufacturer. We anticipate the development of the "smart car" through closer technological and cooperative relationships between semiconductor manufacturers, system designers and automotive manufacturers. The outlook is good, particularly in Europe which has the largest volume of both production and sales worldwide.

Mike Williams

FIGURE 3
Comparison of Annual Growth Rates



Source: Dataquest
April 1990

Dataquest
a company of
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Research Newsletter

1990 FORECAST BY APPLICATION—THE KEY TRENDS

SUMMARY

Dataquest's survey of European semiconductor consumption in 1989 gives a total revenue of $9,537 million, a 12.3 percent growth over 1988. In terms of growth by application, data processing ($3,080 million) and transportation ($677 million) come top of the league with 21.3 and 21.1 percent growth rates respectively, followed some distance behind by industrial ($1,792 million) with 10.3 percent, communications ($1,880 million) with 8.3 percent, military ($533 million) with 5.5 percent and, lastly, consumer ($1,575 million) with 3.2 percent.

Over the period 1990 to 1995, we forecast the compound annual growth rate (CAGR) for total semiconductor consumption in Europe to be 17.4 percent, higher than that of both Japan (16.6 percent) and North America (17.1 percent). In terms of growth by application in Europe, we forecast the dominance of data processing and transportation applications to continue with 21.0 and 20.3 percent CAGRs respectively. These are followed by communications with 17.0 percent, consumer with 14.9 percent, industrial with 13.3 percent, and military with 7.7 percent.

This newsletter gives an overview of the major long-range consumption trends by application in Europe, presenting our five-year semiconductor forecast and an historical analysis for the previous five years.

THE GROWTH-SHARE CHARTS EXPLAINED

The figures in this newsletter present Dataquest's estimates and forecasts for the long-range trends in European semiconductor consumption by application for the period 1986 to 1995. For each application, we show relative market size along the horizontal axis and annual growth along the vertical axis. To aid readability, only relative market sizes and compound annual growths for the extreme years, 1986 and 1995, are shown.

These data are consolidated from analyses of more than 90 application segments in Europe, and incorporate the preliminary results of Dataquest's survey of semiconductor consumption in Europe by application for 1989. For further details, clients of Dataquest's European Semiconductor Application Market service should refer to the recently published "European Semiconductor Application Markets (ESAM) Reference Tables 1990."

Figure 1 gives an overview of the broad trends by the six application categories:

- Data Processing
- Communications
- Industrial
- Consumer
- Military
- Transport

Figures 2 to 7 describe the trends within each of the above segments.

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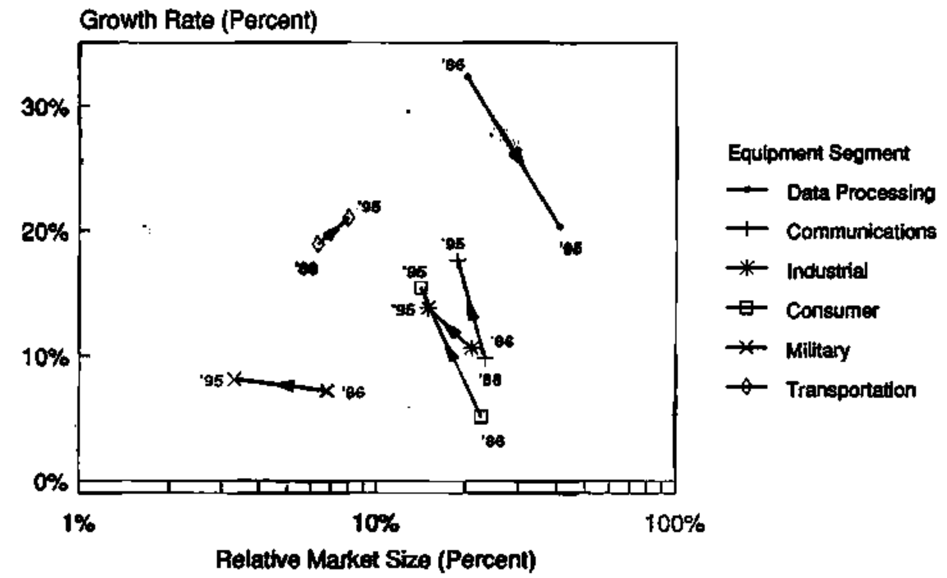
Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

Figure 1
Total European Semiconductor Consumption



Source: Dataquest
April 1990

OVERVIEW

Semiconductor consumption in the data processing sector (see Figure 1) will continue to lead the market. However, we expect the high 32.3 percent CAGR for the 1986 to 1990 period to decline to 20.3 percent over 1991 to 1995, due mainly to two factors:

- Recent rises in MOS memory and microcomponent prices have contributed to abnormally high historic revenue growth.
- Hardening of governmental and European Community attitude towards local content over recent years. The effects have been particularly strong in dot matrix and laser printers, workstations and personal computers, with the result that companies like Amstrad, Apple, Canon, IBM, NEC and Tandon have invested strongly in local production. The consequent growth in semiconductor consumption has boosted the data processing consumption above that of the underlying end-user market.

The same local content issues that have raised data processing equipment production in Europe will next take effect in the consumer market. The low margins in consumer equipment production will induce many Far Eastern-owned factories to seek alternatives to importing PCBs and paying 4.9 percent duty. Instead, we expect them to purchase and mount locally, leading to a strengthening of local consumer semiconductor consumption. We forecast a 14.9 percent CAGR for the 1991 to 1995 period—compared with a poor 3.2 percent CAGR estimated for the 1986 to 1990 period.

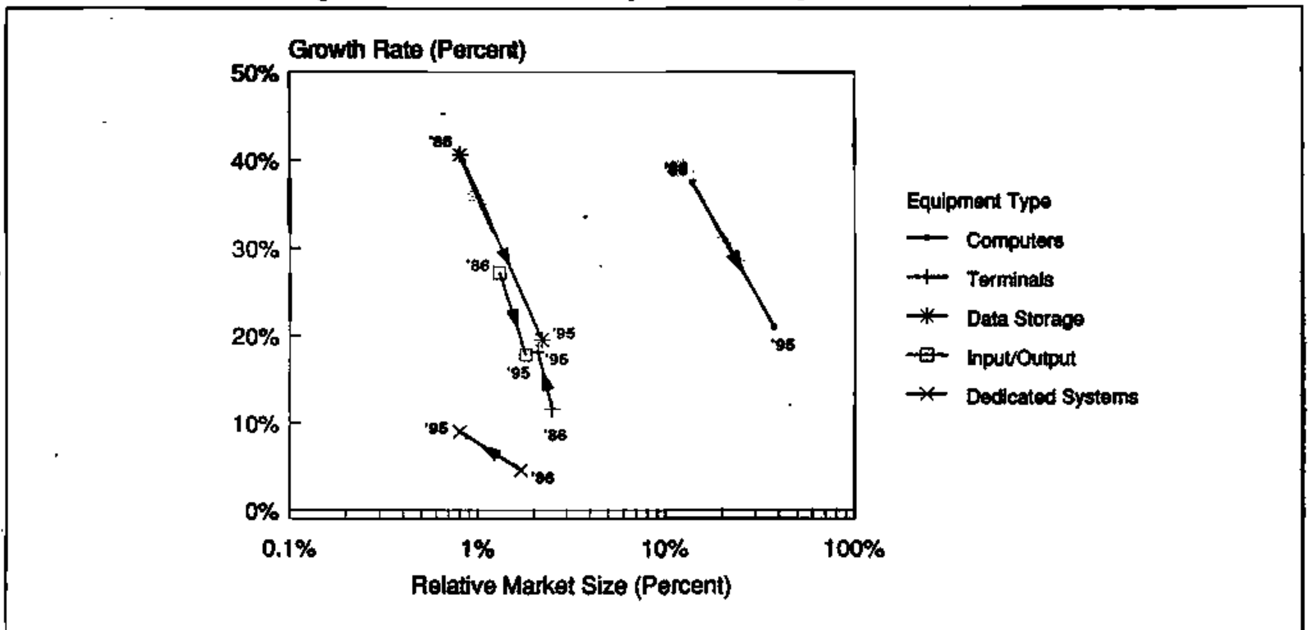
Aside from data processing we forecast that only transportation, pushed by a combination of growing semiconductor content in cars and tightening environmental legislation in Europe, will increase its share of total semiconductor consumption. We forecast a rise from 6.3 percent of total semiconductor consumption in 1986, to 8.0 percent by 1995.

The continuing pattern of declining military spend in Western Europe has led to an outlook of continued, but weak, growth in absolute military semiconductor consumption. We estimate that this failure to show growths comparable with the other major applications segments will force a dramatic decline in share, from 6.8 percent of total European consumption in 1986 to an estimated 3.3 percent by 1995.

DATA PROCESSING—STILL OUT IN FRONT

As mentioned, we forecast reduced semiconductor growths in each of the major data processing sectors (see Figure 2). However, we expect terminals and dedicated systems to buck the overall trend. New developments in terminal design and data communications standards are leading to greatly improved functionality. In particular, recent X.Terminal offerings from NCD and NCR appear set to challenge the trend of the last half-decade from centralized mainframe to distributed workstation based computing. Other terminal and dedicated systems applications will enjoy similar high growths: point-of-sale terminals, smart card automatic teller machines (ATMs) and readers, and bar code readers.

Figure 2
Electronic Data Processing Semiconductor Consumption in Europe



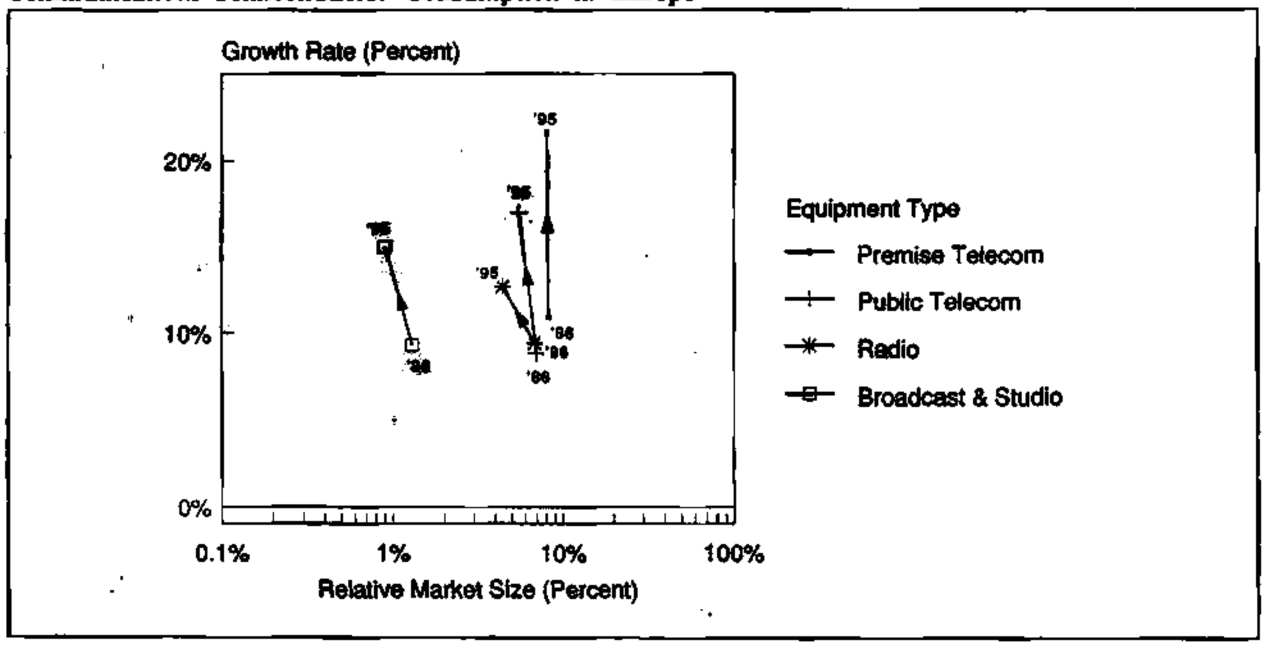
Source: Dataquest
April 1990

COMMUNICATIONS—CUSTOMER PREMISE TO DRIVE DEMAND

Spurred on by the European Commission's Green Paper on telecommunications, liberalization of hardware supply and equipment services will accelerate competition among suppliers to both the public and private networks in Europe. Despite this, we believe the pattern of almost 100 percent supply of the European public network by local production will continue, with suppliers like Alcatel, Ericsson and Siemens maintaining their strong positions against non-European manufacturers.

The strongest applications drivers will increasingly come from telecom premise applications (Figure 3)—particularly from digital cordless (CT2 and DECT), optical local area networks (FDDI), digital cellular (GSM) and facsimile over the coming three to four years. Beyond this period, we foresee that personal communications networks (PCNs) and ISDN (particularly PC cards and videophones) will emerge to drive the market as volume applications.

Figure 3
Communications Semiconductor Consumption in Europe



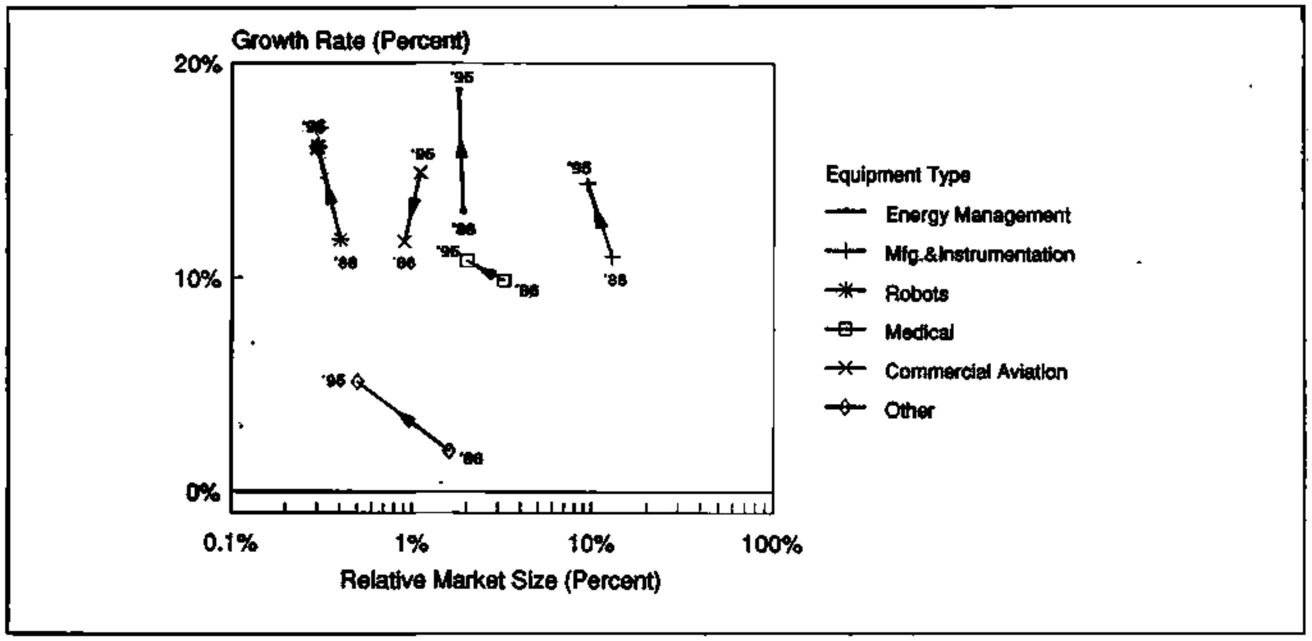
Source: Dataquest
April 1990

INDUSTRIAL

The industrial markets (Figure 4) consist of a large number of small-volume applications, usually served indirectly through semiconductor distributors. European players traditionally perform well in these markets, with companies like ABB, Landis & Gyr, Schlumberger and Siemens on a continued ascendency as powerful global players in key markets such as transportation, power generation, instrumentation, control and medical systems.

Of particular note is energy managment, where many applications (utilities metering, lighting and heating control) are already beginning to benefit from a sense of urgency on environmental issues such as global warming, resource conservation and pollution.

Figure 4
Industrial Semiconductor Consumption in Europe



Source: Dataquest
April 1990

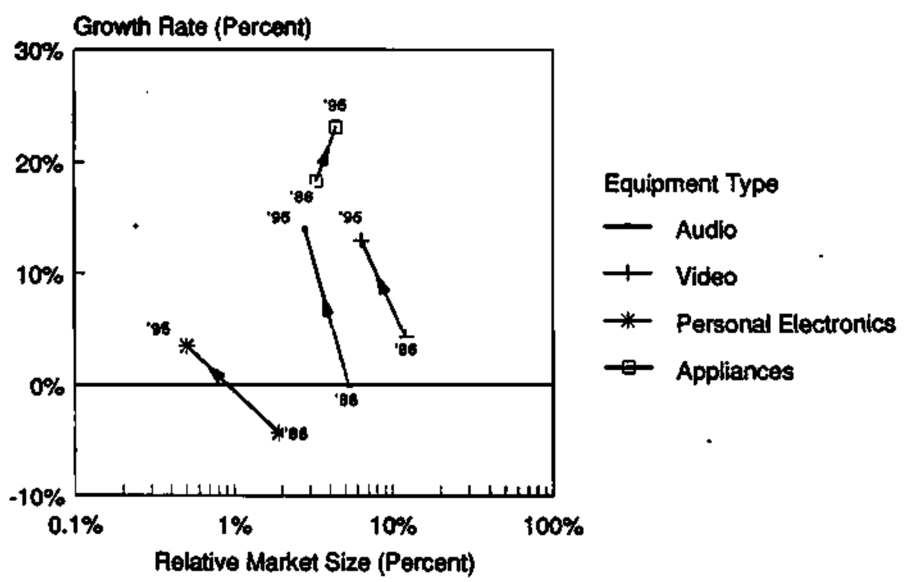
CONSUMER

The consumer electronics market in Europe has been flat for some years, and is forecast to enjoy only moderate 2 to 5 percent growth over the coming years. With the exception of camcorders, almost predominantly manufactured in Japan, only a few innovations appear set to revolutionize home electronics.

In 1989, we estimate that only 40, 48 and 50 percent of European consumption of compact discs (CDs), video recorders (VCRs) and microwave ovens respectively came from European production. Local content rules, antidumping measures and import duties will continue to force a shift towards local production and procurement.

Rising semiconductor content in many consumer applications is another growth contributor, and is especially true for appliances which have not had any semiconductor content previously. Manufacturers increasingly regard adding electronic functions to these applications as opportunities to add functionality and differentiate their products from those of their competitors. This is particularly the case for refrigerators (digital temperature indicators, multiple compartments), microwave ovens (food weighing, cook sensing, programmed cycles), and washing machines and dishwashers (special wash cycles, load weighing).

Figure 5
Consumer Semiconductor Consumption in Europe



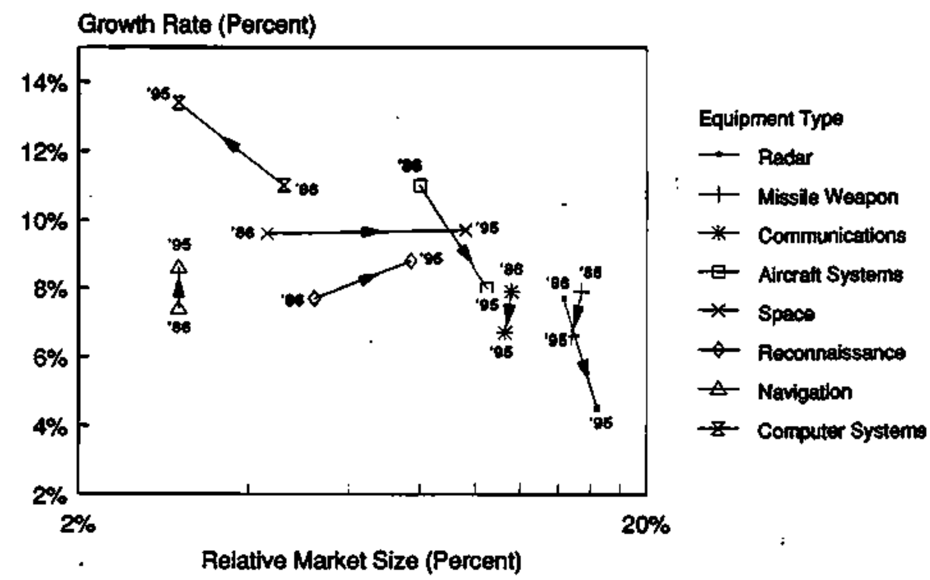
Source: Dataquest
April 1990

MILITARY

Semiconductor consumption for military applications in Europe is inextricably linked to the defense budgets of the United Kingdom, West Germany and France. In recent years these budgets have just kept pace with inflation. Events in Eastern Europe will almost certainly result in a freezing of defense expenditure. Recent plans from the British government, the largest spender on defense in Europe, indicate an increase of only 0.5 percent for equipment procurement for the 1990 to 1991 period. In real terms, this is equivalent to a 7 percent cut. Similar reductions will very probably occur in both France and West Germany.

Traditionally, a strong component of European defense electronics has also come from exports to the Middle East. However, demand from this area has slowed considerably with the decline in spend of these mainly oil-based countries and the cessation of the Iran–Iraq conflict.

Figure 6
Military Semiconductor Consumption in Europe



Source: Dataquest
April 1990

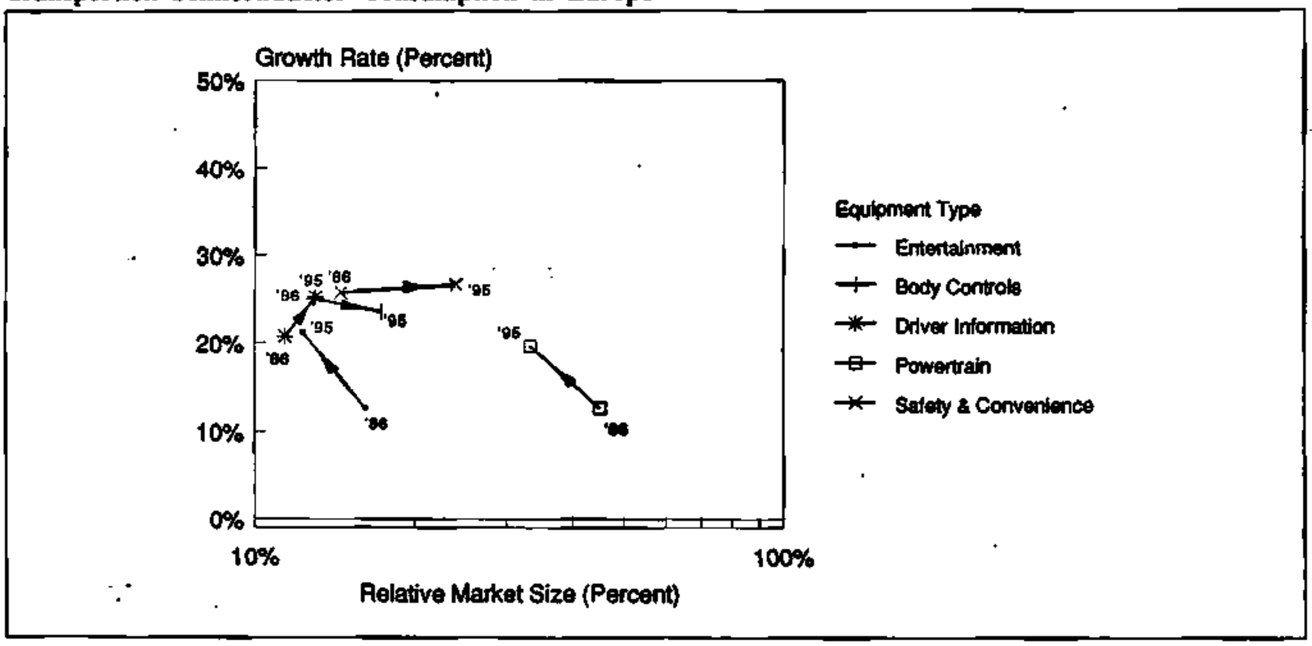
TRANSPORTATION

Fuel economy, safety issues and tightening emission regulations will have a growing influence on transportation applications in future. These factors will have greatest impact on fuel-injection and engine control units. To comply with the Commission's emissions regulations, we expect to see both systems offered as standard on both luxury and standard cars of all sizes from 1993.

In addition, we foresee strong emerging demand for body control systems (multiplexers and subsystem communications) in Europe. These will appear first in European top-range cars (Mercedes and BMW). However, many of these features exist already in a number of Japanese models (Toyota, Honda and Mazda) sold in North America. It is likely that these Japanese manufacturers—which all have substantial European manufacturing facilities—will introduce similar features in Europe, with a consequent demand for local components.

Jonathan Drazin
Mike Williams

Figure 7
Transportion Semiconductor Consumption in Europe



Source: Dataquest
April 1990

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Research Newsletter

PRINTER SEMICONDUCTOR CONTENT TRENDS

SUMMARY

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

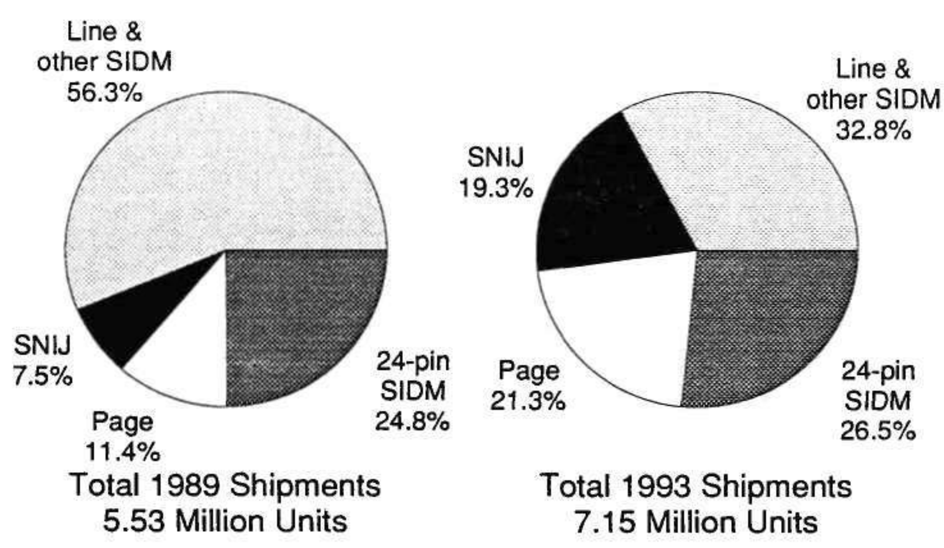
This newsletter will provide a quantitative analysis of this market at the component level and will examine the critical price and performance issues facing semiconductor suppliers seeking to meet the needs of this dynamic market.

OVERVIEW

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

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

FIGURE 1
European Market Unit Shipments by Printer Type



Source: Dataquest
March 1990

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MARKET ISSUES AND OPPORTUNITIES

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

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

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

We believe that these challenges translate directly into market opportunities for semiconductor manufacturers. Products that reduce total system costs and/or boost system performance will not only be well received by the industry, but could actually accelerate market expansion. Table 1 summarizes Dataquest's view of the European page printer semiconductor market; Table 2 lists the manufacturing locations of page printers in Europe.

Table 2
Page Printer Manufacturing Locations in Europe

Manufacturer	Location	Country
Agfa-Gevaert	Mortsel	Belgium
Bull	Belfort	France
Canon	Brittany	France
Dataproducts	Dublin	Eire
IBM	Stockholm	Sweden
Mercante	Copenhagen	Denmark
Olivetti	Aglie	Italy
Philips	Siegen	West Germany
Rank Xerox	Madrid	Spain
	Gloucester	United Kingdom
Siemens	Munich	West Germany
Technitron	Slough	United Kingdom

Source: Dataquest
March 1990

THE TREND TOWARD INTELLIGENT PRINTERS

Traditional printers have been primarily mechanical devices that apply ink to paper as specified by the host computer. Page printers, on the other hand, are nonimpact devices with sophisticated controllers. The host computer issues output information in the form of a PDL, such as Adobe's PostScript or Hewlett-Packard's recently released PCL 5. The controller (usually located within the printer itself) then interprets this high-

Table 1
European Page Printer Market Forecasts

	1989	1993	CAGR 1989-1993
Market Shipments (K)	652	1,519	23.6%
Market Revenue ($M)	$2,686	$5,195	17.9%
Average Selling Price ($)	$4,120	$3,420	(4.5%)
Semiconductor Content per Unit ($)	$407.2	$489.0	4.7%
Semiconductor I/O Ratio	9.9%	14.3%	
Percent Local Semiconductor Consumption	15%	24%	
European Semiconductor Consumption ($M)	$39.1	$182	46.9%

Source: Dataquest
March 1990

level output description and generates detailed instructions for the print engine. Although they lack the sophistication and power of the page printer, most new ink jet printers qualify as smart in that they usually have a microprocessor-based controller that interprets a PDL.

IMPLEMENTATION

In order to interpret PDL commands and drive the print engine, the controller must implement the basic functions of system interface, raster image generation, and print-engine control. The controller also requires its own subsystem clock as well as page and software storage. Figure 2 shows a typical printer controller block diagram.

System Interface—Versatility Is Key

The system interface block implements the functions of interface protocol and handshaking along with the buffering of input data and instructions. Because there are several different connector standards, the controller must be capable of receiving data via a variety of serial and parallel connectors. In addition, data may also be transmitted via a system bus such as AppleTalk or SCSI.

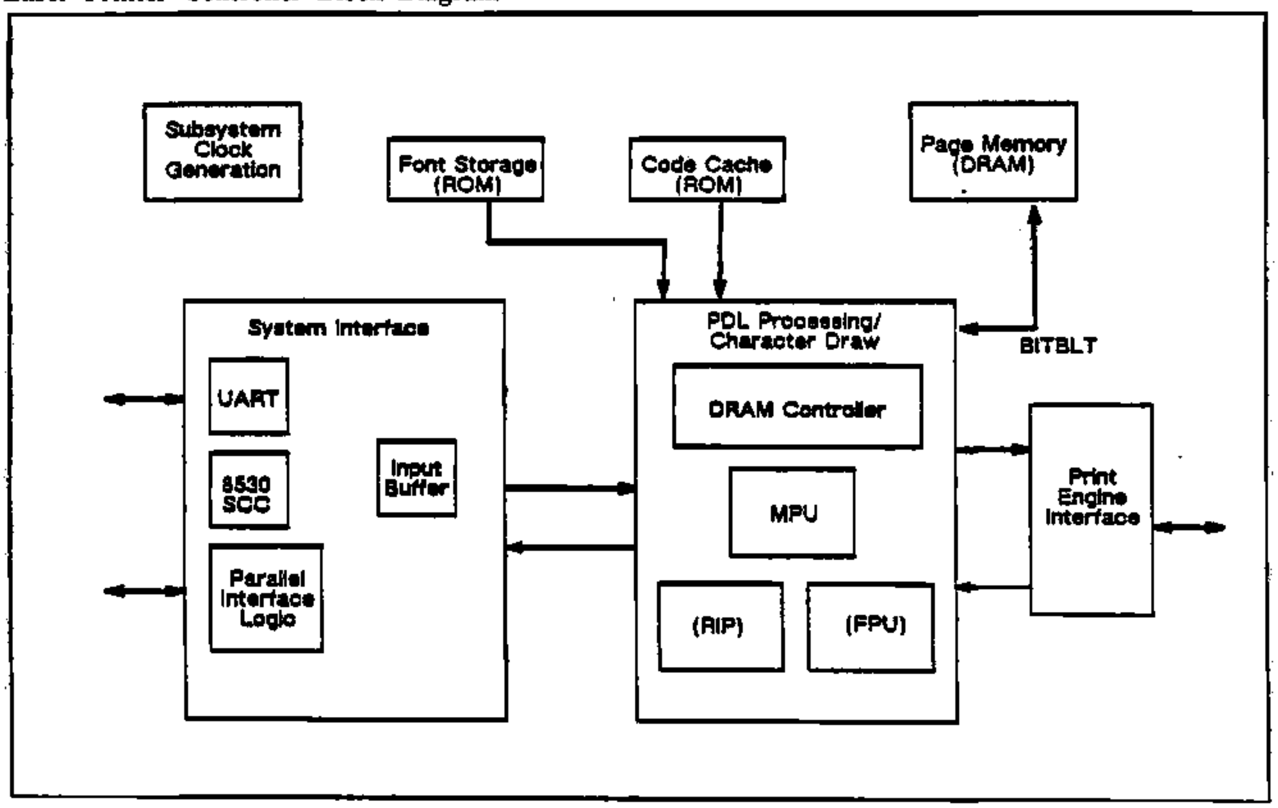
Systems interface circuitry usually consists of transceiver chips coupled to off-the-shelf peripheral communications devices for the serial interface and an interface logic section for the parallel and/or bus interface. The growing acceptance of intelligent subsystems buses, such as SCSI and AppleTalk, is likely to call for an ASIC or application-specific standard product (ASSP) solution, which would provide designers with a universal systems interface building block.

The typical input buffer is currently implemented in a simple FIFO configuration (usually two 512 × 9 FIFOs).

Processor Core—Toward a Specialized Compute Engine

Once the PDL data and commands are cued into the input buffer, the microprocessor (MPU)

FIGURE 2
Laser Printer Controller Block Diagram



Source: Dataquest
March 1990

must execute the commands in order to generate output images. Although this could be done by the MPU alone, character generation and graphics tasks sometimes are off-loaded to a raster image processor (RIP) and/or a floating-point unit (FPU). In addition, the bit-block transfer (BITBLT) function can be assigned to a dedicated "traffic cop" in order to streamline operations.

Current implementations tend to use a standard general-purpose microprocessor. This results in severe performance bottlenecks due to the processor-intensive nature of the BITBLT and character drawing and manipulation operations.

In Dataquest's opinion, this is a temporary solution that will soon give way to chip set implementation in which the various drawing, manipulation, and image-transfer functions are executed by separate dedicated blocks of customized logic.

We believe that this will be the next logical step, as it allows for the optimization of each logic block to a particular function (character drawing and BITBLT, for example, make very different demands on the CPU) and then allows them to run concurrently. A chip set approach enables system designers to mix and match, making the price/performance trade-offs necessary to position the printer for a particular end-user segment (such as single-user or departmental print server).

Because high-performance applications will continue to place speed ahead of system cost, high-end controllers should feature multiple device implementations for the foreseeable future. We expect to see the current implementation, using programmable logic devices (PLDs) and other fast logic to augment a standard processor, giving way to high-performance chip sets.

Low-end laser and ink jet printers are another matter, however. In order for single-user printers to achieve maximum market penetration, total system cost must decline substantially. This cost pressure argues for the eventual use of a low-cost, single-chip, application-specific processor. Interim solutions should feature low-cost standard microprocessors that are augmented by simple ASICs.

Storage—Color, High-Resolution Demand More Bits

Memory requirements fall into two categories: nonvolatile memories (typically ROM), which are used for code and font storage, and page memory (typically DRAM), which is used to store the bit-mapped images of the page to be printed.

Nonvolatile applications routinely require 1MB or 1.5MB of memory, depending on the number of fonts supported. A typical high-performance page printer can contain as much as 4MB to 6MB of ROM. This figure will depend on the variety of fonts required and on the amount of memory required to support each font (which, in turn, varies according to the sophistication of the PDL). Dataquest anticipates that future systems will store many more fonts in memory ranging from DRAM to various types of disk drives.

Page memory applications can require anywhere from 512KB to 8MB of DRAM, but the majority currently use 1MB to 1.5MB. Most printers with less than 1MB use a technique known as band buffering, in which only a fraction of a page is stored at a given time. Banding can greatly reduce memory costs; however, the substantial speed trade-off imposed by banding argues against widespread use of this technique in the future.

Performance enhancements and the addition of color output capabilities are likely to increase memory requirements substantially over the next five years. By 1993, we expect that the average system may utilize 8MB of DRAM.

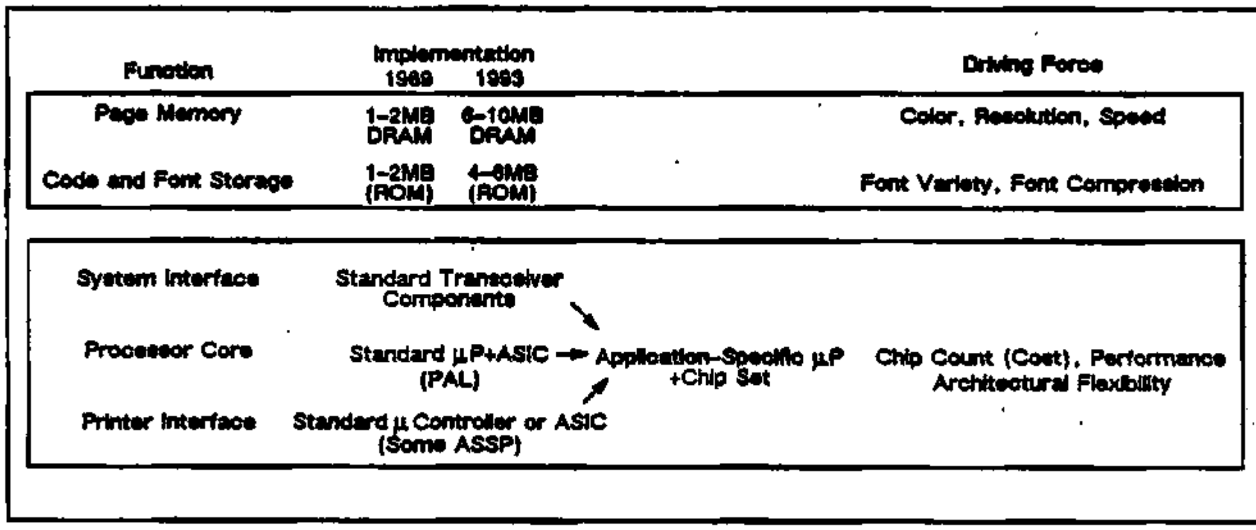
Print Engine Interface—Standardization, Consolidation to Come

Although much of the interface functionality could eventually be integrated into the processor core, current design constraints should ensure that the print engine interface remains an independent functional block for the foreseeable future. The print sequencer, status monitoring, and control functions can be implemented in an ASIC or through the use of either a standard microcontroller (such as the 68008) or a dedicated interface chip (such as the WD65C10). Because they represent support logic rather than core logic, these functions are likely candidates for consolidation into future generations of chip sets or ASSPs. Figure 3 summarizes the anticipated evolution of the various functional blocks.

SEMICONDUCTOR CONTENT/ CONSUMPTION FORECAST

The previous discussion deals with the entire class of intelligent printers. The quantative portion of this analysis, however, addresses only the page printer portion of the intelligent market. The other

FIGURE 3
Typical Semiconductor Implementation



Source: Dataquest
March 1990

Table 3
European Page Printer Semiconductor Consumption (Millions of Dollars)

	1989	1993	CAGR 1989-1993
Total Semiconductor	$39.1	$181.8	46.9%
IC	$39.1	$181.8	46.9%
Bipolar Digital	$1.2	$0.9	(5.7%)
Memory	$0.0	$0.0	-
Logic	$1.2	$0.9	(6.7%)
MOS Digital	$37.6	$180.0	47.9%
Memory	$31.6	$153.9	48.5%
Microcomponents	$3.3	$24.3	64.2%
Logic	$2.6	$1.8	(8.8%)
Analog	$0.3	$0.9	33.5%
Discrete	$0.0	$0.0	-

Source: Dataquest
March 1990

significant segment, ink jet printers, is not expected to surpass page printers in either dollar or unit terms by 1993. With lower average selling prices (ASPs) putting strong pressure on component costs, the total available semiconductor market for ink jet printers is expected to remain substantially smaller than that of the page printer through 1993.

Table 3 gives Dataquest's estimated European semiconductor market for page printer controllers. We expect total semiconductor demand for these controllers to increase from $39.1 million in 1989 to more than $180 million in 1993.

The high overall compound annual growth rate (CAGR) of 46.9 percent will be driven by continued strong growth (17.9 percent CAGR) of the laser printer market in Europe. This will be further bolstered by additional manufacturers to those shown in Table 2 deciding to locate production facilities in Europe. We estimate that, at present, European production supplies less than 20 percent of the European market.

During this period, CAGRs are forecast to range from a negative 6.7 percent for bipolar logic to a positive 64.2 percent for MOS microcomponents. Although this is not the highest growth area in percentage terms, MOS memories will realize the greatest growth in absolute terms.

Table 4 summarizes Dataquest's estimated semiconductor content trends for the page printer market. Three factors drive the shifts in semiconductor content. First, the sliding price of page printers exaggerates the increase in semiconductor content percentages. Second, recent high memory costs have encouraged printer manufacturers to minimize their memory content—the falling cost per bit of most memory products along with the increasing requirements discussed earlier should combine to push the memory content percentage up sharply. Finally, the rapid increase in microcomponent content is a direct result of that category's cannibalization of the other logic categories.

DATAQUEST CONCLUSIONS

Laser printer controllers appear to be the next emerging embedded control market. Unlike most past nonreprogrammable applications, it appears that the processing requirements of intelligent printer control cannot be fully satisfied using standard microcomponents alone. This calls for the emergence of high-performance, application-specific standard products to serve this market.

The growing popularity of intelligent printers, along with current performance shortfalls, virtually ensures enthusiastic market reception for high-performance application-specific standard products that reduce total system cost.

DATAQUEST RECOMMENDATIONS

Memory Suppliers

Because memory costs represent a large portion of total controller cost, system designers are likely to continue using standard, lower-cost memories wherever possible. Competition for memory suppliers should turn on the issues of price and availability. However, because this market is a rapidly changing one, in terms of both market growth and system architectures, we recommend that memory suppliers keep close ties with systems designers in order to accommodate any changes in future systems requirements.

Microprocessor Suppliers

Today's compute engines have provided only marginal system performance, partly as a result of the specialized requirements associated with PDL implementation. We therefore recommend that MPU manufacturers develop compute engines that are specifically optimized for this application. Certain companies are already modifying existing designs for this purpose while others are creating completely new processors. In addition, system designers are likely to have strong preferences

Table 4
Page Printer Semiconductor Content Forecast (Dollars)

	1989	1993	CAGR 1989-1993
Total Semiconductor	$407.2	$489.0	4.7%
IC	$407.2	$489.0	4.7%
Bipolar Digital	$12.4	$2.4	(33.5%)
Memory	$0.0	$0.0	-
Logic	$12.4	$2.4	(33.5%)
MOS Digital	$391.9	$484.2	5.4%
Memory	$27.1	$4.8	(35.0%)
Microcomponents	$3.0	$2.4	(4.8%)
Logic	$0.0	$0.0	-
Analog	$27.1	$4.8	(35.0%)
Discrete	$0.0	$0.0	-

Source: Dataquest
March 1990

toward designing around a single compute engine for their entire product lines. We therefore recommend that MPU suppliers offer a complete product line with a full price/performance range of its own.

ASIC Suppliers

Opportunities in the ASIC arena are likely to be transitional. As systems designs mature, processor-supporting ASICs should give way to ASSPs. In order to survive this transition, we recommend that ASIC manufacturers translate these designs into their own ASSPs. In diversifying into ASSPs, ASIC manufacturers will have to adjust their sales and marketing approach for these products. This adjustment usually involves establishing a standard products division.

Chip Set Suppliers

Chip set suppliers have done well in the PC arena by capitalizing on their systems-level expertise to consolidate a standard architecture. Although the time is not yet right for such a consolidation on the printer controller board, soon it will be. Chip set companies would do well to follow this market closely, looking for general acceptance of application-specific processors and then consolidating the support logic that surrounds them.

Table 5 summarizes Dataquest's recommendations for the various semiconductor supplier groups.

FINAL PREDICTION

Once this market matures and controller architecture becomes more stable, price pressure will force further consolidation. Dataquest believes that the chip count on the logic portion of the controller board will continue to decline. This will pit ASIC, chip set, and processor suppliers against one another as the controller approaches a one-chip implementation. Winners in this battle will possess strength not only in microprocessor design but also in system design and low-cost manufacturing.

Jonathan Drazin
Sarah Weeks
Kevin Landis

TABLE 5
Recommendations

Supplier Group	Key Issues	Recommendations
Memory Suppliers	Price, availability	Emphasize good communications; JIT delivery
Microprocessor	System performance, chip count	Develop application-specific compute engine; offer broad price/performance range
ASIC	Increasing integration, consolidation	Develop application-specific cores; evolve into standard chip set products
Chip Set	System expertise, stability of architecture	Follow market closely; enter when architecture stabilizes

Source: Dataquest
March 1990

APPENDIX—GLOSSARY OF TERMS

Semiconductor Industry Abbreviations

ASIC	application-specific integrated circuit
ASSP	application-specific standard product
BITBLT	bit-block transfer
DRAM	dynamic RAM
FIFO	first in first out
FPU	floating-point unit RAM
JIT	just-in-time
MPU	microprocessor unit
RAM	random access memory
RIP	raster image processor
ROM	read-only memory
SCSI	small computer systems interface
UART	universal asynchronous receiver transmitter

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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 kbit/s, less than one-quarter of the 64-kbit/s 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.

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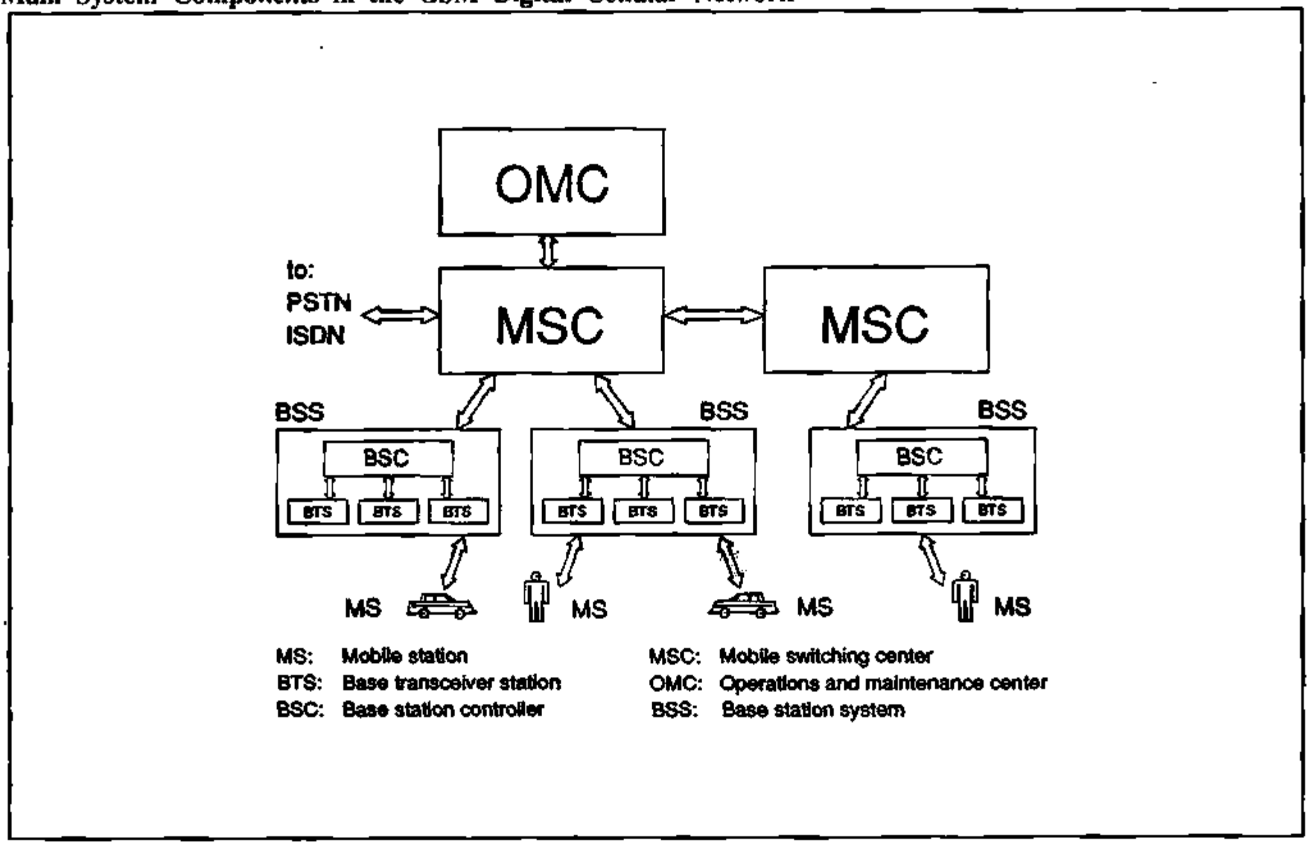
Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398 / (408) 437-8000 / Telex 171973 / Fax (408) 437-0292

FIGURE 1
Main System Components in the GSM Digital Cellular Network



Source: Dataquest
March 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.

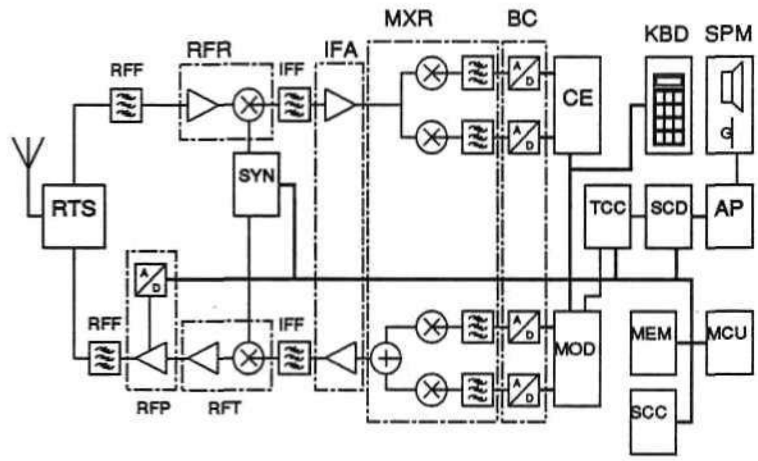
INSIDE THE GSM TELEPHONE

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, since 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, there will be few standard parts 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



RTS:	Receive/transmit switch	CE:	Channel equaliser
RFR:	Receive amplifier/mixer	MOD:	GMSK modulator
RFT:	Transmit amplifier mixer	TCC:	TDMA channel coder/decoder
RFP:	Transmit power amplifier	SCD:	Speech coder/decoder
RFF:	RF bandpass filters	AP:	Audio processor
SYN:	Frequency synthesizer	KBD:	Keyboard / LCD controller
IFF:	IF bandpass filters	SPM:	Speaker / microphone
IFA:	IF amplifiers	MCU:	16-bit microcontroller
MXR:	IF and IQ mixers / low pass filters	SCC:	Smart card controller
BC:	Baseband D/A and A/D converters	MEM:	Non-volatile memory (EEPROM)

Source: Dataquest
March 1990

yield but, 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 kbit/s per voice channel. However, there is provision to provide for a 6.5-kbit/s option in the near future, with the effect of doubling the cell capacity from approximately 200 callers per cell, for 13-kbit/s codecs, to 400 callers per cell for 6.5-kbit/s.

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 Non-Semiconductor Content		$39.00
Total Component Content		$190.50
Average Selling Price		$2,149.00
Semiconductor I/O Ratio		7.0%

Source: Dataquest
March 1990

WHAT PRICE GSM INITIALLY?

Table 1 costs 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 prices paid for handsets today in regions like France, Scandinavia and West Germany will reduce towards 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) 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 (see below).

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.

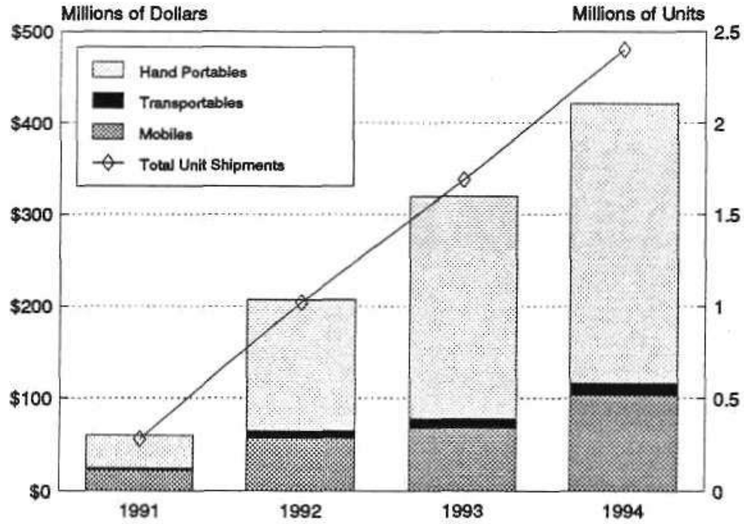
We forecast total semiconductor sales for GSM handsets in 1991 to be $60 million, rising sharply to $207 million by 1992, through to $421 million by 1994, representing a 190 percent CAGR over the 1991 to 1994 period. Of this revenue, we estimate that approximately 60 percent will consist of CMOS logic, 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

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



Source: Dataquest
March 1990

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 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.

Jonathan Drazin

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Research Newsletter

SIEMENS ACQUIRES NIXDORF'S COMPUTER ACTIVITIES

Siemens AG officially announced on January 10, 1990, that it has decided to acquire Nixdorf Computer AG and intends to merge the computer activities of the two companies into a new company that will be called Siemens-Nixdorf Informationssysteme AG. Pending government approval, Siemens initially will acquire 51 percent of Nixdorf Computer's voting shares, which is equal to roughly one-quarter of its overall market capital. The new entity, which will be a subsidiary of Siemens AG, will have the equivalent of DM 12 billion in annual sales (combined worldwide sales of Siemens and Nixdorf are about DM 68 billion). This is roughly twice Nixdorf's worldwide sales of DM 5.6 billion. The West German Cartel Office will review the planned merger, and a final decision is expected within four months.

OVERVIEW: A PC PERSPECTIVE

Although neither company is in the "top 10" list of PC manufacturers Europe-wide, both are very well known in their local market, especially within the business sector. Unlike other recent mergers, there are not so many geographical synergies between the two companies. Instead, there is a potential for strengthening their local position (possibly becoming number two in the West German business market) and preparing for whatever opportunities Eastern Germany, Eastern Europe, and the USSR have to offer.

The probabilities for making the merger work are good because both companies share a number of similarities that will help them understand each other. In addition to the obvious fact that both companies are German, they both came into PCs from the mini/mainframe world with third-party-sourced products. Realizing the strategic importance of PCs, they moved toward designing and in-house manufacturing of their own products. Both also began with a direct sales force selling primarily into their own existing client base but then became active in developing dealer channel strategies and targeting the open market. In addition, they share a common focus on the upper end of the business market and have no interest in the home sector or in mass merchandising.

Siemens is generally recognized as one of the strongest vendors of high-end PCs in the West German business market, with a wide range of laptop, desktop, and industrial models. The company's shipment figures for West Germany rose from 21,500 PCs in 1987 (4.9 percent of the business market) to an estimated 50,000 in 1989 (5.6 percent of the business market). Practically all of Siemens' PCs are now manufactured by the company in its Augsburg, West Germany, production facility.

Nixdorf's PC activities began several years ago, but volumes have remained low and the company, although it had the potential, never succeeded in establishing itself as a leading vendor on the West German PC market. This was probably due to an overconcentration on its midrange systems. Then in 1988 and 1989, the company began expanding its product line, broadening its range of target customers, and shifting from third-party sourcing to in-house manufacturing. Although Nixdorf has manufacturing capabilities in Paderborn, West Germany, a significant proportion of PC production has been done in the company's Singapore-based plants.

DATAQUEST ANALYSIS

The takeover will provide greater critical mass across the range of computing platforms and provide access to a larger combined set of major accounts. The new company will benefit not only from Siemens' financial strengths but also from its

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TABLE 1
West Germany Business Market Shipments (Units)

	1987	1988	1989 (est.)
Siemens	21,500	34,450	50,000
Nixdorf	13,200	24,650	39,500
S-N I AG	34,700	59,100	89,500
Total Business Market	439,759	684,741	895,135
Siemens-Nixdorf Percent of Business Market	7.9%	8.6%	10.0%

Source: Dataquest Europe S.A.
February 1990

components know-how in microprocessors and memory devices.

From a PC point of view, this will not result in a significant increase in geographic coverage, nor will it create a top contender in Europe's PC market. However, the merging of resources does create in West Germany an entity that will be able to command 10 percent of the PC business market (see Table 1) and possibly become the future number two player.

Given the current developments in East Germany and Eastern Europe, as well as Siemens' recent business prospects with the USSR, Siemens-Nixdorf Informationssysteme AG is well positioned to monitor and take advantage of whatever opportunities develop in the East. From a PC perspective, there may be a better return on investment from strengthening its position in West Germany and preparing itself for potential Eastern European markets than from trying to force itself into and develop market share in the rest of Western Europe.

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Jennifer Berg
Kees Dobbelaar

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Research Newsletter

SIEMENS AG INTENDS TO ACQUIRE "MAJORITY" OF NIXDORF COMPUTER AG

Nixdorf Computer AG and Siemens AG officially announced on Wednesday, January 10, that Siemens intends to acquire 51 percent of Nixdorf's capital, pending the West German Cartel Office's approval. (The Cartel Office's final decision is expected within four months.) The financial value of the transaction has not been disclosed. Common shares were acquired from the Nixdorf family, which previously controlled all the voting shares. Nixdorf said that nonvoting preferred shares listed in German exchanges will not be affected by the merger.

The new company, a majority-owned subsidiary of Siemens called Siemens-Nixdorf Information Systems AG, would combine the Siemens data and information systems activities with those of Nixdorf. Annual sales of the company would be DM 12.0 billion (US$7.15 billion), which contrasts with Nixdorf's current worldwide sales of DM 5.6 billion (US$3.34 billion).

Nixdorf stated that "given the relatively few overlapping lines of business, a merger opens up good business opportunities and favorable synergistic aspects."

DATAQUEST ANALYSIS

The move clearly places into context the difficulties faced by Nixdorf. Despite repeated claims from Paderborn, West Germany, where Nixdorf is located, that the company intended to remain independent, Nixdorf has had to accept the inevitable in the face of very poor results anticipated for 1989.

From Siemens' point of view, the merged company would have greater critical mass in the computer and midrange markets and would have access to both Siemens' and Nixdorf's large accounts. In addition, the components division of Siemens most likely would have a guaranteed customer for memory and microprocessor devices. This will be important in 1990 and beyond, as the semiconductor industry looks set for a recession.

Traditionally, Siemens and Nixdorf have not addressed identical market segments. In the cases where there have been overlaps, they usually have involved complementary product lines. The new company will benefit from strength in the mainframe business (number two in Europe, with a 15 percent market share from the BS 2000 Siemens range) and the midrange where it would have a combined share of 10 percent of the work group, small department, and large department computer categories. Its share of the PC business remains low. Although Dataquest anticipates that the new company will not aim to be a leader in the mass market for PCs, the provision of PCs as part of its distributed product offering within a client-server environment will be a key challenge for the company in the 1990s.

The new company clearly will benefit from the huge financial resources of Siemens and will gain access to technology in the high-end computer market, as well as in the areas of telecommunications and semiconductors.

In addition, the new company will find a degree of synergy in its geographic coverage. Nixdorf has considerable strength in Spain, for example, although both companies are relatively weak in Northern Europe. However, the merger may not be sufficient to gain international positions outside its traditional markets. In particular, the new company would still be virtually absent from the United States.

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WILL THE OPERATION BE A SUCCESS?

It is, of course, far too early to be categorical about this question. Indeed, several formalities still remain to be undertaken before the company can be formed. It does appear, however, that a large amount of synergy could be gained from the acquisition.

On a worldwide scale, the company would be positioned firmly within the top 10 manufacturers in the world and would be vying with Bull and Olivetti to be the top Europe-based supplier.

To reiterate, the company would face the following two key challenges in the 1990s:

- The lack of U.S. market share
- The development and implementation of a unified strategy incorporating mainframes, UNIX minicomputers, and PCs

On a final note, although the new entity will be a clear second in Germany behind IBM, its share in the very volatile computer market should not justify a negative decision from the Cartel Office.

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Research Newsletter

CONTINUED VITALITY OF THE ITALIAN ECONOMY

SUMMARY

Italy's economic performance in the last decade was the best of the big four European countries. Growth in 1989 was buoyant at 3.3 percent and is expected to show rates of 3.2 percent in 1990 and 3 percent in 1991. This year started well in 1989 with total domestic demand continuing to expand rapidly, boosted by productive investment. Domestic demand was bouyant and production picked up during the year.

This newsletter presents an overview of Italy's economic prospects and highlights the political and technological factors contributing to them.

ECONOMIC PROSPECTS

The Italian economy has had the highest average growth rate of the big four European economies during the past decade. Of the big four, only West Germany is forecast to have a slightly higher growth rate in 1991.

Investment in machinery and equipment increased by 8.6 percent in 1989. Favorable demand prospects and high-capacity utilization should stimulate the growth of productive investment further. But growth rates for 1990 and 1991 will be lower at 5.2 percent and 4.9 percent respectively. Profitability has been affected by the increase in wage costs. Lower profits are the main cause for the reduced expansion of investment in 1990 and 1991.

Italy's unemployment rate is by far the highest among the big four at 12 percent in 1989. It is expected to increase slightly to 12.2 percent in 1990 and 12.3 percent in 1991. In OECD Europe only Ireland and Spain have higher unemployment rates. Unemployment in northern Italy, however, affects only about 6 percent of the workforce, while the rate in the south has risen to just over 21 percent.

Consumer spending remained strong in 1989 and should continue to grow in line with increased disposable income due to upward trends in private and public-sector wages. Italian consumers continue to save more of their disposable income than any other nation in the world, including the Japanese. In 1988 they saved 23 percent of their disposable income, compared with 4 percent in the United States, 15 percent in Japan and 13 percent in West Germany.

Italy's export performance is still heavily dependent on traditional sectors such as textiles and clothing, leather products and consumer goods of modest technological content. Overall, Italy's manufacturing industry has managed to hold its share of world trade at around 5.5 to 5.9 percent during the past decade. But, since Italy is less specialized in high-tech products, this position could come under pressure from the changing nature of world demand.

The current account of the balance of payments will continue to record a deficit, which is forecast to increase from $12 billion in 1989 to $14 billion in 1991, around 1.5 percent of GDP. Exports of goods and services, which grew by 8.7 percent in 1989, will continue to increase but at a lower rate of about 5 percent in 1990. The expected growth in markets for manufactured goods should boost Italian exports, but market shares may continue to be lost because of worsening competitiveness. Import growth will be stronger than export growth at 5.8 percent per annum in 1990 and 1991.

