MANAGEMENT, TECHNOLOGY, AND STRATEGY

PERIPHERALS AND TERMINALS

INPUT

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OFFICES

Headquarters
1943 Landings Drive
Mountain View, CA 94043
(415) 960-3990
Telex 171407

Detroit
220 E. Huron
Suite 209
Ann Arbor, MI 48104
(313) 971-0667

New York
Park 80 Plaza West-1
Saddle Brook, NJ 07662
(201) 368-9471
Telex 134630

United Kingdom
INPUT, Ltd.
Airwork House
35 Piccadilly
London, W1V 9PB
England
01-439-8985
Telex 23116

Service Company, Ltd.
lding
a Aoyama
ato-ku
0

ult
& Co AB
ckholm

ny
N GmbH
henbrunnen 1
D-6380 Bad Homburg
West Germany
Telex 418094

Via Soperga 36
Italy
Milan 284-2850
Telex 310352

INPUT Planning Services for Management

MANAGEMENT, TECHNOLOGY, AND STRATEGY FOR FIELD SERVICE OF PERIPHERALS AND TERMINALS

DECEMBER 1983

MANAGEMENT, TECHNOLOGY, AND STRATEGY FOR FIELD SERVICE OF PERIPHERALS AND TERMINALS

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MANAGEMENT, TECHNOLOGY, AND STRATEGY FOR FIELD SERVICE OF PERIPHERALS AND TERMINALS

EXHIBITS

I INTRODUCTION

- As a result of significant changes taking place with respect to the peripheral equipment and terminals market, service management is faced with a number of challenges. These challenges stem from:

  - Increasing competition from network-based personal computers as an alternative to mainframe-system-based peripherals and terminals.

  - Growing reliance of users on all elements of a system, which requires more rapid responses and faster repair times.

  - New developments in input and output technology, including voice recognition, integrated voice/data terminals and systems, multifunction terminals, and graphics.

  - The increasing intelligence and embedded software in peripheral display equipment and terminals, requiring more sophisticated service and support capabilities.

  - Increasing end-user focus on service cost containment and responsiveness.

- In summary, service is becoming more technologically intensive and more competitive. Thus service managers supporting peripheral and terminal equipment must become more innovative and sophisticated in their ability to

manage service. They must also deliver cost-effective and responsive service by efficiently controlling all service resources (i.e., personnel, parts, and data) in response to changing customer needs.

- For the third-party maintenance organization, the peripheral and terminal market is an existing opportunity that is becoming more challenging as it becomes more technologically complex and more competitive.

A. SCOPE

- This report concentrates on tactical and strategic conclusions and recommendations for peripheral and terminal vendors in regard to the technology trends, service trends, and challenges facing them.

- Where possible, reference is made to market size, growth rates, specific vendor products, and service approaches. For the most part, however, the report focuses on the expected evolution of the peripheral and terminal market environment in the next five years, and how this evolution will affect the service organizations of participating vendors.

B. METHODOLOGY

- While interviews with users and vendors of peripheral and terminal products were the basis of the trends highlighted, much of the information presented is based on extensive secondary research of available public information, supplemented by INPUT's conclusions about the marketplace as a whole. The goal is to provoke new vendors to rethink and evaluate their service approaches and plans for the future.

- As always, comments and queries from clients are welcomed.

II EXECUTIVE SUMMARY

II EXECUTIVE SUMMARY

A. INTRODUCTION

- This Executive Summary is designed to help the busy reader quickly review the research findings of this report without having to read each section, while ensuring that the key points are not missed. Each main point is summarized as an exhibit, and an accompanying script is given on the facing page.

- INPUT believes that the peripheral and terminal marketplace is reaching a critical stage, where service margins are being pressured by constantly shortening life cycles. The start-up costs of service for each product can no longer be spread over seven or eight years of in-field service revenue.

- This report addresses the main trends in product technology developments, service management, delivery, and user requirements, and suggests tactical (short-term) and strategic (long-term) action plans to meet the challenges found in today's peripheral and terminal service marketplace.

B. KEY TRENDS IN PERIPHERAL/TERMINAL SERVICE

- In line with every category of computer hardware product, the average user requirements for response and repair time are shortening. In the last three years INPUT has seen the user insist on a 25% reduction in response time and a 30% reduction in repair time.

- Most of this demand has been generated by existing vendors, as they struggled for market share, and by new vendors that have no installed base to worry about. The constant flow of new products with better in-built reliability has raised user expectations - while hardening resistance to service price increases.

- INPUT believes that while the average product's built-in reliability has increased, the average level of end-user satisfaction with after-sales service has decreased, mainly due to the complex distribution channel network that many vendors use to reach their markets. Most of these distribution channels are principally concerned with sales performance - rather than service performance - and it shows.

- In addition, peripheral and terminal product complexity is increasing so that it has become necessary for much of the diagnostic function to be accomplished by hardwired routines built into the product itself, not necessarily for end-user self-maintenance but to assist the dealer/distributors and the vendor's own in-field service force to handle fault calls within a profitable timeframe.

EXHIBIT II-1

KEY TRENDS IN PERIPHERAL/TERMINAL SERVICE

- Increasingly tight response and repair time requirements
- Nonstop competition from rapid flow of new products and new companies with better reliability
- Increasing user concern over service cost containment
- Dissatisfaction with services offered by OEM vendors and retail chain distribution channels
- Increasing complexity of equipment requires in-built diagnostics

C. PERIPHERAL/TERMINAL SERVICE MARKET NEEDS

- The two overriding concerns of customer service - profitability and customer satisfaction - are coming into conflict more than ever in the peripheral/terminal service market. What is needed is a strategic service pricing approach that satisfies the peculiar nature of each market segment.

- Many of the markets served need to be serviced by the distributor/dealer/retail chain that sells the product, independent of the vendor/manufacturer (other than for spares, documentation, and training). This trend is more and more toward this kind of service, so that it is desirable for the vendor/manufacturer to constitute a complete portfolio of post-sales support services to the end user and the independent third-party supplier.

- From the user standpoint it is desirable to have a single source of service for all of the products found at the user site (irrespective of origin). Vendors must decide whether they wish to enter the third-party maintenance (TPM) market (servicing other vendors' products) or whether they are willing to divest themselves of first-level service responsibilities in favor of a TPM or other vendor.

- In making this decision it must be born in mind that service quality and cost are an increasingly significant component of the purchase decision process. Therefore, whichever route is chosen, vendors must be sure that a competitively high standard of service is provided to the end user - whoever supplies it.

EXHIBIT II-2

PERIPHERAL/TERMINAL SERVICE MARKET NEEDS

- A strategic service pricing approach that focuses on each market segment
- A comprehensive portfolio of services to support all aspects of after-sales support
- A single source of integrated support for each customer site
- Recognition of the growing importance of service in purchase decision as life cycles shorten

D. SERVICE PACKAGING ACCORDING TO DISTRIBUTION CHANNEL MIX

- As with the small-system market, the large number of specific distribution channels open to peripheral and terminal vendors requires a separate and equally specific package of support and service, customized for the special needs, capabilities, and requirements of the retail dealers, distributors, OEMs/systems houses, and third-party service organizations.

- An increasing percentage of these peripheral and terminal sales outlets requires only over-the-counter parts and OEM-type support, with their own service provided to the end user. These include:

  - Systems integrators.

  - Master distributors.

  - Industrial distributors.

  - Some OEMs.

  - Third-party service companies.

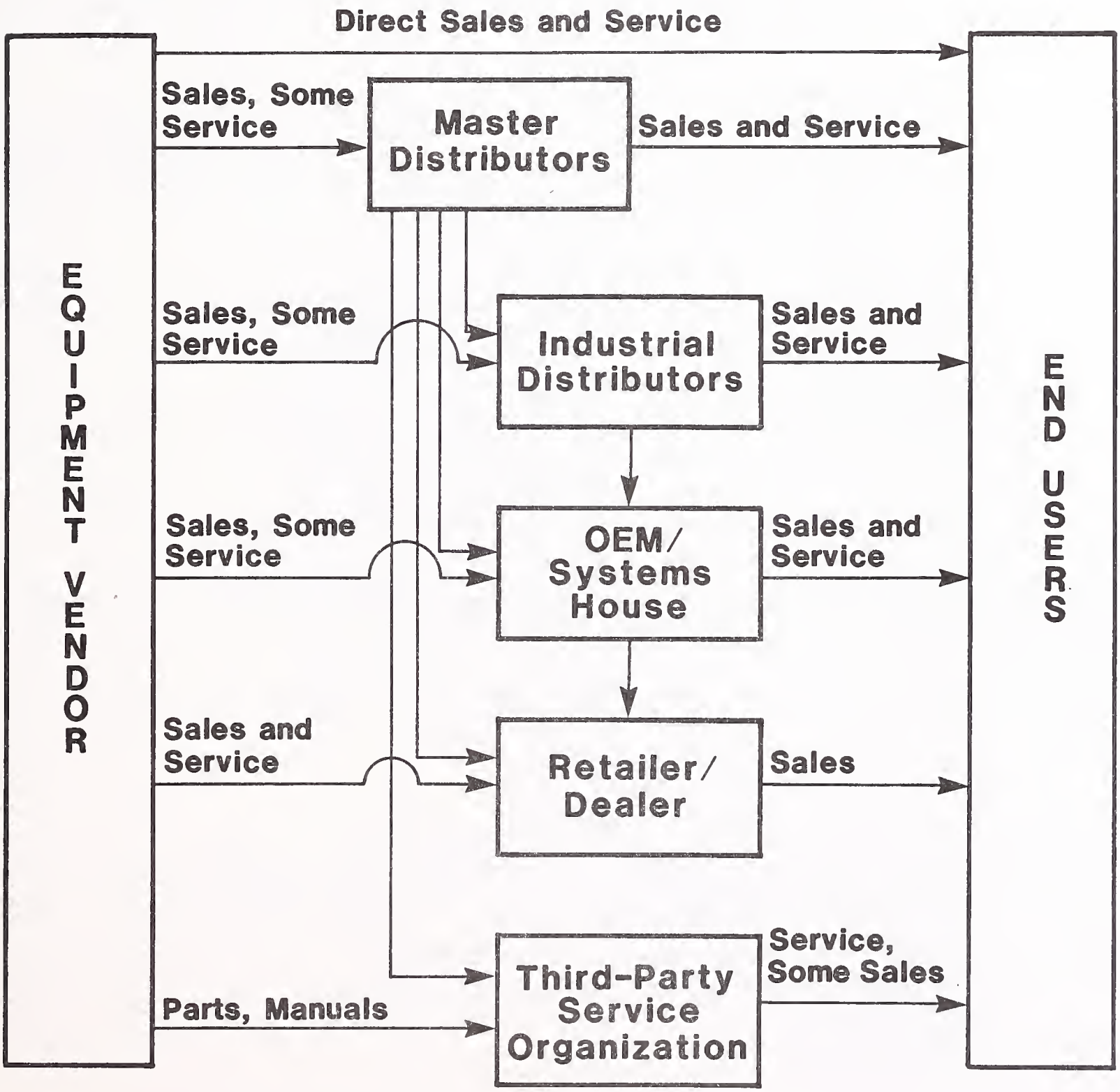
- INPUT believes that this trend will continue, with many retail store chains taking on the responsibility for end-user service.

- Third-party maintenance firms are likely to be aggressive in this regard and are capable of coming to an agreement with other retail outlets and chains for nationwide support of entire lines of products.

- This, as for the small-system service market, could have the short-term effect of reducing the product manufacturers' service revenue substantially, while increasing the gross margin on operations (since much of the business would come from over-the-counter parts - a high-margin contributor). The essential need is for the product manufacturer to closely monitor the overall response received by the end user, so that good product image is maintained.

EXHIBIT II-3

SERVICE PACKAGING ACCORDING TO DISTRIBUTION CHANNEL MIX



E. PRINCIPAL PERIPHERAL/TERMINAL SERVICE MARKETS

- The goals for the vendor of peripheral/terminal products are as follows:

  - Increase the productivity of the in-field service staff by automating diagnostic procedures (built-in), making use of floating "loaner" units where possible, and using on-site swap/off-site fix methods as broadly as possible.

  - Carefully tailor service of support products and procedures to the particular mix of distribution channels that each vendor has or expects to have in the next five years.

  - Closely monitor end-user satisfaction with service and support, whether it is direct or indirect (through a third party).

- The principal peripheral/terminal service markets by 1987 are expected to be:

  - Terminals, with 31% of the $7 billion service revenue in 1987.

  - Printers, with 26% or $1.8 billion in service revenue.

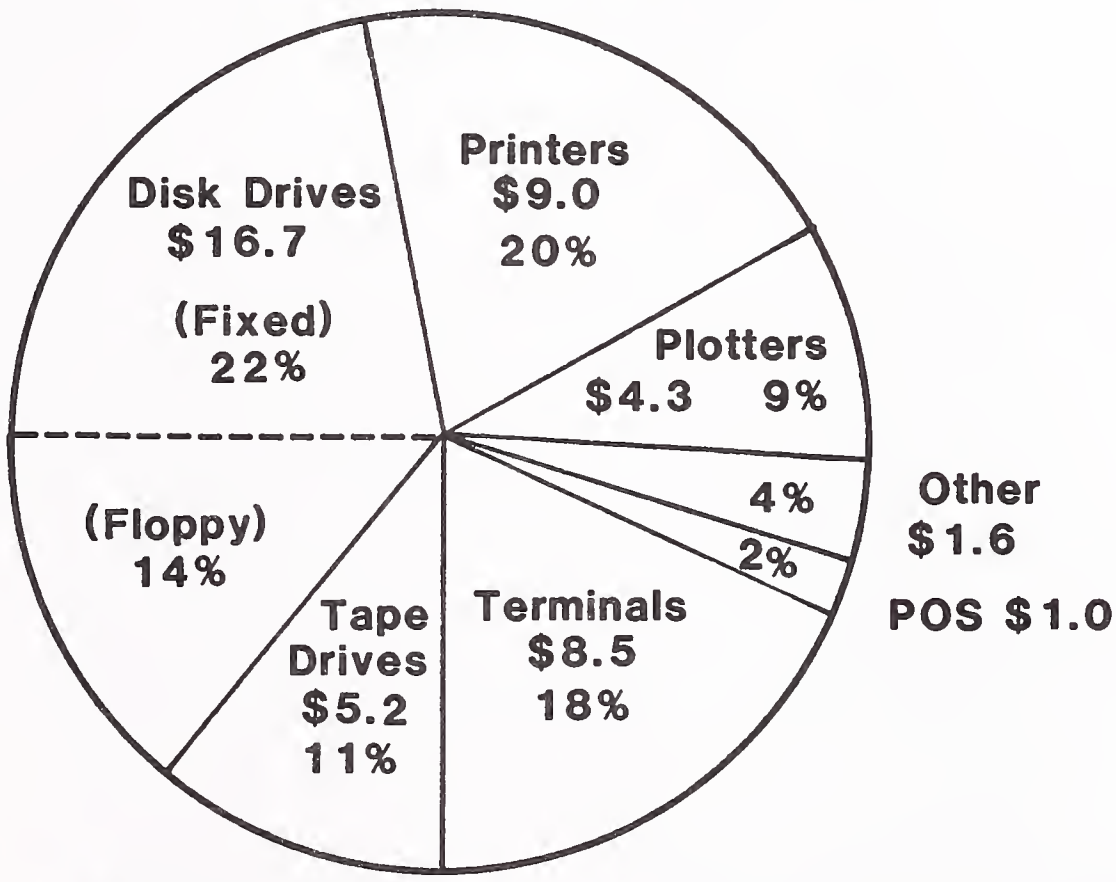
  - Fixed-disk drives, with 18% or $1.3 billion in service revenue.

  - Floppy disk drives, with 12%.

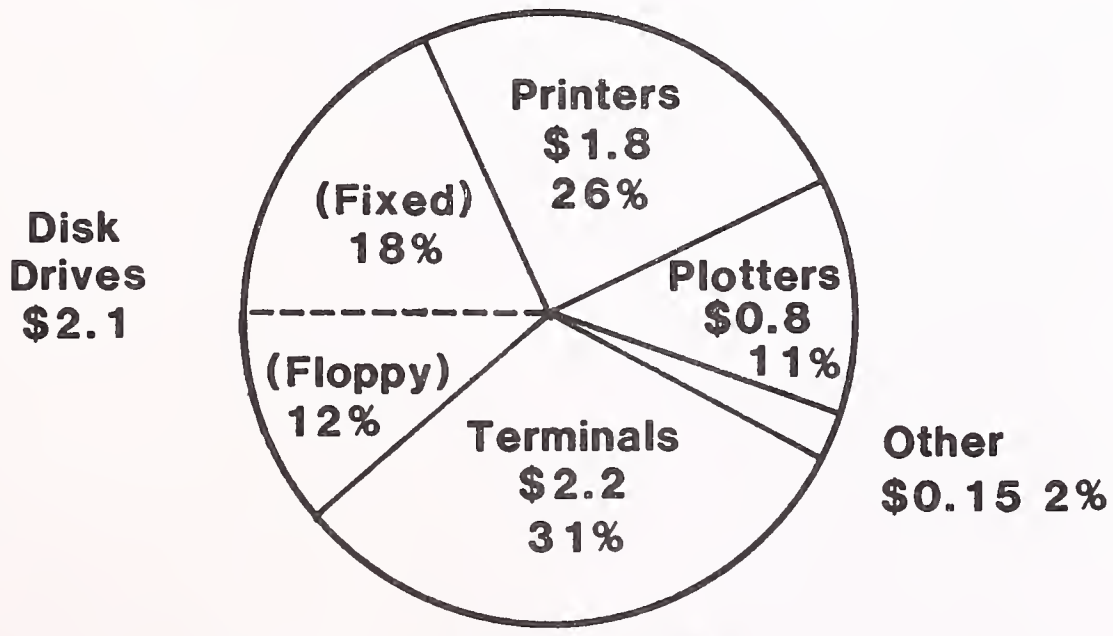
- These opportunities call for product design changes (to incorporate the necessary automated diagnostic routines), manufacturing targets (to improve product quality and inherent reliability), and marketing plans (to design and produce service pricing and packaging plans that respond to each vendor's specific needs).

EXHIBIT II-4

PRINCIPAL PERIPHERAL/TERMINAL SERVICE MARKETS ($ Billions)



1987 SALES OF PERIPHERAL/TERMINAL PRODUCTS: $46.3



1987 SERVICE REVENUE FROM PERIPHERAL/TERMINAL PRODUCTS: $7.05

III TECHNOLOGY AND PRODUCTS

III TECHNOLOGY AND PRODUCTS

A. INTRODUCTION

- The peripheral and terminal market is a large, diverse, and highly complex industry, involving many suppliers, a broad range of different electronic and electromechanical technologies, and very complex distribution and support channels. The market consists of a wide variety of different products, including:
  - Line and serial printers.
  - Disk and tape storage units.
  - Terminals and displays.
  - Special input/output units.
  - Other peripheral subsystems.
- A more complete outline of the major types of peripheral equipment is shown in Exhibit III-1.
- The peripheral equipment market started with the development and introduction of computer systems. Typically, peripherals were manufactured directly

EXHIBIT III-1

TYPES OF PERIPHERALS AND TERMINALS COVERED IN THIS REPORT

- Printers
  - Dot Matrix
  - Letter-Quality (Daisy-Wheel, Thimble)
  - Line Printers (Under 300 LPM)
  - Line Printers (300 LPM and Up)
  - Teleprinter Terminals (With Keyboard)
- Disk Drives/Storage Units
  - Diskette (Floppy) Drives
  - 5-$\frac{1}{4}$-Inch Winchester Drives
  - 8-Inch Winchester Drives
  - 14-Inch Winchester Drives
  - Fixed Disk Drives
  - Removable Disk Drives
- Tape Drives
  - Cassette/Cartridge Drives
  - Reel-to-Reel Drives
- CRT Terminals/Monitors
  - Alphanumeric
  - Graphic
- Other Peripheral Subsystems
  - Memory Expansion Boards
  - Keyboards
- Special Input/ Output Units
  - Plotters
  - Point of Sale (POS)
  - Optical Character Readers (OCR)

or under subcontract by the mainframe vendors and sold as part of the overall system. In general, in the 1960s and early 1970s the cost of peripherals, as a percentage of overall systems costs, was in the range of 20-25% and was not considered to be an independent market per se. Independent manufacturers of peripheral equipment and terminals sold their products to the mainframe OEMs, and sales and service to the end user was then managed by the mainframe supplier directly. However, as CPU costs dropped, as peripheral equipment became more sophisticated and complex, and as new technology was developed, the end users became more sophisticated in their purchase decision-making. As a result, the independent peripheral and terminal market began to develop and grow.

- The trend of overall systems costs (CPU versus peripherals), as shown in Exhibit III-2, clearly shows the peripheral market expanding. Today, peripherals account for 60% of total systems shipments, and it is projected that, by 1987, they will account for almost 75% of the value of system shipments. The peripheral and terminal market has grown to a substantial size and is currently in the range of $20 billion annually for U.S. domestic sales, as shown in Exhibit III-3; the market is projected to grow to over $45 billion by 1987.

- The use of peripheral equipment and terminals varies by type of system. Cost projections for peripherals, terminals, and CPU/main memories suggest that the major growth markets will be for disk storage units and CRT/terminals, with increasing resources being allocated for systems-related communications and communication-oriented input/output units. Details are shown in Exhibit III-4.

I. GENERAL MARKET TRENDS

- Computer peripherals have not been significantly affected in the past by the price-cutting that has plagued the computers themselves; peripherals are thought to be a silver lining in a clouded business - the high-margin "swords" that make selling all those low-margin "razors" worthwhile.

EXHIBIT III-2

TRENDS IN PERIPHERALS VERSUS CPUs:
SHIPMENTS OF COMPUTER SYSTEMS BY VALUE
1975-1985

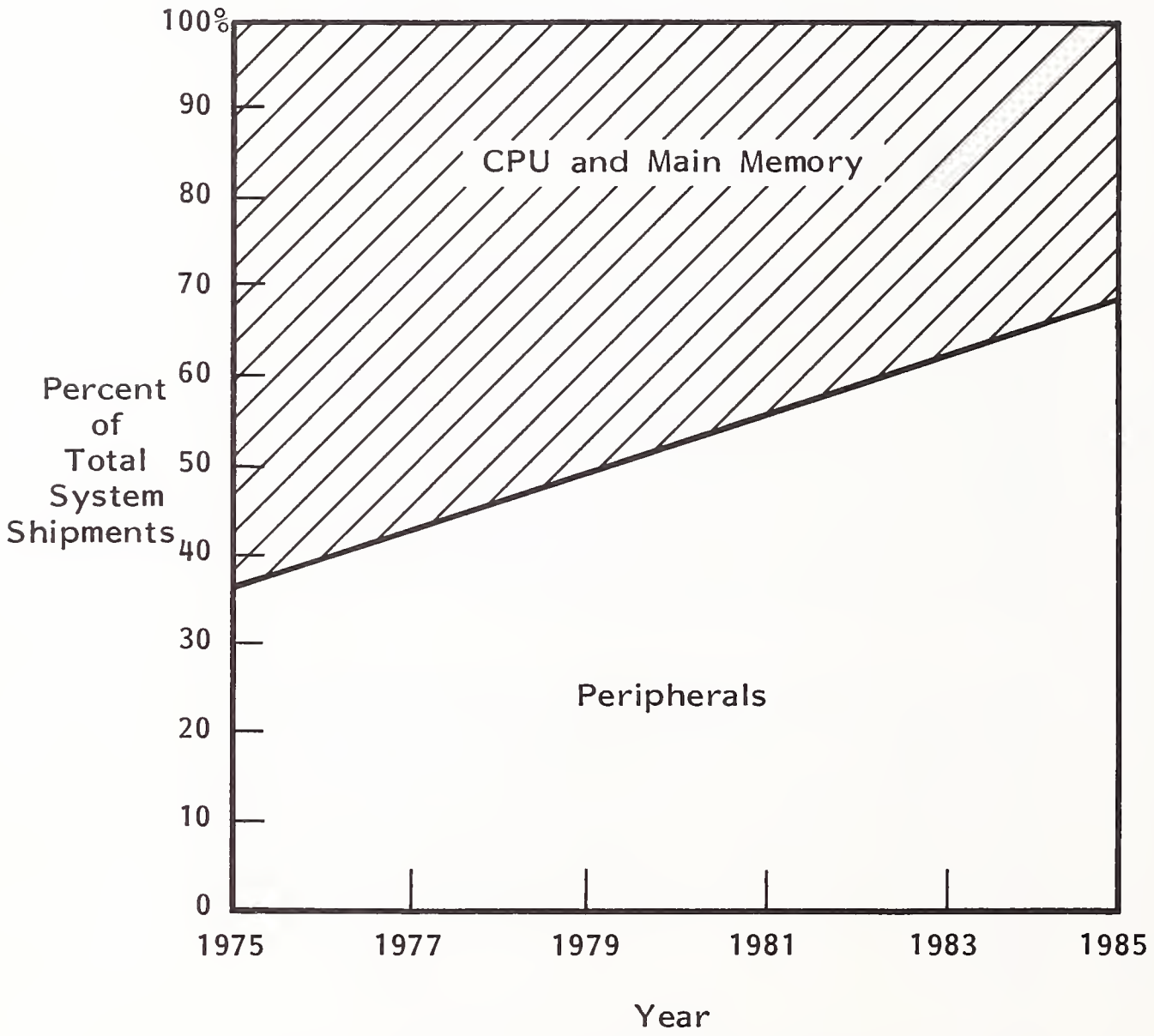


EXHIBIT III-3

ESTIMATED SIZE OF THE
U.S. PERIPHERAL AND TERMINAL EQUIPMENT MARKET
(Shipments, $ Billions)

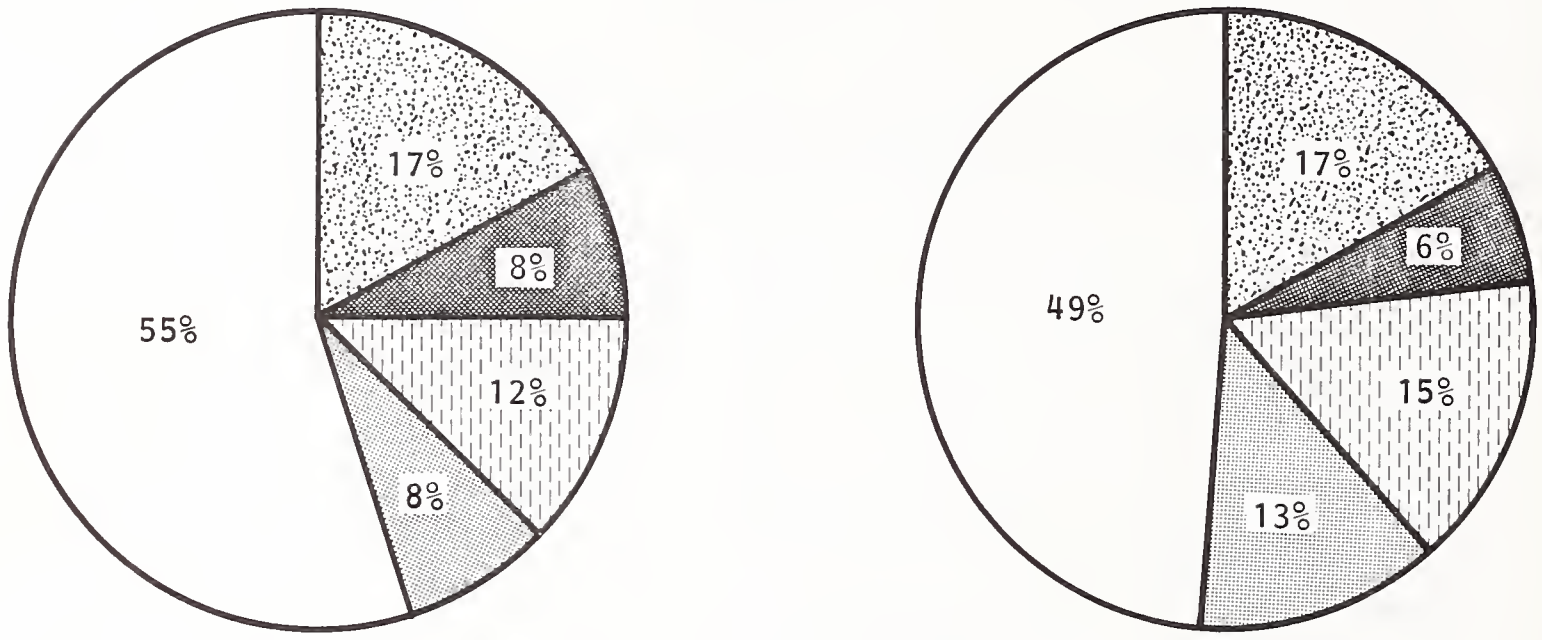
PERIPHERAL EQUIPMENT	YEAR	
	1983	1987
Printers	$ 3.7	$ 9.0
Disc Drives	7.4	16.7
Fixed	4.6	10.3
Floppy	2.8	6.4
Tape Drives	2.5	5.2
CRT Terminals/Displays	3.5	8.5
Standard/Dumb	2.4	4.2
Intelligent	0.7	3.5
Graphics	0.2	0.5
Video and Teletext	0.2	0.3
Optical Character Recognition	0.5	0.7
Plotters	1.7	4.3
Point-of-Sale	0.2	1.0
Other Peripherals	0.3	0.9
Speech Recognition, Digitizers, End Processors Other		
TOTAL	$19.8	$46.3

NOTE: Excludes personal computers used as terminals

SOURCE: INPUT Estimates

EXHIBIT III-4

ESTIMATED SYSTEM COST COMPONENTS*, BY TYPE OF SYSTEM - 1987
(Percent of Costs)



SOURCE: INPUT Estimates

- While performance has increased, prices have remained relatively stable. However, with the rapid decrease in the cost of LSI and VLSI technology, and the rapidly increasing direct market for peripherals and terminals, both the big manufacturers and the hundreds of small startup firms manufacturing peripherals and terminals, are coping with many of the same pressures related to pricing and distribution that are facing the computer mainframe manufacturers. Thus, major price competition is expected to occur in the peripheral equipment and terminal market in the remainder of this decade.

- In summary, there are pressures arising from shifting distribution channels, increasing standardization, a deemphasis of technology in favor of marketing and service and, ultimately, price cutting to gain market share. It is extremely naive to think that computer peripherals will not face the same trends as small computers themselves.

- The computer peripherals market is a good market for several reasons. Computer buyers typically spend $1.50 on peripherals for every $1 they spend on the CPU. This ratio tends to increase as users become familiar with their machines and demand more functions. Peripheral equipment manufacturers' margins average 30% pretax, significantly more than the margins on CPUs. That is partly because peripherals, unlike processors and software, contain more intricate mechanical subassemblies, many of which retain a proprietary edge. Thus, if no manufacturer has been able to achieve more than 20% of the market for any one product, none is likely to start a price war in order to do so.

- However, this past stability is changing. As a handful of manufacturers begin to dominate the market for CPUs, de facto standards for peripherals are emerging. Standardization tends to result in low-cost, high-volume producers, and tends to force out small custom-builders who cannot compete in price. In addition, as the market for small computers grows, manufacturers of peripherals must rely more on indirect distribution channels - chain stores or inde-

pendent distributors - that provide marketing support and service in return for a portion of those margins.

- Aggressive peripherals equipment makers are already developing new ways to adjust to these changes. Coleco, for example, introduced the Adam, a home computer with a Daisy wheel printer "bundled" into a $600 price tag. IBM's "basic system" PC contains the CPU, memory, keyboard, monitor, and a floppy disk drive. It is expected that other manufacturers will follow this pattern for certain systems; this would leave less of the peripheral add-on market to smaller companies.