The pattern of Italian trade has changed during the last decade. Trade with the U.S. and OPEC markets has declined, while trade with the EC has increased. Trade with both France and West Germany is twice as important as U.S. trade.

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Competitiveness

The most dynamic and flexible sector of the Italian economy is the small and medium-size enterprise. Close to 60 percent of all employment is provided by companies with less than 100 employees. This compares with 25 percent in France and under 20 percent in West Germany and the United Kingdom. This very competitive sector accounts for 25 percent of total Italian manufacturing exports.

Italian industry, especially small and medium-size firms, is affected by the poor infrastructure, that is, slow installation of telephones and telex, neglected railways and ports, erratic postal services and power cuts. But strikes have diminished and industrial relations have improved in the 1980s. This reflects partly the growing fear of unemployment and partly the decline in union membership. Absenteeism, once a major problem for the Italian industry, is less pronounced. In many sectors of the Italian economy productivity has improved significantly, but between 1979 and 1988 labor productivity in the business sector increased only 1.6 percent in Italy compared with 2.6 percent in the United Kingdom, 2.4 percent in France and 1.9 percent in West Germany.

Unit labor costs in the business sector increased strongly in 1989 by 5.7 percent and are expected to increase by over 4 percent per annum in 1990 and 1991. This rate is more than double the projected growth rate in France and West Germany but lower than the expected increase in U.K. unit labor costs. Italian employers are concerned not only about the level of wages but also by the high social security payments. An Italian worker costs the employer three times his/her wage.

If the present trends of average annual wage increases of 8 percent continue, then the inflation rate will stay at the present level of over 6 percent. This rate is lower than U.K. inflation but more than double the French and German rates. The Italian government has set an inflation target of 4.5 percent in 1990 but this is generally regarded as overoptimistic.

Italy's competitiveness position is also adversely affected by high taxes and high interest rates which are second only to those in the United Kingdom.

Government Policies

In the last decade the Italian public sector deficit climbed from 8 percent of GDP in 1980 to 13.7 percent in 1985. Since then it has decreased; in 1989 it was down to about 11 percent of GDP. For 1990, the Italian government aims at a budget deficit of L 133,000 billion or 10.4 percent of GDP. But because of high health and welfare spending the actual deficit could be between L 137,000 billion and L 145,000 billion.

A very large proportion of the deficit is caused by the interest payments on the huge public debt of L 1,000 trillion. These interest payments have risen to 8.5 percent of GDP. The debt/GDP ratio is expected to reach 106 percent by 1992.

The Italian government is planning to cut industrial aid by around L 2,500 billion in the 1990 budget in line with EC policy, which considers state aid unfair.

In the 1990s, the Italian government will find it more difficult to finance its budget deficit and increasing debt. So far, 96 percent of the public debt has been financed domestically because of the high personal savings ratio. Capital outflows remain a real prospective danger if Italian investors lose confidence in the government's determination to halt the spiral in public debt. With the abolition of exchange controls in the single European market, the Italian government will lose its grip on domestic savings.

The Italian government is considering the privatization of a limited number of state assets to help finance the public-sector debt, but there are no wide-ranging privatization plans.

Technological Resources

Italian industry is preparing technologically, financially and commercially for the challenge of the single European market. There are plans to merge Italy's three telephone operating companies into a single operation aimed at raising the range and quality of telecom services to the European level.

The alliance between AT&T and Italtel, the Italian state-owned telecom equipment maker, is the most significant event of the past decade in the Italian telecom sector. This alliance will provide new technologies and products needed to modernize the country's poor-quality telephone system.

Italian industry has been very dynamic in its use of technology, but it has mostly been imported from abroad. Some of Italy's major corporations have gained access to technology through mergers or joint ventures.

SGS-Thomson, an example of a high technology merger, is Europe's second biggest chip maker with worldwide revenue in 1989 of $1,301 million. The merger has been successful; the overlap between the two companies has been reduced and profitability achieved. In spring 1989, SGS-Thomson acquired Inmos in the United Kingdom. The joint company has maintained a level of R&D spending above the industry average, 20 percent of turnover against an industry average of 13 percent.

Italy's manufacturing industry has not been penetrated by foreign investment to the same extent as in other leading West European countries. But it is benefiting from technology transfers carried out by multinational companies. Foreign participation or control accounts for 59 percent of employment in information technology and 29 percent in electronics and telecoms.

Sony of Japan opened its first manufacturing plant in Italy in spring 1989 to expand its production facilities in Europe. The plant produces cassette tapes, 80 percent of them for export. Sony claims roughly 10 percent of the Italian consumer electronics market, taking second place after Philips.

AT&T switched its 22.2 percent stake in Olivetti for an 18.6 percent stake in De Benedetti's holding company, CIR. Olivetti has experienced growing Asian competition in hardware and tougher U.S. competition in software. This has led to restructuring of the company with the aim of regaining market share in Europe's office automation and computer markets.

Pirelli is creating a science park in Milan with the objective of bringing together universities, state research bodies and private industry. Companies are being encouraged to set up their research and administration offices in the science park.

DATAQUEST ANALYSIS

The highly entrepreneurial small business sector—export-oriented, flexible and hard-working—has contributed considerably to Italy's impressive economic performance in the 1980s. Italy has to launch a new phase of economic development in the south of the country. More industrial investment is needed to provide the basis for economic and employment growth in that area.

The Italian government has to continue its fight against inflation. The inflation differential between Italy and its main European trading partners, France and West Germany, remains too high. A strict incomes policy in the public and private sector is needed to maintain the country's competitiveness.

The government budget should be a tool for national development. Major spending items have to be analysed for their impact on economic efficiency, productivity and growth.

More privatization and industrial competition, and more market-oriented solutions to the country's financial problems are necessary to strengthen the private sector. The Italian economy needs a more decisive response from the political system to help reduce its structural disadvantages.

Italy's R&D spending is the lowest among the main industrial countries at 1.5 percent of GDP. The government, together with the private sector, has to decide how to improve Italy's R&D record.

In the engineering sector the technological content in many products is comparatively low in spite of success with robotized systems. This means Italy sells to developing countries and Eastern Europe and buys high-tech products from its EC partners.

The single European market will provide opportunities for Italy, but the Italian economy can no longer shelter behind protective barriers.

If Italian companies are to prosper in the 1990s they must solve the problem of how to combine global economies of scale with local-market knowledge and service.

European Corporate Research

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Research Newsletter

VISUAL EVOLUTION AT ELECTRONICS SHOW

SUMMARY

The 1989 Electronics Show, sponsored by the Electronic Industries Association of Japan (EIAJ), was held in Osaka in October and reflected the current interest in the consumer electronics market. Participants included 466 companies and organizations from 19 countries. The five-day show attracted approximately 255,000 visitors, with a notable increase in attendees from the Newly Industrialized Economies (NIEs).

NEW VISUAL PRODUCTS

Many companies exhibited new products related to high-grade visual equipment, including large-screen TV, projection displays, and extended-definition television (EDTV). The advanced S-VHS VCRs, which are rapidly becoming popular, were demonstrated through the use of videocassettes and received a great deal of attention from the attending public. Table 1 indicates the Japanese companies that presented new or existing consumer products at the show.

Extended-Definition TV

Of the state-of-the-art consumer electronic products that were displayed, EDTV attracted the most attention. EDTV broadcasting service started on August 24, 1989, in Japan. The new Japanese EDTV system enables existing TV systems to receive ghost-free broadcasts. The EDTV manufacturers actively promoted their products at the Osaka

TABLE 1
Japanese Participants in Visual Equipment Markets

Company	Color TV	Liquid Crystal TV	Satellite Broadcast Receiver	Portable VTR	Camcorder	Digital Audio Tape Recorder	TV Phone
Casio		*		*		*	
Citizen		*					
Fujitsu	*		*	*	*	*	
Hitachi	*	*	*	*	*	*	*
JVC	*	*	*	*	*	*	
Matsushita	*	*	*	*	*	*	*
Mitsubishi	*		*	*	*	*	*
NEC	*	*	*	*	*	*	*
Pioneer	*		*			*	
Sanyo	*	*	*	*	*	*	*
Sony	*	*	*	*	*	*	*
Toshiba	*	*	*		*	*	*

Source: Dataquest
January 1990

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show, because it was the first large-scale exhibition held since the new broadcasting service began. Table 2 summarizes the major features of the EDTV sets displayed by major suppliers.

DATAQUEST CONCLUSIONS

In the Japanese color television market, there is an increasing demand for television sets with high-quality pictures and larger screens. These preferences reflect the Japanese consumers' regard for high-grade durable goods. With the rapid shift of purchasing trends from "anything available" to "something of value," it is natural to see a strong demand for color TV sets with higher qualities. This aim for the best available product is also observed in other consumer electronic equipment.

With this favorable environment, TV manufacturers expect the EDTV broadcasting service to stimulate the current sluggish demand for TV sets. However, prices for the EDTV sets are more than ¥100,000 higher than prices of ordinary sets; we believe that a price reduction is needed before EDTV gains wide consumer acceptance.

The Broadcasting Technology Association (BTA) has begun development of second-generation EDTV, which is expected to be available in the next six to seven years. The second-generation products are expected to have higher-quality pictures and screens with 9:16 aspect ratios—the same as the high-definition TV currently under development.

In order to move EDTV into a major market, we expect television manufacturers to step up promotional measures, including advertising, software improvements, and price reductions.

Jonathan Drazin
Hideaki Nemoto

TABLE 2
EDTV Comparison

Company	Size (Inches)	Product Code	Price (Yen)	Vertical Resolution	Horizontal Resolution	Connector for Ghost Free	Merits/Technology
Fujitsu	29	BS-29D35	410,000	450	—	X	Broadcasting satellite, built-in type
	32	BS-32D35	480,000	450	—	X	Broadcasting satellite, built-in type
	32	32V-D35	430,000	450	—	X	Audio-visual surrounding type
Hitachi	33	C33-ED1	408,000	450	—	X	High-capacity digital circuits Lower price
Matsushita	29	TH-29XD1	360,000	450	600	—	Three-dimension filter
	67	VIP70	4,500,000	450	650	—	Electronic conference use
NEC	29	C-29ED1	368,000	450	560	X	
	29	C-29ED2	398,000	450	750	X	Ghost-free tuner (GCT-1000/ ¥250,000) Scan converter (NSC-2100/ ¥480,000)
Sanyo	32	C-32ED1	460,000	450	—	X	Field memories and line memories
Sharp	33	33C-ED1	465,000	450	—	X	—
Sony	29	KV-29ED1	369,000	450	—	—	—
	45	KX-45ED1	2,430,000	450	—	—	OEM production (monitor type)
	45	KX-45ED1T	2,520,000	450	—	—	OEM production (tuner built-in type)
Toshiba	34	34ED1A(N)	468,000	450	—	X	Ghost-free TV tuner (TT-GC9/ ¥109,000)

Source: Dataquest
January 1990

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Research Newsletter

EUROPEAN DEFENSE ELECTRONICS: 1992 AND BEYOND

SUMMARY

Given the general relaxation of military tensions, progress in arms talks, and tightening fiscal constraints, Western European governments are focusing defense resources increasingly on quantitatively smaller but qualitatively more capable forces. This trend emphasizes procurement of electronics and, therefore, semiconductors for new weapon systems, modernization and upgrading of existing systems, and the development of force multipliers such as improved command, control, communications, and intelligence (C3I) systems.

THE MARKET

The determination of the members of the European Community (EC) to integrate Western European markets in 1992 may pose a significant new challenge to non-European defense electronics companies that are seeking contracts abroad. European officials deny any protectionist intent, yet there is considerable concern that outside businesses may be subject to protectionist barriers in various forms—for example, import quotas or local content requirements. Although defense items ostensibly are to be excluded from EC regulations, members have pushed for tariffs on dual-use technologies because of their civilian applications. Because the majority of U.S. defense exports to EC nations are system components, such tariffs could have significant impact on the trade relationship.

The year 1992 will be less a market watershed than a continuation of an ongoing process of integration in Europe. Taking a cue from the success of other pan-European ventures such as Ariane-Space and Airbus industries, the Independent European Program Group (IEPG) has sought to develop a European-wide defense procurement system. European avionics and electronics industries are currently undergoing major restructuring that will probably result in more concentrated groupings in areas such as flight controls, optical systems, and sensors. The GEC/Siemens takeover of Plessey is the most recent example of this concentration. The real effect of the 1992 phenomenon will be the more effective competition from rationalized European industries made possible by integrated economies.

One continuing area of dispute for U.S. and European companies is technology security. European and U.S. government views on the export of high-technology items always have differed, with the United States favoring tighter restraints and political controls over transfers. U.S. restrictions on technology transfers to third-world countries will continue to dampen American exports. Moreover, the relationship between the regulations of the 17-member Coordinating Committee on Multilateral Export Controls (COCOM) regarding restricted technologies and trade relationships involving EC members that are not part of COCOM is not clear.

MARKET OUTLOOK

The outlook for defense spending in the major European countries is not much different than that in the United States. Fiscal and political pressures in every nation are leading to real declines in defense expenditure or, at best, level budgets in real terms. Popular support for defense spending is eroding rapidly in many European states; the erosion is being fed by continuing improvements in East/West relations, increasing environmental concerns, and tighter budgetary constraints overall. Rapid progress in the Vienna talks on conventional forces in Europe could produce an arms-control agreement by the middle of the next decade that will require NATO governments to reduce their ground and air forces by up to 20 percent in some weapons categories.

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These factors threaten the initiation of new development programs as well as the continuation of several high-profile procurement programs that already are under way. As a result, many European governments are looking for means to upgrade existing systems with new electronics rather than procure new weapons. Belgium's decision in May 1989 to reduce defense spending is a case in point, as it dashed previous hopes for Belgian purchases of the European Fighter Aircraft (EFA), the French Rafale, or the Agile Falcon F-16 planned to be developed by the United States and certain European countries.

Traditionally, a strong component of European-produced defense electronics has been exports to the Middle East; however, demand for systems has slowed substantially as the war between Iran and Iraq has subsided and oil-based economies struggle with continuing lower prices of that commodity.

Figures 1 and 2 present Dataquest's forecast of military electronics production and derived semiconductor consumption. We expect electronic equipment production to grow 3.3 percent in 1990 and accompanying semiconductor consumption to grow 5.6 percent.

MAJOR PROGRAMS

Figure 3 presents the estimated total development and production spending and the accompanying electronics content of some of the important, electronics-intensive, Western European defense programs.

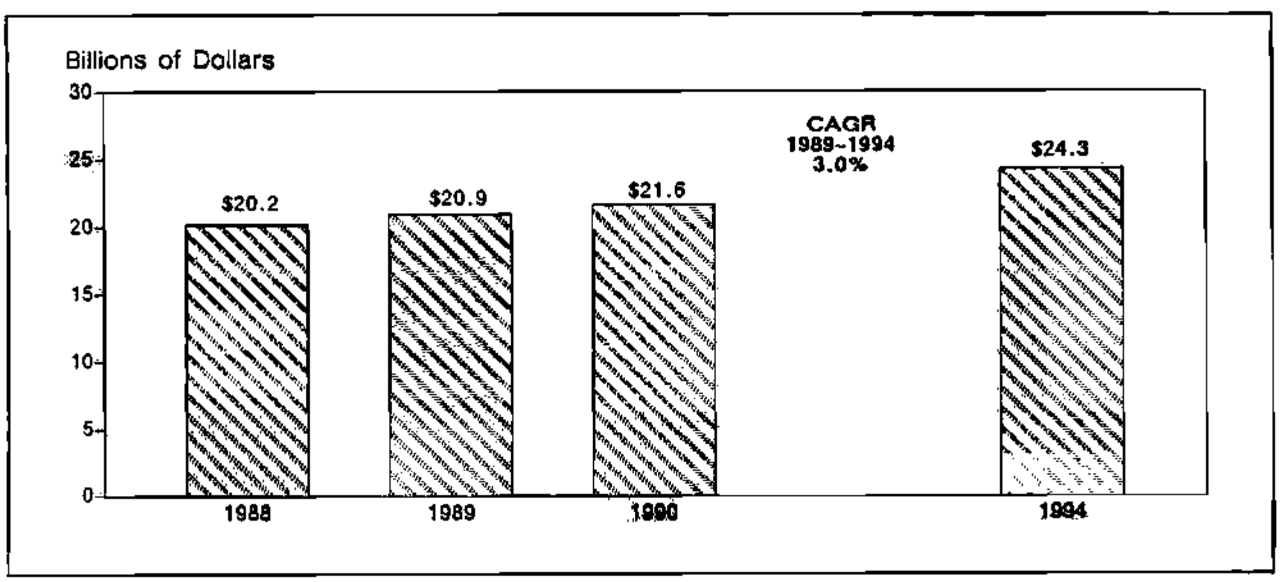
Rafale Aircraft

France dropped out of the EFA program in 1986 to pursue its own new fighter aircraft, the Rafale. Among other things, the Rafale will be armed with an antiradar missile and laser-guided missiles, as well as the MICA and Magic 2 air-to-air missiles. The Rafale also will incorporate terrain-avoidance capability with track-while-scan radar and simultaneous ground attack/air defense scan modes.

A joint company, Avion de Combat European (ACE) International, has been established by the four primary Rafale contractors—Dassault-Breguet (60 percent), SNECMA (20 percent),. Thomson-CSF (10 percent), and Electronique Serge Dassault (ESD) (10 percent). Dassault-Breguet will build the airframe, and SNECMA will manufacture the M88 engine for the Rafale. The first prototype is expected to fly in 1991, and full-scale production is scheduled for 1994.

The radar will be based on Thomson's RBG (formerly RDX) multimode phased array radar. Thomson-CSF, with 66 percent of the work, will concentrate on the antenna and air-to-air operating modes; ESD will be responsible for ECCM and air-to-ground operating modes. The $318 million

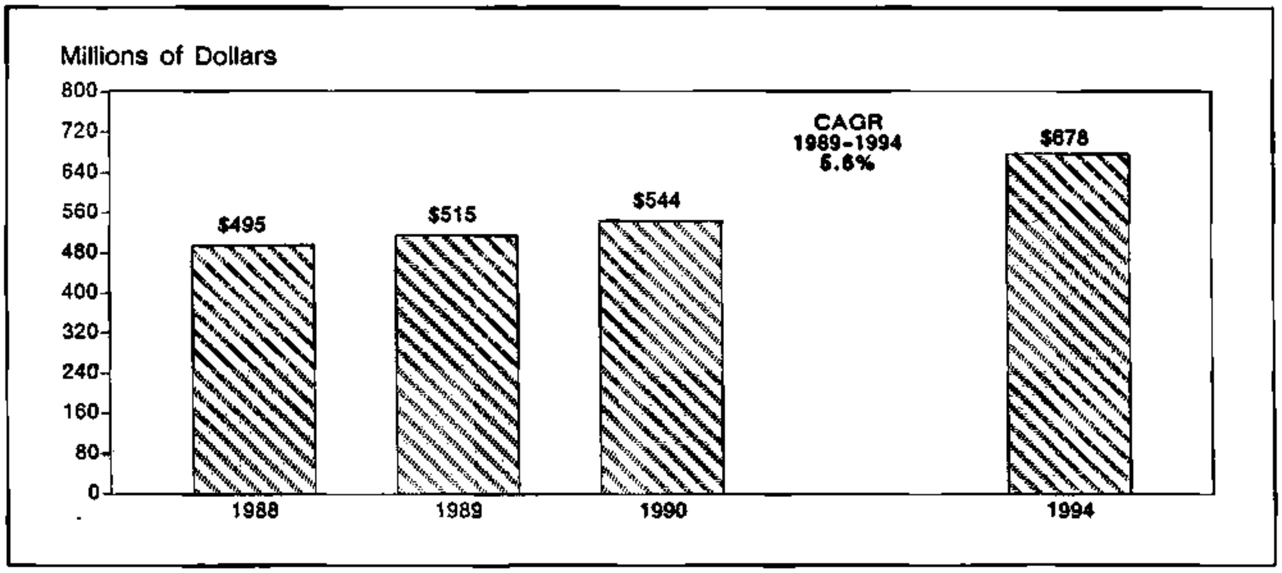
FIGURE 1
European Military Electronic Equipment Production



0005616-1

Source: Dataquest
November 1989

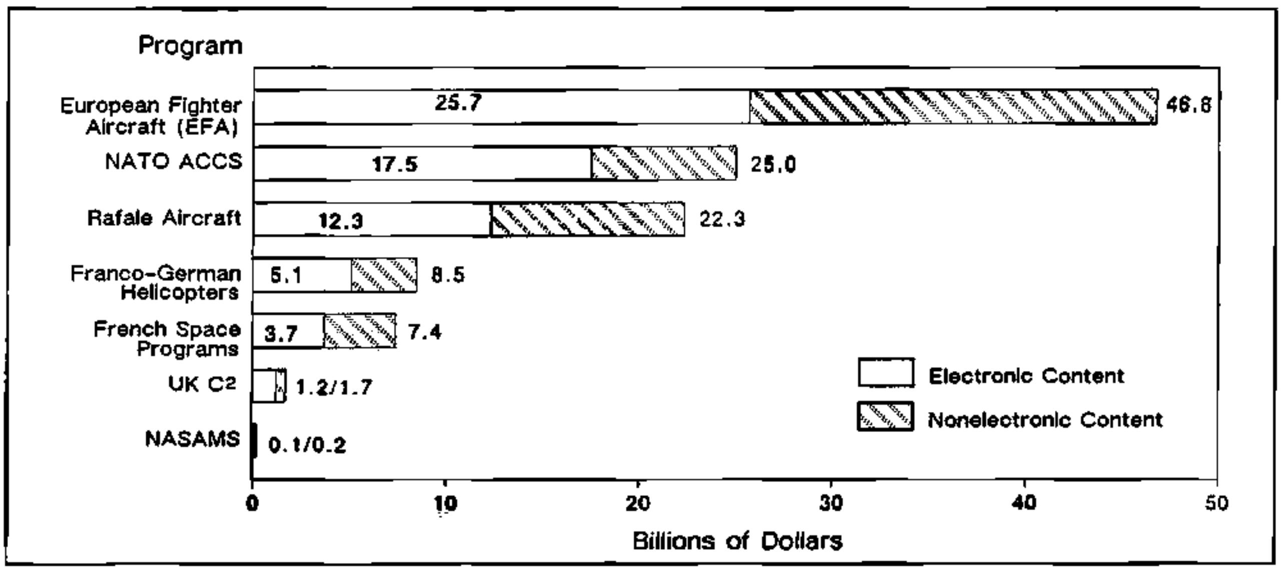
FIGURE 2
European Military Semiconductor Consumption



0005616-2

Source: Dataquest
November 1989

FIGURE 3
Important European Military Program Spending



0005616-3

Source: Defense Forecasts
Dataquest
November 1989

radar contract, which eventually could total approximately $1.6 billion, was awarded to Thomson and ESD in April 1989.

Space Programs

France has an active space program and will be expanding its military satellite program. In December 1988, Minister of Defense Jean-Pierre Chevenement revealed a 15-year military space program that would increase funding as well as European cooperative efforts. The plan calls for spending approximately $7.4 billion to add a radar-based reconnaissance satellite, a ground-based space surveillance system, and an electronic intelligence satellite to existing programs.

France is expected to contribute approximately $1.1 billion between 1987 and 1991 to two satellite programs developed jointly with Italy and Spain. The programs are the Helios military observation satellite and the Syracuse Communications Systems satellite. Another major program is the Telecom (I, II, and III) satellite.

Command and Control Systems

The Improved U.K. Air Defense Ground Environment C2 System (IUKADGE/ICCS) program is approximately five years behind schedule and $200 million over budget. Designed to link air- and ground-based radars and command centers for air defense of the United Kingdom, the largest obstacle for the IUKADGE has been software. Contractors have been using a mix of COBOL, FORTRAN, and RTL 2 programming languages. The total program cost is estimated to be approximately $1.7 billion; the prime contractor is UKADGE Systems Ltd., a consortium comprised of Hughes Aircraft, Marconi, and Plessey. More than 80 percent of the IUKADGE program is funded by NATO.

Norwegian Advanced Surface-to-Air Missile System (NASAMS)

The NASAMS will adapt the Hughes AIM-20 AMRAAM for surface-to-air use as part of the Norwegian southern air defense system upgrade. Beginning in 1991 or 1992, Norway hopes to replace Nike missile batteries with two full batteries of NASAMS. The six-year program will include a total of 18 launchers with 118 AMRAAM missiles; the three-phase contract is valued at $215 million.

The NASAMS fire unit will consist of a Hughes TPQ-36A 3-D low-altitude surveillance radar, a fire distribution center manufactured by Norsh Forrsvarsteknologi A/S (NFT) of Norway and three missile launcher subunits each with six missiles; a battery will consist of three fire units.

HKV, a joint venture of Hughes Aircraft and NFT, was awarded $13 million in early 1989 for a Phase I demonstration and evaluation of this surface-to-air application of the AMRAAM.

JOINT EUROPEAN PROGRAMS

European Fighter Aircraft (EFA)

The EFA is being developed jointly by the United Kingdom, West Germany, Italy, and Spain. A multirole fighter, the EFA will feature, among other things, fly-by-wire controls, stealth characteristics, composite materials, look-down-shoot-down radar, terrain-following capability, and multiple target acquisition systems.

Development work on the aircraft has been divided among the four members of the Eurofighter consortium, according to the proportion of planes each country plans to buy: British Aerospace, 33 percent; Messerschmitt-Boelkow-Blohm (MBB) of West Germany, 33 percent; Aeritalia of Italy 21 percent; and CASA of Spain, 13 percent. A four-country agreement was signed in May 1988 that authorized full-scale development of the EFA, with contracts signed in early 1989 for close to $8 billion. Production is scheduled to begin in 1995, with initial deployment in 1996, but this schedule is not likely to be met. The program calls for 765 aircraft to be produced through 2005, although more may be added later to accommodate foreign sales. Development costs for the EFA are estimated at $10.8 billion, with procurement costing another $36.0 billion.

Electronics manufacturers will be the main beneficiaries of the EFA program, as avionics systems are expected to account for at least one-half, and perhaps as much as 65 percent, of the total cost. Although most electronic subsystems still are in early conceptual stages, a four-country consortium has been formed to bid on design and production of the EFA's digital fly-by-wire flight control system: Aeritalia, Bodenseewerk Geratetechnik (West Germany), GEC Avionics (United Kingdom), and Inisel (Spain). A group led by FIAR of Italy also was formed to develop the infrared search and track system for the EFA. Other members of the group include Eltro of West Germany and Thorn-EMI of the United Kingdom.

Of the EFA's components, its multimode pulse-Doppler radar system requires the longest lead time in development and paces the development of other items. Two multinational industry teams—one led by Ferranti Defense Systems (United Kingdom) and the other by AEG (West Germany) and Marconi Defense Systems (United Kingdom), are bidding fiercely for the contract. Ferranti's proposal, the ECR-90, is based on radars developed for Sweden's JAS-39 Gripen program and in service with the United Kingdom's Royal Navy Harriers. The ECR-90 will use a high-power signal processor that incorporates Ericsson's 32-bit D80A chip. AEG's proposal, the MSD 2000, is based on Hughes' APG-65 radar.

The radar selection already is one year overdue and, accordingly, the delivery of the first 12 flyable preproduction radar units has slipped to November 1991. The entire radar program is expected to be worth approximately $1.8 billion. Work on radar development and production eventually will be divided among the four EFA participating countries using the same ratio as for the overall program.

PAH-2/HAC-3GT/HAP Franco-German Helicopter

France and West Germany are working together to develop and produce a new combat helicopter that will be fielded in the late 1990s. The constant dollar cost of the program is projected at $8.5 billion. Two versions of the helicopter are to be produced: one for antitank missions and one for escort and fire support.

Of the real procurement costs, $1.3 billion is earmarked for mission equipment packages, including navigation aids, observation equipment, weapon sights, fire control gear, and a mast-mounted avionics package. The main contractor for the mission equipment packages will be SOFRADIR, a French concern owned jointly by Thomson-CSF, SAT, and CEA Industries. French and West German subcontractors will be involved. In January 1989, three teams made bids for the avionics and mission management contracts, which are valued at more than $100 million: ESD and Litef of West Germany; Societe Francaise d'Instruments de Mesure (SFIM) and Bodenseewerk Geratetechnik; and a team made up of Crouzet (France), SFENA (France), Teldix (Bosch) (West Germany), and MBB's Dynamics Division (West Germany).

France and West Germany also will jointly develop infrared charge-coupled device (IRCCD) technology for the helicopter's optronic systems. The main contractor for the helicopter program as a whole is Eurocopter, a consortium of Aerospatiale (France) and MBB.

NATO Air Command and Control System (ACCS)

When deployed in the year 2000 (at the earliest), Dataquest believes that ACCS will integrate, process, and relay NATO air-defense tracking and targeting information, providing an automated command and control system to support all European air operations. We also expect data to be gathered into mobile, ground-based automated data processing systems and then channeled into a Combined Air Operations Center for dissemination. The ACCS consists of eight elements: AFATDS, ASAS, FAADC2I, CSSCS, MCS, MSE, and SINCGARS. ACCS funding should double from $4 billion in fiscal 1988 to $8 billion by fiscal 1992. ACCS will replace the existing NATO Air Defense Ground Environment system. Work is expected to begin in 1991 and last 18 years. France has indicated that it may participate.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Because of slowing growth of local defense spending and export markets, Western European defense electronics production growth is expected to remain in the 3 percent range. However, a selected set of modernization and upgrade opportunities remain for electronic OEMs and their semiconductor suppliers. 4.9%

In the spirit of 1992, defense program spending and risk are being shared increasingly among countries. Additionally, Dataquest believes that the consolidation of defense electronics OEMs is not over. The implication for semiconductor suppliers is that extensive local presence will be needed in multiple countries for each program in order to obtain and retain design wins. As OEMs continue consolidating, they will begin enjoying the benefits of economy of scale, including more purchasing leverage.

Jonathan Drazin
Greg Sheppard
Barry Blechman

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Research Newsletter

EUROPEAN SEMICONDUCTOR PROCUREMENT SURVEY

SUMMARY

Dataquest periodically conducts procurement surveys of the leading semiconductor purchasing locations in Europe. The information from these surveys is then analyzed to provide key industry indicators such as regional, product, and application forecasts and trends. This newsletter covers a number of important procurement trends within different market sectors and highlights major issues currently facing procurement executives and semiconductor marketing managers. Table 1 summarizes the results obtained in Dataquest's most recent survey.

THE MARKET SEGMENTS

Data Processing Segment

When asked to specify, in local currency terms, the percentage of increase in their semiconductor purchases from 1988 to 1989, the majority of respondents indicated a range between 25 and 60 percent. For 1989 to 1990, the growth expectation varies from 0 to 5 percent. The decline in growth rate stems first from a decline in the average selling price of MOS memory products and second from an increase in inventory levels within the PC sector. Most of the large users, especially those concentrating on PC production, indicated that their actual inventory levels were five to six weeks higher than their targeted inventory levels. The major culprit causing this excess inventory level is memory, which represents more than 50 percent of these companies' semiconductor purchases in dollar terms. No new large orders have been placed for DRAMs over the last few months, and our analysis indicates that many buyers are hedging for the best prices before they place more DRAM orders. Very little double ordering is occurring because most buyers are not rescheduling their delivery dates. The market for PCs grew by more

TABLE 1
European Procurement Survey Key Results

Segment	Target Inventory Levels	Semiconductor Spending 1989-1988	Semiconductor Spending 1990-1989	Key Concerns
Data Processing	5-6 weeks over	+25%-60%	0%-5%	Memory inventories and prices
Communications	2 weeks over	+10%-15%	5%-10%	Increased complexity of ASICs memory prices
Transportation	2-3 weeks under	+5%-10%	+10%	Discrete, opto
Industrial	3 weeks over	5%-10%	Flat	On-time delivery, distribution shakeup
Military	OK	20%	5%	Reduction of military memory suppliers
Consumer	High	10%	Negative	Slowdown in consumer spending

Source: Dataquest
October 1989

ESAM Volume II, Newsletters 1989-22
0005330

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than 50 percent in the first half of 1989. The inventory build-up is due to suppliers catching up on long-term agreed contract delivery dates and prices. We expect inventories to be used up by the fourth quarter of 1989.

One sign of major concern facing this sector is that most Japanese vendors are cutting back on 1Mb DRAM capacity in favor of 256K SRAMs and 4Mb DRAMs. This situation could cause some hiccups in supply of 1Mb DRAMs, especially when 4Mb DRAMs become widely available in 1990.

Communications Segment

The major central office equipment manufacturers indicated a growth of 10 to 15 percent in semiconductor purchases in 1989 over 1988. However, this growth is expected to decline to 5 to 10 percent in 1990. This segment is also a very large user of ASIC devices. Dataquest believes that full-custom ASICs will still dominate over standard cell and gate array devices in terms of purchasing dollars spent in 1990.

The next biggest expenditure should be for memories, followed by microcontrollers. Inventory levels in these products are two weeks over targeted levels and are expected to remain the same in the near future. The datacommunication sector showed some signs of weakness, with some buyers indicating very little growth in 1989 over 1988 and a minimal increase of 5 percent in 1990.

Issues that caused procurement managers in the telecommunications sector most concern were pricing, on-time delivery, and quality of incoming goods—ranked in that order.

Transportation Segment

Most survey respondents indicated that they are two to three weeks below their targeted inventory levels of three to four weeks holdings. The majority of them participate in just-in-time programs with their key vendors. Comparatively speaking, they spend a large portion of their purchasing dollars on discrete and optoelectronics products, followed by linear devices and microcontrollers. Exceptionally, most buyers indicated that they were budgeting for a 10 percent growth in 1990 in contrast to other segments that indicated a gradual slowdown in semiconductor purchase dollars. This growth is being driven specifically by the greater use of electronic systems and components in the mass market range of automobiles.

Major issues ranked by transportation buyers were on-time delivery, pricing, quality, and accurate forecasting of demand. Interestingly, a number of buyers intimated that they relied upon making up to 5 percent of their purchases via distributors in order to make up for shortfalls in delivered quantities from major vendors.

Industrial Segment

As in the transportation segment, discrete and optoelectronic devices enjoy a relatively high proportion of the total semiconductor expenditure in the industrial segment. These devices make up more than 50 percent of the purchased devices in dollars, followed by linear, memory, and standard logic. Most respondents indicated that between 20 and 35 percent of their purchases were via franchised distributors. Despite this fact, most of the microcontrollers and ASICs are purchased directly from semiconductor vendors.

Inventory levels in this segment are three weeks over targeted levels. Overall, industrial segment buyers anticipate that their 1990 spending will be flat compared with 1989 despite buoyant market conditions in the test, instrumentation, and medical markets.

Military Segment

Most military buyers indicated a slowdown in their purchasing power in 1990, with some stating a positive 20 percent growth in 1989 over 1988. Inventory levels do not seem to be a major problem because of the availability of standard parts from distributor shelves and the long lead times required for some military parts.

Major concerns are the shrinking base of military high-density memory suppliers and the switch from bipolar to CMOS devices. A large percentage of dollars is spent on memory products, followed by ASICs, linear, microcomponents, and standard logic. A number of respondents intimated that a high proportion of their memory spending is taken up by specialized hybrid configurations. Among their ASIC expenditures, 80 percent were in the PLD segment, with standard cells becoming more popular.

Consumer Segment

Within the consumer segment, procurement executives indicated concern about the overall economic situation. Most economists are forecasting a reduction in GNP during the first half of 1990. In the United Kingdom in particular, high interest rates have affected the amount of disposable income in circulation, leading to a reduction in order intake. Inventory levels at present are high, and total spending in 1990 could be reduced by up to 10 percent over 1989. Key concerns in this sector were just-in-time, quality, and pricing.

DATAQUEST CONCLUSIONS

Dataquest's overall analysis shows that it will take time for excess inventory to be used up, resulting in slow growth in 1990. We believe that the brightest sectors will be transportation, telecommunications, and industrial; the data processing, military, and consumer segments will show some decline.

Bipin Parmar

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Research Newsletter

ESAM Code: Volume II, Newsletters
1989-20
0005082

PRINTER MANUFACTURING SCENE TRANSFORMED IN EUROPE

SUMMARY

The European printer industry is experiencing a period of rapid change caused by the increase of Japanese plants in Europe. This newsletter examines the European printer industry changes in three parts. The first part explores the reasons behind the Japanese influx, studies the European printer industry's recent history, and shows the results of a Dataquest survey of Japanese printer plants. The second part looks at the European printer market in detail and analyzes the potential impact on the semiconductor market of the increase in local production. Finally, the third part lists the major printer manufacturing locations in Europe by the types of printers manufactured at each site.

RECENT PRINTER INDUSTRY HISTORY

Until 1970, the European printer market was dominated by Centronics. In 1984, as the potential demand for printers for the oncoming PC boom was recognized, European and North American companies started to invest in new printer production sites in Europe. European printer production focused mainly on high-quality, heavy-duty printer products for multiuser systems. Brother was the first company to prepare for volume dot matrix printer production in Japan.

With the boom in PC markets, there was a clear demand for low-priced, high-quality printers. Although Centronics was the first company to provide a dot matrix printer costing less than $1,000, the product had too many technical problems to survive in the market. North American and European companies noted this problem and many gave up their products in this market.

Meanwhile, two Japanese manufacturers (namely, Epson and Oki) responded with high-quality, low-cost products that were produced in high-volume factories. With a well-established distribution network in Europe, the Japanese producers managed to gain a 60 percent market share; virtually all of this was in products that cost less than $1,000. In 1987, Japanese market share had risen to 75 percent of the European market.

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Europe-based manufacturers were concerned, which resulted in a large-scale investigation by the European Community (EC) that was instigated by the Europrint Group. In March 1987, the EC Antidumping Committee initiated an information-gathering process for analyzing the intricacies of the complex path from manufacturers to end users. The EC's objective was to raise the prices of Japanese dot matrix printers and to allow European manufacturers breathing room so that they could become more competitive, but the EC did not anticipate the 13 new Japanese printer production plants in Europe. These plants were set up to avoid the high tariff on imported printers.

In 1988, the EC imposed import tariffs on the majority of imported printers from Japan. The companies that received maximum tariff penalties of 33.4 percent accounted for more than 50 percent of the printer market share in 1987. This resulted in more than $500 million in import tariffs from sales of more than $1.6 billion. To make sure that end-user prices reflected the import tariffs, the EC produced a new regulation, 2423/88, which compelled Japanese manufacturers to apply the tariff on imports sold at the first European point of sale. The idea behind the rule was to prevent manufacturers from spreading import tariffs over a wider range of products or to recover tariffs from the more expensive models. The EC, after finalizing an investigation into local content for photocopiers, started a similar investigation into the printer industry in 1988.

DATAQUEST SURVEY OF JAPANESE PRINTER MANUFACTURERS

In 1987, there was only one Japanese printer manufacturing plant in Europe—that of Canon in France. By 1988, there were 14. More than 70 percent of total investment was situated in the United Kingdom. Table 1 lists the most important factors cited by manufacturers in deciding where to locate.

Table 1

Factors in Choosing Locations

Most Important	Less Important
Local government grants	Wage cost
Communication	Skilled labor
Language	Overall cost
Component sourcing	

Source: Dataquest
October 1989

As indicated in Table 1, sourcing of components is considered very important. The major problems currently encountered in local sourcing are that of quality, price, and delivery. The companies surveyed estimated that it would take them 12 months to reach 40 percent local content, 18 months to reach 50 percent, and 24 months to reach 60 percent. What is apparent is that most companies are determined to source more than the required minimum of 40 percent local content.

As the printer manufacturing industry in Europe begins to mature, we expect an infrastructure comparable to that of Japan to emerge. Until then, most of these semiconductor components probably will be sourced from Japan. Fujitsu's announcement that it will locate its semiconductor fab in the United Kingdom is just the beginning of a potential wave of investment by Japanese component suppliers and printed circuit board (PCB) assembly subcontractors in Europe.

Major Printer Components

The main components of a printer are the printheads, PCB with electronic components, and specialized mechanical subassemblies. Dataquest believes that although the 40 percent content rule can easily be met without PCB, some Japanese plants have started inclusion of subcontract to local PCB assembly houses. These PCB boards can then be counted as local content as they are invoiced in local currencies. The majority of semiconductor components on the PCB still are sourced from Japanese vendors because most of the value is added via ASICs that are designed in Japan and sourced from either an in-house semiconductor supplier or an appropriate merchant supplier. Table 2 shows the major semiconductor components used in three types of printers.

Table 2

Major Semiconductor Printer Components

Serial Dot Matrix Printer

Quantity	Components
1	Serial EEPROM and small RAM buffer
1	128-Kbit EPROM
1	8155 8-bit parallel port
1	8-bit controller with 128-Kbit EPROM and four 8-bit A/D converters
1	Printhead electronics with 9 Darlington pairs delivering up to 2 amps and 24 pulsed volts
10	Standard TTL

Estimated total semiconductor value = $18.10

(Continued)

Table 2 (Continued)

Major Semiconductor Printer Components

Ink Jet Printer

Quantity	Components
2	ASIC nozzle-control 8-bit input and 4 x 8-bit output
2	ASIC parallel ports
2	ASIC bus controllers
1	16-bit MPU
2	Diode arrays
3	Discrete power supply regulator chips
7	Custom nozzle drives
1	LSI decoder
12	Standard TTL logic

Estimated total semiconductor value = $58.10

Page Printer (Laser Printer)

Quantity	Components
1	16/32-bit image processor
1	8-bit MCU
3	ASIC control logic, bus controllers, clock chip
30	Standard TTL logic
16	256-Kbit DRAMs
1	Hybrid laser driver, with controllers for lens, motors, mirrors, scanners

Estimated total semiconductor value = $214.10

Source: Dataquest
October 1989

OPPORTUNITIES FOR EUROPE-BASED SEMICONDUCTOR VENDORS

An analysis of the semiconductor content of a printer shows that most of the technology, and therefore value, is packed into ASICs. Considerable use is made of gate arrays and full-custom ICs, particularly in the printer head controlling the pin drivers. Most of this technology is proprietary, and in the case of Japanese printer companies, the design is done in Japan. This makes it very hard for European semiconductor companies to design in their products. The fundamental requirement must be to have a design center in Japan.

Other than ASICs, printers incorporate standard logic, EEPROM, EPROM, DRAM, MCUs, and power transistors. Further integration of standard logic into ASICs is difficult, since this mainly comprises octal bus functions.

The Printer Market's Potential Impact on the Semiconductor Market

The printer market can be broken down into the following three major categories:

- Serial printers
- Line printers
- Page printers

Each category has several types of printers; for a full breakdown, please refer to the "Definition Section" of your ESAM binder or turn to the glossary at the end of this newsletter.

Serial Printers

The total serial printer market in 1988 was estimated to be 4.5 million units in Europe. Of these, Dataquest estimates that 1.6 million units were produced in Europe. This many units would represent a potential semiconductor market of $29 million if semiconductors were sourced locally. The market is expected to grow at a compound annual growth rate (CAGR) of 5.5 percent, reaching 5.9 million units by 1993. We estimate that 4.5 million units will be produced in Europe by 1993. Assuming that the majority of semiconductors will be purchased locally, this represents a potential market of $82 million.

The market is led by Epson, Star Micronics, and NEC, which together control 40 percent of the market. Citizen, Oki, and Amstrad follow; together they control 19 percent of the market.

Line Printers

The line printer market is aimed at professional users (i.e., mainframes, microcomputers, and workstation installations). The total line printer market for 1988 was estimated to be 46,500 units and is expected to grow to 61,800 units by 1993. The largest growth would be in line, impact, thermal transfer printers; we expect this market to grow at a CAGR of 33.8 percent to reach 28,600 units.

Dataquest estimates that 14,000 line printers were produced in Europe in 1988. Of these, 9,000 were in the line, impact, fully formed category. The leading companies in this category are: Dataproducts, Gemicron, Fujitsu, IBM, and Nixdorf.

Page Printers

Page printers are commonly known as laser printers. Dataquest estimates that the 1988 market was 445,000 units, and we expect it to grow at a CAGR of 27.9 percent to reach 1.5 million units in 1993. We estimate that 45,000 laser printers were produced in Europe in 1988. The largest category in unit shipment terms will be in the 1- to 10-ppm (page per minute) category representing 1.3 million units; of this, we estimate that 540,000 will be produced locally. Although laser printer unit shipments are relatively low compared with serial printers (see Table 2), their semiconductor content in 1988 was estimated at $214.10. This amount represents a semiconductor market of $9.6 million in 1988 for semiconductors that were sourced locally and should rise to $113 million for the 1- to 10-ppm category by 1993.

The leaders in the 1- to 10-ppm printer category are Hewlett-Packard, Canon, and Kyocera, which together control a 50 percent market share. Apple, NEC, and Qume follow, together controlling 14 percent of the market.

Printer Production in Europe

During 1988, 13 additional plants relocated to Europe, the result of the EC Antidumping duties on imported printers. Currently, 42 printer manufacturing plants are located in Europe—12 in the United Kingdom and Ireland, 11 in West Germany, 5 in France, 4 in the Benelux countries, 3 in both Scandinavia and Italy, and 2 each in Spain and Switzerland. Table 3 shows plant locations and types of printers manufactured.

Table 3

Western European Printer Manufacturing Sites

Company	City(ies)	Country	Technology
Agfa-Gevaert	Mortsel	Belgium	PNPP
Daisy Systems	Wijchen	Netherlands	SIFF
IBM	Amsterdam	Netherlands	SIDM
Printronix	Wijchen	Netherlands	LIDM
Bull Peripherals	Belfort	France	LIFF, PNPP
Canon	Liffre, Brittany	France	PNPP
Epson	Paris	France	SIDM
IER	Besancon	France	SIDM
TIV	Lognes	France	SIDM
Canon/Olivetti*	Aglie	Italy	PNPP
Honeywell Bull	Milan	Italy	SIDM
Olivetti	Ivrea	Italy	SIDM, SIFF, SNTT
Facit	Atvidaberg	Sweden	SIFF, SIDM
IBM	Stockholm	Sweden	LIFF, PNPP
Mercante	Copenhagen	Denmark	PNPP

(Continued)

Table 3 (Continued)

Western European Printer Manufacturing Sites

Company	City(ies)	Country	Technology
Fujitsu	Malaga	Spain	SIDM
Rank Xerox	Madrid	Spain	PNPP
Hermes	Yverdon les Bains	Switzerland	SIDM, SNTT
Wenger	Reinach	Switzerland	SIDM
Dataproducts	Dublin	Ireland	SIFF, LIFF, PNPP
Brother	Wrexham	United Kingdom	SIDM
Citizen	Scunthorpe	United Kingdom	SIDM
Epson	Telford	United Kingdom	SIDM
Newbury Data	Staines	United Kingdom	SIDM
NEC	Telford	United Kingdom	SIDM
Okidata*	Glasgow	United Kingdom	SIDM
Panasonic	Newport, Gwent	United Kingdom	SIDM
Rank Xerox	Gloucester	United Kingdom	PNPP
Star*	Tredegar, Wales	United Kingdom	SIDM
Technitron	Slough	United Kingdom	PNPP
Walters	High Wycombe	United Kingdom	SIDM
Binder	Villingen	West Germany	SIDM
Kienzle	Villingen	West Germany	SIDM
Mannesmann Tally	Elchingen	West Germany	SIDM
Nixdorf	Paderborn	West Germany	SIDM
Olympia	Wilhelmshaven	West Germany	SIFF
Philips	Siegen	West Germany	SIDM,PNPP
Siemens	Muenchen	West Germany	PNPP
Siemens	Berlin	West Germany	SIDM,SNIJ,SNTT
TEC	Braunschweig	West Germany	SIDM
Triumph-Adler	Nuremburg	West Germany	SIFF
Walther	Gerstetten	West Germany	SIDM

*Production plans announced, but not yet finalized

Source: Dataquest
October 1989

DATAQUEST CONCLUSIONS

The European PC market has created a strong demand for low-cost printers; the demand was originally satisfied by low-cost imports from Japan. The EC investigation and subsequent imposing of dumping duties and local content rules have resulted in an invasion of Japanese printer plant locations in Europe. The market demand for printers remains high, and pressure for higher local content has resulted in the use of local subcontractors for PCB assembly and a gradual rise in locally purchased semiconductors. Dataquest estimates that a potential $200 million semiconductor market will be created by these new printer production plants in Europe by 1993. We believe that long-term opportunities exist for locally based semiconductor vendors making the right investments and planning the right penetration strategies now.

Bipin Parmar

APPENDIX

PRINTER INDUSTRY DEFINITIONS

The following categories comprise all electronic printers:

- Serial printers
- Line printers
- Page printers

Serial Printers

Serial printers are printers that use a single printhead or striking mechanism to print characters sequentially across the page. They include the following:

- Serial, impact, fully formed (SIFF) printers
- Serial, impact, dot matrix (SIDM) printers
- Serial, nonimpact, direct thermal (SNDT) printers
- Serial, nonimpact, thermal transfer (SNTT) printers
- Serial, nonimpact, ink jet (SNIJ) printers

Line Printers

These are printers with a printhead that covers a full line of the printed page and a striking mechanism that prints one full line at a time. They include the following:

- Line, impact, fully formed (LIFF) printers
- Line, impact, dot matrix (LIDM) printers
- Line, nonimpact, direct thermal (LNDT) printers
- Line, nonimpact, thermal transfer (LNTT) printers

Page Printers

Page printers can buffer, in part or whole, a page of images received from an electronic source and then transmit these images to a receiving substrate. They include:

Page, nonimpact, plain paper printers (PNPP) using laser, LED, ionography, magnetography, or ink jet technology.

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Research Newsletter

DOMESTIC METERING: THE MARKET IN EUROPE

SUMMARY

This newsletter examines the prospects for semiconductor consumption in electronic domestic meters used for measuring electricity, gas, and water in Europe. In it, we will discuss the main factors that will affect the rate of substitution of these meters over mechanical rivals and forecast the demand for semiconductors during the next five years. Dataquest forecasts that the total market will increase from an estimated $18 million in 1989 to $83 million by 1994, showing an overall 35 percent compound annual growth rate (CAGR).

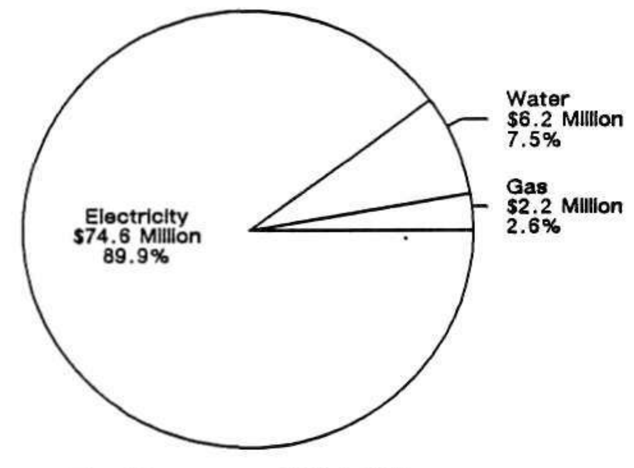
Figure 1 shows our estimation of the demand among electricity, water, and gas applications for 1994. Electricity meters and teleswitches should account for the lion's share—90 percent—of this market, with consumption for meter applications forecast to grow at a heady 54 percent CAGR between 1989 and 1994.

ELECTRONIC METERS BRING NEW FEATURES

Although electronic meters cannot exactly match mechanical products point for point on cost, they do offer features that traditional meters cannot provide. Table 1 summarizes these features, which are the "back doors" to the meter market.

Electronic meters allow multiple rate tariffs to be administered according to the season, day of the

FIGURE 1
European Semiconductor Revenue Forecast by Domestic Metering Application (1994)



0005070-1

Source: Dataquest
October 1989

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

TABLE 1
Benefits from Electronic Functionality for Electricity, Gas, and Water Meters

Function	Electricity	Gas	Water
Multiple Tariffs	1	N/M	3
Supply Management	2	N/M	3
Data Capture	3	3	3

Note: 1 = Most Important; 2 = Important; 3 = Least Important N/M = Not Meaningful

Source: Dataquest October 1989

week, or time of day. The benefits are most pronounced for electricity metering where considerable power savings may be made to encourage or shape demand.

Supply management functions allow the utility companies to switch off certain home appliances during periods of peak demand. As for multiple rate tariffs, the greatest benefit is in electricity management. Trials have been conducted in the United Kingdom using the public telephone network, radio, and mains signaling to control household appliances. Savings are as much as $50 per annum per domestic consumer; however, this is not sufficient to justify equipment and installation costs.

Data capture features can either shorten the manual measurement process or remove the need for meter-reading personnel to visit each home. Although automated measurement is common in the United States where the utility companies have a statutory obligation to read and bill monthly, this is not the case in Europe. Combined with the lower cost of labor in Europe, the prospects for remote measurement systems are weak.

ELECTRICITY—COGS AND DISKS RULE ... FOR NOW

Dataquest expects the greatest demand for semiconductors to occur in the electricity segment, where extra features offered by electronic meters bring the greatest utility.

However, traditional mechanical, nonelectronic meters still dominate the market in Europe years after many predicted a switch to electronic meters. With few exceptions, this is true worldwide. Whether used for measurement of electricity, gas, or water, the crucial selling points for both products are price, reliability, and durability.

Electricity meters using the spinning Ferraris disk cost $35 and have a proven useful life of up to 30 years. They are approximately $10 less expensive than electronic versions, which have lifetimes that can only be estimated.

Semiconductor Content

Many solutions have been developed for domestic power measurement. The most common solution is to feed current signal from a laser-trimmed shunt and voltage signal into an analog multiplier to derive a power signal (see the semiconductor breakdown in Table 2). This power signal is, in turn, passed to a voltage-frequency converter and frequency counter to enable reading by a standard microcontroller (MCU). Excluding the MCU, all these functions are integrated onto a single, low-noise CMOS or bipolar ASIC. An EEPROM provides a nonvolatile store in case of power failure. We estimate the semiconductor cost for this approach to be $8.95, 21 percent of an average selling price of $42.00.

Another approach dispenses with the analog multiplier circuit and resistive shunt by combining current-voltage measurement and power multiplication functions onto a single Hall probe attached to a slow 12-bit A/D converter and MCU.

Electronic teleswitches are common adjuncts to either electronic or electromechanical meters. There are two basic types that differ in terms of the transmission medium the utility companies use to control them. First, radio teleswitches using the 198-kHz radio band are employed widely in the United Kingdom. Second, ripple teleswitches, or "ripple controllers," are used widely in Austria, France, and West Germany; they use the electricity supply grid as the transmission medium.

Except for the front-end receiving circuitry, the semiconductor contents for radio and ripple teleswitches are similar. Dataquest's estimation for the semiconductor content of a radio teleswitch is shown in Table 2. The major components are a radio-frequency preamplifier IC, a switch capacitor filter/data decoder ASIC, and an 8-bit MCU. We

TABLE 2
Estimated Semiconductor Content for an Electronic Meter and Teleswitch

Electronic Meter (With LCD Display)		
Function	**Technology**	**Cost**
8-Bit Microcontroller with LCD Controller	Standard CMOS	$ 4.00
1-Kbit EEPROM	Standard NMOS	0.65
Analog Power Multiplier and Frequency Conversion	Linear CMOS ASIC	3.50
Discretes	Bipolar	0.80
Total Semiconductor Content		$ 8.95
Average Selling Price		$42.00
I/O Ratio		21.3%

Tariff Teleswitch*		
Function	**Technology**	**Cost**
8-Bit Microcontroller	Standard CMOS	$ 4.00
RF Front-End/Preamplifier	Analog ASIC bipolar	3.00
Receiver/Filter/Decoder	Analog/digital ASIC CMOS	5.50
Discretes (Relay Drivers & LED)	Mixed	0.90
Total Semiconductor Content		$13.40
Average Selling Price		$60.00
I/O Ratio		22.3%

*Content estimated for U.K. 198-kHz radio teleswitch

Source: Dataquest
October 1989

estimate the semiconductor content of these units to be $13.40, which is 22 percent of an average selling price of $60.00.

At present, most teleswitches are designed to complement double-rate Ferraris disk meters, which are less expensive to supply than electronic versions. As Table 2 indicates, there is a significant scope for the combination of meters and teleswitches into one unit, allowing sharing of the same MCU and integration of the ASIC functions onto one IC.

Market Analysis

Table 3 shows the major companies that have commenced domestic electronic metering equipment manufacture in Europe. In addition, many smaller national suppliers of conventional meters are developing electronic versions too.

By region, France and the United Kingdom currently lead Europe in domestic electronic meter implementation. The public utility Electricite de France (EDF) is the most ambitious, with plans to build its initial trial of 90,000 electronic meters (supplied by Sauter and Schlumberger) to full electronic metering across all of France by 1995.

In 1989, Dataquest estimates that only 330,000 electronic meters will be sold out of 7.4 million meters shipped to Europe each year. Most of these units are electronic budget meters that replace vulnerable coin meters in the United Kingdom. By 1994, we expect electronic meters to account for 40 percent of all meters shipped.

This year, we estimate that 1.1 million teleswitch units will be fitted in Europe. Of these, 430,000 are radio versions for use in the United Kingdom and the rest are ripple controllers going mainly to France, West Germany, and Austria. We predict that this volume of teleswitch shipments will have risen to 4.1 million units within five years; one-half of these units will be integrated with an electronic electricity measurement function.

TABLE 3
Key Electronic Electricity Meter Suppliers

Company	Town	Country
AEG	Hameln	West Germany
GEC Meters	Stone	England
Landis & Gyr	Acton	England
	Telford	England
	Frankfurt	West Germany
	Zug	Switzerland
Sauter	Mulhouse	France
Schlumberger	Felixstowe	England
	Poitiers	France
	Chasseneuil	France
Siemens	Vienna	Austria
	Oldham	England
	Nuremburg	West Germany

Source: Dataquest
October 1989

Figure 2 shows Dataquest's estimate for semiconductors consumed in domestic electronic electricity meters and teleswitches in Europe. We estimate this market to be worth $18 million in 1989, rising to $75 million by 1994, a 32 percent CAGR.

MIXED PROSPECTS FOR WATER METERS

Although no electronics are used in water meters, electronic encoders can be connected to them to allow fast transmission of water usage data to meter reading personnel. The major suppliers of these encoders in Europe are Kent (ASEA Brown Boveri) and Neptune (Schlumberger).

Except for the United Kingdom, where very few domestic water meters currently are used, meters are installed in each of Europe's 120 million households. Dataquest estimates that 7.6 million new meters will be fitted in Europe this year, rising to 8.9 million units by 1994. The increasing demand is due largely to the privatization of the water industry in the United Kingdom, where rapid demand is expected. We estimate that only 0.13 percent of these shipments will be fitted with encoders this year, resulting in semiconductor consumption of only $60,000. Of the several water authorities we contacted in Europe, none will be prepared to fit electronic meters for a few years, for the following reasons:

- Cost—With a selling price of $60, encoders presently cost many times more than the $20 for the meters themselves, thus making manual reading more attractive.
- Power availability-Batteries are a common solution, but their lifetimes (10 to 12 years) and reliability are unacceptably low.
- Industry standards—Industry standards for encoder transmission techniques are lacking.

As encoder prices fall compared with the cost of labor, this situation will change. Assuming that one in five water meters will have encoders in 1994, we estimate the European semiconductor market to be $6.2 million in 1994. This market is small compared with the demand for semiconductors in domestic electricity metering.

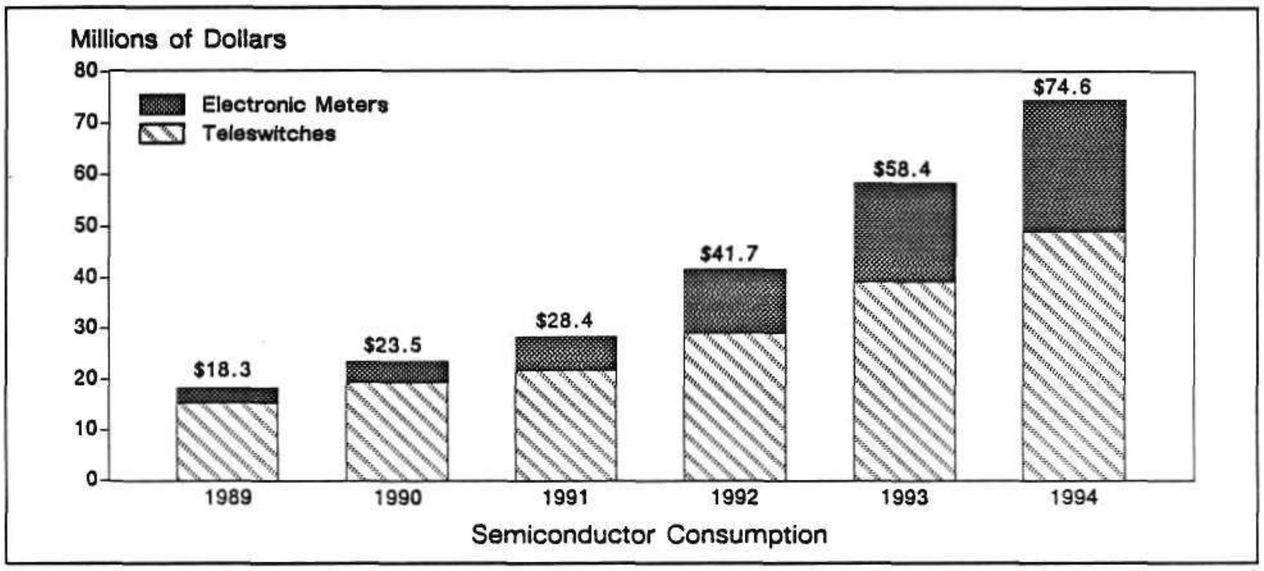
ELECTRIFIED GAS?

Conventional mechanical bellows gas meters are bulky and inaccurate. At $60 each, they also are far more expensive than their electricity or water counterparts.

Limited electronic meter trials are under way in West Germany. However, inexpensive electronic versions are not currently available. Research and development is under way, some of it funded by the utility companies themselves. The major companies involved are Ferranti Meters Limited (Siemens), Sauter, and Schlumberger.

Of the utility companies we contacted, none expect electronic gas meters to be widely used for

FIGURE 2
Semiconductor Consumption Forecast for Electronic Electricity Meters in Europe (1989-1994)



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Source: Dataquest October 1989

at least another five years. The reason is cost. Today, electronic versions cost $110 to build—twice what is acceptable. Furthermore, without access to an electricity supply they must use lithium batteries, which are both expensive and labor intensive for the gas companies to replace.

The consequent demand for semiconductors in Europe is uncertain. Assuming a semiconductor content of $20 and that electronic versions are forecast to account for 1 in 20 of Europe's annual shipments by 1994, this European semiconductor market could be worth $2.2 million.