- In summary, the general outlook is for increasing vertical integration, both upward and downward, by the big competitors; a shakeout among the smaller companies; and an eventual slump in prices, paralleling the experience in mainframe computers. In essence, continued reductions in processor-electronics prices are resulting in peripherals representing a larger percentage of the hardware cost of computer systems. The result is a trend in which systems integrators demand smaller, less expensive peripherals or move to shared-resources system architectures.

2. STRUCTURE OF MANUFACTURERS IN THE MARKET

- In general, the manufacturers of peripherals and terminals include three types:

  - Vertically-oriented mainframe manufacturers, supplying a complete product line.

  - Compatible units manufacturers producing units that are capable of interfacing with the mainframe CPUs produced by major leaders.

  - Producers of standalone or special feature units offering specialized and sophisticated capabilities and requiring a specialized or network-based interface.

- Of the three types of vendors, the largest in number are the plug-compatible manufacturers. However, as shown in Exhibit III-5, the major market shares are still dominated by the mainframe suppliers. More than 300 independently produced, plug-compatible peripherals that come equipped with controller interfaces for specific make/model computer systems are being marketed. Most of these are designed for the large mainframe-supplied systems, including IBM, DEC, Honeywell, Burroughs, Univac, and NCR. Typically, plug-compatible equipment includes:

  - Plug-compatible memory - add-in memory boards and add-on/extension memory subsystems that effectively enlarge system memory.

  - Plug-compatible disk subsystems - floppy disk (diskette), Winchester, disk-cartridge/pack and head-per-track controllers or controller-drive subsystems, and memory subsystems that emulate disk storage to create greater storage capacity.

  - Plug-compatible, magnetic-tape subsystems - cassette/cartridge and reel-to-reel magnetic-tape controllers or controller-drive subsystems, and tape cartridge mass tape storage systems.

  - Plug-compatible printer subsystems - serial and line printer controllers or controller-driven subsystems with parallel interfaces for specific computers.

  - Plug-compatible card and paper-tape subsystems - punch-card readers and paper-tape perforators, card and tape readers, and reader-perforator controllers and subsystems.

  - Plug-compatible input/output and communications modules - add-in or extension CPU I/O port interfaces, multiplexers, and general-purpose controllers that add communications capabilities.

EXHIBIT III-5

MAJOR PERIPHERAL AND

TERMINAL VENDORS' MARKET SHARE - 1983

MAJOR VENDORS	TYPES OF EQUIPMENT			
	TERMINALS	PRINTERS	DISK STORAGE	TAPE STORAGE, DISK PACKS AND STORAGE MODULES
IBM	27%	18%	45%	15%
DEC	8	-	4	-
AT&T	5	-	-	-
ADDS	4	-	-	-
CDC	-	-	14	26
Hewlett-Packard	3	2	1	6
Sperry-Univac	2	2	1	5
Lear Siegler	3	1	-	-
Pertec	-	-	2	15
ITT Courier	2	-	-	-
Data General	1	-	1	5
Centronics	-	10	-	-
Diablo	-	8	-	-
Qume	-	8	-	-
Epson	-	7	-	-
Storage Technology	-	1	9	5
Memorex	-	-	5	5
Other	45	43	18	18
TOTAL	100%	100%	100%	100%

- Communications buffers and storage subsystems - buffer memory and magnetic-tape or floppy-disk storage subsystems that connect via RS-232C interfaces to the CPU or intelligent terminal.

3. DISTRIBUTION CHANNELS FOR PERIPHERALS AND TERMINALS

- The basic channels through which peripheral equipment flows on their way to end users is shown in Figure III-6. Peripherals from large computer vendors, such as IBM and Digital Equipment Corporation, reach end users via the captive channel. Plug-compatible and industry-standard units and subsystems reach end users through the indirect-OEM and direct-end-user channels. The OEM channel is the most popular among smaller manufacturers, which provide peripheral units and subsystems to systems integrators.

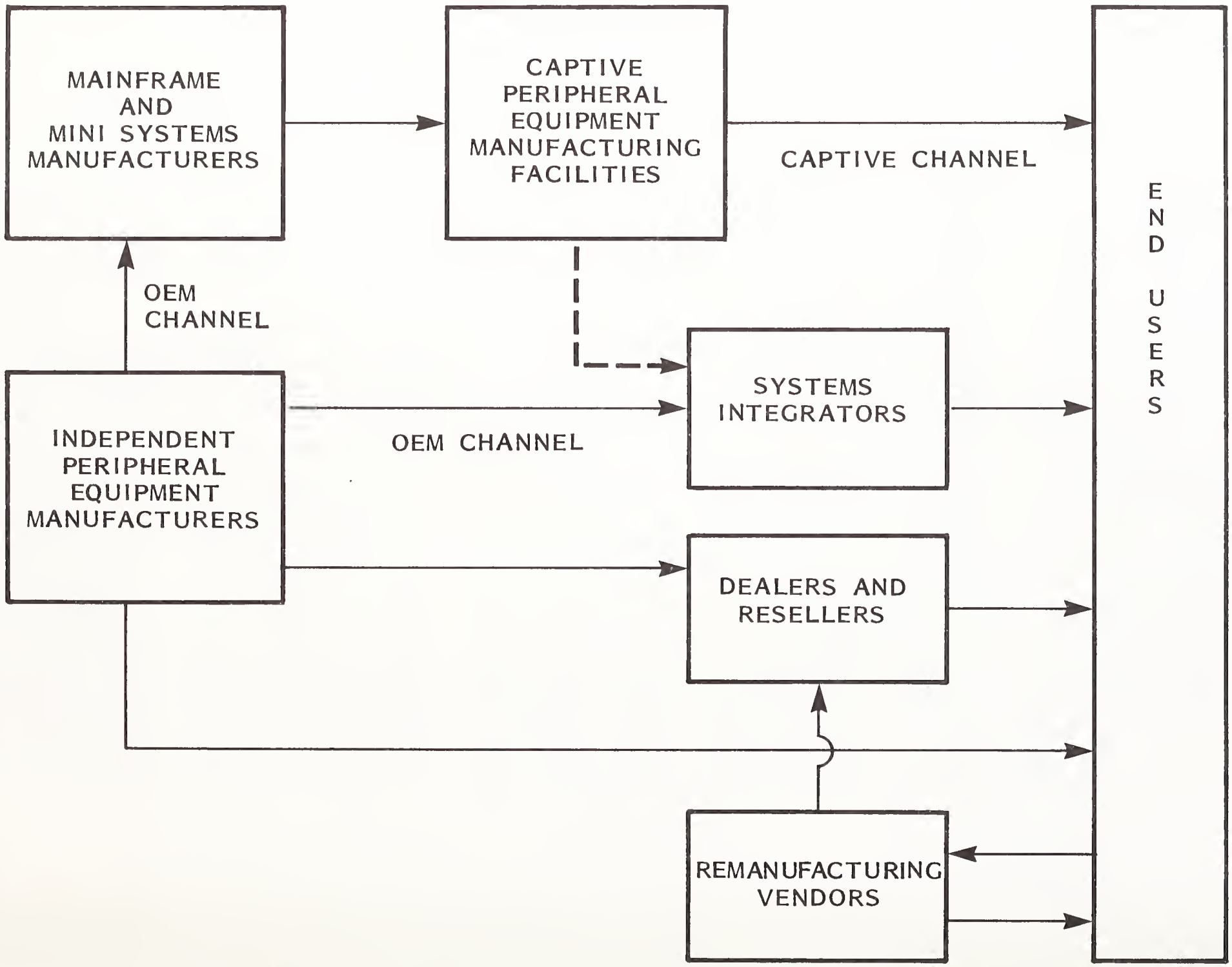
- Systems integrators then build data processing systems and sell them to end users directly or through dealers and distributors. Just as the systems integrators add value and create subsystems for applications too small for major manufacturers to service, dealers provide sales and support to those users too small to interest the manufacturers or systems vendors.

- The four classes of market distribution participants are: dealers that handle the products of various manufacturers, independent peripheral and terminal manufacturers that design and manufacture plug-compatible industry-standard units and complete subsystems, computer manufacturers that build peripheral and terminal units for their own systems, and systems integrators who add control electronics and/or software to integrate into data processing systems.

- Development of the OEM distribution channel followed development of the end-user plug-compatible manufacturer channel, which followed the captive market channel. Independent peripheral and terminal equipment manufacturers have historically borrowed from IBM technology, first to produce IBM-compatible subsystems, and then to produce systems for use with non-IBM equipment.

EXHIBIT III-6

DISTRIBUTION CHANNELS FOR PERIPHERAL/TERMINAL EQUIPMENT



- These distribution channels are changing and expanding with the increasing introduction of direct end-user retailers and with third-party service organizations entering the market. A projected (1984) view of peripheral and terminal equipment distribution channels is shown in Exhibit III-7.

- In general, while small at the moment, the most rapidly growing distribution channel, and one that will become a major factor with the growth of fully distributed network-based systems and personal computers, is the retail channel. In general, peripheral units and terminals will increasingly be directly purchased as add-ons to existing networks by end users.

- A new distribution channel is also now emerging. Telecommunications systems organizations such as ATTIS, the seven new Regional Bell Operating Companies, and other integrated telecommunications vendors are expanding into the total integrated information system market and selling terminals and other peripheral equipment as part of their network product offering. In summary, the channels of distribution for peripheral equipment and terminals are changing rapidly and are affected by:

  - Increasing cost of peripherals and decrease in cost of CPUs.

  - Increasing array of technology.

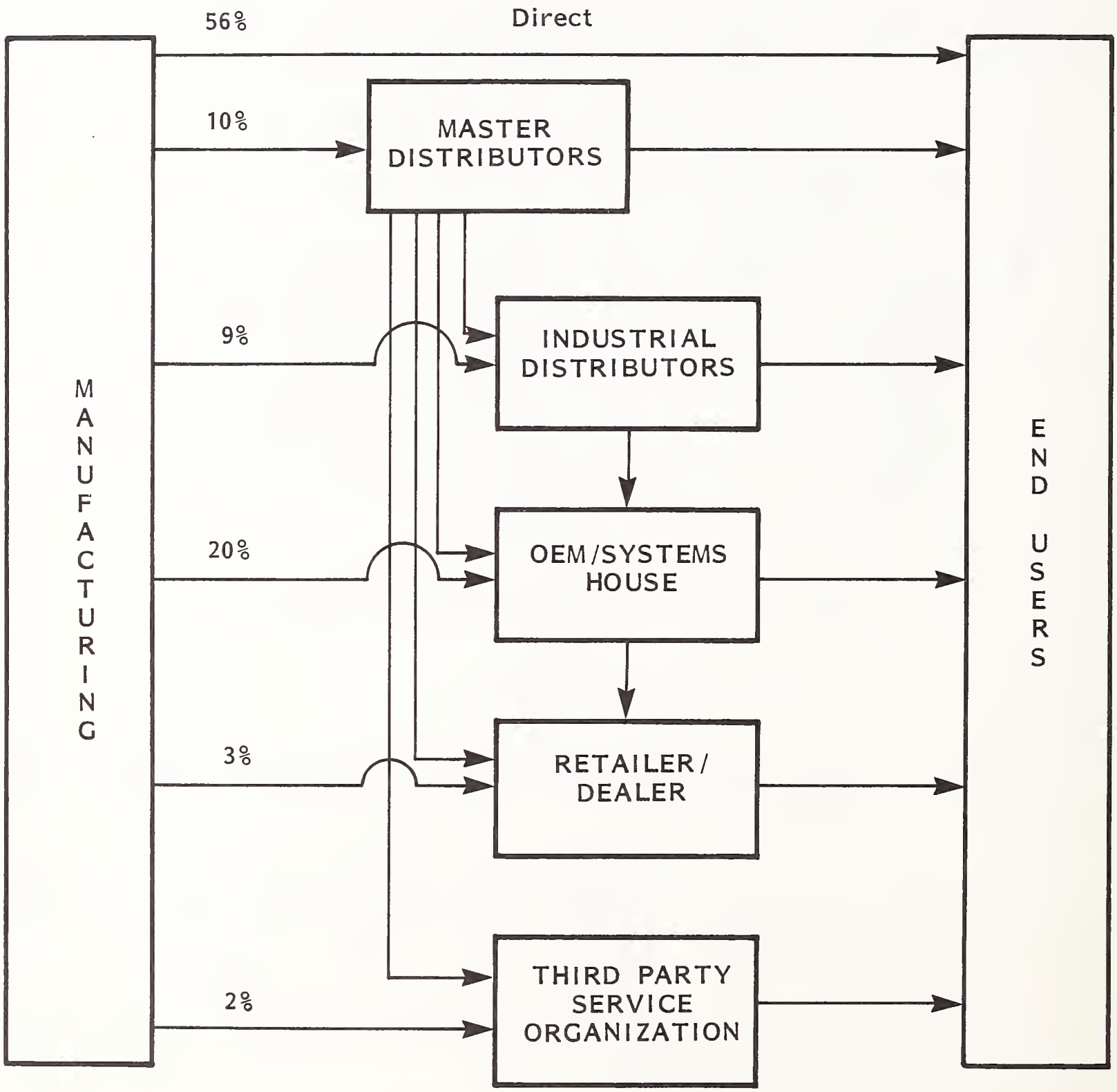
  - Increasing interest in direct purchase of peripherals by the end user at the retail level.

  - Increasing emphasis on the quality of service and support, available on distribution channels.

  - Increased competition from telecommunications and network-based vendors.

EXHIBIT III-7

GENERAL DISTRIBUTION STRUCTURE
FOR PERIPHERAL/TERMINAL EQUIPMENT



- Vertical integration downward by mainframe vendors and upward by large peripheral equipment vendors.

B. PRODUCT TECHNOLOGY AND STATE OF THE ART

- Product state of the art and development in the peripheral equipment and terminal market varies by technology. Each of the major product areas are discussed below.

1. DATA STORAGE

- There are a number of different data storage technologies available, including fixed and floppy disks, tape, cartridges, etc., as shown in Exhibit III-8. The most important of the data storage units are fixed rigid disks, as shown in Exhibit III-9, and floppy disks. Magnetic storage is one of the hottest growth segments in computer manufacturing. All sectors - from the high-end, plug-compatible disk drives, to mini- and micro-Winchester disks, to floppy drives - continue to show strength.

- The demand for large, plug-compatible disks (as measured in M-bytes of storage) is growing by 50% annually. Although IBM will ship a relatively small number of its new 3380 spindles, the company may still increase its percentage of disk drive demand. Storage Technology Corporation (STC) plans to ship 30,000 of its 8650 spindles, up from 18,000 in 1981. IBM 3380 shipments have accelerated dramatically to meet demand; however, shipments of STC's high-capacity 8380 disks have been delayed and volume shipments are not expected until early 1984. This may spell problems for STC and its customers who expected to use the plug-compatibles as IBM replacements.

- The low-end, rigid-disk market is experiencing explosive growth. The world-wide market in 1981 for 8-inch drives below 30-M-byte capacity grew at a

EXHIBIT III-8

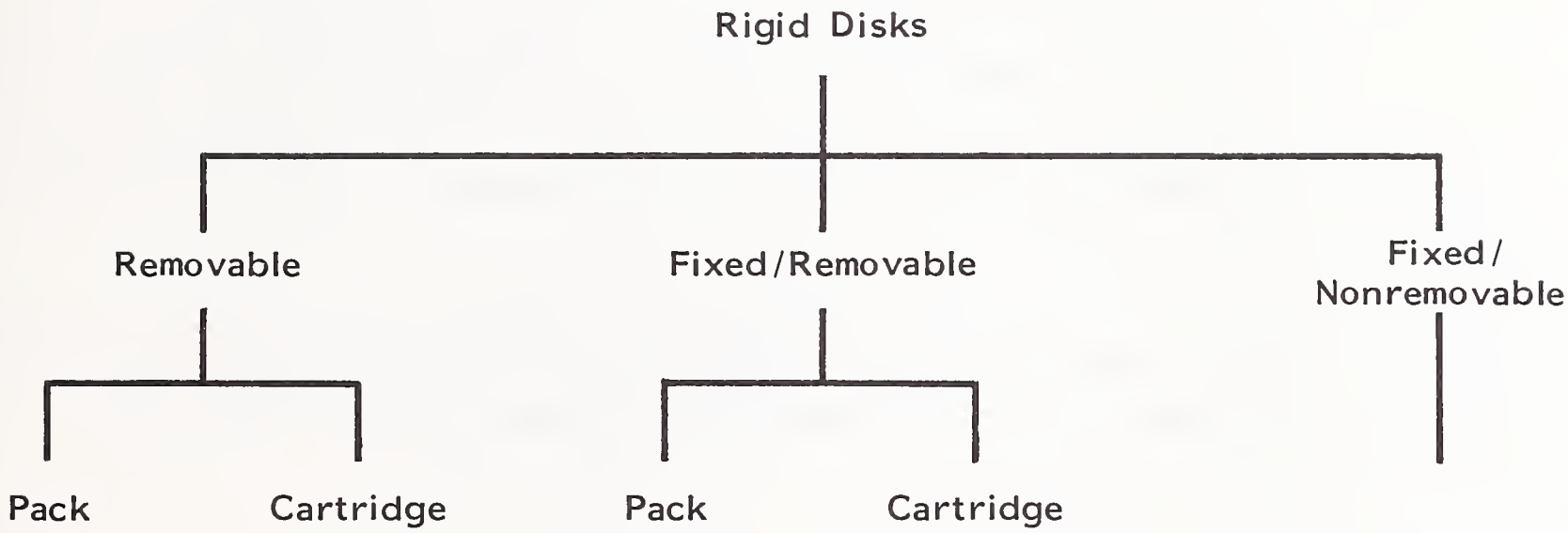
TYPES OF DATA STORAGE MEDIA

CHARACTERISTICS OF MEDIA	TYPE OF DATA STORAGE							
	MAGNETIC TAPE	CASSETTE CARTRIDGE	FLEXIBLE DISK	REMOVABLE DISK	OPTICAL	FDD MAGAZINE	REDUNDANT DISK	COMMUNICATION SYSTEM
Physical Size	−	+	+	+	−	−	−	−
Access to Data	−	−	0	+	+	−	+	−
Box Cost	−	+	+	+	−	−	−	−
Storage Cost	+	0	0	−	+	0	−	−
Integration	+	−	+	+	−	+	+	+
Ease of Use	0	+	+	+	+	+	+	+
Transfer Rate	0	−	−	+	+	−	+	−
Store Capacity	+	−	−	+	+	+	+	+
Standardization	+	−	+	+	−	+	+	+
Maturity	+	0	+	+	−	−	+	+
Data Integrity	0	−	−	+	+	−	+	+

+ = Advantageous, 0 = Neutral, − = Disadvantageous

EXHIBIT III-9

TYPES OF RIGID DISKS



40% annual rate; the market for 8-inch drives with over 30 M-bytes grew 50%. These growth rates should remain steady through 1984, but more than half the 1984 shipments may be supplied by IBM. Revenue growth will trail shipment growth for both 8-inch markets. The 5-1/4-inch market is expected to grow even faster; total shipments will increase by more than 100% per year for at least the next three years.

- Floppy-disk drives are also experiencing rapid growth, with last year's shipments exceeding two million. Unit growth may approach 40% over the next three years. Single-sided, 8-inch drives accounted for 35% of 1981 shipments; however, by 1984 these drives will probably account for less than 20% of total volume as the industry, striving for greater densities, shifts to double-density drives.

- As the use of hard disks becomes even more widespread, demand for streaming-tape drives, used as a backup for Winchester drives, will increase.

a. Disk Storage Units

- The disk and diskette drive industries were, in general, more than prosperous this year. While unit prices kept falling, performance, measured in storage capacity, access time, transfer rate, and physical size, kept improving. The most popular hard disks were 8-inch drives, followed by 14- and 5-1/4-inch sizes. Growth in demand for 5-1/4-inch diskette drives, estimated at 30% annually, exceeds the 20% annual growth forecast for 8-inch diskette drives.

b. Hard/Rigid Disks

- In disks, recent developments center on increasing capacities and media removability. The 5-M-byte, first-generation, 5-1/4-inch Winchesters of 1980 gave way to 2-M- to 40-M-byte, 5-1/4-inch Winchesters in 1981 and 1982, and prototypes for 60-M- to 180-M-byte, 5-1/4-inch devices have been developed. CDC, DMA Systems, Inc., and others announced new removable-disk

units to cater to the backup needs of small-system users. Optical disks could revolutionize first high-, then low-end drive markets, but production of optical disks is unlikely before 1984.

- The mature high-end disk market should remain through the 1980s. The 8-inch disk market should prosper for a few more years, but is on the wane. The mini-Winchester and mini-diskette markets are like the CRT market of the late 1970s. Dozens of new entrants are cropping up, and a shakeout appears inevitable. However, since the demand seems inexhaustible and the stakes immense, there appears to be room for more than a handful of survivors.

- The strongest growth will occur in the fixed-disk markets, with lower-capacity Winchester drives leading the way. Storage media growth will be paced by Winchesters and optical technologies for the remainder of the decade. Winchesters will more than triple their current penetration by 1990. Optical storage devices, rare today, will grow 32% annually beginning in 1985. Details are shown in Exhibit III-10.

- Hard or rigid disk drives lead all other storage technology media in capacity, access speed, and price. However, the cost of disk drives is declining, and the selection is broad. Disk drives are available in several disk diameters, technology levels, product configurations, and capacities.

- Capacities of today's rigid disk drives vary greatly. Rigid disk products are available in diameters ranging from less than 5 inches to 14 inches for fixed or removable disk drives and 8, 11, and 14 inches for fixed and removable devices. By 1987, the sub-5-inch disk drive will effectively handle as much as 20 M-bytes; the 5-inch disk, 20 M- to 150 M-bytes; and the 8-inch disk, 150 M- to 450 M-bytes. Anything higher than 450 M-bytes will be handled on a 14-inch drive.

- Regardless of capacity, the total storage is generally divided into working, or scratchpad storage, which consumes about 55%; permanent files, about 20%;

EXHIBIT III-10

OPTICAL VERSUS MAGNETIC STORAGE MEDIA
(Percent by Shipment Value)

	YEAR		
	1982	1985	1990
Floppy	52%	45%	39%
Winchester	8	16	25
Hard Disk	40	37	28
Optical Storage	-	2	8
TOTAL	100%	100%	100%

SOURCE: INPUT Estimates

and operating systems, about 15%. This leaves about 10% of the total file space for future expansion.

- Rigid disks compare favorably in price/performance with other removable media. In the three most significant categories - data access, transfer rate, and storage capacity - they beat all contenders except optical storage and redundant disks. But optical disks are not reusable and are difficult to integrate with conventional technologies, and redundant disk storage is expensive and space consuming.

- The limiting performance factor in real-time systems is disk access time, which depends on both system performance and disk drive technology. For example, mainframes require a 10- to 35-msec. access time; minicomputers, 25- to 55-msec; and microcomputers, 50- to 200-msec.

- A drive's intelligence makes performance more efficient by permitting speed matching, local error correction, and self-diagnostics. The greater the intelligence, the more expensive the drive.

- Disk drive prices range from $170 for a sub-5-inch (e.g., 3-1/2-inch) unit, to more than $100,000 for a 1.5 G-byte drive. Price per megabyte varies depending on drive size and technology, and price/capacity ratios are still falling, as shown in Exhibit III-11. History shows that disk storage is a major cost contributor to total system prices; it is estimated that disk storage will be the most expensive part of minicomputer and microcomputer systems of all sizes by 1987. Thus, a systems integrator's projected end-user prices will determine what he pays for a rigid disk storage component.

- Computer users are pressuring disk drive manufacturers for interface standards. Standard rigid disk interfaces have evolved slowly over the past few years to the point at which three or four de facto standards exist, and two or three others are becoming standards, as shown in Exhibit III-12.

EXHIBIT III-11

DISK PRICING TRENDS

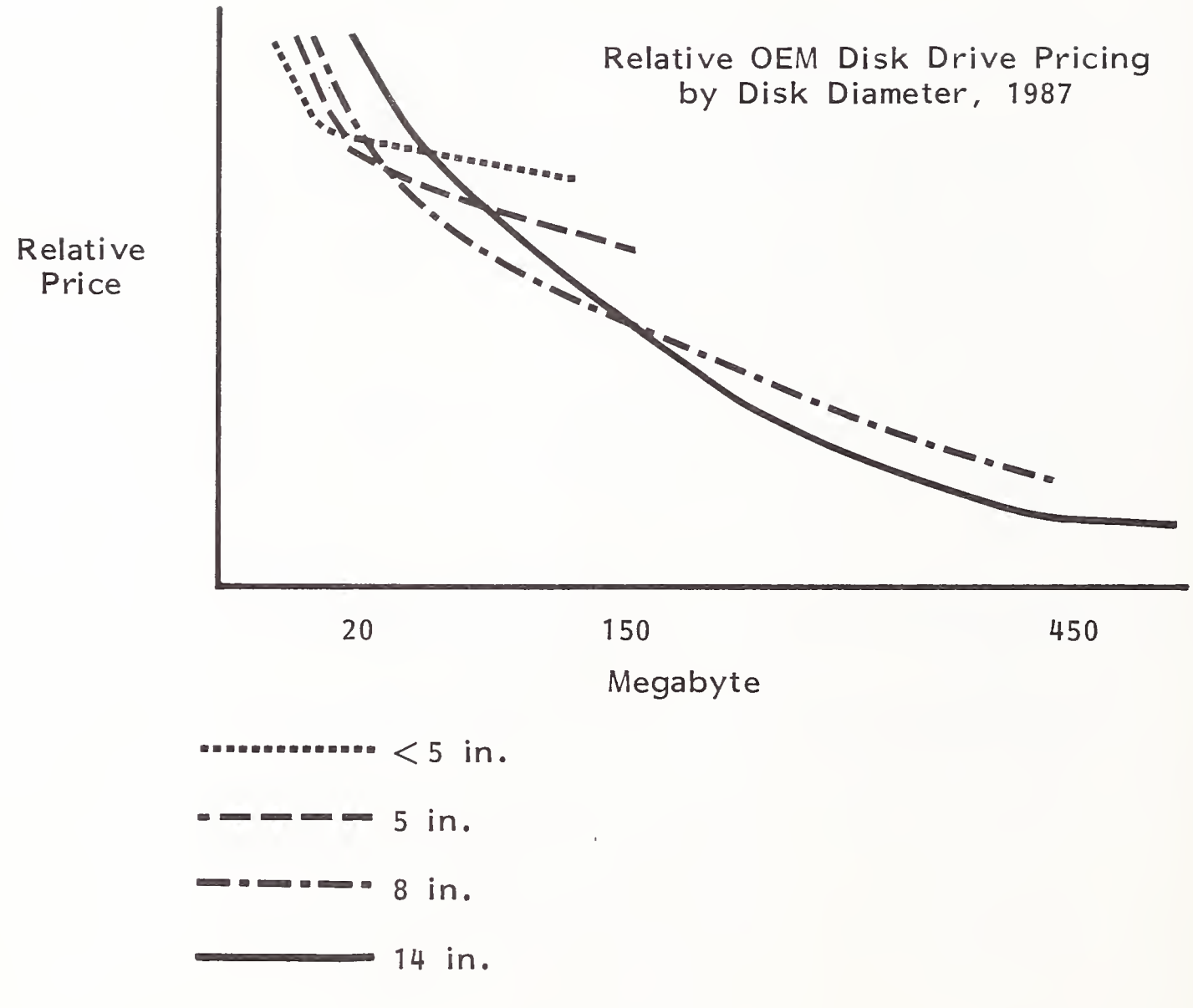
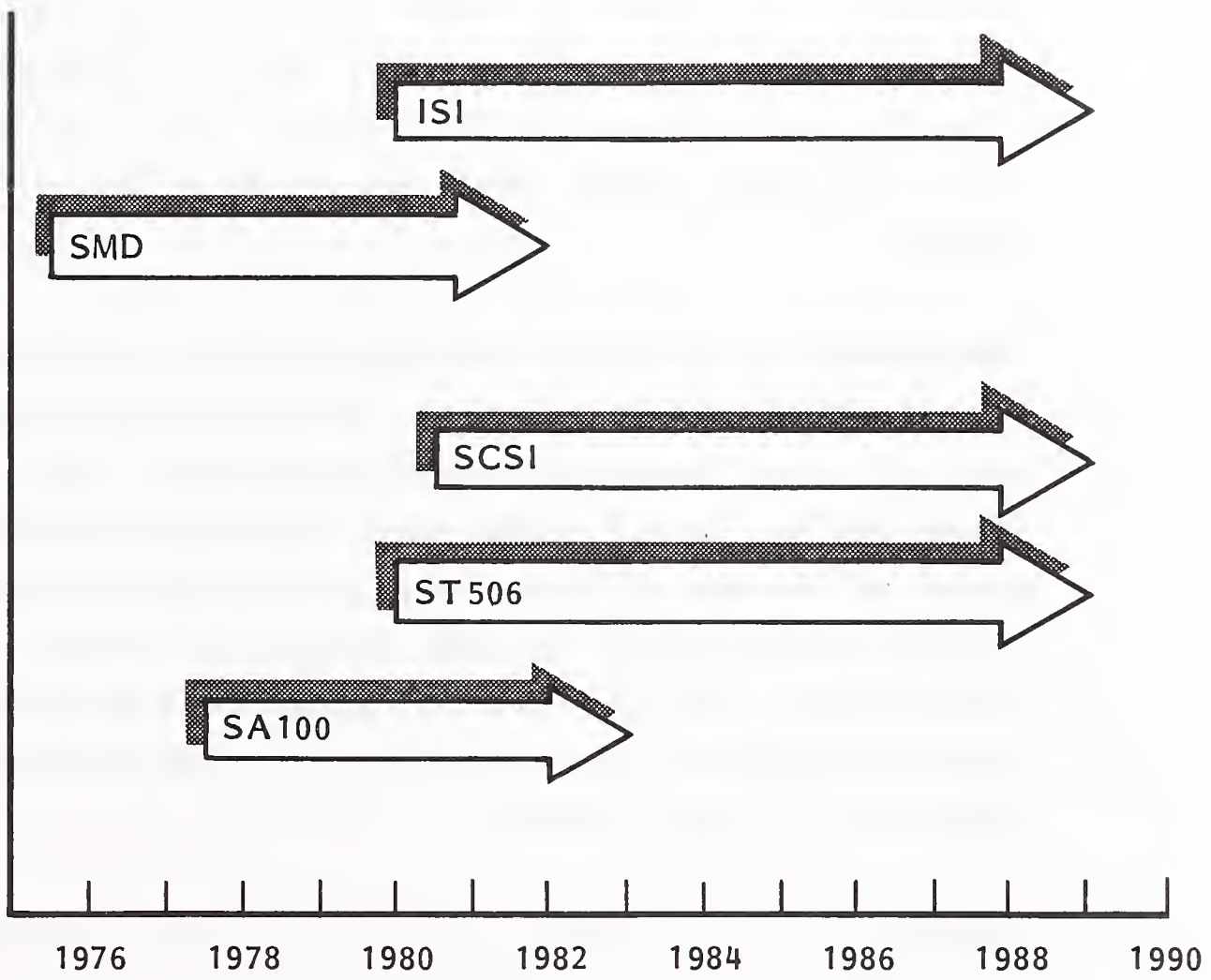


EXHIBIT III-12

EMERGING DISK INTERFACE STANDARDS



- In 1973 IBM introduced the 3340, which was developed under the internal code name "Winchester." This drive provided higher densities and better reliability by using low-mass heads and lubricated disks in an environment sealed against outside contamination. The industry has borrowed the term "Winchester," and now generally uses the name to describe any disk drive using similar technology, regardless of capacity or disk size.

- Also in 1973, IBM introduced the 8-inch floppy disk drive format, which immediately set a worldwide standard. The floppy became the preferred interchange standard for minicomputers and small-business systems within a few years. IBM's 8-inch floppy format was followed in 1976 by Shugart Associates' 5-1/4-inch version, which was better suited to desktop computer systems.