DATAQUEST CONCLUSIONS

Clear evidence exists that electronic meters are positioned to fully replace their mechanical rivals, particularly in electricity metering. All the key manufacturers contacted by Dataquest have electronic designs on their drawing boards. Schlumberger Industries already has ceased production of Ferraris meters in Europe in favor of electronic meters. A similar situation appears imminent at Landis & Gyr following its announced construction of an all-electronic meter factory in Telford, England.

Environmental issues such as the potential greenhouse effect have come to the public's attention. European governments presently are looking at ways in which energy waste can be minimized to avert environmental damage. Sophisticated electronic domestic and industrial energy management systems will make a major contribution and further drive the demand for features that only electronic products can satisfy.

The factors that have kept the electronic metering markets in check now are disappearing. Mechanical technologies have reached the bottom of their experience curves, with prices for these products expected to increase, not decrease, with time. In contrast, the quest toward inexpensive mass-produced electronic meters has only just begun.

Jonathan Drazin

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Research Newsletter

ESAM Code: Newsletters
1989-18
0002383

THE EUROPEAN PC HOME MARKET: AN UNKNOWN POTENTIAL

SUMMARY

The home market for microcomputers is often associated with fringe activities such as family entertainment and hobbyist usage. But with growth rates in the business market expected to flatten out over the next few years, an increasing number of PC vendors, including IBM, are taking the home market seriously. Throughout Europe, shipments to the home market currently account for one quarter of all PCs shipped. However, a more significant statistic is that current household penetration rates are low, attaining less than 5 percent in even the most developed home markets. This means that the potential of the equivalent home market is still far from being fully exploited when compared with the European business markets. In this respect, it is interesting to look at the penetration of PCs into U.S. households; Dataquest estimates that, in 1988, the U.S. penetration was around 15 percent.

In this newsletter, the home market is defined as the sum total of PCs purchased by individuals rather than by corporate or other legal entities. The basic distinctive criterion for the home market is therefore "who pays for the PC." This implies that the distinction is not at all related to product characteristics of the hardware acquired. In defining a PC, Dataquest only considers fully functional PC models sold with a central processing unit, keyboard, display monitor and with at least one internal floppy disk drive, costing US$600 or more, exclusive of value-added tax. This definition excludes the dedicated word processors, low-performance 8-bit PCs and games consoles currently sold to home users by vendors such as Amstrad, Atari, Commodore and Nintendo.

CHARACTERISTICS OF THE HOME MARKET

Price-Driven with Special Requirements

Home users traditionally have more limited budgets and tend to be far more price sensitive than business users when it comes to buying personal computers. However, price is not the only deciding factor. In certain respects, such as a machine's graphical and musical capabilities, home users are very demanding and have very specific requirements. Vendors such as Atari and Commodore were quick to recognize the fact, and developed PCs that provided fairly sophisticated graphics and sound capabilities at a modest price. Amstrad's PCs are successful because they provided IBM compatibility at a low price. But the PC1512's integral design and the bundling of inexpensive, cut-down versions of professional software were also important factors.

Figure 1 shows the business/home breakdown of the European market and Figure 2 shows the percentage penetration of PCs into European households.

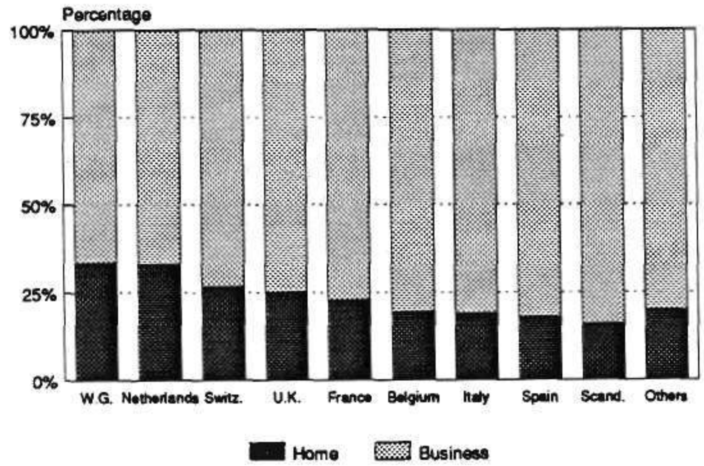
Increasingly Sophisticated Applications

Home users have always differed from business users in terms of their needs and their motivation for buying a PC. Businesses purchase PCs to increase their competitive edge, either by computerizing individual tasks or by installing more encompassing management tools. Home users typically buy for yet another set of reasons, which now stretches well beyond the traditional leisure and hobbyist activities. Currently, the basic application for PCs within households is still the home/hobbyist application. However, educational or instructional usages, as well as "household productivity or commercial" applications, are gaining in importance.

Educational applications include both the more sedentary education activities usually associated with parents and their children, and the more specialized activities of students. Of these, the student "home campus" market is currently the most developed and sophisticated. Students are also the most mobile members of the educational population. As laptops become smaller and lighter, and as more vendors introduce IBM-compatible notepad-size PCs and "palmtops," students are likely to become a major driving force in the development of this lightweight PC market. However, a major price/performance issue still needs to be solved by the laptop vendors before laptops become really successful in the student market.

Figure 1

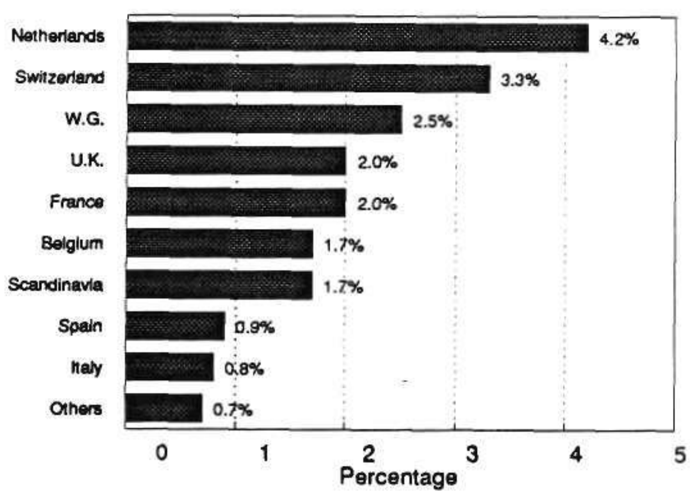
European 1988 PC Market
Estimated Breakdown by Market Sector



Source: Dataquest
September 1989

Figure 2

European 1988 PC Market
Estimated Penetration of Households by Country



Source: Dataquest
September 1989

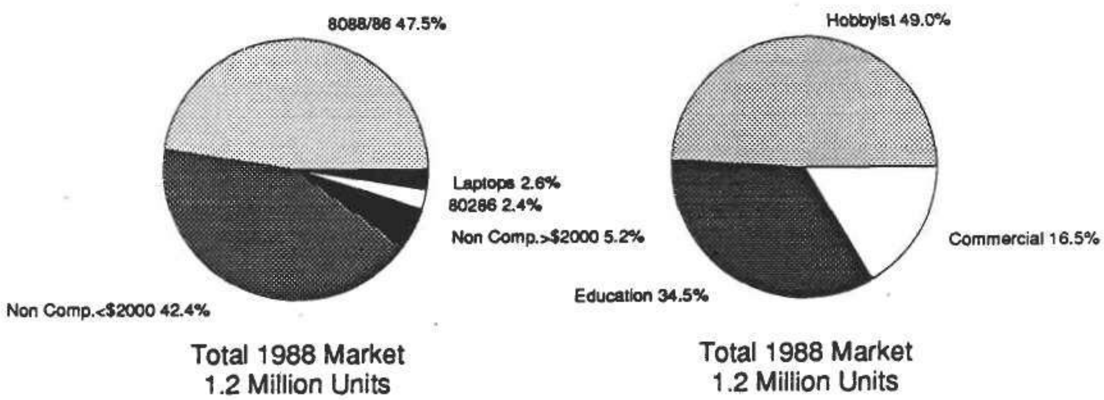
In the past, using computers to work at home was limited to executives and the professions, but more and more employees are now taking work home, and a small but growing number of employees actually work at home. Links between the office and the "home office" are thus likely to become much more widespread with the development of networking and communications in workplaces, and as these home-to-work links become effective and affordable. With job mobility also tending to increase and employees having to learn new work skills, home-based computerized adult education is also likely to experience renewed growth. This formal instruction dimension also seems a prerequisite for the success of joint employer–employee financed schemes such as the Private Computer Projects which, although they have become a major driving force of the Dutch PC market, are increasingly criticized for their lack of effectiveness. Without appropriate software and a high level of formalized training, many of these PCs are collecting dust in cupboards.

The commercial applications in the home market are likely to assume significant proportions in the coming years. The scope of this market ranges from traditional uses, such as word processing, accounting and filing, to the integrated computerization of homes. The French have termed this latter concept "Domotique." It entails cabling houses and apartment blocks during their construction to allow for the computerized control of heating, lighting, security systems, and audio/visual and kitchen appliances. No reference point exists at present and the market is wide open.

Figure 3 shows 1988 shipments in the European market by both product type and application.

Figure 3

European 1988 PC Home Market
Total Shipments by Product Type and Application



Source: Dataquest
September 1989

Which Computer?

The computers purchased by home users are strongly influenced by their previous experience with computers, either in the classroom, at their workplace or at their home with a game/hobbyist machine. Thus, IBM compatibility is almost a prerequisite for most employees wishing to work at home, while non-compatible machines tend to predominate where PCs are used in a strictly family environment.

PCs bought by home users are also becoming more high powered. Already, certain long-established vendors of home computers, such as the British vendor Acorn, have introduced highly sophisticated models equipped with RISC processors. Low-cost UNIX workstations are also on the horizon. As in the business market, the availability of increasingly powerful hardware, including hardware based on the Intel family, is one of the driving forces of the home market. If the percentage for PC penetration in the home market is really to increase, the hardware needs to become considerably more user-friendly, and with better performance, than at present. Both requirements—user-friendliness and pure performance—can only be met by more powerful processors, allowing really sophisticated applications to be run, such as the previously mentioned Domotique applications. Current pricing will initially limit the market for such models to the more elitist and affluent "power users," but prices are expected to drop and highly user-friendly and powerful PCs will become available for even the most computer-illiterate households.

Expensive Entry Tickets in Promotion and Distribution

The home market is characterized by its high barriers for entry, which make it difficult for any newcomer to this market to acquire a market share that really challenges the current market leaders. The sheer investment in marketing and promotion in order to build up a market presence, and the resources involved in the development of services and other complementary activities around the PC hardware, are all factors adding to the high barriers for entry in the home market. Most established home vendors are deeply involved in the area of software, and support user clubs, dedicated brand-oriented magazines, and so on. Additionally, the research and development (R&D) costs involved in the supply of a challenging and complete product line are high and prohibitive for many potential newcomers.

Another significant entry barrier is the structure of the distribution channels for the home market. The home segment is typically supplied by non-dedicated PC dealers, such as the various kinds of mass merchandisers—department stores, hypermarkets and cash and carry stores—hi-fi and video shops, and stationery stores. These home market dealers tend to have a highly concentrated structure, and are mainly controlled by large chains or a purchasing group. It is therefore critical to get shelf space among the relatively few companies that control a large proportion of the home market at the retail level. At the same time, mass merchandisers that sell PCs are very selective and are willing to sell only a restricted number of strong and potentially best-selling brands. Examples of these mass merchandisers are Auchan, FNAC and NASA in France; Dixons in the United Kingdom;

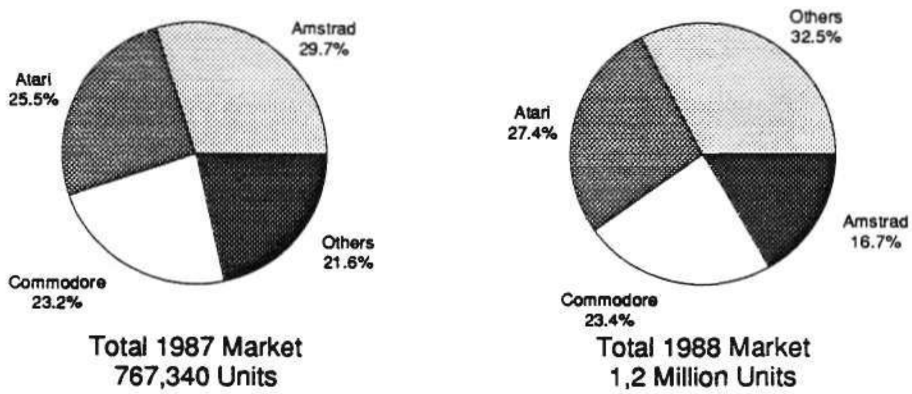
El Corte Inglés in Spain; Vroom & Dreesmann in the Netherlands; Bilka in Denmark; and Kaufhof in West Germany.

Specialist Vendors Dominate the Market

Largely as a result of the importance of these entry barriers, the competitive situation on the home market is one of extreme concentration. In 1988 three vendors, Atari, Commodore and Amstrad, had a combined market share of close to 70 percent. This almost oligopolistic nature of the home market contrasts sharply with the structure of the 1988 business market, where 11 vendors accounted for not more than 60 percent of total sales. Figure 4 shows the percentage market shares in terms of shipments of the main vendors in both 1987 and 1988.

Figure 4

European PC Home Market
1987 and 1988 Shipments by Vendor



Source: Dataquest
September 1989

The three leading vendors in the home market are companies that are highly specialized toward, and with a background in, consumer-electronics products. Currently, their specialization is also reflected in the fact that a high proportion of their business is done on the home market, with sales to the business market accounting for a relatively low proportion of their total sales.

Atari, which became the number one supplier to the home market in 1988, is the best example of this. In 1988, 83 percent of all Atari sales went into the home market. As far as sales to the business market are concerned, Atari follows an approach very much oriented to niche markets, where it specializes in the MIDI (musical instrument digital interface) and multimedia markets (such as desktop video, CD-ROM and animation).

Interestingly, several of the home-market vendors have currently embarked on a strategy to move upmarket, and are planning to take a greater share of the business market; the best examples are Amstrad, with a new strategy based on its P200 range, and Commodore, which has recruited several top executives from Apple, Hewlett-Packard, Olivetti and Compaq in the past year. However, it remains to be seen whether a highly developed home image jeopardizes sales to the business market, or whether the home-market vendors can remain competitive through the high-margin professional dealer outlets.

Despite the structural difficulties in challenging the position of the leading vendors on the home market, it is possible that several high-end vendors will take a share of the home market, and that companies with strong R&D and mass-merchandising muscle, such as Philips and Olivetti, will increase their stake in this market.

DATAQUEST ANALYSIS

In view of the many uncertainties about product development, applications and market entrants affecting the development of the home market, it is difficult to predict how far this market will increase. However, the sheer number of households in Europe (124 million), combined with the still very low penetration figures, shows that there is probably a large potential market waiting to be developed.

(This document was first published in *European Monitor*, August, 1989.)

Brian Pearce
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Research *Newsletter*

ESAM Code: Volume II Newsletters
1989-17
0004612

PART III
DIGITAL CELLULAR RADIO—THE MARKET FORCES

INTRODUCTION

This is the third newsletter in an initial series of three examining various aspects of the European cellular radio industry. These newsletters are entitled:

- Part I: Cellular Radio—Its History and Principles
- Part II: Cellular Radio in Europe—Growing into the Future
- Part III: Digital Cellular Radio—The Market Forces

The first newsletter outlined the history and the principles of cellular radio, and the second examined the growth of the European market. This newsletter examines the potential dynamic market forces that could affect the initial launch of digital cellular radio in the early 1990s.

BACKGROUND

Pan-European digital cellular technology represents the most cooperative development project ever experienced within the European Telecommunications industry. In just a few years the idea has been conceived, standards agreed upon, collaborative ventures established (shown as follows), and product development initiated as the race began to start implementing the networks by 1991.

- Ericsson—Siemens
- Philips Kommunikation Industrie—ANT—Bosch
- Alcatel NV; Nokia—AEG
- Racal—Plessey (Orbitel)
- Orbitel—Ericsson

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However, although there can be little doubt that digital networks will be successful in the longer term, there are some factors which, in the short term, could slow the initial adoption of the new technology.

Current Networks

Cellular networks in Europe currently conform to many standards, but this has not prevented a substantial growth in the subscriber base over the last four years. Indeed, in many of the continental European countries where initial growth was rather slow, more recent statistics show that growth rates are accelerating.

At present growth rates, the installed base of analog system subscribers could approach 5 million by 1992. Historically, estimates of cellular growth have tended to be conservative, so it is clear that, by 1992, there will be a significant number of users employing analog technology.

IMPLEMENTATION OF DIGITAL NETWORKS

One of the major factors that has governed the growth of cellular radio is believed to have been the large latent demand for widespread, economic mobile communications. Some may regard current cellular technology as far from economic. However, it is significantly less expensive—and more widespread—than the systems that preceded it. Much of this latent demand has been satisfied by the analog networks and therefore will not be present to provide an impetus to the digital system, except in those countries where networks are very small.

Additionally, the growth rate experienced by the analog systems was in an environment of no competing technologies. A digital cellular system will not have this luxury and will have to compete in the marketplace on its own merits as would any other product or service. Consequently, it must be perceived by the customer to offer an advantage in price and performance over existing systems; specifically, improved performance at a lower price.

This particular requirement presents the network operators with something of a dilemma; that between earning a good return on investment in the now-mature analog system and at the same time promoting a technologically superior product that initially will show a lower return.

Similarly, the customer has also made an investment in purchasing and subscribing to the analog network. Only in a few cases will this equipment be discarded prior to its normal life expectancy simply to change network technology. In cases where mobile equipment is leased, the lessor could have significant funds invested in equipment that possibly relies on one- to three-year leasing contracts to recover that investment. There is no financial incentive to change that installed base until such time as those leasing agreements expire. There is a real possibility that as the introduction of digital networks approaches, the resale value of leased mobile equipment could tend toward zero.

Moreover, in the early days of a digital cellular system, its coverage will not be as widespread as the existing analog system. This could be a major delaying factor for those users wishing to adopt digital technology.

Another factor in the dynamics equation is the appearance of new operators building and operating a competing network infrastructure. A new operator would have to install a digital network from scratch. Initially, there would be no disadvantage in this respect as other licensed digital operators would also have to install their networks. However, there would still be competition from the existing analog system operators (some or all of whom might also be digital operators).

As yet, there has been no significant downward pressure on air-time charges on the analog networks. Faced with attempts from the new digital operators to establish their place in the market, there could well be room for analog operators to cut tariffs on their networks to a level at which the digital operators, with their heavy investment costs and initially smaller subscriber base, would find it extremely difficult to compete. It could be possible, therefore, without some form of regulation, for current operators (which will themselves move to digital) to inhibit competition in new networks at an early stage.

Digital cellular radio could also experience competition from other emerging technologies—a problem that analog systems did not experience. In particular, the emergence of CT2 cordless telephones, together with the deployment of "phone-point" or "zone-phone" public cordless services, could impinge on users who are unsure as to whether they really need the level of flexibility that cellular radio offers. It is too early in the development of CT2 to analyze its impact. At present, Dataquest believes that CT2 and cellular technologies will be initially largely complementary rather than competitive.

Although all of the foregoing factors will affect the development of digital cellular networks, probably the most significant will be the quality of service provided by the analog networks in three years' time. Already during peak hours in the densely populated (in cellular terms) Southeast England, there are signs that the networks cannot cope and users are complaining of poor transmission quality, dropped calls, and interference from other calls in progress.

With an increasing number of users subscribing to the service and the frequency spectrum becoming fully utilized, network operators will find it increasingly difficult to overcome these problems. If this scenario does occur when digital systems become available, it is possible that discontented users will switch to the new system. However, this mechanism could be self-limiting, because as the number of subscribers on the analog network decreases, the quality of service will begin to improve, removing the need to switch networks.

DATAQUEST CONCLUSIONS

The assertion that digital cellular technology will be successful still holds true for the longer term. However, this newsletter has aimed to demonstrate that the mechanics of the marketplace are not as simple and straightforward as when analog systems were launched. As a result, the available choice could well confuse both existing and potential customers. This could cause them to defer making a decision until the new networks have proven themselves capable of offering an improved solution.

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Jim Eastlake
Ted Richardson

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Research Newsletter

ESAM Code: Volume II Newsletters
1989–16
0004613

PART II
CELLULAR RADIO IN EUROPE—GROWING INTO THE FUTURE

INTRODUCTION

This is the second newsletter in an initial series of three about cellular radio. These newsletters are entitled:

- Part I: Cellular Radio—Its History and Principles
- Part II: Cellular Radio in Europe—Growing into the Future
- Part III: Digital Cellular Radio—The Market Forces

The first in the series deals with the principles of operation of this exciting communications medium. This newsletter reviews the growth in the European market for cellular radio, and the reasons and factors for its success and forthcoming development. The third newsletter reviews the possible market dynamics that could interact when digital networks are deployed in the early 1990s.

BACKGROUND

Cellular radio began in earnest in Europe as recently as October 1981, when Sweden launched its NMT–450 system. By the following March, the system was available throughout Scandinavia. The new medium experienced spectacular growth, reaching a level of 100,000 subscribers in just three years (see Figure 1: Scandinavian Cellular Market).

In January 1985, the United Kingdom launched its two networks (three months ahead of schedule). Demand for the service was huge, exceeding even the operators' optimistic forecasts (see Figure 2: United Kingdom Cellular Market). Since then, many European countries have launched cellular radio networks. However, due to proprietary system designs and available spectrum in each of the individual countries, most of the systems are incompatible and do not permit country–to–country mobile roaming. The exceptions are the Nordic countries (Denmark, Finland, Norway and Sweden) who all adopted the same system, thereby allowing a mobile to be used in each of the four countries. Table 1 shows the systems operated in some of the major European countries.

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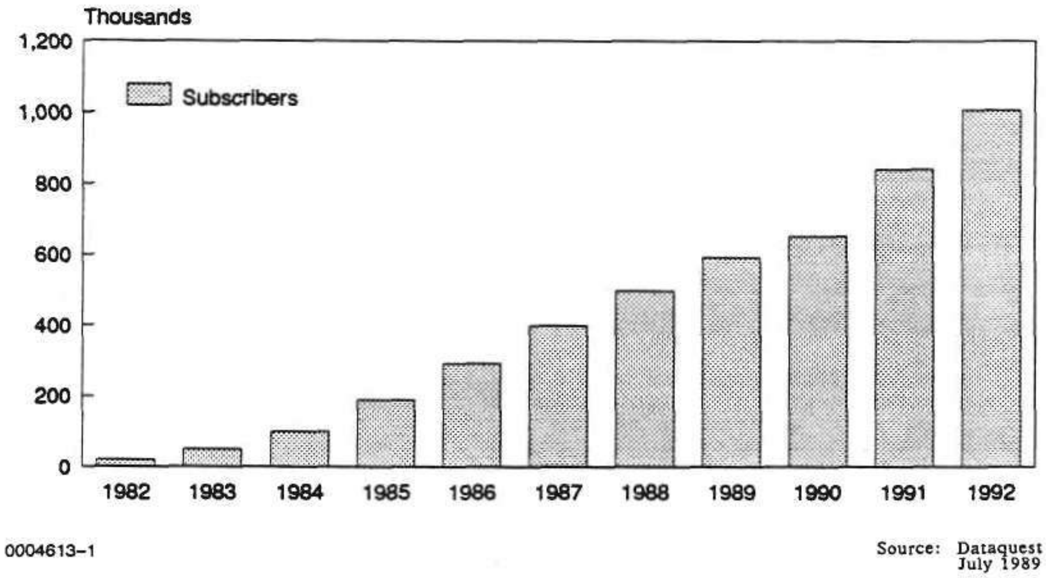
Figure 1

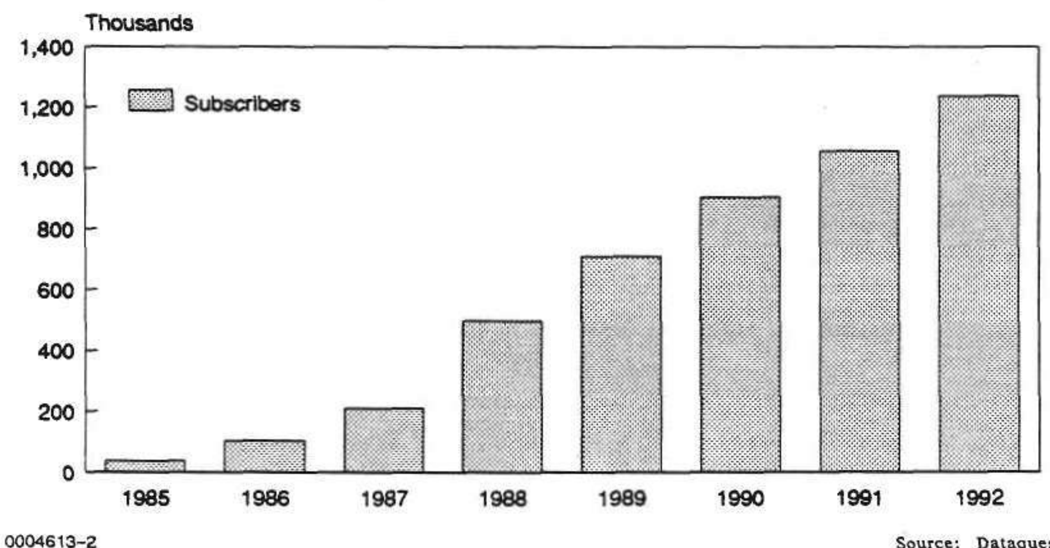
Scandinavian Cellular Market 1982–1992



Source: Dataquest
July 1989

Figure 2

United Kingdom Cellular Market 1985–1992



Source: Dataquest
July 1989

Table 1

Systems in Operations Across Europe

Austria	NMT-450
Denmark	NMT-450/900
Finland	NMT-450/900
France	RC2000 (quasi-cellular)
Ireland	TACS
Italy	RTMS (quasi-cellular)
Netherlands	NMT-450
Norway	NMT-450/900
Spain	NMT-450
Sweden	NMT-450/900
West Germany	C-450
United Kingdom	TACS (and ETACS)

Source: Dataquest
July 1989

Market Structure

In common with traditional telecommunications networks, cellular radio in most European countries is run by the Post, Telegraph and Telephone organizations (PTTs) on a monopoly basis. The main exception is the United Kingdom, where two network operators compete for market penetration. There is also limited competition in Sweden. France has licensed a second cellular radio operator whose NMT-450 network was scheduled to begin service in March 1989.

COMPETITIVE ENVIRONMENT IN THE UNITED KINGDOM

It is significant that the U.K. market has shown the most prolific growth in its subscriber base as well as the greatest price erosion of mobile telephone handsets. Rapid growth has been experienced for several reasons:

- There was an immense latent demand for an accessible mobile service.
- The economic climate was fostering economic growth, mindful of ever-improving efficiency.
- Two network operators were able to cope with high demand whereas one may have been overwhelmed, with resultant waiting lists (which in turn may have stifled demand).
- Competition was growing.

The provision of cellular services in the United Kingdom is based on a hierarchical structure. Under the terms of their licenses, Racal Vodaphone and Cellnet are not permitted to sell equipment directly to the end user. This has caused the growth of a competitive infrastructure of retailers and dealers, who also sell the air-time on the network and provide the necessary billing services.

These dealers and retailers have been operating in an environment that has become increasingly fierce, to the benefit of customers but to the detriment of some retailers. The first move came when some retailers started to discount mobile telephone sets in an attempt to establish and increase their market share. Over the last two years, this has continued to such an extent that it is believed that some retailers are earning no revenue from the sale of equipment, but are instead relying on the sale of air-time for their revenue. This discounting has been partly offset by bonuses that network operators pay to the retailers for each new subscriber they connect to the network.

Air-time to retailers is sold at a discounted rate compared to that which the end user pays, so that a margin is present from which the retailer can earn revenue. The greater the number of subscribers a retailer has, the larger is the discount received from the network provider. Clearly, this system benefits the larger retailers, who thus have a greater overall margin than their smaller competitors. This in turn exerts pressure on the smaller retailers to supply the mobile equipment itself at competitive prices.

Consequently, we believe only retailers with a sufficiently large subscriber base are likely to survive in the longer term. Approximately 65 retailers operate in the United Kingdom today; it is possible that as few as 15 will survive in their present form over the next two years.

The Market in Mainland Europe

With the exception of Scandinavia, initial growth on most of the national cellular networks in Europe was relatively slow. However, more interest has been aroused recently, and the growth in the subscriber base has increased.

We believe that this previous lack of interest was due to the high cost of subscribing to the system, the shortage of suppliers of the service, slow growth in the area covered by the system, and the absence of competition.

THE FUTURE

Currently all operating networks use analog transmission technology and each type of system is incompatible with others. Consequently, subscribers are limited to using their mobile only in their own country.

This shortcoming should be overcome with the introduction of second-generation digital cellular technology in 1991, implementing a common standard throughout Europe. The drive behind the "pan-European digital cellular system" is motivated by several reasons:

- To permit Europe-wide cellular usage.
- Common standards enable a single technology, and therefore economies of scale, to be achieved.
- To provide the first real example of Europe-wide telecommunications cooperation.
- To provide European industry with a technological lead in mobile systems over the rest of the world.
- Digital technology permits greater utilization of available bandwidth (by a factor of between 2.5 and 5).
- Enhancements providing new features/services would be easier with a digital system.
- To provide higher-quality service.

Certainly, this international co-operation in largely agreeing standards in just under two years fulfills the promise that the pan-European digital system can become a successful reality.

However, having overcome the technical and logistical problems of a digital system, the next hurdle for the network operators will be a commercial one. They will be in the position of operating two networks with different characteristics:

- An analog network with wide coverage and a large subscriber base

- A digital network with low coverage and few subscribers.

The challenge for the operators is to manage successfully the transition from analog to digital system.

DATAQUEST ANALYSIS

Cellular radio has become firmly established across Europe as an indispensable communications medium. Dataquest believes that current trends indicate continued strong growth in the subscriber base well into the 1990s.

Although the United Kingdom has experienced severe price erosion of radio telephone handsets, the prices throughout the rest of Europe are still relatively high. Increased growth in the subscriber base should enable manufacturers to improve manufacturing efficiency, and reduce the prices of mobile equipment. Dataquest also believes that there is room for suppliers of end-user equipment to reduce margins per unit, and increase revenues from the larger volumes that should result.

The introduction of digital networks in 1991 will produce additional challenges for equipment suppliers and network operators. Dataquest believes the advent of competition in network operation will be of benefit to all parties, since prices will fall and demand will rise. The additional features offered by a digital system should greatly enhance its utility to current and future users of mobile technology.

However, we do envisage some transient problems during the introductory period. This topic is discussed in the third newsletter in the series about cellular radio.

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Jim Eastlake
Ted Richardson

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Research Newsletter

ESAM Code: Volume II Newsletters
1989-15
0004614

PART I
CELLULAR RADIO—ITS HISTORY AND PRINCIPLES

INTRODUCTION

Cellular radio has been operating for just seven years in Europe and in that time has experienced tremendous growth which at present shows no sign of slowing down. This newsletter 'is the first in a series of three newsletters about cellular radio. These newsletters are entitled:

- Part I: Cellular Radio—Its History and Principles
- Part II: Cellular Radio in Europe—Growing into the Future
- Part III: Digital Cellular Radio—The Market Forces

This newsletter reviews the history and principles of this communication medium. The second newsletter reviews the current European market and its short-term prospects, while the third newsletter takes a longer-term view and discusses the prospects for the pan-European digital cellular network.

PRINCIPLES OF CELLULAR RADIO

Although the main idea for a "cellular" radio system originated in the Bell Telephone Laboratories in 1947, it was not until the early 1980s that technology made the first systems practicable. The main advantage of a cellular system over conventional mobile radio systems is its ability to handle a wider range of traffic loading through a more efficient reuse of available frequency spectrum. Ultimately cellular systems cater for considerably more customers than the earlier, traditional mobile radio systems.

Cell Structure

The area required to be covered is split into a number of smaller areas (cells). Each cell is equipped with its own radio base station. The cells are arranged together into clusters, the available number of radio channels being allocated to the clusters in a regular pattern that repeats over the entire coverage area. This technique enables radio channels to be reused several times throughout the coverage area.

The number of cells in a cluster has to be chosen such that the clusters fit together into a continuous area. Only certain configurations do this. Typical cluster arrangements are based on 4, 7, 12, or 21 cells (see Figure 1).

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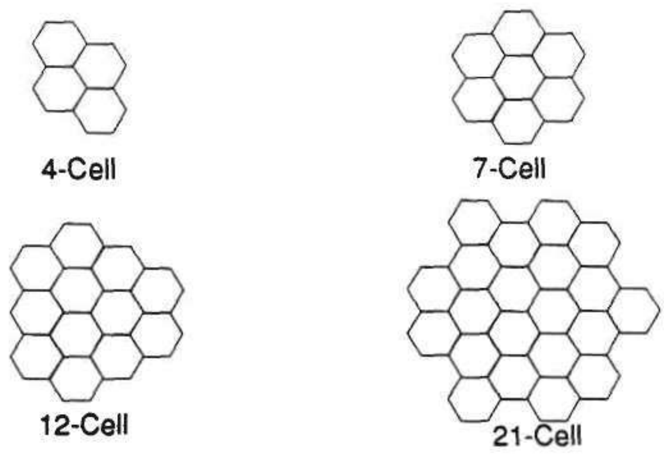
Figure 1

Cell–Repeat Patterns



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Source: Dataquest July 1989

The number of cells in each cluster has a significant impact on the overall capacity of the system. The smaller the number of cells per cluster, the larger the number of channels per cell, and consequently the traffic carried per cell is higher. However, there is a trade–off. Since more channels are being used per cell and the cluster size is smaller (fewer cells), then the distance between cells using the same channels reduces, with the consequence that interference from adjacent clusters increases (co–channel interference).

The total number of channels per cell (and therefore, the traffic) is governed by the total number of channels available and the cell–repeat pattern that is:

$$\text{Total number of channels per cell} = \frac{\text{Total number available channels}}{\text{Cell–repeat pattern (4, 7, 12, 21)}}$$

However, traffic in a particular area can be increased (bearing in mind interference constraints) by reducing the cell size, thereby increasing the number of available radio channels in that area.

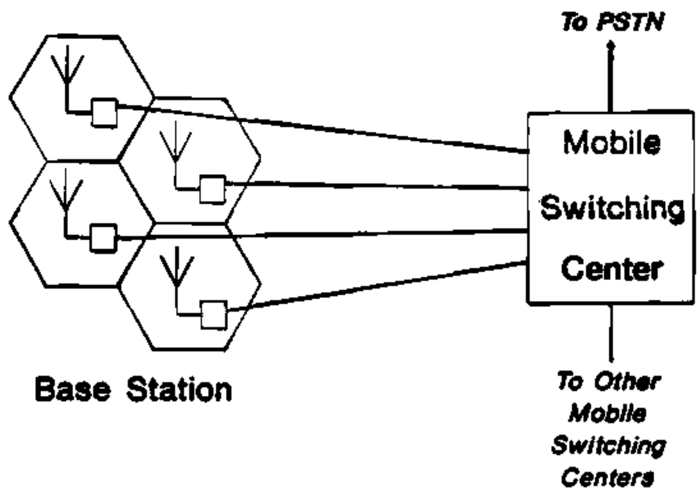
System Structure

Each cell's base station is connected to a switching center, which is a modified central office switch. In practice, a cellular network will consist of several interconnected switching centers, which are themselves also connected to the public telephone network (see Figure 2). This configuration enables the full permutation of call types to be initiated and completed, that is, PSTN to mobile, mobile to mobile, etc.

Two main features within a cellular system enable efficient communication with a mobile subscriber to be maintained. The first of these is the process of "registration", which is the ability of the system to maintain a knowledge of an individual mobile's whereabouts. This is described below.

Figure 2

Cellular Radio Network



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Source: Dataquest
July 1989

Registration

Within the system, a number of radio channels are reserved as common signaling channels. Additionally the network is divided up into a number of traffic areas, each area consisting of a group of cells. The base station generates a code identifying the traffic area to which it belongs, as part of the information transmitted on the signaling channels. A mobile subscriber travels through the network, monitoring the strongest common signaling channel. As the mobile moves from one cell and/or traffic area to the next, it will detect a deterioration in the received quality (usability) of the existing common signaling channel and, therefore, will begin a search for a stronger, more usable signal.

After the mobile has tuned to the new signal, two options for action are possible. The first option is that having crossed a cell boundary, the mobile is still in the same traffic area, in which case (in respect of registration) no further action is taken.

The second option is that the mobile has crossed not only a cell boundary but also a traffic area boundary. In this instance, the mobile transmits its identity to the new base station, which passes the information onto the switching center. Thus the mobile has registered its location with that of the system so that the network is able to route an incoming call to the mobile efficiently and quickly.

In-Call Hand-Off

The second process in the cellular system is that of "in-call hand-off". As a mobile moves throughout the coverage area it may cross a cell boundary while a call is in progress. So that the call is not dropped as it moves from one cell to another, the current base station monitors the received signal from the mobile and will detect any deterioration of the signal in the region of the cell boundary. At this point the base station informs the switching center that a "hand-off" may be necessary. The switching center then commands the base stations in the adjacent cells to monitor the mobile's signal and chooses the best cell to which to transfer the call. A radio channel allocation in the new cell is made and the mobile, via the original base station, is instructed (over the signaling channel) to tune to that selected channel. The final part of the hand-off takes slightly less than 500 ms typically and is barely noticeable to the user. This small break in transmission hardly affects a voice call but, of course, could be disastrous for a data call. Consequently, modems with specific error-correcting protocols are necessary if a user wishes to use a cellular network for the reception/transmission of data.

ADJACENT AND CO-CHANNEL INTERFERENCE

Voice communication is carried on the speech channels. In addition, at certain times, some signaling is also carried on the speech channels.

Speech is carried on the speech channel as an analog frequency-modulated (FM) signal with a frequency deviation of 9.5 kHz. (More traditional radio telephone systems using the same 25 kHz channel spacing generally have a maximum frequency deviation of 5 kHz. This approach was taken to minimize interference problems in adjacent channels.)

The use of higher deviation in cellular radio greatly improves the rejection of unwanted signals on the same frequency (co-channel interference). Co-channel interference is the most significant limiting factor determining the cell-repeat pattern used. However, there has to be a compromise. Increasing the deviation increases the interference to adjacent channels, and if this effect becomes too large it will negate the effect of using higher deviations. This can be controlled by careful channel allocation, for example ensuring that adjacent channels are never allocated in the same cell.

CONCLUSIONS

This newsletter has given a brief overview of the general principles of cellular radio. While cellular radio is not a recent idea, the practicalities of planning and operating such high-capacity systems have been rapidly learnt. Further advances in antenna design, for example, have enabled capacity to be increased by further dividing urban cells (sectorization).

The rapid move towards an all-digital technology will again increase the utilization of the available frequency spectrum. Further techniques still to be honed into practical solutions lie in the areas of modulation techniques and reduced channel spacing.

The number of cellular subscribers has grown considerably over the past seven years, and is still growing—proof that there is a considerable future market to exploit this technology further.

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Jim Eastlake
Ted Richardson

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Research Newsletter

ESAM Code: Volume II, Newsletters
1989-14
0004480

DATAQUEST'S EUROPEAN SEMICONDUCTOR INDUSTRY CONFERENCE: "THE EUROPEAN RENAISSANCE"

SUMMARY

Dataquest's eighth annual European Semiconductor Industry Conference was held recently at the Park Hilton, Munich, West Germany. The theme of the conference, "The European Renaissance," provided an excellent opportunity to discuss how Europe's consolidation of twelve economic entities into one will affect the ways that both Europeans and non-Europeans do business.

Many key issues were discussed, including the following:

- Application markets
- International trade
- Distribution
- Deregulation
- Mergers and acquisitions
- New technology

This newsletter summarizes the information presented, by topic and speaker, at the conference.

SPEAKER HIGHLIGHTS

The following extracts are highlights from the conference presentations.

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"World Economic Overview"
Joseph W. Duncan, Corporate Economist and Chief Statistician
Dun & Bradstreet Corporation

The U.S. trade deficit has been the world's engine of growth, but President George Bush's economic policy will have to tread a careful path between Draconian deficit reduction, which could lead to recession, and reduction measures that are too lax, which could lead to higher inflation. Mr. Duncan believes that President Bush can find the right balance and predicts high growth for the U.S. economy in the first half of 1989 and slow growth in the second half.

However, five factors could affect that prediction as follows:

- A bail-out for the savings and loans will occur this year and will cost each U.S. citizen $1,000.
- The U.S fiscal deficit can only be reduced by higher taxes, and it is expected that corporation taxes will be increased.
- New Soviet links offer the United States the chance to reduce its obligations to NATO and give economic credits to Russia, which would help reduce the budget and trade deficits.
- Action will have to be taken on the debt burden of the less developed countries.
- Action will have to be taken on the growth of leveraged buyout debt.

"New Frontiers in Technology"
Hans Geyer, Assistant General Manager
Intel Europe

Intel has spent $250 million in the last five years on CAD, and every Intel design engineer has a Sun hooked to VAXes and IBM mainframes for simulation. Thus, Intel's 'Megaprocessor' strategy for 1-million-plus transistor chips like the 486, i860, and the new version of its 80960 is well supported. These chips require close cooperation in the early stages of the design cycle between design technologists, process technologists, and manufacturing personnel. The result is that Intel's chips will be made on processes so complicated and unique to Intel that no other company will be capable of manufacturing them. Processor technology is evolving fast toward the microprocessor of the future, which, by 2000, will have 100 million transistors, 250-MHz operation, 2,000 mips and 1-billion-flops performance.

"Manufacturing Globally"
Joel Monnier, Worldwide Corporate Manufacturing Manager
SGS-Thomson Microelectronics

The Japanese strength is in manufacturing science. SGS-Thomson has targeted the manufacturing standards it wants to attain within the next six years to match Japanese capability. The key is equipment uptime: SGS-Thomson's target is to increase the average length of time for which equipment works without stopping from today's

30 minutes to 600 minutes by 1995. In 1995, SGS-Thomson expects to have peopleless fabs that will be six times more productive than present fabs. SGS-Thomson has targeted 1990 for its 4-Mbit EPROM on a 0.8-micron process, 1993 for a 16-Mbit EPROM on a 0.5-micron process, and 1996 for a 64-Mbit EPROM at 0.3 micron.

"The New Cordless Community"
Barry Moxley, Managing Director
Phonepoint

Research indicates that a cheap, light, cordless telephone that is usable anywhere would have a large market. Semiconductor technology now allows digital cordless systems to replace analog systems, thus allowing for a high density of users—3,000 per square kilometer—for which interference problems have ruled out analog systems. When combined with the lower power, which means smaller, lighter batteries are required for the modern telephone chip sets, this allows for the rapid evolution of cheaper, lighter, and smaller phones. Prices will follow a similar course, as was seen with calculators, and in the future, it will be common for people to own several cordless telephones.

"RISC versus CISC"
Bob Miller, President, Chairman and CEO
MIPS Computer Systems Inc.

With MIPS' performance capabilities on 260,000 transistors, there is no need to design 1-million-plus transistor microprocessors like Intel's. Also, MIPS has five competing sources (instead of one for Intel microprocessors) and a rapidly increasing level of performance—60 to 70 mips in CMOS this year, 120 mips in ECL in 1991, and 180 to 220 mips in GaAs in 3 to 4 years' time. In 1993, 7 million of the estimated 16 million processors sold will be RISC based. The RISC performance levels are achieved primarily through software (particularly the compilers), rather than from pushing the technological limits of silicon hardware. If Microsoft succeeds in making OS/2 portable, and an "informed rumor" says it is working on it, then RISC must win over CISC.

"Electronics in the Automotive Environment"
Enrico Ferrati, Research and Development Manager
Marelli Autronica SpA

The value of electronics in a car is now about 5 percent of the value of the car, but this percentage will rise to 20 percent by the year 2000. Electronics will be used in power steering, digital displays, information control, active suspension, electronic transmission, shock damping, antilock systems, and engine management. Electronics features will amalgamate into electronics subsystems, which will be integrated together on ASIC chips. Such subsystems will be in the areas of power management, chassis control, information management, and various convenience features. ASICs and smart power will account for 50 percent of the automotive semiconductor's total available market (TAM) in 2000, whereas the current TAM is 50 percent discretes, 35 percent standard ICs, 10 percent microcontrollers, and 5 percent ASICs.

"Positioning Internationally"
Robert Freischlag, President
Fujitsu Mikroelektronik

The European semiconductor market is expected to grow from $8.5 billion in 1988 to $12 billion by 1992. European companies that rely on state support and protectionist legislation will lose out, while the most efficient companies will survive. Cars and semiconductors, however, will receive national protection from their governments. Non-European companies that merely export to Europe will be in trouble. Those who want to win will need a European headquarters sales office, assembly, packaging and test facilities and diffusion plants. To support the future market they will also need increased R&D. Companies will need to pursue global strategies, while retaining their sensitivities to local needs.

"Integrating into Europe"
Barry Waite, Vice President and General Manager Europe
Motorola Semiconductor

Europe has 360 million consumers, of whom 320 million are in the European Economic Communities (EEC) compared with 250 million in the United States. Europe's GNP is $4.7 billion—10 percent more than the U.S.'s GNP. Europe's semiconductor requirements are supplied 43 percent by U.S. producers, 38 percent by European producers and 19 percent by Japanese producers. New markets for semiconductors will account for 40 percent of the 1994 semiconductor TAM. These markets will be in car safety, emission controls, intelligent credit cards, ISDN, HDTV, CD-I, pan-European digital cellular phones, and satellite TV. As Europe grows in self-sufficiency, it will increasingly manage free trade to the point where capital and information will be the only freely traded worldwide commodities.

"Global Distribution in the 1990s"
Stephen Segal, Executive Vice President
Future Electronics Inc.

The world is becoming a global marketplace characterized by huge TAMs (e.g., a 1993 distributor TAM of $5.7 billion); world trade liberalization (e.g., the push to open up the Japanese market); consolidations, acquisitions, and mergers (e.g., Harris/GE/RCA); technology alliances (e.g., Motorola/Toshiba, Texas/Hitachi, and new fabs (e.g., Amphenol and Fujitsu in Scotland). The strategy for non-European distributors in Europe is fourfold, as follows:

- Have deep pockets to prepare for a nonprofit period of up to two years
- Enter Europe through start-ups or takeovers
- Be structurally efficient—ship-from-stock and credit, single price globally, MIS systems, regional warehousing
- Form quality partnerships with a few global customers on a global supply basis

"Think Global—Act Global"
Jose Menendez, General Manager and President of the Executive Committee
Sonepar Group

Think global and act local. Europe is a more difficult place to do business in than outsiders expect: the many different currencies, local customs, languages, and credit practices all contribute to outsiders' confusion. Sonepar deals with nine different nationalities and believes that there is a long way to go before the European market can be addressed in a single, logical manner using standardized methods. Sonepar's personalized contacts, market data, and ability to provide local assistance and service can help manufacturers to penetrate Europe by providing manufacturers with early anticipation of demand (without manufacturers losing control of their marketing and distribution networks).

"A Vendor's Viewpoint on Distribution"
Marco Landi, Vice President, Semiconductor Marketing and Sales
Texas Instruments

A shake-up is coming in European distribution. One reason for the shake-up is the declining profitability of the industry (e.g., a major distributor has closed in Italy, and Unitech has made a major disinvestment). The year 1992 will accelerate this shakeout because there are new European distributors (BMW bought Kontron). Also, new non-European companies want to enter the market. Who will survive? The following characteristics point to success:

- Pay attention to cost of sales
- Differentiate in selected market segments
- Commit to close relationships with manufacturers
- Invest in EDP for inventory management
- Look for profit before sales growth
- Broadline
- Generate demand as well as serve it

"Pan-European Distribution"
Edward D Burgess, General Manager
ITT Distribution Worldwide

Pan-European distribution must satisfy 80,000 customers in 15 countries which collectively purchase $2 billion worth of semiconductors annually. Furthermore, it needs to help its major customers reach customers that they cannot serve directly, which represent 15 to 35 percent of the TAM. It would be attractive for a supplier to sign one agreement that contains the same contractual conditions for all 15 countries with one distributor and have that distributor service 15 national markets. But pan-European franchises are rare, and not all distributors have Europewide management or warehousing. The year 1992 should see an increase in the share of the TAM that goes through distribution, but the large investments required to be pan-European and the declining profitability of the industry may turn out to be insurmountable hurdles for some companies.

"Introductory Remarks on the European Renaissance"
Jean-Marie Cadiou, Director of ESPRIT
Commission of the European Communities

The European IT industry has some weaknesses—it is dependent on non-European microprocessors and foreign chips—but it is looking better. ESPRIT 2 will produce 0.5-micron CMOS ASIC and 0.5-micron SOI processes. Europe still needs an engineering culture to bring leading-edge chips to market. ESPRIT 1's successes included a state-of-the-art BiCMOS process; spectacular results in the silicon compiler project; and the Supernode project, which produced parallel processing machines that beat Intel. Opportunities for Europe lie in HDTV, ISDN, and broadband communications networks.

"Procuring in the 1990s"
Dan Byrne, Director of European Operations
Apple Computer

Apple wants to be a truly European computer company. Since 1986, it has been doubling the annual amount of its European-sourced components. Recently that process has accelerated and in 1989, the company will source the same number of components from Europe in one quarter as it sourced in the whole of 1988. Apple's procurement requirements are as follows:

- Shipment on an as-needed basis to fit with the Cork manufacturing plant's flexible production schedules
- Apple works to 0.5 percent defects today and is moving to 0.05 percent in the early 1990s as part of its commitment to high quality
- Competitive prices that are key to Apple, because 90 percent of its product cost is materials cost
- New products/technology, because Apple has a total bias toward innovation and needs suppliers that can keep it ahead of the technology curve

"A European in the International Scene"
Heinz W. Hagmeister, Managing Director and CEO, Business Unit ICs
Philips Components

Fewer companies are buying more and more of the world IC output. These companies are multinationals that operate with local profit centers, but which demand worldwide pricing and high standards of service and quality. Currently, 15 companies buy 15 percent of the output of the semiconductor industry. These major customers are reducing the numbers of vendors that they deal with and thus require global servicing. Philips Components is responding by strengthening its presence in the Asia/Pacific region.

"Telecommunications Technologies for the 1990s"
Horst Ohnsorge, Director, Research and Technology
Alcatel

Already the 29 biggest cities in Germany have been linked with 500,000 kilometers of fiber-optic cable for a broadband communications system. Fiber-optic technology is also prevalent in other countries: Fiber-to-the-home is the goal in the United States, with trials in 11 cities; France has the Biarritz network; the United Kingdom has the Milton Keynes network; Canada has the Elie Manitoba net; and Japan has the Hi Ovis network. Technical advances that are required to service broadband communications equipment include the following:

- 1-million-plus transistor ASICs with less than 50ps gate delays
- 32-Mbit memories with 1 ns access time costing 10 ECUs
- 500-mips, 32-bit microprocessors with 100-MHz clock rates costing 50 ECU

"Eastern Europe and Perestroika"
Yuri Levine, Senior Research Fellow
Institute of World Economy and International Relations, USSR Academy of Sciences

Having a nonconvertible currency, an inefficient bureaucracy, and a state monopoly on foreign trade have contributed to slow economic growth in Russia. However, since December 1988, every Russian company has had the right to trade abroad and find partners. By the end of 1988, 200 joint ventures—representing Western investment of $441 million—had been registered. So far, in 1989, 300 more have been added. There is no limit on the percentage share that foreign companies can hold. Nonconvertibility of the ruble poses problems for foreign companies that want to repatriate profits. Either the Commerce Ministry could find ways around that problem, or Western companies could either purchase Russian goods and export them or export the products of the joint venture.

"Consumer Europe"
Jacques Noels, President and CEO
Nokia Consumer Electronics

A revolution is taking place in Europe on several fronts. First, a revival of interest in consumer electronics with big investments in HDTV, in satellite broadcasting, and DSP is taking place. Second, the technical revolution that has changed the computer world has not yet affected consumer electronics, but it will—TVs in the 1990s will have 50 Mbytes of RAM. Third, personal electronics will become big business, especially with home-integrated systems. Fourth, what effect will 1992 have? And, last but not least, are the effects of deregulation. European governments should support the industry that is fighting not only the Japanese but the developing countries as well.

"The European Renaissance"
Jurgen Knorr, Senior Vice President, Components Division
Siemens

If a renaissance in Europe's electronics industry is to occur, the industry will need to catch up in microelectronics technology. Siemens believes that it is only six months behind the Japanese with the 4-Mbit generation of DRAMs and will catch up with 16 Mbit technology. It will cost $3.7 billion to reach the stage of producing 10 million 16-Mbit DRAMs a month. The R&D cost for the 16-Mbit DRAMs will be $500 million. It is an expensive and risky business, but dependency could result if only one member of the triad has DRAM manufacturing capability. JESSI, funded 50 percent by participating companies and 25 percent by the EEC, will ensure that Europe maintains its position in DRAMs. "So we see a green light for the European semiconductor industry."

Byron Harding

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A new directory describing 30 Dataquest Research Publications is now available from Dataquest's Direct Marketing Group. The directory includes information on the following:

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ESAM Code: Volume II, Newsletters
1989-13
0004342

INTERNATIONAL SEMICONDUCTOR TRADE ISSUES—DOMINANCE, DEPENDENCE, AND FUTURE STRATEGIES

OVERVIEW

Trade issues have been a major concern throughout the world thus far in 1989. The Japanese semiconductor manufacturers have achieved dominance of the worldwide DRAM market, while U.S. manufacturers still hold a comfortable lead in high-end microprocessors. The European semiconductor producers, particularly in view of the forthcoming 1992 combined-market scenario, have pledged that they will be in a position to supply Europe's semiconductor needs. Finally, substantial growth is being seen throughout the Asia/Pacific region as Taiwan, Korea, and Singapore rapidly expand their semiconductor production base.

Dataquest forecasts a global semiconductor industry taking shape by the mid-1990s, with a more balanced distribution of products and technologies than we witnessed in the 1970s and 1980s. However, with the trade press burgeoning with weekly—if not daily—statistics regarding export balances, threats of protectionism, and national agendas for critical electronic components, it is difficult to sort out the true current situation in the worldwide market. Dataquest has taken an alternate perspective on current worldwide production/consumption of semiconductor components and has classified each region as to whether it consumes more ICs than it produces or has a sufficiency for export after satisfying domestic needs. This net difference for each region, presented by major product category, is a measure of the self-sufficiency profile for each region. By understanding the net consumer or net producer profile of each region, we can anticipate strategic moves that the IC producers in these regions may make in the international marketplace.

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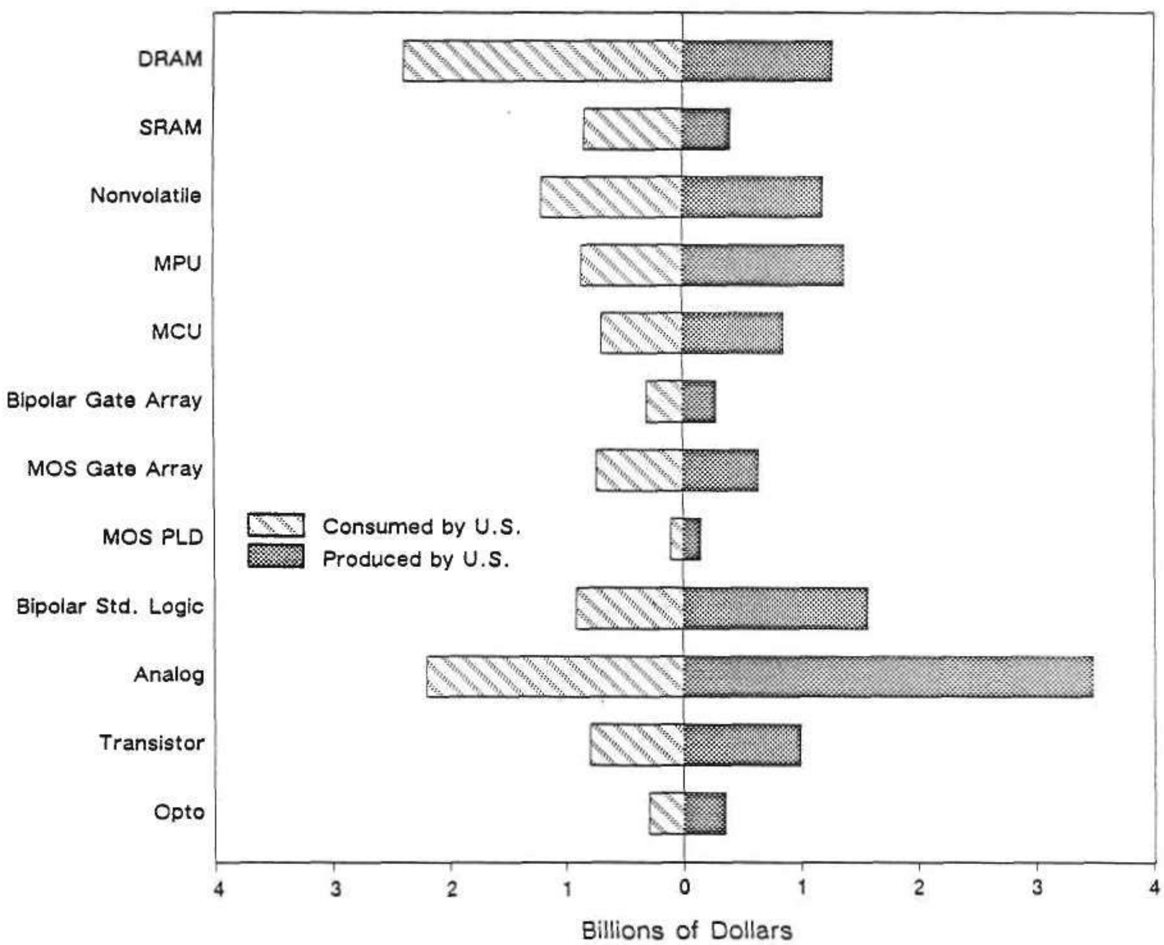
PROFILES BY REGION

U.S. Companies

We begin our analysis of worldwide production and consumption of ICs with a look at the U.S. semiconductor consumption/production profile. Figure 1 illustrates that the United States has a relatively symmetrical consumption/production profile, except for DRAMs and analog ICs. Figure 2 presents a better picture of the United States' position as a net consumer or net producer of ICs. From it, we can see that the United States is a net producer of both microprocessors and microcontrollers of bipolar standard logic, analog ICs, and discrete transistors. However, as expected, the United States also is a net consumer of DRAMs, a net consumer of SRAMs, and, surprisingly, a net consumer of both bipolar and MOS gate arrays.

Figure 1

Semiconductor Consumption/Production Profile
United States

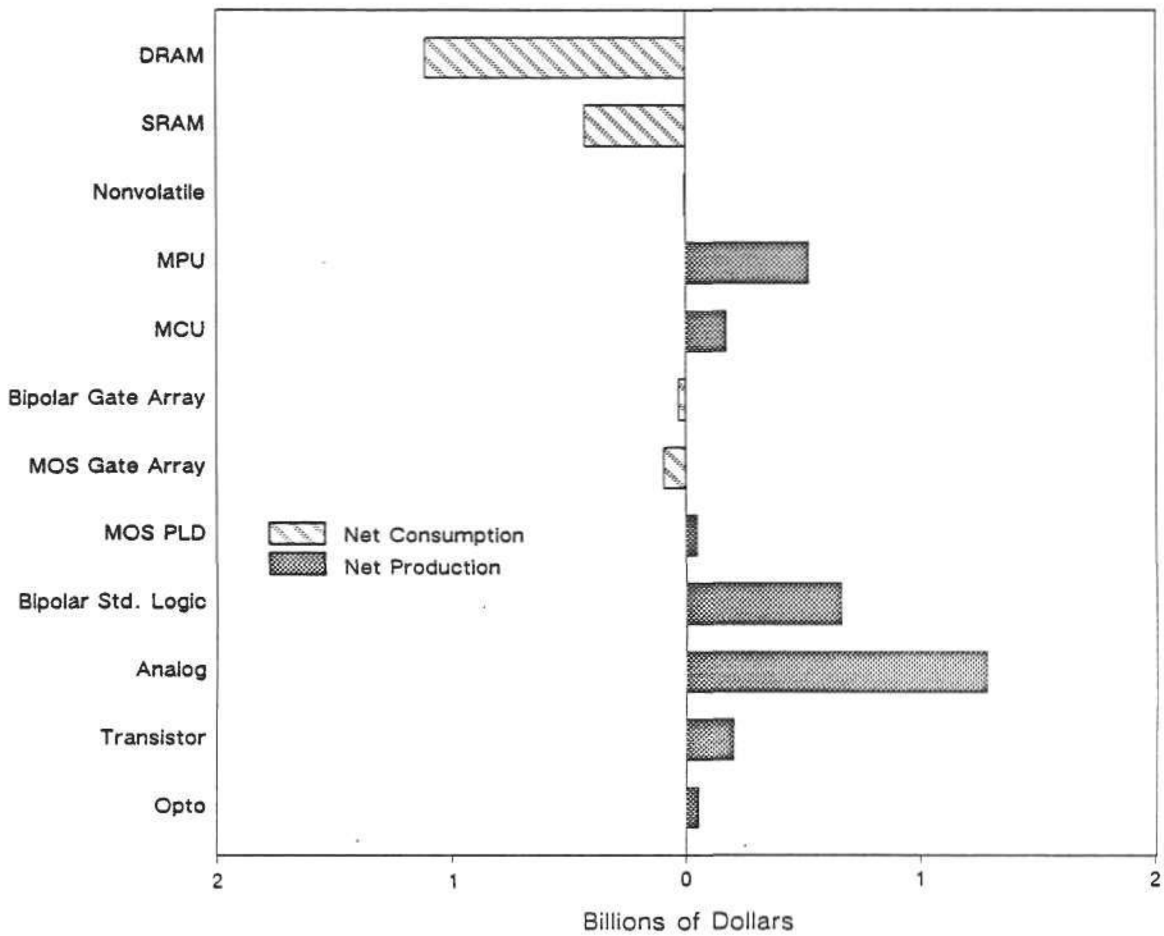


0004342-1

Source: Dataquest July 1989

Figure 2

Difference between Semiconductor Consumption and Production United States



0004342-2

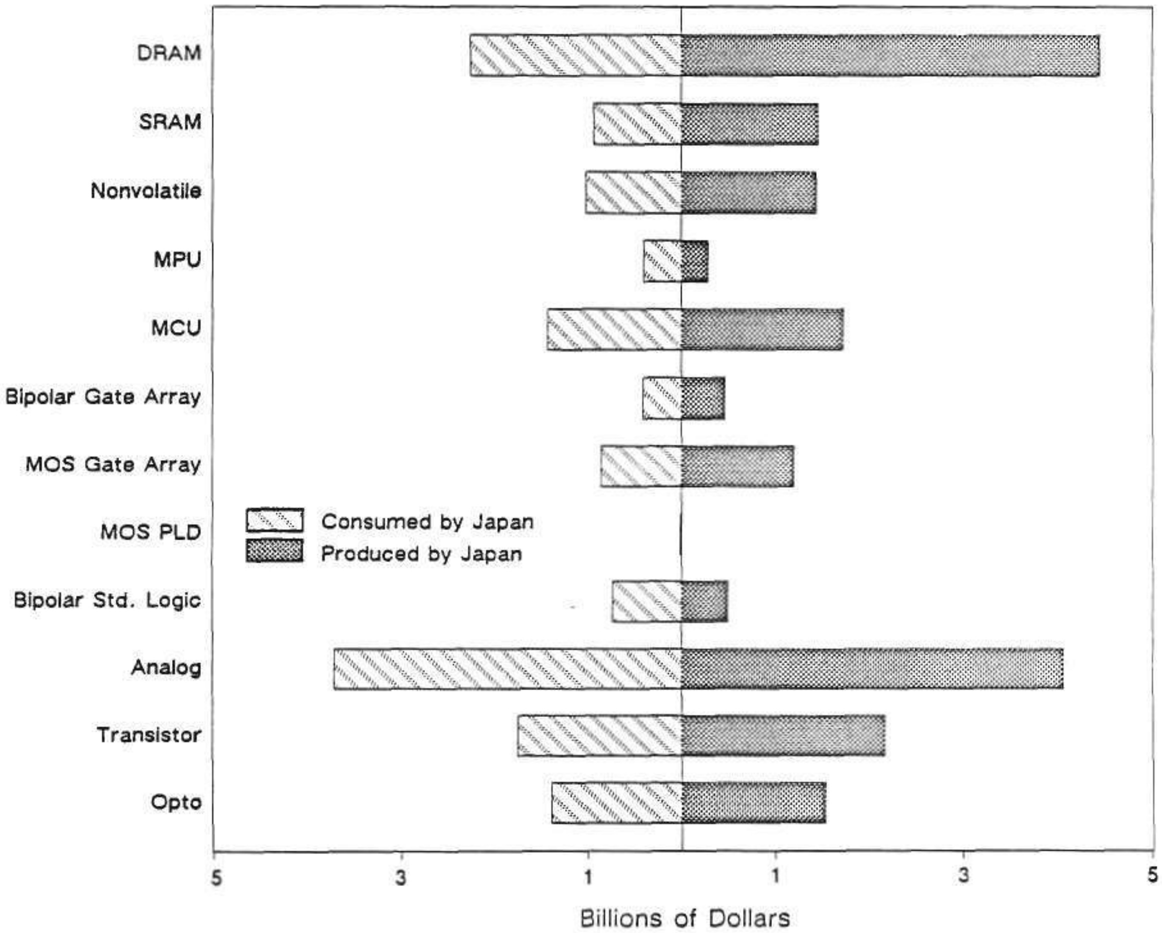
Source: Dataquest July 1989

Japanese Companies

Figure 3 presents the overlay of Japanese semiconductor consumption, and Figure 4 presents the net consumption/production chart as it relates to Japan. These figures illustrate that Japan is overwhelmingly a net producer of ICs and that it consumes only microprocessor units, MOS PLDs, and bipolar standard logic from foreign sources.