- The packaging of Winchester technology into the physical dimensions established for floppy disk drives has been driven by the sharp growth in floppy disk drive shipments for small computers, especially small business systems. Almost half of the 4.8 million floppy disk drives expected to be shipped worldwide this year will be used with small business systems, and most users of these systems develop voracious appetites for increased storage capacity. To capitalize on this appetite for capacity, system manufacturers have shown they are all ready to upgrade to higher-capacity Winchesters that fit the same system slot as a floppy disk drive.

- At about the same time IBM was delivering its first 8-inch Piccolo drives in early 1979, International Memories, Inc. (now a division of Dorado Micro Systems), delivered the first OEM 8-inch drive. Shugart Associates with its SA1000 drives soon joined IMI in this market, and the two firms continue to lead the industry in 8-inch Winchester shipments, most of which store 10 M-bytes of data.

- The growth period for low-end 8-inch Winchesters in the 10-M-byte range was severely limited by the emergence of 5-1/4-inch Winchesters in the same

range. The future for 8-inch fixed-disk drives is in applications requiring higher capacities and faster access.

c. Floppy Disks

- In the floppy disk area the primary issues are drive prices, form factors, and storage capacities. OEM prices for 5-1/4-inch floppies will be less than $200 (with electronics) within two years, as large U.S. manufacturers such as Tandem Corporation, Shugart Associates, and Micro Peripherals, Inc. exploit overseas manufacturing economies.

- Users clearly prefer smaller floppies. While 8-inch drives still use the standard diskette, they are losing favor. Half-height, 8-inch drives have proved popular with system integrators that want to give their systems midlife kickers without retooling, and double-sided, 8-inch drives have overcome their bad reliability reputations. However, many analysts believe that 8-inch shipments have already peaked. Minifloppy 5-1/4-inch drives will be the most popular form factor, at least until a standard sub-5-1/4-inch microfloppy emerges.

- Diskette capacities have begun to stabilize within these form factors. Double-sided, 8-inch drives hold 1.6 M- or 3.2 M-bytes, and 5-1/4-inch diskette drives from Control Data Corporation, Irwin/Olivetti, Shugart, Micropolis Corporation, Micro Peripherals and Qume Corporation now store 1 M-byte.

- Diskette drives originated in the early 1970s with 8-inch media and were used primarily for leading programs into computer systems. The 5-1/4-inch diskettes now popular are used as mass storage devices in small computer systems, data collection terminals, and programmable instrumentation. A large number of flexible disk drives with a wide range of features and performance characteristics is available. To select a 5-1/4-inch diskette drive, a system integrator must evaluate nearly a dozen parameters, weighing trade-

offs and benefits. Among key selection criteria are price, capacity, access time, operational features, reliability, and the ability to be upgraded.

- Systems designers and integrators evaluating 5-1/4-inch diskette drives face a wide range of options. Large-scale price reductions in the past year are making this product a virtual commodity, with prices on some popular models cut 50% or more. Manufacturers are also offering increased performance: the 1 M-byte drive is becoming commonplace, and 2 M-byte drives are available. Even while seeking a bargain, the typical system designer will generally select a vendor that can meet delivery, service, and quality requirements. Regardless of the pricing levels, the price that is ultimately paid also depends on the quantities and performance of the 5-1/4-inch drive.

- Pricing is based on a stairstep structure with successively higher discounts for quantity purchases. This structure provides from 1 to 10,000 units a month and beyond. The quantity needed can also dictate the vendor selected. A high-volume requirement, such as 10,000 per month, may be satisfied only by a manufacturer that can quickly and efficiently produce to a customer's schedule.

- A lowest price, basic, mechanics-only drive becomes more expensive as capabilities are added. The manufacturer can provide electronics or the customer can save money by using his own. He can start from the 250 K-byte capacity of a 48-tpi, single-sided drive and expand to 2 M-bytes with a 96-tpi, double-sided drive. Price will also be affected by features and options that add sophistication and security to a drive.

- Capacity is a function of a disk sectoring and recording technique. A system designer beginning with a drive having a specified unformatted capacity determines the formatted capacity by organizing the media surface into sectors. Sectoring is classified as either soft or hard. Hard and soft sectoring techniques differ in that hard sectoring uses punched holes to locate sectors, while soft sectoring uses a timing pulse under software control. Hard sector-

ing uses 10- or 16-sector formats, while soft-sector formats can vary, although 16 is most common. Both techniques use an index hold to initiate sector location.

- Soft sectoring uses a single index hole on the disk to provide a track timing pulse. Sectoring is then determined by software that tells the controller how many pulses to count to locate a sector. The sectors can be defined, therefore, by the system designer. The number of sectors can vary, but for interchange purposes the industry standard is 16.

- Hard sectoring is controlled by hardware detection of sector holes that market the beginning of each sector. The two standards are 10 and 16 holes per disk, plus a single index hold. In the 16-sector disk, for example, 16 holes are equally spaced around the radius of the disk. The index hole lies between two of these holes. The controller decodes index and sectoring pulses to determine sector location.

- A system designer can adopt industry-standard sectoring techniques or bend them to his own needs. A combination of hard and soft sectoring techniques is often used, or a single track might contain an entire sector.

- Two basic track densities are offered: 48 and 96 tpi. The actual number of tracks on each side of a diskette is 40 tracks on a 48-tpi drive and 80 tracks on a 96-tpi drive. A single-side, 48-tpi drive stores 250 K-bytes on 40 tracks of data on one side of a diskette and a 96-tpi, single-sided drive provides 80 tracks.

- Although size, capacity, and throughput are becoming standardized in diskette systems, diskettes typically can be obtained with different operational features, including:

  - Write protect, a standard option on most drives. A write-protect switch senses a special tab on the diskette and signals the drive that

the data are protected and that new data should not be written on the disk. If the controller issues a write-operation command, the switch inhibits write current.

- Daisy chaining, a cost-cutting option allowing as many as four disk drives to be hooked on a single controller. The controller addresses individual drives to transfer data.

- An industry standard interface, which allows a user to mix disk drives of different manufacturers on one controller.

- A high-precision stepper motor, which is offered to save power. Track position is held by magnetic stepping of the motor, rather than by continuous application of power.

- Software security, which can be provided by a ready line in several variations. A ready-line signal can indicate that the media door is closed, that the door has been reclosed following media insertion, alerting the controller that the media have been disturbed and to take special action, or that the drive is ready and has been selected, index pulses have been detected, and the door is closed.

- A disk-in-place switch, which provides software security and lowers overhead costs by verifying the absence or presence of media before access is attempted. Inappropriate media access can be prevented through a controller-activated solenoid that engages a pin to lock the media door. This software security option also saves controller overhead time.

- A motor start, which improves disk centering and eliminates media pinching. As the media door is closed, the spindle motor is turned for a few seconds while the centering cone engages the media. Centrifugal force pushes the media out against the spinning hub and centers it properly.

- Most manufacturers also offer a 5-1/4-inch drive without electronics in mechanics-only versions. They are also available with servo board only or with complete electronics, including both servo and logic boards.

- Power consumption is also an important selection criterion. Operating power varies significantly among manufacturers and should be figured as a fixed cost. Standby power consumption, however, if not specified properly, can make operating costs soar. Standby power is power that keeps the drive operating when the spindle motor has been turned off and the stepper motor is not accessing. A cost-saving solution in multidrive systems consists of a switch that turns a drive's power off when other drives are being accessed and on again when access is required.

- Common failures in diskette drives fall into the categories of soft and hard errors, as well as mechanical and electrical component failures. A soft error is a read error that is recovered in a specified number of recovery attempts. An industry-accepted rate is one error in 10 bits. There are several error-recovery techniques. One is for the controller to "sit" on a track, wait for the appropriate sector to come under the read-write head a number of times, and recover the error. A second is for the controller to move off to other tasks and to return a specified number of times to recover the data. If the error can't be recovered in the predetermined number of retries, say 10, the error is considered a hard error. Hard-error rates are typically one error in 10 bits. Write-error rates are not typically listed on specification sheets. But error rates are a function of the media itself.

- Mean-time-between-failure rates are normally listed for several elements of a drive. Heads are generally specified for 20,000 hours of life, logic cards are specified for an average of 15,000 hours, and spindle motors typically have an MTBF figure of 2,000 power-on hours in worst-case applications for carbon-brush motors. The mean-time-to-repair figure for a typical drive is 30 minutes or less. Empirical data substantiate this figure. A major variable is

the expertise of a vendor's service technician, who can shave minutes off this figure. Serviceability should be evaluated on the basis of the difficulty of replacing components such as the spindle motor belt and logic boards. Head alignment, too, should be a simple task.

- Although most 5-1/4-inch diskette manufacturers claim that their drives require no preventive maintenance, this is simply not the case. If a drive is maintained in a clean environment and the media are handled properly, the need for preventive maintenance is reduced. However, typical handling procedures often result in damage. Spilling coffee on the media, for example, can loosen oxide from the media, which can be deposited on the head, resulting in rapid degradation of the head and media. Head cleaning is the logical maintenance step. Preventive maintenance should be directed not only to the drive, but also to its environment.

- More than 13 years after their introduction, 8-inch floppy disk drives still offer a good combination of price, performance, and reliability in both single- and double-sided configurations. They are well suited for various applications in both standalone and distributed systems. New technologies have created exciting new possibilities in terms of overall system performance, while increasing the number of alternatives available to prospective customers.

- The first step in drive selection should be selecting a size. In choosing a size, a system integrator determines the drive form factor to be used in a system for years to come. Users of 8-inch floppies, for example, most likely will upgrade to half-height 8-inch floppies or 8-inch Winchesters, rather than 5-1/4-inch products. Staying with same-sized drives prevents costly and time-consuming system redesigns to accommodate a different-sized drive.

- The choice of standard-height or half-height drives should be made before investigating models or vendors. The recent availability of half-height products has provided an attractive alternative to standard-height drives. These products typically offer the same capacity as standard models in half

the space. Thus, as much as 800 K-bytes of unformatted capacity is available in single-sided models and as much as 1.6 M-bytes is available in double-sided models.

- Because prices of half-heights are roughly comparable to those of their full-sized predecessors, these new products also provide a cost-effective alternative to redesigning a system to accommodate minifloppies, a move involving the sacrifice of substantial investments in media and software.

- Besides the benefit of reduced size, many half-heights provide designers with increased performance and higher reliability over previous models.

- Although half-heights offer many advantages, a case can still be made for selecting full-sized floppies. They are mature products, well advanced on manufacturing and cost-learning curves and are readily available in high volumes. Buyers choosing full-sized floppies are not locked into these products because future upgrades can be made to half-heights or 8-inch Winchesters.

- Once fundamental performance and flexibility features have been considered and the choice between full- or half-height has been made, designers should then identify the key drive characteristics required to satisfy the system application. Depending on system use, the most important drive requirement might be capacity, reliability, or cost. Because most floppies are used in single-user systems, access time is seldom a major concern, and the 99- to 200-msec. range of current drives is sufficient for most applications.

- When selecting floppies for a word processing system, capacity is probably the most important factor. Even a moderate volume of letters, reports, memos, and mailing lists generated in a small-to-medium department can quickly fill a double-sided diskette. To avoid accumulating an unwieldly number of diskettes, two double-sided, double-density floppies, each providing as much as 1.6 M-bytes of unformatted capacity, would be a good choice for such a system.

- In some applications, reliability rather than capacity is the most important drive requirement. One example is the use of a floppy disk drive to load operating software into a mainframe's main memory. Because banks and insurance companies often use mainframes, a drive breakdown could inconvenience thousands of customers.

- Capacity is not the dominant factor here, as the operating system typically occupies only a portion of one side of a diskette. In this application, a single-sided drive provides sufficient capacity for the operating system, plus room for updates and enhancements. Reliability ranks second only to capacity when choosing a drive for word processing systems because businesses increasingly depend on the ability of these systems to boost office productivity.

- Numerous product developments have appeared in the last few years, and multi-megabyte floppies will soon become a reality. Innovative manufacturers have grabbed large chunks of the market, especially with newer configurations of 5-1/4-inch drives. Changes in industry structure have been signaled by vertical integration, such as the joint venture by Tandy Corporation and Datapoint Corporation, which now share drive development and manufacturing efforts. Predictably, the floppy configuration that started the floppy stampede in 1973, the single-sided 8-inch drive, is peaking and faces declining future shipments.

- Floppy disk drives quickly replaced tape/cassette drives as the most popular storage devices for up-based systems in those systems' earliest days. No other method matches the floppy's combination of low price, random access, and removable media. The availability of floppy disk drives has significantly changed the architecture, software, and sales figures for small-business systems, word processors, personal computers, and intelligent terminals.

- In 1980, small-business systems used 64% of all floppy disk drives shipped worldwide. Business data processing applications have traditionally been

gluttons for auxiliary data storage, whatever the system's size, and this tendency will probably continue, even with desktop computers. As evidence, 65% of worldwide 1981 shipments of double-sided 8-inch drives, the highest capacity floppy configuration, were used in small-business systems.

- The projection for 1984 sees this proportion growing to 75%, but by then double-sided 5-1/4-inch drives will rival 8-inch drives in the small-business-system market, despite a later start. The double-sided versions of both drive sizes will be leaders in capacity, but 5-1/4-inch drives will be more widely used because of faster-growing desktop small-business systems.

- Word processing applications accounted for 16% of 1980's floppy disk drive shipments, with single-sided 8-inch drives still the leader. By 1984 the leadership will have passed to the more compact 5-1/4-inch drives, both single- and double-sided models, which are expected to dominate the word processing market.

- Hobby and personal computers made up 12% of floppy disk drive shipments in 1982. This is probably the most price-sensitive application in which floppy disk drives are widely used. The least expensive floppy drive, the single-sided 5-1/4-inch model, is the biggest seller in this market.

- Evolutionary changes, such as double linear density, double track density, or smaller sizes, can occur gradually in response to market demand, but revolutionary advances, such as changes in media standards or disk diameters, need the sponsorship of an industry leader if rapid industry consensus is to be achieved.

- Large-quantity shipments of drives with capacities higher than 1.6 M-bytes for 8-inch drives and 1 M-byte for 5-1/4-inch drives still have not occurred, despite a demand for such products. Various drive and media manufacturers are joining forces to offer 5-1/4-inch drives with higher capacities. The same combinations are imminent in the 8-inch floppy disk market, with several manufacturers seeking higher capacities with existing or new media.

- A major trend during the last year for both 8- and 5-1/4-inch floppy disk drives has been a move to a smaller size. BASF was joined by several other manufacturers last year, all with the same two-thirds height.

- Drives that are half the height of industry standard 5-1/4-inch and 8-inch drives have recently appeared. The floppy disk drive industry seems poised at the starting line for a race to introduce major new improvements, but most of the competitors have not decided which direction to go. Most manufacturers in the volatile OEM drive market know that only firms with major momentum in the industry are likely to see their innovations quickly become industry standards, especially if significant changes are involved.

- If IBM does not act quickly by introducing a high-capacity floppy disk drive, several additional announcements of higher capacity drives, both 8- and 5-1/4-inch, can be expected. This should be followed by an extended period of jockeying for position while standards emerge as a result of market demand.

2. DATA TERMINALS

a. Current Status

- Vast numbers of terminals with increasingly complex and sophisticated capabilities will be required in the offices and factories of the future. By 1987 it is estimated that terminal sales will top $8 billion - more than twice today's total.

- There are now 205 U.S. vendors selling over 400 terminal models to either original equipment manufacturers or end users. The major vendors are IBM, ADDS, Datapoint, DEC, and H-P, as shown in Exhibit III-13. However, they have plenty of foreign rivals, including Japanese firms that are reportedly switching TV production to terminals. In fact, between now and 1985 the U.S. share of the installed base of terminals worldwide is expected to decline from 56% to 51% due to foreign vendor penetration.

EXHIBIT III-13

TERMINAL MARKET SHARE - 1983
(Based on Shipments)

VENDOR	MARKET SHARE
IBM	30%
ADDS	5
Datapoint	4
DEC	5
Hewlett-Packard	4
Televideo	3
Lear Siegler	4
ITT Courier	3
Others	42
TOTAL	100%

- There are four basic types - dumb terminals, smart or intelligent terminals, editing terminals, and desktop microcomputers. Dozens of companies make each type. The general price distinctions and the number of vendors by type are shown in Exhibit III-14.

- Dumb terminals, as the name suggests, can perform only the most simple functions, such as the input and output of data, and have a very limited editing capability.

- Smart terminals, however, contain microprocessors and some memory capacity, which makes them much more versatile. They come programmed for specific chores by the manufacturer.

- Intelligent terminals, similar to smart terminals, have one additional advantage - they can be programmed by users to suit the users' own needs.

- Typically, terminals with the greatest capabilities sell for the highest price markups. The manufacturer of dumb terminals may sell more units but net less profit than the maker of smart terminals.

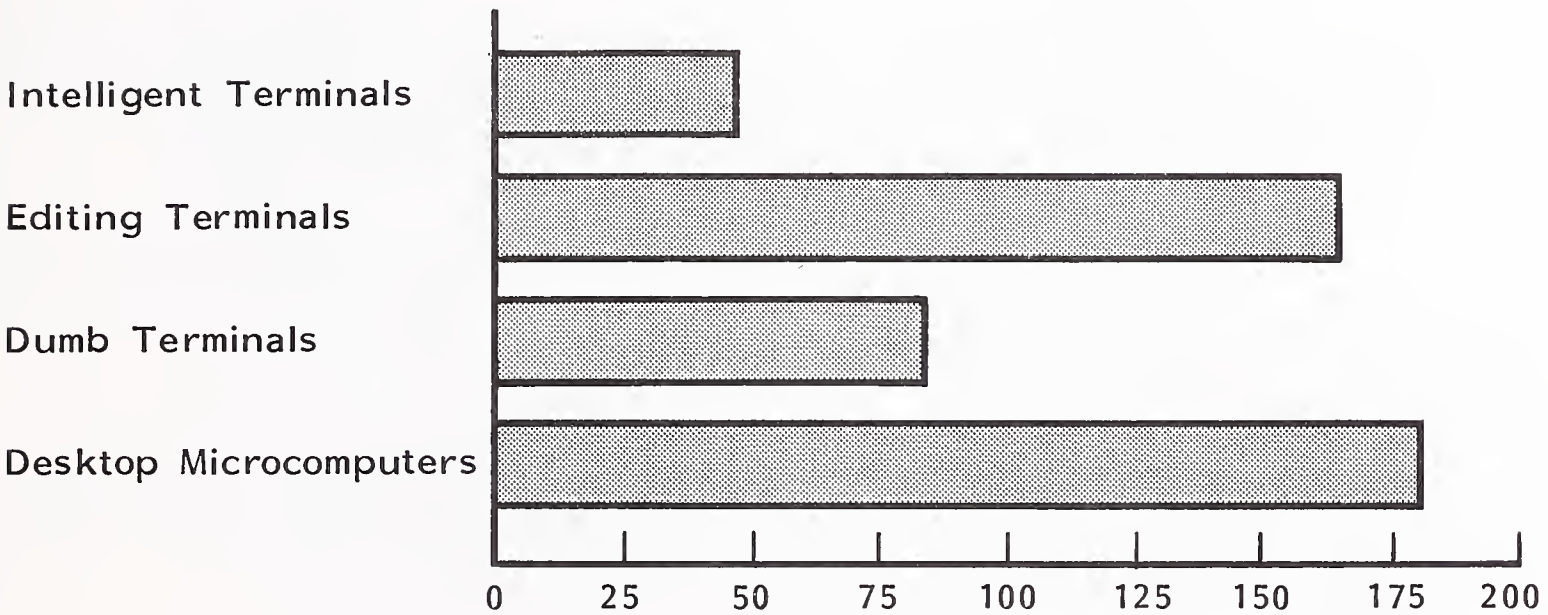
- Demand for alphanumeric terminals of every capability will be fueled by distributed data processing, sales of new multiuser microcomputers, and new value-added communications networks such as videotex, The Source, Prestel, and Dialog.

- The low-end peripheral computer terminal market is also beginning to grow again in response to increased pressure from both OEMs and end users for lower cost "no frills" terminals. There have been a number of recent introductions of low-end $700 (end-user) and $500 OEM-priced terminals. These new terminals, however, are not as stripped down as their price tags might indicate. Most of them offer as many features as terminals selling for over $1,000. Most of the terminals are "smart," providing editing functions and

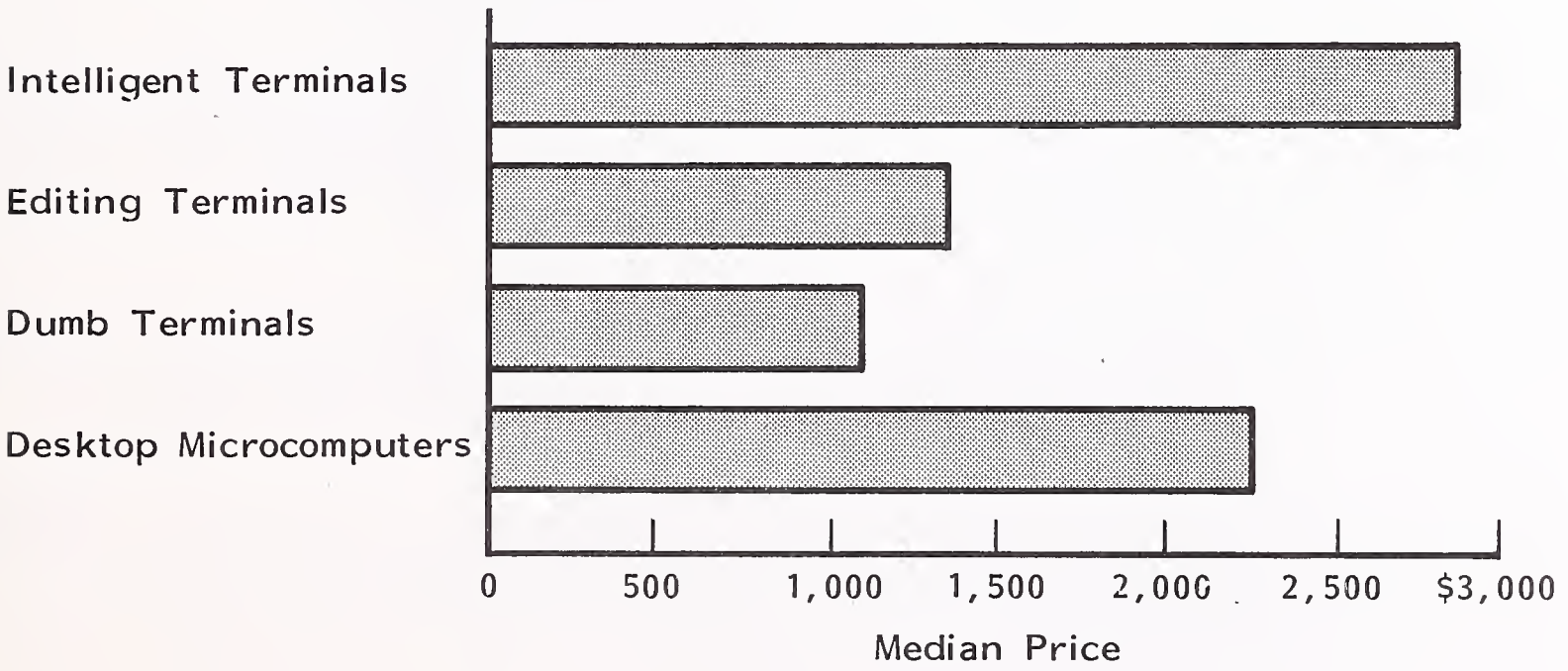
EXHIBIT III-14

TERMINAL/DISPLAY VENDOR POPULATIONS AND PRICING

Number of Vendors By Type of Terminal



Average Prices By Type of Terminal



other features. Most incorporate microprocessors for controlling keyboards and CRT-monitoring functions.

- Manufacturers have developed the low-cost terminals without using either major technological breakthroughs or highly innovative and cost-effective circuit design techniques. Rather, they have applied more fundamental approaches to achieving economy, such as:

  - Vertical integration - Manufacturers are bringing more component functions in-house, performing such tasks as injection-molding their own cabinets and producing their own PC boards.

  - Greater LSI use - Standard off-the-shelf LSI functions such as CRT-controller chips are replacing multichip designs.

  - Better manufacturing techniques - Improved assembly techniques and new capital equipment are increasing production efficiencies while keeping labor content low.

  - Increased imports - More manufacturers are purchasing assemblies (and in some cases entire terminals) from Far East and European high-volume suppliers for resale under their own labels.

  - Offshore assembly - Manufacturers have set up assembly facilities in areas such as Taiwan and Korea where labor rates and overhead are much lower than in the U.S.

  - Volume goals - Many suppliers have based their pricing on the high-volume demand they expect the low-cost terminals to generate.

- Although each manufacturer hasn't used to full advantage all of these economic and cost-cutting strategies, each has chosen some of them.

- Almost all of the terminals have a 12-inch CRT display. A 9-inch version is considered the bare minimum required for ergonomic requirements and aesthetic appeal. Additionally, a full ASCII keyboard is generally provided (with good tactile feedback, like a typewriter) and an IBM (sculpted and stepped) design. Some also have a separate numeric keypad as an option. Typically, an RS232 interface and one or more ports for a separate printer and other auxiliary devices are provided.

- Although none of the low-end price terminals offers a fully programmable keyboard/terminal, some devices achieve at least some user programmability. For example, several special-function keys can be set by the user for specific codes.

- With respect to keyboard function, most manufacturers feel that users need only limited capabilities. Cursor controls such as Left, Right, Up, Down, Home, Tab, and Line Feed should all be standard. In addition, some form of display highlighting is required. This function includes reverse video, a blinking cursor, and dual intensity or underlining capability. Most of the available low-cost terminals don't have all these features, but manufacturers agree that the user needs some level of highlighting.

- Users also get some editing capability on all of the low-cost terminals. Although some manufacturers feel that limited editing such as Erase to End of Line, Erase to End of Page, and Replace Characters is sufficient, others argue that users require more advanced functions, such as Line and Character Insert/Delete. Oddly enough, the lower priced terminals have some of the more advanced features, so it appears that manufacturers are picking and choosing the features they can incorporate in the most cost-effective manner.

- Some vendors targeting their low-cost terminals at the installed base offer emulation capabilities. One vendor's model can emulate another's after activation of several code-changing switches. These firms obviously feel that users will need this capability when deciding to replace a terminal with a lower cost alternative in an existing product line.

- The manufacturers not offering emulation capability, on the other hand, are primarily targeting their terminals at new markets. In fact, most agree that the new breed of less than $700 units will make terminal use attractive to those companies that heretofore used no terminals at all in their systems because of the high costs involved.

- Aggressively pursuing the low-priced terminal leaders is another set of manufacturers whose new terminals, in most cases, offer a good deal more functionality for an additional $200 to $300. OEM prices for most of these vendors' units will be approximately $700, placing them within $200 of the lower cost versions.

- Interestingly, though, some of the higher priced models offer features almost identical to those of the less expensive units. There are three reasons for the higher selling price. First, some manufacturers don't take full advantage of all the cost-cutting approaches initiated by the low-priced terminal manufacturers; even a slightly higher labor content can quickly add $50 to $100 to a terminal's ultimate selling price.

- Second, because many terminal manufacturers sell their products through distributors, they want to assure that those distributors have sufficient economic incentive to carry the line; hence the higher prices and the accompanying higher distributor profit margins. (It will be interesting to see whether this philosophy continues. Once distributors start carrying the super-low-priced terminals, competitive pressures could change the strategies of the high-priced terminal manufacturers.)

- Third, some manufacturers merely want higher profits for themselves. Whether this attitude is based on a more conservative market forecast for low-cost terminals or strictly on matters of investment return is not clear, but several manufacturers have stated that they plan to hold their current pricing as is, at least for the near term.

- There could also be a fourth reason for the higher prices that is implied but not actually stated. Because the low-cost terminal introductions have all been recent, some manufacturers could be sitting back and watching what happens to the market. The underlying attitude is that still lower cost terminals are in the works. Additional low-cost terminals will probably be announced by the end of this year to complement the current lines of the holdout manufacturers.

- Most observers agree that the low-cost terminal market will be dominated by a few companies, while the 50 or so other terminal manufacturers will continue to function in the "intelligent" terminal marketplace. However, if the market really expands and very low cost, $400 terminals appear by next year, the market structure and competitive position could change dramatically.

- Most manufacturers agree that one of two things, both unlikely over the next one to two years, must occur for this scenario to take place. If a major technological breakthrough appears, such as a single-chip terminal circuit, prices will drop to the $400 level. Alternatively, if unprecedented volume demand (similar to that for ordinary television sets) ever arises, prices could also drop. Although both factors are discounted by all manufacturers, they nevertheless can't be totally ruled out.

- The alphanumeric display terminal market is generally acknowledged to contain two major segments. The fastest growing and most active segment is currently the asynchronous terminal market. This field boasts the largest number of competitors, with no one vendor holding a dominant position. Technological advances have triggered major price reductions in this area, putting many terminals with basic editing capabilities in the $500 to $700 range (less than $400 when part of volume purchases).

- The second major segment of the display market is the IBM 3270 synchronous terminal market. Although growth in this segment has been slower than that enjoyed in the ASCII segment, the sheer number of installed IBM 360, 370, 30 series, and 4300 computer systems guarantees a healthy market for both IBM and independent vendors of 3270-compatible equipment.

- IBM 3270-type terminals account for approximately one-fourth of all CRT terminals currently installed in the U.S. Of these, about one-half are actually IBM terminals - the rest are compatible models offered by vendors such as Harris Corporation, ITT Courier, Inc., Lee Data Corporation, Teletype Corporation, Telex Corporation, Raytheon Data Systems, Inc., and several others.

- IBM's competitors in the 3270 marketplace are using various strategies in an attempt to capture a share of the market. The two most prevalent strategies are to offer 3270-compatible equipment at a lower price than what IBM is charging and to feature faster delivery of equipment than IBM (delivery time for IBM 3270 components currently is about 11 months). In many cases, these are the only ways a new vendor can hope to penetrate a shop that has traditionally used only IBM equipment.

- Other strategies include offering increased price/performance (that is, providing capabilities not found on the IBM unit at the same price) or enhanced ergonomic features (tilt/swivel screen, detachable keyboard).

- One trend that has been increasing in popularity in the past few months is the replacement of 3270-type terminals with ASCII terminals on a 3270 network. The replacement of synchronous terminals with asynchronous units is achieved through the use of a protocol converter, which allows the ASCII terminal to support the functional characteristics of the 3270-type units.

- The advantages of this strategy are obvious - ASCII terminals are considerably less expensive than their 3270 counterparts. One terminal vendor, Beehive,

has introduced an ASCII terminal that, when combined with a protocol converter, is intended to emulate the IBM 3278 display station. There is reason to believe that other ASCII terminal vendors may follow suit.

- The coming years will see an increasing need for the typical terminal user to access a large information base that is distributed throughout a network composed of large mainframes, minicomputers, timesharing services, and even personal computers.

- In this environment "information workers" will have at their fingertips data and computing power that literally may be on their desktops or on another continent. This distribution of computing resources and the need for convenient access to these resources will be the impetus behind the development of new terminal systems.

- The 1980s will see an increasing variety of communications protocols and physical facilities being used. Protocols will include:

  - IBM's 3270 local and remote Systems Network Architecture (SNA) - non-SNA, asynchronous (e.g., Digital Equipment Corporation VT100 and others) - packet switching (e.g., X.25).

  - File handling (IBM's 3776), and others specific to local area networks.

- Today, in many offices, users already are faced with the need for multiple terminals to access information and applications at large mainframes (using a 3270-type protocol) and at minicomputers (using the asynchronous protocol). This dual-terminal approach becomes less cost-effective and less convenient as the number of users increases. A system where one display can dynamically interact with the large mainframes, minicomputers, and timesharing services is the answer.

- Broadband facilities appear to fit this generalized network profile. Broadband cable can accommodate 3270 terminal devices, cable TV signals, facsimile transmissions, and a variety of low-speed terminal devices. All of these will be the information worker's tools for gathering information and therefore must be addressed by the communications network and the terminal system.

- Computing resources that are private to the information worker are a key element in today's office environment. These resources are being provided by intelligent terminals, computer workstations, and personal computers. The personal computer is now the key product in this area because it provides users with access to what will be the largest and most readily available base of software and application packages to date.

- Users realize that many office and management functions are more effectively accomplished with a personal computer. The fact that many organizations are beginning to purchase personal computers in large numbers is adequate evidence. However, these personal computers must become more than just standalone computing devices.

- The trends in office automation strongly indicate that personal computers will become a component of the next generation of terminal systems. The personal computer can become an even more effective tool for the information worker, without changing its basic nature, if its potential is not restricted by the limited communications capabilities it now has as a standalone device.

- Providing the personal computer with the many communications capabilities discussed earlier (3270, Async, broadband, X.25, and so forth) through a clustered communications controller gives users access to corporate data files and applications, timesharing services, and specific information services.

- MTBF for terminals generally ranges between 7,000 and 20,000 hours. Generally speaking, the smaller the number of discrete items, boards, and connections, the higher the MTBF. Warranties for terminals are typically for 90

days. Maintenance generally runs from $20-$25 per dumb terminal/CRT to $40-$100 per smart or intelligent terminal.

- Given the trend toward distributed processing, the benefits of having local intelligence at the terminal might be regarded by many users as useful, if not necessary. To meet this need, terminal manufacturers have provided an array of devices that offer intelligence that ranges from function keys to high-level programmability.

- There is no agreed-upon point at which an editing terminal has enough intelligence to be called an intelligent terminal. At the lower end of the intelligence spectrum are terminals like Matrox Electronic Systems' CMT-300 and RCA Global Communications Inc.'s ZMS-50.

- For users requiring a higher degree of programmability, several terminals support high-level language applications. Most such terminals offer extensive peripheral support, including off-line storage, which makes them almost indistinguishable from microcomputers. But intelligent terminals boast one advantage - they were designed to operate on-line, while microcomputers generally can offer this feature only through the addition of optional hardware and software.

- The incorporation of firmware into intelligent terminals has led to the emergence of several dedicated applications. Most prominent among these applications are word processing and graphics. Workstations such as Xerox Corporations' Star enable users to extensively manipulate text before sending it off to a host computer, peripherals, or a network.

- Many such workstations do not support programming and can only be used as word processors, but the current trend is toward multifunction terminals that support versatile operating systems such as CP/M. IBM and Wang Laboratories, Inc., for example, have both moved to CP/M support for their word processing stations.

- Graphics terminals probably represent the most advantageous integration of local processing and host communications features. Terminals from manufacturers such as Tektronix, Inc., Laxidata Corporation, and Sander Associates, Inc. provide for the local creation and manipulation of vectors, conics, and other forms, while leaving the bulk of the data crunching necessary for graphics to their host.

- Another terminal application for which intelligence has become popular is that of clustered systems, as in transaction processing, and IBM 3270-compatible terminal systems.

b. Emerging Product Features in Terminals

- As microcomputers incorporate communications features, the distinction between them and general-purpose, dumb, smart, and intelligent terminals will disappear. As they grow in popularity, workstation-oriented distributed processing systems like those from Convergent Technologies, Inc. and Apollo Computer, Inc. will probably eliminate much of the current demand for intelligent terminals.

- Users may even choose to forego the benefits of local processing in the face of the unbeatable price/performance ratio of editing terminals. For as little as $200 over the cost of dumb terminals, many editing terminals provide features like video attributes, formatting, emulations, a few pages of memory and, of course, local editing. Confronted by such bargains, purchasers will think twice before paying $2,000 or $3,000 extra for programmability and the off-line storage needed to utilize it.

- Thus, vendors of video display terminals are at something of a turning point in terms of potential future growth. As indicated, the problem is due to the rapid proliferation and development of personal computers (PCs). One view is that PCs will ultimately replace terminals because they can simultaneously

act as both terminals and local processors, either sequentially or with embedded software. Another view is that terminals are, and will remain, cheaper than PCs for on-line interaction with host computers for applications involving data entry and retrieval, graphics timesharing, and software development. This assumption suggests that terminals will continue to have a place in the data processing environment.

- Whatever future is postulated, the fact remains that there are a number of rapidly moving developments in data terminals. These include:

(i) Multifunction Intelligent Terminals

- Multifunction Intelligent Terminals offer both on-line access and desktop computation. These terminals are designed to operate in a network environment. The multifunction terminal provides single-unit solutions implemented in different ways. Many of the terminals are based on a common technology: the use of a microcomputer and associated semiconductor memory.

- By taking this technology a bit further and by borrowing ideas from personal computers, multifunction workstation/terminal manufacturers are providing not only the best of both worlds - terminals and personal computers - but data processing, word processing, data base access, data communications, personal computing, and voice communications.

- The "multifunction terminal," "executive workstation," or "desktop computer" is usually tied to other units via a network. Networking provides a backbone connection so that from a single terminal the user has to have multifunctional workstation capabilities.

- The personal computer capability embedded into the terminal will play a major role as a product of this kind. In general, personal computers' capacity (including communications capabilities and local-area networking (LAN)), is going to change the structure of the computer industry. The typical user has

hungered for such a solution. In essence, using a multifunction workstation has added no increase in cost (over an IBM 3278 CRT terminal). The user can get an enormous increase in capability. The DP manager can provide those additional services that everyone is clamoring for, plus he can insist they use a particular product (IBM PC) because it has the right communications.

- Electronic mail and data communications features are also fundamental to the multifunction workstation, allowing a voice conversation at the same time as data transmission. Thus, a user can review a transmitted document while also talking on the phone.

- Several other features are often used to make the multifunction workstation easy to use and "friendly," but electronic voice and data mail is fundamental. The multifunction workstation provides point-to-point mail and, with networked data communications, access to central mail service.

- Most of the new workstations also often have "soft" function keys that provide a choice of application or function, such as calculator, phone, mail, word processing, data communications, or maintenance. Once turned on, the system can be used to switch back and forth between functions without shutting down the workstation or loading a new diskette.

- The future of these multifunction terminals appears bright. The number of automated office workstations will exceed the existing number of electric typewriters in offices by the end of the decade. One out of every four white-collar workers will have an automated workstation.

(ii) IBM Plug-Compatible Terminals with SNA Capability

- At least 60 IBM plug-compatible manufacturers are offering BSC or SNA 3270-lookalikes. IBM recently introduced its IBM PC 3278 attachment, which allows a 3278 to also operate as a personal computer; however, unlike a PC that emulates a 3278, the 3278 PC attachment allows host and PC programs

to execute concurrently. A similar attachment offered by C. Itoh Electronics (Newport Beach, California) allows a CIE 7800 terminal, as well as a 3278, to operate as a PC. Many of the newer terminals can operate as either SNA 3270 or VT100 (Digital Equipment Corporation, Maynard, MA) devices, and thus can access SNA as well as asynchronous minicomputer-based networks (where VT100 is the de facto standard). Most of these devices are either multifunction or intelligent terminals, but several firms offer systems allowing low-end (dumb) terminals to act as VT100 or SNA 3270 terminals (or even multifunction terminals).

(iii) Graphics Terminals

- A new wave of mid-range graphics terminals is arising that only cost between $5,000 and $15,000, yet offer many of the features previously found in graphics workstations selling for at least $40,000. The new terminals are not standalone units but are designed to process graphics information with the help of a host computer. Some can also double as standalone microcomputers for business as well as engineering applications.

- Graphics software standards are evolving rapidly now and are boosting profitability by providing a high-level interface between graphics software and different graphics terminals. Inexpensive chip sets are now available that would let systems houses/OEMs build color graphics terminals at a lower cost than ever before. The idea is that the color monitor is the most costly element in the system - so costs can be cut substantially by purchasing the color monitor and processor circuits from different vendors.

- The computer graphics market is expanding with the development, availability, and acceptance of software and associated hardware. Graphics has become a sought-after capability, and the industry is in an early stage of growth that seems likely to accelerate rapidly during the next few years.

- With new and more advanced business terminal software, increased display resolution will enable users to employ special labeling fonts to rotate text on graphs and charts and to view information with better-defined and more complex figures. In addition, the integration of office automation, data processing, and business graphics will require improved alphanumeric capabilities.

- With the expansion of the graphics market, system configurations will demand that more users be connected to each system and performance be increased. This will foster a requirement to offload onto the terminal some host-based software functions.

- The terminals will increase feature content by including primitives to generate circles, arcs, rectangles, and other presentation capabilities such as line styles and patterns. Although these are already available in many graphics products, nonstandard implementation as well as reliance on all-inclusive, host-based software has made it difficult to take advantage of these features. Standards are being worked on and will have an impact on this environment, as will increased demand for greater system efficiency.

- One major market emerging for graphics terminals is business graphics units selling for less than $6,000. These units will capture the bulk of this market. Already, roughly one dozen vendors offer color graphics terminals in this price range.

- Business computer systems suppliers use the graphics capability to make their products time-saving productivity aids for managers inundated with information. Recent studies indicate that the human brain can visually interpret pictures at rates equivalent to 50 million words per minute. Considering that in comparison, people can read only approximately 900 words per minute, it comes as no surprise that graphics has become an important management, industrial, and scientific tool. Moreover, adding color to an image further enhances its usefulness and ease of interpretation.

- Color proves very effective in isolating data on a screen, whether to locate specific information or to combine data into meaningful groupings. Color will find extensive use in improving the operator-machine interface in error messages and in business applications - especially for automatic searching and sorting.

- Furthermore, combining color and graphics results in several advantages for the operator: greater data comprehension, increased interest, reduced fatigue, and higher data throughput. However, color terminals and hard-copy devices are considerably more expensive than comparable monochrome units. Multiple color reproductions from a color original are also expensive and inconvenient.

- Software that makes appropriate use of color has not been updated in many areas and is not widely available. The resolution of color monitors is low compared to monochrome units, and this reduces their alphanumeric capability and graphics quality. In addition, because of their wide exposure to Tektronix and Hewlett-Packard terminals, lab users are accustomed to monochrome. These deficiencies will be resolved in the future and color will be made more viable and widely applicable. While the business user is likely to accept color, ultimately penetration will be constrained in the short run by hard-copy and color reproduction capabilities.

- Buyers of computer graphics equipment, software, and services have generally been insensitive to price. As the market matures and as computer graphics applications become more commonplace, price will become more important. Price insensitivity with respect to the purchase of terminals in sophisticated graphics systems such as CAD/CAM is due in large part to the low cost of terminals relative to total system cost. For applications in which the terminal represents a large portion of the graphics system, and where larger numbers are employed, price is an important purchase determinant.

- The graphic terminal market as an entity is one of the fastest growing of all computer hardware markets. The use of graphic terminals for more and different applications has created a market of vast potential.

- It is predicted that total unit shipments of terminals will grow from 28,765 in 1979 to 159,775 in 1985, an average annual compound growth rate of more than 33%.

(iv) Teleprinters

- A teleprinter terminal is any device that combines a low-speed printer with a communications interface. Today's teleprinters are available with a wide variety of printing techniques and range of print speeds. The microprocessor has found its way into teleprinters, as it has with other terminals. From the user's viewpoint, microprocessor technology offers the advantage of price in the highly competitive terminal marketplace.

- Teleprinter vendors have been extremely active in realigning their role and developing new markets that have not been penetrated by the CRTs. Teleprinters will continue to be the major link between remote computing (time-sharing) companies and their clients. The user has the keyboard to access service, sign off, and perform data entry. When the user is ready to have the reports printed, proper forms are inserted in the printer station and the teleprinter prepares the report. Higher teleprinter speeds can result in less connect time, so that units literally pay for themselves.

- The advent of large-scale integrated (LSI) circuitry has made teleprinters simpler to design and manufacture - as attested by many new entrants to the industry.

- The majority of teleprinters are being used for inquiry/response applications. The growing use of word processing is driving the demand for fully formed character teleprinters, which are gaining popularity over dot matrix tele-

printers because of their high quality print. Despite the increase in fully formed character teleprinter shipments, dot matrix teleprinters will continue to sell because of lower prices and faster print speeds.

- The vast majority of teleprinter users require print speeds of 75 cps and up. With current technologies, fully formed character teleprinters cannot print at this speed and maintain high quality print. New developments may make this possible.

- Leading manufacturers of teleprinters are:

  - Teletype Corporation, a subsidiary of AT&T, is the traditional patriarch of the industry. Its family of teleprinters has dominated the terminal marketplace for more than a decade and has long represented the primary de facto standard.

  - Digital Equipment Corporation's (DEC) popular DECwriter line consists of pedestal-mounted and desktop impact printers. Since the first DECwriter was introduced in 1975, more than a quarter of a million of these teleprinters have been produced.

  - General Electric's TermiNet family, with more than 250,000 units installed, has grown steadily since 1969 when the TermiNet 300 was announced. The family includes a wide variety of printing terminals, including serial matrix and full-character teleprinters and low-to-medium speed line printers that can be equipped with remote communications interfaces.

  - Texas Instruments' Silent 700 thermal teleprinters include a portable unit and two models equipped with bubble memory. Its Omni 800 buffered impact printer terminals typify the "new generation" of teleprinters aimed at a broad range of specialty markets.

- The teleprinter market, forecast to grow to $1 billion by 1985, combines elements of printers and terminals. Historically, the teleprinter market was controlled by Teletype, which almost singlehandedly nurtured the teleprinter through its first 50 years. However, in the past 20 years or so a number of new vendors have entered the market. The advent of teleprocessing and data communications expanded that marketplace and there have been a number of competitors since that time.

- There are now over 120 terminal models emanating from more than 50 vendors. Top suppliers include Teletype, Digital Equipment Corporation (DEC), General Electric, Texas Instruments, Extel, Computer Devices, and Anderson-Jacobson. DEC and Teletype are the largest manufacturers. Teleprinters appear to have a thriving market. In addition to traditional telecommunications business applications, a tremendous potential for teleprinters exists in conjunction with public data networks, automated electronic mail, and the vast, untapped home consumer market.

- In general, products from today's teleprinter industry are more communications-oriented than their similarly priced counterparts in the office products marketplace. Teleprinters also lack the standard word processing software of other office keyboard printers, such as intelligent typewriters and printer-based word processors.

- Teletype always changed with the times. Its most popular model, the 33, originally handled only messages. With modifications, it could query data bases and function as a timesharing terminal. The same thing is happening today. The major thrust right now covers editing teleprinter applications. Through solid state memory we can provide the user with simultaneous local preparation of copy while the machine is sending or receiving.

- Widespread use of videotex and videophone (CRT-equipped telephone) terminals "in the near future" will help generate shipments of more than four million alphanumeric CRT terminals in 1985.

c. Summary

- In summary, currently some 205 vendors offer more than 400 models of CRT terminal equipment and "compete fiercely." The number of new entrants has slowed in the last few years. An imminent shakeout is expected in the dumb and smart terminal sectors, but there will be a counterbalancing steady influx of new vendors. Other marketing trends include:

  - Clustered intelligent terminals and workstations will be the biggest revenue producers during the next five years, but unit shipments of dumb terminals will far exceed shipments of intelligent terminals.

  - Although IBM dominates the smart CRT terminal market sector, independent vendors are slowly eroding its market share in this area.

  - Throughout the industry, there is a trend toward the combined use of dumb and smart terminals - despite the continued introduction of more-intelligent terminals. Growing user sophistication, together with a desire for state-of-the-art intelligent terminals, is "offset by an uncertain economic atmosphere and continually declining prices for dumb and low-end smart terminals."

- During the next five years, computer terminals will offer more features for less money, greater reliability, and easier servicing. These improvements will result from the increasing use of large-scale and very large-scale integration in terminal circuitry.

- Competition is heating up at all levels of the terminal business, and prices will continue to erode. The industry will undergo another shakeout of vendors over the next few years (despite a 40% annual growth rate in the installed base). Increased competition, vertical integration, and the growth of microcomputers could all cause significant profit disruptions for several vendors.

- The user-programmable terminal market is threatened by microcomputers, which can be good substitutes at little added cost. Microcomputers will eventually assume the role of intelligent terminals.

- Low-cost production is imperative for success in the non-intelligent terminal market. Also, manufacturers must become acutely aware of features (including ergonomic characteristics like readability, detachable keyboards, and swivel/tilting) required or desired by users. Although microcomputers will begin to invade the intelligent (user programmable) terminal domain, vertical market opportunities will continue to exist.

3. PRINTERS

- This year has been one of fantastic market growth for serial printers and a rather slow year for line printers. Driven by explosive home and business microcomputer markets, sales of impact matrix and solid-font serial printers up more than 40%. Impact line printer sales were sluggish, hampered by economic pressures that affected sales of all high-cost capital goods and forced large OEM customers to defer shipments.

- Two printer-based market demands - low cost and flexibility - were behind the most significant serial-printer developments. Demand for inexpensive letter-quality output inspired a wave of less-than-$2,000, letter-quality printers from SCM Corporation, Primages, Inc., Computers International, Irwin/Olivetti, and NEC Information Systems, Inc.; Dataproducts Corporation, Diablo Systems, Inc., and Qume Corporation are said to be eyeing the low-end market.

- Demand for microcomputer printer flexibility has led Lear Siegler, Inc., Mannesmann-Tally Corporation, Okidata Corporation, General Electric Company, Facit, Inc., Integral Data Systems, Inc., Qantex, Santec Corporation, Digital Equipment Corporation, and others to introduce multi-mode

printers that handle data processing, draft- and near-letter-quality output. The new printers make two, three, or even four passes per line of output and use print heads that contain 9, 14, 18, or more wires.

- Nonimpact serial printer technologies are getting lots of attention at the patent office, but not much more than usual in the market. Thermal mechanisms remain popular in portable and military printers, and ink-jet mechanisms are gaining most popularity in color units that are actually graphics hard-copy devices rather than character printers.

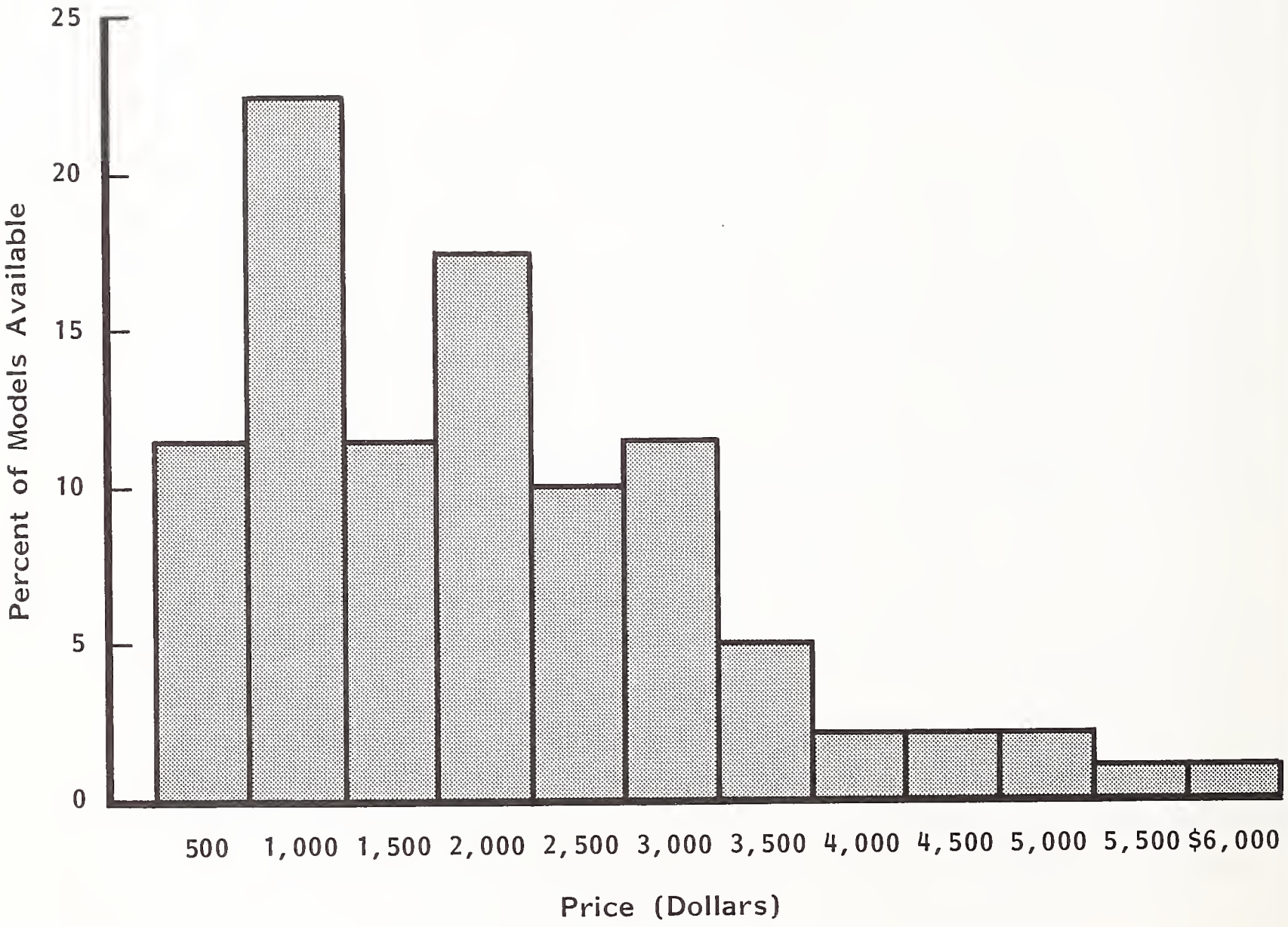
- The impact line printer market is dominated by band mechanisms, and the once-preeminent drum line printer has essentially gone out of production. Band printers offer economies and font changeability that other impact line printer technologies are hard pressed to match. Band printer speeds range from 300 to 2,500 lines per minute (lpm). The fastest impact line printers still use chain train technology to reach speeds of 2,000 lpm or more.

- Magnetic, ion-deposition, electrographic, and electrophotographic printers once threatened only high-end, impact line-printer vendors, but prices for these very fast, inherently flexible machines are dropping quickly and forcing medium- and even low-speed (300-lpm) impact line-printer prices downward. A 300-lpm impact line printer can be had today at an OEM price of less than $6,000.

- Impact line printers will share more of their minicomputer turf with nonimpact units in the next few years. Serial printer prices, shown in Exhibit III-15, reflect the fact the microcomputer systems are creating the vast majority of new serial printer demand. Versatile microprocessor-based matrix printers are plentiful at less than $1,000, and many solid-font, letter-quality printers are now available for less than $2,000. As always, serial-printer prices are inversely proportional to speed and resolution.

EXHIBIT III-15

SERIAL PRINTER PRICE DISTRIBUTION



- Impact line printer speeds, shown in Exhibit III-16, fall into traditional ranges based around multiples of 300 lpm. The 300 lpm speed is the most popular, followed by 600, 900/1000, 1200, and 1800 lpm. Many speed requirements can be satisfied by band, chain, train, and matrix technologies. Expensive drum technology once dominated medium-speed line printers, but band technology is now dominant across most speed ranges.

- As indicated in Exhibit III-17, serial-printer technology trends are strongly toward matrix methods and away from solid fonts. Fully formed character printers generate letter-quality output but print at 75 cps or less. Matrix printers reach 900 cps and generate near-letter-quality output at 50 to 150 cps. Thermal printing is losing popularity in serial printers but gaining interest in teleprinters. Electrostatic methods still suffer from low quality and high paper costs. Ink-jet printing is available in only a few expensive units but holds promise for the future.

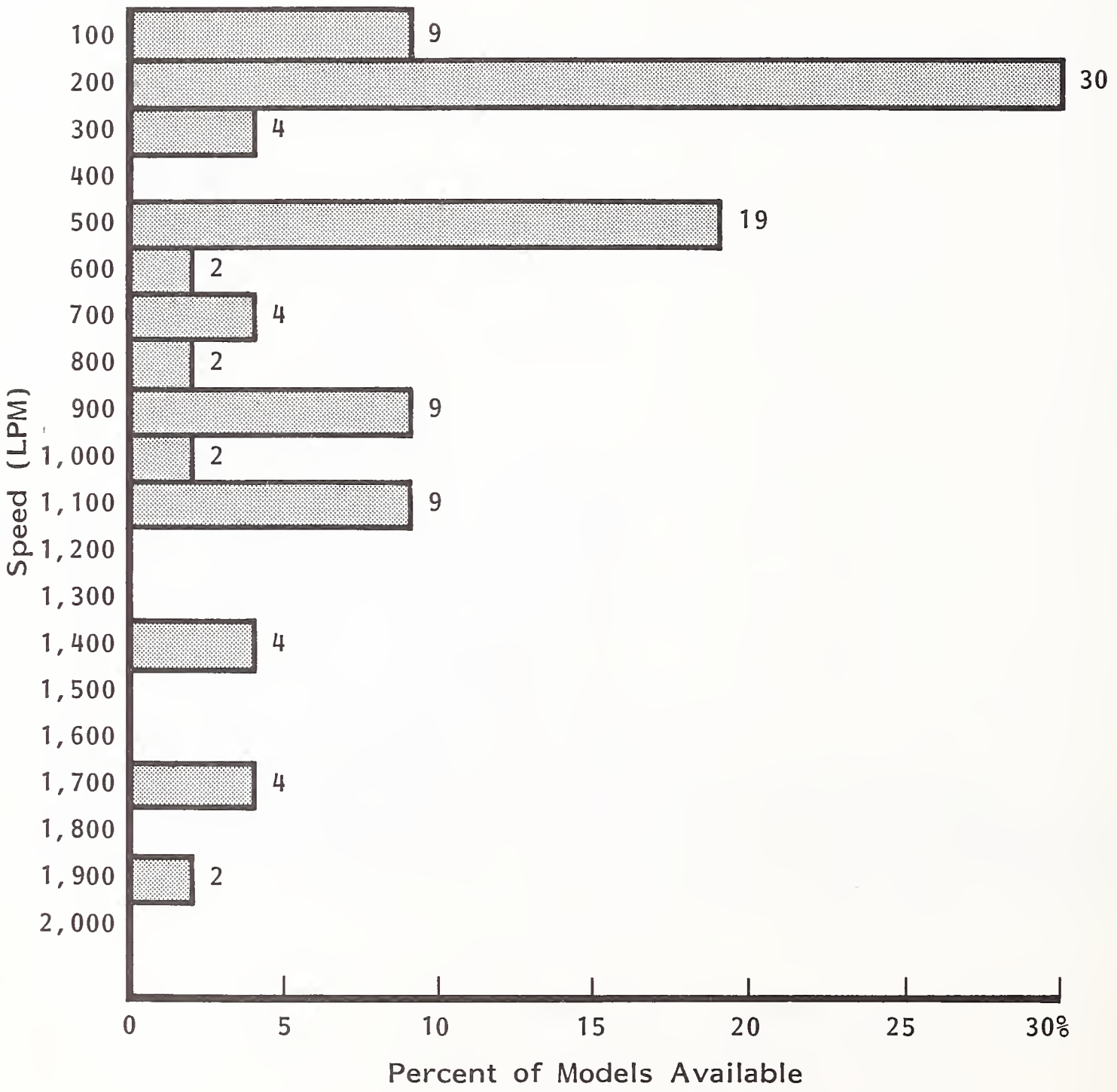
- Serial-printer speeds span a 600 cps range to accommodate a wide variety of applications and price ranges. Solid-font, daisy-wheel, and thimble printers operate in the 15- to 70-cps range. Single-pass matrix printers operate between 30 and 300 cps, and multipass matrix printers print at many speeds, depending on resolution.

- Data processing needs have changed, and printer technology has developed to meet those needs. After many years of faithful service, the dependable drum printer is being phased out of the data processing scene, and soon most models will be out of production. Although reliable, these printers lacked the versatility necessary in today's data processing environment.

- The most versatile fully formed character line printers available are band printers. All methods of solid-font impact line printing use the same type of mechanical action - an actuator, or solenoid-type device, contacts the rear of a hammer assembly whose hardened steel face strikes a print medium. The ribbon and paper are between the hammer face and the type character. In

EXHIBIT III-16

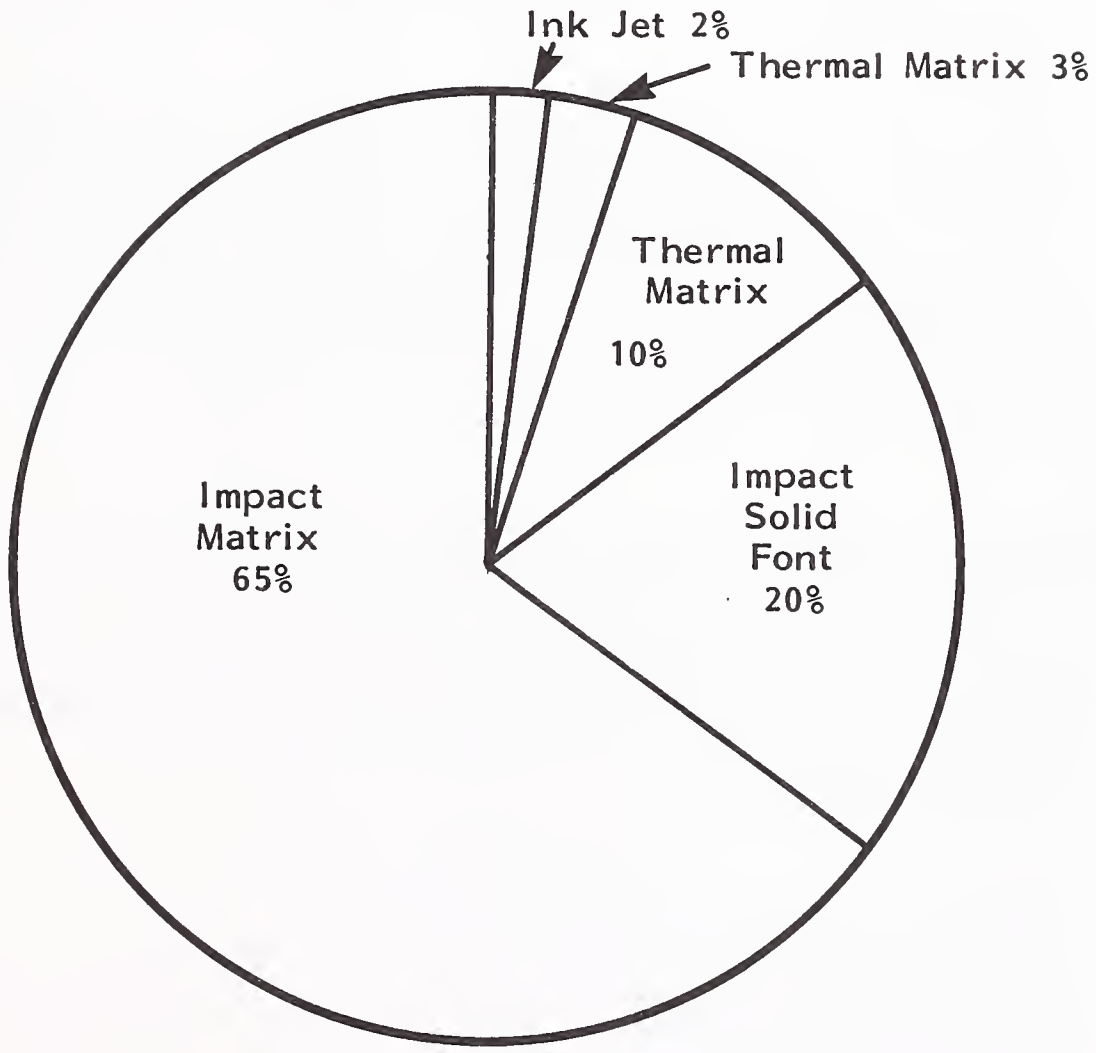
IMPACT LINE PRINTER SPEED DISTRIBUTION



SOURCE: Mini-Micro Systems

EXHIBIT III-17

TYPES OF PRINTER TECHNOLOGY IN USE
(Percent of Type)



some cases, the actuator and print hammer are combined in one mechanism. There is usually one hammer and actuator for each column.