Figure 3

Semiconductor Consumption/Production Profile Japan

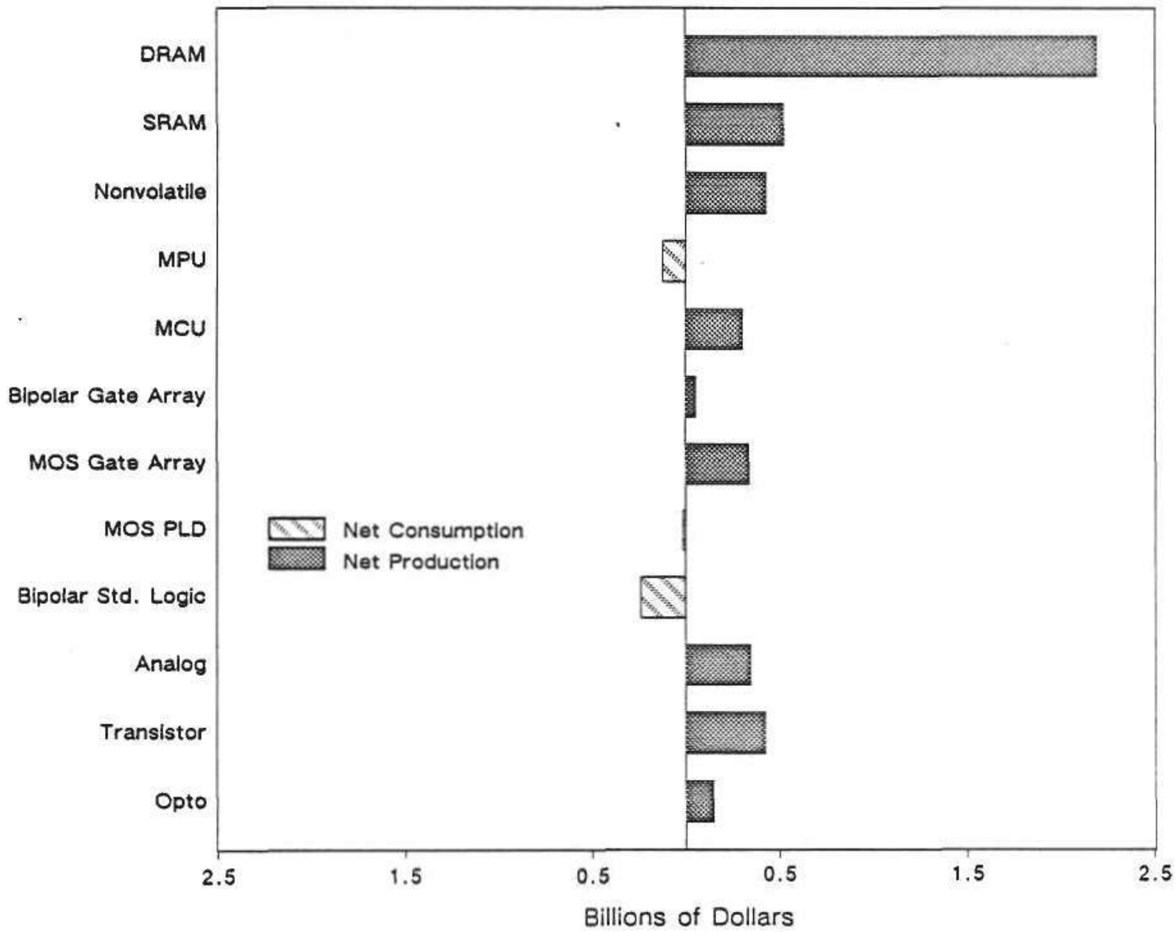


0004342-3

Source: Dataquest July 1989

Figure 4

Difference between Semiconductor Consumption and Production
Japan



0004342-4

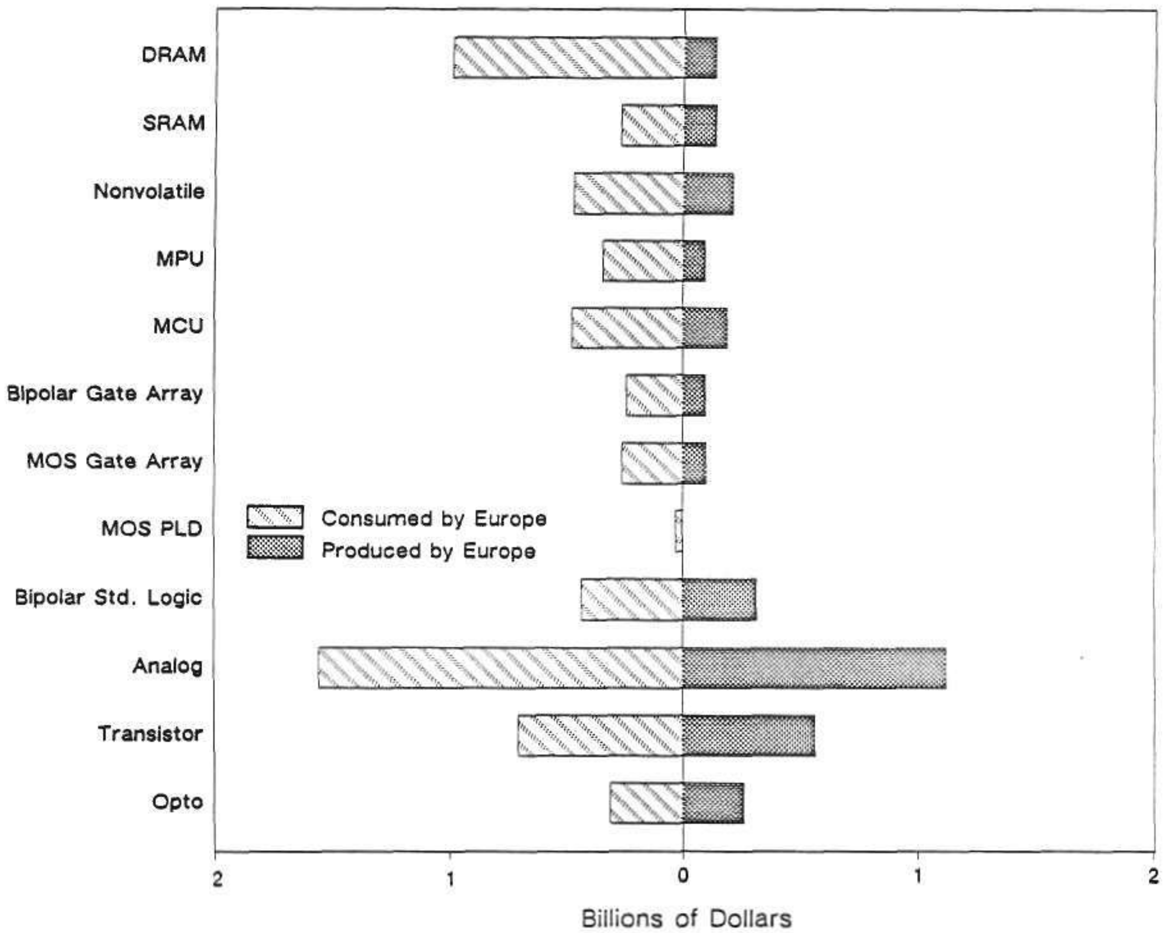
Source: Dataquest
July 1989

European Companies

Figures 5 and 6 depict the consumption/production scenario for Europe. As seen in Figure 6, Europe is a net consumer of foreign semiconductors in all categories.

Figure 5

Semiconductor Consumption/Production Profile
Europe



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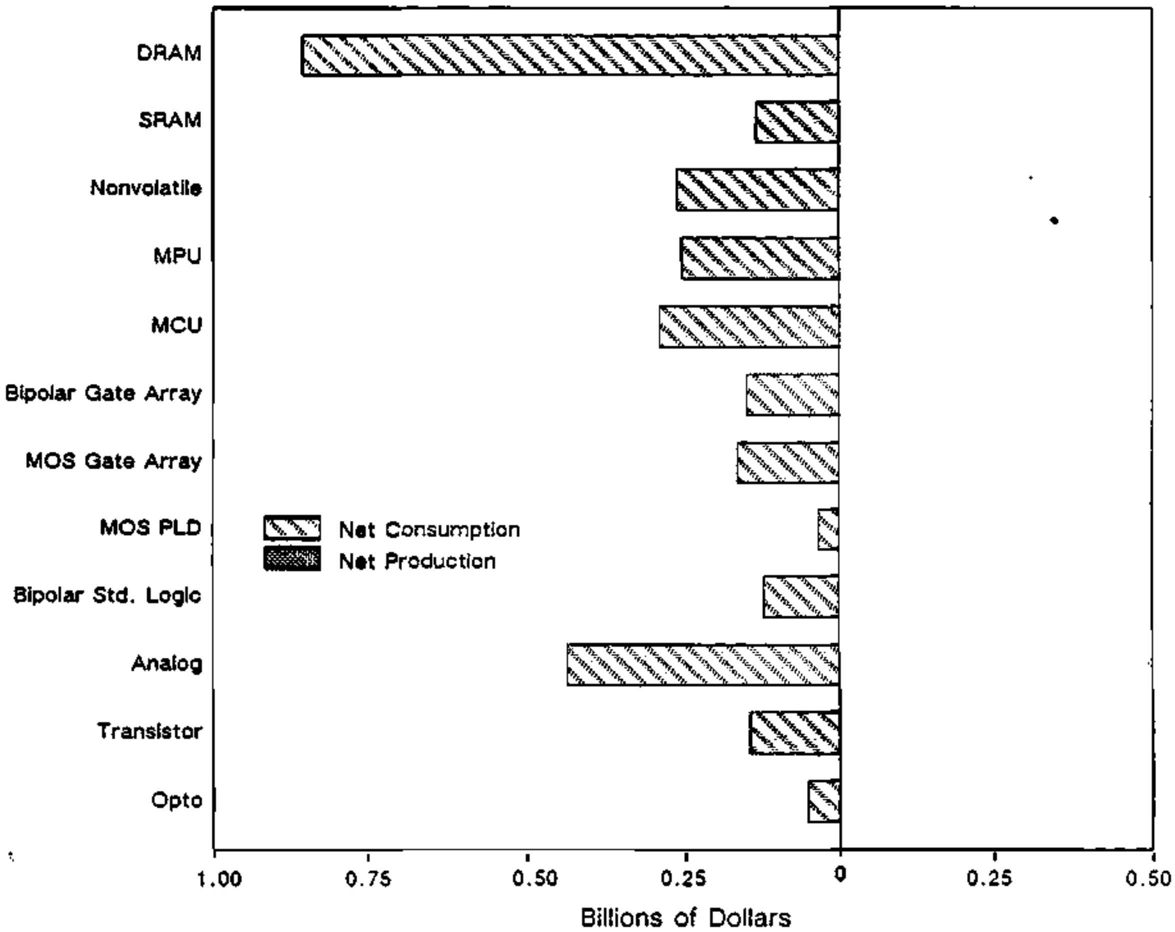
Source: Dataquest
July 1989

Figure 6

Difference between Semiconductor Consumption and Production
Europe



0004342-6

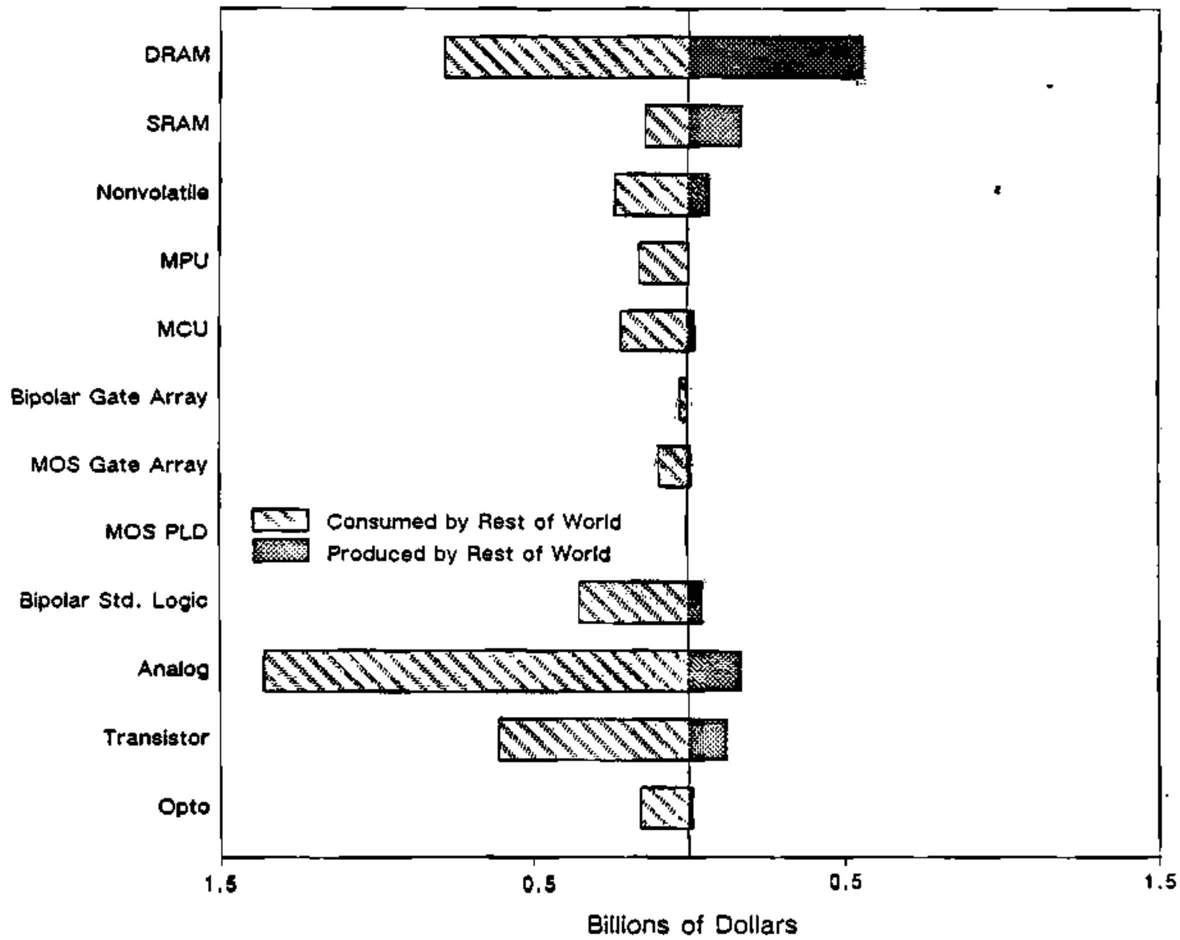
Source: Dataquest
July 1989

Asia/Pacific and ROW Companies

Figures 7 and 8 depict the consumption/production profile for the rest of the world, which is essentially Asia/Pacific. As seen in these figures, ROW is a net consumer of foreign ICs, with the exception of SRAMs.

Figure 7

Semiconductor Consumption/Production Profile
Rest of World



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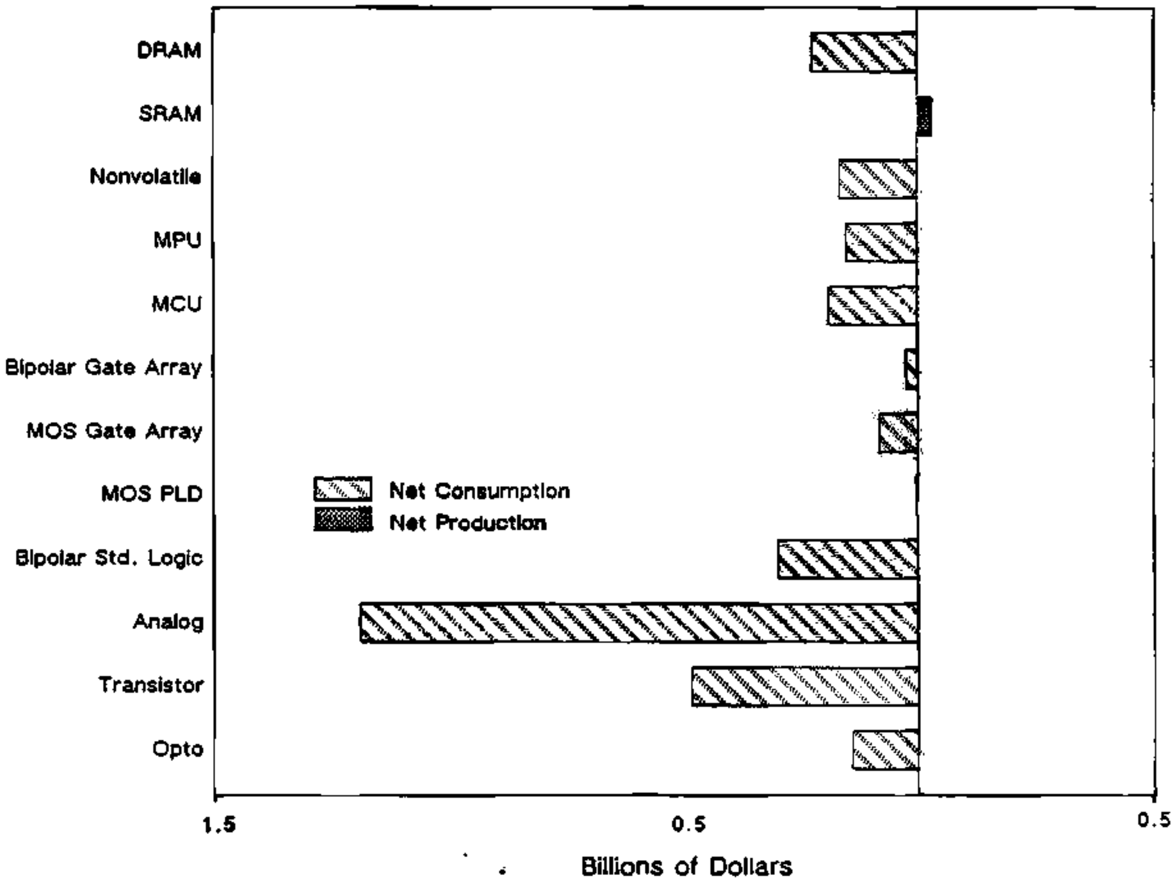
Source: Dataquest
July 1989

Figure 8

Difference between Semiconductor Consumption and Production
Rest of World



0004342-8

Source: Dataquest July 1989

DATAQUEST ANALYSIS

Viewing the information in the net consumer/producer format allows one to quickly assess the characteristics of a certain region and also allows one to anticipate strategic moves that the semiconductor producers and system manufacturers in the region may make to defend markets or to obtain a better balance between consumption and production. Viewing the U.S. consumption/production profile, Dataquest believes that the United States will become a larger producer of both DRAMs and SRAMs and may become a net exporter of SRAMs in the next four to five years. Most of the semiconductor start-up companies that have begun operations in the United States in the last four years have some plans in place to produce SRAMs and specialty memories. Therefore, we believe that the United States will take a stronger position in SRAMs in the 1990s.

Dataquest believes that U.S. producers will continue to exercise dominance in microprocessors, given their superiority in complex design and software expertise; however, we also believe that the United States will become a net consumer of microcontrollers as Japanese companies gain expertise in this technology. This is particularly true for the less complex microcontrollers, which are embedded into a vast array of consumer electronic products and office equipment.

The U.S. companies' position in gate arrays, both bipolar and MOS, is surprising. Already, in this relatively young market, the United States does not produce enough to satisfy its own needs, suggesting underinvestment in this important and growing market. Unless dramatic changes occur, and occur very soon, we believe that non-U.S. suppliers will gain dominance in MOS gate arrays and that the U.S. electronics industry will continue to consume more gate arrays than it produces in the 1990s. Finally, although the U.S. IC producers appear to have a strong position in analog ICs, we believe that this strength will diminish somewhat in the 1990s, resulting from the lack of an indigenous consumer electronics industry.

To no one's surprise, the Japanese IC suppliers are the world's leaders in DRAMs. Dataquest believes that the Japanese companies will continue in their dominance of these markets and will be substantial net producers of DRAMs in the 1990s. Numerous Japanese companies are well positioned in 4Mb DRAMs already and are beginning to focus their attention on the 16 and 64Mb DRAMs. With this much inertial energy, we believe that it will be difficult for anyone to dislodge the Japanese IC producers from this number-one status. We believe that the Japanese semiconductor producers will continue to strengthen their position in gate arrays and soon will begin to focus their energies on the MOS programmable logic device (PLD) area. Although it is purely speculation at this point, we believe that in the light of increasing trade friction, the Japanese suppliers may pursue microprocessor devices with less intensity and that the Japanese electronics industry will continue to be a net importer of MPUs, particularly 32- and 64-bit MPUs.

The European region forecast is less clear. The European electronics industry, at this time, is substantially dependent upon non-European sources for its critical semiconductor devices. We will have to wait to see if the "1992 Effect" and the recent consolidation of several European IC manufacturers will have a positive impact upon this profile as we head into the 1990s.

Dataquest believes that the area wherein the greatest change in profile could occur will be ROW--principally, Taiwan, Korea, Singapore, and Malaysia. Taiwanese and Korean companies are making substantial increases in semiconductor manufacturing capacity. In the last year alone, Taiwan has witnessed several new IC start-ups focused on the SRAM market as well as incorporation of SRAMs into the product profiles of many of the existing Taiwanese companies. Korean companies are well positioned to gain a major role in DRAMs. Singapore, Malaysia, and Taiwan, to some extent, have large amounts of installed foundry capacity. Dataquest believes that several of these foundries may begin to run SRAM-type products as technology drivers and as capacity balancers, further enhancing the region's image as a net producer of SRAM-type products. We also believe that there will be increased activity in both microprocessor- and microcontroller-type products, especially in Taiwan and Korea, as these regions' technical competency increases in high-end personal computers and workstations.

Dataquest anticipates an era of greater interdependence among geographic regions, beginning in the early 1990s. We believe that this will be especially true among the electronic IC companies of the United States, Japan, and Asia/Pacific, as all of these regions attempt to arrive at an amenable trade balance. We further believe that European industry will first focus on meeting a greater share of its own internal needs in the early 1990s and then join the other regions of the world in the mid- to late 1990s as the electronics industry becomes truly global in nature, with virtually no geographical boundaries.

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Byron Harding
David Angel

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Research Newsletter

ESAM Code: Volume II, Newsletters
1989-12
0004018

THE PC CHIP SET MARKET: WADE IN CAREFULLY—THE POOL IS FULL!

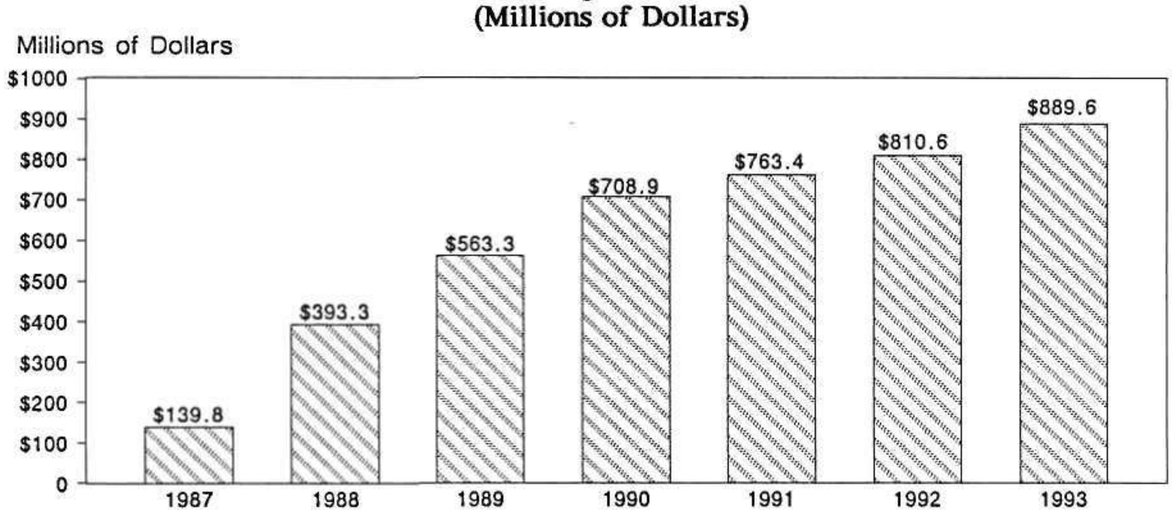
INTRODUCTION

Worldwide, there were only six PC logic chip set vendors in 1987. In 1988, the number climbed to 13, and by the end of this year Dataquest expects to see 19 vendors worldwide. The new entrants are both large, well-capitalized semiconductor manufacturers and small, start-up design houses. These new suppliers have been attracted by the tremendous growth rate of the market and the initially small number of participants. This is characteristic of any emerging market. The main differences between this market and other emerging markets are the large amount of standardization already present and the ease of sizing the market by examination of the total number of PCs shipped.

Dataquest believes that the rapid increase in new entrants and capacity will bring this industry to the saturation level by the end of this year, based on the Dataquest PC shipment forecast. We expect this saturation to lead to aggressive price competition, driving vendors to look for penetration of these products into new applications and markets. Figure 1 presents Dataquest's estimated actual and forecast revenue for the worldwide PC logic chip set market.

Figure 1

Worldwide PC Chip Set Market Forecast
(Millions of Dollars)



0004018-1

Source: Dataquest
May 1989

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HIGH GROWTH RATE ATTRACTS MANY NEW ENTRANTS

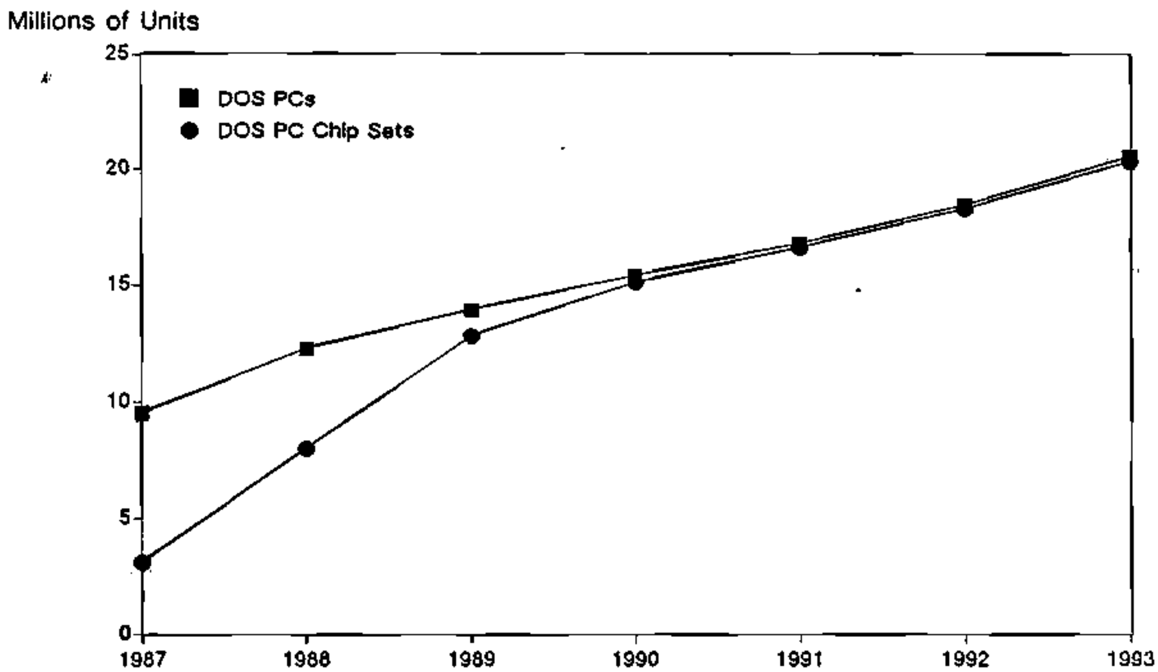
Dataquest estimates the compound annual growth rate (CAGR) for chip set unit shipments from 1987 to 1993 to be about 38 percent, an attractive rate of growth to investors, which should entice them to seek ways to participate in this industry. However, because of the nature of the relationship between PC consumption and chip set consumption, it is important for potential new entrants to look at the development of this market in terms of the product life cycle.

Figure 2 graphs shipments of chip sets against the shipments of DOS PCs, showing the rapid rise of chip set shipments as they approach the level of PC shipments. Between 1987 and 1988, chip set shipments grew by 157 percent. The estimated CAGR for 1987 to 1990 is still almost 70 percent. Dataquest estimates that during this same period, the number of chip set vendors will increase from 6 to 23.

Dataquest believes that, in 1990, the penetration of chip sets into PCs will likely approach saturation. By the end of 1989, the penetration will be about 92 percent. At this point, the growth rate of chip set shipments will be tied directly to the growth rate of PC shipments. In fact, the CAGR for chip set shipments from 1989 to 1993 is estimated at only 12.2 percent. This level of growth should attract fewer new entrants and cause some participants to exit the industry.

Figure 2

Worldwide PC Logic Chip Set Market Forecast as Compared with the DOS PC Forecast (Millions of Units)



Number of Vendors:	6	13	19	23	20	18	17

0004018-2

Source: Dataquest May 1989

A Case of Overcapacity

According to a Dataquest survey, worldwide logic chip set vendors expect to ship more than 15 million units in 1989. Table 1 lists the results of this survey along with Dataquest's estimated actual and forecast numbers for chip set and PC unit consumption for 1987 through 1989. The vendors expect to ship 17.5 percent more than the forecast for chip sets in 1989 and 8.1 percent more than the forecast PC consumption.

Table 1

Worldwide PC Chip Set Vendor Survey Results
(Thousands of Units)

	1987	1988	1989
Dataquest DOS PC Consumption Estimate	9,552	12,293	13,953
Dataquest DOS Chip Set Consumption Estimate	3,116	8,014	12,837
Vendor-Estimated Chip Set Shipments	3,116	8,014	15,095

Source: Dataquest
May 1989

The difference between the vendors' expectations and the Dataquest forecast might be explained by aggressive goal setting on the part of the vendors. One could also argue that some units will be shipped into inventory. It is clear, however, that more than enough capacity exists to satisfy the demand for chip sets, and it is expected that new entrants to the industry will aggravate this situation.

The implications of this analysis should be obvious. The competition for market share in this industry is likely to lead to aggressive, if not predatory, pricing policies on the part of participants. Given the degree of standardization of these products, they will take on more of the attributes of a commodity, where pricing and service are the keys to success.

FORECAST METHODOLOGY AND ASSUMPTIONS

The PC chip set forecast is derived from the Dataquest Personal Computer Industry Service PC forecast and from a survey of worldwide chip set vendors. Each year, Dataquest forecasts worldwide shipments of personal computers. Table 2 gives the Dataquest estimated worldwide shipments for DOS PCs. Dataquest's new chip set forecast for 1989 through 1993 is derived as a function of saturation of the DOS market. The estimates for 1987 and 1988 are based on the chip set vendor survey and Dataquest analysis. The following significant assumptions were made in these forecasts:

- The worldwide DOS PC market will continue to grow through the period at a CAGR of about 14 percent.
- As a general trend, discrete chips will be displaced by very large scale integration. In personal computers specifically, discrete logic chips will be replaced by logic chip sets. Because of the advantages of chip sets for the systems manufacturers—lower cost, better performance, faster time to market—this displacement has happened very rapidly.

- Average selling prices (ASPs) will fall in 1989 because of price competition. They will rise in 1990 as the introduction of EISA chip sets and increased penetration of the MCA chip sets shifts the product mix toward the high end. ASPs will then come down slowly through the rest of the period as price decreases are offset by the continued move in product mix toward the high end.

Table 2

Worldwide PC Logic Chip Set Market Forecast
(Thousands of Units)

	1987	1988	1989	1990	1991	1992	1993	1987-1993 CAGR
DOS PC Shipments	9,552	12,293	13,953	15,444	16,807	18,491	20,570	13.64%
Chip Set Shipments	3,116	8,014	12,837	15,136	16,639	18,306	20,364	36.73%
Saturation	33%	65%	92%	98%	99%	99%	99%	
Chip Set ASP	$44.88	$49.08	$43.88	$46.84	$45.88	$44.28	$43.69	(0.45%)
Chip Set Revenue ($M)	$139.8	$393.3	$563.3	$708.9	$763.4	$810.6	$889.6	36.12%
Chip Set Revenue Growth	N/A	181.2%	43.2%	25.9%	7.7%	6.2%	9.7%	

N/A = Not Available

Source: Dataquest
May 1989

DATAQUEST ANALYSIS

Critical Success Factors for Participants

In order to participate successfully in this industry, vendors will require certain capabilities and resources, including the following:

- Systems Expertise—Systems designers are looking for vendors that can work with them from the beginning of the board design to integrate and sometimes customize a chip set into the system. Chip set vendors with board design and systems expertise will be able to provide this capability.

- Design Tools—Fast chip design turnaround will be required because of short product life cycles. Access to design tools will allow vendors to offer products as a core that can be modified to allow customers some degree of differentiation.

- High-Volume/Low-Cost Manufacturing—Because of the increasing commodity status of these products, access to high-volume/low-cost foundries will be essential.

- Customer Service/Support—Because of the lack of any major differentiation in these products, service and customer support is as important as pricing. A user might not switch vendors for either better pricing or better service, but if offered both, will find it difficult to resist.

Opportunities

As the chip set market approaches saturation and vendors find themselves with excess capacity, they will be forced to look for new applications for logic chip sets outside of the personal computer. Two areas that will benefit from this are the embedded DOS market and the personal workstation market.

Embedded DOS Market

At least one chip set vendor is pursuing embedded DOS applications as its primary strategy, and most others have thought about it as a secondary strategy but have not yet dedicated resources toward this market. The embedded DOS market can be defined as having applications that contain some form of keyboard (input device) and some sort of display (output device) that could benefit from the protocol of the DOS PC logic interface. These applications tend to be for low-end PC logic products. Examples are vending machines, traffic controllers, process controllers, communications, and medical and analytical instrumentation.

Personal Workstation Market

As the high-end personal computer products approach the functionality of low-end workstation products, a segment is developing that some have called the personal workstation market. With the introduction of the Intel 80486 and i860 microprocessors, opportunities exist to develop high-end chip sets that will combine the use of complex-instruction-set computer (CISC) and reduced-instruction-set computer (RISC) microprocessors to offer a system that will run both DOS and UNIX applications. One chip set vendor already has announced plans to develop a RISC chip set.

This market is not well defined. Questions exist as to the size and viability of this segment, and standardization issues need to be resolved.

DATAQUEST CONCLUSIONS

The rapid initial growth rate of the DOS PC logic chip set market has invited many new entrants to this industry and has brought the market from infancy to saturation in a very short period of time. Although a change in product mix toward the high-end products will somewhat offset price declines over the next several years, pricing pressure will be considerable. This will cause some vendors to exit this market altogether and others to dedicate resources to seeking out new applications for these products. Vendors with access to low-cost foundries, appropriate design tools and expertise, and high-quality global sales organizations will stand the best chance of success.

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Jennifer Berg
Ken Pearlman

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Research Newsletter

ESAM Code: Volume II, Newsletters
1989-11
0004016

WILL THE JAPANESE OWN THE 3.5-INCH RIGID MARKET?

SUMMARY

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

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

BACKGROUND

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

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

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

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

SO WHAT'S THE ALARM?

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

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

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

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

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

THE DOMINOS WILL FALL

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

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

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

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

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

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

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

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

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

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

DATAQUEST CONCLUSIONS

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

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

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

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

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Dataquest
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Research Newsletter

ESAM Code: Volume II, Newsletters
1989-10
0003915

CT2—A RISING STAR IN EUROPE

SUMMARY

In this newsletter, Dataquest will examine the equipment and semiconductor markets that the new CT2 digital cordless telephone technologies will drive. We will develop two contrasting but feasible scenarios, an "upside" and a "downside," to assess the markets for the applications that will follow.

CT2 will allow users to make calls onto the public telephone network using portable handsets that will be both very compact and very inexpensive compared with cellular telephones. Calls must be made from fixed points. These may be private places, such as homes and offices, or public locations, such as airports, stations, and main streets. Tariffs for use of the public CT2 "telepoint" services will be smaller than existing cellular ones, and reflect the lower levels of investment per subscriber needed to set up a static cordless network compared with a mobile cellular one.

A common air interface (CAI) standard has recently been developed for CT2 that will transform the cordless telephone into a universal tool for use in homes, offices, and public places throughout Europe. We expect CT2 handsets to reach the market two years before CT2's rival, the technically superior Digital European Cordless Telephone (DECT) standard, is finalized.

In the upside example, we assume that the market for CT2 handsets will be driven mainly by a strong take-up of telepoint services across Europe. These services will allow subscribers to place calls on the public telephone network from pocket-size handsets, provided they are within about 100 meters of a public base station. Following trials in each country, telepoint is likely to begin using the CAI standard in at least five European countries: Finland, France, Spain, the United Kingdom, and West Germany. In this scenario, we estimate that there will be 16 million CT2 handsets in Europe by 1995, or 1 handset per 8 households. From this information, we estimate the total European market for CT2 equipment to be worth $334 million in 1991, rising to $1.2 billion by 1995. By the year 2000, the cordless telephone will have become as much a part of everyday life as the hand calculator is today.

The downside version takes a pessimistic view of the uptake of telepoint systems in Europe, restricting them to only the United Kingdom and France. Using this perspective, we estimate the total European market for CT2 equipment to be worth $75 million in 1991, rising to $666 million by 1995, driven mainly by the demand for office and home-based CT2 systems.

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CORDLESS STANDARDS

CT2 cordless technology developments have been most prolific in the United Kingdom, with six different applications for standards submitted to the United Kingdom's Department of Trade and Industry (DTI) by early 1988. To overcome these conflicts, a single CAI specification since has been developed by seven UK companies—British Telecom, Ferranti, GPT, Mercury, Orbitel, Shaye, and STC—under the guidance of the DTI.

After three public consultative meetings attended by manufacturers and operators from most European countries, the DTI now has frozen the CAI to make it the basis of a memorandum of understanding (MOU) between several countries for a roaming telepoint service in Europe. These countries are likely to include Finland, France, Spain, the United Kingdom, and West Germany, and may also include others such as Ireland, Italy, and Portugal if consumers accept the telepoint system.

The CAI standard outlines the minimum specifications necessary to permit handsets to interwork on a public telepoint or private network, yet afford manufacturers the maximum opportunity to differentiate and enhance their products with special functions. The following key features may be deduced from the CAI document:

- High call density—CAI provides for dynamic allocation of 40 100-kHz channels that span 864 to 868 MHz, compared with a fixed allocation of 8 channels for CT1. With its low transmit power levels (1mW and 10mW), CAI is expected to permit an active call density of at least 2,000 calls/km^2.

- Compactness and lightness—CAI handsets will consume less power than CT1 or cellular handsets and consequently will require smaller batteries. Use of the UHF radio frequency band will allow the handset to enclose the antenna, making it easy to hold in a hand or stow in a pocket.

- Bidirectional call capability—The CAI standard allows handsets to both receive calls from and send calls to nearby base stations. However, the United Kingdom's telepoint operators are licensed only to provide their subscribers with outgoing call capability.

- Digital transmission—In either direction, the CAI provides an average usable rate of 32 kbps for speech coding according to the Consultative Committee on International Telephony and Telegraphy (CCITT) G.721 Adaptive Differential Pulse Code Modulation (ADPCM) recommendation.

Cordless technology will remain in a state of continual change for some time. Like CT1, the CAI is not destined to become a European cordless standard. However, it may become an Interim European Telecommunications Standard (IETS) while the European Telecommunications Standards Institute (ETSI) works on the more advanced DECT standard. DECT uses a different method to transmit data and is expected to provide at least five-times-greater call density than CT2, but it will not be finalized until mid-1991—after CT2 has received consumer exposure in Europe. No compatibility is foreseen between CT2 and DECT equipment.

APPLICATIONS

CT2's new features will lead to many new products not technically or commercially feasible using current CT1 or cellular radio technologies. Table 1 shows new applications envisaged for CT2 in the four main operating environments: home, office, public places, and mobile.

Table 1

Suitability of CT2 Compared with Other Technologies by Application and Environment

	Home	Office	Public Places	Mobile
CT1	Single base station	T	T	T
CT2	Single base station	Multiple base stations	Telepoint handset	T
DECT	Single base station	Multiple nested base stations Cordless PBX extension	Telepoint handset	T
Cellular	U	U	Portable handset	Mobile handset

Note: T = technically not feasible; U = economically not feasible; CT1 = first-generation analog cordless telephones, as used in the home today; CT2 = second-generation digital cordless telephones, to reach the market after mid-1989; DECT = third-generation DECT standards currently being developed by ETSI. Handsets are expected to reach the market after 1992.

Source: Dataquest
July 1989

The first CT2 handsets (Shaye Communications' Forum and Ferranti's Zonephone) will go on sale in the United Kingdom this summer for use with the new telepoint services. These early handsets will use different and mutually incompatible standards, but will be superseded by handsets using the CAI standard after mid-1990.

CT2's strengths reside in its applicability as a universal communicator that can be used in public places, in the office, and as a replacement for CT1 units in the home. Little overlap is expected between the market for CT2 handsets and the market for cellular handsets. Homes and offices are places where the cellular application, with its low call density and high tariffs, will remain rarely used.

TELEPOINT FOR ALL

Telepoint services will be the main factor driving the demand for CT2 handsets, because they will be targeted to the largest possible group of end users—Europe's population of 267 million urban dwellers. During the first years, coverage will be limited to public places (shopping centers, airports, and railway stations) in major cities. For the five countries that are likely to participate in the MOU, this represents a smaller target population of 80 million people, or 32 million households.

The level of penetration will depend on whether or not telepoint can win people's hearts and minds in the same way the Sony Walkman did in the early 1980s. For the personal communicator concept to succeed, the handsets must be sufficiently small and light, so as not to intrude upon everyday life. The Shaye handset, weighing less than 130 grams (4.6 ozs)—just more than one-half the weight of the lightest cellular portable on the market today—does not yet conform to the CAI standard. We expect CAI handsets to weigh more at first, but to become progressively smaller, lighter, and less expensive as successive drives are made to reduce standard ICs into fewer custom parts.

We forecast that the CT2 handset will have become a mass consumer item retailing for about $140 by 1993, compared with at least $250 for the first proprietary CT2 handsets expected to be launched by Shaye and Ferranti within the next few weeks.

CT2 at Home

The handset manufacturers also will offer domestic base stations that connect to a telephone socket in place of a normal telephone. They will resemble existing CT1 base stations, but they will provide the following additional benefits:

- More than one cordless handset for use with a base station
- Improved speech quality
- Prevention of illicit outgoing calls
- Security from eavesdropping

CT2 base units will retail separately for about $250 by early 1990, but one cannot help but wonder if private consumers will pay $500 for a complete CT2 handset/base station combination when CT1 units can be purchased now for $150. Consequently, we do not expect the volume of CT2 home-base unit sales to match CT1 unit sales until around 1993. By then, CT2 prices should be greatly reduced.

CT2 in the Office

Greater demand for CT2 base stations will come from the business market. However, CT2 is unlikely to support sufficient call density for use in large, densely packed office environments, which will limit it to small office environments.

At least two manufacturers, GPT and STC, are expected to launch a range of standalone multiple-line cordless base stations in sizes ranging from 6 to 24 handsets. These will possess some PBX-like features such as individual extensions, call forwarding, and conference calling. A wide-area pager may be incorporated into some handset models, partly to overcome the telepoint restriction of making outgoing calls only.

DATAQUEST ANALYSIS

This is the beginning of a new market—a time when predictions are most difficult to make, but when, for investment purposes, they are most needed. The market for CT2 semiconductors depends on the market for CT2 equipment which will, in turn, depend on how widespread telepoint usage becomes. Dataquest foresees three factors most critical for the success of a CT2-based telepoint service in Europe. These factors are as follows:

- The CAI standard must succeed in becoming a European interim standard. This is a vital step toward the European PTTs recognizing and adopting it for telepoint use before DECT is finalized.
- The cost of a telepoint call compared with a normal call is significant. In the United Kingdom, with heavy competition likely between the four licensed consortia, we expect telepoint to cost roughly twice as much as a normal telephone call. It is less clear if similar low tariffs will be adopted by the PTTs in the other European countries.
- Handset prices must fall to about $140 by 1993 to make them affordable on a wide scale. The interest shown by many potential handset manufacturers, coupled with the several possibilities to reduce IC costs, suggests that this is achievable (as discussed later in this newsletter).

We believe that the variability of these factors undermines the reliability of a single forecast. Instead, we present estimates for the CT2 equipment markets according to the two contrasting views outlined in the summary.

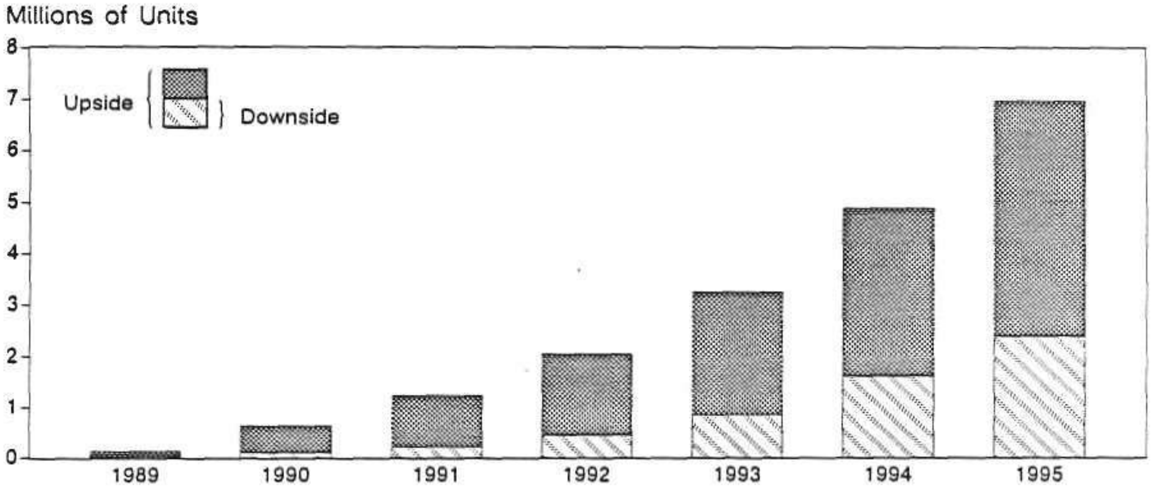
The Upside Scenario

Figure 1 shows a positive upside outlook for the unit sales of telepoint handsets in Europe, according to the upside perspective, which estimates a total installed base of 16 million CT2 handsets in Europe by the end of 1995. This is based on the following assumptions:

- The CT2 telepoint market will be in those countries expected to be party to the MOU—Finland, France, Spain, the United Kingdom, and West Germany.
- One in three households located in the major cities of these countries will possess a single handset by the end of 1995.
- Telepoint service subscriptions and call tariffs will be competitively priced in each country, so that a telepoint call will cost no more than double the price of an equivalent call placed through a normal payphone.
- Strong price erosion will weaken the average selling price (ASP) of a telepoint handset from $250 in 1989 to $100 by 1995.
- CT2 home base unit sales will match CT1 sales by 1993.
- By 1995, offices with PBXs of 100 lines or less will have reached a penetration of 1 in 10 installed lines.

Figure 1

Estimated CT2 Hardset Shipments for Europe
Upside and Downside Scenarios



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Source: Dataquest
July 1989

We estimate that the total CT2 equipment market will rise from $334 million in 1991 to $1.2 billion by 1995, a 38 percent compound annual growth rate (CAGR). Telepoint handsets will account for the largest proportion of this revenue with 46 percent, followed by office handsets and base stations with 40 percent and home base stations with 14 percent.

The Downside Scenario

Figure 1 also presents a somber, yet conceivable, downside point of view for the unit sales of telepoint handsets in Europe if CT2 fails to win support from all but two European countries. We estimate that this would result in a total telepoint and office installed base of 4 million handsets in Europe by the end of 1995. Our assumptions are as follows:

- Telepoint services will be adopted in the United Kingdom and France only.
- One in 10 U.K. households located in major cities will possess a single handset by the end of 1995.
- Late commencement of telepoint and less aggressive pricing by France-Telecom will result in only 1 in 20 French households in major cities possessing a single telepoint handset by the end of 1995.
- Weaker price erosion will reduce the telepoint handset ASP from $250 in 1989 to $150 by 1995.
- CT2 home-base unit sales will match CT1 unit sales by 1995.
- There will be a lower penetration into small offices with PBXs of 100 lines or less, with cordless telephones attached to 1 in 20 of these lines by 1995.

This outcome would lead to a total CT2 equipment market of $75 million in 1991, growing to $666 million by 1995 (72 percent CAGR). Office equipment would account for the greatest part of this market with 36 percent, followed by telepoint handsets with 37 percent and home base stations with 27 percent.

SEMICONDUCTOR CONSUMPTION

Table 2 describes one typical integrated circuit (IC) breakdown for the first CAI handsets, which are expected to reach the market in early 1990. We estimate the total semiconductor content to be $51, giving an I/O ratio of 20 percent, which is high compared with that of other consumer electronic products.

The expensive radio frequency (RF) hybrid receiver module is a major candidate for cost reduction, which could be accomplished by integrating it into one or two ICs. Funded by British Telecom, one leading U.K. IC vendor is believed to have accomplished this using zero intermediate frequency (IF) techniques to reduce the input stages to a single BiCMOS full-custom IC.

Table 2

Estimated Semiconductor Content for an Early CAI CT2 Handset

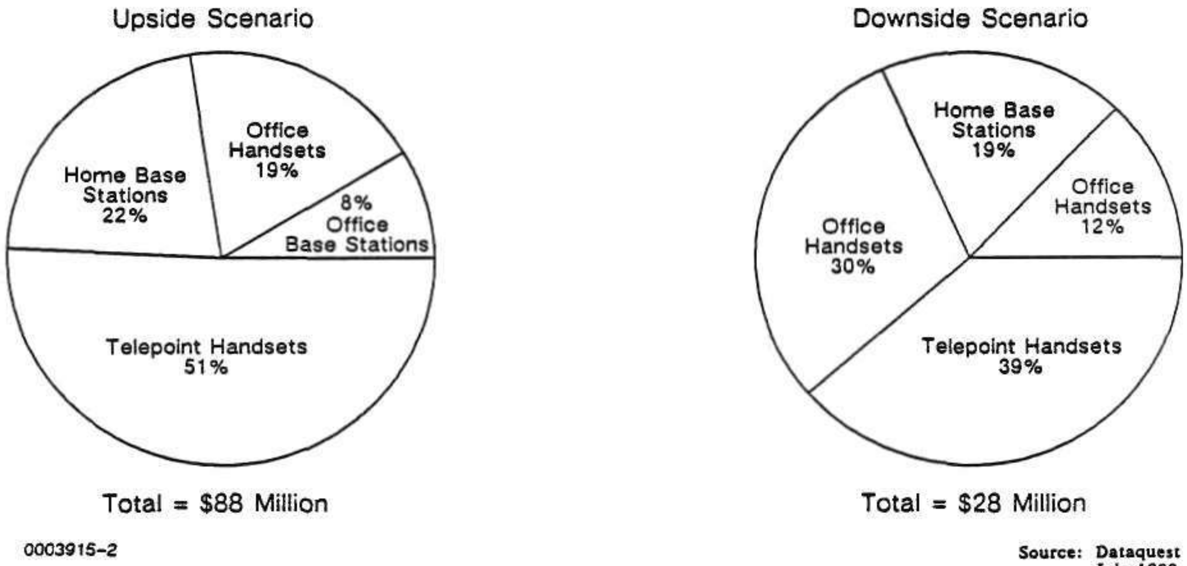
Function	Technology	Cost
4-bit microcontroller with special features	Standard CMOS	$ 3.50
27256 UV EPROM	Standard CMOS	4.00
Burst mode logic	CMOS ASIC(s)	3.50
RF receive circuit	Bipolar hybrid	20.00
G.721 ADPCM	Standard CMOS	14.00
CODEC	Standard CMOS	3.00
RF front end	RF MOSFET discretes	1.70
7-segment LCD driver	Standard CMOS	1.00
Total Semiconductor Content		$ 50.70
Average Selling Price		$250.00
I/O Ratio		20.3%

Source: Dataquest
July 1989

Other opportunities exist to integrate standard parts (LCD driver, MCU, PLL/synthesizer, CODEC, ADPCM). For example, the integration of the standard CODEC and ADPCM parts into a single IC not only reduces IC count, but also eliminates unnecessary features, thereby reducing power consumption. Given a strong market, we estimate that these and other cost reductions will squeeze the semiconductor content to $29 by 1992, leading to a less expensive and more compact product. Figure 2 presents our estimation of the breakdown of IC revenue by CT2 equipment type in 1992, according to each point of view.

Figure 2

Estimated IC Consumption Breakdown by CT2 Equipment Type—1992



Source: Dataquest
July 1989

The Players

Our forecast of who the players will be in the CT2 equipment market is as follows:

- First movers: Expected product announcements from second quarter of 1989 to second quarter of 1990—Ferranti Creditphone, GEC-Plessey Telecommunications, Shaye Communications, STC Telecommunications

- Later entrants: Possible announcements from third quarter of 1990—Alcatel, Autophon, Bosch, Crouzet, Ericsson, Matra, Motorola, NEC, Nokia-Mobira, Orbitel, Panasonic, Philip, Samsung, Sony, Uniden

The first handsets, non-CAI and for the United Kingdom only, will be announced by Ferranti and Shaye within the next few weeks. CAI units will go on sale in mid-1990, and initially come from those companies that participated in the CAI's development last year. These companies will continue to derive some temporal advantage from the standard's ambiguity in certain areas, despite the fact that it has been public for some weeks. The combined production plan for these firms alone is aggressive, building from 60,000 pieces per month in late 1990 to nearly 200,000 per month by 1992.

In the longer term, considerable Far Eastern interest is expected because CT2 is attractive as a global consumer product, and because Japan is considering similar cordless telepoint networks. Their presence is likely to fragment the market from the beginning, with European manufacturers opting to develop higher-margin products for the office market, and Far Eastern companies supplying the consumer segment of products.

DATAQUEST CONCLUSIONS

CT2's main application will be handsets for use with telepoint services, but its technical strengths will make it suitable for use in office environments where CT1 technology previously has failed. We expect CT2 handsets and base stations to make inroads mainly into small office environments, but the advent of cordless technology for large offices must await the arrival of DECT equipment in the early 1990s.

One major future possibility is that CT2 or its DECT successor might provide an alternative to the local loop that connects local exchanges to subscribers' premises. This is most conceivable in the United Kingdom, where the local telecommunications regulatory body, Oftel, has already expressed its desire to further break British Telecom's near-total monopoly of the public telephone network. A removal of the restriction on its four telepoint operators prohibiting incoming calls would create an enormous new opportunity for these consortia, resulting in a significantly greater market for CT2 equipment in the United Kingdom than was forecast in either scenario.

We believe that designers of CT2 handsets must avoid the temptation to target both telepoint and office users with the same product. The features sought by each group of users may prove mutually exclusive. Telepoint handsets will sell on the basis of compactness, style, and price, whereas office users will seek durability and functionality.

Judging from the large number of interested players, we expect the telepoint market to be extremely competitive. Cost reduction through mass production will be critical for success. This will favor many of the powerful potential later entrants to the CT2 market that we identified earlier. In contrast, we expect the office markets to be more differentiated and to offer safer, albeit smaller, opportunities for the smaller first movers manufacturers to tailor CT2 equipment to individual PBXs and office systems.

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1989-2
0002513

PART II
ISDN—THE EARLY MARKETS, 1988-1992

EXECUTIVE SUMMARY

This newsletter discusses the major issues affecting the markets for ISDN integrated circuits over the period from 1988 to 1992. ISDN is not growing as rapidly as expected in Europe. This is due to the following three major obstacles:

- Conflicting ISDN standards
- Lack of tariff harmonization between countries
- Alternative LAN technology

With these constraints, Dataquest estimates that the market for ISDN semiconductors in Europe will be $137 million in 1992.

A SERIES OF THREE NEWSLETTERS

This is the second in a series of three newsletters that Dataquest is preparing in order to reflect the level of impact that ISDN will have on the European semiconductor markets. These newsletters are entitled:

- Part I: ISDN—The ICs and Their Applications
- Part II: ISDN—The Early Markets, 1988-1992
- Part III: ISDN—Long-Term Market Outlook, 1992-2000

Readers should refer to the first newsletter for an explanation of the ISDN concept and the ICs and their applications. Part I also contains a glossary of ISDN and related terms. Part III will analyze the long-term outlook for the ISDN semiconductor markets in Europe; it will be published in the third quarter of 1989.

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TOO MANY HURDLES?

The promise that ISDN will answer most of our communications needs has been steadily eroded. It is clear that the European Commission's target for 5 percent (4 million lines) of all public digital lines to be ISDN by 1992 cannot be met until the mid-1990s.

ISDN's two most advanced PTTs, France Telecom and Deutsche Bundespost, are now working to targets of only 150,000 and 370,000 Basic Rate lines, respectively, by 1992. British Telecom, the first to experiment with ISDN, is not expected to launch a Basic Rate service until late in 1989. Until recently, these delays had been attributed to ISDN's technical unreadiness (i.e. incomplete CCITT standards, lack of central office and PBX ISDN software, and chip unavailability). These technicalities are now largely resolved, but ISDN must overcome other tougher hurdles before it can live up to expectations. These hurdles include the following:

- Rival technologies
- Conflicting standards
- Unclear tariffs

Rival Technologies

The new IEEE-802.6 and 802.9 Integrated Voice Data LAN standards may displace ISDN from large corporate users. IEEE 802.6 will provide a 140-Mbit/sec (Mbps) fiber-optic Metropolitan Area Network (MAN) suitable for connecting large sites. The 802.9 LAN will give Primary Access data rates (2 Mbps) on twisted-pair lines, albeit limited to a 100-meter range. Many argue that these are more appropriate technologies for large offices populated with personal computers and workstations. If 802.6 and 802.9 prevail, existing cheap analog telephones will be difficult to displace for voice applications. This will leave ISDN relegated to providing external communication between a PBX and a public network.

Conflicting Standards

In spite of emerging European Commission directives and CCITT recommendations, some European PTTs may retain their old Primary Rate signaling standards. The continued use of British Telecom's DASS-2 and Deutsche Bundespost's 1TR6 signaling standards to connect central offices will harm close interworking between private and public networks. A similar connectivity problem exists with PBXs, where GEC-Plessey Telecommunications (GPT) has adopted DPNSS and Siemens has gone with CorNet. This situation reduces the attraction of private ISDN networks in Europe, particularly international ones.

The short-term prospects for Basic Rate are not wholly clear either. The CEPT is likely to endorse ANSI's adoption in the United States of British Telecom's 2B1Q U-interface line code in the next few months. The PTTs will then have to decide whether to postpone expansion of their present Basic Rate service or commit to a costly retrofit later on. In any case, 2B1Q ICs will not become available until the end of 1989.