- Drum printers use a cylindrical steel drum embossed with print characters. As the drum rotates at high speed, timing marks on its end allow the printer's logic to determine which character is in front of each hammer at any given time. When most characters are at the columns in which they are to be printed, the hammers fire. The printer's logic can scan hammer-to-character alignment many times before an entire line of information is printed and the paper is advanced to the next line.

- Chain and train printers use embossed slugs, each containing several character images. The slugs are linked together or pressed into rubber belts and rotated horizontally between an idler and drive pulley. The print mechanism is similar to that of a drum printer, and each print position across the page has its own hammer and actuator assembly.

- Some manufacturers have successfully combined both chain and train technologies, producing a printer with the qualities of both. Chain/train-type printers are popular for their rugged construction and crisp print quality. They are expensive, however, and the chains are individually expensive and difficult to change.

- Band printers use flexible, stainless-steel print bands that are photo engraved with printable characters. The band is rotated horizontally, much like a chain, between an idler and drive pulley. Band printers are relatively inexpensive, offer high quality print and use easily changed print bands. If operated within the parameters for which they were designed, they are the best alternative to the outdated technology of a drum and the high price and font change difficulties of a chain/train printer.

- Modern band printers use cartridge, spool-to-spool or towel-type ribbons. A cartridge ribbon is the quickest, easiest, and neatest ribbon to change. An

experienced operator can typically change a cartridge ribbon in 30 to 45 seconds without touching any inked material. Cartridge ribbons have a shorter life span, however, than spool or towel ribbons.

- The cartridge itself is a rectangular plastic box. The ribbon is pulled out of one end, passed through the print area and force-fed into the other end by a pair of rubber rollers. While passing through the print area, the ribbon is skewed diagonally so that its entire area is used. A twist in the ribbon creates a Mobius, or one-sided loop, so that both sides of the ribbon are used.

- New printers now provide several interface capabilities. Most of the new printers now provide serial and parallel RS232 interface. Several also offer IEEE-488 interface as well. Some printers are provided with an all-purpose interface. Diablo's all-purpose interface, for example, can automatically emulate any of three popular interfaces used most often with 8-bit microcomputer systems, requiring nothing more than a cable to change an interface.

- Printers are also being developed with added intelligence. Intelligence makes the printer more application flexible, user friendly, and capable. With built-in standard buffers, an intelligent printer can accept data transmission at off-peak periods, saving hundreds of dollars in line costs. Self-diagnostics can be built in, allowing the end user either to fix the printer himself or tell a service representative in advance what is wrong.

- Another development is the use of firmware for special application programs for special tasks. Word processing firmware can automatically offload system functions such as text centering, proportional spacing, shadow printing, subscript and superscript generation, boldface printing, and underlining. This leaves more system power for other tasks.

- Most of the newer printers meet applicable regulatory standards, including FCC approvals for home computing. Newer printers also provide electrostatic discharge immunity to avoid safety hazards or requirements for maintenance

calls. New printers are also being designed to accept standard accessories internally, rather than rely on outside "stunt" boxes for accessory attachments, and to have the flexibility to accept add-on cards or other features to maintain a competitive edge or to serve a specific customer niche.

- The printer market divides a number of different ways. Among them are speed, application, printing technique, and price. Further divisions within each of these areas seem innumerable. For instance, one market analyst identifies as many as 30 technologies. Each area also overlaps with the others, often providing a bone of contention for end users to gnaw on when they enter these common grounds.

- Nonimpact printing techniques, such as laser, ink jet, and thermal, are expected to grow more rapidly than impact techniques in the future. A 23% annual growth rate for nonimpact printers is anticipated between 1980 and 1985.

- Full-character serial (one character at a time) printers will retain their lead, while matrix printers stand to achieve nearly twice the market share held by band printers. Drum and chain train printers will hold only 1% each by the end of the decade. Nonimpact printers will achieve nearly a 40% share of the overall market by the end of the 1980s from a lowly 7% in 1979.

- Printers typically operate at speeds of 100 to 3,000 lines per minute. Some units allow a service technician to field upgrade their speed. Print quality typically degrades as print speed increases. To achieve higher print speed, most band printer designs require increased band speed, which can result in "ghosting," or blurred characters. Regular adjustments can minimize ghosting.

- Printer technical manuals generally specify service schedules and reliability estimates. These figures are good indicators and should be compared among various models. In general, a printer's mean time to repair (MTTR) is higher

and mean time between failure (MTBF) figures are lower than for other peripheral units. The MTTR is the amount of time required for a trained service person to repair an average problem. MTBF is the average amount of hours between printer failures.

- MTBF is based on a specific duty cycle - the recommended maximum ratio of time the printer is actually printing to the time the printer is powered on. Thus, a printer that is powered on for an entire eight hours a day but prints for a total of only four hours is operating at a 50% duty cycle. Judging a printer's durability on its duty cycle or MTBF figure alone can be misleading. MTBF/duty-cycle figures should also reflect the number of lines printed per page and the column density of the printer pattern.

- Despite the overall reliability of most band printers, a drum printer cannot be replaced by a band printer with equal reliability. If both a drum and band printer are operated at similar duty cycles, the band printer will probably require service more often than the drum. The severity of this shortcoming depends upon many variables, including which models are being compared.

- The trend of the band printer industry is toward modular components and fewer adjustments. Because of the increasing price of test equipment, many service companies do not have their technicians carry oscilloscopes, and few technicians can operate complicated diagnostic equipment. An OEM that has band printers using outdated electronics requiring oscilloscope adjustments may soon find itself at a disadvantage.

- To minimize downtime and to speed repairs, most or all of a line printer's mechanical adjustments should be factory preset. Adjustments should not require special tools, which are often not available even to service technicians. Each of the printer's functions can be controlled by a microprocessor, providing extensive diagnostic capabilities. Subroutines for initialization, paper motion, and print cycles can now be implemented in PROMs, which can usually be changed in minutes to accommodate additional or deleted options, such as vertical format units or new character sets.

- Printers should incorporate diagnostic display. For example, one or two seven-segment displays in Digital Associates Corporation's printers inform an operator or service technician of as many as 60 diagnostic conditions, such as ribbon-motion fault, paper jam, paper out, band not seated properly and band-firmware incompatibility error. Of these conditions, 20 to 25 are operator correctable. The remaining diagnostics give a service technician an accurate account of the problem, often reducing troubleshooting time to a fraction of what it would otherwise be.

- Well-written, unambiguous documentation is a must for a printer's operator and service technician. Some manufacturers provide a theory-of-operation manual with flowcharts, and some of these include a section on trouble-shooting.

4. OTHER PERIPHERAL EQUIPMENT TECHNOLOGY

a. Character Recognition

- With the advent of bigger and better CPUs, two newer technologies - dynamic- and optical-character recognition - are appearing in more applications to speed up data input, facilitate the conversion of large amounts of data into digital form, and simplify the human interface to computers (especially if data inputs require more than one keystroke.

- Because semiconductor memories and processors are faster and denser, data may be automatically captured, stored, and displayed at a data terminal, a welcome alternative to alphanumeric capture by means of keyboard entry. Many, if not all, of the functions involved - video digitization, image storage, image display, data processing, and data communications interfacing - can be realized on a single board.

(i) Dynamic Character Recognition

- Dynamic character recognition (DCR) systems are built around a nonkeyboard input device, often a graphic tablet with a writing surface, that senses the position of a pen or pencil. The input device provides data coordinates as characters are being written to the processor, usually an LSI-based device.

- The writing tablet converts the hand-written data directly into computer code. Because a writing tablet is used, nontechnical personnel can input data directly without being overwhelmed by the CPU.

- The system's processor performs two functions: preprocessing and recognition. Preprocessing averages variations like jitter, and filters out unnecessary data points, for example, points that are on top of or very close to one another. Thus, filtering removes some of the burden on the storage medium.

- The DCR system contains recognition algorithms that are applied in two stages: feature extraction and recognition. The important recognition parameters for any handwriting style accepted by the DCR system are the number of strokes, the location of intersections, and the aspect ratio of the characters.

- One of the three commercially available systems that employ DCR as a replacement for the ubiquitous keyboard comes from Pencept Inc. (Waltham, Massachusetts). The two other manufacturers of DCR equiment are Image Data Products Ltd. in Bristol, England, and Micropad Ltd. in Dorset, England).

(ii) Optical Character Recognition

- Another form of alternative data entry is optical character recognition. OCR is the primary technology base for image processing in which the technology base for image processing and the main objective is the optical digitization, storage, manipulation, and retrieval of two-dimensional visual data by

computers. OCR systems are being designed as peripherals to intelligent terminals because they can capture large amounts of data at the source and can eliminate much of the paper output usually required before data reentry.

- OCR is also reaping the benefits of improvements in VLSI (which lead to smaller boards) and improvements in scanning and detecting technologies (which help the system tolerate media defects).

- The importance of capturing large amounts of data is also the impetus behind the evolution of digital FAX. Both facsimile and xerography may soon be based on imaging so that copy can be transmitted and received directly, as well as indirectly from a computer or tape.

- OCR can now be combined with digital FAX because communications lines are opening up to speeds beyond 9600 baud. As a result, images can be stored on tape along with digital information. The tape is easier to store than paper hard copy for archives and it expedites data reentry.

b. Point-of-Sale Terminals

- A POS terminal functions as both a cash register and as a physical link to a computer. The link may or may not be in-store, depending on the type and model. The typical point-of-sale unit monitors inventory; catalogs prices; updates prices; logs sales and statistics; evaluates profitability, turns, and GMROI; and increases security at the cashier's workstation. Some POS terminals, like electronic cash registers, can suffice and be upgraded by addition of an in-store CPU at a later date.

- For $23,000, an Ace store owner can purchase an entire POS system. It includes one CRT, one keyboard, one printer, and all hardware and software. It also includes problem support for one year, training, and installation. More advanced packages sell for $31,500 and $40,000, again depending on size and need.

c. Digitizers

- Greater accuracy, more software support, and less mechanical content are making input digitizers more efficient, fast, and reliable graphics-input devices. The overall shift in digitizer technology from mechanical to electronic will continue as more VLSI becomes available and more software is embedded in firmware for such functions as placing, deleting, and rescaling graphic elements.

- As an example of this trend toward electronics, at least one major manufacturer believes that an electrostatic tablet will provide better resolution than the traditional magneto-acoustic delay lines in sensing the location of a point for digitizing. The 9111A digitizer system from Hewlett-Packard (Cupertino, California) adds a CRT to the electrostatic tablet to display the digitized drawing and also offers a menu of standard graphic shapes and functions.

- A user can draw on the tablet, as the picture appears on the screen. In the unit's single-function mode, a program can interpret an entered point as the end of a line, the center of a circle, a point on the circumference of a circle, or a specific location in a drawing. The continuous mode allows freehand sketching and the tracing of existing drawings, charts, or photographs, when the 9111A is linked to the company's system 45 desktop computer series.

- Once a drawing is put into a data base, it can be checked, modified, rescaled, and plotted, which means that data are verified at the source. The 9111A is also compatible with the HP-85 and HP-1000 series and with the 9800 desktop computer series.

- Being able to interface with popular microcomputer buses - not to mention other peripherals like tape drives and floppy disk drives - is another attraction of digitizers. The Series 800 digitizers from Talos System, Inc. (Scottsdale, AZ), a division of CalComp, use a multibus-compatible card module for dual

tablets, dual cursors, and multiple interface capabilities. Besides the multibus interface, the digitizers accept dual- or single-port RS232C, parallel, IEEE-488, and quad-sequential interfaces.

- Because of advances in firmware and LSI, digitizers can automatically follow and digitize chart traces, scan photos for optical density, and enhance images. The Summatrac automatic digitizer from Summagraphics Corporation (Fairfield, Connecticut) automatically converts visual analog data (like strip chart traces, photographs, or drawings) into digital data, and thereby eliminates operator-generated inaccuracies.

- The Summatrac uses a microprocessor-controlled photosensor to detect a recorded curve from reflectance measurements. This detection process improves both the speed and the accuracy of locating the stylus/cursor over selected areas of the trace. The photosensor, which is mounted on the pen-holder of the X-Y plotter, sends signals to the microprocessor, which analyzes these reflectance measurements to determine whether or not the photo-detector is over the trace.

d. Voice Recognition

- Voice recognition will be widely applied for data entry before the end of the 1980s. Advances in Automated Speech Recognition (ASR) are accelerating at the chip, board, and system level. Although developments in voice recognition still lag behind those in voice synthesis, system designers have at least one strong incentive to implementing voice recognition - currently, data input bottlenecks can consume as much as 50% of a data processing budget.

- Improvements in dedicated hardware and recognition algorithms are enlarging recognition vocabularies and enhancing phonetic-acoustic response, detection accuracy, and response time. However, one improvement that is still sorely needed is a standard for evaluating speech recognition accuracy.

- With fewer components and with more analog functions translated into digital components, speech recognition systems should become more reliable. For example, one of the first companies to announce a single-board implementation of isolated word recognition, Interstate Electronics (Anaheim, California), intends to reduce the component count on its 100-word VRM board by replacing the analog front-end filters with a customized filter chip.

- Packaged in a 28-pin DIP, the chip will contain 16 bandpass filters (identical to the VRM's current single-board frontend filters), in addition to rectifiers, a low-pass filter, and a 16-channel multiplexer. Given this redesign, the input section of the board would consist of an input preamplifier and equalizer (discrete parts), the filter chip, a clock, and an a-d converter chip - a reduction from more than 280 components to less than 25. In fact, the entire voice recognition portion of the board would consist of just the filter chip, a-d converter, clock, ROM, and microprocessor.

- In the future, VLSI will take over more than the filtering aspects of speech recognition. Working in concert with its parent company, Threshold Technology (Delran, New Jersey), Auricle, Inc. (Cupertino, California) is developing custom voice-recognition ICs. They say that its all-digital approach will give the same performance as analog circuits or filters, but will require a 12-bit a-d converter for the initial processing into digital format. The a-d conversion would take about 1 ms. Until the recognition process can be made, all digital signal processor chips will serve as analog filter ICs.

- Two-stage optimization is one of the highly specialized algorithms that may eventually improve system performance and reduce costs as well. To quality the algorithm for a role in the recognition and detection of single syllables and in the verification of speaker identity, Philips GmbH (Hamburg, West Germany) is examining acoustic response in 20-ms timeframes and comparing them to prerecorded data on transition templates. The optimized algorithm can be used to determine the end points of isolated utterances. It relies on dynamic programming to improve recognition accuracy regardless of local disturbances (white noise) in the input signal.

- For recognizing isolated words, a two-pass pattern approach is under investigation at Bell Labs (Murray Hill, New Jersey). The output of the first recognition pass is an ordered set of word classes, among which the unknown spoken word appears. The output of the second pass is an order list of word candidates within each of the word classes. Evaluation of these lists shows that a two-pass approach to isolated word recognition is viable when the vocabulary consists of sets of acoustically similar words.

- Voice recognition requires that parameters be generated and stored so that subsequent words can be compared to the stored library. Centigram (Sunnyvale, California) believes that speaker-independent speech recognition can be aided with a PWC algorithm, which was originally developed for digital store/forward programs.

- Centigram is also a firm believer in the potential of silicon for reducing the cost and improving the quality of voice recognition in the field. The company plans to develop a fast array-processing board that will take advantage of fast signal processor ICs. The resulting board should perform matrix operations quickly enough for real-time voice transmission, store/forward of voice, and the creation of voice files. The company is also considering the possibility of specialized chip sets that will improve the operation of the PWC algorithm.

- The idea of using digitally programmed LSIs for voice recognition is very attractive. Another trend is to use a dedicated microprocessor to handle I/O processing and open up the I/O bandwidth of CPUs. The restructuring of computer systems will produce the quality and quantity of I/O channels needed for speech recognition.

e. Communications Modems

- The demand for modems continues due to the significant limitations on the physical and economic environment with which data communications must

exist. The telephone companies continue to provide three-kilohertz channel models. New market entries now compete with the telephone companies using essentially the same technologies; although the cost of their three-kilohertz product may be less, the same ratio of cost for extended bandwidths applies, so new entries predominantly build for the interconnect market.

- While tremendous bandwidths are available on satellites, coaxial cable, wave guides, or fiber optics, for distances exceeding a local haul, the only economic payback comes in three-kilohertz voice channels. In the future, as computer-to-computer interchange networks are installed, wider band channels will also increase, requiring larger modems.

- Even when modified by removing part of a plant, the cost of wider bandwidth facilities is high - about 75% of the cost of an equal number of voice channels. The 48 kilohertz of bandwidth that bears 12 voice channels, when made a single wide channel, still costs about the same as nine individual voice channels. Implementing today's modem state of the art, the 48 kilohertz might support 256,000 b/s, but the marketplace remains so narrow that modem makers only produce units getting 60,000 b/s through that 48-kilohertz channel. The cost of fully developing a more capable modem has not yet been accepted by the market. AT&T's DDS (Dataphone Digital Service) uses modems with names like Data Service Unit, Channel Service Unit, and Office Channel Unit. The Data Under Voice of DDS uses large, 1.544 megabit modems that operate just like a big 201-type modem.

C. NEW PRODUCT TECHNOLOGY DEVELOPMENTS

- There are a number of new developments taking place in the peripheral and terminal market. These are outlined below:

I. NEW DEVELOPMENTS IN MASS STORAGE UNITS

- Coping with the increasing demand for on-line storage capacity has become a major concern for many data processing managers. Because more tasks are run concurrently with larger and more numerous data files, much larger on-line storage capacity is needed. In recent years users of medium- and large-scale computer systems have increased their requirements for processing power by about 20% per year, but their need for on-line storage in the same period has jumped 45-70% per year.

- Acquiring the necessary on-line storage is more complex than just attaching more disk drives. Even with advances in disk storage - more than an order of magnitude increase in capacity per spindle in the last ten years - demand for storage is outstripping supply. Deliveries have been delayed on the newest disk models, prices are high, and factors such as floor space and utility costs limit the application of disk drives.

- Two alternatives can help solve the data growth and data management problems: the mass storage systems (MSSs) (such as the IBM 3850 and the Masstor M850) and the "intelligent backend," typified by the Virtual Storage System (VSS) recently announced by Storage Technology Corporation.

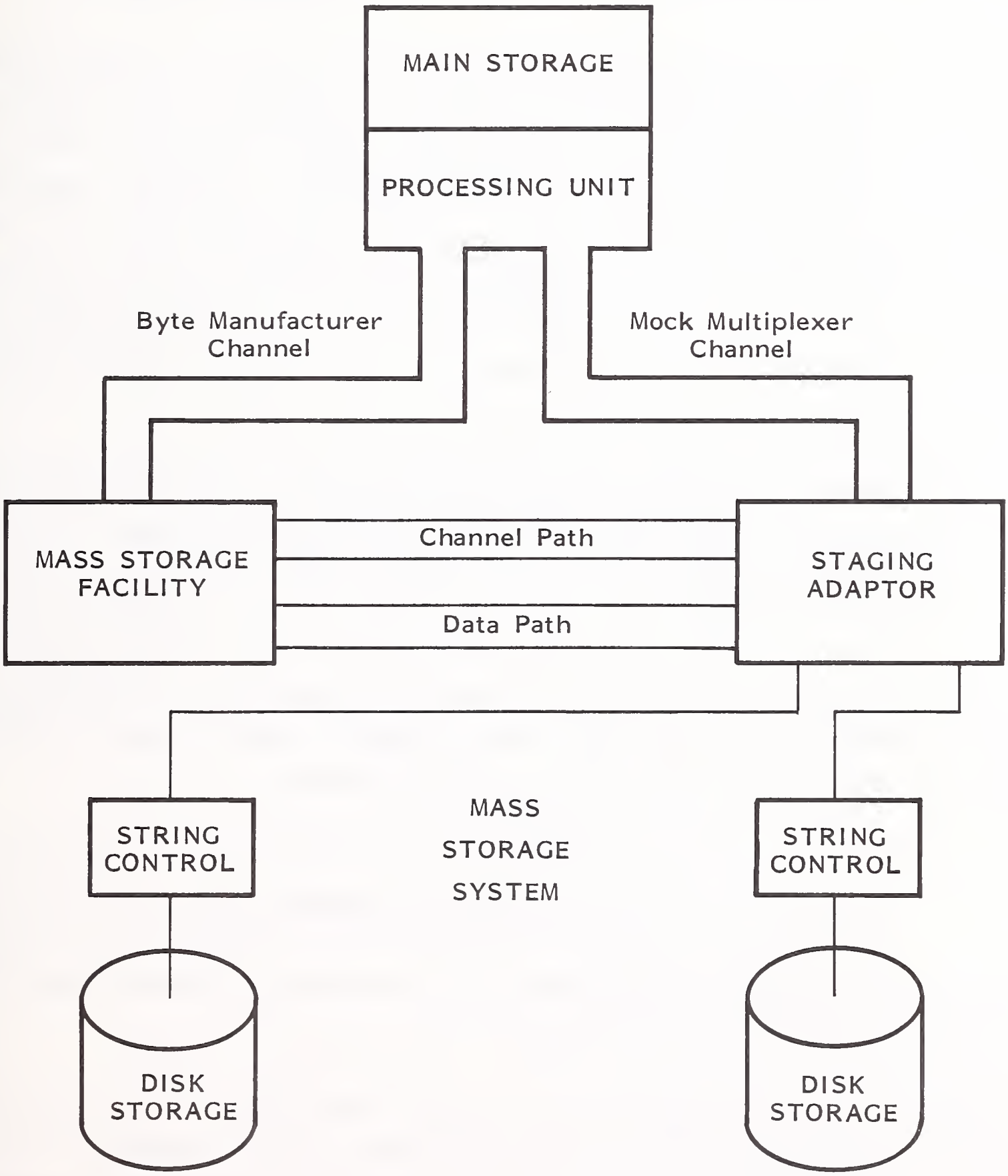
a. Mass Storage Systems (MSS)

- The MSS uses the storage hierarchy concept. Highly active data that must be immediately available to a user are kept on high performance disk storage. The vast majority of data sets are less active and are placed in lower-speed, lower-cost storage. The latter data are migrated to faster storage when needed for processing. This frees the applications programmer from worrying about on-line storage limitations by extending the concept to the peripherals.

- The principal element of a mass storage system is the mass storage facility, as shown in Exhibit III-18. Depending on the model, it can store between 35

EXHIBIT III-18

MASS STORAGE SYSTEM (MSS) CONCEPT



billion and 4,572 billion bytes of data. The MSS facility contains numerous data cartridges in an arrangement of honeycomb-like cartridge storage cells, one or two active accessors, and two or more data-recording devices.

- The data cartridge, produced by IBM, consists of a strip of magnetic tape 2.7 inches wide and 66.2 feet long wound on a plastic spool and enclosed in a protective plastic shell. Through video recording technology, data are recorded on the magnetic tape in disk image format in segments called strips. Two data cartridges have the same capacity as one disk volume of an IBM 3330. Storage cells hold the data cartridges when they are not in use, and the accessor transports the data cartridges between the cartridge storage cells and the data recording devices, which transfer data to and from the cartridges.

- An MSS gives the user some distinct advantages. In most installations disk capacity is used inefficiently. Typically, a very large portion of a user's disk holds sequential batch data or infrequently used convenience data sets of small to medium size. Such data could be stored on magnetic tape and mounted on tape drives when needed, but the additional labor and tape drive costs, plus built-in time delays and the high probability of mishandling, make that approach impractical. These data sets are ideal candidates for storage in an MSS with little or no loss of system throughput.

- The disk capacity saved, the tape and operational costs eliminated, and the overall systems efficiencies achieved can readily justify the costs of an MSS. Once the system is installed, the cost for additional capacity is far lower in terms of energy, floor space, and hardware and media cost per megabyte than it would be with disk storage.

- The cost of added capacity is approximately $32 per megabyte for an IBM 3380-B4 and $50 for an IBM 3350-B2, but only $4 for an addition to an MSS. Furthermore, the initial hardware cost per megabyte for an MSS is one-eighth and one-twelfth that of the two disk units, respectively. In terms of physical

space (megabytes per square foot), the MSS is respectively 17 times and 77 times more effective than the disks. The power required per megabyte is 29 times and 99 times less.

- Larger computer installations can have an enhanced capability when an MSS is installed and the processors are interconnected through a local network. Over a network, for example, more than four processors can share data from an MSS at processor channel rates, as shown in Exhibit III-19. Non-IBM (or IBM/PCM) processors can be attached to the network, and the processors can be physically remote from one another.

- The benefits of MSS in this type of data network are significant. A network user can take maximum advantage of the data storage resources he already has and can limit the requirement for acquiring more. The user has less need for redundant or duplicated peripheral storage equipment if the user's processors are from different vendors. But the user can still use specialized peripherals, which otherwise might not be available from the processor manufacturer.

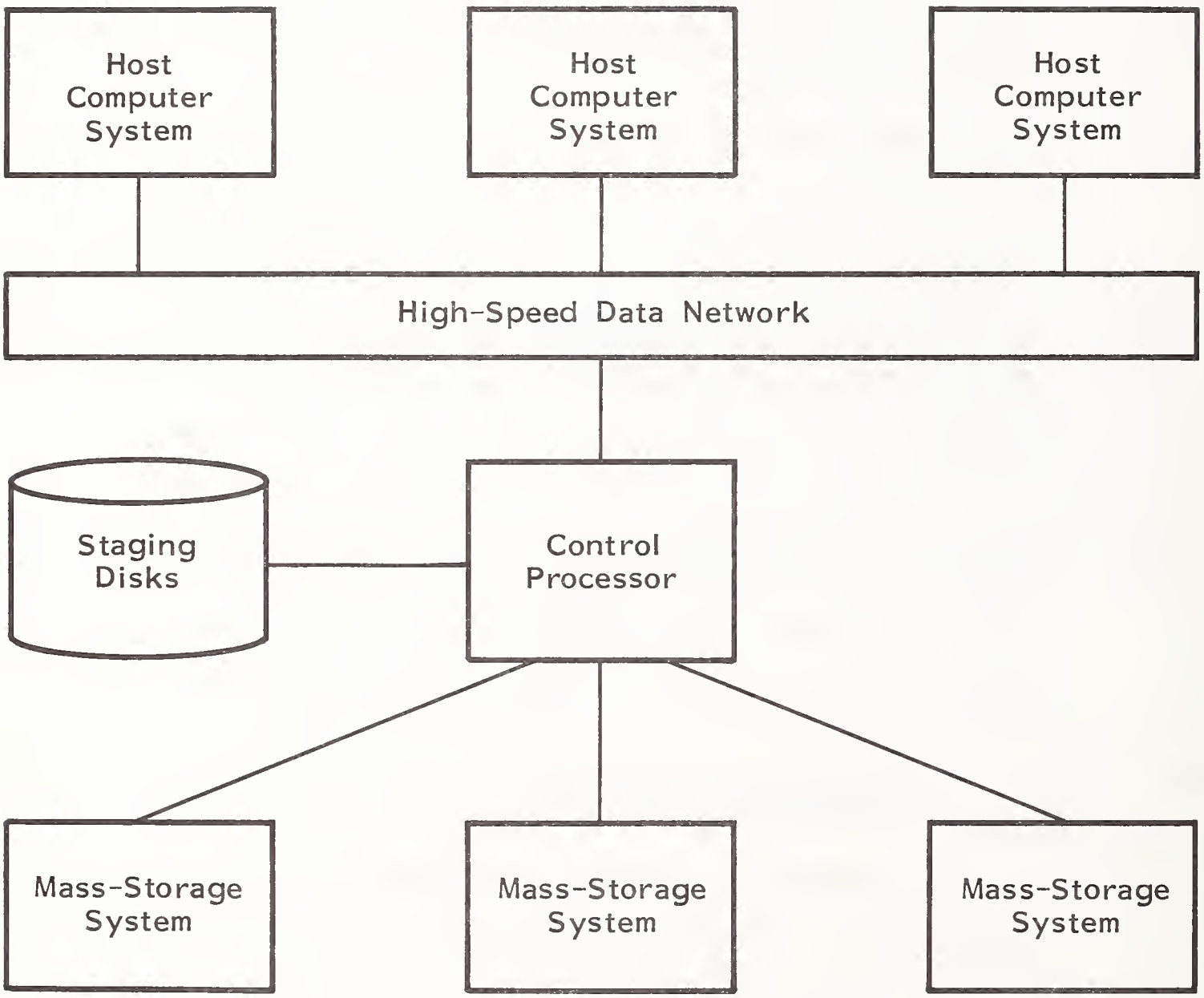
- Univac, for instance, does not have a mass storage system for direct attachment, but such a device can be utilized over a network. Other benefits include automatic, error-free data exchange between unlike processors, improved response time, and reduced space and energy requirements.

b. Virtual Storage Systems (VSS)

- The other alternative to expanded disk storage, the VSS (the so-called intelligent backend) is a centralized facility to manage extremely large collections of data. Files are stored on disk and mass storage devices connected to control processors. Subscribing host processors are linked to the control processor through a high-speed network and have access to files as if they were on local storage devices.

EXHIBIT III-19

USE OF A MASS STORAGE SYSTEM
IN A DATA NETWORK



- The VSS intelligent backend is useful in multi-mainframe computation facilities where data storage and retrieval requirements exceed the practical or physical limitations of conventional mass storage devices. Such capabilities are becoming increasingly important as modern data processing moves from a processing to a data orientation.

- This approach to storage systems has numerous advantages: it offers a self-contained storage system that is independent of host computer systems - any or all subscribing hosts may be inoperative without affecting it. It works with many hosts of various kinds, which can share access to the data at the same time. (Exclusion requests are queued and arbitrated by the control processor, which is itself an IBM-compatible mainframe running the MVS system control program.)

- Subscribing hosts are completely independent of mass storage device technology; any device that works when connected to an IBM 370-compatible mainframe can also work when it is part of the SVSS intelligent backend, regardless of the nature of the host computer systems. And it can be configured anywhere within a wide range of capacity and throughput requirements, including the use of multiple storage technologies for support to different applications.

2. OTHER DATA STORAGE DEVELOPMENTS

- Until 1979, when IBM introduced the 3370 disk drive with its thin-film heads, magnetic disk storage densities were limited to about 6 x 10 bits per inch because of the limitations of the ferrite heads and oxide media. Thin-film heads and thin-film media now promise to improve storage densities by two orders of magnitude. This advance will keep magnetic disk drives at the forefront of large-capacity file storage through the 1980s.

- The industry is beginning to cross over from ferrite to thin-film heads. A number of independent thin-film head suppliers have already announced

products. Thin-film technology, however, is being phased in slowly. Most initial products couple thin-film heads with conventional oxide media; later product announcements will incorporate thin-film media surfaces as well. Both thin-film heads and media can be expected in the high-performance disk drives of 1983-1985 and will be able to achieve storage densities of 50 x 10 bits per inch at the end of that time period. Further rounds of component enhancement should enable disk drives to remain the data storage price/performance leaders for several more years.

- After the shift to thin-film magnetics is completed, vertical recording techniques promise to enhance magnetic disks further. This approach will enable still higher recording densities by crowding bits closer together. Several techniques are likely to be employed to achieve fast access to the data on the disk. Since electromagnetic positioners cannot be made to operate much faster and still accommodate narrower track spacing, the need to move the positioner will have to be minimized. A likely solution is multiple heads per surface and multitrack heads, a combination that will enlarge the amount of data accessible at electronic switching speed without having to reposition.

- Multiple positioners will also be used, providing both seek overlap within the spindle and an alternate path to the data in case of failure. Parallel transfer of data can be expected as data rates move up past the 3-M-bytes range.

- The advent of the microprocessor, coupled with thin-film head capability, will contribute to changes in storage architecture. On the one hand, thin-film components will enable much higher capacity drives. On the other, microprocessors will help overcome the problem created by having so much data tied up on one spindle.