Unclear Tariffs

The bottom line for all potential ISDN users will be how the cost of using the public ISDN compares with alternative services. Enormous disharmonies exist between tariffs in each European country. The cost, for instance, of leased lines in the United Kingdom is many times lower than that in Germany. To abide with the EC Green Paper on telecommunications, the PTTs are expected to harmonize their tariffs over the next few years. But the fear is that multinational users will not commit to a public ISDN until the result is known.

THE EARLY MARKET: 1988–1992

Considering the above constraints, our estimation of the ISDN installed base in Europe by 1992 is:

- 450,000 Basic Rate lines
- 9,000 Primary Rate lines connected to offices with full internal ISDN

We forecast the market for ISDN semiconductors in Europe to be $137 million in 1992. This assumes that semiconductor demand leads line installations by 12 months. Our estimation of the market shares by IC category is shown in Figure 1, and Figure 2 gives the estimated market size of each category from 1988 to 1992.

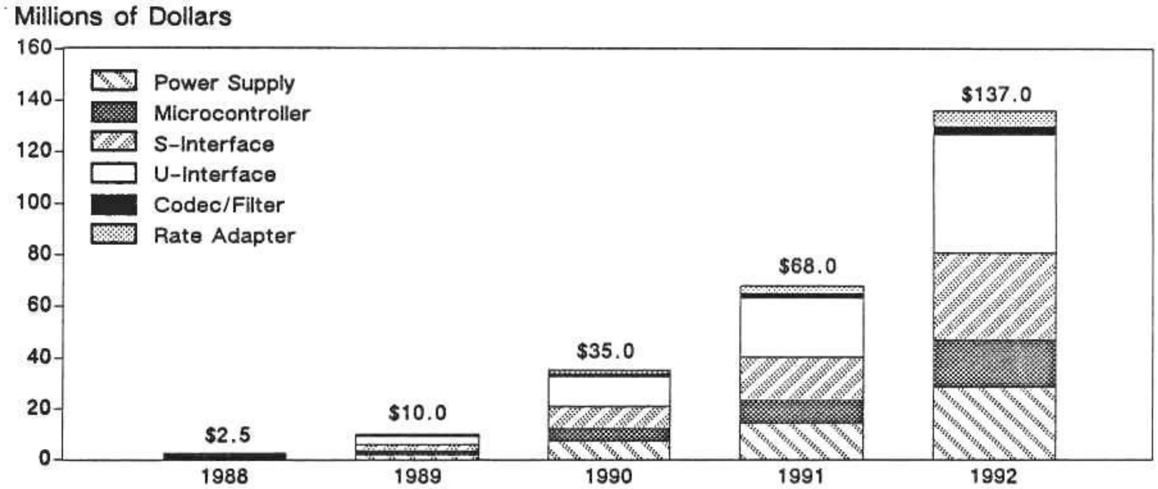
We expect public Basic Rate services to represent most of the demand for ISDN transceiver ICs. Although the volume of S–interface chips will far exceed that for U–interface ICs, we expect the U–interface to have greater dollar market share (34 percent) than S–interface ICs (25 percent). This is due to the U–interface ICs' higher average selling price. Microcontrollers (13 percent) are expected to be less numerous than transceivers and confined mainly to terminal equipment.

Unglamorous ISDN power supply ICs are forecast to occupy a sizeable 21 percent of the market. These are required in every application and provide specialized ISDN functions (power feed, shutdown, line drivers) not provided by other non–ISDN power supply ICs. Vendors are offering advanced technologies, ranging from AMD's 65V bipolar process to SGS–Thomson's mixed 100V bipolar/CMOS/DMOS process currently under development.

We expect ISDN rate adapters and speech codec/filters to take only a small fraction of the market, 4 percent and 2 percent of market share, respectively. The codec market will be small for two reasons. First, unlike S– or U–interface ICs, they are not required at the LT or NT1 reference points. Second, we expect the traditional COMBO suppliers to compete aggressively, resulting in low average selling prices.

Figure 1

Estimated European ISDN IC Markets (Millions of Dollars)



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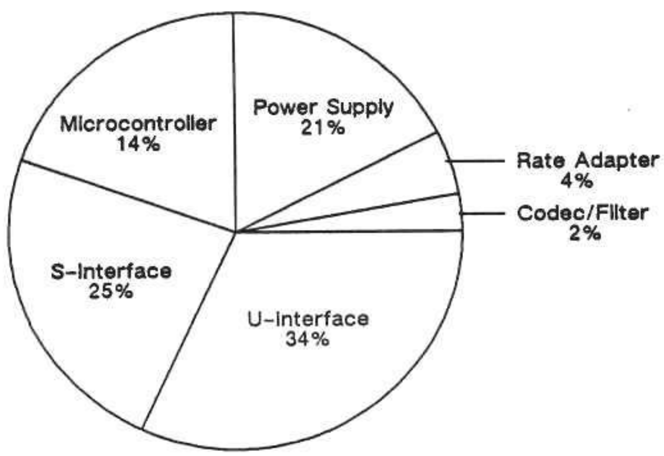
Source: Dataquest January 1989

Figure 2

Estimated European ISDN Market Share by Chip Type 1992



Total = $137 Million

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Source: Dataquest January 1989

DATAQUEST CONCLUSIONS

Major obstacles continue to hinder ISDN's acceptance as a true standard for telecommunications in Europe. Time is running out as newer, more aspirant MAN and LAN technologies threaten to rob ISDN's markets in large corporate environments.

So who will use the ISDN? The brightest future lies with small business and residential Basic Rate subscribers for whom no alternative to ISDN exists. Small business users will benefit from a wide range of bearer services (telephone, packet switch, telex, facsimile) provided through a single physical socket. Further, the economic impetus for Basic Rate will strengthen as the number of small businesses in Europe increases and the trend toward residential teleworking starts to grow.

If the standards and tariffs hurdles can be overcome, we believe that ISDN's momentum will recover in Europe and bring a probable two- to threefold increase in ISDN semiconductor revenue.

ACKNOWLEDGEMENT

We would like to thank Dataquest's European Telecommunications Industry Service for sharing their insight and estimates on ISDN line takeup in Europe.

Jonathan Drazin

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1989-1
0002532

PART I
ISDN—THE ICs AND THEIR APPLICATIONS

EXECUTIVE SUMMARY

This newsletter explains the basic concepts of the Integrated Services Digital Network (ISDN) and describes the main functions and applications for ISDN semiconductors.

The diverse range of applications that ISDN embraces has caused most vendors to opt for highly modular chip sets. As a result of high design costs, most vendors have formed cross-sourcing agreements to offer a full ISDN product range.

Dataquest estimates that from 1988 through 1992, 40 percent of the total market for ISDN ICs will go to providing an infrastructure for the public Basic Rate services, with 16 percent going into the infrastructure for public and private Primary Rate services. Customer premises equipment (CPE) manufacturers will account for the remaining 44 percent of demand.

A glossary of ISDN terms has been included at the end of this newsletter for those who are unfamiliar with ISDN terminology.

A SERIES OF THREE NEWSLETTERS

This is the first in a series of three research newsletters that Dataquest is preparing in order to reflect the level of impact that ISDN will have on the European semiconductor markets. These three newsletters are entitled:

- Part I: ISDN—The ICs and Their Applications
- Part II: ISDN—The Early Markets, 1988-1992
- Part III: ISDN—Long-Term Market Outlook, 1992-2000

The two subsequent newsletters, Parts II and III, will analyze the market for ISDN semiconductors in Europe. Part II of this newsletter accompanies Part I, and Part III will be published in the third quarter of 1989.

INTRODUCTION

ISDN is a collective term for the I series of telecommunications standards recommended by the Consultative Committee on International Telephone and Telegraph (CCITT) and ratified by the Conference Européenne des Administrations des Postes et des Télécommunications (CEPT). These standards will have a strong influence on the telecommunications semiconductor markets because they describe a single physical interface to be adopted worldwide for many forms of electronic communications equipment, including the following:

- Voice telephony
- Facsimile transmission
- Data transmission (packet switch and virtual circuit)
- Telex

Many new applications for ISDN are likely to appear in the mid-1990s and to increase further the market for ISDN semiconductors. These include the following:

- Integrated voice and data workstations (IVDWs)
- Video telephony
- Mixed video/text terminals
- Home automation and remote diagnosis

ISDN ACCESS AND REFERENCE POINTS

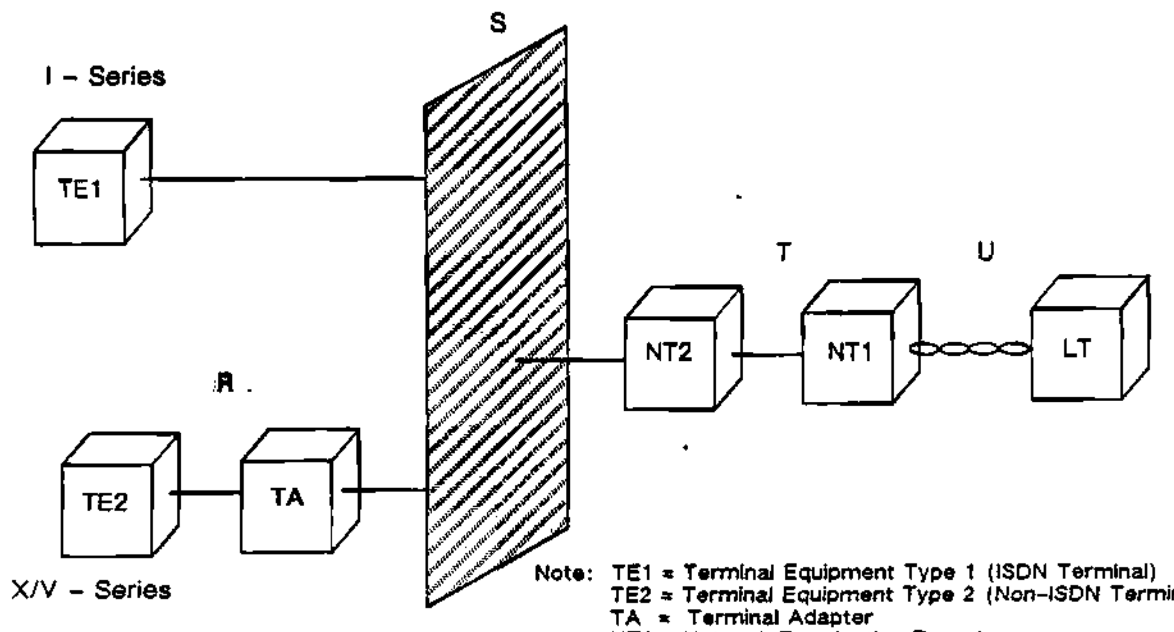
The existing I series recommendations define the following two forms of ISDN access:

- Basic Rate Access consists of two 64-Kbps B channels and 1 16-Kbps D channel with a total bandwidth of 144 Kbps, suitable for transmission across existing two-wire loops between subscribers and central offices or PBXs.
- Primary Rate Access consists of 30 B channels and 1 D channel with a total bandwidth of 2.048 Mbps (in Europe).

Figure 1 shows how the ISDN fits together for the Basic Rate service. TE1 represents new ISDN terminal equipment that connects directly to the ISDN at the S-interface. TE2 represents existing equipment such as RS-232-C or X.21 terminals. This equipment may connect to the S-interface via a terminal adaptor, TA. NT2 is a multiplexer that concentrates two or more TE1s or TAs. The NT1 provides physical and electrical termination between the S-interface and U-interface transmission lines. The U-interface transmission is two-wire transmission at 144 Kbps and uses echo-canceling techniques to correct for signal reflections along the line. Transmission at the S-interface is four-wire transmission and will require substantial rewiring of most buildings to accommodate it.

Figure 1

ISDN Functional Entities



Note: TE1 = Terminal Equipment Type 1 (ISDN Terminal)
TE2 = Terminal Equipment Type 2 (Non-ISDN Terminal)
TA = Terminal Adapter
NT1 = Network Termination Type 1
NT2 = Network Termination Type 2 (mainly Primary Rate)
U = European Basic Rate Digital Subscriber Line
LT = Local Exchange Termination

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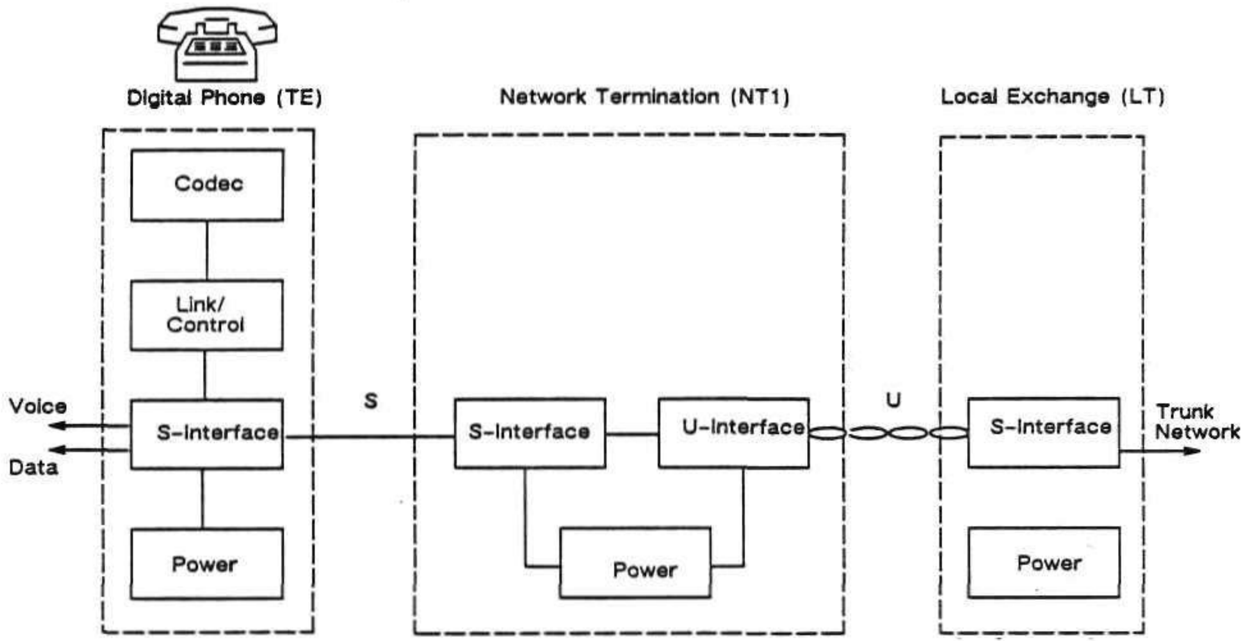
Source: Dataquest January 1989

THE CHIP SETS

The same types of ISDN ICs are used in several different ISDN applications. Figure 2 describes one possible example of an ISDN chip set by function for a digital telephone handset connected to a central office (CO) exchange via a U-interface. For future volume applications, these functions are likely to be integrated into a single IC.

Figure 2

Main ISDN Chip Functions



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Source: Dataquest
January 1989

Most vendors offer a modular family of CMOS devices that can be mixed and matched for a given application. No ISDN recommendations for connectivity at the IC level have been drafted or planned, although a single bus format would be desirable to maximize chip-to-chip compatibility between different vendors.

Table 1 describes some of the bus schemes adopted. Most European vendors have chosen the General Component Interface (GCI). This is similar to Siemens' ISDN-Oriented Modular Revision 2 (IOM-2) scheme. The GCI bus has four lines: two for data receive and transmit, one for frame synchronization, and one clock line. Data for the D and two B channels are multiplexed onto a single line. Intel's Subscriber Line Datalink (SLD) combines the receive and transmit signals onto a single bidirectional line. Mitel's ST bus works in a similar way to GCI but can operate in an alternate mode where the B and D channels are transmitted on different lines.

Control pins are eliminated from the GCI, ST, and SLD buses by interleaving data and control codes onto one line. This increases the complexity of the IC but eases the design process of integrating onto one piece of silicon.

Table 1

Bus Formats Adopted by the Major ISDN IC Vendors

Bus Name	Vendors
GCI/IOM-2	Advanced Micro Devices National Semiconductor Philips Plessey SGS-Thomson Siemens Signetics
SLD	Intel National Semiconductor
ST	Mitel
IDL	Motorola National Semiconductor

Source: Dataquest
January 1989

ISDN IC FUNCTIONS

Exchange and terminal equipment will be composed mainly of the following types of ISDN ICs.

- U-Interface IC—echo-canceling 192-Kbps digital transceivers for twisted-pair subscriber loops
- S-Interface IC—four-wire S-interface transceivers providing link layer functions
- Microcontroller IC—provides layer 2, LAPD data link control; may also perform higher-level functions (e.g., keyboard control)
- Codec/Filter IC—performs codec and filter functions for voice telephone applications
- Rate Adaptor IC—adaption of the ISDN B channel to non-ISDN protocols (e.g., V.24, X.21) for terminal adaptor (TA) applications
- Power supply IC—voltage regulation, line driver, and power-down functions

The major ISDN applications over the next five years will be the following:

- Central Office (CO) and PBX line cards (LT)
- Network Termination (NT1) at customers' premises
- Terminal Adapters (TAs) to allow connection of existing terminal equipment (e.g., RS-232/V.24, X.21) to the ISDN network
- Intelligent voice/data workstations (IVDWs)
- Facsimile Group 4
- Digital feature phones
- Digital handsets

Table 2 describes typical IC uses for the different ISDN applications.

Table 2

ISDN IC Use by Application

	Application*						
	LT	NT	TA	IVDW	Fax	Feature Phone	Digital Handset
IC Function							
U-interface	X	X					
S-interface		X	X	X	X	X	X
Microcontroller			X	X	X	X	X
Codec/Filter				X		X	X
Rate Adaptor			X	X			
Power Supply	X	X	X	X	X	X	X

*Please see glossary for terminology

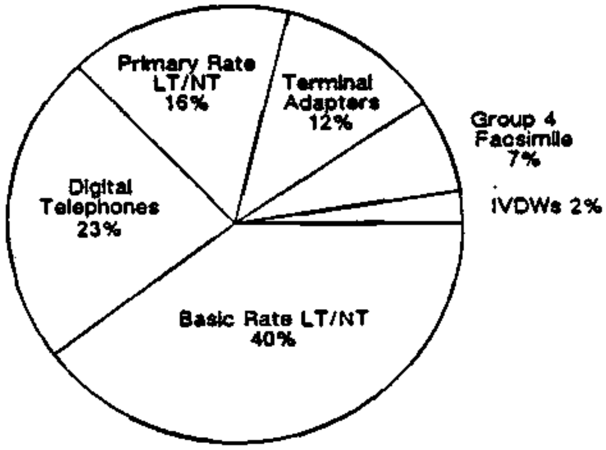
Source: Dataquest
January 1989

DEMAND BY APPLICATION

Figure 3 illustrates Dataquest's forecast for the ISDN IC market revenue shares by application in Europe from 1988 through 1992. The infrastructure (line cards, repeaters, and network termination) for the public Basic Rate services will receive 40 percent of the ISDN ICs. Public and private Primary Rate networks will take a smaller 16 percent share.

Figure 3

ISDN Semiconductor Demand by Application



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Source: Dataquest January 1989

Among customer premises equipment, the digital telephone will represent the largest single market (23 percent) for ISDN ICs. ISDN terminal adaptors will take second place with 12 percent, followed by facsimile machines (7 percent) and IVDWs (2 percent).

DATAQUEST CONCLUSIONS

Vendors are offering a number of highly modular ISDN chip sets. The CGI standard, a derivation of Siemens' IOM-2 bus protocol, has been most widely adopted by vendors for the European market. ISDN ICs are highly application independent at present. However, as volume applications develop (e.g., digital handsets), multiple ISDN functions will be integrated onto one piece of silicon.

Dataquest estimates that during the period from 1988 through 1992, 40 percent of the total market for ISDN ICs will go to providing an infrastructure for the public Basic Rate services, with 16 percent going into the infrastructure for public and private Primary Rate services. Customer premises equipment (CPE) manufacturers will account for the remaining 45 percent of demand.

Jonathan Drazin

GLOSSARY

ANSI (American National Standards Institute). A subcommittee of the Electrical Industry Association (EIA) that prepares software and electrical standards for U.S. industry.

CCITT (Consultative Committee on International Telephone and Telegraph). A body of the ITU (International Telegraph Union) that prepares recommendations to resolve technical telegraph and telephone problems.

CEPT (Conference Européenne des Administrations des Postes et des Télécommunications). A body that coordinates the policies of the PTTs of Western Europe.

CPE (Customer Premises Equipment). All forms of equipment used on customers' premises, excluding the termination (NT1) with the public network.

DASS-2 (Digital Access Signaling Standard-2). British Telecom's signaling protocol for connecting Primary Rate subscribers with its central offices.

DPNSS (Digital Private Network Signaling Standard). British Telecom's signaling protocol for connecting PBXs together to form a private network.

GCI (General Component Interface). A common bus standard for ISDN chip sets, based on Siemens' IOM-2 standard and agreed between the main European vendors.

Group 4. A high-speed facsimile protocol specific to ISDN, as defined in the CCITT F.5 recommendations.

IDL (Interchip Digital Link). An ISDN bus developed by Motorola, consisting of separate data and control lines.

IOM-2 (ISDN Oriented Modular Revision 2). A modular bus devised by Siemens for its ISDN chip set.

IVDW. Integrated voice/data workstation. Provides multiple functions, including voice/video telephony, PC features, and data transmission.

LAPB. The Link Access Protocol for the ISDN B channel defined in the CCITT X.25 packet switch recommendations.

LAPD. The Link Access Protocol for the ISDN D channel as defined by the CCITT I.440 and I.441 recommendations.

LT (Line Termination). A line card that provides termination of the subscriber loop at the PBX or central office.

NT1 (Network Termination 1). A unit that provides physical and electromagnetic termination of the U-interface two-wire transmission line.

NT2 (Network Termination 2). A unit that provides switching and concentration of subscribers' lines at the S-interface (mainly for Primary Rate).

PTT (Post, Telegraph, and Telecommunications administration). Refers to the state-run telecommunications administrations of Europe.

S-Interface. The interface that connects an ISDN terminal (TE1) or a terminal adapter (TA) to the NT2 reference point as defined in the I.411 recommendation.

SLD (Subscriber Line Datalink). A three-line serial ISDN bus devised by Intel for its ISDN chip set.

ST-Bus. A four- or six-line time division multiplexed bus devised by Mitel for its ISDN chip set.

TA (Terminal Adaptor). A unit that interfaces non-ISDN TE2 equipment to the S-interface.

TE1 (Terminal Equipment 1). Represents all ISDN-compatible terminal equipment.

TE2 (Terminal Equipment 2). Refers to all non-ISDN terminal equipment, i.e., existing RS232/V.24, X.21, or X.25 equipment.

U-Interface. A twisted pair subscriber loop that connects the NT1 reference point to the ISDN network, as defined in the I.411 recommendation. This interface provides Basic Rate access with a capacity of 144 Kbps.

Newsletters 1988

Dataquest
a company of The Dun & Bradstreet Corporation

Research *Newsletter*

ESAM Code: Vol. II, Newsletters
1988-6
0000883

1992—WHAT'S IN A NUMBER?

SUMMARY

On June 21, 1988, Malcolm Penn, Vice President and Director of Dataquest's European Operations, gave a keynote address at the Semiconductor Equipment and Materials Industry (SEMI) European Industry Focus Conference held in Munich, West Germany. The theme of this conference was "Can Europe Make It?" The theme of the Dataquest keynote address was "1992—Has Europe Got It? An Analyst's View." A copy of this speech with its accompanying slides is attached and is being published by all the Dataquest European Services.

1992—HAS EUROPE GOT IT? AN ANALYST'S VIEW

1992 represents the metamorphosis of the European Economic Community (EEC)—the transition from caterpillar to butterfly. The genesis was in 1957 when the six founder member states (Belgium, Federal Republic of Germany, France, Italy, Luxembourg, and Netherlands) formed the EEC. It grew to nine in 1973 (Denmark, Republic of Ireland, and United Kingdom), ten in 1981 (Greece), and twelve in 1986 (Spain and Portugal).

The next move is now coming—in 1992 the EEC will grow into one—the single market.

The objective of creating a single "common market" in the EEC goes back to the EEC Treaty of Rome which established the Community 31 years ago. In 1985, the EEC heads of government committed themselves to completing the single market progressively by 31 December 1992. Their commitment has been included in a package of treaty reforms known as the Single European Act, which came into force on 1 July 1987.

Dataquest's European Research Operations have been tracking the European electronic equipment industries since 1981 and recently, with the significant winds of change that have been dominating the European industrial scene, the potential that the 1992 single European market could have. This keynote address presents the issues and analysis of the present situation, one year after the passing of the Single European Act, together with the challenges and opportunities that lie ahead.

This speech was written using research material provided by the European Semiconductor, Computer, Telecommunication, Printer, Copying and Duplicating, Industrial Automation, and Personal Computer groups.

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(Slide 1)

Ladies and gentlemen, good morning. Yesterday Guy de Jonquieres from the Financial Times opened the proceedings of this conference with what I thought was a very thought-provoking speech entitled "1992: Has Europe Got It?—A Political View." I would like to continue from where Guy left off and look at the same issue from an analytical perspective.

We analysts are charged with a challenge to piece together all the available data on a particular subject, rationalize it, sanitize it, and come up with a consensus view on what the issues and facts are—actually more specifically, the facts behind the facts; the trend behind the first glance. That is what I will attempt to do over the next 45 minutes or so.

Dataquest held its seventh annual European Semiconductor Industry Conference approximately two weeks ago, at which we gathered together the top executives from makers and users of semiconductors. Part of the proceedings included a workshop to look at the issues of 1992.

From this workshop, four major barriers to the growth of business and trade in Europe emerged: technical barriers—differing technical standards in broadcasting, telecoms, and consumer electronics; environmental barriers—different levels of safety in the various national laws on pollution, drugs, radiation levels on computer terminals, etc; government barriers—differing tariffs, duties, local subsidies, procurement policies and monopolies; and finally financial barriers—differences in the cost of capital, availability of venture capital, and tax incentives. These are the front-line analyses. So what was the fact behind the facts?

Ignorance is the single biggest key barrier to the implementation of the single European market due to be created in 1992. While nearly everyone present knew something about the significance of 1992, no one there really knew how it was going to effect them or what the specific implications were for their business.

(Slide 2)

I'd like to draw your attention to a statement Jacques Delors, the president of the EEC made earlier this year. Specifically I'd like to refer you to the following words: "The 31st December 1992 deadline is now enshrined in a Single European Act."

Ladies and Gentlemen, 1992 is a reality. On 31st December 1992, that Act will become law. That law will override local governments. Majority voting, as opposed to the present almost universal procedure of unanimous voting, will ensure that the days of filibustering are finally dead and buried. The four major barriers to trade mentioned above will no longer exist.

The first of my recommendations this morning is that we had all better take this reality seriously—the days of the cozy cartels, monopolies, hidden tariffs, and other protectionist or self-interest motivated practices are numbered—1,653 days to be precise.

Nobody likes change—we're all very much creatures of habit—but this is one change that will be viewed with hindsight as worthwhile. That is my second prognostication of the morning.

What, I hear you ask, gives me the confidence to make such an equivocal statement? To answer that I would like to look back over past decades of the western world's economic performance.

(Slide 3)

The single biggest contributor to the postwar world economic recovery was market liberalization. The 1920s/'30s saw trade barriers dismantled, government-nurtured cartels broken up and controls on direct foreign investment lifted. The western world enjoyed a market-led sustained high GNP growth throughout this period.

The oil shocks of the 1970s triggered a gradual shift away from market-led forces with an increasing tendency for cozy self-interests to prevail. GNP growth has slowed—unemployment has reached an intolerably high level (pan-Europe) and doggedly refuses to nudge down. EEC estimates reveal that the cost of non-European unity currently exceeds $100 billion dollars—$100 billion revenue lost due to internal trade barriers. To put that into perspective, that represents a year's growth in Europe today. SEA (The Single European Act) will change all that—prognosis number three.

(Slide 4)

Listed here are just a few examples of "hidden" trade barriers, and these are just some. Believe me, they are multitudinous in nature. This is today's reality. A reality we've grown up with, and a reality we've organized our activities, built factories, marketing plans, business strategies, and end products around.

(Slide 5)

At the stroke of midnight, 30 December 1992, all of these strategies and plans will be rendered obsolescent. They are all obsolescent now. Companies that are today still acting in a "country" organization structure and defining tactical issues on a local basis are in grave danger of missing the boat. On the 31st December 1992, we will have a have a free domestic market of over 330 million people, very nearly as many people as in the U.S. and Japan combined. Some of today's companies will not make the transition—they will fail to survive in this new competitive environment.

If you would allow me to hypothesize that you accept that this will be the consequence of the SEA—given the drastic consequences it will bring—why then is it so necessary to change in the first place?

(Slide 6)

One of the few things in life that is a given certainty is progress. It is inevitable—I agree that not all progress is necessarily for the best, but nonetheless it happens. In the economic scenario, progress has taken us to a new dawning—one I would like to call "globalization." Joe Duncan, Dun & Bradstreet's corporate economist and chief statistician, points to seven factors that together characterize the new global economy.

- First, trade and the fact that this has become now largely deficit driven. Large regional trade imbalances are no longer politically or commercially an acceptable way of life.

- Second, macroeconomic policy—it ripples around the world. We worry about the size of the U.S. budget deficit, the fact that Germany remains unwilling to stimulate internal demand, and whether or not Japan really will open up its markets.

- Third, currency fluctuations are a real wild card. How do you plan where to build new factories in an environment where an exchange rate variance can render them uncompetitive overnight, even before they have come on stream?

- Fourth, international competition. That situation will continue to intensify.

- Fifth, direct and indirect investment. Do I manufacture or buy the component or service I need? Will this be via an outsourcing agreement or via a joint venture?

- Sixth, foreign capital flows. The excess liquidity at the global level slopping around the world seeking the best interest level or return is 26 times bigger than the total of all world trade put together. It is no longer trade factors that determine exchange rate values today—it is excess liquidity.

- And, finally, information transfer. It is far easier than ever before, since financial transactions etc. are knitted together by instantaneous communications.

I would like now to turn more specifically to your own industry, i.e. semiconductors, and its related fields, and to examine just where this industry is positioned today against the global backdrop I have just painted.

(Slide 7)

The semiconductor industry is currently embarking on a new phase in its evolutionary process. Phase 1 was technology-driven and the U.S. won that round. This was primarily due to the social and political environment at the time, ready access to venture capital, lots of innovation, and a strong military/aerospace industrial driver.

Eventually technological strength alone was not sufficient and the mid-70s saw Phase 2 arrive—manufacturing. That round went to Japan, again due to their social and economic environment at the time, manufacturing science, people discipline, culture, and better economies of scale. That too is no longer sufficient.

The 1980s have brought us to Phase 3—the marketing era. This is opening right now and no clear winners have yet emerged.

(Slide 8)

The implications, though, that it has on our industry have emerged. The winners in the marketing phase will be determined by these companies who today are positioning themselves internationally. And by that I don't just mean selling internationally, I mean sharing internationally: sharing products and technologies; embarking on horizontal and vertical alliances; and restructuring their organizations accordingly. All of this of course must clearly keep the focus on the customer as the priority objective.

Let's now get down to the next level of detail and look first to see how Europe's end equipment industries are faring, and then, the position of Europe's semiconductor industry and its prospects for being among the winners for this next phase of the semiconductor evolution.

(Slide 9)

At the time the SEA becomes law, Dataquest predicts that the European semiconductor market will exceed $10 billion in value, up from our current estimate of the 1987 European market of $6.4 billion. That delta is slightly more the size of the whole of the 1983 European market. I would like to examine now what lies behind this growth rate and at the key industry segments that will impact the growth.

(Slide 10)

The computer segment will continue to have a major impact. With the creation of new emerging standards like UNIX and X OPEN, we expect to see more aggressive postures adopted by equipment vendors for larger market shares. This in turn will impact on price/performance ratios of semiconductors.

It is important to remember when talking about computers nowadays that this industrial segment is no longer dominated by the mainframe computer. That era is fading after 30 years of dominance—the micro is taking command and in this area Europe's manufacturers have an already established strong position.

In 1987, microcomputer revenue surpassed mainframes and there were over 15 million PCs shipped into U.S. offices alone. The balance of power has moved to small systems that didn't even exist 10 years ago. Today's 80386-based machines can be bought for between $5K to $10K and offer the computing potential equivalent to the last generation of mainframes. By 1992, you will have 100 mips of computing power on your desk for the same cost as an 80386-based machine today.

(Slide 11)

Overall, the telecommunications market is not expected to experience rapid growth rates, mostly due to the slowdown in the number of digital lines installed as the system upgrade program reaches maturity, and the fierce PABX competition continues. The picture looks brighter for modems, cellular phones, and local area networks, other areas of European strength. In the wake of the recent consolidation amongst the European industry leaders, the now slimmed-down companies are better equipped to grasp the challenge that these opportunities will provide.

(Slide 12)

The consumer industry is making increasing use of sophisticated semiconductor devices and is responsible for driving some leading-edge products like data conversion and DSP products. Philips and Thomson dominate this market in Europe and together with Amstrad, especially as DSB starts to impact, are well poised to maintain this leadership position.

(Slide 13)

The joint Eurofighter project will have a major impact in Europe as it is not clear which military specification will be used for semiconductor components. This could be either U.S. specifications or the recently adopted CECC specifications. The resounding success that Airbus has had on the civil aircraft market is best measured by the rapid increase in protectionist political lobbying by Boeing in the United States over the past two years.

(Slide 14)

The relative strength of the European currencies over the U.S. dollar has resulted in a slowdown of exports of luxury models to the U.S. market. However the future trends for higher semiconductor contents in the midrange models will make the automotive market one of the most exciting segments for semiconductors.

It is important here to remember that Europe produces more cars (12 million) than either the U.S. or Japan (8 million each), almost comparable with the total production of the U.S. and Japan added together. The problem today is that current "nontariff" trade barriers don't allow this potential economy of scale to be realized—1992 will change all that.

(Slide 15)

Finally, the industrial segment. This remains fragmented, but, for example, the adoption of solid-state electricity-measuring meters will give this area a big boost in semiconductor consumption, as the potential volumes involved are similar to those seen in the video games arena. Last year alone saw 2 million units shipped in field trials.

An even bigger potential market will be that of the smart card, not particularly the financial sector of this market (though I agree that will be significant) but the disposable market, e.g. intelligent (nonforgable) tickets.

What I would like to do now is to examine how Europe's big three semiconductor manufacturers are positioned in these six industrial segments, i.e. Philips, SGS-Thomson, and Siemens.

(Slide 16)

This slide shows the relative market size within the total European market along with the three companies' relative market ranking within the individual sectors. As you can see, apart from data processing and military sector, Europe's big three hold a commanding position. Now let's examine the facts behind these already impressive facts.

First, military. I've already discussed that this is a future high-growth segment, yet apparently Europe's semiconductor manufacturers do not participate strongly? Wrong, the number two supplier is Plessey/Ferranti just slightly behind National/Fairchild and ahead of Texas Instruments at number three. And with SGS-Thomson's total commitment to the European CECC program-I predict this picture will change dramatically over the next five years.

In industrial, ASEA Brown Boveri commands the number five position and in consumer, ITT is number four. Though strictly speaking ITT is in our definition a U.S.-owned company—in reality it is totally European in structure, management, and control. I do not believe I am distorting the facts therefore by including ITT amongst the European manufacturers for the purpose of this analysis.

In the other segment, data processing, we are all well aware that Europe's computer manufacturers conceded defeat to the U.S. in the mainframe market in the 1970's. No wonder, therefore, that the European semiconductor manufacturer's share here is the lowest. As I mentioned before, though, the whole characteristic of the data processing segment has changed—by 1992, therefore, we predict that Europe's semiconductor market share in this segment will increase from its present 24 percent to 35 percent.

(Slide 17)

The overall impact is shown here. Today's reality is that Europe's semiconductor companies control significant market share on a by-segment basis within Europe, from a low of 24 percent in data processing to an impressive high of 65 percent in consumer electronics.

This achievement is the state of play at the entry point of the SEA. It has been achieved from a position of disadvantage brought about by fragmented markets, specification differences, and other operating and marketing inefficiencies. By 1992, those disadvantages will no longer be relevant. The true potential power that these numbers reflect will be capable of being unleashed against Europe's global competitors.

Furthermore, I predict that the market pull will increase dramatically over the same time period, especially as Europe continues to flex its new-found cooperative strength under the banner "united we stand—divided we fall." For example, we are all well aware of the EEC antidumping issues that have affected the electronic printer industry over the last few months. This next slide clearly demonstrates the impact.

(Slide 18)

This year, Japanese production of electronic printers in Europe will reach 1.2 billion units, up from less than 100K units in 1987. Next year, it will rise a further dramatic 40 percent to 1.7 billion units. And with an EEC mandated 40 percent minimum local content, this is a huge shot in the arm; a tremendous marketing opportunity for Europe. There will be many more examples of this kind to follow as Europe starts getting tough in the globalization economic era.

(Slide 19)

Let's now step down one more level to look at the area of semiconductor production in Europe. Approximately 75 percent of the total semiconductor manufacturing base in Europe is European-owned. I predict that this will decrease over the next five years, not in real terms, but as a percent of total, as foreign companies rush to build new factories in Europe. And here I'm not talking about low value-added assembly plants—the semiconductor equivalent of a screwdriver plant. I'm speaking about full-blown wafer manufacturing facilities. Already Japan, led by NEC in Scotland, has gotten this message loud and clear.

I'd like to pause now to reflect on what I've been discussing over the past 30 minutes or so. What I've tried to do is to walk you "top down" through the current economic, political, and social environment, and show you how we see this changing over the next five years; to look at where Europe's end equipment markets are within this context; and the position of Europe's semiconductor industry to support this. I've made several prognostications en route, but so far no conclusions. Before I do that, I'd like to traverse that same route, "bottom up"—the classical analyst's approach to issue solving.

(Slide 20)

Whenever I've shown this slide in the past, it is always the first-level facts that dominate the dialogue. "See how dominant Japan is in its home market—isn't it time we forced them to open their markets?" Another common statement is "Look how small Europe's share of its own market is, compared with that of Japan and the U.S." To me though, the correct analysis is that Europe, far from being the laggard, is actually a perfect representation of the model multinational citizen of the future—build where you sell, buy where you build—emphasis on local value added.

(Slide 21)

In this new model of future excellence, the essence will be focused on a more even balance and sharing internationally. I would remind you of my earlier comments on the factors characterizing the new globalization economic era.

Europe has already achieved this balance. Its downsizing and adjustment process is well down the track. The U.S and Japan are only just beginning on this route and for them, the painful adjustment process that Europe went through in the 1970s and early 1980s lies ahead. I'm sure they will adjust quicker than Europe did, but today Europe has the strategic and tactical advantage.

(Slide 22)

This necessary adjustment to the U.S and Japanese semiconductor domestic supply markets is of course an export opportunity for Europe's semiconductor manufacturers. In past years, poor export performance has been a fundamental characteristic of the so-called European malaise. Not any more I am glad to say.

In 1987, exports accounted for 42 percent of Philips' worldwide revenue, 38 percent of SGS-Thomson's, and even Siemens, with its still essentially parochial marketing approach to semiconductors, achieved a commendable 28 percent figure. With the already strong home base I talked about earlier, the impact 1992 will have will be in making this position even stronger. European companies are positioned with the strongest set of cards than at any time previously in the history of the semiconductor industry.

Let's turn now to the political initiative in the EEC. What chance does the EEC really have of significantly influencing industrial policy after 40 years or so of internal wrangling over such items of global importance as the price of sugar beet, milk quotas, and other agricultural related issues?

(Slide 23)

In the beginning was Esprit, considered at the time as doomed to failure, except perhaps by the more visionary champions.

This slide shows the present status at the end of the first phase of the program. Even the most cynical are now compelled to accept that this initiative has not been a failure. I would agree it is too early to say it has been a resounding success, but I believe it is fair to say that it has exceeded even the most optimistic of expectations at the onset. It also showed that collaborative research could work and it spawned many clones, e.g. Alvey, Eureka, and Jessi as well as specific company collaboratives, e.g. Philips' and Siemens' Megaproject. Moving on from collaborative research and development to manufacturing, I would remind you of a prophecy I made in 1984 that a major restructuring in the world semiconductor industry was imminent.

To succeed in the semiconductor industry you need to have either a sufficiently large market share to be somewhat isolated and protected from the industry's cyclical or tactical issues (that figure is around 4 to 8 percent market share). Or you need to be small enough to exploit a niche market opportunity, either technology or market related, where other factors allow a leadership position to be developed within a narrow field. Only a handful, perhaps 10 or 12 companies, will be in the former position, whereas in the latter position, this is where the bulk of the semiconductor companies will lie. Each will have less than 1 percent market share.

It is in the middle band where the bulk of the industry realignments will occur—companies that are too big to be small and too small to be big. For these companies there is only one of two options. Merge (or be merged) or face extinction.

(Slide 24)

As you are aware, there have been many such examples of mergers in the semiconductor industry over the past 18 months, most noticeable in Europe that of SGS and Thomson, Plessey and Ferranti, and Brown Boveri and ASEA. In all cases, the combined companies are potentially much stronger and better equipped to face the issues of globalization than either part could have done independently.

(Slide 25)

Moving on now to Europe's equipment manufacturers. Here, too, evidence of change is endemic. I'd like to draw your attention to two interesting examples.

First, cellular radio in Scandinavia. As the result of cooperation between the four local manufacturers and their PTTs, Sweden, Norway, Denmark, and Finland have managed to achieve an economy of scale and technological leadership that none could possibly have achieved unilaterally. And that in perhaps the most closeted of all industries—telecommunications.

(Slide 26)

Secondly, the activities of an organization called STACK. In existence now since the early 1970s, STACK is a user group of predominantly European system manufacturers whose role is to exploit the benefits of shared resources. An incredibly visionary decision when first formed and one of Europe's true success stories.

Its early pioneering work has already put in place real programs covering the issues that are today only just beginning to achieve the necessary level of visibility in many other companies.

(Slide 27–29)

These three slides show a sample of some of the programs STACK has already established.

(Slide 30)

If one returns to the changing industry characteristics brought about by the era of global economy, these driving forces at work in the changing supplier/customer relationships show remarkable coincidence to the programs already successfully undertaken by STACK.

(Slide 31)

I mentioned this briefly earlier in my talk, but the implication of the previous slide is that as a result of the changing supplier/manufacturing relationships, foreign companies operating in Europe will progressively move down the so-called "value added" manufacturing chain, from sales, moving rapidly through pure assembly (or screwdriver operations) down to design, development, real local manufacturing, and local procurement, to eventual export of original European conceived and manufactured products. IBM is probably the best established in this regard at the present time, though other foreign companies, notably Digital and Sony, are catching up fast—the trend is inevitable. Given the 1992 deadline, we expect an acceleration of this trend as foreign companies strive to become good Europeans before the internal trade barriers fall.

(Slide 32)

I polled our internal Dataquest statistics recently to review the five hottest areas in the electronics equipment markets. They are shown here listed in this slide. Europe's electronics manufacturers are already strongly positioned in all of these areas of activity. The SEA and the resultant strength that a consolidated single market will provide gives them a unique opportunity to achieve a world-class position as these industrial segments reach maturity.

I would like now to use my closing minutes to draw some conclusions.

(Slide 33)

First, Europe <u>will</u> become a unified market after 1992. Restrictive trade barriers will be illegal, the market size will truly be 330 million people, and new European standards will emerge, especially in the areas of consumer electronics, telecommunications, and data processing. Companies that fail to recognize this prospective reality are destined for the scrap heap. And no matter how intransigent the problems may appear today, ignoring the inevitable will not help.

The resultant economies of scale will drive down operating costs and Europe will be not only more competitive in its own market, but strategically and tactically positioned to exploit the export opportunities from a position of strength and equality with its other world competitors.

(Slide 34)

Europe will have the necessary semiconductor technology in place. Programs such as Esprit, Eureka, Megaproject, and Jessi will ensure that. It has today a production process capability comparable to the best, e.g. 1.2 micron CMOS, 1.5 micron bipolar, BiCMOS, and state-of-the-art sophisticated packaging techniques.

The EEC initiative will also ensure that multinationals do adopt sound "good citizen" operating principles already discussed, including a high value-added local procurement content, and collaborative research and development, to ensure a strong manufacturing base is maintained. Europe's existing industrial strength will increase significantly.

(Slide 35)

As I speak to you here today, 1992 is only 1,653 days away. The question that remains on the table is whether the progress towards it will be evolutionary or revolutionary. Clearly the methods of managing revolution are different from evolution.

I believe it will be revolutionary—and those companies that act the fastest will be the ones to make the substantial gains in the future. Indeed, I would go even further. I believe that if you haven't today already got a clear plan in place to take account of this effect that the SEA will have when it comes to force an 31st December 1992, it may already be too late.

Now for some tactical advice—how to organize a revolution.

(Slide 36)

For this I've called upon the collective wisdom of prior experts to this field: Marx, Lenin, and Mao.

- Get rid of the old guard
- Build a new team
- Explain the new reality
- Develop a new philosophy and culture
- Implement a new strategy
- Declare a general modularization
- Keep the revolution going

(Slide 37)

To conclude, I believe we do have a picture of 1992; we think we know what it will look like, but the trouble is, it is currently a jigsaw and the pieces are distributed throughout the countries in Europe. For the first time in nearly two decades, the 1990s offer the outlook of a new springboard for economic policy management and for major reductions in chronic European unemployment.

I would like to close by postulating the answer to the following question: What will be the critical success milestones looking back to 1992 in, say, 1998?

The first is really a prerequisite, without which the reality of a single European market will be unattainable—monetary unity and a central European bank. The second is qualitative, a perspective, and that is the feeling that the job is not quite finished yet. And third, the quantitative aspect, that the growth in Europe was higher than it would have been had unity not occurred.

The challenge of a single European market by 1992 is first and foremost a challenge for Europeans. If they respond robustly, they will propel Europe onto the world stage in a position of competitive strength and on an upward trajectory of economic growth lasting into the next century.

Jennifer Berg
Malcolm Penn

(Slide 1)

1992: HAS EUROPE GOT IT?

MALCOLM G. PENN

VICE PRESIDENT

DATAQUEST EUROPE

(Slide 2)

1992

In 1992 the EEC countries form a genuine "Common Market".

"The 31st December 1992 deadline is now enshrined in a single European Act which defines the international market as an area without frontiers in which the free movement of goods, persons, services and capital is insured". "In recent months there has been an upsurge of support from businesses for the grand design implicit in the 1992 deadline".

"The Commission will develop a policy to promote the services market with an eye to completion of the internal market and the growing globalisation of trade".

JACQUES DELORS – EEC PRESIDENT – 20 JANUARY 1988

(Slide 3)

POSTWAR WORLD ECONOMIC RECOVERY

- Market liberalization
- 1920s/'30s trade barriers dismantled
- Government-nurtured cartels broken up
- Controls on direct foreign investment lifted

Since the 1970s there has been
a gradual shift away from market-led forces

The Single European Act will turn the tide

(Slide 4)

TRADE BARRIERS -- EUROPE

- Technical
  - -Standards (TV, telecommunications, power supplies)
  - -Safety
  - -Environmental (RF radiation, automobiles)
- Financial
  - -Standard terms and conditions
  - -Local currency trade
  - -Interest rates and capital sources
- Government and legal
  - -Tariffs and tax rates
  - -Duties
  - -Quotas
  - -Subsidies

(Slide 5)

1992 IMPACT

- This will require a substantial re-think of our marketing strategies
- Can manufacturers continue to have "Country" organisations defining
  - marketing strategies?
  - sell prices?
  - inventory levels?
  - support?

(Slide 6)

NEW ECONOMIC ERA - GLOBALIZATION

Seven factors on global economy

- Trade
- Macroeconomic policy
- Currency fluctuations
- International competition
- Direct and indirect investment
- Foreign capital flows
- Information transfer

(Slide 7)

THREE PHASES OF SEMICONDUCTOR INDUSTRY

- Phase 1 – Technology
- Phase 2 – Manufacturing
- Phase 3 – Marketing

(Slide 8)

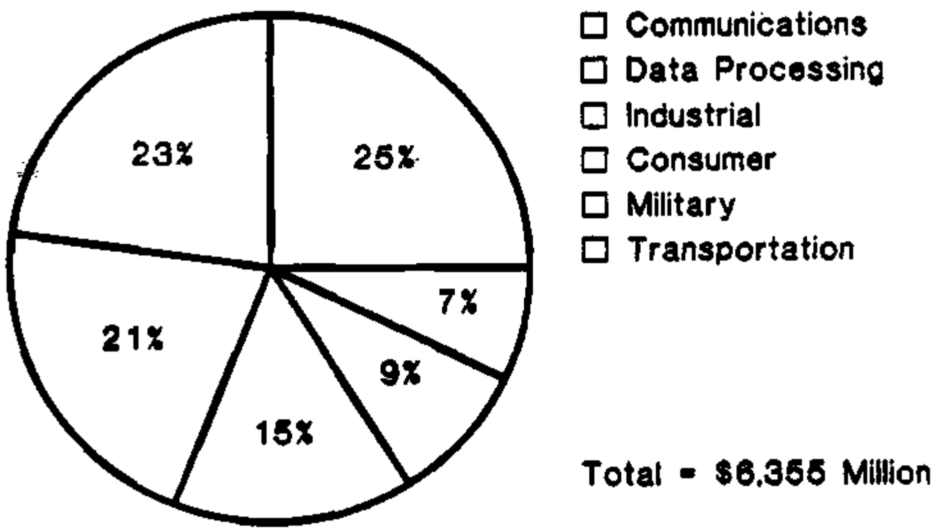
POSITIONING INTERNATIONALLY

Means sharing internationally

- Products and technologies
- Organizational restructuring
- Horizontal and vertical alliances
- Customer–orientated as first objective

(Slide 9)

EUROPEAN SEMICONDUCTOR MARKET BY END-USE SEGEMENT - 1987



Source: Dataquest

(Slide 10)

EUROPEAN COMPONENTS GROUP

Telecommunications

- Merger mania
  - GEC-Plessey
  - Ericsson-Matra
  - Bosch-Schneider
  - Alcatel-ITT
- Growth areas - 1987-1988
  - Modems - $540 million to $611 million - 13.1% growth
  - Central switches - $8.7 billion to $8.9 billion - 2.8% growth
  - Cellular phones - $730 million to $951 million - 30.3% growth
  - LANs - $524 million to $786 million - 49.9% growth

Source: Dataquest

(Slide 11)

EUROPEAN COMPONENTS GROUP

Computers

- Northern Europe takes the lead
  - Amadahl. Apple. Compaq. Digital. IBM. ICL. Wang
- Higher-resolution graphics
- Networking
- 3.5" disk drives

(Slide 12)

EUROPEAN COMPONENTS GROUP

Industrial

- Medical
  - GEC/Philips venture abandoned
- Energy management
  - Solid-state meter trials in U.K. and France successful
  - Enertec. Ferranti. GEC. Sangamo. Siemens

(Slide 13)

EUROPEAN COMPONENTS GROUP

Consumer

- "Professional consumers"
  - Nokia, Philips, Siemens, Thomson
- Compact disks (DSPs, video, RAMs)
- High-definition TVs (DACs, DSPs, ECL)
- Digital audio tape

(Slide 14)

EUROPEAN COMPONENTS GROUP

Military

- Eurofighter project
- Procurement flat in U.K. and France
- Potential growth in German market
- Airbus Industrie

(Slide 15)

EUROPEAN COMPONENTS GROUP

Transportation

- Huge impact due to currency revaluation
- Slow growth in luxury models
- Semiconductor content increasing
- Car production higher in Europe than in U.S. and Japan

(Slide 16)

EUROPEAN END-USE VENDOR RANKINES - 1987

(Millions of US Dollars)

Segement	Philips	SGS-Thomson	Siemens	Market Size
Data processing	4	8	6	23%
Communications	1	3	5	25%
Industrial	1	3	2	21%
Consumer	1	2	3	15%
Military	4	8	N/A	9%
Transportation	6	2	1	7%
Total	1	2	5	100%
Revenues	$930	$537	$475	$6,335

Source: Dataquest

(Slide 17)

EUROPEAN END-USE VENDOR MARKET SHARES - 1987

Segement	% Share
Data processing	24
Communications	40
Industrial	49
Consumer	65
Military	36
Transportation	48
Total	43

TOP 5 EUROPEAN COMPANIES CONTROL 38% OF THE MARKET

Source: Dataquest

(Slide 18)

JAPANESE PRINTER MANUFACTURER SURVEY

Expected Offshore Printer Production (Thousands of Units)

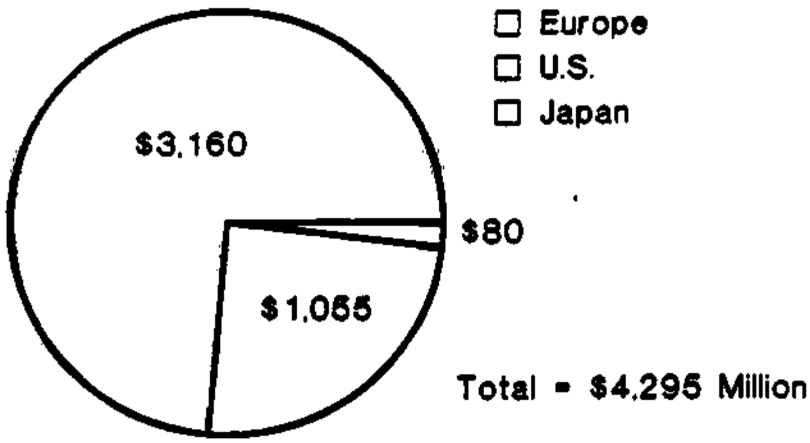
	1987	1988	1990
North America	205	500	850
Western Europe	92	1,245	1,740
Rest of World	3	5	10
Total	300	1,750	2,600

Source: Dataquest

(Slide 19)

ESTIMATED EUROPEAN SEMICONDUCTOR PRODUCTION IN 1987

(Millions of U.S. Dollars)



Source: Dataquest

(Slide 20)

1987 REGIONAL MARKET SHARES

(Billions of US Dollars)

	Europe	US	Japan	ROW	Total
Europe	2.6	0.8	0.1	0.5	4.0
US	2.9	8.7	1.2	1.1	13.9
Japan	0.9	2.0	13.0	1.9	17.8
ROW	0.0	0.2	0.0	0.4	0.6
Total	6.4	11.7	14.3	3.9	36.3

Source: Dataquest

(Slide 21)

1987 EUROPEAN EXPORTS

(Millions of US Dollars)

	Philips	SGS-Thomson	Siemens
Europe	$930	$537	$475
Other	673	322	182
Total	$1,603	$859	$657
% Export	42.0	37.5	27.7

Source: Dataquest

(Slide 22)

IN THE BEGINNING - ESPRIT

Of the 227 projects in first phase

- 143 Industrial significance
- 27 Marketed products
- 44 Products in developments
- 44 Transferred outside esprit
- 28 Contributed to international standards
- 11 Scrapped or merged

(Slide 23)

EUROPEAN SEMICONDUCTOR MERGEOVERS

- Plessey/Ferranti
- Brown Boveri/Asea
- SGS/Thomson

(Slide 24)

CELLULAR RADIO - SCANDINAVIAN EXAMPLE

- Common system throughout Scandinavia
  - Sweden
  - Norway
  - Denmark
  - Finland
- Co-operation between PTT's and local manufacturers

(Slide 25)

stack

STANDARD COMPUTER KOMPONENTEN GmbH

Control Data Corporation
International Computers Limited
The Plessey Company plc
Nixdorf Computer A.G.
Ing. C. Olivetti & C., S.p.A.
British Telecom plc
The General Electric Company plc
Standard Telephones & Cables plc
General Telephone & Electronics Corp.
Honywell Bull Inc.
Italtal S.p.A.
Northern Telecom Limited

(Slide 26)

VENDORS - USERS
CLOSER CO-OPERATION - TO ACHIEVE

- Better Communication
- Improved Quality and Reliability
- Optimum Testing
- Ship to Stock Procedures
- On Time Delivery
- Just in Time Delivery
- Accurate Forecasting
- Shorter Lead Times
- Electronic Data Interchange

(Slide 27)

VENDORS - USERS CLOSER CO-OPERATION - TO ACHIEVE Cont.

- Standard Packeting for Devices
- Standard Labelling e.g. Bar Codes
- Electronic Data Sheets
- Computerized Device Models
- Realistic ASIC Second Sourcing
- Productive R & D
- Realistic Pricing
- Improved Quality and Realiability
- Lower Cost of Ownership

(Slide 28)

FORMAL MEETINGS

- Technical Policy
- Purchasing - Trend and Techniques
- Test and Correlation
- Purchase Specifications
- Shared Evaluation
- Semi-Custom - USICs
- ASICs
- Failure Analysis Techniques
- Surface Mount Technology
- Surface Mount Dimensions
- Reliability

(Slide 29)

SUPPLIER / CUSTOMER RELATIONSHIP

Closer	Strategy – Technology roadmaps Product migration linkage Matched quality programmes Co–operative programmes – Developments – Qualifications – Tools Total data sharing
Longer–fewer	Take time to establish Resources to maintain Sensitive data transfer Win–win requires changes

(Slide 30)

VALUE ADDED MANUFACTURING CHAIN

- Sales
- Assembly
- Manufacturing
- Local procurement
- Design and Development
- Export

(Slide 31)

MULTINATIONAL CITIZEN PROFILE

Buy where we build and sell

- Products
- Services
- Technology
- Jobs
- Export

(Slide 32)

MAJOR MARKET OPPORTUNITIES

Markets	5-Year CAGR*
32-bit PCs	53.0%
Digital TVs	30.0%
Smart Card Electronics	60.0%
Automotive Electronics	10.7%
Personal Communications	26.0%

* Measured in dollars

Source: Dataquest

(Slide 33)

EUROPEAN ELECTRONICS INDUSTRY

Future Trends

- Europe will become a unified market after 1992
- Restrictive trade barriers will disappear
- Size of population will be 330 million
- New European standards will emerge in consumer, telecommunications, computer
- Scale of economy will drive down costs
- Europe will be more competitive in its own market

(Slide 34)

EUROPEAN ELECTRONICS INDUSTRY

Future Trends

- Europe will have state-of-the-art processing capability
  - Esprit, Eureka, Megaproject, Jessi
- European Community will ensure:
  - Multinationals sourcing components locally
  - Collaborative R & D on all fronts
  - Maintaining strong manufacturing base
- Europe
  - Still strong in consumer, automotive
  - Telecommunications will get stronger
  - Stability in military market

(Slide 35)

ARE WE FACING EVOLUTION OR REVOLUTION?

- If we decide the 1992 opportunity will substantially change the "rules" under which we operate – then it must be "revolution".
- The methods of managing revolution are clearly different from evolution!

(Slide 36)

HOW TO ORGANISE A REVOLUTION

1. Get rid of old guard
2. Build a new team
3. Explain the new reality
4. Develop a new philosophy and culture
5. Implement a new strategy
6. Declare a general mobilisation
7. Keep the revolution going!

Source: Marx, Lein, Mao

(Slide 37)

THE 1992 CHALLENGE

HIGH STAKES FOR EUROPE –

THE PRIZE WITHIN THE GRASP

Dataquest
a company of The Dun & Bradstreet Corporation

Research Newsletter

ESAM Code: Vol. II, Newsletters
1988-5
0000387

FAR EAST MARKET OVERVIEW

SUMMARY

The year 1987 was full of major changes for Japanese printer manufacturers. The dollar-to-yen exchange rate reached the highest point in history, antidumping pressures from Western Europe became a reality, and Japan was asked to change its export-oriented economic structure.

This newsletter focuses on several topics relating to the Japanese printer industry, including the following:

- Japanese worldwide printer shipments
- The Japanese domestic market
- Trade friction
- Japanese overseas manufacturing trends

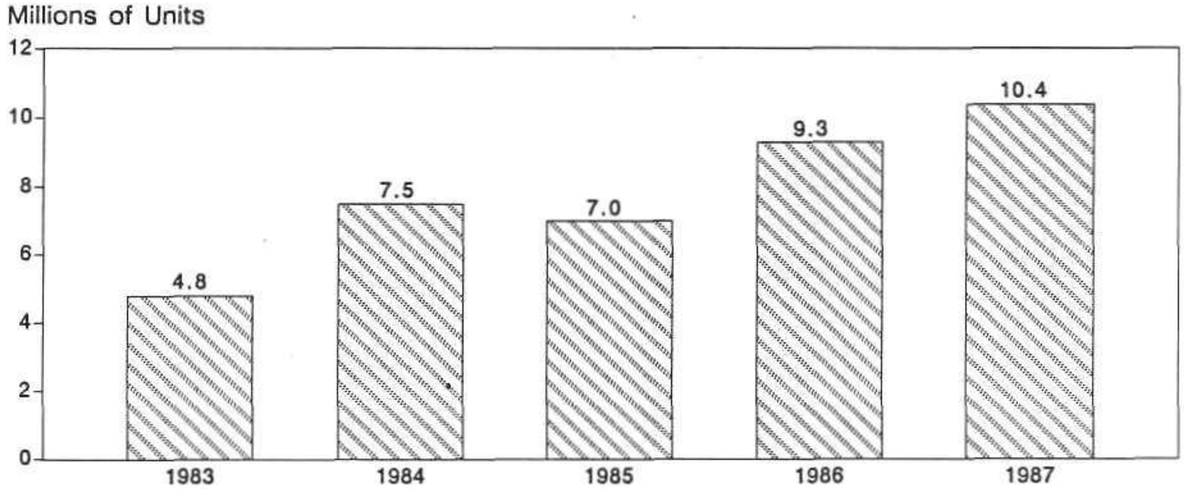
(The material in this newsletter was derived from a presentation given by Kenji Muto, an Industry Analyst at Dataquest Japan. Mr. Muto gave his presentation at Dataquest's thirteenth annual Electronic Printer Industry Conference in April 1988.)

JAPANESE WORLDWIDE PRINTER SHIPMENTS

As shown in Figure 1, Japanese printer shipments for the past five years have grown at a compound annual growth rate (CAGR) of 22 percent. In 1983, 4.8 million units were shipped; in 1987, 10.4 million units were shipped with an export ratio of 90 percent. Dataquest expects that Japanese local printer production will drop below 10 million units in 1988. This expected decline in local Japanese production will result from the production shift to Western Europe due to EEC protectionist actions.