- The storage hierarchy will continue to evolve in terms of both storage levels and sophistication of control. The data management function will become much more complex, in both hardware and software. This implies a marked increase in the intelligence allocated to the central storage control function

and also to each individual storage device. In effect, the popular concept of distributed data processing will have its analog in "distributed storage control" - made possible by low-cost microprocessors.

- Cache memories will be used more and more to speed up effective access to data. Staging and destaging techniques will become more prevalent and sophisticated. Direct interaction between different types of storage will become more common.

- Error detection and correction, now requiring the direct interaction of the host computer, will be moved out to the disk drive/controller domain. Error-free data will be presented to the host computer without CPU involvement. This implies that the controller has the intelligence to perform the task of quality assurance as well as managing itself in the process. Additionally, data storage devices will be standalone resources that can also internally perform addressing and lookup functions within, thus freeing the computer from involving itself with device-dependent functions like physical locations. Much more responsibility will be given storage devices, particularly with the advent of distributed data processing and networks.

- Optical storage technologies have been threatening to overtake magnetic disks for decades. The appeal of optical storage is that of even higher recording densities, upwards of 1×10^8 bits per inch. The major disadvantage of optical storage to date has been the inability to erase. At present, very sophisticated error detection and correction techniques are also required, resulting in poor space efficiency and complex circuitry.

- Investment in optical storage technology continues to be made. Commercial devices, especially in large data storage applications, are considered many years off and when available will best be suited for special applications, such as archival storage and inquire-only data bases. Instead of displacing magnetic storage, optical storage technology will complement it.

- In general, several trends will continue in the 1980s.
  - Storage density will continue to double every two and one-half years in terms of bits per inch.
  - Thin film heads and media will enable rotating disk storage to keep its price/performance edge over competing technologies through the 1980s for large drives.
  - Performance increases will be made in tape drives principally to provide adequate backup for advanced new disk drives.
  - Improved data access will be accomplished via staging and the use of multiple multitrack heads rather than faster positioners and spindles.
  - Parallel transfer of data will occur by the mid-1980s as rates approach 5 M-bytes.
  - Multiple positoners per spindle will continue to be the direction for large-capacity drives.
- The result is that 8-inch Winchester vendors are concentrating on designing drives with access times in the 30-millisecond range, using voice coil actuators and providing greater capacity. These drives, geared to multiuser systems, will offer up to 200 megabytes in the mid-1980s. Recording densities for "standard" floppy drives will rise to three million bits per square inch by 1985, from the 327,000 bits per square inch on today's dual-density 8-inch drives and the 531,000 bits per square inch for minidiskettes. In bits per square inch, the Microplois 2-megabyte floppy has a 1.2-million-bit density.

3. NEW DEVELOPMENTS IN DATA RECORDING

- Recording 1 M-byte of data 25 years ago required a magnetic surface the size of a double bed. Today, 1 M-byte fits on a surface the size of a postage stamp, and in a quarter century hence, this data will fit on one facet of a grain of salt.

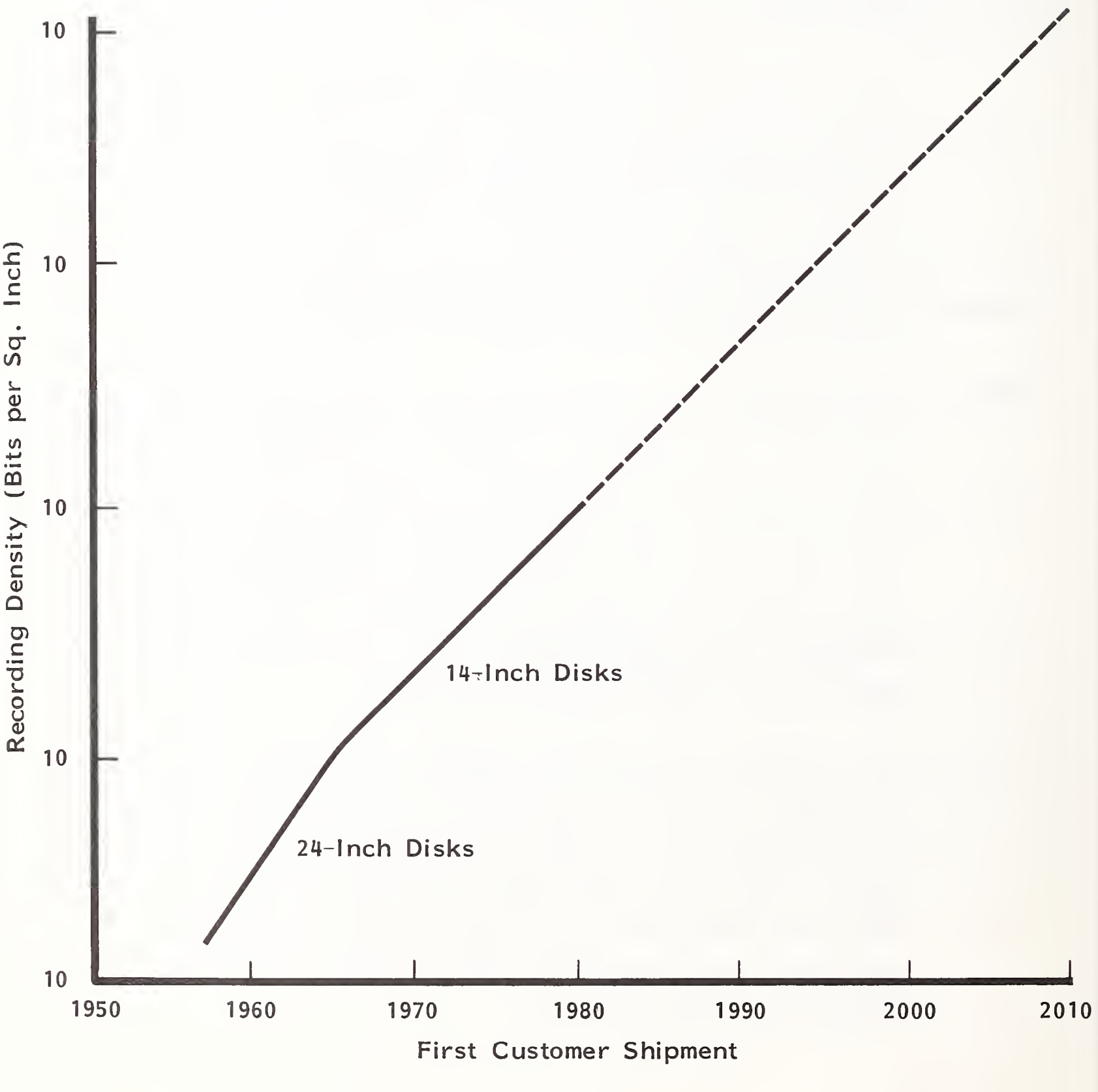
- This prediction is based on trends that reliably show continuing reductions in physical size versus data storage ratios. Independent of technology type, equipment configuration, or industry participants, data storage densities have followed a steady upward trajectory, as shown in Exhibit III-20, and there are no signs this trend won't continue. Thus, 25 years from now, there will be an estimated 3000-fold increase in storage density for random access devices, and an estimated 1000-fold increase for sequential access units.

- IBM announced its first disk storage drive more than 25 years ago in September 1956. The 350 Mod 1, conceived and developed for the 305 RAMAC system, stacked 50 24-inch disks on a spindle to achieve storage of five million characters, although the disks were not operator removable. Storing 105 bits per inch and 20 tracks per inch, the 350 started the disk recording derby at 2,100 bits per square inch. Subsequent introductions have typically doubled disk storage densities every 2-1/2 years, leading to today's 5000-fold improvement compared with 1956 performance.

- During the past 25 years, random access storage has been provided largely by moving-head magnetic disk drives. But new classes of products, first optical and then holographic, will begin to displace magnetic disks in the next quarter century. Even though these new product forms are not clear yet, storage density can be predicted by plotting past advances and extending them into the future. Coming technology shifts will keep the industry on this ever-upward ramp of recording density.

EXHIBIT III-20

RECORDING DENSITY FORECAST
RANDOM ACCESS STORAGE DEVICES



- Economics will govern the timing of these shifts. As magnetic disks reach their practical recording limits and become unable to sustain further bit-per-dollar increases, new higher density technologies will supplant them. The resulting growth in recording densities will tend to remain continuous rather than jump abruptly upward.

- Magnetic disk recording will continue to dominate the decade of the 1980s. Technological shifts to thin-film heads and media and later to vertical recording will keep magnetic disks at the leading edge of price/performance economics. Optical disks are expected to be active in the market of the 1990s and will principally service large inquire-only reference file roles.

- By the end of this century, though, magnetic recording will have reached its practical limits, and new technology will take over the role of random-access storage. The most likely choice, viewed from today's vantage point, is solid-state holography. This technique, using no moving parts, holds the promise of achieving very high storage densities that provide nanosecond data access times. Furthermore, holography will elevate storage to the page level rather than bit or word levels and thus add a third dimension to considerations of areal density (bpi x tpi). Whatever technology might take its place, however, should achieve at least the storage densities of 3 x 10 bpsi by the year 2010.

- The boundary between hard and floppy disk drives will become a war zone as diameters of rigid disks continue to shrink and capacities of floppy disk drives continue to grow. Historically, there has been a capacity gap between the two classes of drives, with each filling a different market niche. That separation is now blurring as 6-M-, 8-M-, and 10-M-byte floppy disk drives appear. Extensions of these technologies will lead to a significant overlap with low-end hard disk drives. The likelihood of 3-1/2-inch hard disk drives in the form factor of the Sony 3-1/2-inch floppy disk drive will further accentuate capacity overlap between the two classes.

- The decade ahead will witness widespread acceptance of narrow-width magnetic tape within the computer community. Both 0.25 and 0.16-inch tape cartridges will achieve significant inroads for backup and loading applications. It is, however, difficult to envision the role of 1/2-inch tape after the turn of the century; this uncertainty applies to the narrower widths as well.

- There are those who suggest that new technology products in the 2000s will blur the distinction between random- and sequential-access products. They contend that very compact, high-capacity, random-access, solid-state storage devices will sell for so little that they will obviate the need for sequential-access products. This view is probably incorrect; storage should continue to be hierarchical. Economics will continue to pull lower performance and lower cost products into the market for secondary storage.

- To summarize, random access storage recording densities will increase 3000-fold in the next quarter century. Disk technology will evolve through the 1990s and then give way to new, higher performance technology, very likely holography. Additionally, sequential-access storage is undergoing a renaissance as development funding has resumed for tape products. Recording densities will be pushed upward through the 1980s and into the 1990s, but not at a rate as fast as those for disk products.

- A technology shift should also occur in the sequential-access product area, but its nature is not yet in focus. Sequential-access recording densities will be 1,000 times greater by the turn of the century, as compared to today's technology.

4. DATA/VOICE TERMINALS

a. Integrated Voice/Data Functions

- New developmetns will take place in the implementation of data/voice technology. Data/voice terminals can be used as data terminals and telephone

stations connecting to existing or new PBXs. Newly enhanced data/voice terminals provide a number of features, including:

- Normal telephone services.
- Calendar.
- Word processing.
- Electronic mail.
- Data storage and retrieval.
- Telephone direction.
- Automatic dial.
- Voice mail.

b. Developing Ergonomic and Design Standards for CRT Terminals

- The application of ergonomics to computer terminals started as early as 1952 when IBM in Armonk (NY) established an ergonomics department in one laboratory, and by 1960 most IBM research laboratories had one. In the mid-1970s, users in West Germany began to push for better designed terminals. Today, the guidelines used by most developers of new terminals stem from that country's Trade Cooperative Association (a rough translation of Hauptverband der bewerblichen Berufsgenossenschaften eV), which in October 1980 issued safety regulations for displays in the office sector workplace.

- The major terminals design requirements of the TCA regulations, which are subject to change as technology changes, are for flicker-free displays, positive images (dark characters on a light background), nonreflecting screens, legible characters and phosphors, and low-profile, detachable keyboards (see table).

- On January 1, 1982, most of the TCA regulations became part of the West German government's equipment safety laws. The rest will become legally binding only as soon as they become technically - and presumably economically - feasible, but no later than January 1, 1985.

- To date, these laws, along with several DIN (Deutsches Institut fur Normung), VDE (Verein Deutscher Elektroniker), and VDI (Verein Deutscher Ingenieure) standards are the only binding ones to exit anywhere in the world for establishing video workplace regulations. The laws affect producers and importers of display terminals for use in West German offices (and office-like workplaces) by workers who spend their entire day operating them.

- In the U.S., most, if not all, terminal manufacturers are concerned with ease of use and safety for competitive as well as social reasons. The ergonomics subcommittee of the Computer and Business Equipment Manufacturers Association, an association of the major computer companies in the U.S., has been carrying on a dialog with the West German TCA regarding display terminal regulations.

- The association's members are interested in terminal ergonomics in two capacities - as large users as well as manufacturers - and agree with the intent and general approaches of the TCA regulations. CBEMA's main concerns as voiced to the TCA - and presumably directed also to any regulatory or would-be regulatory agency - are that any regulations or standards "be technically correct, not needlessly limit the usability of the equipment, not inhibit future improvement or development, and that any such regulations do not add cost without adding value." That concern is not unique. The realization that specific recommendations will be hard-put to stay up with the changing technology is admitted by the TCA, the Swedish occupational safety board and unions, and others worldwide. In essence, the TCA, DIN, and their standards for ergonomic design provide at least a framework in which new terminal developments will occur.

- The German Deutsche Industrie Norm (DIN) dictates that the maximum keyboard profile be less than 0.75 inch for operator comfort when the keyboard is mounted at 11 degrees to the console surface. They also demanded ergonomic (human) factors be considered. Among the ergonomic factors receiving the most attention were operator comfort and tactile feel - the "snap-over" sensation from feeling the keyswitch operating point. By mid-1982 both large and small keyboard suppliers were introducing or already manufacturing new DIN profile keyboards.

- The low-profile keyboard was developed in 1975 with a maximum keyboard height of 1-1/2 inches (bottom of the keyboard to the top of the keys) and usually employing full-travel keyswitch technology. Full-travel, low-profile keyboards incorporate long keystrokes (0.150 to 0.190 inch), which normally create an audible noise for operator feedback when the keys are bottomed.

- Although the keyboard height of the low-profile products exceeds the DIN standards, low-profile keyboards will continue to be used by customers who require medium to high volume of keyboards for rapid date entry. The three predominant keyswitch technologies associated with the low-profile, full-travel keyboard are capacitance, hard mechanical, and ferrite core.

  - Capacitance is the most popular full-travel keyswitching technology, utilizing a flexible mylar capacitor plate mounted to the bottom of the switch plunger. The switching takes place when the key and plunger assembly is depressed and the increased plate capacitance is detected by an electronic scanning circuit. This technology's higher basic electronics costs are often offset by its lower keyswitch and circuit board cost. Common applications for full-travel capacitance switching include office equipment and computer terminals.

  - Hard mechanical keyswitch technology utilizes either gold crosspoint or bifurcated wiping contacts to perform the switching function. When

the key is pushed, the attached plunger forces the SPST contacts to close. Hard mechanical switching lends itself primarily to applications requiring a lower volume cost alternative to capacitance switching.

- Ferrite core keyswitch technology offers high reliability with only a small price premium over capacitance. The heart of the switch is a linear saturable ferrite core with two preformed leads through it. The drive lead is periodically driven by a current pulse. Through transformer action, the response to the current pulse is revealed on the sense lead.

  . The magnitude of the sense response is determined by the proximity of a magnet to the ferrite core. If the magnet is close to the core (undepressed key), flux from the magnet saturates the core, restraining the sense response. As the plunger is depressed, the magnet moves away from the core and the response increases until it triggers the sensing electronics.

  . Technologies most often associated with microprofile keyboards include dome-switch, membrane, and conductive rubber. Since dome-switch and membrane are used in the most applications, they will be the focus of attention.

- Dome-switch technology consists of a stainless steel dome-shaped switch sealed to a printed circuit board. When actuated, the dome center collapses, forming a metal jumper from one set of PC board pads (at the perimeter) to a pad located at the center. The dome's inherent memory (flexibility) allows it to snap down, creating a true "snap-over" tactile feel.

- Membrane keyboards normally use conductive silver contacts and interconnections screened on two sections of thin, flexible polyester sheet. A spacer layer with contact openings or gaps is sandwiched

between the two circuits. When the graphic overlay is pressed, the upper membrane flexes downward until it touches the silver conductor, thereby closing the SPST circuit. Actuation force normally varies from two to eight ounces and the laminate assembly usually requires a rigid backing plate to prevent flexing.

- Since their introduction, microprofile keyboards and keypanels have found wide acceptance, particularly in handheld applications. Executive desktop terminals, instrumentation, PABX equipment, and telephones normally have opted for the dome-switch technology, while overlay membranes are proving popular for home consumer products, where low prices are paramount.

c. New CRT/Keyboard Technology Developments

- As new "lower profile" requirements developed in Germany are being accepted throughout Europe, mandating major and costly redesign programs to shrink the size of most full-travel keyboards, the low-profile keyboard is completely revamping the industry. Introductions of new full-travel keyboards to meet the lower price demands of terminal OEMs, the down-sized European requirements, or both, are occurring rapidly. Full-travel keyboards feature keys that move (travel) up and down like those on a standard typewriter, a vital consideration for many touch-typists who operate terminals and word processors.

- While low profile represents just a fraction of today's full-travel keyboard sales, within two years it will surpass standard profile businesses.

- The more streamlined, lower profile dimensions are recommended by the German DIN standards-writing committee on the basis of government-backed research and are strongly supported by German labor unions.

- The DIN specs allow only a maximum of 30 mm from the table top to the home row (the keys ASDFGHJKL) of the keyboard. They also call for de-

tached keyboards that can be moved and positioned on the table to suit the operator's convenience.

- Typists working on low-profile keyboards should be able to use the desktop as a palm rest more easily than on current standard profile models, on which the home row is located higher. The goal of the DIN specs is to enable typists to rest their hands and arms more comfortably, reducing fatigue.

- Lower-profile keyboards and other DIN recommendations for computer terminals are designed to improve safety and comfort conditions in the workplace by paying attention to so-called ergonomic or human factors. Most keyboard marketers believe low profile will win the majority of the business in a few years.

- The fate of full-travel membranes, which have been unveiled by a number of top keyboard firms but have yet to find widespread acceptance in the marketplace, has become a leading focus of attention as the battle of less expensive keyboard technologies heats up.

- The full-travel membranes feature moving keys but are an outgrowth of the flat membrane touch-panel technology popularized in appliances and games. A number of the first full-travel membranes to appear in the industry reportedly experienced technical difficulties, but firms currently offering the products insist that these problems have been ironed out.

- With cost-sensitive terminal and word processor OEMs increasingly pressing for less expensive keyboards, almost every major keyboard house has either added a lower-priced technology to its repertoire over the past few years, plans to shortly, or is actively considering it.

- The largest portion of future keyboard business is expected in lower-priced models, as the highly competitive terminal makers seek to cut costs, while still insisting on full movement, as on a standard typewriter. Touch-typists

have been trained to feel such movement as an indication that the keys have been struck.

- The future role of standalone keyboards, such as the microware-linked unit used in the new IBM PC Jr., is still in question. The reliability and ease of use of the concept will be extensively evaluated in the real world environment and standalone keyboards may become a future standard.

5. PRINTER TECHNOLOGY DEVELOPMENTS

- In printer technology, design and variety are responding not only to the increased potential made possible by VLSI components and the microprocessors that printers use internally, but also the technological advances in the computer systems with which they work. As individual small computers become widespread, the demand grows for hard-copy printers that are size and cost compatible with the small machines.

- Specifically, scientific instruments gaining in capability require compact, cost-effective printers that can be either built into the instrument or plugged in and interfaced handily. In data processing operations, the continuing improvement in word processing capabilities is increasing the need for letter-quality printers, while local networks with multiple standalone workstations demand lower cost printers.

- High-speed, high-performance printers have always been needed in large mainframe data processing installations, and even distributing computer installations in workstations linked by a local network won't eliminate this need. Many such networks will require the sharing of printing resources for economy's sake, especially when the local network plays the traditional data processing role. To meet such demands, printer manufacturers such as Dataproducts provide band and drum printers that can print 300 to 1,500 lines per minute.

- However, more than speed is needed in this high-end, well-established market, according to Dataproducts. With even large EDP operations heading toward distributed processing and remote batch terminal operations, some intelligence in the printer should be devoted to the task of handling remote diagnostics.

- The inclusion of word processing in computer systems, on the other hand, has brought a demand for letter quality print at reasonable prices and with less demand for high speed. For that matter, there is no compelling reason for distributed systems doing both data and word processing to have a central printing resource. In fact, as Diablo Systems observes, a drive is on to put a total package - terminal, processor, and printer - at each workstation, if it can be done at a reasonable price. High volume at the workstation is no longer the deciding factor; the main driving forces are quality and cost. In addition, speed is expected to be around 40 characters per second.

- In this applications area, the undisputed dominant technology is the daisy-wheel printer and printing terminal. Not surprisingly, daisy-wheel printer manufacturers are very actively seeking competitive edges, with great attention being paid to improving the horizontal registration or the accuracy of overstrike, which at the moment is around .007 inches, and to reducing the number and complexity of mechanical parts.

- Nonimpact printers such as the Hewlett-Packard 2680 laser printer and the Xerox 9700 electronic printing system greatly increase forms flexibility. Since such printers can store user-created character sets, logos, and the layout of the forms themselves, the system can change forms from page to page. If, say, there are too many items to fit on one page of an invoice (which contains customer address and other information in its header), the computer simply tells the printer to switch forms and print a second page consisting entirely of columns. Thus, the entire invoice can be printed without stopping.

- Dot-matrix impact printers have long held a strong position in a broad range of applications, and their capabilities approach line printers' for speed and reliability. In fact, serial matrix printers such as the Dataproducts M-200 print as many as 340 characters per second, with an average throughput of 200 lines per minute, which reaches to the lower performance end of Dataproducts' band printers.

- Microprocessor control also makes it easy for the small matrix printers to feature dot addressability, which means they can perform dot graphics - a real plus for any sort of instrumentation. Here, the functions are not lodged in the peripheral, but left to the host software because of the wide variety of possible applications and bus interfaces that printers may encounter.

- Smaller, low-cost printers come to be used even in applications that require relatively high speed, buffering, and some intelligence. The Sprinter 40 by Alphacom (San Jose, California) can print up to 240 40-character lines per minute using a 5 x 7 dot-matrix thermal mechanism. In the graphics mode, dots are handled as 280-x n matrix for reproducing a CRT display or for continuous plotting of data. The Sprinter 40 also boasts some intelligent features that can be invoked by sending the printer hexadecimal codes. These include automatic carriage return, right justification, multiple line feed, and graphic control.

- One notable development in low-cost dot matrix printers is a simplified mechanical design that features a single hammer, which strikes the ribbon over the paper while a spindle platen rotates behind.

- Dot-matrix printers have greater flexibility for graphics than do full-formed character printers, and thus lend themselves more readily to software-controlled font selection. When this flexibility must be combined with near letter quality, microprocessor control comes to the rescue again. In the Model 12/7 by Sanders Technology (Amherst, New Hampshire), the Z80 CPU controls not only the printhead and hammer strike, but also the vertical paper movement.

- Meanwhile, some potential users don't want to bother with ribbons when changing paper. For this reason, small, nonimpact matrix printers are becoming popular in such areas as medical instrumentation and low-volume telecommunications. Trendcom (Sunnyvale, California) offers the 400 and 600 desktop teleprinters, which contain a Bell 103/114-compatible modem. The printer plugs into the phone jack and the phone into the printer. In receive-only applications, the modem will answer after a predetermined number of rings and print the incoming message. For send-receive operations, a keyboard with a 4 K-byte message memory can be attached.

- Small, nonimpact printers are also being developed for applications that require the copying of data from a video display. To copy the video directly, an Axiom EX-850 video printer accepts a standard video input (either composite or separate video and sync). The information is printed out by a 24-wire matrix printhead with overlapping wires. The user can select normal or high-resolution and positive or negative images from the front panel.

D. SUMMARY AND INSTALLED-BASE SIZE AND PROJECTIONS

- In summary, the peripheral and terminal market is extremely large, complex, and fragmented from the standpoint of vendors, distribution channels, and installed base. New product and competitive developments, with respect to the major components of the peripheral equipment market, are outlined below.

1. DISK STORAGE EQUIPMENT

- There are three major classes of disk storage units:

  - Fixed, fixed/removable, and removable disk drives.

- Winchester disk drives.

- Floppy or diskette drives.

- Winchester disk technology, particularly the 5.25-inch drives, continue to be the major growth product. At present, there are close to 1,800 different disk and diskette drive products on the market, with over 250 vendors active. The fixed, fixed/removable, and removable disk drive markets tend to rely on older technology rather than the Winchester segment and have relatively low growth rates. The primary growth segment is observed for companies entering the 5.25-inch market. The older and more stable 8-inch market has not grown as rapidly.

- The growing microcomputer base has generated substantial demand for diskettes. The diskette market has grown substantially as a result of this market and has attracted more than 75 vendors, primarily producing 5.25-inch and 8-inch diskettes. In overall market terms, the Winchester disk segment represents the significant portion of the total disk market. High growth is also taking place in sub-4-inch disk drives and the established 5.25- and 8-inch drives. While the 5.25-inch size is the most popular, technological developments in the sub-4-inch area are now taking place that may provide price/performance ratios of some interest in the 1985-1987 timeframe. The installed base of approximately 22 million units is expected to grow to over 55 million units by 1986, as shown in Exhibit III-21.

2. MAGNETIC TAPE STORAGE UNITS

- Magnetic tape drive products include reel-to-reel, cartridge, and cassette tapes, with the growth areas primarily relating to cartridge drives. Expansion of the cartridge tape drive market has been triggered by the need for streaming devices and the growing popularity of start/stop cartridge devices. Both these factors will increase the size of this market. Approximately 100 com-

EXHIBIT III-21

STORAGE UNIT INSTALLED BASE
(Millions of Units, By Type)

TYPE OF UNIT	YEAR	
	1983	1986
Floppy Disks	18.2	45.3
Cartridge	0.7	1.9
Rigid Disks	2.2	8.7
Other Disk Drives	0.7	0.8
Tape-Driven	2.3	3.5
TOTAL	24.1	60.2

panies in the tape drive business are offering more than 600 products. The installed base of 2.3 million tape-driven units will grow to over 3.5 million by 1986, as shown in Exhibit III-21.

3. TERMINALS

- The terminal market continues to grow at a fairly rapid rate, with incredible proliferation of products and companies in the market. There are today over 500 different companies offering more than 1,700 different products, including display terminals, intelligent terminals, teleprinters, and special-purpose graphics and system-programmable terminals. In general, companies are entering the market more rapidly than the growth of the market, resulting in continuing price decreases and a competitive shakeout.

a. Standard Display Terminals

- Most standard display terminals support a display of 24 lines, with 80 characters per line, for a total of 1,920 characters. Some have a 25th line display for system status information.

b. Intelligent Terminals

- There are a wide variety of intelligent terminals available on the market. Intelligence is provided through 8- or 16-bit microprocessors. In general, there is a high degree of competition between intelligent terminals and personal computers, since both essentially offer the same types of capabilities and functions.

- Intelligent terminals are generally equipped with a mix of random access memory (RAM) and read only memory (ROM). Intelligent terminals and workstations include auxiliary data storage such as floppy disks and some type of line printer. Most such terminals come equipped with RS232C or RS449 ports and interfaces to modems or multiplexers. The speed and types of

modems or multiplexers depend on the volume of data generated by local applications. In general, the installed base of terminals will grow from 10 million to 22 million by 1987, as shown in Exhibit III-22.

4. PRINTERS

- There are a large number of printers available on the market today, including serial printers, line printers, and other classes of printers. Approximately 220 companies are currently in the market and offering over 1,000 printer products. The major percentage of printers available are serial printers, accounting for approximately 90% of the market. Other types of printers, including page and laser printers and printer-plotters, are also available. The installed printer base will grow from 4.8 million to 12.9 million units by 1986, as shown in Exhibit III-23.

- In summary, the peripheral equipment and terminal base represents the largest market by far, with approximately 40 million units of all types installed. This base will grow to over 90 million units by 1986-1987 and will represent the largest base by far of any class of equipment to be serviced and supported. Thus, the service and support of peripheral equipment and terminals represents both a major task and sizable opportunity for service managers in the future.

EXHIBIT III-22

TERMINALS INSTALLED BASE
(Millions of Units, By Type)

ENTRY UNITS		EXAMPLES	YEAR	
			1983	1987 (Estimate)
Non-User Programmable	Conversational Terminal	Teletype 33 DEC Writer TI 700 GE Terminet	3.7	7.0
	Editors' Terminals	IBM 3270 Teletype 40 HIS VIP	5.6	13.8
	Key/Tape or Key/Disk	Pontec MDS	0.3	0.2
User Programmable		Raytheon PTS -1200 Datapoint 1800 Four Phase IV 40	0.5	0.9
TOTAL			10.1	21.9

EXHIBIT III-23

PRINTERS MARKET INSTALLED BASE
(In Millions of Units, By Type)

TYPE OF PRINTER	TECHNOLOGY	YEAR	
		1983	1986 (Estimate)
Serial	Daisy Wheel Golfball Trimble Impact Dot Matrix Electrosensitive Thermal Ink Jet	4.3	12.2
Line	Chain/Train Belt/Band Drum Electrophotographic Impact Dot Matrix	0.4	0.7
Page	Electrostatic Electrophotographic Magnetic	0.1	0.1
TOTAL		4.8	12.9

IV NEW DEVELOPMENTS IN PERIPHERALS AND TERMINALS: SERVICE MANAGEMENT, TECHNOLOGY, AND SUPPORT

IV NEW DEVELOPMENTS IN PERIPHERALS AND TERMINALS: SERVICE MANAGEMENT, TECHNOLOGY, AND SUPPORT

A. INTRODUCTION

- Because of the very large and continuing growth in the installed base of peripheral equipment and terminals, a major issue is the question of cost-effective service delivery. While many peripheral equipment and terminals vendors have provided good service, and it is possible to get on-site field service with 24-hours response, it is clear that user service requirements are becoming more demanding.

- A number of OEM vendors rely on the systems integrators or distributors to provide field service after sale. These vendors require that the ultimate end user return the unit to a central repair depot. However, from the user standpoint, service is as critical for peripherals and terminals as for the central-unit-based processing system. Due to the growing interest in on-site responsive service, some smaller peripheral equipment and terminal vendors are beginning to use third-party organizations to provide on-site service to their customers.

- The larger system vendor organizations, particularly the mainframe-based vendors with existing large service forces and support infrastructures, such as Honeywell, NCR, DEC, and Xerox, are moving toward integrated service, a form of third-party service, for certain classes of peripheral equipment,

terminals, and personal computer-based workstations. Increasingly, the peripheral equipment and terminal user may not have much in-house technical expertise. Consequently, it is important to make these units easy to use and easy to repair.

- A major difference between the existing system vendors and many of the smaller peripheral and terminal vendors, is in the area of service. The majority of the peripheral and terminal OEMs today simply don't have the service capability to support the user. Services are essentially on a phone-in basis or mail-/carry-in basis for depot-level repair. However, it would appear that it is only a matter of time until all the peripheral and terminal vendors begin building good, reputable service organizations of their own, or enter into agreements with other third-party service organizations to supply service to customers who want and need on-site support.

- In summary, the servicing of peripherals and terminals is becoming increasingly important as a key component of the systems market. Typically, most manufacturers, other than the major suppliers and the larger, vertically integrated mainframe systems suppliers, left the area of service to third-party maintenance firms or established a small service support group as part of its marketing force.

- However, the increasingly packaged nature of the distributed-network-based system now in use requires new service capabilities, skills, and delivery mechanisms that must be managed on a cost-effective basis. In addition, the independent distributors of peripheral equipment and terminals do not appear to be providing business customers with the levels of service and responsiveness they require. Thus, peripheral and terminal vendors are searching for new, more effective methods for cost-effective service support and delivery. Some new service delivery concepts are outlined below.

B. NEW DEVELOPMENTS IN SERVICING OF PERIPHERALS AND TERMINALS

- As indicated above, a number of new developments are taking place with respect to servicing peripheral equipment and terminal units. These include:

  - Self-maintenance - In a number of larger companies using fully integrated and distributed network-based systems, particularly in high-tech processes, and those in which the systems are used in a critical on-line mode, such as in chemical companies and telephone-operating companies, the use of self-maintenance is being developed.

    . For example, a number of Bell Operating Companies have developed computerized systems for self-maintenance control and diagnostics. Dupont has developed an in-house approach to maintenance of systems and peripheral equipment used in process control applications.

    . Self-maintenance is still very limited, but may increase in the future if the quality and responsiveness of small computer systems by the vendors does not significantly improve.

  - Van repair - Some vendors are experimenting with the use of mobile vans, equipped with service technician specialists, diagnostics equipment, repair parts, and some limited test and repair capability. The "man in the van" concept is of some value in providing full service for peripheral equipment and terminals in high-density urban areas on a timely and cost-effective basis.

  - Remote diagnostics - The use of remote diagnostics, aided by portable terminals, is another concept now being developed. This involves establishment of a Technical Assistance Center (TAC) supported by technical specialists, connected via telephone either directly to the user or the user system, or through a technician-owned portable terminal, to assist in diagnostic evaluation and fault isolation.

- Improved dispatch, resource allocation, and reporting systems - A number of peripheral equipment and terminal vendors, including ITT Courier and Decision Data, have automated some portion of their call handling, dispatching, and call closeout operations to improve responsiveness, reduce lost time in call handling, and make use of data on calls (to determine how to best allocate labor and parts resources).

  . Many of these firms are also now using automated paging and/or "beeping" systems to maintain contact with field service technicians and are tracking the location of service technicians to optimize their allocation to meet customer requirements.

  . Cellular radio will in the near future (1984-1985) provide the capability for real-time control of service technicians in major metropolitan areas.

C. TYPICAL RELIABILITY AND SERVICE PROBLEMS OF PERIPHERALS AND TERMINALS

- Based upon discussions with several vendors, it would appear that the most common causes of peripheral equipment and terminal failures are directly related to their use in an office environment. Typical maintenance and service problems include:

  - Overheating - Most peripheral equipment and terminals operate in a normal room environment, rather than the controlled environment of the typical mainframe. Overheating, which decreases the circuit level MTBF, is thus a substantial problem.

  - Static electricity - Static electricity generated by touching the machine or by external electromagnetic pulses from local power lines, etc., can be a problem, particularly for small systems located in a standard office environment or near windows.

- Dirt and dust - These can be fatal to disk drives and diskettes. This is particularly a problem if the small system is utilized in a "dirty" environment, such as a warehouse or a manufacturing area.

- Local power failure - This can be a problem, particularly for small, rapidly growing offices. A power loss will wipe out some of the memory of most small computers.

- Voltage fluctuations - Lower power sources normally used for small computers vary widely, especially in urban and industrial areas. These types of fluctuations can cause particularly difficult types of intermittent problems. While a voltage regulator will protect a computer from this type of problem, it is generally expensive (i.e., $1,000 plus) when compared to small-system prices.

- Modem and phone line problems - This is a particular problem for network-based small systems or small systems tied to a central host. This is a particularly difficult problem area to isolate because more than one service unit is usually involved.

- In order to offset these types of problems, several alternatives should be considered:

  - Preventive maintenance - To identify and isolate problem areas and take action before the problem becomes serious.

  - User and operator training - Improved training both at and after installation can be extremely useful in helping system operators to recognize service problems and take appropriate self-corrective action.

  - Loaner/replacement - Another approach is to use loaners or replacements in the event of a serious or recurring service problem.

- Peripheral and terminal vendors need to develop more precise data bases that relate symptoms to causes and corrective actions by product configuration in order to develop more effective methods for rapidly identifying and isolating service problems and initiating preventive maintenance or field fixes.

- More than any other class of product, the efficient service and support of peripheral equipment and terminals requires full management of reliability and failure rate data parameters and characteristics. Of all of the installed base types of equipment in the data processing, office automation, and telecommunications market, peripheral equipment utilizes the most electromechanical technology and, therefore, is most prone to failure.

- In general, the highest failure rate characteristics can be associated with disks, tapes, and printers; all electromechanical in nature and design. On the other hand, this type of equipment is least suitable to the newer diagnostics technology. Thus, to a large extent, the servicing of the peripheral equiment must require some type of on-site service. On the other hand, due to the electromechanical nature of the technology, failure rates can be directly related to use. Thus, in many cases preventive maintenance techniques can generate significant returns since, in general, the failure rate characteristics (MTBF) of peripheral equipment is more highly predictable and amenable to more precise methods for preventive maintenance scheduling and fault diagnosis.

D. NEW SERVICE PRODUCT DEVELOPMENTS

- In addition to the above technological developments, work is being done to improve and expand service product portfolios. The developments are outlined below.

1. TIME-OF-DAY AND DAY-OF-WEEK COVERAGE

- Several vendors have increased the flexibility of being able to select time-of-day coverage, Monday through Friday, which provides maintenance service availability when the system will have its heaviest use and the greatest need for service. This service is priced at a premium beyond the standard 8-A.M.-to-5-P.M. timeframe.

- If the customer requires additional service outside the standard weekday period, it can be rendered in one of two ways selected by the customer. In the first instance, the customer pays a fixed monthly rate over the prime shift period. The customer's second option is to pay for service performed outside the standard period at an hourly rate. These service options are designed to give the customer a wider range of choice in deciding how maintenance is to be performed.

2. GUARANTEED UPTIME

- Guaranteed uptime is another feature being offered by some vendors.

3. LEVELS OF SERVICE RESPONSE

- Some firms now offer users cost-saving or premium service for different levels of response. For example, most service organizations have had only one level of response time - four-hour, same-day service - but now users can opt for next-day service and receive a 25% savings over the same-day service option. Alternatively, they can receive one- or two-hour service at a premium of 25-50% over same-day, four-hour service.

4. REMOTE DIAGNOSTICS SERVICE

- Some firms are also directly providing users with up-to-date hardware and software maintenance techniques, for example remote diagnostics. Remote

diagnostics was originally used as a phone dial-up service for consulting on hardware and software problems by field technicians. However, several companies have since expanded this use and offer self-maintenance support directly to a user.

E. SELLING, SERVICING, AND SUPPORTING NEW PERIPHERAL AND TERMINAL TECHNOLOGY

- A number of changes are taking place in the peripheral equipment and terminal market that will affect the servicing and support of these technologies and products.

1. CHANGES IN DISTRIBUTION

- Distribution of office products is changing rapidly, as shown in Exhibit IV-1. While office products were usually sold through direct sales forces or through dealers/distributors or manufacturers' representatives, the new retail and mass merchandise channels have become a major factor. New distribution channels now include:

  - Franchised nationwide and regional retail store chains such as Computerland, which has already opened over 400 stores and has plans for more than 250 more outlets in the 1983-1984 timeframe, are becoming major distribution channels.

  - Mail order houses are selling primarily dumb and intelligent terminals, printers, and floppy disk units.

  - Computer mart shopping centers, which are composed of many vendor-specific stores, are being opened. Boston's BOSCOM, scheduled to open in 1984, is planning to have up to 300 companies with permanent show-

EXHIBIT IV-1

CHANNELS OF DISTRIBUTION FOR PERIPHERAL AND TERMINAL PRODUCTS

(Percent of Units Sold - 1982, By Channel of Distribution)

DISTRIBUTION CHANNELS	EQUIPMENT/HARDWARE							
	Fixed Disks	Floppy Disks	Tape Drives	Low-Speed Printers	High-Speed Printers	Dumb and Intelligent Terminals	Graphic Terminals	Printers, Disk & Tape Supplies
Retail Stores	5%	28%	5%	15%	3%	24%	5%	20%
Independent Systems Vendor/Distributor	30	34	28	27	31	28	29	10
Local Office Products Dealer	4	4	5	10	5	2	-*	35
Direct From Manufacturer	56	30	61	48	54	46	34	27
Mail Order	1	3	1	-	5	-	4	6
Other	4	1	-	-	2	-	28*	2
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%

* CAD/CAM Vendors

rooms. A new computer mart in Dallas is also scheduled to open in 1984.

- OEM/systems houses purchase hardware in quantities and add value in terms of additional hardware and/or software before resale to the end-user market (in smaller market niches and segments).

- Existing major merchandise and general department stores - Sears, for example - have established business centers within their stores. Other stores and chains have also created computer departments for sale to the home market and industry.

- Independent retail stores, including stationery, telephone, and office products stores, are distributing copiers and other office equipment.

- Manufacturer-owned retail stores include those of IBM, Digital, and Xerox. By the end of 1983 IBM is planning to have approximately 200 IBM product centers. Tandy distributes through a massive distribution chain of over 8,000 Radio Shack store outlets.

- Other distribution channels include the existing market mechanisms, such as:

  - Manufacturers' direct sales forces.

  - Independent and manufacturer-linked distributors.

- This wide array of new and existing distribution channels is opening up new markets and creating a massive installed base of equipment that must be serviced and supported. It is clear that these distribution mechanisms will affect the future growth and needs of the market. It is, however, important to understand that these changes are not consistent across all product areas.

- As shown in Exhibit IV-1, the percentage of peripheral equipment and terminal

products sold through different distribution channels differs widely. For example, retail stores and other mass merchandise channels are primarily selling the lower end, less expensive, and unsophisticated units, while the more expensive equipment, particularly large disks, page printers, etc., tends to be sold directly by the OEM or systems integrator.

2. CHANGING USER REQUIREMENTS

- User maintenance requirements for service in support of peripheral equipment and terminal products is also changing. In general, there is a small but growing percentage of all users who do not feel that the level of hardware maintenance received is satisfactory. Surveys indicate that approximately 30% of all peripheral equipment and terminal customers are not satisfied with the current levels of service received. This is particularly true for those who use peripheral equipment and terminals for on-line applications.

- In the case of these on-line applications, users, particularly business customers, are becoming increasingly dependent on the equipment. In this regard, their service response time requirements are becoming tighter and closer to those of large systems, as shown in Exhibit IV-2. However, the quality of service as viewed by users requiring such service is not high, because the existing vendors have little capability or experience in on-site service and support, or, if they do, they have failed to recognize these changing requirements. Thus, peripheral equipment user ratings of trouble call dispatching and problem escalation is ranked lower than for other classes of products, as shown in Exhibit IV-3.

- There is also growing dissatisfaction with equipment installation planning. Again, this is due to the growing complexity and diversity of the equipment and the increasing network-based integration, resulting in problems caused due to the interface between different units. In essence, the effect of increasing integration and the growing array of features and capabilities changes user dependence on and, therefore, requirements for service and

EXHIBIT IV-2

MEAN RESPONSE TIME, BY TYPE OF PRODUCT
(Hours)

TYPE OF PRODUCT	REQUIRED	ACTUAL-PROVIDED
Large Systems	1.78	1.68
Small Systems	4.45	4.82
Peripherals and Terminals	2.80	2.70

SOURCE: INPUT User Surveys

EXHIBIT IV-3

USER RATINGS OF
SERVICE COORDINATION AND CONTROL*

TYPE OF SYSTEM	DISPATCHING OF TROUBLE CALLS	ESCALATION OF EXTENDED DOWNTIME
Large Systems	7.85	7.55
Small Systems	7.85	7.47
Peripherals and Terminals	7.60	7.40

* Scale: 1 = Worst, 10 = Best

support. This is particularly true for the product technologies that are changing most rapidly (intelligent terminals and workstations).

- As indicated above, user requirements are also affected by growing dependence on the equipment as part of daily operations. This is reflected in increasingly tight user requirements for both uptime and repair response. These requirements have been increasing particularly for terminal equipment and central mass storage units.

3. CHANGING VIEWS OF SERVICE DELIVERY MECHANISMS

- The changing technology and user requirements are, in turn, affecting user acceptance of, and interest in, alternative service delivery mechanisms.

  - Although vendors have attempted to introduce other, less expensive delivery mechanisms, most users are still oriented to the traditional method of on-site service, as shown in Exhibit IV-4.

  - While some printer users are most willing to provide direct assistance to support the repair process by changing ink supplies, making adjustments, etc., most users (particularly business customers) demand on-site service.

  - There is growing acceptance on the part of all users toward involvement with remote diagnostic centers to isolate and/or correct problems for both hardware and software.

- User service response and repair times are generally being met, even though the requirements have become stricter.

- While peripheral equipment and terminal response and repair time requirements have become tighter, some vendor service organizations have generally

EXHIBIT IV-4

USER RATINGS OF ALTERNATIVE DELIVERY METHODS

TYPE OF PROBLEM	DELIVERY METHODS					
	TRADITIONAL ON-SITE RESPONSE	CUSTOMER FIX WITHOUT REMOTE CENTER SUPPORT	CUSTOMER FIX WITH REMOTE CENTER SUPPORT	CUSTOMER REPLACEMENT WITH MATERIALS ON PROGRAM FIXES	CUSTOMER DELIVERS MODULES TO REPAIR FIXES	ON-SITE STANDBY DURING CRITICAL PERIODS
Hardware Problems	(8.3)	5.8	6.0	4.6	3.4	4.2
Software Problems	(8.1)	6.0	6.2	4.8	3.6	4.4

( ) = Preferred Delivery Method

responded well to these needs. However, others, particularly ITT Courier, Xerox, Telex, and NAS, have not responded as well to these new requirements.

4. CHANGING REQUIREMENTS FOR SERVICE MANAGEMENT AND SUPPORT

- Of greatest importance and challenge (resulting from the increasing proliferation and integration of peripherals and terminals) is the emerging requirement for overall integrated service management. Users are increasingly interested in a single organization that can handle the array of problems generated by the installed base of products supporting their operations. These requirements stem from the need to:

  - Avoid finger pointing - providing a single source of responsibility for service.

  - Provide overall management of service response and repair times.

  - Provide service cost containment.

- As an indication of this emerging requirement, an increasing percentage of users are either currently using or are considering using third-party maintenance service organizations, as shown in Exhibit IV-5. Product areas currently using third-party maintenance to some extent (30% or more) include disks, printers, and intelligent terminal workstations. It is estimated that 30% or more of intelligent terminals and workstation users are now considering third-party maintenance as an alternative to OEM vendor service.

- Service management, involving the ability to deliver total service on a controlled basis for a variety of products in the office environment, is being developed as an alternative delivery mechanism by several organizations. There appears to be interest in this concept, particularly by large users with integrated office systems composed of multiple vendor units/products.

EXHIBIT IV-5

USE AND CONSIDERATION OF THIRD-PARTY MAINTENANCE (TPM),
BY CLASS OF USERS
(Percent of Survey Respondents)

TYPE OF USER	NOW USING THIRD-PARTY MAINTENANCE	CONSIDERING THIRD-PARTY MAINTENANCE	CONSIDERING SERVICE MAINTENANCE MANAGEMENT
Large Systems	31.2%	30.9%	31.5%
Small Systems	22.5	17.3	23.4
Peripherals and Terminals	31.0	38.0	30.0

SOURCE: INPUT User Surveys

5. SUMMARY

- In summary, there are a number of new challenges being created as a result of the technological developments relative to:

  - Increasing capabilities and functions.

  - Overall integration.

  - Growing dependency on products.

  - Decreasing cost and size.

  - Increasing use of very high speed LAN and integrated voice/data PBXs to tie together peripheral equipment and terminal products in a single network.

- These challenges can be categorized in terms of:

  - Changes in distribution, creating the need to provide needed service to products sold through new mass merchandising and distribution mechanisms.

  - Changes in user requirements, creating the need to be increasingly responsive and more efficient.

  - Changes in attitudes toward alternative service delivery mechanisms, creating the need for a full portfolio of service alternatives and products to meet individual user service needs.

  - Changes in views of service management and third-party maintenance, creating the need to manage service totally and to reduce focus on specific products or on self-manufactured products only - recognizing the user's need for total management of service response.

- Changes in service needs due to the requirements of integrated, interconnected peripheral equipment and terminal products.

F. TRENDS IN SERVICE DELIVERY TECHNOLOGY

- Increasing emphasis is being placed on more effective management of service on a centralized basis. This has involved the development and implementation of computerized systems for:

1. SERVICE CALL HANDLING AND DISPATCH

- Capabilities should be provided for the centralized handling and processing of service calls, which includes identifying customers, calling up of information on equipment at the customer site, assigning service engineers, tracking calls, and closing out the call.

2. REMOTE DIAGNOSTICS/TECHNICAL ASSISTANCE

- The object is to provide capabilities for the screening and processing of received service calls, to determine the problem's cause, and to fix the problem in conjunction with the user to avoid an on-site service call. For some classes of equipment, particularly integrated workstations, this can also involve remotely diagnosing and repairing equipment via phone line interchange, or at least introducing limited hardware and/or software "patches" or fixes, until a service engineer can be dispatched.

3. ORDER PROCESSING/INVENTORY CONTROL

- This is the capability for controlling the material/logistics pipeline of whole units, components, parts, materials, and supplies from control warehouses and

depots down to and including the field engineer trunk level. Typically, these systems provide for emergency reorder, maintenance of stock levels to achieve a given fill rate, and the tracking of returns.

4. RETURN/REHABILITATION CONTROL

- Systems are now being developed independently or as an extension of basic inventory control systems to control the return/rehabilitation process and thus manage the fill-material/logistics pipeline.

5. DATA MANGEMENT AND REPORTING

- This provides capabilities for managing data associated with failure rates, response and repair times, costs, time utilization, etc. by geographic service area, product group, customer class, etc. and for providing standard and exception reports. Typically such capabilities include the ability to generate exception or alert reports if service call response and/or repair times exceed cerain thresholds.

6. INVOICING AND BILLING

- The above involves capabilities for automatically generating invoices and cost allocations based on completed installation and service calls, and is based on the ability to allocate costs by product, customer class, geographic area, etc.

7. OTHER NEW SYSTEMS DEVELOPMENTS

- Work is now being done to develop capabilities for:

  - Installation planning and scheduling.

  - Preventive maintenance scheduling.

- Changes, upgrades, and removals scheduling and planning.

- Control of service force assets, including vehicles, test equipment, loaners, etc.

- In addition to service management systems developments, major service organizations are developing technology for:

  - Automated or semiautomated board testing.

  - Controlled rehabilitation and rework systems using MRP and scheduling technology.

- Finally, considerable work is being done on the development of product-based modules for direct circuit testing and recovering, enabling modular pull and replacement in case of failure, remote diagnostic interface with central TAC or diagnostic centers via telephone, and built-in backup and recovery hardware and software capabilities via redundant or fault-tolerant circuits or self-diagnostics. These advanced techniques are usually employed in more sophisticated on-line products, such as interactive workstations and terminals, and large disk storage systems used in support of integrated system networks.

G. OTHER KEY FUNCTIONS SUPPORTING THE PERIPHERAL AND TERMINAL MANUFACTURING AND DISTRIBUTION OPERATION

- Buyers of peripheral equipment, particularly large-volume OEM and end-user purchasers, look for a number of service- and logistics-support-related factors from their vendors as part of their decision to buy. These factors, outlined below, must be considered in developing a fully comprehensive service and support strategy and implementation plan.

I. INVENTORY MANAGEMENT AND CONTROL

- An OEM buyer will look for a supplier that can manage its product inventory. These inventory-management capabilities should extend well beyond the warehousing of printers and terminals for small-volume shipments at regular intervals.

- Large manufacturers typically ship directly to system integrators in moderate volumes for arrival when required. This usually means the peripheral unit must be unpacked at the volume purchaser's location, inspected, tested, repacked, and then reshipped as an add-on or as part of a total system. The cost of storing the unit, performing the incoming quality assurance and re-shipping, can be enormous. As a result, large OEMs and other high-volume purchasers look beyond the price tag and consider inventory alternatives.

- Drop shipments are one such alternative, including shipments direct to a system integrator or regional depot location, or direct (in single or multiple volumes) to any end-user site in the country. Only peripheral manufacturers that can show a very high "installability" rate can offer drop shipments. Without an installability rate of 95% or more, many end users would receive many inoperative printers.

- A large investment in peripheral inventory and the use of drop-shipment procedures can enable a company to drop-ship a peripheral unit or model in any quantity desired within 48 hours after receipt of the order at approximately one-fourth the cost that a system manufacturer would pay to send one printer to an end user. A credible drop-ship inventory mangement program can produce average per-unit savings of more than $100 in shipping costs alone.

2. PRODUCTION CAPACITY AND SHIPMENT RATES

- The volume purchase of peripheral units will also determine whether the manufacturer can confidently maintain on-time shipments. A company that plans to ship $30 million in low-cost microcomputer systems over the next 60 days cannot afford to delay those sales, even if the peripheral unit that is causing the delivery bottleneck is a technological breakthrough. The loss of that revenue over a 60-day period can be enormous with today's high interest rates - as much as $1.8 million, or hundreds of dollars per printer.

- The system supplier also faces the risk of losing market opportunities, customers, and market credibility if an externally purchased peripheral unit causes delayed shipments. To guard against this problem, an OEM will typically ask to see the peripheral equipment vendor's manufacturing facilities and examine build and ship statistics.

3. VERTICAL INTEGRATION

- A buyer will consider whether a peripheral equipment manufacturer provides just the essential or a complete line of products and supplies. For example, when a manufacturer of printers also produces spares and supplies, the cost to the systems integrator or end-user buyer for these materials is often reduced. When the OEM buys supplies and spares in volume from a manufacturer that, in turn, has to buy these products from other vendors, the buyer faces another series of markups.

- A supplier that can offer refurbished, lower cost spares that carry the same warranty and performance levels of new parts is also at an advantage. These spares should be available by overnight mail, driving their price to the OEM even lower. A spares refurbishment program for electromechanical mechanisms can reduce an OEM's spares expenses by 40% or more - above and beyond the volume discounts that should be available. For example, depending on a printer's MTBF over a three-year period, a fully formed-character, daisy-

wheel printer, printing at about 40 cps, can consume as much as $300 in spares - if all spares are purchased new.

4. PRODUCT RELIABILITY AND LEARNING CURVES

- A peripheral unit's newness must also be considered. While a new product might offer better technology and higher quality components, it also presents new manufacturing challenges that take time to be resolved. Every new product follows a "learning curve" in its startup phase. It often can take several months for a new product to meet its intended reliability statistics. Lack of production and design maturity, which are functions of cumulative shipments and manufacturing experience, often yield MTBF statistics different from design specifications.

- A new peripheral unit or model should eventually achieve better reliability statistics than an earlier generation model, and buyers are willing to trade temporary reliability shortfalls in return for state-of-the-art technology. The buyer should know, however, the unit's maturity phase so that he can make the purchase knowing what reliability issues a new product may encounter that an older product has long since overcome. A reliability shortfall in a new or mature product, measured by MTTR, MTBF, and duty-cycle specifications, can cause unexpected costs to the buyer. For example, if a peripheral unit is expected to provide an MTBF of 2,500 hours and the figure proves to be closer to 1,000 hours, the purchaser should prepare for more frequent and more costly service expenses.

5. QUALITY AND RELIABILITY

- Quality and reliability are especially critical with the large number of vendors in the market. This intense competition means that quality levels that are acceptable today will be rejected by customers as more reliable products become available from other vendors. When evaluating vendors, prospective cutomers will look for a quality assurance program to prevent problems before

units are shipped instead of when they are in the field. Such a program considers product reliability while a unit is on the drawing boards, uses high-quality parts obtained through stringent vendor qualification, monitors assembly, and maintains effective channels for customer feedback.

- Strong post-sales support is another essential service provided by qualified vendors. Post-sales support should include easy access both to application engineers who can help integrate units quickly into new or existing systems and to technical support people who can answer questions about drive functions and performance. Comprehensive documentation is a sign of a good customer support organization.

- Other major post-sale considerations are the number of locations of a vendor's regional service center. Repair centers should be readily available, rather than requiring units to be returned to the factory for repair. Repair centers should include facilities for repair. This could be important when a system integrator or its customers want to upgrade.

6. SPARES AND SERVICE SUPPORT

- A manufacturer will also be evaluated for spare and service policies that match a system integrator's needs. An integrator should look for a vendor's commitment to stock recommended spares and to service spares in a mutually agreeable period of time. In addition, the manufacturer's ability to provide a convenient repair depot, on-site support, and assistance in establishing a repair facility are important.

7. SUPPLIES AND SPARES

- An OEM should be careful not to overlook an opportunity for better profits from supplies and spares. The retail cost of supplies alone - averaging 0.05¢ to 0.008¢ per printed page for printers - can exceed the purchase price of the printer itself. At typical industry margins of 40-50%, printer supplies provide

an excellent source of major new revenue. But superior supply revenue is possible only if the printer purchaser selects a manufacturer that can support supply requirements with a full range of supplies that are available when needed.

H. BALANCING RELIABILITY, RESPONSIVENESS, AND PRODUCTIVITY GOALS

- For a number of reasons most service and product organizations often fail to effectively balance reliability, service responsiveness, and productivity goals.

1. THE LACK OF AVAILABLE DATA ON EQUIPMENT FAILURE RATES, REPAIR TIMES, ETC.

- Most service organizations do not track or report on such key factors as mean time between failures (MTBF) and mean time to repair (MTTR) by product or cause. In addition, most service organizations do not measure service costs or productivity by product to evaluate the effect of alternative reliability levels, use of built-in test equipment, and design modularity on service repair times and productivity. As a result, even basic information on reliability, maintainability, and repairability is lacking, inaccurate, or not available in a useful form.

2. THE LACK OF FORMAL METHODS FOR RELIABILITY, REPAIRABILITY, AND MAINTAINABILITY CONSIDERATIONS IN INITIAL PRODUCT AND ENGINEERING DESIGN STAGES OF THE PRODUCT DEVELOPMENT CYCLE

- Most manufacturing organizations fail to consider the impact of design alternatives on service productivity and performance or to bring in service personnel at an early enough stage in the product design cycle to ensure an effective balance of product reliability and repairability.

3. THE LACK OF EFFECTIVE MECHANISMS FOR TRACKING AND REPORTING ON PRODUCT-, SUBSYSTEM-, AND COMPONENT-LEVEL FAILURE AFTER INITIAL PHASE-IN

- This problem of not effectively managing the product from a service standpoint is compounded due to the lack of effective mechanisms for tracking of MTBF/MTTR data for products newly phased in, or evaluating the need for engineering and design modifications and changes for products that have an unusually high field failure rate.

- In essence, there is a tradeoff to be made for each product, a tradeoff that relates price, reliability, and service supportability. For each individual product, there is a crossover point where it is less expensive on a per-product-unit basis to provide service to a product after sale in order to achieve a given uptime, than to add more redundancy to improve inherent reliability and extend the product MTBF.

- Many large service organizations, particularly in the disk, printer, and integrated workstation field, are establishing product management organizations within the service group to:

  - Track MTBF and MTTR data by product.

  - Manage product service and costs.

  - Provide direct input into new product design decisions to support the tradeoff analysis.

- In essence, it is essential to manage the product design reliability (versus service response and repairability) on a continuing basis. This requires data on product failure rates by cause and a dedicated and committed product management group to affect changes in a timely and cost-effective manner.

V TACTICAL CONCLUSIONS AND RECOMMENDATIONS

V TACTICAL CONCLUSIONS AND RECOMMENDATIONS

A. GENERAL CONCLUSIONS

- The increasing complexity, proliferation, and integration of peripheral equipment and terminals into overall information systems have made the problems of providing services more difficult and more challenging. Peripheral equipment and terminal users are growing more dependent on the equipment and are looking for:

  - More cost-effective and responsive service and support.

  - A single source of maintenance for the array of products installed, especially if the products are both integrated into a network and intended for large users.

  - Improved related support services, including improved documentation and training.

- Associated with these needs is the customer's increasing requirement for improved and controlled hardware and software maintenance response and repair times and performance. In some product areas (such as large disk storage units; large, high-capacity printers; and integrated network-based workstations and terminals) service organizations have been created and are currently managing the product. However, in other product areas, particu-

larly personal computers, there has been little recognition of the rapidly emerging service needs of the business/professional user. The general attitude of users toward key service elements, by vendor, is shown in Exhibit V-1.

- Because of the failure of many service organizations to meet user needs, there is a strong interest in the use of third-party maintenance organizations, particularly in the area of personal computers.

- An evaluation of specific service factor needs and requirements by major product area indicates that almost all peripheral and terminal users need improved installation planning and software and hardware maintenance. Other requirements that must be met include:

  - Faster controlled service response and repair time for both hardware and software maintenance.

  - Better mechanisms for parts and supplies delivery.

  - Need for "hotline" and remote technical assistance and diagnostics.

  - Significant improvement in overall service support for workstations.

  - Need for improvement in user and systems training, particularly for integrated workstations and terminals.

- The blurring of the distinction between data processing, office automation, and telecommunications will create more problems and opportunities, particularly in the short run. The deregulated ATTIS and the seven new Regional Bell Operating Companies may now begin to compete in the full peripheral and terminal market, providing the end user with new products and a new set of channels for service and support. As peripheral and terminal equipment becomes more integrated and network-related, service management and the ability to provide full service to all components of the network will be increasingly important to the user.

EXHIBIT V-1

EVALUATION OF VENDOR SERVICE PERFORMANCE†

SERVICE ELEMENTS	VENDORS											
	CDC	CENTRONICS	DECISION DATA	IBM	ITT	MEMOREX	MOHAWK	NAS	STC/ DOCUMENTATION	TELEX	XEROX	ALL
Environmental Planning	●	–	–	●	●	●	●	●	–	●	●	●
Physical Site Planning	●	–	●	●	●	●	–	●	–	●	●	●
Consulting	●	●	P	●	●	●	●	●	●	P	●	●
Documentation	–	●	–	–	P	●	●	–	–	●	●	–
Training	●	●	●	●	P	P	●	●	–	●	P	–
Installation Planning	–	0	●	●	●	●	●	–	P	●	●	P
Hardware Maintenance	●	P	●	●	P	P	–	P	P	P	P	●
Software Maintenance	●	0	0	●	P	●	●	P	●	P	P	–
Supplies Sales	0	●	P	●	●	●	●	●	P	–	●	●
Add-On Sales	●	●	–	●	●	●	–	–	P	–	●	●
Site Audits	0	●	–	●	●	●	●	●	●	0	●	●
Relocation	–	0	–	●	–	●	●	●	–	0	●	●
Deinstallation	–	0	●	●	●	●	●	●	–	0	●	●
Overall Rating*	8.0	7.7	7.6	8.0	8.0	7.4	8.0	8.0	7.4	8.1	6.6	7.7

† ● = Users Mostly Satisfied, – = Users Mostly Oversatisfied
P = Users Mostly Dissatisfied, 0 = Insufficient Data

* Scale of 1 - 10

- Third-party maintenance firms are entering the market because of the needs expressed above. This will have the effect of increasing the competition associated with service quality and responsiveness. In essence, the user will be presented with many more options with respect to service.

B. CHALLENGES TO FIELD SERVICE MANAGEMENT

- The major challenges facing field service management include:

1. DEVELOPMENT OF A FULL-SERVICE PORTFOLIO

- Customers are demanding a greater array of service products. These needs and requirements differ by market segment and product area. This is particularly true in the area of intelligent workstations.

2. DEVELOPMENT OF A STRATEGIC APPROACH TO SERVICE PRICING FOR THE SERVICE PRODUCT PORTFOLIO

- While customers are increasingly focusing on the cost of service and the full cost of ownership, it is clear that customers are willing to pay more for the services they need. Little attention has been given in the past to service pricing. In most of the product markets, service has been priced based on the industry leader. As a result, IBM has generally served as a basis for setting service prices. The effect of increasing competition from third-party and integrated service organizations will be to unbundle service prices. In essence, the development of prices for the service portfolios must be based on a full evaluation of:

  - Cost of providing service.

- Competitive prices.

- Value in use.