Figure 1

Total Japanese Printer Shipments



Source: Dataquest
June 1988

The 1987 Japanese printer shipments by world region are shown in Figure 2. The 10.4 million units shipped are broken out into the following regions:

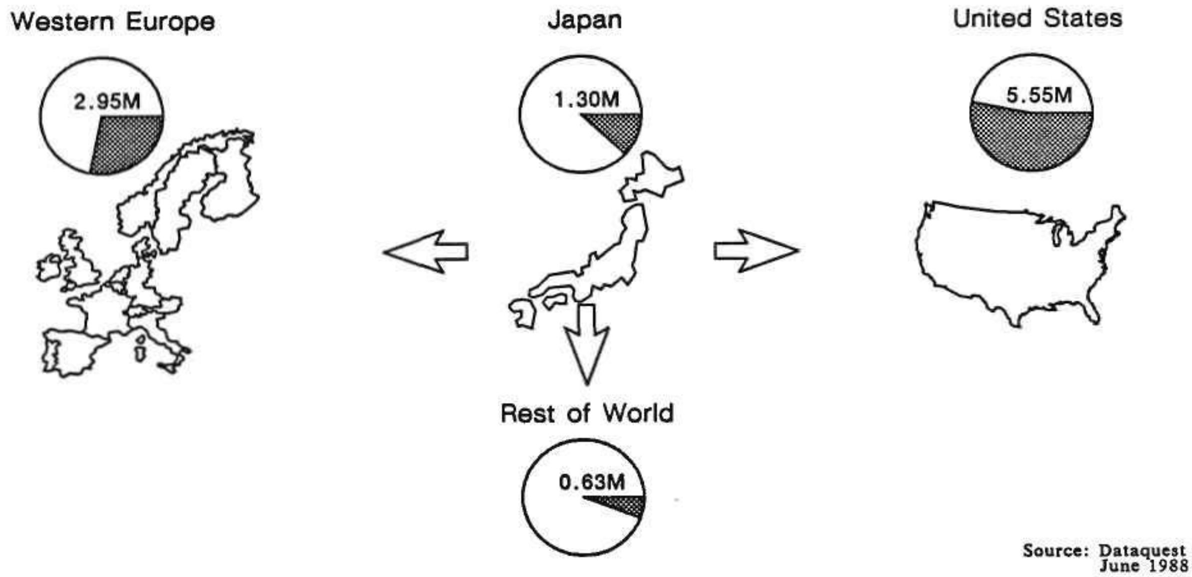
- 5.55 million, 53 percent, shipped to the United States
- 2.95 million, 28 percent, shipped to Western Europe
- 0.63 million, 6 percent, shipped to the Rest of World countries
- 1.30 million, 12.5 percent, remained in the Japanese domestic market

Table 1 illustrates the 1987 Japanese printer shipments for the overseas and domestic markets, by printer technology. For the 1987 overseas market, the combined serial, impact, dot matrix (SIDM) and page, nonimpact, plain paper (PNPP) printers represented more than 90 percent of total units shipped. For the 1987 Japanese domestic market, however, the serial, nonimpact, thermal transfer (SNTT) and serial, impact, dot matrix printers accounted for more than 90 percent of the shipments.

In terms of units, Epson is the world's leading printer shipper with its products under the Epson brand name. The second leading exporter is TEC, which is an OEM-oriented company. Following TEC is Oki. For the Japanese domestic market however, NEC is the leading shipper because of its 40 percent personal computer market share. Total Japanese domestic computer shipments for 1987 were estimated at 1.3 million units, with PCs accounting for 1.2 million units. Following NEC in the domestic printer market are Epson and Oki.

Figure 2

1987 Japanese Printer Shipments by Region



Source: Dataquest
June 1988

Table 1

1987 Japanese Printer Shipments, by Technology

Technology	Overseas		Domestic	
	Units(M)	Percent	Units(M)	Percent
Serial, Impact, Dot Matrix	7.61	83.5%	0.94	72.1%
Page, Nonimpact, Plain Paper	1.14	12.5	0.03	1.9
Serial, Nonimpact, Thermal Transfer/ Direct Thermal	0.08	0.9	0.27	21.0
Serial, Impact, Fully Formed	0.23	2.5	0	0.1
Serial, Nonimpact, Ink Jet	0.04	0.4	0.02	1.6
Line, Impact, Fully Formed/ Dot Matrix	0.01	0.1	0.03	2.6
Line, Nonimpact, Thermal Transfer/ Direct Thermal	0.01	0.1	0.01	0.7
Total	9.12	100.0%	1.30	100.0%

Source: Dataquest
June 1988

Most of the Japanese firms are quite diversified. Consequently, printer sales are a small portion of their total business. For Epson, TEC, and Oki, 40, 25, and 20 percent of their total sales, respectively, are attributed to printers, and only 4 percent of NEC's sales are attributed to printers.

Japanese Domestic Market

The 1987 Japanese domestic printer market represented 1.3 million units (12.5 percent) of the total worldwide Japanese shipments. Dot matrix printers accounted for 940 thousand units (72.1 percent) and thermal transfer printers accounted for 270 thousand units (21 percent). Shipments of other printer technologies represented rather small shares of the market.

Shipments of the 24-wire, dot matrix printers in Japan accounted for 93 percent of all serial, dot matrix printer shipments, whereas the 18-wire printers accounted for only a few thousand units shipped. This imbalance is a result of the high resolution offered by 24-wire printers, which is needed when printing kanji characters. It is interesting to note that Epson recently introduced a $2,500, 48-wire, 300-dpi dot matrix printer, to the domestic market, the VP-4800.

The previously discussed Japanese domestic printers are those that are connected to computers. In the thermal transfer market, there is another market segment, the built-in Japanese word processor market (JWP). In 1987, more than 2 million JWP units were sold, of which at least 1.5 million were lap-top type printers. The JWP lap-top configuration consists of the following:

- A keyboard
- An LCS 4 x 10-inch display
- A 3.5-inch flexible disk drive
- An 80-column serial, nonimpact, thermal transfer (SNTT) printer

If this shipment segment were counted, the total serial, thermal transfer market would consist of 1.8 million units. In terms of resolution, JWP printers are increasing to 36, 42, and even 56 elements per printhead.

Table 2 shows the Japanese domestic printer market rankings segmented by technology. As noted in the table, NEC is strong in the serial, dot matrix technology. The most popular speed range is 120 to 180 cps, accounting for 40 percent, followed by 181 to 250 cps, accounting for 25 percent. Printing kanji takes approximately one-third to one-half the time required for printing the Japanese alphabet—alphanumeric Kana (ANK).

Table 2

Japanese Domestic Market Share
(Based on Units)

SIDM		SNTT		PNPP	
1. NEC 2. Epson 3. Oki	49%	1. NEC 2. Epson 3. Hitachi	80%	1. Canon 2. TEC 3. NEC	90%

Source: Dataquest
June 1988

For the serial, thermal transfer technology, NEC is again the top market participant. The personal computer market affects this segment because the printers used are for the low-end PCs. The top three participants hold 80 percent of the market and offer speeds of less than 120 cps.

In 1987, Japanese page printers were in the introductory stage, and only 28 thousand units were shipped to the domestic market. However, we expect the Japanese domestic page printer market to soar in 1988. The desktop publishing market is also expected to grow in the third quarter of 1988.

TRADE ISSUES

Our trade friction analysis is based on our Japanese printer manufacturer survey in the first quarter last year. The survey results are based on 27 of the major Japanese printer manufacturers. Seventeen companies responded to the survey. Our survey covered the following topics:

- The movement of overseas production and its related problems
- The exchange rate issue and its effect on overseas production
- The Japanese printer manufacturers' response to trading difficulties

As previously stated, the major Japanese printer production technology is serial, dot matrix. The survey respondents accounted for over 70 percent of the entire serial, dot matrix production. We believe that this percentage qualifies the validity of the survey results.

Table 3 illustrates the respondents' offshore printer production plans. As shown for 1987, the actual production was 300 thousand units, of which 200 thousand were produced in North America and 92 thousand were produced in Western Europe. We project that in 1988, production units will increase to 500 thousand for North America and 1.25 million for Western Europe.

Table 3

Japanese Printer Manufacturers' Projections for
Estimated Offshore Printer Production
(Thousands of Units)

	1987	1988	1990
Western Europe	92	1,245	1,740
North America	205	500	850
Rest of World	3	5	10
Total	300	1,750	2,600

Source: Dataquest
June 1988

MOVE TO WESTERN EUROPE

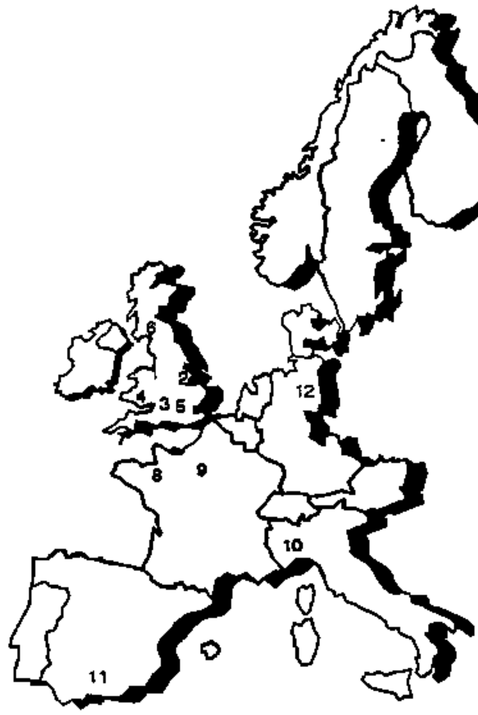
The primary reason for Western Europe's production growth stems from the expected EEC antidumping duty expected to be levied on serial, dot matrix printers. In 1987, Japanese printer exports to Western Europe were 2.9 million units and both serial dot matrix and fully formed printers were produced in Western Europe by Japanese companies. We expect that in 1988, 38 percent of the Western European market shipments will be produced locally by Japanese firms. Page printers will also be manufactured in Western Europe. By 1990, the number of locally produced units is predicted to increase to 1.74 million units.

The situation is different for Japanese production in North America, however. Production growth is moderate in North America compared with Western Europe.

The locations of Japanese printer factories in Western Europe are shown in Figure 3. These factories have commenced operations within the last 15 months and should expand production this year. We believe that the expected monthly run rate will reach 160 thousand units. The average factory size is anticipated to be 8,000 square meters with 1,200 total employees for this factory expansion.

Figure 3

Location of Japanese Printer Manufacturers in Western Europe



1.	Brother	Wrexham
2.	Citizen	Scunthorpe
3.	Epson	Telford
4.	Star	Tredagar
5.	NEC	Tekfird
6.	Oki	Glasgow
7.	Panasonic	Newport
8.	Canon	Littre
9.	Epson	Paris
10.	Canon	Aglie
11.	Fujitsu	Malagre
12.	TEC	Braunschweig

Source: Dataquest
June 1988

Local Content

In June 1987, the EEC passed legislation to control local content of new factories set up by companies with products subject to EEC antidumping duties. Essentially, the law states that products assembled in the EEC to escape antidumping duties must have 40 percent local content. The EEC group investigating local content in European factories has recently completed its investigation of electronic typewriter factories, and it is currently evaluating local content in copier factories. The investigation of SIDM factories will begin in the fall of 1988.

How soon can Japanese printer manufacturers meet with local content requirements? Table 4 focuses on this issue. As shown, within the next two years, a 50 percent local content goal is possible, but it will pose a challenge for manufacturers.

Table 4

Japanese Printer Manufacturers' Projections for Meeting Local Content Requirements (Western Europe)

Number of Years	% Content	Part	
0.5	22	Case Mechanism	Electronic, PWB
1.0	41	Case PCB	Manual Book
1.5	45	Motor PCB	Mechanism, Electronic
2.0	50	PCB	

Source: Dataquest
June 1988

Japanese manufacturers indicated that it would take twice as long to reach a 50 percent goal, compared with 40 percent, which is the requirement mandated by the EEC. Table 5 illustrates the key concerns of Japanese manufacturers regarding overseas production in both North America and Western Europe. The three primary problems for Japanese companies manufacturing overseas are:

- Parts procurement
- Quality control
- Production costs

In the past, these problems were advantageous for Japanese manufacturers, however, but now, production and local content requirements are making overseas production disadvantageous. Production cost is a key element in manufacturing.

Table 5

Japanese Printer Manufacturers' Key Concerns in Overseas Production

Concern	Points*
Parts Procurement	91
Quality Control	82
Production Cost	71
Delivery	40
Worker Education	36
Local Government	35
Domestic Employment	31
Research and Development	23

*Maximum points possible = 100

Source: Dataquest
June 1988

This year, Japanese manufacturers have projected the dollar-to-yen exchange rate as $1 to ¥123.8. The projected range is relatively small: between ¥120 and ¥130. If the yen rises to 100, the expected overseas production ratio increases by nearly 50 percent. Changes in the dollar-to-yen exchange rate will primarily affect overseas production in North America.

Table 6 illustrates the Japanese printer manufacturers' projected actions toward government dumping charges. The top three answers to our survey question were factory set up, joint ventures with local manufacturers, and rationalization of production. In the case of Western Europe, factory set up has already taken place due to the European community movement.

One-half of the survey respondents said they believe that some sort of trade restriction action will be taken by the U.S. government. The reasons they gave dealt with inconclusive trade laws and the U.S. manufacturers' appeal regarding dumping of serial, dot matrix printers.

Regarding the high yen exchange rate, the respondents said they believe that a decrease in sales will occur. To maintain revenue, either price or volume will have to increase, resulting in either a value-added product or low-cost, high-volume production. Japanese manufacturers indicate they will focus on the following value-added areas, by technology:

- PNPP—Higher functionality, dependability, software, controller, and color
- SIDM—Paper handling, increased copies and speed, lower noise level, and special paper capabilities
- SNIJ and SNTT—Regular paper, color, and high resolution

Table 6

Japanese Printer Manufacturers'
Projected Actions from Government Dumping Charges

Activity	North America*	Western Europe*
Factory Set Up	90	89
Change Export Item	31	32
Lobby Japanese Government	46	50
Withdraw from Market	17	20
Local Joint Venture	72	83
Lobby Local Government	39	37
Rationalize Production	73	71
Review Marketing Channel	42	55

*Maximum points possible = 100

Source: Dataquest
June 1988

The characteristics of the Japanese manufacturers in the printer business include the following:

- No Japanese company manufactures printers exclusively.
- Diversification of business is the mission for Japanese manufacturers.
- Capturing market share is a prime strategy. Adequate market share, low-cost, and mass-quality production can provide enough investment return.

Even among Japanese manufacturers, these characteristics lead to highly competitive environments. On the other hand, both Western Europe and the U.S. SIDM producers' governments are focused on local production and niche markets.

DATAQUEST ANALYSIS

We expect 15 percent of Japan's 1988 production capacity to move overseas. This trend is likely to continue because Japanese players are not only questioning the world economy, they are also realizing that cooperation and peaceful coexistence is imperative in order to maintain their prior levels of success. Thus many Japanese manufacturers are now seeking new ways of becoming recognized international companies by adding value to their products and contributing to the local economy.

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Jennifer Berg
Robert Fennell

Dataquest
a company of
The Dun & Bradstreet Corporation

Research *Newsletter*

ESAM Code: Vol. II Newsletters
1988-4

FAX MARKET SURGES AHEAD; JAPAN LEADS THE PACK

SUMMARY

The year 1987 proved to be another period of major growth for the worldwide facsimile market. In regional terms, the European market grew the fastest, with a compound annual growth rate (CAGR) of 110 percent (1987 versus 1986). The Japanese market, which is more mature, increased at a CAGR of 49 percent, while the U.S. market grew by a significant CAGR of 102 percent.

In terms of unit shipments, the Japanese still led in 1987 with 1.1 million units. The number of European shipments (421,000 units) was slightly higher than U.S. shipments (417,000 units) for the second year running (see Table 1).

Table 1

Estimated Worldwide Facsimile Shipments
(Thousands of Units)

	1986	1987	1991	CAGR 1987-1991
Asia	40	60	329	53.0%
Europe	199	420	1,876	46.0%
France	21	45	256	54.5%
Italy	21	60	211	37.0%
Sweden	11	20	64	34.0%
United Kingdom	50	100	340	35.8%
West Germany	24	60	340	54.3%
Rest of Europe	72	135	665	49.5%
Japan	738	1,100	2,280	22.0%
North America	227	456	1,500	34.5%
United States	206	417	1,380	35.0%
Canada	21	39	120	34.0%
Rest of World	25	45	136	32.0%
Total	1,229	2,081	6,121	31.0%

Source: Dataquest
May 1988

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All this activity is of great interest to Japan, where 98 percent of the world fax manufacturing is currently taking place.

In this newsletter, we will review the present fax market and the Japanese manufacturing phenomena. In addition, we will look at some development factors affecting the market into the 1990s.

MARKET OVERVIEW

A facsimile (fax) machine is a telecommunications product that must meet the stringent and often restrictive requirements of local PTTs and operating companies in order to receive approval for connection to the public switched telephone network (PSTN). Given that fact, it is a remarkable phenomenon that, in 1987, more than 98 percent of the approved fax machines were of Japanese origin. Furthermore, as the market continues to grow, Dataquest expects the proportion of Japanese fax machines to exceed 99 percent in 1988. The following factors contribute to this situation:

- Although the fax machine was initially developed in Europe by Muirhead and in the United States by Xerox, these western manufacturers were unable to maintain high volumes of commercially attractive products; they had stopped manufacturing fax machines by 1975.

- The fax machine was then found to fulfill a major user requirement in the Japanese market as a mean of communicating kanji characters. Consequently, the Japanese domestic fax market grew rapidly; local production became firmly established, helped by this strong internal demand.

- The fax machine proved to be a product ideally matching Japan's skills in high-volume electronic production, based on the country's abilities in improved productivity and electronic miniaturization.

- By 1987, Alcatel of France was the only non-Japanese manufacturer producing its own fax equipment (sold under the brand name Thomfax).

  - Alcatel had trouble manufacturing products to the same price margins as the Japanese, however. Consequently, during 1987, Alcatel made an agreement to manufacture equipment in France under license from Toshiba.

  - Alcatel will continue to manufacture the high-end "feature machines" but will only partly manufacture and assemble Toshiba products for the low end of its product portfolio.

- Sagem, another French manufacturer, has reached a similar agreement with Murata of Japan. However, under this agreement, Murata will supply all the products of the Sagem portfolio.

- These two agreements permit continued fax manufacturing in France and an increased dependence on Japan as the low-end fax product market share continues to increase.

- Dataquest believes that as Japanese manufacturers proceed further along the learning curve of high-volume fax production, it will become much more difficult for any other country to successfully compete in the production of facsimile equipment.

Tariffs and Import Restrictions

Having noted the domination of the fax market by Japanese manufacturers, we must also consider the issue of trade barriers. Similar situations of overwhelming Japanese production superiority have developed in both the copier and the electronic printer industries. A review of these industries may help to explain the international reaction.

During the last 12 months, action has been taken by the European Commission and a number of individual countries to impose severe penalties on products that are not at least assembled within relevant trade zones such as Europe or America. In the case of fax products, the issue of PTT approval further complicates free access to a market.

Dataquest believes that the Japanese manufacturers should take note of this international trend to require local manufacturing and should make appropriate plans. In fact, a number of Japanese manufacturers have already positioned themselves to meet such market restrictions. Most notable is Canon, which has reached a marketing and manufacturing agreement with Olivetti in Italy and has established its own fax manufacturing facilities in France.

Ricoh with Kalle Infotec, NEC, and Toshiba also have local manufacturing facilities that could commence fax operations, if required.

The 1987 Fax Market

Table 1 presents the initial Dataquest estimates of worldwide facsimile shipments for 1986, 1987, and 1991.

Table 2 shows the initial Dataquest market share estimates for the top suppliers in the European facsimile market for 1987.

Table 3 provides a breakdown of 1987 shipments into the major European countries.

Table 2

European Facsimile Market Share by Supplier
(Actual Units)

Supplier	Units	Percent Share
Panasonic	70,800	16.8%
NEC	45,274	10.7%
Canon	73,900	17.5%
Infotec	38,727	9.2%
Alcatel	39,200	9.3%
Toshiba	31,650	7.5%
Oki	39,995	9.5%
Sharp	20,670	4.9%
Xerox	8,610	2.0%
Murata	17,765	4.2%
Hitachi	13,604	3.2%
Fujitsu	10,013	2.4%
Pitney Bowes	4,750	1.1%
Others	6,905	1.7%
Total	421,863	100.0%

Table 3

Estimated 1987 European Facsimile Placements
(Actual Units)

Country	Units	Percent Share
United Kingdom	102,951	24.4%
France	45,032	10.7%
West Germany	59,294	14.1%
Italy	57,391	13.6%
The Netherlands	21,593	5.1%
Norway	17,392	4.1%
Sweden	21,530	5.1%
Switzerland	16,727	4.0%
Belgium	18,393	4.4%
Greece	1,839	0.4%
Finland	7,784	1.8%
Denmark	15,577	3.7%
Spain	18,827	4.5%
Turkey	3,755	0.9%
Ireland	3,030	0.7%
Austria	6,582	1.6%
Portugal	2,725	0.6%
Others	1,449	0.3%
Total	421,871	100.0%

Source: Dataquest
May 1988

Market Analysis and Forecast

From 1984 through 1986, most facsimile shipments in Europe and in the United States were aimed at businesses' communication rooms, in which the fax machine typically stood next to the telex machine. In 1986 and 1987, the low-end facsimile products began to penetrate smaller business organizations and started to find their way into department-level applications.

Dataquest believes that shipments through 1992 will show the greatest growth in the low-end product sectors. The low-end products are becoming increasingly popular in Japan; now they are becoming known by the alternative name, "personal fax." Using innovative production techniques, the Japanese manufacturers are making these products even more compact, progressively decreasing the footprint size, and integrating a telephone handset with the box.

Personal faxes are beginning to penetrate very small businesses now, in addition to being targeted for executive desktops. As the average selling price (ASP) of these machines continues to decline, two questions arise:

- What proportion of desktops and homes of business executives will become populated by faxes? In other words, what is the personal fax total available market (TAM)?

- What channels of distribution should be used for these products as the cost of sales becomes a proportionally more significant factor in the product price?

The Japanese fax market, which is one to two years ahead of the European and U.S. markets in maturity, is already beginning to face these issues. Retail channels are being tried, and Dataquest recently noted personal fax machines on sale in Tokyo stores for as little as ¥79,000 ($640).

Focusing on retail channels, however, ignores the issue that the fax machine remains, in principal, a business tool with the need for effective supplier provisions and maintenance contracts. Thus, the retail channel is less attractive to the business purchaser. Home, door-to-door salespeople are finding resistance for similar reasons.

Dataquest speculates whether improved advertising techniques, combined with toll-free call facilities for more accurate prospective customer identification prior to sales calls, would reduce direct sales costs (i.e., through achieving a higher percentage sales close rate). Other low-cost sales channels may exist, including office-related electronics retail stores and mail order sales.

TECHNOLOGY TRENDS

Personal Fax Machines

Personal fax machines that are compatible with CCITT Group III standards certainly show much growth potential in the short to medium term.

Color Facsimile Machines

The Japanese, however, are also working on new facsimile developments, and one specialized development is color facsimile. NEC recently demonstrated a prototype of such a machine; however, the technology is still very expensive at this time. We believe that color facsimile certainly could become a very successful niche market sector in the future. Two-color-image (red and black on white) faxes are also becoming available, and Ricoh recently demonstrated a prototype of such a product. These machines are likely to be used in editing applications such as highlighting or making corrections to areas of text and graphics.

Group III Facsimile Machines

High-end Group III fax machines with store-and-forward capabilities, although currently representing only 5 percent of all fax units sold, are expected to show strong growth, with a 70 percent CAGR through 1992. This segment is less price sensitive and is aimed at placements within the headquarters of large companies. Consequently, we believe that many extra new functions and technology advancements will be seen in this area. Other capabilities that we expect to become available with machines in this segment are fax networking and switching functions.

A further advancement that is currently receiving a lot of research and development attention is error correction for secure transmission. The CCITT has put together a preliminary specification for such a facility, and a number of manufacturers are working to have this feature available with their products by the end of 1988.

Plain Paper Facsimile Machines

Much effort continues in the area of plain paper facsimile (PPF) machines. At this stage, these machines are at least twice as expensive as thermal paper machines. Such a high price effectively makes PPF products unacceptable in a market where the user usually has a plain paper copier not far from the fax machine, which means that if required, a PPF copy can be produced easily and at minimal extra cost. The Japanese are currently working on technologies that may eventually drop the price of a PPF machine much nearer to that of a thermal machine. If such a price reduction is achieved, Dataquest expects the PPF market to open up quite rapidly.

Group IV Facsimile Machines

Looking forward, the big question is about Group IV facsimile machines. These products will require an ISDN or compatible 64K digital network to operate. We do not believe that they will be widely available before 1995, even in countries with advanced telecommunications infrastructures. Although Group IV faxes will be capable of sending messages at approximately 3 seconds per page, this capability is already being achieved through improved Group III coding techniques such as Modified Modified Read (MMR), which currently has reduced the transmission time from about 20 seconds to 9 seconds. Further transmission improvements are under development. The recent advancements of Group III clearly reduce the advantage of Group IV. Furthermore, the fax machine became attractive as a text-transmission medium only once a solid user base had been established. The same problem will be encountered by Group IV machines until they gain acceptance and establish a worldwide user base.

Although Group IV will certainly establish its market niche, particularly within large internal network applications, we do not expect it to take a dominant position over Group III in terms of shipments until well into the 21st century.

JAPANESE MANUFACTURING

Japan's success in the realm of facsimile is due to the country's formidable record of achieving economy of scale in electronic manufacturing techniques. Although one South Korean manufacturer has recently entered the facsimile market, its product is comparatively much lower in quality. We believe that this product will need considerable improvement before it becomes a serious contender against Japanese products in world markets.

Factory Automation

Meanwhile, Japan continues to improve its electronic production techniques through advances in semiconductor technology as well as increasingly sophisticated production robots, such as pick-and-place semiconductor component assembly systems.

The Oki Honjo (North of Tokyo) is one of the most modern automated facsimile assembly facilities in Japan. Following a recent refurbishment program, it uses 300 assembly and quality-inspection robots linked to a fully computerized stores-and-supplies system in what is known as an FA (factory automation) environment. Nevertheless, the facility still employs 900 direct workers involved in the fax manufacturing area, as well as a number of subcontractor companies that deliver completed and tested subassemblies and other components to the plant at least twice daily.

Oki insists that all the subcontractors are in the area, close to the Honjo plant to ensure secure product delivery. The subcontractors themselves all work in a typically Japanese manner, with timely deliveries of high-quality products. The stores area is thus minimized, and the reject rate is extremely low. Subassembly and other partly finished components are shuttled around the facility on computerized delivery vehicles that beep and flash warning lights whenever humans cross their paths.

In order to address new target markets, Japanese manufacturers also plan to design fax products with an ever-decreasing footprint size. One of the factors contributing to this effort is a new and extremely compact image-scanning system.

To achieve this smaller footprint, Oki, like a number of other Japanese manufacturers, has recently introduced the direct-contact technology for the image-scanning mechanism. Although not particularly less expensive than the older charged couple device (CCD) technology, it is able to achieve a significant reduction in the equipment size. This size reduction results in an implied saving in material cost, as well as a machine with a more attractive user footprint.

A second route to achieving smaller product size is through the ever-increasing miniaturization of electronic components. For example, a number of manufacturers have started using the new Rockwell single-chip modem, replacing the four IC chips used in previous generations of facsimile modems.

Productivity Race

The facsimile output capacity of the Honjo plant is currently 460 units per day. The final assembly is done on two parallel lines, each with an indicator of the daily production target and a second counter to show performance against the target. As each finished machine comes off the assembly lines, the daily tally is incremented and the performance counter adjusted. The two production-line staffs essentially race against each other, as much for the honor of being ahead as for the small bonus that they can win at the end of the month.

Even the computerized delivery vehicles seem to be in an hurry, competing with one another to raise the daily production quota. At 460 fax units per day, the Honjo plant output is running at approximately $1.5 million daily. This output is far from the plant's ultimate capacity. The factory management anticipates easily reaching more than 700 units daily through shift work at the current facilities. Management further claims that even higher output could be reached through additional improvement in production techniques.

Such increased production capacity will be critical to Harris/3M, Oki's largest worldwide OEM customer. Indeed, in 1987, Harris/3M ramped up its production requirement with Oki by more than 168 percent against its 1986 shipments and is now responsible for more than 55 percent of Oki's total worldwide facsimile output.

Clearly, any restrictions applied on facsimile imports into Europe would have a major impact on Oki and its OEM partners alike. Should such restrictions be applied, however, Oki does have a European manufacturing facility in Scotland and would be able to move fax production there within six months.

DATAQUEST ANALYSIS

Dataquest anticipates that the worldwide fax market will remain one of the fastest-growing telecommunications market segments over the next few years. In terms of unit shipments, we estimate that the worldwide fax market will increase by a 30 percent CAGR from 1988 through 1993. In telecommunications, only the cellular radio handset market is expected to grow as rapidly during this period. Here, again, the Japanese have significant presence.

Dataquest believes that Japanese manufacturing skills, combined with a closely affiliated semiconductor technology and the current level of R&D spending to maintain technical innovation, will make Japanese manufacturers a tough team to beat. This will be particularly true in product areas where production volumes are high and the software content is low. A typical product of this kind is the facsimile machine. Central office switching technology, however, is an example of a product requiring specialized software. In the case of central office switching, we do not expect the Japanese to make a significant market impact in Europe.

Dataquest anticipates that with the continuation of worldwide telecommunications market deregulation, governments and PTT authorities in many countries will be assessing the increasing impact of Japanese products on their markets. We believe that Japan does have an excellent chance for success in the U.S. and European markets with its current and future products in areas such as facsimile. However, we also believe that Japanese manufacturers should seriously consider strategies that would give them a local manufacturing presence in the U.S. and European markets. Dataquest considers such a capacity to be an essential requirement for Japanese facsimile manufacturers hoping to avoid the imposition of future punitive trade restrictions.

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Dataquest
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The Dun & Bradstreet Corporation

Research Newsletter

ESAM Code: Vol. IV, Newsletters
1988-3

YEAR-END EUROPEAN PROCUREMENT SURVEY: THE ISSUES ARE AVAILABILITY, PRICING, AND SUPPLY

INTRODUCTION

This newsletter presents the results of our second European Semiconductor Application Markets (ESAM) procurement survey conducted across a wide range of major Europe-based electronic equipment manufacturers in the fourth quarter of 1987. The first European purchasing survey, conducted during the second quarter of 1987, revealed the then global concern of pricing. Since then, the emphasis has moved away from the issue of pricing and toward that of the availability of components.

The object of the survey was to determine the major concerns of semiconductor buyers in Europe. One major concern is the resulting shortage of memory parts that is due to the export license requirements imposed by MITI on Japanese suppliers. Other issues that were important to buyers included possible price increases on selected products in short supply, increasing demand, and longer lead times.

Table 1 shows the primary concerns emphasized by our respondents.

Table 1

Semiconductor Buyer Concerns

Concern	Percent of Respondents
Availability	20.4%
Pricing	16.3
Supply	12.2
Quality	12.2
Lead Times	12.1
Tariffs	10.3
Surface-Mount Technology	6.1
ASICs	4.1
Memory	4.1
Currency Exchange Rates	2.2
Total Respondents	100.0%

Source: Dataquest
March 1988

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SURVEY STRUCTURE

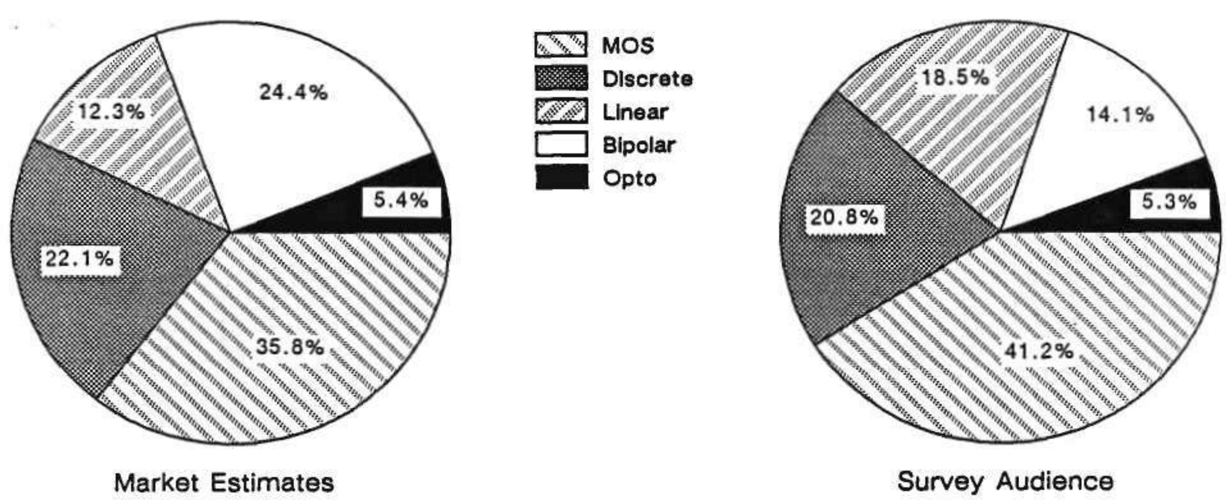
Dataquest selected survey participants from the top electronics manufacturers in Europe, successfully repolling the majority of manufacturers that participated in our first data- and trends-gathering project. We surveyed manufacturers that are actively purchasing semiconductors for electronic systems and subassemblies, interviewing individuals who are purchasing managers and directors, or who are involved in material or corporate contract management.

Subsequently, we compared our survey data on the semiconductor purchase mix with our 1986 European estimates; Figure 1 shows how closely they correspond. The survey results show a higher percentage of bipolar logic purchases than Dataquest's market share estimate of this segment. In the MOS market, however, the situation is reversed, with purchases lower than expected. Overall, the survey results demonstrate that our sample of purchasers closely reflects the total European demand.

Figure 2 shows the geographic distribution of our survey respondents. Although we tried to achieve an even distribution of respondents throughout Europe, the results show that there was a bias toward the United Kingdom. This bias was probably due to the fact that the survey was conducted from the United Kingdom; however, we do not believe that it detracts from the validity of our analysis.

Figure 1

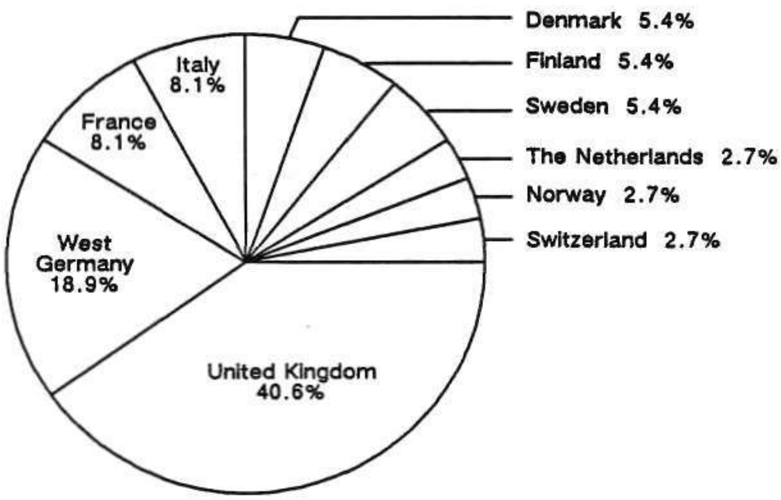
Semiconductor Purchase Mix
Survey Results Compared with 1986 Estimates
(Percent of U.S. Dollars)



Source: Dataquest
March 1988

Figure 2

Geographic Distribution of Survey Respondents
(Percent of Respondents' Regional Base)



Source: Dataquest
March 1988

The survey centered around factors influencing and driving semiconductor purchasers. It focused on the types of products that these purchasers manufacture and the semiconductor quantities/value they bought in 1987. We further asked questions about the sources of their semiconductor purchases on a regional basis. The survey reveals that the majority of manufacturers' purchasing was influenced by price, quality, and availability, in that order. Comparing this survey with the previous one conducted in the second quarter of 1987, a trend emerges showing that buyers are moving away from Europe-based suppliers and toward Japan-based suppliers. The survey results indicate that the purchasing community perceives that a good number of European and U.S. suppliers have difficulty matching Japanese vendors in price and quality on MOS ASIC, microprocessor, and memory product lines.

EUROPEAN MARKET TRENDS

Overall, Dataquest believes that distribution-channel purchases are increasing in Europe as a percent of total semiconductor purchases for two reasons. First, the movement from electromechanical industries to electronic systems implies that more companies are entering the market with relatively modest requirements for semiconductor purchases; these companies are best served by distributors. Second, semiconductor vendors are moving to regulate and minimize sales costs by limiting the number of companies with which they deal directly. By servicing some of these companies through their franchised distributors, the vendors can increase their overall efficiency.

Table 2 shows the currently perceived worldwide shift in supplier base compared with our previous survey's results.

Table 2

Worldwide Shift in Supplier Base

Supplier Base	Q2 1987 Survey Results	Q4 1987 Survey Results
Europe	32.9%	32.0%
United States	50.0	46.0
Japan	14.9	18.9
ROW	2.2	3.1
Total	100.0%	100.0%

Source: Dataquest
March 1988

Figures 1 and 2 indicate a shift in the buying patterns of these equipment manufacturers. Most of the surveyed companies would prefer to buy locally manufactured semiconductor devices. Unfortunately, local suppliers still have to go some way in order to deliver the breadth and depth of the required product range. The increase in Japanese preference for procurement was partially due to a switch to higher-density memories, but it also was moderated by the effects of the U.S.-Japan Semiconductor Trade Arrangement.

The survey also confirmed the penetration of rest of world (ROW) suppliers (such as those based in Korea, Taiwan, and Singapore), with some equipment manufacturers relying on up to 10 percent of their semiconductor requirements from these suppliers.

ASSESSING INVENTORY LEVELS

Dataquest clients have frequently asked us to assess inventory levels. However, it is very difficult to estimate inventory levels because of the varied product mix for discrete, linear, memory, and logic. Table 3 shows our respondents' estimates of their inventories relative to target. Overall, 42.4 percent reported that their inventories were above target. Only 12.1 percent indicated below-target levels. The trend that began two years ago to reduce the excessive levels of 1984 has continued, and we believe that inventories have now reached stable levels. The majority of respondents indicated that their inventories are expected to increase from an average of 6 weeks to 8 to 10 weeks, as the expected demand and growth will create temporary shortages in key areas such as DRAMs and some 32-bit microprocessors.

Table 3

Semiconductor Inventories Relative to Target
(Percent of Total Respondents)

Inventory Level	Percent of Respondents
Extremely Low	3.0%
Somewhat Low	9.1
On Target	45.5
Above Target	39.4
In Significant Excess of Target	3.0
Total	100.0%

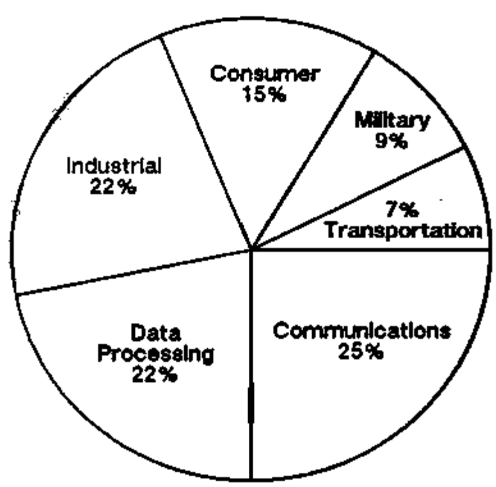
Source: Dataquest
March 1988

PROCUREMENT TRENDS BY SEMICONDUCTOR APPLICATION SEGMENT

Figure 3 shows Dataquest's estimates for 1986 European electronic equipment production by application.

Figure 3

Electronic Equipment Production by Application Segment
(Percent of U.S. Dollars)
1986



Source: Dataquest
March 1988

Consumer Application Market

The purchasing pattern in the consumer segment still favors the Europe-based supplier. This segment is a relatively large user of discrete and optoelectronics devices, a market of which Europe-based suppliers have a substantial share.

Most buyers expect these discrete devices to be customized to achieve better price/performance integration, and for this they require close, long-term relationships with local suppliers. They also expect the number of ICs used in consumer products to be substantially reduced in favor of a semicustom/custom approach, which will require a major shift toward surface-mount devices.

Surprisingly, major consumer manufacturers are purchasing up to 30 percent of their requirements from offshore sites rather than from the local sales offices of these off-shore suppliers. This situation could be explained by the consumer market requiring close links with the supplier manufacturing site to interface on all levels—design, test, quality, shipping, and logistics.

Major Japanese consumer manufacturers in Europe have started to procure locally, especially with discrete and opto devices. Most of these manufacturers complain that local suppliers do not have the right manufacturing technology to supply their special needs. However, they face increasing pressure from the EEC to source more components locally.

Overall, consumer manufacturers in Europe reported a healthy growth in 1987 compared with 1986, but indicated that they expect to further reduce inventory levels and start engaging more JIT (just-in-time) programs with their suppliers.

Automotive Application Market

Purchasing managers in the automotive segment responded very positively about their inventory levels, as most of them have ongoing JIT programs that have passed the learning-curve period. They reported that suppliers failing to meet their specification and delivery commitments do not win future contracts for supply.

Major concern is still shown over the long-term reliability of semiconductor devices, fault coverage, and incoming test correlation. Very few suppliers are able to meet more than 80 percent of these purchasers' requirements. The suppliers' concern is amplified when dealing with the purchasers' ASIC requirements. Among the major European automotive electronic equipment manufacturers, preference is shown toward Europe-based suppliers or foreign suppliers with a manufacturing base in Europe.

In general, the automotive market anticipates greater IC use in the future as more features are added to standard models.

Military Application Market

Purchasers in the military segment are prepared to hold relatively large inventories for parts that are prohibitively expensive at low volumes. This segment shows heavy reliance on the semiconductor distribution network for standard military-grade parts. Most purchasers indicate above-average inventory levels. North American suppliers are heavily used over their European counterparts, except for ASIC requirements. Major military contractors prefer in-house suppliers for ASICs because of the complex nature of meeting as yet undefined military-standard specifications for these parts.

Major concern was shown about U.S. versus European military specification issues and specifications for surface-mount devices.

Computer Application Market

This segment showed the most volatility, with purchasing managers expressing much concern about the availability of 256K and 1-Mbit DRAMS and the impact of MITI export licensing requirements. This segment is heavily dependent on Japanese suppliers for its memory devices. The supply shortage of these devices, coupled with price rises, is starting to hurt some manufacturers, with the exception of those manufacturers with steady in-house supplies.

Most U.S. multinationals based in Europe procure, on average, 30 percent from European manufacturing sites, including U.S. suppliers manufacturing in Europe.

We believe that 1988 will be a big year for surface-mount devices, as most purchasers reported substantial increases in their purchases of these devices.

Inventory levels of computer manufacturers are, on average, down to 6 weeks, but most manufacturers expect this time to increase to 8 to 10 weeks as a result of shortages of leading-edge products such as 1-Mbit DRAMs and 32-bit processors.

The computer segment also showed a substantial increase in the use of gate arrays and programmable logic. Most purchasers indicated requirements for higher-speed PALs and high-density gate arrays.

Regional preference in this group is still for U.S. suppliers because of the large presence of U.S.-based computer manufacturers in Europe. CMOS now accounts for more than 50 percent of total purchases in the computer segment.

Telecommunications Application Market

Most purchasing managers in the telecommunications segment indicated healthy growth in the amount of semiconductor purchases when expressed in U.S. dollars, but showed a virtually flat pattern when the purchases were expressed in local currency. They expect prices to decrease with the increasing volumes. The use of surface-mount devices is somewhat erratic: Some major manufacturers use surface-mount devices up to 10 percent, while others, at 2 percent, barely use them.

Most purchasers reported inventories on target, but they also expected to further reduce their levels. Some purchasers in this segment have started JIT programs, and many others are moving in this direction.

Purchasers expressed uncertainty about recent mergers in the telecommunications industry, focusing on the issues of plant location, products, and personnel rationalization.

It appears that the telecommunications segment, like the other industry segments, has been unable to reduce the number of its suppliers because of the diverse range of semiconductor devices required. A supplier with a broad product line and the right telecommunications products stands a better chance than one with a narrow product line.

The major concerns shown in this segment are procurement logistics and management of ASIC supplies.

DATAQUEST CONCLUSIONS

The buyers' responses to Dataquest's second European procurement survey primarily indicate concern over availability and cost-related issues. The emphasis on availability, pricing, supply, and quality leads us to believe that this concern is indeed a positive signal for steady growth in the industry. Quality was not at all mentioned in our second quarter 1987 survey; however, this issue ranks high on the list of concerns generated by our latest survey. European semiconductor buyers' mindfulness of ASICs and surface-mount technology reflects the fact that these two product areas are now impacting the marketplace with their cost-competitive and overall system design advantages.

We believe that there is a pressing need for semiconductor vendors to better educate the purchasing community on changing technology and product trends. A large proportion of the respondents indicated that they were swamped with product specifications; however, the information from maunufacturers concerning key areas of interest, such as packaging, quality, and cost benefits, was insufficient.

Bipin Parmar
Mike Williams

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1988-2

IS THERE A TRANSPUTER IN YOUR FUTURE?

INTRODUCTION

In the last few years, both Intel and Motorola have introduced microprocessors that have changed the face of the PC industry. However, a third company, Inmos Corporation, has introduced the transputer, a microprocessor designed to bring the power of a supercomputer to desktop computing.

This newsletter examines some of the products utilizing transputer technology and discusses the implications of the transputer for the personal computer industry.

BACKGROUND

In November 1986, Inmos Corporation, a subsidiary of United Kingdom-based Thorn EMI, introduced the T800 transputer, a 32-bit microprocessor capable of achieving performance ratings of 10 to 12 mips. Since this announcement, the T800 transputer and its predecessors, the T212 and T414, have been catching the eye of many computer product manufacturers.

The transputer is not a coprocessor. The T800 transputer combines a 32-bit CPU; standard IEEE, 64-bit, floating-point processor; 4KB of fast RAM; and four communications links that are used to connect transputers into networks.

The transputer is designed for high-performance single-microprocessor applications; however, the real power of the transputer is in its capability to be linked with other transputers to provide ultrahigh-performance multiprocessor applications ranging from PC workstation accelerators to supercomputers.

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The Inmos T800 competes directly with microprocessors manufactured by Intel and Motorola. The Inmos T800 is the first microprocessor to offer a processor and a floating-point processor on a single VLSI device. This combination is ideal for applications such as high-end graphics and artificial intelligence.

TRANSPUTER APPLICATIONS

The Atari Abaq

At the fall Comdex, Atari Corporation demonstrated a prototype of the Abaq, a 32-bit transputer-based workstation. The Abaq uses the Inmos T800 and is capable of operating at 10 to 12 mips. This level of performance would give the Abaq the ability to operate at speeds 10 times greater than the IBM AT. The Abaq is equipped with 4MB of RAM and 1MB of display RAM. The Abaq supports four graphics modes: 1,280 x 768 pixels in 16 colors or monochrome; 1,024 x 768 pixels in 256 colors; 640 x 480 pixels in 256 colors with two screens; and 512 x 480 pixels in 16 million colors plus overlay.

Perihelion Software is currently developing Helios, a UNIX-like operating system for the Abaq. In addition, an MS-DOS emulator is currently being developed for the Abaq by a third-party developer.

Apple Macintosh Enhancement

Levco has announced an add-on board for the Macintosh II and Macintosh SE, based on the Inmos T800 transputer. The Levco TransLink transputer card will range in price from $2,000 to $12,000, depending on the number of transputers installed on the board and the amount of memory allocated to each transputer. A transputer card with four T800 processors, C compiler and assembler, and 1MB of RAM dedicated to each processor will provide 20 times the performance of the Mac II. Pricing for this configuration will range from $11,000 to $12,000.

Microport V/TT System

Microport Inc., a supplier of UNIX software, recently announced the Microport V/TT System, a UNIX-based implementation of the Inmos T800 transputer.

The system runs on an IBM AT and is equipped with the Inmos B008 transputer module board. The B008 board utilizes four T800 transputers, and it is claimed that this combination can deliver 50 times the power of UNIX running on the IBM PC AT itself.

DATAQUEST ANALYSIS

Prior to the introduction of the PC, users were forced to share the same processor. With the advent of the PC, users now have their own dedicated processors. Transputers linked within a network take the one person/one processor concept a step further by providing a user with access to several processors at a time. Application tasks are distributed among the processors in order to optimize the total application performance.

The problem facing vendors of transputer technology is that very few software applications have been written with the capability of utilizing multiple processors. In order for this technology to gain a foothold in the PC marketplace, we believe that Inmos must persuade software developers to adapt their applications to a multiprocessor environment.

Parallel processing is not a new concept in the computer industry as a whole; however, for the PC industry, it represents the ultimate solution for power-intensive applications. It opens the door to having mainframe computing power on the desktop and is the next logical step for the PC of the future. The embodiment of this capability in IBM's Micro Channel and Apple's Nubus is a reaffirmation of this philosophy.

Although multitasking is the current topic of conversation in the PC industry, we believe that multiprocessing will have a significant impact on the future of the PC industry. How significant an impact the Inmos transputers will have in the area of multiprocessing will ultimately be decided by software developers.

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1988-1

ERICSSON GETS LEANER WHILE NOKIA CONTINUES ACQUISITIONS

SUMMARY

Ericsson's pending sale of its Data System Division to Nokia will put Nokia in a commanding position as the number two European supplier of computer terminals after Olivetti.

This event is of major significance in the European telecommunications market, as it reverses the trend of the early 1980s when telecommunications companies created and/or acquired computer companies due to the pending fusion of communication and information technologies. In the majority of these cases, the ventures have been major drains in financial and management resources.

ERICSSON

The newly acquired Data System Division manufactures terminals, personal computers, minicomputers, and banking and business systems, and has a turnover of SKr 4 billion (US$631 million.) It will be merged with Nokia's existing Information Division, Nokia Data. The merged division will have a turnover of SKr 7 billion (US$1.1 billion).

Ericsson's strategy has been to offload business units that do not form part of its core business, i.e., telecommunications. In October 1987, Ericsson sold off its Office Equipment Division, which manufactures typewriters and office furniture, to Design Funktion of Norway.

Ericsson's sale of its Data System Division and its Office Equipment Division will stem the flow of red ink that has plagued its Information Division since its inception. This division reported a loss of SKr 284 million (US$45 million) on a turnover of SKr 10 billion (US$1.6 billion) in 1986.

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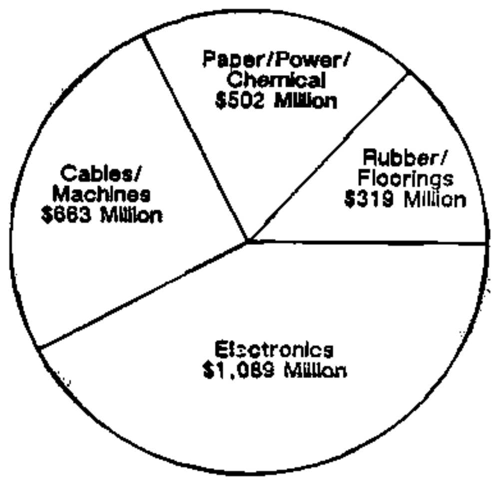
NOKIA

As shown in Figure 1, the Nokia Group of companies' total 1986 sales were Fmk 12 billion (US$2.5 billion), with almost 60 percent coming from the export market. The group's 1986 profit was Fmk 675 million (US$141 million), or 5.6 percent of sales. The Electronics Group represented 43 percent of the Nokia Group's net sales in 1986, before its recent acquisition of Ericsson's Data System Division and the consumer division of Alcatel N.V. (formerly the consumer division of ITT).

Figure 1

Nokia Group Major Activities
Net Sales by Division



1986 Net Sales = $2.5 Billion

Source: Nokia Corp.
Dataquest
February 1988

Electronics Group Activities—1986

The group achieved net sales of Fmk 3.7 billion ($843 million) in the first eight months of 1987, compared with Fmk 2.9 billion ($572 million) in the corresponding period in 1986, and represented a local currency growth of 27 percent (47 percent growth in U.S. dollars).

Information Systems

This division represented Fmk 1.6 billion ($334 million) of the company's 1986 sales. The division consisted of a Data Processing Systems Unit (computer systems and equipment), Data Transmission Unit (modems and multiplexers), Business Communications Unit (digital PABX and key telephone systems), Components Unit (thick film hybrids and PCBs), and a Control and Instrumentation Unit (automation equipment in wood pulping and energy sectors).

Telecommunications

Net sales for this division totaled Fmk 939 million ($196 million) in 1986. The division consisted of a Transmission Systems Unit (PCM equipment and radio relay links), Dedicated Networks Unit (for energy and railway sectors), and Telenokia Ltd. (digital PABXs).

Nokia-Mobira

This division's net sales totaled Fmk 847 million ($177 million) in 1986. The division consisted of an NMT Unit (Nordic Mobile Telephones for the 450- and 900-MHz system) and a USA Unit (mobile telephones for the U.S. Advanced Mobile Phone System (AMPS), and the Tandy Mobira Corp. (TMC) joint venture with sales via Radio Shack). There was also a Euro Unit (mobile telephones for the Total Access Communications System (TACS), R200, and Netz-C networks), an Oulu Unit (base stations for cellular and paging networks), and a PMR (Private Mobile Radio) Unit.

Salora-Luxor

Net sales for this division totaled Fmk 2.1 billion ($439 million) in 1986. The Group consisted of a Consumer Electronics Unit (TV and video recorders), Monitors Unit (color and high resolution), Components Unit (hybrids, TV tuners and power supplies), Satellite Systems Unit (receivers and transmitters, plus cable and pay TV), and an Industrial Electronics Unit (customer-specific components for the automotive, engineering, and plastics industries).

Electronics Group Restructuring—1987

Information Systems

This division is a combination of the former Information Systems Division and the Telecommunications Division. It comprises the Data Processing Systems Unit, the Data Transmission Unit, the Business Communications Unit, the Public Telecommunications Networks Unit, the Dedicated Networks Unit, Nokia Cellular Systems, and Telenokia. Net sales from this division for the first eight months of 1987 amounted to Fmk 1.1 billion ($250 million), a growth in local currency of 19 percent compared with the same period in 1986 (37 percent growth in U.S. dollars). This growth can be attributed to increased sales, particularly in Sweden and West Germany, and deliveries of electronic point-of-sales systems to retailers in Finland.

Consumer Electronics

This division was mainly created from the former Salora-Luxor Division, and comprises the Video/Audio Unit, the Monitors Unit, the Components Unit (formerly the Information Systems Division and the Salora-Luxor Division), and the Industrial Electronics Unit.

Net sales from this division for the first eight months of 1987 amounted to Fmk 1.4 billion ($319 million), a growth in local currency of 17 percent compared with the same period in 1986 (35 percent growth in U.S. dollars). This growth can be attributed to the company's successful penetration of the French consumer electronics market, where it holds a 10 percent market share, and its continuing leadership in Scandinavia as a supplier of color television sets and video recorders. The recent purchase of Oceanic S.A., a French consumer electronics manufacturer (part of the Swedish Electrolux Group), has given Nokia two more recognized brand names, Oceanic and Sonolor. The division has significantly enhanced Nokia's position in the European Economic Community.

Nokia-Mobira

This division is restructured internally, and now comprises the NMT Unit, the AMPS/TACS Unit, the Euro Unit, the Paging Equipment Unit, and the Cordless Unit.

Net sales from this division for the first eight months of 1987 amounted to Fmk 613 million (US$140 million), a growth in local currency of 22 percent compared with the same period in 1986 (41 percent growth in U.S. dollars). Operations overseas accounted for 75 percent of 1987 sales, and included the acquisition of Diversicom in the United States (the only nationwide long-range paging service for the U.S. market). Agreements also were made with McCaw Cellular Equipment (which owns and operates 40 mobile telephone networks in the United States), Mobile Telephone Systems (based in Kuwait), and Shaye Communications (based in the United Kingdom).

DATAQUEST ANALYSIS

Nokia's recent acquisition of the Consumer Electronics Division of Alcatel (formerly ITT) makes Nokia the third-biggest consumer electronics manufacturer in Europe after Philips and Thomson. This will allow Nokia to consolidate and rationalize its European manufacturing and marketing base and allow it to gain further market share while competing effectively against Japanese suppliers. The recent rise in the value of the Japanese yen, together with Nokia's manufacturing synergy with computer monitors and its number two position in the corporate microcomputer market, will allow the company to raise its value-added contribution in these markets. Another significant factor is that Nokia will now be able to make inroads into the European Community through its new acquisitions, as Finland is a nonmember of the EEC.

Dataquest estimates that Nokia-Mobira was number one in the rapidly expanding European cellular radio market in 1987, although the five different standards for cellular radio used in Europe has hindered its growth. Nokia will be able to leverage its number one position when the new GSM (Group Speciale Mobile) European Cellular Network Standard is established, which should be by 1991. Nokia has already taken steps to address the base station market by forming a consortium with Alcatel and AEG, in which Nokia has a 35 percent share.

Together with its strength in cellular subscriber equipment and base station equipment, Nokia will become a commanding force in the European cellular radio market, estimated to reach $3.5 billion by 1995.

Nokia was already the largest manufacturer of microcomputers in Scandinavia prior to its acquisition of Ericsson Data System. These combined forces put Nokia in the number two position in Europe after Olivetti. The relatively successful market penetration in the United Kingdom and the United States of the Ericsson Data System's banking terminals, together with Nokia's microcomputer and digital PABX technologies, will allow Nokia to leverage itself into the lucrative market for fully integrated information systems. Nokia already has an agreement with the Honeywell-Bull-NEC consortium in the midrange computer market.

Although the European market for systems integration already has numerous participants, the biggest potential for growth lies in the North American market. It is not obvious how Nokia will consolidate its position in this important market; but, it already has a head start with its joint venture with the Tandy Corporation and its numerous sales outlets via Radio Shack.

Dataquest believes that because of its leading position in consumer, cellular radio, and business microcomputer markets, which require highly automated volume manufacturing and continuous technological advances, Nokia will become a significant participant in the European market and will join the ranks of Philips, Siemens, and Thomson. This represents a new challenge and potential for the suppliers of semiconductors that previously considered Nokia a small niche player.

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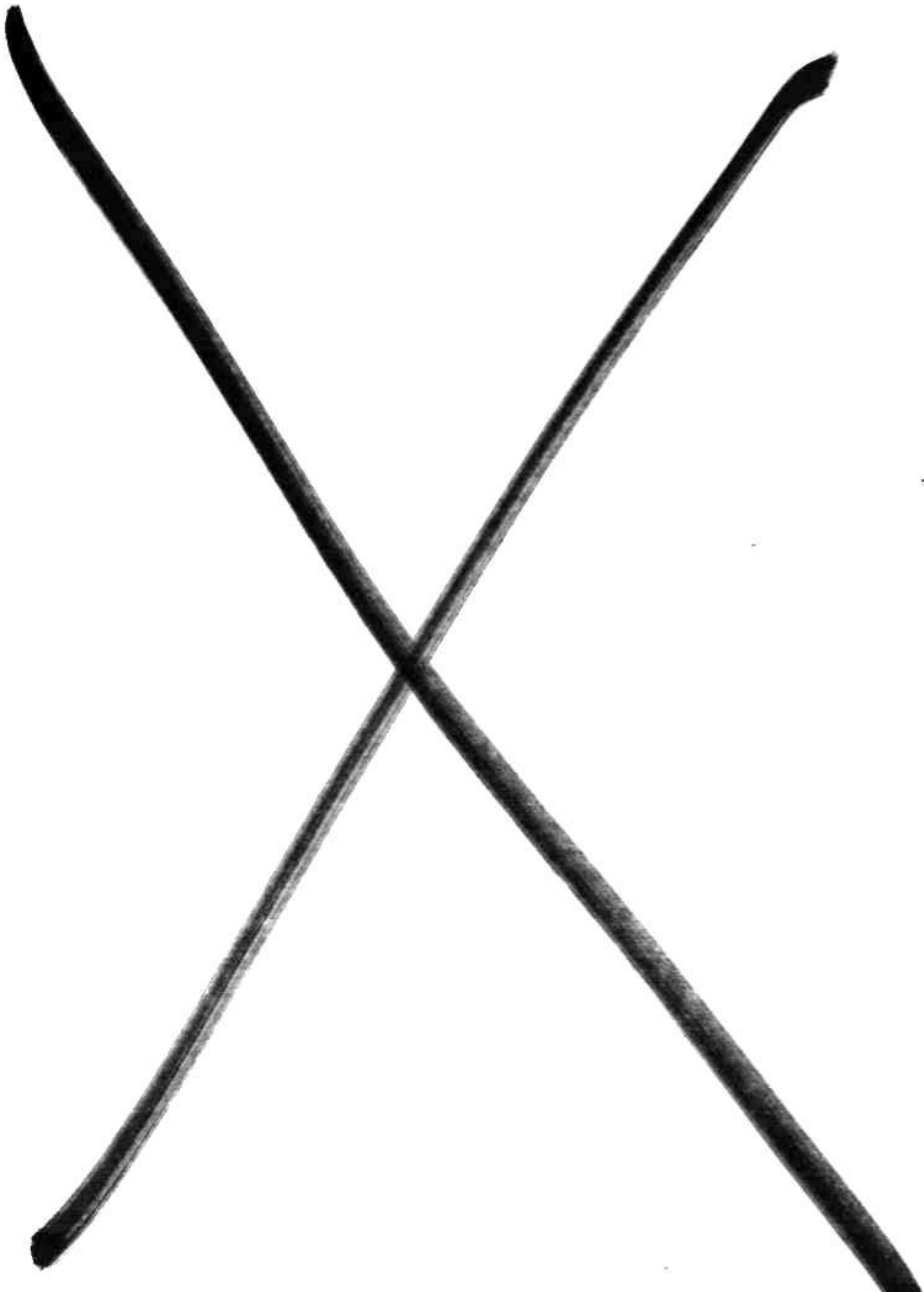

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Research Newsletter

ESAM Code: Vol. IV, Newsletters
1987-8

EUROPEAN PC PRODUCTION CAPABILITY SHOWS EMERGING STRENGTH

INTRODUCTION

Dataquest estimates that PC production in Europe grew, in unit terms, 12 percent in 1987, reaching an estimated 2 million units. More than 75 percent of all PCs sold in Europe are manufactured locally; approximately 275,000 units produced in Europe will be exported outside the Continent.

Dataquest's wholly owned subsidiary, Intelligent Electronics Europe, shares its perspective of this strengthening commitment by PC manufacturers to produce in Europe.

PC MANUFACTURERS

Two broad categories of PC makers have a presence in Europe: the non-European multinational PC vendors that operate in Europe and the European companies. Currently, of the main PC manufacturers in Europe, 11 are non-European; of these, the only non-American vendor is the Japanese company Fujitsu, which manages a micro-computer plant in Malaga, Spain. Fujitsu Spain operates through a joint venture, Fesa, with a government-controlled agency. This is fairly typical of the Spanish computer industry, whereby the company can be considered a local company—and all the more valuable—since its microcomputer production is targeted essentially at the Spanish market.

Table 1 shows the main PC manufacturers in Europe, the location of their production facilities, and their product ranges.

Many U.S. multinational computer companies with ambitions to have significant presence throughout the world have established wholly owned PC-manufacturing plants in Europe. Companies such as Apple, Commodore, Hewlett-Packard, IBM, NCR, NorthStar, Unisys, Wang, and Zenith have all expressed their dedication to the European countries through their direct investments. Compaq is the latest to follow suit, and its plant located in Scotland will be operational this month. This European production facility should give the company a more committed image in the minds of the European end users.

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Table 1

European PC Manufacturers

Manufacturer	Country of Origin	Plant Location	Product Range
APD	Spain	Madrid, Spain	Europa, APD Uno 32/4, 32XX, 32/40
Apple	United States	Cork, Ireland	Apple II, Macintosh
Apricot	United Kingdom	Glenrothes, Scotland	Apricot Xen
Bull	France	Villeneuve, France	PC range, terminals
Bull	France	D'Ascq, France	PC range, terminals
Bull	France	Barcelona, Spain	Micral
Commodore	United States	Braunschweig, West Germany	PCs, home computers, Amiga
Compaq	United States	Erskine,	PCs
Dava	Finland	Helsinki, Finland	PCs 286 & 386
Ericsson	Sweden	Sweden	Ericsson PCs
Ferranti	United Kingdom	Withershaw, United Kingdom	PC AT, PCs 1860 & 2860
Fesa	Spain/Japan	Malaga, Spain	Secorusa 20, Senda
Forum	France	Longwy, France	Multiuser systems
HP	United States	Grenoble, France	Vectra 150, PCs
IBM	United States	Greenock, Scotland	PCs, ATs, PS/2
ICL	United Kingdom	United Kingdom	Multiuser system
ICL	United Kingdom	United Kingdom	Series 25, 39
Leanord	France	Aubourdin, France	System 2966
NCR	United States	Augsburg, West Germany	Silz Elan, PCs
Nixdorf	West Germany	Padenborn, West Germany	PCs 710/810/916, NCR 3390, 3392
Nokia Luxor	Finland	Espoo, Finland	Nokia PC, ABC
Nokia Luxor	Finland	Rodja, Finland	Terminals, Nokia PC
Normerel	France	Granville, France	Vectra 150, PCs
NorthStar	United States	Cork, Ireland	Multiuser system
Olivetti	Italy	Italy	PC series
Olivetti	Italy	Spain	PC series
Philips	The Netherlands	Vienna, Austria	PCs
Regencentralen	Denmark	Presto, Denmark	Piccoline-Partner
Siemens	West Germany	Augsburg, West Germany	PCD, PCX, PCM
Siemens	West Germany	Karlsruhe, West Germany	PC 16
SMT Goupil	France	Montpelier, France	G40, G65
SMT Goupil	France	Redon, France	G4, G40, G5
SMT Goupil	France	Granville, France	G5
SMT Goupil	France	Soisson, France	G4 Club
Telenova	Sweden	Nynashamm, Sweden	Scandis/Compis
Tikidata	Norway	Nuremberg, West Germany	PC Tiki
Triumph Adler	West Germany	Nuremberg, West Germany	Alphatronics PCs
Tulip	The Netherlands	Den Bosch, The Netherlands	PC, Compact, 8386
Unisys	United States	Villers Ecale, France	B20, B25
Wang	United States	Stirling, Scotland	Wang PC
Zenith	United States	Kells, Ireland	Desktop PCs

Source: Intelligent Electronics Europe
Dataquest
December 1987

The U.S. multinational companies have integrated worldwide corporate production strategies, with the assignment of each of their plants to specific regions. Production facilities in Europe usually serve the European markets. Often, they also serve the Middle East and Africa, or, like the Wang factory in Scotland, the non-European Commonwealth countries such as New Zealand and Australia.

More rarely, as with both NorthStar and NCR, the European manufacturing bases of the U.S. corporations cater to worldwide markets. Since the NorthStar operation in Ireland now houses the company's only manufacturing facility, it supplies the whole world. The NCR plant, located in the southern German town of Augsburg, ships nearly half of its PCs outside Europe. The German NCR company is also responsible for most of the R&D activities in the PC area. Together with the European manufacturers Olivetti and Ericsson, NCR is the only Europe-based PC manufacturer to have produced significant volumes for the OEM markets. Through OEM contracts with the German companies Nixdorf, Olympia, and Siemens, and with HISI, now Honeywell Bull, from Italy, the firm has realized a large share of its sales through the OEM business.

A major effect of this large investment in Europe-based PC plants by foreign firms has been the relative absence of protectionism in the field of PCs by either the national and local governments or from the EEC. France is possibly the main exception, in that, until recently, the French national manufacturers have enjoyed almost a monopolistic position within the French government-controlled markets. In spite of this, there have been no protectionist moves to halt imports of PCs. In addition, as Europe has a positive trade balance as far as PCs are concerned, no real efforts have been made to institute any protectionist measures like those undertaken in the fields of typewriters, photocopiers, and, more recently, printers.

Olivetti is still the leading European PC manufacturer. After recently having stopped the production of PCs at its French Logabax factory in Meaux, the Italian company now has only two PC plants: one in Scarmagno, Italy, and one in Barcelona, Spain. In addition, Olivetti now uses some of its existing production capacity near Naples to manufacture its new home computer model, the PC1.

SEMICONDUCTOR ANALYSIS

Dataquest estimates that personal computers will consume approximately 7 percent of the $6,780 million semiconductor market in Europe. Table 2 shows a comparison of the integrated circuit content of an IBM PC AT, a Compaq 386, and the IBM PS/2 Model 50.

Overall, the growth of semiconductor revenue for the computer marketplace looks healthy. The ratio of semiconductor revenue to computer revenue is expected to remain relatively constant from 1988 through 1990, at about 5 percent for the market as a whole and at about 6 percent for just PCs. Dataquest believes that the greatest opportunities for IC manufacturers serving the PC market lie in separate areas. The first is a continued growth in application-specific ICs. As PC manufacturers attempt to introduce smaller, faster, and less expensive machines, the demand for highly integrated chips is inevitable. Those ASICs directed at integrating traditional motherboard logic and also at maximizing peripheral controller functions and high-resolution graphics capabilities hold great promise. Second, along with the growth of application-specific logic chips, there are opportunities for dedicated processors and microcontrollers, particularly in the areas of computer graphics and storage subsystems. Additionally, as notorious "memory munchers," these 32-bit machines will require ICs that are faster and have denser memories than their predecessors. Static RAMs and static column RAMs, as well as traditional DRAMs with densities of 1 megabit and above, will be consumed in ever-greater ratios within the PC market.

Table 2

The Integrated Circuit Content of PCs
Number of Integrated Circuits

Description	IBM PC AT	Compaq 386	IBM PS/2 Model 50
Standard Logic	128	115	82
Memory			
RAM	41	36	21
EPROM	N/A	2	5
Microdevices	9	14	4
Microprocessor	80286 (6 MHz)	80386	80286 (10 MHz)
Interrupt Control	x	x	x
DMA Control	x	x	
Counter/Timer	x	x	
I/O Port	x		
CRT Control	x		
Floppy Disk Control	x		x
Asyncronous Communications Control	x		
RTC plus RAM Upgrade		x	
RAM Control		x	
Peripheral Control		x	
ASICs	4	10	6

Note: x means that the chip is included in that model.
N/A = Not Available

Source: Dataquest
December 1987

DATAQUEST CONCLUSIONS

Although several of the European PC manufacturers already have built up markets outside their own countries, or even outside Europe, more European companies are now strengthening their activities in order to boost their export performances. In some cases, European companies have started to become significant worldwide players. A major reason for this change in marketing strategy is directly associated with production issues. Considering the high fixed costs of a manufacturing facility, it has become necessary, in order to remain competitive, to realize high sales volumes, which in turn require a deeper penetration of the home market and/or an increased marketing and sales effort aimed toward export markets. Companies such as APD, Bull, Ericsson, Goupil, Nixdorf, Nokia, Siemens, and Tulip are all increasing their marketing investments outside their home countries or traditional regional bases.

Jennifer Berg

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1987-7

CONVERGENCE AND CONNECTIVITY IN EUROPE: THE RACE HEATS UP

Now that many desktop computing devices in Europe have achieved significant market penetration, the focus is changing to making these devices communicate. It is widely accepted that desktop devices are more useful when connected than when used as standalone units.

Dataquest has combined the resources of several of its European industry programs to focus on the issues of work group computing. This research provides our clients with a context in which to consider how all these pieces of the information processing puzzle interrelate. (Appendices A and B define the terminal types and connection technologies referred to in this analysis.)

Tables 1 through 6 show the estimated installed base of terminals in Europe for 1986, 1987, and 1991, and their connection methods. Tables 1 through 3 show the actual numbers for each connection method, and Tables 4 through 6 show the percentage of use of each connection method.

This newsletter has the following objectives:

- To define the installed base of desktop terminals
- To identify the important connection technologies employed and analyze the trends in types of connection from 1986 to 1991
- To outline the implications for suppliers

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Table 1

Dataquest Connection Matrix—1986 Estimated Units (Thousands of Units)

Type of Desktop Device	Installed Base at Year End	Units Connected Via: LAN	PBX	Data PBX	Hard-Wired	Remote	Not Connected	Total
Display Terminal	6,630.5	379.3	33.2	186.8	4,918.6	1,112.6	0.0	6,630.5
Word Processor	295.3	29.2	0.3	7.1	77.1	17.4	164.2	295.3
IVDT	15.7	0.0	11.8	0.0	0.0	3.9	0.0	15.7
Electronic Typewriter	140.1	0.0	0.0	0.0	0.7	2.1	137.3	140.1
Personal Computer	4,325.7	298.5	1.7	110.4	558.0	372.0	2,985.0	4,325.7
CAD/CAM	100.4	10.0	0.0	0.0	40.2	5.0	45.2	100.4
Telex	772.4	0.0	0.0	0.0	0.0	772.4	0.0	772.4
Teletex	41.8	0.0	0.0	0.0	0.0	41.8	0.0	41.8
Facsimile	344.1	0.0	0.0	0.0	0.0	344.1	0.0	344.1
Videotex	2,986.2	0.0	0.0	0.0	149.3	2,836.9	0.0	2,986.2
Total	15,652.2	717.0	47.0	304.3	5,743.9	5,508.3	3,331.8	15,652.2

Source: Dataquest
October 1987

Table 2

Dataquest Connection Matrix—1987 Estimated Units (Thousands of Units)

Type of Desktop Device	Installed Base at Year End	Units Connected Via: LAN	PBX	Data PBX	Hard-Wired	Remote	Not Connected	Total
Display Terminal	7,268.6	567.0	94.5	225.3	4,753.7	1,628.1	0.0	7,268.6
Word Processor	306.8	36.8	2.8	8.0	83.1	18.1	157.9	306.8
IVDT	25.4	0.0	19.1	0.0	0.0	6.4	0.0	25.4
Electronic Typewriter	203.4	0.0	0.0	0.0	1.0	3.1	199.3	203.4
Personal Computer	6,000.2	534.0	36.0	155.5	978.0	606.0	3,690.6	6,000.2
CAD/CAM	179.8	18.0	0.0	0.0	71.9	9.0	80.9	179.8
Telex	811.1	0.0	0.0	0.0	0.0	811.1	0.0	811.1
Teletex	73.9	0.0	0.0	0.0	0.0	73.9	0.0	73.9
Facsimile	658.4	0.0	0.0	0.0	0.0	658.4	0.0	658.4
Videotex	4,571.1	0.0	0.0	0.0	228.6	4,342.5	0.0	4,571.1
Total	20,098.7	1,155.8	152.3	388.8	6,116.4	8,156.6	4,128.9	20,098.7

Source: Dataquest
October 1987

Table 3

Dataquest Connection Matrix—1991 Estimated Units

Type of Desktop Device	Installed Base at Year End	Units Connected Via: LAN	PBX	Data PBX	Hard-Wired	Remote	Not Connected	Total
Display Terminal	9,667.9	2,030.3	290.0	290.0	5,259.4	1,798.2	0.0	9,667.9
Word Processor	251.7	42.7	3.8	6.2	167.9	20.7	10.4	251.7
IVDT	107.6	0.0	80.7	0.0	0.0	26.9	0.0	107.6
Electronic Typewriter	655.1	0.0	0.0	0.0	3.3	9.8	642.0	655.1
Personal Computer	12,814.6	1,922.2	76.9	291.8	2,703.9	1,671.0	6,148.8	12,814.6
CAD/CAM	776.1	77.6	0.0	0.0	310.4	38.8	349.2	776.1
Telex	946.8	0.0	0.0	0.0	0.0	946.8	0.0	946.8
Teletex	376.2	0.0	0.0	0.0	0.0	376.2	0.0	376.2
Facsimile	3,073.5	0.0	0.0	0.0	0.0	3,073.5	0.0	3,073.5
Videotex	10,752.5	0.0	0.0	0.0	537.6	10,214.9	0.0	10,752.5
Total	39,422.0	4,062.8	451.4	588.0	8,885.3	18,284.0	7,150.5	39,422.0

Source: Dataquest
October 1987

Table 4

Dataquest Connection Matrix—1986 Estimated Percentages

Type of Desktop Device	Installed Base at Year End	Percentage Connected Via: LAN	PBX	Data PBX	Hard-Wired	Remote	Not Connected	Total
Display Terminal	6,630.5	5.7%	0.5%	2.8%	74.2%	16.8%	0.0%	100.0%
Word Processor	295.3	9.9%	0.1%	2.4%	26.1%	5.9%	55.6%	100.0%
IVDT	15.7	0.0%	75.0%	0.0%	0.0%	25.0%	0.0%	100.0%
Electronic Typewriter	140.1	0.0%	0.0%	0.0%	0.5%	1.5%	98.0%	100.0%
Personal Computer	4,325.7	6.9%	0.0%	2.6%	12.9%	8.6%	69.0%	100.0%
CAD/CAM	100.4	10.0%	0.0%	0.0%	40.0%	5.0%	45.0%	100.0%
Telex	772.4	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Teletex	41.8	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Facsimile	344.1	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Videotex	2,986.2	0.0%	0.0%	0.0%	5.0%	95.0%	0.0%	100.0%
Total	15,652.2	4.6%	0.3%	1.9%	36.7%	35.2%	21.3%	100.0%

Source: Dataquest
October 1987

Table 5

Dataquest Connection Matrix—1987 Estimated Percentages

Type of Desktop Device	Installed Base at Year End	Percentage Connected Via LAN	PBX	Data PBX	Hard-Wired	Remote	Not Connected	Total
Display Terminal	7,268.7	7.8%	1.3%	3.1%	65.4%	22.4%	0.0%	100.0%
Word Processor	306.8	12.0%	0.9%	2.6%	27.1%	5.9%	51.5%	100.0%
IVDT	25.4	0.0%	75.0%	0.0%	0.0%	25.0%	0.0%	100.0%
Electronic Typewriter	203.4	0.0%	0.0%	0.0%	0.5%	1.5%	98.0%	100.0%
Personal Computer	6,000.2	8.9%	0.6%	2.6%	16.3%	10.1%	61.5%	100.0%
CAD/CAM	179.8	10.0%	0.0%	0.0%	40.0%	5.0%	45.0%	100.0%
Telex	811.1	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Teletex	73.9	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Facsimile	658.4	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Videotex	4,571.1	0.0%	0.0%	0.0%	5.0%	95.0%	0.0%	100.0%
Total	20,098.8	5.8%	0.8%	1.9%	30.4%	40.6%	20.5%	100.0%

Source: Dataquest
October 1987

Table 6

Dataquest Connection Matrix—1991 Estimated Percentages

Type of Desktop Device	Installed Base at Year End	Percentage Connected Via LAN	PBX	Data PBX	Hard-Wired	Remote	Not Connected	Total
Display Terminal	9,668.0	21.0%	3.0%	3.0%	54.4%	18.6%	0.0%	100.0%
Word Processor	251.7	17.0%	1.5%	2.5%	66.7%	8.2%	4.1%	100.0%
IVDT	107.6	0.0%	75.0%	0.0%	0.0%	25.0%	0.0%	100.0%
Electronic Typewriter	655.1	0.0%	0.0%	0.0%	0.5%	1.5%	98.0%	100.0%
Personal Computer	12,814.6	15.0%	0.6%	2.3%	21.1%	13.0%	48.0%	100.0%
CAD/CAM	776.1	10.0%	0.0%	0.0%	40.0%	5.0%	45.0%	100.0%
Telex	946.8	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Teletex	376.2	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Facsimile	3,073.5	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Videotex	10,752.5	0.0%	0.0%	0.0%	5.0%	95.0%	0.0%	100.0%
Total	39,422.1	10.3%	1.1%	1.5%	22.5%	46.4%	18.1%	100.0%

Source: Dataquest
October 1987

INSTALLED BASE OF DESKTOP TERMINALS

Figures 1 and 2 show the estimated installed base of terminals for 1986 and 1991 in Europe. The trends are reviewed below:

- While the number of terminals is growing at a 26.1 percent compound annual growth rate (CAGR), the number of potential desks is estimated to grow at only a 3 percent CAGR. Suppliers will have to fight hard for greater penetration into the existing installed base of desktops.

- The replacement market is expected to be low because many users do not discard desktop devices. They simply pass them on to someone else.

- Many suppliers are expected to move toward offering desktop systems (for example, 3Com, which offers LAN connections as well as terminals). Digital Equipment and IBM have been doing this for some years already.

Personal Computers and Display Terminals

- The wide availability of personal computers (PCs) at prices similar to display terminals will obviously have an impact on the sale of display terminals. The installed base of PCs will have overtaken that of display terminals by the end of 1988.

- The launch of IBM's PS/2 range of PCs will lead to a further decline in the price of PCs. Also, the differences between applications supported by PCs and display terminals is fast eroding. The success of PC plug-in terminal emulation boards such as the IRMA board from DCA is leading this trend.

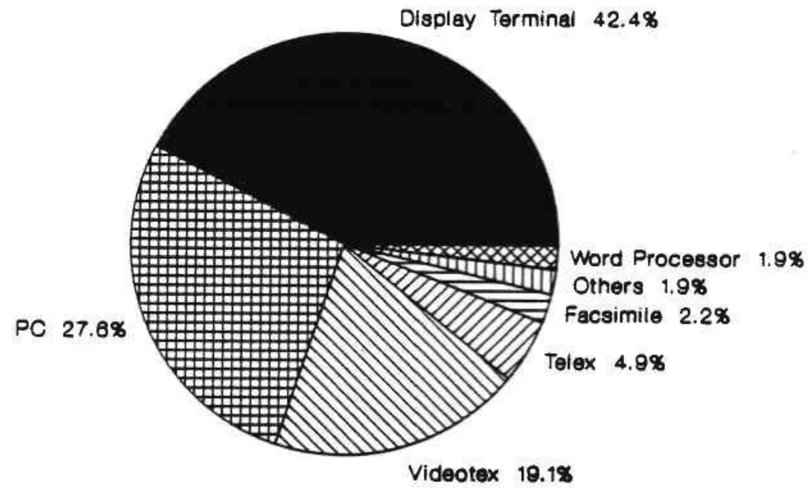
Integrated Voice/Data Terminals

- Dataquest expects the integrated voice/data terminal (IVDT) to have a limited penetration in the European market. These products are often not standards sold as compatible and sold as part of PBX. The Siemens Hicom PBX with its proprietary IVDT is a typical example.

- IVDTs are generally relatively expensive and, being proprietary, are a less flexible solution. Since IVDTs are rarely compatible with PCs, they consequently are limited in the number of application programs they can run.

Figure 1

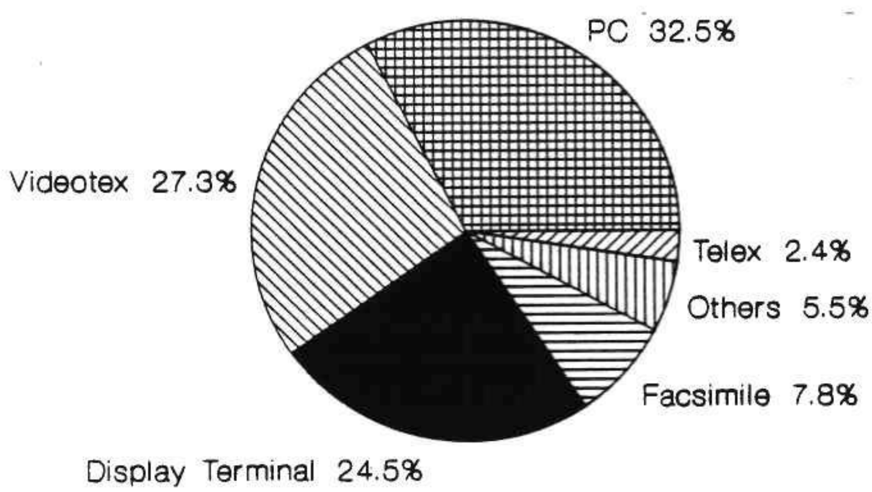
European Desktop Terminal Population—1986 Estimate



Source: Dataquest
October 1987

Figure 2

European Desktop Terminal Population—1991 Estimate



Source: Dataquest
October 1987

Word Processors

Shipments of standalone word processors will quickly decline. Dedicated minicomputer-based word processor systems are experiencing little growth. Dataquest expects these products to be overtaken by "office systems" that, in addition to text processing, will encompass various levels of voice, data, and graphics integration.

The differences between applications supported by PCs and traditional word processors, like those between word processors and display terminals, are also eroding.

CONNECTION TECHNOLOGIES

This section describes how the installed base of terminals connects. Figure 3 shows the spread of connection technologies for all terminals. The trend is clearly toward greater connectivity, using more than one of the connection methods in Table 1.

A standalone PC today may be connected to a local area network (LAN) soon, which will extend to a remote gateway (e.g., a modem) through a wide area network, an international link, and then to another LAN across the world. In consequence, the percentage of standalone terminals will drop to 18.1 percent of terminals in use by 1991. The main beneficiaries will be LANs and remote connection technologies. Data PBX, voice/data PBX, and hard-wired connections will not make significant gains. Figures 4, 5, and 6 show the spread of connection technologies for PCs, dumb terminals, and word processors in 1986, 1987, and 1991.

LAN

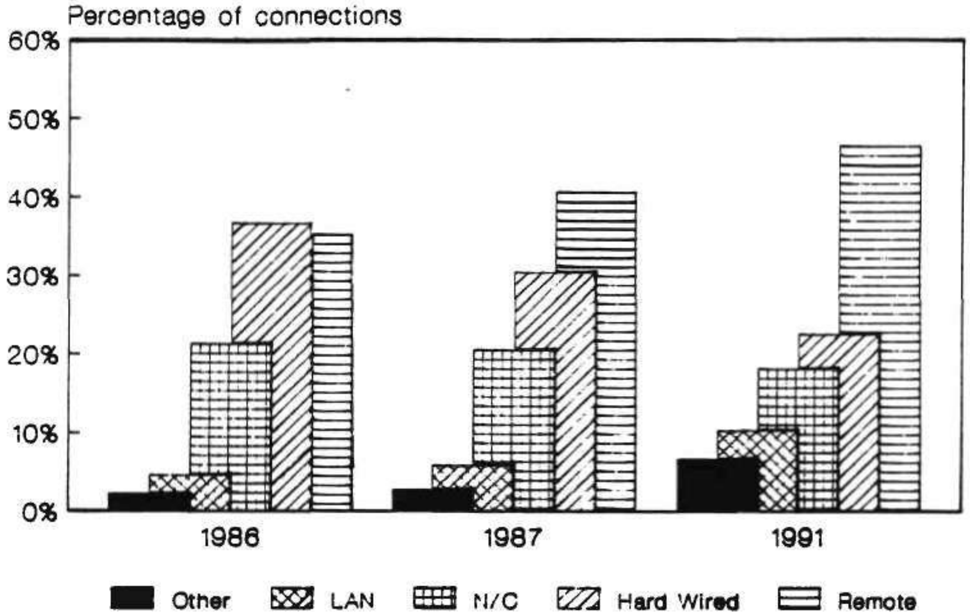
We believe that connections via LANs will show a tremendous growth rate, from 4.6 percent of all connections in 1986 to 10.3 percent by 1991.

Apart from the resource sharing offered by LANs (e.g., storage or printer sharing), one of their key benefits to large organizations is that they provide a flexible cabling solution. When users move around on a LAN, it is simple to unplug a terminal from the network and insert it elsewhere. With a hard-wired connection, such moves require recabling, which is both disruptive and expensive.

LAN connections to PCs and dumb terminals are expected to show significant growth. This will limit the growth of hard-wired and data PBX connections.

Figure 3

European Terminal Connection Trends (All Terminals)

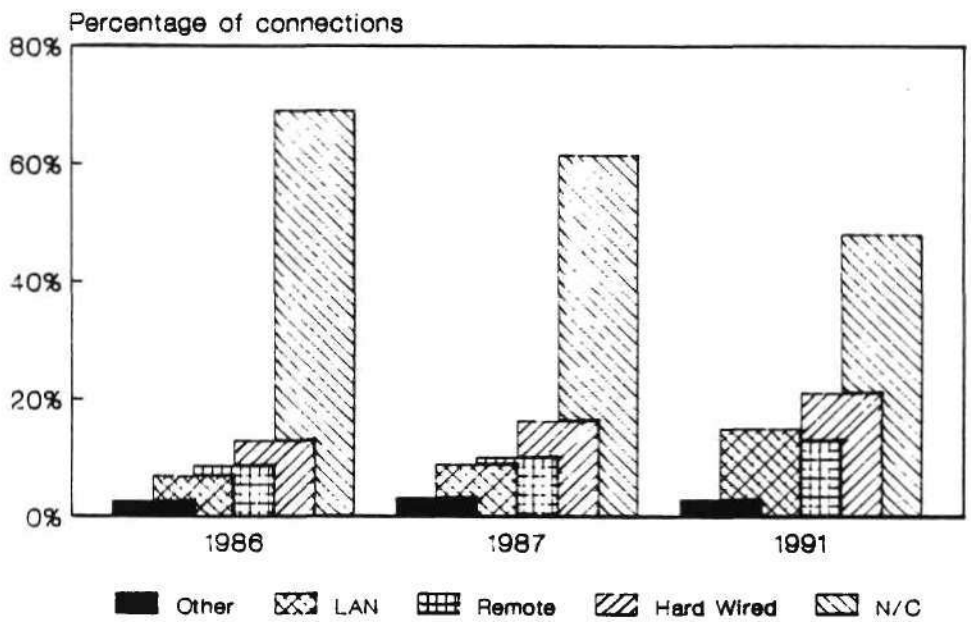


N/C not connected

Source: Dataquest October 1987

Figure 4

Euroepan Terminal Connection Trends (Personal Computers)

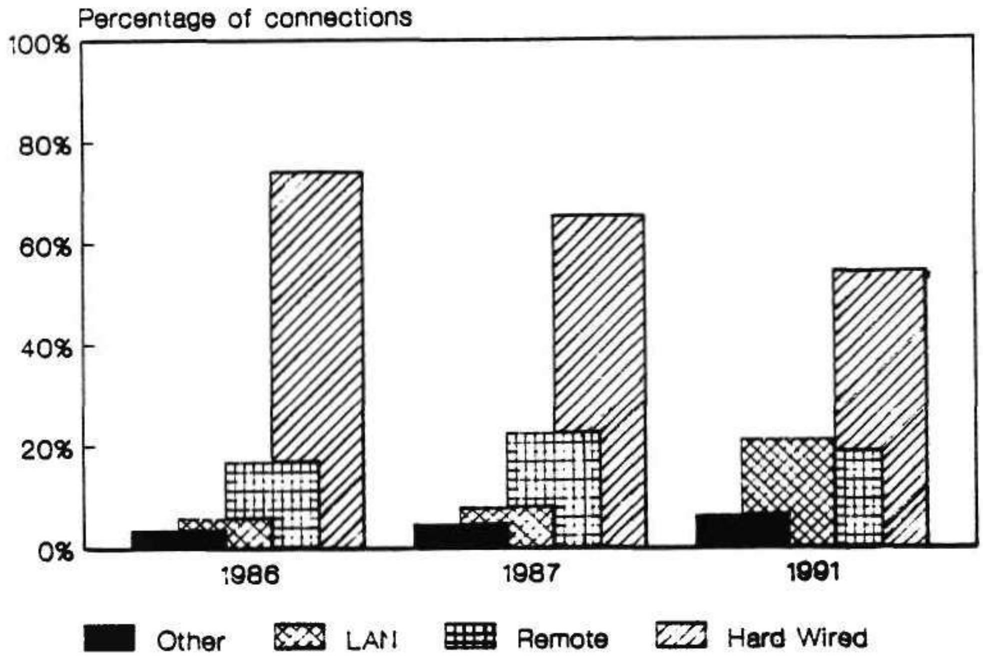


N/C = not connected

Source: Dataquest October 1987

Figure 5

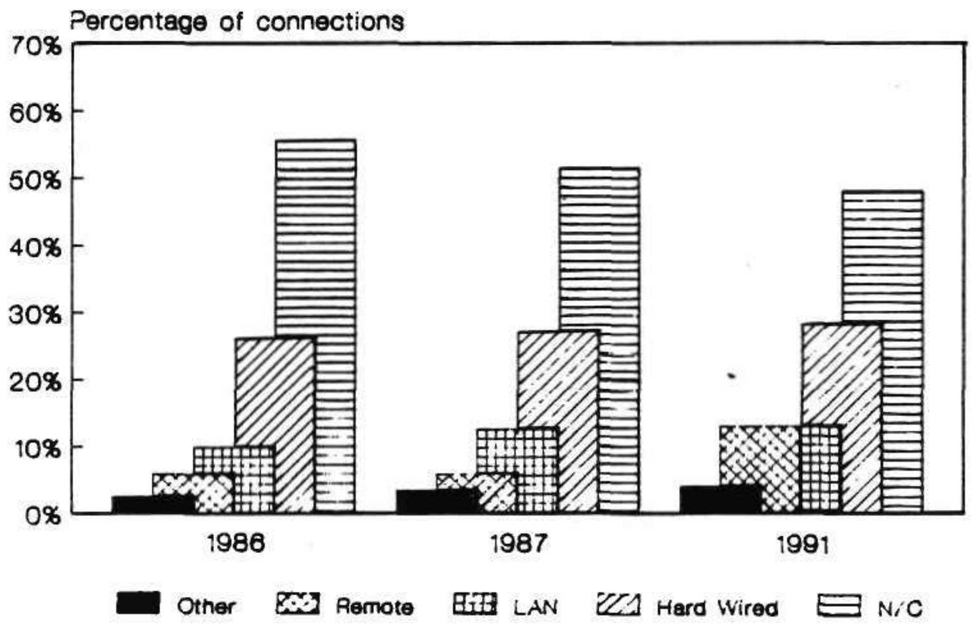
European Terminal Connection Trends
(Display Terminals)



Source: Dataquest
October 1987

Figure 6

European Terminal Connection Trends
(Word Processors)



N/C = not connected

Source: Dataquest
October 1987

PBX

PBXs will continue to be the main connection means for FAX, teletex, and videotex in 1991. Dataquest expects, though, that PBX or voice/data PBX solutions in Europe will show limited growth in data connections for the following reasons:

- The relatively high cost of connecting a terminal to a digital PBX compared to a data PBX

- The low data throughput (up to 64 Kbits per second for local connections on current products) compared to 1 Mbit per second for even a low-speed LAN

- Their low functionality (file handling and printer sharing facilities like PC LANs) for resource sharing compared to that of LANs

- The slow acceptance by data processing managers of traditional communications solutions to data communications connectivity

However, wide area gateways from LANs through a PBX represents a potential growth area.

Data PBX

Data PBX connections are expected to decline in importance for the following reasons:

- Users are migrating to LANs to achieve higher throughput speeds.

- The size and cost of low-end data PBXs precludes their use in new small networks, where LANs provide a cheap entry solution for as few as three users. These systems then grow into large LAN-based networks.

- Although data PBXs are very economic solutions for asynchronous connections when compared to LANs, users are more inclined toward LANs, which are seen to be the vogue in networking. (A typical cost per connection for a data PBX is $185, as opposed to $640 for a LAN.)

- The data PBX market has never gained any large momentum in Europe.

Hard-Wired

The hard-wired connections segment represents direct connections from data terminal equipment to multiuser minicomputers or mainframes. The high cost of reconfiguring a hard-wired network is leading customers to opt for more flexible solutions such as LANs, especially in new installations. The need to switch between resources (mainframes, etc.) in the hard-wired environment requires costly equipment compared to LANs.

Dataquest expects that by 1991, the large installed base of hard-wired connections will decline overall, from 36.7 percent to 22.5 percent of connections. The percentage of PC hard-wired connections will grow, however, from 12.9 percent to 21.1 percent. This represents the rapid growth of PC-to-mainframe connectivity by users who are not ready to use LANs.

Remote

A key growth trend will be in PC remote links; the PC is quickly becoming the focus for office systems technology. A significant growth area in remote lines will be X.25, while X.21 and modem links will also increase in percentage terms. The penetration of the X.400 standard for electronic mail will add to the growth in remote connections over the next three to five years.

ISDN

The connection technologies discussed so far raise important issues about the role of ISDN in local communications. The IEEE 802.9 standard for LANs could provide for 2-Mbit per second connections to the desktop on unshielded, twisted-pair cables. This could support voice/text and image on a distributed system. If IEEE 802.9 becomes a significant standard, the relative merits of ISDN connectivity will be reduced. While the merits of ISDN are being debated, LAN technology is making significant advances.

IMPLICATIONS FOR SUPPLIERS

Dataquest expects to see the following trends in supplier strategies:

- A conscious effort to understand previously unfamiliar markets, for example, communications suppliers moving into the computing area and vice versa. Digital Equipment in the United States recently made public its plans for wide area networking. This surprising move foreshadows the rapid changes to come in the connectivity race.

- An increase in joint ventures, mergers, and takeovers. Suppliers are finding this to be an attractive way of entering new markets and catching up with technology.

- More suppliers offering integrated communications hardware and office applications software as systems solutions. Although this is currently achieved by dealers, we expect to see suppliers use it as a product differentiation strategy.

- A prominence of vertical market offerings. More and more suppliers are beginning to identify specific segments like retailing rather than simply selling into general markets.

- Higher functionality and new features being offered on existing products in an effort to achieve product differentiation. What was once a plain old telephone can now be bought with IVDT functions (the Qwerty phone from British Telecom is an example).

- A plethora of new products, especially in the PC plug-in board market, like plug-in fax, telex, or voice store-and-forward cards. The recent launch of the Orator (voice/data card) from Lion Systems in the United Kingdom is an example of this rapid evolution.

- A significant price erosion across markets. Suppliers will fight to penetrate an installed base of desktops that is showing little growth.

DATAQUEST CONCLUSIONS

Dataquest expects the trends described in this newsletter to result in suppliers fighting for market share in Europe, not only with their traditional competitors, but also with organizations from previously separate areas. Hence computer, telecom, data communications, and LAN suppliers will be in competition with each other for the same business. The market will be characterized by numerous offerings from suppliers of incompatible desktop solutions. In these conditions, suppliers with standards-compatible, user-friendly, systems-based products will have an advantage.

Rapid changes in technology and sharp price competition will mean that market share will be more expensive to achieve and brand loyalty will be difficult to maintain. Dataquest believes that, despite the steady growth in the European data communications market, many suppliers will find themselves working very hard to maintain profitability in an increasingly fierce environment.

This newsletter shows that, after many years of talk about the convergence of computing and communications, and the integration of voice and data, these areas are finally beginning to merge, albeit at the transmission level at the moment. Integrated voice/data products or applications on the desktop have yet to succeed.

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Jennifer Berg
Michael D'Souza

Appendix A

DEFINITIONS OF KEYBOARD INFORMATION DEVICES

Display terminals are desktop electronic devices that are dependent upon a data communications link to a computer system. They have the following characteristics:

- They provide an interface between a human operator and a computer system or a communications network.
- They deliver a visual presentation of incoming data to the operator.
- They allow the operator to enter or modify information in the computer system via a keyboard, media reader, or other local device.

Personal computers (PCs) are computer systems that have the following characteristics:

- They are human-orientated, meaning they are intended to meet individual business, professional, educational, and personal data processing needs, and they do not generally act as instrument controllers or automation devices.
- They are single-user-orientated, meaning that, although communications may be involved, the systems are intended for the data processing needs of individuals and involve only one interactive device. PCs can generally be purchased, operated, and used by an individual rather than by an organization.
- They have full alphanumeric keyboards, which distinguishes them from programmable calculators, video games, and dedicated special-function computers.
- They have local programming capabilities using high-level programming languages, with most personal computers supporting BASIC, or a derivative of it. Other languages such as Pascal, FORTAN, and COBOL are also available on personal computers.
- They have a resident operating system in ROM or magnetic media. This distinguishes PCs from terminals.
- They are able to run general-purpose applications. This distinguishes PCs from systems that are dedicated through permanent hardware or firmware adaptation to functions such as word processing and financial analysis.
- For this study, PCs used in hobby or educational environments are not included. PCs that have integrated voice capability are also not included.

Integrated voice/data workstation (IVDT) products are desktop or board-level devices that integrate the functionality of a telephone and a terminal. This integrated functionality includes, at a minimum, simultaneous voice and data transmission. These devices are not double-counted in the display terminal or personal computer categories.

Word processors are workstations that are designed for entering, manipulation, filing, and printing text documents only. Workstations are defined as computer-based products that perform specifically defined functions as an aid to a user in completing a specifically defined task or series of tasks.

Full-size electronic typewriters are letter-quality printing devices that can be activated by depressing the keys of an electronically driven keyboard (flat or movable keys). This action causes type characters to be selected for printing by solid-state electronic logic and circuitry. These are desktop devices; this definition does not include portable or compact electronic typewriters. Nor does it include half-screen electronic typewriters.

Appendix B

CONNECTION TECHNOLOGIES

Generally speaking, a connection is defined as what the device is directly connected to, not what the device ultimately communicates with. Therefore, any device that has both a remote connection and another type of connection is counted under the other type of connection. Further, if a device has two types of connections, neither of which is remote, the most heavily used type is counted.

Private branch exchanges (PBXs) are customer premises telephone-switching systems that, by the dialing of an access code, permit telephones to interface to the public telephone central exchange of office. A PBX includes desktop end-user terminals, attendant consoles, switching cabinets, and interconnections between switching cabinets. An integrated voice/data PBX can switch both voice and data through the same equipment.

Local area network (LAN) Connections are combinations of hardware and software that enable connection of a device to a cable-based network system that serves a building or campus environment. Excluded are connections that are point-to-point, through PBXs or through data PBXs or data-over-voice products.

Data PBXs are digital electronic switches that allow terminals to switch and contend for computer ports by providing RS-232-C connections. Data PBXs do not provide for voice switching as a PBX or voice/data PBX would.

Hard-wired connection is a point-to-point connection from a device to a CPU, either directly or via a direct or nonintelligient intermediate communication controller or a multiplexer.

Remote connection is a connection to a modem, packet assembler/disassembler (PAD), wide area network or other device for transmitting data over remote-communication lines.

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1987-1

EUROPEAN CD MARKET SYNOPSIS

INTRODUCTION

For a number of years, optical storage has been regarded as the mass memory storage technology of the future. One product, the compact disk (CD), has emerged as the technology driver, gaining mass acceptance with devotees of hi-fi sound. Compact disks and players became the darlings of the European audio world in 1986. In this watershed year, CDs gained broad acceptance by music lovers as the medium of choice for the enjoyment of jazz, rock, and classics. Approximately 5 percent of householders in Europe owned CD players in 1986. Half of the current CD players owned were purchased in 1986.

Dataquest's European semiconductor analysts have researched the production and marketing of CD players in Europe between 1984 and 1992, and have estimated the semiconductor content of the players produced in 1987. As indicated in Figure 1, we believe that 1987's European CD market will reach $447 million, a 226 percent increase over 1986. We estimate that this represents a $73 million semiconductor opportunity for 1987 alone.

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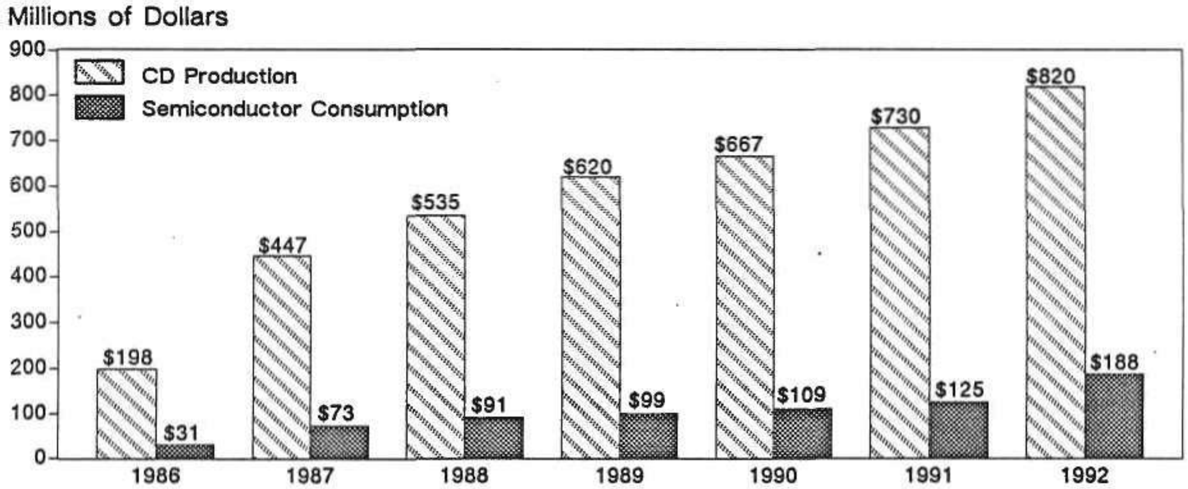
Figure 1

ESTIMATED EUROPEAN CD PLAYER PRODUCTION



Source: Dataquest
June 1987

BACKGROUND

Developed jointly by Philips of the Netherlands and the Sony Corporation of Japan, compact disk players were the first commercially available digital audio systems to offer far more accurate sound reproduction than conventional analog systems. CD players were introduced to Europe in February 1983 and quickly caught the consumer's attention because of their compact size, easy handling, and superior sound reproduction. However, initial sales were slow because of the CD player's high retail price compared with that of its analog counterpart.

COMPACT DISK PLAYER PRODUCTION IN EUROPE

CD player production is highly competitive in Europe. In order to avoid large import tariffs (19 percent) placed on the goods, many Japanese manufacturers have set up production facilities here. Table 1 lists the major manufacturers, which we believe account for approximately 100 percent of the total CD player production.

Table 1

CD PLAYER MANUFACTURERS IN EUROPE

Country	Company
West Germany	Dual (Thomson subsidiary)* Grundig*
France	Aiwa Akai JVC Pioneer Sony
United Kingdom	Aiwa
Italy	Pioneer Autovox**
Belgium	Philips
Denmark	Bang and Olufsen*
Switzerland	Studer-Revox
Turkey	Crown**

*Assembly only
**Production to start in 1987

Source: Dataquest
June 1987

SEMICONDUCTOR CONTENT

We have examined a medium-scale CD player and its components and have estimated the semiconductor value as shown in Table 2. The component values, based on contract-volume prices, result in an input-output ratio (semiconductor value as a percentage of equipment average selling price) of 16.3 percent.

Table 2

ESTIMATED SEMICONDUCTOR CONTENT OF A COMPACT DISK PLAYER

Components	Quantity	Cost
Integrated Circuits	13	
Standard Logic (SSI/MSI)	1	
Microcontroller (8-bit)	1	
D/A Converter (16-bit)	1	
Digital Filter	1	
Signal Conditioner	1	
Servo Control Unit	1	
Subtotal	19	$24.50
Optoelectronic		
Laser Diode	1	
Optical Sensor	1	
LED Lamp	1	
Subtotal	3	$17.50
Discrete Components	25	$ 3.00
Total	47	$45.00

$$\frac{\text{Semiconductor Value}}{\text{Retail Value}} = \frac{\$\ 45.00}{\$276.00} = 0.163 = 16.3\%$$

Source: Dataquest
June 1987

CD TECHNOLOGY AS A CATALYST

Consumer acceptance of CD players will act as a catalyst in the development of other optoelectronic products. CD-ROM technology is virtually the same as that found in audio CD players, with the exception of more stringent error-correcting demands for data applications. Potential applications for CD technology include the following:

- Computer data storage
- Video disks
- Publishing

- Road map directories in automobile dashboards
- Medical records
- Laser smart cards

The potential applications for CD technology represent numerous attractive markets. They could all gain widespread use by the consumer, in part because of the enthusiastic acceptance of CD players.

DATAQUEST ANALYSIS

Digital audio disks offer better sound than conventional records and tapes and put an end to noise and signal degradation over time. This is because a laser pickup eliminates direct contact with the disk surface; hence, disk wear is avoided. Using error-detection and -correction circuitry together with software, the conventional analog filtering techniques are eliminated. This provides audio that is free of noise and that has concert hall dynamic range. Digital audio tapes (DAT) and DAT players also offer perfect sound reproduction with virtually no deterioration regardless of the number of times the tape is played.

The supply of integrated circuits to CD or DAT player manufacturers is a significant market opportunity for semiconductor manufacturers in the late 1980s and early 1990s. Dataquest believes that as prices for players, CDs, and DATs come down, and as older music systems wear out, owners will replace their combination LP/cassette music libraries with CDs and DATs.

Kathleen Killian
Jennifer Berg

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1987-2

TELECOMMUNICATIONS--SNAPSHOT OF '87

SUMMARY

Dataquest forecasts that the European Communications Equipment marketplace will increase from $17,871 million in 1986 to $19,914 million in 1987, representing an increase of 11.4 percent (see Table 1). The European semiconductor consumption for communications equipment is forecast to increase from $1,411 million in 1986 to $1,700 million in 1987. The purpose of this newsletter is to provide our summary outlook for customer premise equipment in 1987 (see Tables 2 and 3). We estimate that customer premise equipment sales accounted for $7,084 million in revenue and represented 39.6 percent of European communications equipment sales in 1986.

Jim Beveridge
Jennifer Berg

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Table 1

EUROPEAN COMMUNICATIONS EQUIPMENT MARKET FORECAST
(Millions of Dollars)

Equipment	1984	1985	1986	1987	1988
Customer Premise	$ 5,391	$ 5,860	$ 7,085	$ 7,850	$ 8,482
Public Telecommunications	5,125	5,571	5,292	5,960	6,504
Radio	1,790	1,946	2,594	2,882	3,178
Broadcast and Studio	1,305	1,418	1,891	2,101	2,319
Other	693	753	1,009	1,121	1,284
Total	$14,304	$15,548	$17,871	$19,914	$21,767

Equipment	1989	1990	1991	1992
Customer Premise	$ 9,088	$10,187	$11,562	$12,524
Public Telecommunications	6,965	7,649	8,245	8,442
Radio	3,425	3,806	4,165	4,205
Broadcast and Studio	2,480	2,747	3,150	3,157
Other	1,411	1,561	1,705	1,776
Total	$23,369	$25,950	$28,827	$30,104

Source: Dataquest
June 1987
Ref. 0587-05

Table 2

1987 EUROPEAN CUSTOMER PREMISES EQUIPMENT FORECAST
(Millions of Dollars)

Equipment Type	1987
Terminal Equipment	$3,680
Single-Line Telephones	2,019
Integrated Voice/Data Wkstn.	7
Facsimile Machines	470
Telex Machines	477
Teletex Terminals	139
Videotex Terminals	314
Other	254
Data Communications Equipment	$ 992
Modems	580
Statistical Multiplexers	72
TDM Multiplexers	196
Data Network Control Systems	43
Data PBX	4
Packet Switching Networks	55
Local Area Networks	42
Business Communication Systems	$3,156
Key Telephone Systems	1,073
PBX	1,948
Centrex	1
Automatic Call Distributors	134
Attached Network Functions	$ 22
Voice Messaging	11
Call Accounting	3
Video Teleconferencing	8
Total	$7,850

Source: Dataquest
June 1987
Ref. 0587-05

Table 3

EUROPEAN CUSTOMER PREMISE APPLICATION SUMMARY

Application	End Equipment Percentage Growth Rate 1976-1987	1987 Market Estimate ($M)	European Market Outlook
Telex	(6.3%)	$ 477	The market up to present has been characterized by its stability. A modest decline will be experienced during 1987 as the reduction in standalone terminals is not quite compensated for by the increased production of PC telex adapter cards produced by Hasler, (Germany), DCE, (U.K.)
Teletex	57.9%	$ 139	Growth will be mainly confined to Germany. Production is by Siemens and Triumph-Adler.
Videotex	9.0%	$ 314	The product has not gained acceptance in the mass market. Except for France, it is confined to use by the business user groups such as the financial markets and travel agents. Within France, it is enjoying success in the form of Minitel terminals supplied free to PTT subscribers in some regions. Minitel production is running at 1.5 million sets per year. Production is by Alcatel and Matra.
Facsimile	63.7%	$ 470	This is a fast-growing market where supply is dominated by Japanese vendors, NEC and Canon. European production is confined to France where Alcatel Thomson produced 20,000 sets during 1986.

(Continued)

Table 3 (Continued)

EUROPEAN CUSTOMER PREMISE APPLICATION SUMMARY

Application	End Equipment Percentage Growth Rate 1976-1987	1987 Market Estimate ($M)	European Market Outlook
Single-Line Telephones	15.2%	$2,019	Despite the increasing number of Far Eastern imports, European manufacturers continue to dominate production and supply of the standard device. Major manufacturers include Autophon, Comdial, Ericsson, HPF, ITT, Matra, Siemens, and Televerket.
PBX	2.6%	$1,948	Low-end PBX L100 lines are becoming commodity items. Dataquest estimates that 85 percent of the 1986 market in Europe is supplied by local industry: <100 lines = 5.1 million >100 lines = 1.8 million
Modems/ Multiplexers	16.9%	$ 580	The major proportion of growth during 1987 will be accounted for by PC modems. These are manufactured by companies such as Racal, Doughty, and Dacom. The growth area in the multiplexer marketplace is in the installation of private and megabit multiplexers for large companies. Timeplex, (Ireland) and CASE, (England) manufacture for this marketplace.
Local Area Networks	55.6%	$ 42	The market is still in an early growth phase. At present, it is dominated by U.S. manufacturers supplying Europe through distribution. Producers in Europe include Siemens, (Germany), and Philips, (Holland).

Source: Dataquest
June 1987
Ref. 0587-05

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1987-3

EUROPEAN CONSUMER EQUIPMENT--SEMICONDUCTOR MARKET ANALYSIS

INTRODUCTION

As the range of semiconductor applications continues to become increasingly complex, so too has the task of examining and forecasting semiconductor consumption from an electronic equipment perspective.

Dataquest European Semiconductor Division (ESD) has developed a new module called European Semiconductor Application Markets (ESAM) that provides a complete analysis of semiconductor consumption by application market segment. This product is intended to assist decision makers who must take a tactical or strategic approach in their analysis of the semiconductor market, from either an application, demand-side, or end-use perspective.

This newsletter provides ESAM clients with a brief look at the methodology and offers an example of the research and analyses that can be found in this new module.

METHODOLOGY

Market Segmentation

Dataquest's European Semiconductor Industry Service has traditionally broken its end-use analysis into six market segments:

- Automotive
- Computer
- Consumer

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- Industrial
- Government and military
- Telecommunications

The ESAM module uses a slightly different market segmentation, splitting the electronic equipment into the following markets: .

- Data processing
- Communications
- Industrial
- Consumer
- Military
- Transportation

Data processing comprises all equipment whose main function is flexible information processing. Included in this segment are all personal computers, regardless of price, distribution, or use in the office, education, or home environments.

Within the communications market, Dataquest classifies telecommunications as a subsegment that consists of customer premises and public telecommunications equipment. The other communications categories include radio, studio, and broadcast equipment.

The industrial segment comprises all manufacturing-related equipment, including scientific, medical, and dedicated systems.

The consumer segment comprises equipment that is designed primarily for home or personal use and whose primary function is not flexible information processing. Audio and video equipment and appliances are typical examples of equipment that is classified in the consumer application market.

Military equipment is primarily defense-oriented electronic equipment and is classified by major budget area. It does not include all electronic equipment procured by the government because such a breakout would double-count equipment that logically belongs in other market segments.

Finally, transportation consists mainly of automotive and light truck electronics. This designation leaves room to analyze other markets, such as off-highway equipment, that are potentially large users of semiconductors.

Full definitions of these segments are included in the ESAM binder.

Research

Depth of research includes:

- Information on electronic equipment manufacturers in Europe, including revenue and semiconductor consumption
- European electronic equipment forecasts by application market, including equipment type and year
- European semiconductor consumption forecasts by application market: by product, technology, and region
- Detailed service sections covering market trends and semiconductor analyses within each of the major application markets

ANALYSIS

The following section is an example of the type of information that is available as part of the ESAM module.

Table 1 shows Dataquest's forecast for the European consumer equipment market. The appliance market is the largest portion of the European consumer segment. Dataquest estimates that the European market for appliance equipment will reach $13,546 million by 1991, declining slightly at a compound annual growth rate (CAGR) of negative 0.6 percent for 1987 through 1991.

Table 2 shows Dataquest's forecast for European semiconductor consumption for consumer equipment. The consumer semiconductor market is estimated to grow at a CAGR of approximately 2.1 percent between 1987 and 1991. This is lower than the overall semiconductor market, which Dataquest estimates to be growing at a CAGR of 12.3 percent between 1987 and 1991.

Table 3 shows Dataquest's forecast for European input/output (I/O) ratios for consumer equipment. The I/O ratio represents the value of the semiconductors divided by the value of the electronic equipment and expressed as a percentage.

Table 4 shows Dataquest's estimates for the European appliance market. The European home appliance industry (manufacturing such items as refrigerators, washers, dryers, dishwashers, and microwave ovens) is currently severely depressed and has been so for several years. The saturation point has been reached for several products. Notable exceptions to this are microwave ovens, ranges, ovens, dishwashers, and disposals.

Table 1

EUROPEAN CONSUMER EQUIPMENT PRODUCTION
(Millions of Dollars)

	1985	1986	1987	1988	1989	1990	1991
Audio	$ 791	$ 897	$ 1,166	$ 1,101	$ 1,295	$ 1,338	$ 1,485
Video	3,746	3,910	4,280	4,047	5,069	5,256	5,540
Personal Electronics	1,190	1,220	1,284	1,213	1,581	1,742	1,828
Appliances	10,648	11,803	13,880	13,115	12,770	13,011	13,546
Other	227	222	232	219	260	257	285
Total	$16,602	$18,052	$20,842	$19,695	$20,975	$21,604	$22,684

Source: Dataquest
June 1987
Ref. 0587

Table 2

EUROPEAN SEMICONDUCTOR CONSUMPTION
CONSUMER
(Millions of Dollars)

	1985	1986	1987	1988	1989	1990	1991
Audio	$ 68	$ 87	$133	$ 133	$ 134	$ 142	$ 157
Video	426	448	529	584	588	592	641
Personal Electronics	33	34	39	46	49	49	54
Appliances	201	238	230	274	271	270	303
Other	5	6	7	7	7	7	8
Total	$733	$812	$938	$1,044	$1,049	$1,059	$1,163

Source: Dataquest
June 1987
Ref. 0587

Table 3

EUROPEAN INPUT/OUTPUT RATIOS
CONSUMER
(Percent Based on Dollar Values)

	1985	1986	1987	1988	1989	1990	1991
Audio	8.6%	9.7%	11.4%	12.1%	10.3%	10.6%	10.6%
Video	11.4%	11.5%	12.4%	14.4%	11.6%	11.3%	11.6%
Personal Electronics	2.8%	2.8%	3.0%	3.8%	3.1%	2.8%	3.0%
Appliances	1.9%	2.0%	1.7%	2.1%	2.1%	2.1%	2.2%
Other	2.4%	2.5%	3.0%	3.2%	2.6%	2.7%	2.8%
Average I/O Ratio	4.4%	4.5%	4.5%	5.3%	5.0%	4.9%	5.1%

Source: Dataquest
June 1987
Ref. 0587

Table 4

ESTIMATED EUROPEAN APPLIANCE MARKET
(Millions of Dollars)

	1985	1986	1987	1988	1989	1990	1991
Air Conditioners	$ 192	$ 196	$ 219	$ 207	$ 181	$ 184	$ 192
Microwave Ovens	8	60	138	130	162	165	171
Washers and Dryers	2,793	3,044	3,556	3,360	3,100	3,158	3,288
Refrigerators	1,737	1,862	2,139	2,021	1,774	1,808	1,882
Dishwashers and Disposals	599	702	845	798	1,052	1,072	1,116
Ranges & Ovens	1,933	2,175	2,581	2,439	2,461	2,509	2,613
Vacuum Cleaners	1,029	1,134	1,325	1,252	1,099	1,120	1,165
Food Processors	1,162	1,278	1,492	1,410	1,239	1,262	1,314
Heaters	870	963	1,117	1,056	927	943	822
Total	$10,648	$11,803	$13,880	$13,115	$12,770	$13,011	$13,546

Source: Dataquest
June 1987
Ref. 0587

The full advantage of the methodology detailed above is realized by applying I/O ratios to these appliance estimates. This demonstrates that the estimated semiconductor consumption of European appliances will grow from $230 million in 1987 to $303 million in 1991, a CAGR of 7.1 percent. In the appliance market, Europe's leading producers are now stepping up their development of electronic controls and timers, although only for more sophisticated machines. However, Dataquest believes that it will be necessary for them to display a faster rate of innovation in order to avoid being overtaken by the new Japanese products that should be available on the market in the next five years.

Jennifer Berg

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1987-4

A WORLDWIDE SMART CARD OUTLOOK: EUROPE PIONEERS PRODUCTION

The most dramatic change in the smart card market over the last year is that the market appears more application-driven and likely to grow from a demand-pull. For years the smart card has been a great concept in search of a market--a technology push. Today, smart card technology is able to provide solutions to many problems. This newsletter highlights recent worldwide smart card market activities, Dataquest's current unit production projections, and key developments occurring across the globe.

EUROPE--THE BACKDROP FOR MARKET ACTIVITY

The IC credit card or smart card was pioneered in 1976 by French citizen, Ronald Moreno. Three years later, in 1977, the concept became a reality as a result of collaborative work between Cii Honeywell Bull and Motorola Semiconductors (Europe). Initial production started in 1981 using a single-chip 8-bit microcontroller with 1,026 bytes of EPROM. Today, 10 years on from the first development work, IC cards are running in volume production in Europe in addition to undergoing numerous field trials in a variety of applications.

Table 1 lists Dataquest's world unit production estimates for 1987: nearly 50 million units. Of this 50 million, we expect 45 million or 90 percent of the production to take place in Europe. We estimate that this 45 million will comprise 22 million units of the financial card CP8 and 23 million units of the telephone E^2PROM card being marketed by the French PTT.

Production of the telephone card is exclusively by Thomson Semiconductors and takes place in its Rousset Plant, Southern France. Thomson recently moved a number of MOS processes from the Grenoble Plant to Rousset in order to focus key MOS process development in one center. The development of E^2, EPROM, and HCMOS processes at this site allows the company to rationalize the production and development resources associated with the telephone and

CP8 cards. Dataquest estimates that Thomson will supply approximately 20 percent of worldwide demand on CP8 (8.8 million units) during 1987. The other participants during 1987 are Motorola (Scotland) and Philips (RTC France) with 40 percent and 20 percent of the worldwide production, respectively.

Dataquest expects that the present E^{2}PROM telephone credit card will be phased out during 1987/1988 to be replaced by a variant of CP8. By 1992, Dataquest estimates that worldwide IC card production will be 525 million units, Europe accounting for 35 percent of the TAM.

Table 1

ESTIMATED WORLDWIDE SMART CARD PRODUCTION*
(Millions of Units)

	1985	1986	1987	1988	1990	1991	1992
Financial	1	7	25	45	70	135	155
Telephone	3	10	22	50	95	185	260
Other	N/A	N/A	3	7	30	55	110
Total	4	17	50	102	195	375	525

*Assumes financial cards have a life cycle of approximately two years. Other cards have a life cycle of six years. Telephone card life cycle is three months.

N/A = Not Available

Source: Dataquest
May 1987

U.S. SMART CARD MARKET ACTIVITY

In the United States the smart card market has centered around entrepreneurial activity and alternative technologies such as that of Datakey, Inc., a Minnesota company focusing on nonfinancial smart card applications. The much-touted financial arena (the most traditionally thought of application for smart cards) had too many barriers to entry--namely ISO packaging requirements and smart card cost. (Other ISO standards activities for the smart card, for example, communications protocols, are still emerging.) Some confuse the unclear standards as a major market barrier. While smart card standards are more complex than for the mag stripe, it is encouraging to note that it took seven years before standards for mag stripe technology were adopted; today nearly a decade later, over 1 billion mag stripe cards are in circulation--for financial transactions alone.

In the past, Dataquest has noted that nonfinancial applications would be the driving force behind smart card development, particularly in the United States because nonfinancial applications:

- Would not be restricted by ISO packaging and communication standards for plastic cards

- Would not be limited by the current infrastructure and manner in which business is currently performed (i.e., working around the already heavy investment in automatic teller machines)

MasterCard International and Visa International, both with very different philosophies, strategies, and approaches to the market, have begun to change this. The nonfinancial market legitimized the technology to a certain extent and acted as a proving ground for smart card technology. Just as Dataquest originally expected, these applications appear to have inspired the financial community to analyze smart card technology with a view toward applications within the financial arena.

MasterCard--Leading the Way

Things changed in 1985 when MasterCard International formally announced its market test, setting off a flurry of interest including a smart card approach announced shortly thereafter by Visa International. Both MasterCard and Visa are outspoken about their approaches to smart card solutions.

We believe that MasterCard has been actively qualifying and discussing vendor participation and we expect an announcement in the first half of 1987 as to who will be the program's major participants and how the program will expand. We believe that MasterCard has been working with as many as six IC manufacturers including NEC and Motorola whose chips are in the cards currently being tested. We believe Motorola is the only U.S. IC manufacturer among the six or so companies. Requirements for multiple sourcing and MasterCard's requirement for state-of-the-art technology are fostering numerous discussions. Another potential boon to semiconductor manufacturers is that MasterCard is considering the testing of biometric identification as a less cumbersome solution than PIN codes. Proposed methods include digitized signatures or finger characteristics.

We believe that MasterCard will begin testing and using a production IC card by the second or third quarter of 1987. MasterCard views the semiconductor industry as a vital support link, necessary to effectively implement the technology. Unconfirmed estimates place MasterCard IC card use at the low hundreds of thousands by mid-1987, the low millions by 1988, and high volume in the late 1989 to early 1990 time frame.

The Visa Approach

Visa International's strategy for smart cards is quite different from that of its counterpart. Visa believes that the current need for the technology comes from improving current bankcard services and providing new services that can produce incremental income. They believe that the current system works and that operating costs and losses through fraud can be reduced. Visa believes that current services are highly profitable and it disagrees with MasterCard that today's bankcard business can justify smart card technology. MasterCard justifies implementation based on reducing losses and authorization costs.

Visa believes that in order to take advantage of new technologies and new services and improve existing services there must be an increase in terminal penetration because different terminals accept different cards. Therefore, by putting the terminal on the card, the industry has a readable card that also becomes the delivery system--no need for a variety of terminals, especially with a single vendor that accepts more than one card.

For the financial community this is truly forward thinking, because the history of banking holds that authority lies in more than one place--to use the analogy of the safety deposit box, the customer brings a key, the banker brings a key, and together they unlock the box. Visa believes that the key and the lock do not have to be in two different places. MasterCard, on the other hand, is approaching the system from a traditional banking operation perspective. In short, Visa views the concept as pocket banking as compared to controlled banking.

Visa's different perspective, namely its cost justification, view toward providing new services, and pocket banking concept has thrust it toward development of the next generation of smart card technology--a card utilizing E^2 technology, which Visa refers to as a super card and which falls at the high end of the card evolution spectrum.

Visa is currently testing a small number of cards developed by Smart Card International and manufactured by General Instrument's Microelectronics Division. The main purpose is to evaluate users' needs and attitudes toward the technology. Meanwhile, Visa has commissioned Toshiba to make a production version of the card with the charter of putting the technology on a card that meets ISO standards of 30 mils in thickness. The time frame for completion is the fall of 1987 to spring of 1988.

We applaud Visa's strategy to seek "a gradual transition to the smarter cards of the future while supporting the coexistence of several technologies," and we believe that E^2 technology is the long-term answer to most future smart card applications. MasterCard, however, is taking a more realistic approach in its attempt to use current technology within the current financial infrastructure.

E^2 technology for financial applications is still not as technically feasible. MasterCard's testing of the technology in a large-scale pilot is a manageable approach to making the technology realistically meet the needs of today's bankcard environment. We believe that smart cards can work in the financial community today, without having to wait for E^2 technology in the late 1980s time frame. Testing the system as it exists appears most feasible from a smart card market perspective. MasterCard is chartering U.S. market development in financial applications.

JAPAN'S FOCUS ON SMART CARDS

There has been a surge in Japanese smart card activity over the last year. Dataquest's semiconductor market analysts in Japan have kept abreast of smart card market trends and we believe that there is no question that this market is being assessed and targeted very seriously by many sectors of the Japanese economy--much of this activity appears coordinated and orchestrated at a government level. The development of the smart card market is a lesson in Japanese industrial policy at work; competition is said to be fierce. There are as many as 50 to 75 small tests actively being observed. Applications are numerous and a myriad of technologies are being used. Consensus holds that a large number of small tests will provide the best window on market opportunities.

The most striking aspect of Japan's involvement has been the pace with which the Japanese have taken an active interest in the market. In terms of manufacturing technology, smart cards are similar to calculators and digital watches. Smart cards lend themselves to assembly and production by Japan's large electronic watch and calculator manufacturers.

In Japan, partnerships and alliances appear integral to the market's early development. Manufacturers are aligning with users to secure volume sales of products that conform to a worldwide or manufacturer's standard. This is all part of the coordination and cooperation that is being brought to bear on the Japanese focus on this market.

CONCLUSIONS

We are encouraged by smart card activity overall, and in particular the surge of activity seen in 1986. We believe 1987 will bring continued market opportunities and growth as the market begins its early shift into high gear. Market participants should be positioning themselves now; waiting much longer may mean that the market will be closed just as it begins to ramp up. There are opportunities for many types of IC manufacturers because the market has needs in large scale, high-volume applications as well as within the niches. The smart card market will not be only for those who are capable of withstanding the tremendous competition of commodity markets.

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Dataquest
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Research Newsletter

ESAM Code: Vol. II, Newsletters
1987-5

EUROPEAN MANUFACTURING AUTOMATION STATUS--SUMMER 1987

OVERVIEW

Development and installation of manufacturing automation in Europe is continuing on an aggressive scale relative to the rest of the world. Key factors that are sustaining investments in industrial plant modernization include:

- Pressure to reduce manufacturing costs as local currencies rise in comparison with the U.S. dollar

- Rising confidence in the value of automation based upon results of pioneering efforts of innovative industry leaders

- Cooperative programs between governments, universities, and individual companies for investments in technology development

- Focus of management upon strategic manufacturing as a vital element for European economic strength in a global economy

Dataquest believes that Europe is currently leading the rest of the world in implementation of automated work cells. Figure 1 shows the relative positions of Western Europe, Asia, and the United States as of early 1987. The growth of strategic partnerships between European companies both within and across national borders is enabling this technology to spread rapidly.

The 1987 world market for manufacturing automation, excluding design automation and automation services, is estimated to be US$35.0 billion. Europe is expected to purchase US$7.2 billion, or 22.5 percent of the world total. Figure 2 shows the relative shares of the European total that Dataquest estimates will be consumed by individual European countries in 1987.

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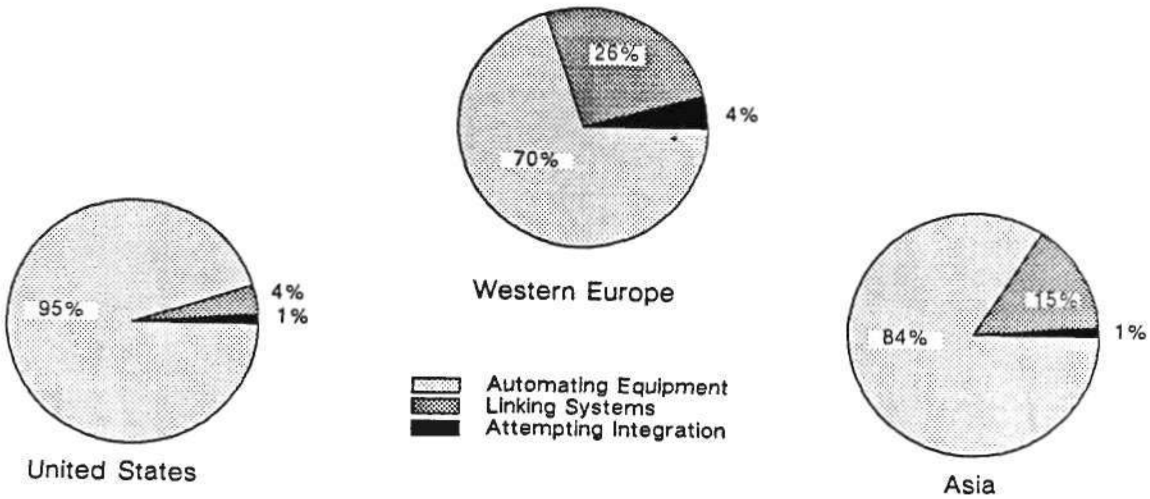
Figure 1

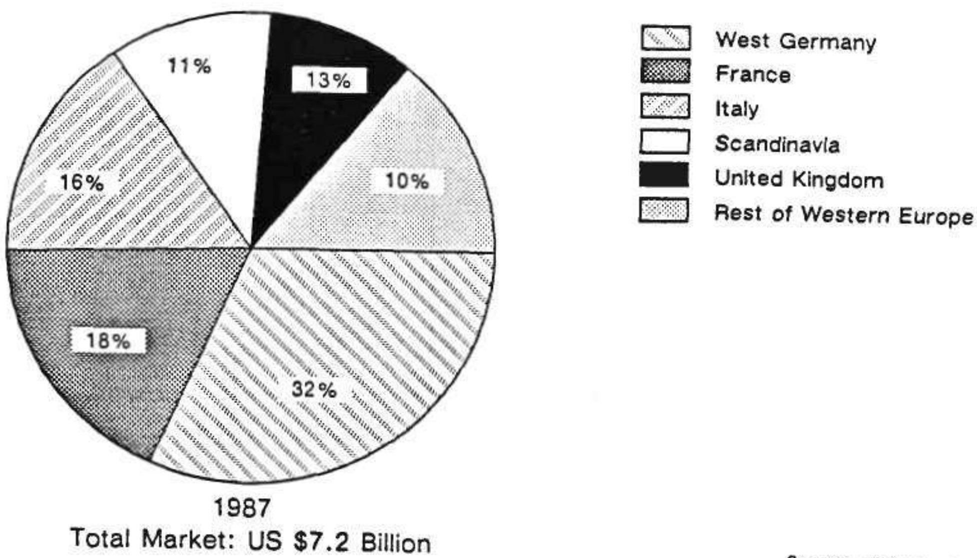
MANUFACTURING AUTOMATION IMPLEMENTATION
Early 1987



Source: Dataquest
August 1987

Figure 2

ESTIMATED WESTERN EUROPEAN MANUFACTURING
AUTOMATION MARKET SEGMENTS BY COUNTRY
1987



Source: Dataquest
August 1987

WESTERN EUROPEAN MANUFACTURING DEVELOPMENT TRENDS

During the spring of 1987, Dataquest toured four of the major industrial countries in Western Europe and attended the Hannover Industrial Fair in West Germany and the SICOB and Convention Automatique Productique exhibits in Paris. Dataquest visited factories of both automation users and vendors, and held press conferences with members of the technical press in London and Hannover regarding the status of manufacturing automation developments and trends for the immediate future.

The Hannover Industrial Fair is a massive display. Taking place in buildings encompassing a total of 380,000-square-meters with more than 6,000 companies, universities, and research institutes from 50 countries exhibiting, it attracted nearly half a million attendees.

Although the Fair had a strong West German vendor flavor, the signs of European unity were clearly discernible from the opening address by the vice-president of the European Economic Communities (EEC) commission. Examples of this unity were programs such as ESPRIT (European Strategic Program for Research and Development in Information Technology) and joint exhibits such as the "Initiatives for the Factory of the Future." The latter consisted of 194 individual stands, encompassing 10,000 square meters, that presented production-related automation technology in an overall, integrated context.

Dataquest believes that a major industrial trend in Western Europe is the emergence of a European community that is replacing the old internecine wars and conflicts that characterize much of European history. According to the Treaty of Rome, signed in 1957, a large common European market and technological community is expected to emerge by 1992. The primary objective is to create a market size for European industry that is comparable to what exists for North American and Japanese firms. The market area is expected to result from the planned dismantling of all trade, monetary, and technology barriers between members of the EEC.

The concept of a united Europe has a high acceptance level, according to surveys that have been taken by members of the community. There is a broad awareness of changing international circumstances and a consequent change in priorities for responding to the new international environment. Manufacturing automation development and implementation is high on the list of priorities.

Governments already are pooling funds in technology development and research via such projects as ESPRIT. The EEC has spent $120 million since 1982 developing ideas for the factory of the future. It is now proposed that $1.2 billion be spent on computer-integrated manufacturing (CIM) research over the next 5 years. In addition, the EEC expects to invest over $900 million in communications research with the Race program and $140 million for the Brite program on industrial technologies.

Manufacturing automation protocol (MAP) is well on the way towards development with a distinctly European flavor. Standards are viewed as a means for widening market opportunities for European automation systems vendors. For example, instead of producing machine tools with Italian standards to serve the Italian market, machine tool builders can address world markets if their machines conform to international standards. European users are involved in the MAP development through the ESPRIT program and through membership in EMUG, the European MAP Users Group.

Another trend is toward joint ventures, strategic alliances, and mergers across borders. An example is the agreement between France's Thomson Semiconducteurs and Italy's SGS Semiconductors. This merger will involve the creation of a Netherlands-based company, owned 50 percent by Thomson-CSF and 50 percent by STET, the Italian group. Other examples of noteworthy cooperative efforts include a joint R&D effort for digital switches by France's CIT-Alcatel, Italy's Italtel, Plessey of Britain, and West Germany's Siemens AG; ICL, Siemens, and Bull cooperating on technology for the next generation of computers; and Philips and Siemens working together to develop megabit chips.

The mood of the European manufacturing automation vendors at the Hannover Fair was one of optimism. The same attitude was expressed by both vendors and end users of automation systems during Dataquest visits to factory sites in Europe. Manufacturing competitiveness on a global scale is viewed as a major factor in the economic well-being of European society. Automation is seen as a key element in the ability of manufacturers to sell products on a worldwide basis.

Installation of automated systems and processes in Europe has progressed to a greater extent than might be realized. Experience with successful automation projects has tended to make both systems vendors and end users highly receptive to further investments in manufacturing systems. Dataquest further believes that the Western European region is taking a back seat to no one in such areas as work cell integration, use of expert systems in manufacturing, robotics, automated material handling systems, and factory floor simulation software.

WEST GERMANY

West Germany leads the world in per capita exports, with 60 percent of its gross national manufactured products exported. This level is twice as high as Japan's and four times that of the United States. German manufacturing managers tend to be technically trained with factory operations experience. These executives view manufacturing operation efficiency as one of the key elements to maintaining worldwide competitiveness. Thus, investments in manufacturing technology are strong.

The recent rise in the value of the deutsche mark relative to the dollar has added additional incentive toward investments in manufacturing automation. Since the United States often represents 30 percent or more of the West German market, every attempt to hold product prices down in the United States is being made. Because the price must be lowered to counter the rising mark value, profit margins can be retained only if product costs are reduced. How is this being accomplished? Through increased automation, say German representatives.

Interviews with West German manufacturing executives reveal that the annual rate of automation systems investments will grow between 15 and 20 percent per year for at least the next two years. This rate is the highest in Europe. Particularly strong are purchases of robotics, material handling automation, and industrial sensors. West Germany has more flexible manufacturing systems (FMS) installations than any other country in the world, with approximately 100 such installations as of the end of 1986.

West German industry has close cooperation with universities. Dataquest saw at least 12 universities that exhibited their state-of-the-art technology developments at the Hannover Fair. In contrast to the U.S. students, the highly motivated West German students were looking forward to careers in manufacturing operations or research in manufacturing technology development.

FRANCE

France is the second-largest market for manufacturing automation systems in Europe, with an estimated total of nearly $1.3 billion to be spent in 1987, as shown in Figure 2. Applications of automation are concentrated in the largest companies. The market has been slow in developing for the following reasons:

- Necessity of retrofitting old factories
- Lack of experience and need for extensive training
- Insufficient resources in the majority of small companies
- Wide product and process diversities
- Disappointments with overly ambitious projects that have not met expectations

Emphasis has been on elimination of unprofitable operations and the discontinuance of poorly performing product lines, such as consumer electronics.

The current strategy of many French companies is to consolidate in order to gain benefits from greater pools of resources and also to eliminate duplications. An example of this strategy is the merger of the Peugeot and Citroen automotive firms.

The automotive, aerospace, and appliance industries lead in French manufacturing automation implementation and developments. Some large firms such as Renault have taken advantage of their internal manufacturing expertise to develop products and services for new business developments. Renault Automation has successfully participated on a worldwide basis as a turnkey supplier of systems integration services and as a supplier of robotic and material handling systems.

In an alliance with EMUG, 30 French companies have been working since June 1986 on development of a factory network standard called Factory Information Protocol (FIP). This network is intended to be implemented at the equipment and workstation level below the factory MAP network. The objective of this standard is to provide analog, nondedicated, low-cost communications at the lowest levels in the factory. FIP would be connected to the MAP network via bridges.

Dataquest attended both the Convention Automatique Productique and the SICOB computer fair in Paris. In conjunction with SICOB, Bull held a separate show where it exhibited its capabilities in both design and process automation. All of these events, while not on the scale of the Hannover Fair, were well attended. The French are determined not to be left behind in the European surge toward manufacturing automation developments. They place particular emphasis on software development, modeling of automated structures and organizations, design automation, and workstation scheduling and control innovations.

Concerted efforts are being made to ensure that workers and executives alike are well trained in the developments that are occurring in manufacturing. For example, Peugeot/Citroen advertises that 3.5 percent of the annual turnover of the combined companies is spent on employee training.

ITALY

Italy is currently experiencing the best economic environment that it has seen in a decade. Always strong in engineering capabilities, Italy is at the forefront of European manufacturing automation technology development. There is a new emphasis on worldwide business alliances and product development. An important example of this trend is Olivetti, which has formed alliances with AT&T in the United States, and with European and Asian firms. In addition, Olivetti is actively pursuing its role as a leading vendor of manufacturing information systems development on a worldwide basis. Comau's acquisition of three French machine tool companies is another example of Italian expansion into European markets.

The automotive, apparel, and appliance industries have gained significant penetration into global markets. According to the Italian Economic Study Office, the export-import balance of trade for machine tools has climbed steadily upward since 1975 to an estimated positive level of nearly 1,000 million liras in 1986. Exports of machine tools exceed domestic consumption by nearly 400 million liras. Nineteen eighty-six machine tool revenue increased by 17 percent over 1985. Italy is the world's fifth largest producer of this class of automation systems.

Turnkey plant installations by Italian firms lead the rest of Europe, with 80 percent of their turnover coming from installations outside Italy, according to the chairman of Italimpianti. Evidence of Italian manufacturing technology prowess can be seen from recent contract awards to Italian firms. For example, Mitsubishi has signed an agreement to market rolling mill technology developed by Pomini Farrel throughout Asia. For the Soviet government's ZAZ towncar, Geico of Milan will provide design and construction of the entire painting structure, including pretreatment, catphoresis, and robotized lines for primer and final coats for vehicle interior and exterior bodywork. This car will be produced and marketed throughout the USSR beginning in 1990.

There are 70 robot manufacturers in Italy. The majority of these are simple pick-and-place devices that do not qualify as robots under the Dataquest or Robotics Industry Association (RIA) definition. For example, in 1985, Italy had an installed base of 5,000 industrial and 15,000 additional pick-and-place machines. Dataquest estimates that robot use in Italy is growing at 25 to 30 percent per year. Major suppliers include Comau, DEA, and Olivetti. Major users include Fiat and its newly acquired subsidiary, Alpha Romeo, and Olivetti--which supplies 90 percent of its robots itself.

UNITED KINGDOM

The weakest link in an otherwise upbeat European manufacturing automation market appears to be the United Kingdom. The London Financial Times has reported that in 1987, Italy's GNP is expected to surpass that of the United Kingdom for the first time in modern history. The United Kingdom will be last in terms of GNP size of the major EEC countries.

Even so, Dataquest believes that there are some signs of encouragement for the future of U.K. manufacturing developments. For example, some 50 Japanese companies have set up factories in Britain, putting it neck-and-neck with West Germany as the European nation of choice for Japanese enterprises. Currently, Japanese firms such as Nissan, Sony, NEC, Hitachi, Komatsu, Sumitomo, and Ricoh employ about 13,000 workers.

At the $650 million Nissan plant in Sunderland, evidence of changes to England's class-ridden industrial past are reported to have resulted in a steady increase in output levels, with quality reportedly equal to that of cars produced in Japan. Further, there have been no union grievances to date. A just-in-time system of scheduling the arrival of parts, the utilization of groups of spot-welding robots, and the emphasis of employee teamwork are fundamental changes in British industrial style.

Other areas of British leadership in European manufacturing automation development are that the chairman of EMUG, Colin Hoptroff, is an executive at Jaguar, and that British Aerospace is the prime contractor for CNMA (Communications Network for Manufacturing Applications). CNMA, a parallel to MAP, is a European initiative funded by EEC as one of the ESPRIT developments. MAP and CNMA have the same objective, which is to get suppliers and users of automation systems to use the open network communications standards as defined by the ISO (International Standards Organization).

In spite of these bright spots, Dataquest believes that the United Kingdom lacks the intensity of development that is occurring elsewhere in Europe. Too many developments appear to be academic, with low levels of acceptance in the mainstream of manufacturing industries. The recent reelection of the Thatcher government is more likely to produce a continuation of the present level of development than it is to produce any revolutionary changes in British industry.

DATAQUEST ANALYSIS

In summary, Dataquest finds the status of European manufacturing automation to be as follows:

- European business is generally good and growing for most manufacturers. Exports to the United States continue in spite of the falling U.S. dollar.

- Technology development is being emphasized throughout Europe, especially in applications software and the integration of programmable equipment into automated work cells.

- Dataquest estimates that Europe is spending 25 percent of its total investment in manufacturing automation for integration of equipment into work cells, 4 percent for integrating entire factory systems, and 71 percent for automating individual pieces of equipment. The level of work cell integration is the highest as a percent of the total automation investment in the entire world.

- Generally, European governmental support for manufacturing automation development is clearly evident. Although governments may not be as enthusiastic about the formation of a single European economic community as is industry, Dataquest believes that developments to this end may well occur at a faster pace than is currently anticipated, both within and outside Europe; this will be particularly true if the United States appears to begin to reduce its Western European military support after 1988.

- Worldwide alliances, as well as intra-European alliances, joint ventures, the pruning of unprofitable products and factories, and the implementation of automation in manufacturing, are well under way in Europe.

- Manufacturing competitiveness is a high-priority item in Europe. There is no debate about becoming a service economy or a post-industrial society. Europe intends to continue to be very much a world industrial power.

- Since exports represent a high percentage of the GNP of European manufacturers, the increase in their currency values relative to the U.S. dollar provides additional impetus to reduce the cost of goods sold. Automation is seen as a major element in meeting this objective.

- Europe enjoys good academic support for technical developments in manufacturing automation. Universities are providing a source of highly qualified and motivated human resources for long-term growth in European manufacturing technologies.

- Dataquest's contacts with European manufacturers confirm that most companies throughout Europe intend to focus on specific market niches rather than expand across broad market areas. They are in the process of strategic consolidation and streamlining of their internal organizations in order to become experts in particular areas with products focused upon global market needs.

- The European industrial leaders are solidly behind the development of world standards, such as MAP. However, Europeans are also intent upon improving standards that are developed in the United States. Dataquest estimates that implementation of the MAP standard in Europe will parallel U.S. efforts.

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Research Newsletter

ESAM Code: Vol. II, Newsletters
1987-6

NIXDORF COMPUTER AG--REACHING FOR THE WORLD

INTRODUCTION

Nixdorf Computer AG has long been one of the most successful computer companies in Europe, particularly in its native Germany. However, the company's success in other important markets in the world, particularly in the United States, has been less than spectacular. In 1987 we may see a positive change in the company's worldwide sales picture as management rededicates itself to the original company goal: to provide standard and tailored vertical programs for small- and medium-size companies in a variety of markets.

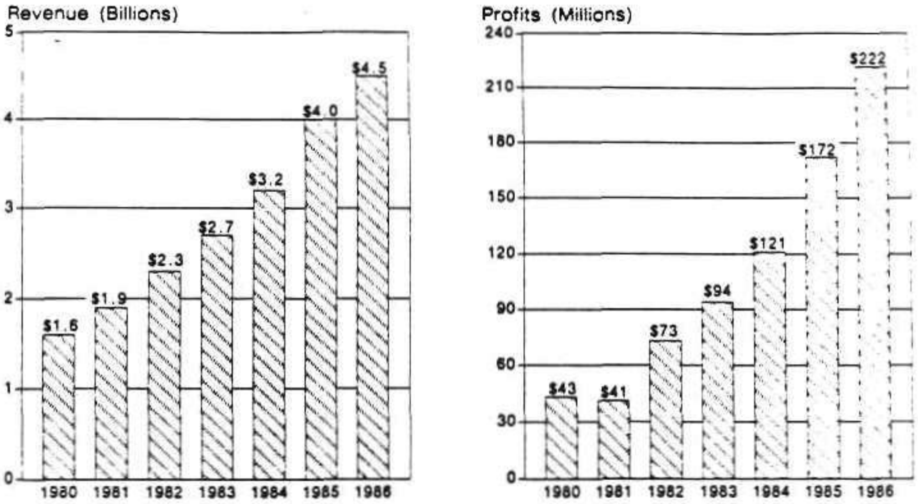
This newsletter discusses Nixdorf's growth, examines its overall product line and its position as a vendor of integrated office systems, and evaluates its marketing strategy in the light of changing end-user requirements.

COMPANY HISTORY

The rise of Nixdorf Computer AG can be considered a success story by any standard. The company was founded in Germany in 1952 by Heinz Nixdorf, and today is represented in more than 44 countries with over 600 branches and service organizations. As shown in Figure 1, revenue has increased steadily by approximately 20 percent per year to DM 4.51 billion (or $2.1 billion) in 1986. More than 89 percent of this revenue is from Europe, the rest from international markets (the United States and Asia). Profits climbed 29 percent in 1986.

Figure 1

Revenue and Profit--1980 to 1986



Source: Nixdorf Computer AG

But Nixdorf measures its success based upon more than just the bottom line. The company takes its social responsibility seriously and regards people and innovative technology as important as an increase in profits. At press and stockholder meetings, Nixdorf always emphasizes two points:

- The size of its research and development budget, which has consistently remained at approximately 10 percent of revenue

- The number of additional people that the company employs each year. In 1986, for example, Nixdorf added 2,300 positions. This increased worldwide personnel to 25,600 people, with approximately 17,000 of them working in Germany.

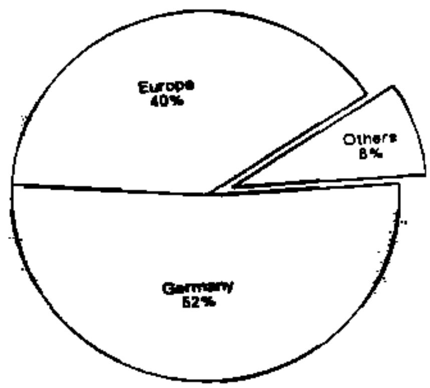
Mr. Nixdorf died prematurely in 1986 at the age of 60. Mr. Klaus Luft, the Vice Chairman of the Board, assumed the position of Chairman of the Board, and Mr. Arno Bohn took the position of Vice Chairman. No other management changes were made. The company continues to be run by the seven board members, five of whom have been with Nixdorf since 1970.

Foreign Markets

As represented in Figure 2, approximately 52 percent of total revenue comes from sales within West Germany, 40 percent from the rest of Europe, and 8 percent from other countries. Excluding Germany, Nixdorf is represented in 325 cities in 17 countries in Europe. Outside of its native Germany, Nixdorf has been most successful in England, France, and Spain. In England, for example, Nixdorf has an 8 percent market share in the retail industry and an 11 percent market share in the banking industry. In addition to Europe and the United States, Nixdorf is represented in 54 cities in 24 countries in South America and Asia.

Figure 2

Revenue by Region



Source: Nixdorf Computer AG

In the United States, Nixdorf has established subsidiaries and service organizations in 110 cities. However, penetrating the U.S. market has proved to be a formidable task. Although Nixdorf is the largest non-American computer business in the United States, its market share after 19 years is 1 percent of midrange computer sales. But several large orders in 1986 (Montgomery Ward, for example) indicate that the trend may be reversing now that Nixdorf has switched from a product-oriented to a solution-oriented approach, the strategy to which it owes its success in Europe.

In its continuing push into international markets, Nixdorf has established software centers in Holland, Ireland, Japan, the United States, and Singapore to develop application programs appropriate to local market requirements. Production facilities have been established in the United States, Ireland, Spain, and Singapore.

Corporate Objectives

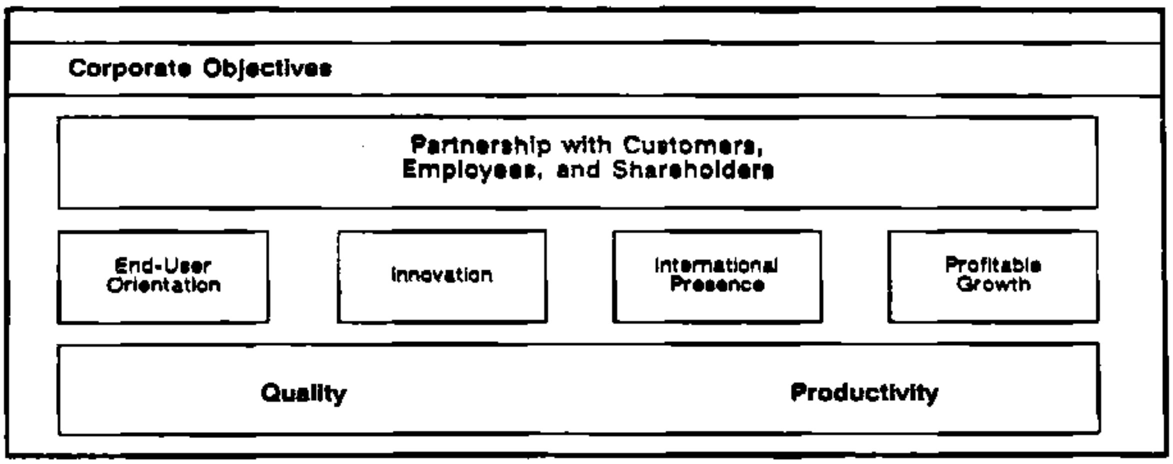
Until his death in 1986, Heinz Nixdorf "was" Nixdorf Computer AG to the public and one of the most prominent personalities in the European computer industry. Yet, when he died unexpectedly in Hannover, the transition to new leadership was untroubled and smooth, largely due to Mr. Nixdorf's vision and long-range planning. Corporate policies had always been set by Mr. Nixdorf in conjunction with the board of directors, and so no changes in corporate strategy were considered necessary.

This includes Nixdorf's determination to remain independent rather than merge with another company. Equity capital is now more than 60 percent, and all voting shares remain in the hands of the Nixdorf family.

Nixdorf's approach to domestic and international business is perhaps best exemplified by the company's traditional corporate objectives as outlined in Figure 3. Nixdorf has always emphasized (and has built its success on) its role as a partner to its customers, its employees, and its shareholders. In its role as partner, Nixdorf has paid primary attention to end-user needs and to the necessary innovation in developing programs for its domestic and international customers.

Figure 3

Corporate Objectives

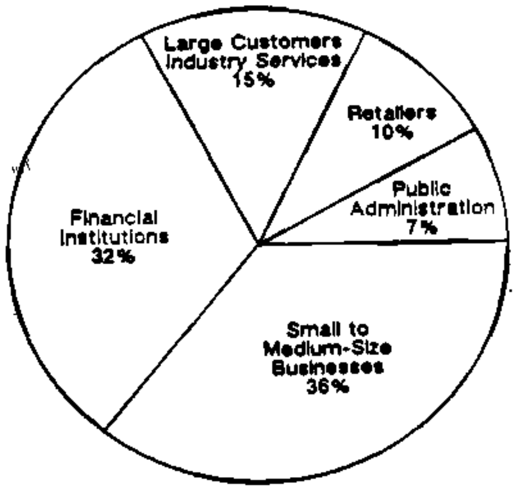


Source: Nixdorf Computer AG

To achieve these objectives, Nixdorf's main strategy has been to penetrate small- and medium-size companies by providing them with tailor-made vertical application programs for solving specific problems. Nixdorf was one of the first to address the needs of vertical markets. In order to produce the numerous tailored, solution-oriented applications, the company established its own 3,500-person software development staff and formed strong alliances with numerous software and system houses. As a result, approximately 36 percent of Nixdorf's revenue comes from sales to small- and medium-size companies as outlined in Figure 4.

Figure 4

Worldwide Revenue by Customer Group



Source: Nixdorf Computer AG

Strategic Changes

Although Nixdorf's basic tenets have not changed over the years, there have been several shifts in the company's strategy that should improve its appeal to multinational companies and international markets. The first shift is in its attitude toward IBM; the second is its attitude toward office automation, reflecting the recent shift from standalone business application solutions to an emphasis on integrated solutions, which include office applications.

Nixdorf initially believed that it could continue to provide its own proprietary hardware and tailored software solutions. Over time, Nixdorf realized that it could be more successful if its products were compatible with IBM and other vendors from large hosts to personal computers. After initial hesitation, Nixdorf added IBM-compatible PCs to its product line. The company's strong support of DISOSS on its primary products (the 8860, the 8890 and the TARGON Series) is additional proof of this change in strategy.

Initially, Nixdorf also viewed office systems as closed solutions appropriate for specific departments of an organization. With its support of the 88BK system, the company paid a high price to recognize that this approach did not work. Nixdorf now believes that office applications are needed throughout an organization and that these products can be cohesive elements tying together the entire organization. If implemented, this approach should make Nixdorf more competitive with other integrated office system vendors such as Digital Equipment, Data General, and Wang.

The shift from standalone, tailored business applications solutions to a more integrated approach has resulted in what Nixdorf calls the Computer Integrated Office (CIO) and Computer Integrated Manufacturing (CIM). CIO consists of three areas: telecommunication, text processing, and data processing/business applications. The three components can be found in each Nixdorf product line, and they are developed to maximize the capabilities of each product family. CIO will be described more fully later on in this newsletter.

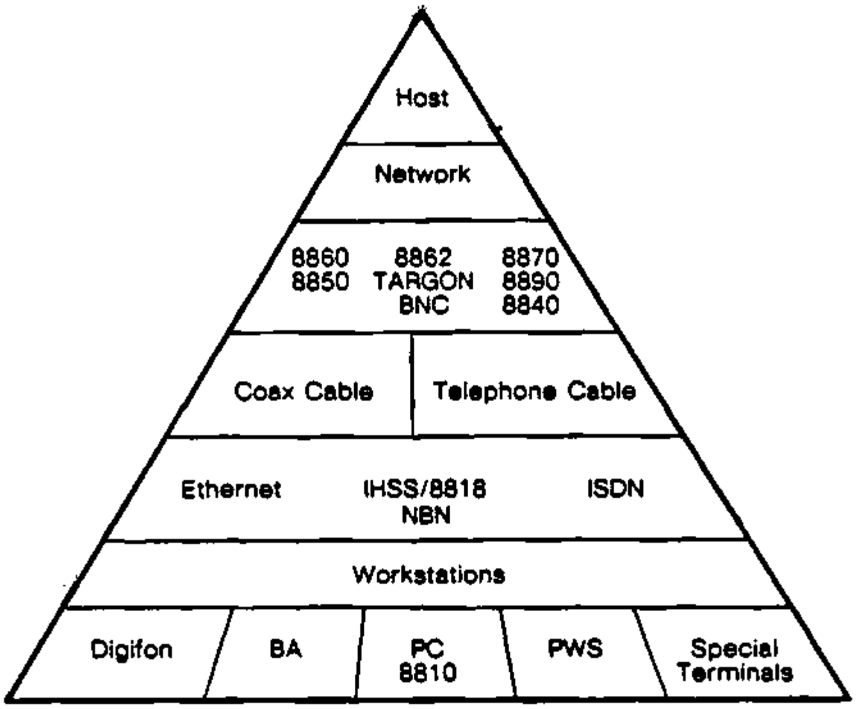
Nixdorf is also a proponent of international standards and continues to work with organizations such as the X/Open Group (UNIX standards); CCITT to promote the X.400 electronic mail standards; X.21 and X.25, with ISO/OSI, ANSI, ECMA, IEEE (Ethernet and Nixdorf Broadband Network) and others.

THE NIXDORF PRODUCT LINE

A brief overview of the product line may be helpful in providing perspective to Nixdorf's offerings. With the exception of large hosts, Nixdorf Computer AG offers an array of hardware and software products for every type of user and application: small- and mid-range computers, personal computers, local area networks, videoconferencing systems, digital PBX systems, image scanners, laser printers, videotex systems, point-of-sales systems, and automatic cash dispensers. Figure 5 outlines Nixdorf's products for the office automation environment.

Figure 5

Pyramid of Products



Source: Nixdorf Computer AG

Terminals

Nixdorf supports character-oriented data processing (DAP) terminals, the personal computer, and the Professional Workstation (PWS). Both PCs and PWS systems function either as standalone workstations or as intelligent workstations to most Nixdorf systems. Through a set of soft keys, the unintelligent DAP 4 terminals offer a user interface similar to the PWS systems.

The Nixdorf 8810 Personal Computer Product Family

Nixdorf models 8810 M 25 and 8810 M 35 IBM compatibles can function as standalone personal computers or they can be attached to other Nixdorf products as workstations. All personal computer models support standard industry software, including the Window Manager from Microsoft and GSX graphics. The 8810/55 is an AT compatible with specific Nixdorf enhancements that is likely to function as Nixdorf's primary desktop publishing system using Page software from Island Graphics.

Professional Workstation (PWS)

The PWS is Nixdorf's primary strategic office workstation. It is a high-resolution (820 x 615 pixels), multifunction workstation with programmable soft keys for use as a videotex terminal, PC, data processing terminal, teletext system, or intelligent workstation to the Series 8840, 8850, 8860, 8862, 8864 BNC (Banking Network Computer), 8870, and 8870 Quattro. Nixdorf markets several models of the PWS: the PWS WP, a low-cost, intelligent, but diskless word processing system terminal; the PWS-D, with diskette; and the PWS-E, the expandable Tower version. The PWS is modular and supports external and internal communications, as well as emulation of the 8840, 8850, 8860, 8870, TARGON, and a variety of host systems from other vendors. It is deeply integrated into each Nixdorf server system for file transfer and remote file access. It supports a wide range of peripherals. Its eight windows permit several applications to run simultaneously, for example MS-DOS (2.11 and 3.2) as well as AT or UNIX software. The PWS can be connected directly, or through the PABX 8818, Ethernet, or the Nixdorf Broadband Network (NBN).

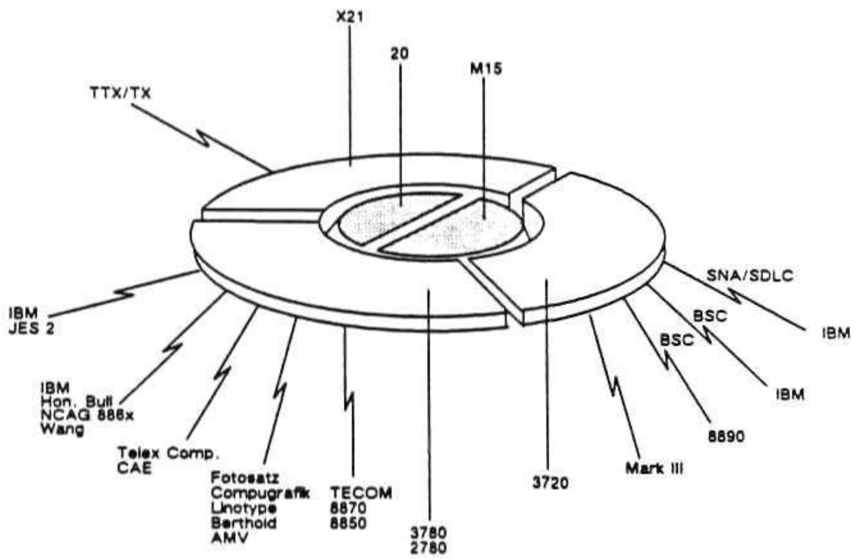
The Nixdorf 8840

Nixdorf's traditional standalone (8840/3) or shared logic (8840/5 to 8840/45) word processing system is expandable to 512K of main memory and 264Mb storage capacity) and supports up to 14 workstations (including personal computers and PWS systems) and 8 printers. The 8840 is designed to handle the integration of text (unstructured) and data (structured) as well as paragraph assembly. The 8840 text software includes mathematical capabilities, teletext capabilities, and communication to a variety of hosts.

Nixdorf has expanded the capabilities of the traditional 8840 text system by providing numerous communication capabilities as outlined in Figure 6. This includes access to the vertical business application capabilities of the larger 8860, 8870, and 8870 Quattro systems. It is also possible for 8840 users to integrate information from the 8870 proprietary data base into the 8840 text program. Editable document exchange is already available between the 8840 and the 8860 text program. Document conversion with the 8870 and the 8870 Quattro text software is planned for 1987.

Figure 6

Communication Capabilities of the Nixdorf 8840



Source: Nixdorf Computer AG

The Nixdorf 8850

The 8850 is a 16-bit decentralized data acquisition and distributed data processing system that is sold primarily to commercial markets. It supports the operating system DIDOS (Distributed Data Processing Operating System), up to 32 workstations including PCs, and a workstation for the blind. The 8850 supports teletext and DETAS (Decentralized Textverarbeitung am Sachplatz), a simple text processing program that merges structured data with addresses and text for mass mailings. The 8850 is able to transfer data and files to the traditional 8840 text system for integration into the more complex text editing programs.

The Nixdorf 8860

The 8860 with Models 60 (industry and public administration), 62 (hotels and wholesale organizations), and 64 BNC (banking systems) is one of Nixdorf's most important and successful products. In the past it was used primarily for distributed data processing applications such as order processing, inventory control, time recording, and recording of production data, and competed with the old IBM 8100. In contrast to the 8870 with its many standard applications, the 8860 fits into environments where tailored systems are needed or where the user develops vertical software.

With the addition of NIOS-TOP at the end of 1986, the 8860 has moved into the office environment and competes against IBM's low-end S/370 line. More than 40,000 processors have been installed: 30,000 in main offices and branches of financial institutions (8864 BNC) and 10,000 (Models 60 and 62) in factories or large organizations as a centralized and distributed information processing system, and more recently, also with terminals for business and office applications. In West Germany, the 8864 is the market share leader in financial institutions.

The 16-bit 8860 with a Nixdorf proprietary operating system consists of modular hardware that provides a user with upgradable systems from standalone micros to MCS, the Multi-Computer System 886X with up to 100 terminals.

The 8860 Multi-Computer System

The MCS was introduced in January 1987 as the most powerful version of the 8860 family. An MCS consists of up to eight autonomous processors coupled with an extremely fast MCS-Bus. Each processor has its own operating system and a copy of the application programs, and each MCS can function as either application or file server. Several Multi-Computer Systems 8860 can be clustered using Ethernet as a local area network. All 8860 software is compatible with the new family.

The application and file server concept of the MCS system provides 8860 users with unlimited growth, and positions Nixdorf to compete directly in the market for major accounts, particularly in the office environment.

The most versatile workstation for the 8860 in an office environment is the Professional Workstation (PWS). Because of its multifunction and windowing capabilities, the PWS can support 8860 emulation in one window, MS-DOS or UNIX software in another, and the NIOS text program (loaded from the 8860) in yet another.

In the office environment, the 8860 supports NIOS-TOP, the Nixdorf Integrated Office Software. NIOS-TOP Word is similar to Quadratron's Q-Office software, and consists of text processing software (including the integration of data processing information), communication (electronic mail, teletext, videotex, and telex), information (calendar, directory, calculator), and document management (filing, retrieval). NIOS-TOP also supports SNA, NCN (Nixdorf Communication Network, and Ethernet, as well as DISOSS DCA/DIA.

The Nixdorf 8870

The 8870 product family is more than 10 years old and has an installed base of more than 50,000 units worldwide. It and the 8860 family are considered by Nixdorf as its "bread and butter" products. The system is primarily sold with standard application programs into small and medium-size organizations as well as into branch offices of large companies.

The Nixdorf 8870 Quattro

The 8870 Quattro family was introduced in early 1987 and offers twice the performance of the 8870 while retaining software compatibility with all 8870 programs. The increased power of the 8870 Quattro is due to the new operating system NIROS 7.0 and its parallel processor architecture with a maximum of four processors. Approximately 50 programs can be run at the same time.

The Micro 7 is the smallest model with two workstations; the high-end Quattro/75 supports up to 30 workstations and 15 printers.

Both the 8870 and the 8870 Quattro support hundreds of standard software programs (bookkeeping, accounting, and so forth) for specific markets under the generic name COMET. As part of Nixdorf's Computer Integrated Office (CIO) approach, the company developed COMET TOP Word, which consists of word processing, filing, archiving, and document creation, as well as COMET data base, telebox, teletext and videotex. COMET TOP Word and COMET Calc can be accessed from all other COMET vertical applications such as bookkeeping, inventory, and so on.

The 8870 and the 8870 Quattro can be networked through the 8818, Nixdorf's digital PABX. Personal computers can be attached through COMET PC-LINK and can support file transfer of business applications information into personal computer programs such as Open Access or Symphony.

The Nixdorf 8890 Product Family

This Nixdorf product competes directly with the IBM 9370 announced in 1986. The Series 8890 (models 32, 13, 18, 23, and 28) is Nixdorf's largest system and ranges from 0.25 mips to 2.8 mips. Together with the 8870 and the 8870 Quattro, it offers a complete modular range, from standalone systems up to the 64-workstation model of the 8890 under VM-Basic. Nixdorf's own PCs, as well as other IBM-compatible PCs, can be attached as intelligent workstations through Ethernet and either in-house or telecommunication lines.

In addition to business application software specific to the 8890, the system supports 8870 and 8870 Quattro compatible COMET TOP commercial software. For the office environment, the 8890 supports COMET TOP Word text processing, electronic mail, resource scheduling (meeting rooms, meeting times, etc.), and meeting facility (videoconferencing). Nixdorf also provides its own relational data base, Reflex.

Reflex is compatible with IBM's Structured Query Language (SQL), a standard set by IBM for its data base products. SQL is portable, independent of application environments, and exchangable. For Nixdorf customers, this means that programs developed under SQL are supported by Reflex. At present, Reflex is available on the 8860, the 8890, and the TARGON systems under Nixdorf's own operating system DIPOS, as well as DOS, VM, and UNIX. Nixdorf is developing Reflex versions for IBM (MVS) and Digital (VMS).

The 8890 systems support IBM's S/370 Office as well as a DISOSS gateway for final-form and revisable-form document exchange.

The Nixdorf TARGON Product Family

Nixdorf has long been a supporter of UNIX V as the standard UNIX implementation. TARGON supports UNIX V, and Nixdorf regards this system as a strategic product, particularly in the public sector. Nixdorf recently received the largest order in its history for more than DM 300 million ($150 million) in TARGON systems from the Bundesanstalt fuer Arbeit (Federal Unemployment Agency). This organization uses Reflex as a distributed data base for its unemployment records and TARGON-Office with teletext and word processing.

The TARGON systems consist of a standalone, the PWS-X (Figure 7) with graphics capabilities, the TARGON/31 M 10 30/50 based on the 86020 processor (8 to 32 users), the TARGON/35 RISC system Models 30 and 50 with 12 mips (32 to 200 users), and the fault-tolerant TARGON/32 (16 to 250 users). PCs and the versatile PWS systems function as workstations to the TARGON system.

Figure 7

PHOTO OF PWS-X

Source: Nixdorf Computer AG

In addition to numerous business applications, TARGON supports TARGON Office software. TARGON Office is the Q-Office program from Quadratron, but it has been enhanced by Nixdorf with soft keys and includes integration of graphics and image. TARGON Office consists of text processing (word processing, text/business applications), notebook, calendar, telephone directory, electronic mail, data base, and calculator. TARGON Calc will be released in 1987. In addition, Nixdorf's TARGON Office supports X.400-Mail, the relational data base Oracle, SQL, and Nixdorf's own data base Reflex in a UNIX coprocessor. TARGON Office also permits access to hosts and networks.

The Nixdorf 8818 PBX

In 1982, Nixdorf launched Germany's first digital PABX, the 8818, a vitally important module in the company's integrated office strategy. According to Nixdorf, the PABX is already being marketed in eleven countries and more than 3000 systems (30 to 3000 users) have been shipped. The 8818 can be integrated into data processing systems to support applications relating to factory data capture (building security, energy management, time recording), charge recording, and wholesale applications. The 8818 also transmits data, text, voice, and graphics within office applications, and will be connected to all Nixdorf products.

All Nixdorf terminals can be attached to the 8818, including the BT01 videotex terminals and the Digifon, a digital telephone used for data switching and telephony. The 8818 permits switching of data from the PC/PWS to personal computers and to midrange computers, as well as from terminals with teletext capabilities to midrange computers.

Voice Box

Nixdorf's Voice Box is a voice store-and-forward system based on 80186 and 80286 Intel microprocessors with the RMX operating system. Voice messages are integrated into electronic mail and appear in the electronic mail directory. Table 1 shows the worldwide installed processor units of the major Nixdorf systems as of the end of 1986:

Table 1

WORLDWIDE INSTALLATIONS OF NIXDORF SYSTEMS

Nixdorf 8840	4,500
Nixdorf 8850	14,500
Nixdorf 8860	40,000
Nixdorf 8870	50,000
Nixdorf 8870 Quattro	released 1987
Nixdorf 8890	700
Nixdorf TARGON	500
Nixdorf 8818 PABX	3,000

Source: Nixdorf Computer AG

CIO, THE COMPUTER-INTEGRATED OFFICE

The CIO concept was developed almost two years ago. To Nixdorf, CIO represents the "informative infrastructure" of an organization, while CIM represents the "productive infrastructure." The CIO concept encompasses all of Nixdorf's hardware products and all data, text, and communication software capabilities, including the digital PBX 8818, Ethernet, and the Nixdorf Broadband Network (NBN).

With CIO, Nixdorf pledges to combine both hardware and software in a number of ways to support managers, secretaries, and knowledge workers in a variety of environments. Through the CIO concept, Nixdorf hopes to show its existing customers that they are already participating in office automation. At the same time, Nixdorf wants to assure them that the investments they have made in Nixdorf products will always be upgradable to state-of-the-art technology without loss of hardware or stored information, and without having to perform duplicate work.

Under the CIO concept, Nixdorf intends to integrate its products according to specific in-house and international standards, perhaps similar to IBM's System Application Architecture that was announced in 1987. In a statement of direction, Nixdorf has formulated rules for each of six main areas:

- Communication with the host
  Rules: RJE (remote job entry), 3270, 8160, SNA, DISOSS/DIA

- Communication between Nixdorf products
  Rules: IHSS in-house communication; remote connection/public networks; Ethernet for server connections; ISDN for workstation connections
  Rules: Ethernet and ISDN

- External postal services:
  Data services: dedicated lines and switched networks; Datex L; Datex P
  Information services: telex, videotex, teletext, telefax, telebox, all according to ISDN standards

- Internal postal services:
  electronic mail according to X.400 and the CCITT standards
  Rules: ISDN standards

- Information management: business applications, word processing, integrated word and business applications, filing and archiving, personal computing, including voice, image and graphics
  Rules: Uniform Information Management (internal Nixdorf standards for uniform integration and user interface)

- Application integration: file transfer, dialog access, multifunctionality (dp + wp + pc + host access and postal services)
  Rules: Multifunctional solutions using standardized interfaces

Dataquest's View of an Integrated System

Dataquest defines an integrated office system as a composite of computer hardware and integrated software that supports and enhances the productivity of work groups. The core functions that have evolved over the years are document management, administrative support, decision support, end-user computing tools, and gateways to other systems.

Vendors must provide for integration, particularly in the area of text, data, image, and voice, and must form them into one compound document. The following capabilities should be available in a tightly integrated system.

- Move data from one application to another without exiting the program or using a conversion utility.

- Move data between applications and files without losing the character of the information (e.g., spreadsheet data inserted into a word processing document retains its spreadsheet identity); when data are changed in one application, the same change is automatically reflected in the second application.

- Store different types of data (such as in compound documents) in one filing system.

- Present a consistent user interface across all applications.

- Run the same software on all proprietary hardware products.

The Nixdorf View of an Integrated System

Nixdorf holds two views of an integrated system. The first one is called CIO, the Computer Integrated Office. CIO champions global integration of data processing, office, and communication applications. This view includes the addition of office and communication capabilities (electronic mail, teletex) to application programs in specific vertical markets, for example, or the addition of those capabilities to already existing installations. Nixdorf has committed to provide this level of integration for all of its products, and is able to deliver many of these capabilities today. For example, many vertical programs access text processing or electronic mail capabilities, or are able to integrate structured data from business applications.

The second view of integration is that of information media: text, voice, graphics, and data. This level of integration provides for the close integration of individual programs in the classical Dataquest definition. Since Nixdorf has never committed to develop a pure integrated office system in the classical sense of Digital's All-in-1 or Wang Office, it must now work to bring its NIOS and COMET office software to the level of these systems. For example, in most Nixdorf systems, spreadsheet information can be integrated into the text program in print mode, but graphic and image data are still stored separately and indicated through a pointer.

However, at the same time, Digital, Data General, and Wang have recognized the need for vertical programs and are working to integrate their office systems software with vertical applications. But even here Nixdorf is more application-oriented and provides this level of integration where its is indicated by customer need and where it provides an enhancement to the existing system.

DATAQUEST ANALYSIS

Nixdorf in the Office Environment

In order to evaluate its office system approach, Nixdorf insists that one must always remember that the company is foremost one that sells into business environments with specifically tailored business applications. This approach has been the primary reason for Nixdorf's success: the ability to give small- and medium-size companies the numerous hardware and software products that solve specific industry-related problems.

The business orientation continues today. Neither in Europe nor internationally does Nixdorf market its systems primarily as office systems. However, in order to compete with companies offering both business and office applications, Nixdorf has added office systems software to most of its systems. In addition, Nixdorf continues to provide its traditional 8840 word processing system in Europe:

- The Series 8860 with NIOS TOP office software
- The Series 8870, 8870 Quattro, and 8890 with COMET TOP office software
- The TARGON Series with TARGON Office

When viewed simply in an office context (a market in which Nixdorf traditionally has not competed), several drawbacks are apparent:

- For Nixdorf, office applications have always been an add-on to business applications. As a result, neither NIOS TOP nor the COMET TOP components are comparable in their depth of integration to the integrated solutions offered by Digital, Data General, Wang, and other competitors.

  However, Nixdorf's strength lies in the numerous specific vertical software programs that the company offers for particular industries. For example, the 8860 is sold primarily into the operating areas of financial and insurance industries, and the office system companies compete primarily in the administrative departments of these organizations. Although NIOS TOP office applications are not as feature-rich or as integrated among themselves as those of its competitors, they can be accessed from NIOS TOP business applications. European customers often prefer this level of integration to office software that is richer in functionality but that lacks integration into business applications.

- The office software programs vary in their ease of use and degree of integration, and some product families consist of incompatible hardware and business applications. This may force users to choose between a strong business application or a strong office application.

- Editable document exchange is possible only from the 8840 to the 8860 and from the 8860 to TARGON. COMET TOP Word is available on the 8870, 8870 Quattro, and 8890, but there is no bridge to the other systems. The document exchange between other products is possible only through teletext.

- The older DAP 4 terminals support only DETAS, an older text processing program well integrated into numerous vertical applications. The newer DAP 4X terminals support COMET TOP Word, but there is no document conversion from DETAS to Word. All new installations are sold only with DAP 4X, leaving DETAS as island applications in specific vertical markets.

However, end-user requirements everywhere have been changing from specific feature/function orientation to an overall systems approach, and from general office solutions to specific vertical applications. In a solution-oriented market, Nixdorf's drawbacks are balanced by an equal number of advantages:

- By positioning itself as the present and future provider of integrated information, Nixdorf has its special emphasis on the integration of business applications, office technology, and communication of all of its products. This means that Nixdorf users can expect continued development of integration capabilities between its major commercial and office software products.

- Nixdorf provides both a digital PABX and computer systems, and intends to integrate them with future ISDN orientation.

- Nixdorf already has strong internal and external communication capabilities and is a strong supporter of international communication standards. These international communication standards are outlined in Nixdorf's statement of direction.

- The company's emphasis on solution-oriented software provides users with a large number of business programs not easily matched by other companies.

- Nixdorf's commitment to software compatibility should assure customers of the longevity of its software programs and company data.

- The TARGON systems now provide Nixdorf with a product that will support truly integrated programs. Nixdorf intends to build on existing programs and to develop an office system that will compete in the office systems market, for example in organizations that already use the 8860 for business applications.

- Nixdorf has announced DISOSS, MAP, and TOP support for the TARGON systems, as well as SNA host functionality and a new 24-mips TARGON system. This expands the TARGON line even farther and positions it as one of Nixdorf's major products.

- Nixdorf intends to exploit the strengths of its PWS systems for all product families and to position it as the workstation of choice. Nixdorf expects to provide the PWS with the more powerful 80386 Intel processor to increase speed and performance.

International Markets

Europe is Nixdorf's primary market. In Germany and in the rest of Europe, Nixdorf's products are well established and will continue to be readily accepted. However, much remains to be done to assure their international competitiveness, primarily in the office systems market. A prime factor aiding Nixdorf in its renewed push into international markets is an increasing emphasis worldwide on vertical applications and solution-oriented software, rather than on the traditional generalized office systems approach.

In order to compete in emerging Asian markets, Nixdorf is busy adapting and translating its COMET TOP vertical software into Japanese, Chinese, and Korean.

One of the largest international markets for Nixdorf could be the United States. However, the office world there is dominated by IBM, Digital, Data General, and Wang; NCR will be a formidable opponent in the vertical application and cash register market.

Several years ago, Nixdorf attempted to compete in the office market with its Nixdorf 8840, designed for predominantly German-oriented integrated text and data applications (for example, merging client addresses resident in a data base with an offer letter originated in word processing, and automatically calculating unit prices). The 8840 was not successful in the United States, and the system was discontinued.

Nixdorf is making another assault on the U.S. marketplace with its 8870, and in particular with its TARGON systems. However, as a pure office systems vendor, Nixdorf at present cannot compete with available integrated office systems from Wang, Digital, and others. Although Nixdorf has rededicated itself to doing what it does best--provide vertical programs for specific U.S. markets--the company is aware that it must continue to deepen the integration level of its office software. In addition, Nixdorf must provide gateways to other vendors and integrate competitors' office software into Nixdorf's vertical business applications.

This is no small task, but Nixdorf is in this business for the duration and realizes that revenue cannot be improved in the short term. Now that the company has moved from a product to a solution approach in the United States, first successes are becoming apparent in the banking, insurance, and retail markets. Nixdorf expects major orders from large companies in 1987, similar to the $100 million order it received from Montgomery Ward & Co.

One of Nixdorf's long-range plans is to bring its ISDN-based products, the 8818 PBX and its Digifone, into the United States. This will put the company not only in direct competition with U.S. vendors of PBX systems, but also with European companies like Philips and Ericsson who intend to garner a share of that market. The 8818 PBX is already sold in Germany, Austria, Belgium, Ireland, Switzerland, Italy, Greece, Portugal, Japan, China, Hong Kong, and Turkey; telephone systems now account for 10 percent of all new orders. In this market, Nixdorf also offers particular vertical applications for hospitals (patient status) and hotels (automatic wake-up calls). Just recently, Nixdorf supplied the renovated Queen Elizabeth II with 1500 digital telephones, to be followed shortly by cash registers connected to the hotel computer 8862 Rio and the 8818 PBX. Again, Nixdorf competed successfully because of its vertical hotel application.

Mr. Luft expects revenue to reach DM 9 billion in five years. As long as Nixdorf retains its market-driven focus (expressed in vertical applications for specific market niches and excellent customer care) Dataquest believes that the company will continue to perform as one of the consistently successful computer companies in Europe and to gain market share in the United States.

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Yearly Exchange Rates

Dataquest analyses involve data from many countries, each of which has different and variable exchange rates against the U.S. dollar. As far as possible, Dataquest estimates are prepared in terms of local currencies before conversion, when necessary, to U.S. dollars. Dataquest uses International Monetary Fund (IMF) average foreign exchange rates for historical data.

Dataquest monitors the exchange rates on a weekly basis using IMF exchange rates supported by Financial Times exchange rates when IMF data are not yet available. (The Financial Times is the accepted U.K. newspaper giving daily updates). The yearly exchange rates table provides a summary of the yearly average exchange rates in local currency per U.S. dollar for each European region from 1979 through 1988. Also shown, for reference purposes, are the same figures for the Japanese yen.

Included in Table 1 is the yearly weighted average of all the individual European countries. This average is weighted according to the semiconductor consumption of each country. For convenience, this has been calculated from a base of 1980 being equal to 100. The weighted average can be used to interpret the effect of the European currency fluctuations with respect to the U.S. dollar in a given year and to provide a better measure of aggregate local currency growth as opposed to U.S. dollar growth.

Yearly Exchange Rates

Table 1

European Currencies—1979 to 1988
(Local Currency per U.S. Dollar)

	1979	1980	1981	1982	1983
Austria	13.37	12.94	15.93	17.06	17.97
Belgium	29.32	29.25	37.13	45.69	51.13
Denmark	5.26	5.64	7.13	8.33	9.15
Finland	3.90	3.73	4.31	4.82	5.57
France	4.25	4.23	5.43	6.57	7.62
Ireland	0.49	0.49	0.62	0.70	0.80
Italy	830.86	856.05	1,136.08	1,352.05	1,518.09
Luxembourg	29.32	29.24	37.13	45.69	51.13
Netherlands	2.01	1.99	2.49	2.67	2.85
Norway	5.06	4.94	5.74	6.45	7.29
Portugal	48.92	50.07	61.55	79.48	110.78
Spain	67.13	71.70	92.31	109.86	143.43
Sweden	4.29	4.23	5.06	6.28	7.67
Switzerland	1.66	1.67	1.96	2.03	2.10
United Kingdom	0.47	0.43	0.49	0.57	0.66
West Germany	1.83	1.82	2.26	2.43	2.55
Weighted Average (Base 1980 = 100)	101.66	100.00	123.69	141.30	157.59
Japan	219.14	226.75	220.54	249.05	237.52

	1984	1985	1986	1987	1988*
Austria	20.00	20.69	15.26	12.64	12.03
Belgium	57.78	59.41	44.66	37.34	35.71
Denmark	10.36	10.60	8.09	6.84	6.53
Finland	6.01	6.20	5.07	4.40	4.08
France	8.74	8.98	6.92	6.01	5.78
Ireland	0.92	0.94	0.75	0.67	0.64
Italy	1,756.98	1,909.05	1,490.00	1,296.01	1,268.01
Luxembourg	62.34	59.38	44.66	37.34	35.71
Netherlands	3.21	3.32	2.45	2.03	1.92
Norway	8.16	8.60	7.39	6.74	6.31
Portugal	146.39	170.40	149.54	140.88	139.70
Spain	160.76	170.05	139.97	123.56	113.58
Sweden	8.27	8.60	7.12	6.34	6.00
Switzerland	2.35	2.46	1.80	1.49	1.42
United Kingdom	0.75	0.77	0.68	0.61	0.55
West Germany	2.85	2.94	2.17	1.80	1.71
Weighted Average (Base 1980 = 100)	178.06	184.70	145.89	125.52	118.41
Japan	237.44	238.54	168.49	144.43	126.24

*Estimate

Source: IMF
Dataquest
September 1988
Ref. 0788-07