- As indicated above, most service organizations have failed to control or measure service costs and very few have attempted to measure customer value in use for service. Thus service prices have historically been driven by competitive prices.

- Market studies show that the user does have specific, differing value-in-use for different classes of service, depending upon the market segment and product. This data should be used in developing an efficient service pricing strategy.

3. DEVELOPMENT OF A SERVICE MANAGEMENT CONCEPT OF SERVICE OPERATIONS

- Many customers have expressed an interest in the overall management of service for their installed base of peripheral and terminal products. The development of this concept requires a total, full-service management of the service call and the concurrent development of support systems for call handling and dispatch, technical assistance, and material/logistics inventory and pipeline. Users primarily want on-site service and, while they are willing to support and work with remote diagnostics, they prefer the service organization to provide integrated response where and when needed.

4. DEVELOPMENT OF AN APPROACH TO THIRD-PARTY MAINTENANCE

- The rapid increase in third-party maintenance as a viable alternative requires that service organizations either enter the third-party service market independently or as part of a service management concept, or develop a competitive posture based on improved service quantity and responsiveness and/or price reductions.

C. RECOMMENDED ACTION PLANS TO MEET IMMEDIATE CHALLENGES

- Service management must take a number of steps to meet the immediate challenges identified above. These include the establishment of full service management capabilities, the implementation of service management systems, and the extension of service to product and market areas that are willing to pay for service.

- The recommended tactical actions required in order to respond to the needs of peripheral equipment and terminal users include:

1. ESTABLISH FORMAL SERVICE RESPONSE AND REPAIR TARGETS FOR HARDWARE AND SOFTWARE

- It is critical that the service organization establish, at least internally, specific response and repair targets that form the objectives and goals of the service force. These targets should be set and managed by market segment and product line. Actual performance should be tracked against targets to identify both overages (i.e., where the elapsed time exceeds the target's) and overkills (i.e., where the elapsed time is significantly less than target's).

- While most service organizations have established a service target for hardware response in general, there is a lack of such targets for overall elapsed time (including response time and repair time), and for software maintenance and repair. The development of these targets and specifications and the implementation of them as part of a managed, controlled system is critical to improving service efficiency and effectiveness with respect to small systems.

2. IMPLEMENT A FULLY INTEGRATED SERVICE MANAGEMENT CALL-HANDLING DISPATCH AND CONTROL SYSTEM

- Only a limited number of peripheral equipment and terminal service organizations have introduced some type of computerized assistance to support initial call handling on a regional or national basis. In fact, some small-system service organizations continue to coordinate and control service calls on a local branch or district basis, failing to make use of economies of scale or more sophisticated methods for remote technical assistance and diagnostic screening of service calls.

- An integrated call-handling and dispatch system should be implemented that is interconnected to technical assistance for remote diagnostic screening, including capabilities for software as well as hardware maintenance. In essence, it is essential to introduce a coordinated system that will manage and handle calls from reception to completion, including the screening and initial diagnostic review of all calls, thus converting the call-handling process from a simple handoff (i.e., message handling) to a managed approach for the control and coordination of the service call from point of initiation to completion. Thus, the service call requiring hardware and software assistance would be managed through the regional or national service management system to ensure that full resources are allocated and directed toward specific customer problems.

- Use of the TAC/Remote Diagnostic Center as part of every call would ensure a cost-efficient and effective response to hardware and software problems. In addition, if a part or material is required in order to successfully complete the assigned call, the parts resupply issue would also be managed and supported by the central service management system.

- In essence, most of today's systems for call handling and dispatch in small-system service organizations primarily are oriented toward initial receipt and handover of the call to a hardware service engineer for action. These systems

fail to provide overall management, including a managed approach to the coordination of hardware and software maintenance and repair, and the tracking of calls in order to ensure controlled escalation of management actions in support of software and material/logistics needs in the event that an open service call's elapsed time exceeds certain established threshold or service targets.

- It is specifically recommended that such a more managed systems approach be introduced at the regional and national level to ensure that the full resources of the service organization are appropriately directed and managed with respect to the arrival of individual service calls.

3. INTRODUCTION OF PRODUCT MANAGEMENT FUNCTION

- The third tactical action points to the creation of a product management function within the field service organization, involving the establishment of a product management group within the staff of the planning organization or as part of the technical assistance and support group of the field service organization. This product management group's responsibility would be primarily to collect, analyze, evaluate, and manage the failure rate and repair time data associated with individual products and to provide a technical interface between marketing, engineering, manufacturing, and the overall product management function, with respect to the design/reliability tradeoff in the introduction of new products, engineering redesign, and phaseout of the existing products.

- In essence, the service product manager would be concerned about the management of total service support for the life cycle of the product. For the products under his direction, the product manager would provide continuing monitoring, analysis, and evaluaton of product failure rates and repair times, and service and support characteristics. The service product manager would also act as a responsible interface for new product introduction, particularly relating to the determination of the tradeoff as to the level of reli-

ability and maintainability to be built into the product, versus the cost of after-sales support.

4. OTHER TACTICAL/STRATEGIC INITIATIVES

- Other initiatives that could be considered tactical or strategic in nature should be developed in response to the above trends. These initiatives are outlined below but discussed in more detail in the strategic analysis and evaluation.

a. Third-Party Maintenance

- Using its existing installed base, the field service organization should seriously consider possible entry into the third-party maintenance market. As indicated above, a significant trend exists with respect to the utilization of peripheral equipment and terminals in support of large network-based distributed data processing systems and equipment. Under such a scenario, mini- and microprocessor systems, personal computers, intelligent terminals, and other peripheral equipment will have to interface with large systems acting as host, network coordinator, and data base manager.

- Thus, it will become increasingly important for the service organization to be able to provide service to the other elements of the network to avoid finger pointing and to allow the user to deal with a single service organization. The inability of the field service organization to provide full (third-party) maintenance on other elements of the network could lead to a competitive disadvantage against full third-party maintenance organizations attempting to provide total service management capability. Thus, the entry into the third-party maintenance market represents a defensive move tactically and a strategic move from an opportunity standpoint.

b. Development of the Service Management Concept

- Related to the third-party maintenance, but an independent tactical and strategic thrust, is the development of the new integrated service product dealing with the management of the total service required in an office or business environment of a particular user. Management of the full array of service required in the total office environment, including office automation, telecommunications, and data processing equipment, will become increasingly offered by service organizations as part of a new innovative approach to creating a totally integrated service portfolio.

- Here again the service organization supporting small systems should view the creation of a service management product as both a tactical defensive move to avoid losing business and a strategic offensive move to gain business.

- Both third-party maintenance and service management will be discussed as part of the strategic recommendations for action.

D. RECOMMENDED ACTION PLANS

- In summary, the tactical recommendations based upon the key technical, marketing, and user requirements and trends discussed above include:

1. DEVELOPMENT OF A STRATEGIC APPROACH TO SERVICE PRICING FOR THE SERVICE PRODUCT PORTFOLIO

- While customers are increasingly focusing on the cost of service and the full cost of ownership, it is clear that customers are willing to pay more for the services they need. Little attention has been given in the past to service pricing. In most of the product markets, service has been priced based on a percentage of acquisition price. As a result, the small-system user has been

given a lower level of service, reflecting the lower purchase cost. The development of a full-service portfolio and different levels of service for different markets and products (i.e., fault-tolerant systems, remote diagnostics systems, etc.) requires a new approach to service pricing. In essence, the development of prices for the service portfolio must be based on a full evaluation of:

- Cost of providing service.

- Competitive prices.

- Value in use.

- Most service organizations have failed to control or measure service performance against specified hardware and software response targets and costs, and very few have attempted to measure customer value-in-use for service. Thus service prices have historically been driven by the percentage-of-acquisition-price standard. However, market studies show that the user does have specific, differing value-in-use for different classes of service, depending upon the market segment and product. This data should be used in developing efficient service pricing strategies and tactics.

2. DEVELOPMENT OF A SERVICE MANAGEMENT CONCEPT OF SERVICE OPERATIONS

- All classes of users have expressed an interest in the overall management of service for their installed base of office automation and data processing products. The development of this concept requires complete management of the service call and the concurrent development of support systems for call handling and dispatch, technical assistance, and material/logistics inventory and pipeline.

- Users primarily want on-site service and, while they are willing to support remote diagnostics, they prefer the service organization to provide integrated response where and when needed. Users are much less interested in delivering a module to a service center or in paying for on-site standby support that has not been requested.

3. DEVELOPMENT OF AN APPROACH TO THIRD-PARTY MAINTENANCE

- The rapid increase in third-party maintenance as a viable alternative requires that service organizations either enter the third-party service market independently, enter it as a part of a service management concept, or develop a competitive posture based on improved service quality and/or price reductions.

- In summary, service management must take a number of steps to meet the immediate challenges identified above. These include the establishment of full-service management capabilities, the implementation of service management systems, and the extension of service to product and market areas willing to pay for service. A summary of recommended tactical actions is presented in Exhibit V-2.

- Service and support of peripherals and terminals represents a significant area of concern and opportunity because of the increasing use of computer-based systems and technology in on-line, real-time applications involving direct user interfacing. These applications are more sensitive to the failure of peripheral equipment and are becoming much more distributed. Peripheral units and terminals are increasingly used outside of the normal data processing center operating environment, in a less friendly operating environment, while at the same time involving users who are less skilled and sophisticated with respect to identifying, evaluating, and recovering from partial or complete unit failure.

EXHIBIT V-2

RECOMMENDED TACTICAL ISSUES AND CONCLUSIONS FOR PERIPHERAL AND TERMINAL SERVICE

KEY TRENDS AND FACTORS	IMMEDIATE CHALLENGES TO FIELD SERVICE ORGANIZATIONS	SHORT-TERM ACTION PLANS 1984-1985
Growing integration of office automation products	Service full product array without finger pointing	1. Establish service management capability and function 2. Expand technical skills and parts availability at field level
Increasing complexity and sophistication of equipment	Improve ability to identify hardware and software problems and provide rapid response	1. Implement remote diagnostics/technical assistance center hot line 2. Improve support and user documentation
Increasingly tight response and repair time requirements due to growing dependence on equipment by user	Manage and control service response and repair by targets in accordance with contractual guarantees and agreements. Avoid "over" or "under" servicing	1. Implement computerized systems to manage and control: • Call handling and dispatch and • Logistics/supply Based on management-set targets and objectives
Wide range of choices due to increasing numbers of vendors and products	Provide consulting and technical assistance as part of initial sales/service decision -- place increasing emphasis on service quality and responsiveness	1. Establish technical consulting assistance and installation support planning services 2. Provide service on a formal basis for a price
Increasing concern over service cost containment	Develop innovative pricing for product portfolio - targeted by market segment	1. Establish full product/price portfolio 2. Evaluate current service prices
Increasing use of local-area networks (LANs) to integrate individual office automation products	Provide ability to service and support LAN technology as part of product services	1. Expand technical capabilities to support LAN technology 2. Offer LAN service and support
Increasing dissatisfaction with services offered by OEM vendors and retail distribution channels	Expand national service, and back up retail/mass merchandise channels to provide integrated service support when required	1. Offer national call handling and technical assistance support to back up local retailers 2. Provide full service at a price for those segments requiring service on-site

- What is more important is the general trend toward utilizing peripherals and terminals as part of a fully distributed network involving mixed vendor equipment configurations and complex communications interactions that may generate apparent failure problems. Peripheral equipment and terminals are becoming much more sophisticated and, at the same time, less expensive. These factors all contribute to making the job of delivering cost-effective, responsive, and quality service in the peripheral equipment and terminal area a difficult and demanding one.

VI STRATEGIC CONCLUSIONS AND RECOMMENDATIONS

VI STRATEGIC CONCLUSIONS AND RECOMMENDATIONS

A. GENERAL CONCLUSIONS

- Significant changes are taking place in the peripheral and terminal service market as a result of product and technological developments, increased price and product competition from large mainframe-based networks and PCs, and the growing use of, and dependence on, peripherals and terminals as part of day-to-day activities. Users are interested in improved, responsive, and total service to meet their needs. The key long-term trends that will affect service in the long run include:

  - The full integration of peripheral and terminal products as part of a full network system.

  - The rapid obsolescence and reduced life cycle of the existing installed base.

  - The growing dependence of the user on the system, placing greater focus on responsive service.

  - The increasing complexity and sophistication of the individual types of equipment as a result of embedding more application-oriented software.

- The growing use of hierarchically structured mass memories and high-speed printers.

- These trends will create challenges and opportunties for services management, particularly those companies that are organized as separate profit center lines of business.

B. NEW LONG-RANGE SERVICE OPPORTUNITIES

- Major opportunities created by these trends and changes are summarized in Exhibit VI-1. There are significant long-term opportunities being created in terms of the servicing of obsolete equipment, the ability to provide total service management, and the extension of service products.

C. RECOMMENDATIONS FOR LONG-TERM ACTION

- The major trends and factors that lead to both challenges and opportunities are also summarized in Exhibit VI-2. Recommended long-term action programs to meet these challenges and opportunities are also shown.

- In developing a long-term strategy to meet field service needs in small systems, it is important to recognize that several major changes are taking place that will affect both the customer service organizations of small-system vendors and the third-party maintenance organizations focusing on the small-systems marketplace. These factors relate to:

  - The significant trend toward the integration of individual units through local-area networks. To a large extent, we will see emerging two classes of small-system users: those operating as part of large, integrated networks and those using only small, individual standalone units.

EXHIBIT VI-1

MAJOR SERVICE OPPORTUNITIES

- Service and Support of Older Peripheral Equipment and Terminals
  - Maintenance and Repair
  - Moves and Upgrades
- Service Management of Integrated Systems
  - Installation of Multiple-Vendor Equipment
  - Maintenance and Repair of Multiple-Vendor Equipment
  - Moves, Upgrades, and Changes to Systems
- Full Service and Support of Printing Equipment
  - Control Over Service - Printers are Now Used in a Distributed Environment, Outside of the Data Processing Center
  - Supply of Materials (Paper, Toner, etc.)
  - Preventive Maintenance
- Service and Support of Local-Area Network (LAN)-Based Integrated Systems
- New Service Products Markets For:
  - Training
  - Documentation
  - Parts and Materials Supply
  - Software

EXHIBIT VI-2

STRATEGIC ISSUES AND CONCLUSIONS

MAJOR TRENDS AND FACTORS	LONG-RANGE CHALLENGES TO FIELD SERVICE MANAGEMENT	STRATEGIC OPPORTUNITIES	RECOMMENDATIONS FOR LONG-TERM ACTION PROGRAM, 1985-1988
Integrated office systems combining data processing, word processing, and telecommunications functions. Growing importance of service in purchase decision as products become increasingly commodity-like and life cycles shorten. Need for integrated, single source of service; especially in connection with fully integrated network-based office automation systems.	• Establish service as a separate line of business in support of general office automation technology. • Develop a full-service organization to produce a full array of "products" for the office environment, including: – Installation and site planning – Installation – Hardware maintenance – Software maintenance – Moves and changes – Upgrades/configuration changes – Documentation – Training – Parts/supplies – Consulting – Other support service	• Service as a separate revenue- and profit-generating line of business. • Service management as a framework/ concept for managing and delivering support.	• Establish full profit center service operation with supporting marketing, product and business planning, and financial/accounting functions. • Define full-service product portfolio. • Expand into third-party maintenance for those products under the service management umbrella.
Need for a comprehensive portfolio of services to support all aspects of after-sales support, including training. Need for establishment of a strategic pricing approach by market segment.	• Implement a comprehensive system to manage and control service as a business, including: – Installation planning and scheduling – Call handling and dispatch – Preventive maintenance scheduling – Technical assistance/remote diagnostics – Order processing and inventory control – Data base management – Reporting – Invoicing & cost accounting • Provide service portfolio customized to meet needs of individual market segments and niches. • Base pricing on evaluated combination of cost, competition, and value in use.	• Management and control of service delivery, responsiveness, and quality to meet customer needs at a profit. • Increase profit margins and return on investment from service-based activities.	• Collect and allocate data on costs and revenues from individual products as a basis for service pricing. • Implement remote diagnostics and technical assistance centers accessible via a national 800 number. • Measure customer needs, requirements, and performance on a continuing basis. • Develop accurate data on MTBF and MTTR as a basis for new product planning. • Implement integrated system for service management control with common data base.

- The growing importance of ensuring that the equipment installed is available when and where required, placing greater emphasis on the need for service management and the provision for a totally integrated service support effort after initial sale.

- Increasing customer focus on cost containment and the provision of reliable, quality service.

- These trends all point toward a need for a comprehensive, integrated strategy that provides for the management of the service function from the point of sale to full after-sale support, including all the associated products, such as:

  - Site and installation planning.

  - Installation.

  - Hardware maintenance.

  - Software maintenance.

  - Documentation.

  - Training.

  - Supply and parts sales.

  - Moves and changes.

  - Upgrades.

  - Environmental and operational audits.

- Consulting and support services.

- Deinstallation/removal.

- In essence, the user will look toward the service organization for the full array of after-sale needs. Larger organizations and users with a full array of products on an integrated systemic basis have a growing interest in those service organizations that can provide a total service management approach and offer the ability to control service on a regional and nationwide basis, with a full commitment to response and repair times, and to providing quality service and after-sale support.

- It would also be necessary for those service organizations wishing to participate significantly in the service and support of peripheral equipment and terminals to establish integrated computerized systems to manage and control full service/processing, including call handling and dispatch, remote diagnostics and technical assistance, management of the data base relating to customer installed base and configuration, and management and control of the logistics pipeline.

- Finally, the service organization must develop a comprehensive, strategic portfolio of service products and develop a service pricing approach strategy that is responsive to both the cost containment interests of certain market segments and the need for highly responsive and quality service for other market segments.

- The size and growth of the peripheral and terminal market and the need for integrated service will tend, in the long run, to create significant economies of scale and efficiencies in large, nationwide service organizations servicing an extensive installed base.

- For those organizations with large service forces and a developed service management infrastructure, basic prices for after-sales service and standard

basic prices for installation, maintenance, and repair will drop. These organizations are currently providing installation service at approximately 15-30% of acquisition price, and after-sales maintenance at approximately 8-14% of acquisition price annually.

- This will place the smaller service organizations attempting to provide national service for small-system products at a competitive disadvantage and will undoubtedly cause less efficient service organizations either to grow through entry into the third-party maintenance market, or to be divested and acquired by other service organizations that can offer quality service at an economically efficient price.

- In summary, the primary strategic challenge to service managers in the small-systems market is to achieve economic and controlled growth through the introduction of integrated service products and the implementation of effective advanced management systems to manage and control the full-service process and to maintain tight controls on costs, levels of responsiveness, and service productivity. It will also be critical to introduce market-segment-oriented, value-in-use pricing to enable appropriate return on investment and operating margins.

- For users of peripheral and terminal equipment, third-party maintenance organizations will offer an attractive alternative, particularly those national third-party service organizations that have established integrated systems to manage and control service dispatch and provide technical assistance, remote diagnostics, and software hotline support.

APPENDIX: QUESTIONNAIRE

A. General Management

1. Please check all of the direct services you currently offer or plan to offer in the near future..

DIRECT SERVICE OFFERED	1983	BY 1985	BY 1987
a) Third-party maintenance			
b) Facility maintenance management			
c) Guaranteed availability (uptime)			
d) Guaranteed response time			
e) Guaranteed repair time (hardware)			
f) On-site standby			
g) Variable shift coverage (versus fixed schedules)			
h) On-site spares			
i) Guaranteed turnaround on software repairs			
j) Remote diagnostics			
k) Preventive maintenance and field changes during nonprime hours			
l) System software maintenance			
m) Application software maintenance			
n) Depot maintenance (pickup)			
o) Depot maintenance (carry/mail)			
p) Local area network maintenance			

2. Please check the ancillary services your field service organization offers or plans to offer in the near future. Also, for those services you currently provide, please indicate the level of quality you believe that your users would give you. (Scale of 1-10: 10 = excellent, 5 = average, 1 = very poor.)

ANCILLARY SERVICES OFFERED	BY 1985	BY 1987	1983	ON A SCALE OF 1-10, USERS WOULD RATE YOU
a) Environmental planning				
b) Physical site planning (layouts)				
c) Consulting services (hardware)				
d) Consulting services (software)				
e) Customer training				
f) Installation management and coordination				
g) Supplies sales				
h) Add-on sales (additional equipment)				
i) Upgrade sales (new equipment or features)				
j) Site audits				
k) Facility relocation				
l) De-installation				
m) Software sales				
n) Ancillary equipment sales and service				

3. How do you rate your field service organization in the following categories, and how do you believe your users would rate you in the same categories? (Scale 1-10: 10 = excellent, 5 = average, 1 = very poor.)

CATEGORIES RATED: (service over the past 12 months)	RATING (1-10)	
	SELF RATING	EXPECTED USER RATING
a) Management's communication with users		
b) Hardware service engineer's communication		
c) Software service engineer's communication		
d) Ability to diagnose hardware problems and to make quality repairs		
e) Ability to maintain software		
f) General responsiveness of the organization to user requirements		
g) Overall service image		
h) Taking initiative to improve user operations		
i) Resolution of invoicing disputes		
j) Dispatching trouble calls		
k) Escalation procedures during extended outages		

4. Please either respond to the following questions or provide us with a functional organization chart (space is provided on the reverse side of this page for your sketch if that is more convenient for you).

FUNCTION	(√) IF NOT FS	TITLE	REPORTS TO (title/function)
a) Top-level field service executive			
b) Top-level domestic line executive			
c) Top international line executive			
d) Field support, general			
e) Field support, hardware			
f) Field support, software			
g) Financial operations			
h) Administration			
i) Logistics			
j) Operations analysis			
k) Education			
l) Personnel			
m) Field service marketing			
n) Engineering liaison			
o) OEM liaison			
p) Legal			
q) Other _____			
r) Other _____			

5. Lower level management and employees are encouraged by some companies to participate in the following activities. Please check those that apply now and in the near future for your company. (Enc. = Encouraged, Mand. = Mandatory.)

ACTIVITIES	1983		1985		1987	
	ENC.	MAND.	ENC.	MAND.	ENC.	MAND.
a) Making good-will calls on users						
b) Selling maintenance contracts						
c) Accompanying sales personnel on sales calls						
d) Attending sales meetings						
e) Furthering formal education						
f) Making public appearances						
g) Joining organizations such as AFSM, Jaycees, etc.						
h) Reading trade journals						
i) Other _____						
j) Other _____						
k) Other _____						

B. Field Support/Product Support

1. Please rate the trends of the influence of your field service management in the following company activities relative to peripherals and terminals. (Scale of 1-10: 10 = excellent, 5 = average, 1 = very poor.)

ACTIVITIES	RATING (1-10)		
	1982	1983	EXPECTED 1984
a) Product specification			
b) Product design			
c) Serviceability design			
d) Documentation			
e) Diagnostic development			
f) Selection of test equipment			
g) Spares requirements			
h) Geographic control of sales			
i) Exceptions to standard maintenance agreements			
j) Product performance objectives			
k) Quality control in manufacturing			
l) OEM acceptance criteria			
m) Customer education			

2. As it relates to servicing attached peripherals and terminals, please indicate the level that software support has been or will be integrated into the hardware support structure. (0% = no field service responsibility, 100% = fully integrated responsibility.)

SOFTWARE SUPPORT ACTIVITY	PERCENT INTEGRATED			
	1982	1983	1985	1987
a) System control programs at headquarters support level	____%	____%	____%	____%
b) System control programs in the field	____	____	____	____
c) Compilers and system utilities at headquarters	____	____	____	____
d) Compilers and system utilities in the field	____	____	____	____
e) Applications software developed, sold, or distributed by your company - headquarters support	____	____	____	____
f) Applications (as in "e" above) in the field	____	____	____	____
g) Maintenance of third-party software, including user's, at headquarters level	____	____	____	____
h) Maintenance of third-party software in the field	____	____	____	____

3. Please describe your field support or support center structure as it relates to:

a) User support requirements when users are involved via remote diagnostics.

b) User support requirements when users are assisted through preliminary stages of problem determination.

3. (Continued)

   c) Support of on-site field personnel via telephone and/or remote diagnostics.

   _____

   _____

   _____

   _____

   _____

   d) Physical, on-site support to field personnel (please discuss criteria):

   _____

   _____

   _____

   _____

   _____

4. Please provide the objectives and actuals in product performance for the most active peripherals and terminals serviced by your organization.

MODEL NUMBER OR NAME OF MAINFRAMES	MEAN TIME TO REPAIR (hours)		MEAN TIME BETWEEN FAILURES (hours)		AVERAGE AVAILABILITY (percent)		MEAN TIME TO RESPOND (hours)	
	OBJ.	ACT.	OBJ.	ACT.	OBJ.	ACT.	OBJ.	ACT.
a) _____								
_____	____	____	____	____	____	____	____	____
b) _____								
_____	____	____	____	____	____	____	____	____
c) _____								
_____	____	____	____	____	____	____	____	____
d) _____								
_____	____	____	____	____	____	____	____	____
e) _____								
_____	____	____	____	____	____	____	____	____

5. Please check the following items that apply in your field support organization (even if applicable to only one product currently serviced in the field). If not presently implemented, please indicate year scheduled.

	CURRENTLY IMPLEMENTED? YES/NO	YEAR SCHEDULED
a) Remote diagnostics	_____	_____
b) Centralized dispatching	_____	_____
c) Modular, plug-in units for user to deliver to repair centers	_____	_____
d) Real-time incident reporting	_____	_____
e) Real-time IR (parts usage included)	_____	_____
f) Signature analysis (field)	_____	_____
g) Regional repair centers	_____	_____
h) Third-party repair centers	_____	_____
i) Third-party on-site maintenance	_____	_____
j) User support centers	_____	_____

6. a) What has been the trend in your capital investment in peripherals and terminals spare parts inventories for the years indicated below? Please respond by percentage of gross service revenues derived from support of peripherals and terminals.

YEAR OF MEASUREMENT	PERCENT OF GROSS SERVICE REVENUES FOR YEAR
1981	_____ %
1982	_____ %
1983 (most recent inventory)	_____ %
1984 (projected)	_____ %
1985 (projected)	_____ %

b) To what most significant factors do you contribute the changes, i.e., growth of installed base, regional spares depots, regional repair centers, reliability of new products, etc.?

Comment: _____

_____

_____

_____

_____

7. a) Have you announced or have you set a policy on the maintenance and support of local area networks serving competitive products? Yes/No_____

   b) If yes, please comment on your position.

   _____

   _____

   _____

   _____

   _____

   _____

   c) If no, do you have any general comment on the subject of local area networks without making a policy statement?

   _____

   _____

   _____

   _____

   _____

   _____

   _____

C. Financial/Administrative Operations

1. How do you measure changes in field service productivity when measuring the effectiveness of changes in operating methods or investment in capital improvements?

MEASUREMENT METHOD:	YES/NO
a) Ratio of gross revenue carried per field service person per month	
b) Ratio of personnel to equipment by category of equipment	
c) Ratio of personnel to management	
d) Net ratio of expenses to revenue after cost of improvement	
e) Other	

2. What levels of productivity have you realized in servicing peripherals and terminals for the following? (Please classify measurement using a-e in question 1 above.)

IMPROVEMENT	MEASUREMENT METHOD (a-e)	PRODUCTIVITY IMPROVEMENT (percent)
a) Remote diagnostics		
b) Repair centers		
c) Regional parts depots		
d) Centralized dispatch		
e) Support centers		
f) Field education		
g) Cross training		
h) Multiple territory assignments		
i) Other		

3. Please indicate the percentage of total operating revenues credited to the field service division coming from the following categories. (If fiscal is different from calendar, please supply FY dates.)

SOURCE OF REVENUE CREDITS	PERCENT OF TOTAL REVENUE		
	1982	1983	1984
a) Equipment warranty credits	%	%	%
b) Basic period contracts for maintenance			
c) Extra shift premium			
d) Time and material (labor)			
e) Time and material (parts)			
f) Third-party contracts			
g) Installation charges			
h) De-installation charges			
i) Technical consulting			
j) Management consulting			
k) Parts repairs			
l) Parts sales			
m) Supplies sales			
n) Sales of ancillary equipment			
o) Maintenance of ancillary equipment			
p) Sales of software products			
q) Maintenance of software products			
r) Revenues from other divisions			
s) Other _____			
t) Other _____			
u) Other _____			

4. Please indicate the percentage of total field service division expenses in the following categories (and supply FY dates if different from calendar year).

EXPENSE LINE ITEM	PERCENT OF TOTAL EXPENSES [use ( ) to indicate credit]		
	1982	1983	1984
a) Basic direct labor, wages, salaries			
b) Direct labor overtime shift premiums and standby pay			
c) Support personnel salaries			
d) Management and administrative salaries and premiums			
e) Benefits programs			
f) Net parts usage			
g) Inventory variances			
h) Depreciation			
i) Travel (includes auto leases)			
j) Relocation			
k) Education			
l) Equipment rental/lease			
m) Office, warehouse space			
n) Communications			
o) Interdivisional transfers			
p) Logistics, repair depot, and other expenses not reported above			
q) Corporate general and administrative allocation (overhead)			
r) Other significant categories			
_____			
_____			

5. Please check any of the following interdivisional transfers of revenues and expenses between your field service division and other departments, and indicate whether they are treated as revenue or expense items by checking the appropriate columns. (Check all columns that apply.)

INTERDIVISIONAL TRANSFERS OF ITEMS	REVENUE (FE)		EXPENSE (FE)	
	CREDIT (✓)	DEBIT (✓)	CREDIT (✓)	DEBIT (✓)
a) Warranty of equipment				
b) Spare parts used during warranty				
c) Direct labor during warranty				
d) Sales assistance				
e) Maintenance sales commissions				
f) Manufacturing assistance				
g) Engineering assistance				
h) Extended warranties				
i) Nonstandard contract terms, e.g., on-site engineers				
j) Defective spare parts				
k) Sales changes to equipment				
l) Saftey changes				
m) Engineering changes				
n) Other _____				
_____				
_____				

6. Please supply the figures as indicated for your overall financial performance (indicate fiscal year if different from calendar year).

FINANCIAL PERFORMANCE	FISCAL YEAR END _____			
	1982	1983	1984	1987
a) Field service revenue ($ millions)				
b) Field service expenses ($ millions)				
c) Pretax profit (percent)				
d) Revenue per field service engineer (direct labor)				
e) Direct expense per field service engineer (direct labor)				
f) Fully burdened expense per field service engineer (direct labor)				
g) Basic hourly rate charged for service				
h) Fully burdened field service expense per field service employee (all categories)				

7. Please comment below on service to remote customers: zone charges, response times, etc.

a) Zone definitions:

Primary zone 0 – ___ miles

Zone 2 ___ – ___ miles

Zone 3 ___ – ___ miles

Other criteria: _____

b) Zone premiums added to basic maintenance charges: _____

c) Response time targets for zones: _____

d) Other comments: _____

8. a) Please describe the methodology your company uses to set maintenance prices (percent of purchase tested against cost of service projection, etc.):

_____

_____

_____

_____

_____

b) At what ratio of basic maintenance price to list price do you believe that:

	PERIPHERALS	TERMINALS
i) Users will actively consider alternative sources	____%	____%
ii) Users will definitely contract third party or maintain own equipment	____%	____%
iii) Users will refuse to buy the original product, given the option	____%	____%

c) How frequently have you and do you expect to change prices of maintenance for:

	FREQUENCY OF CHANGE (months)			
	1982	1983	1984	1985
i) Peripherals	_____	_____	_____	_____
ii) Terminals	_____	_____	_____	_____
iii) Basic hourly rates	_____	_____	_____	_____
iv) Shift differential	_____	_____	_____	_____

d) Do you offer discounts for:

	PERCENT DISCOUNT
i) User assistance in remote diagnostics	____%
ii) User replacement of plug-in modules or units	____%
iii) User delivery of plug-in modules or units to repair center	____%
iv) Relaxed requirement on response time	____%
v) User purchase of spare parts kits	____%
vi) Other: _____	____%

9. Contract administration:

a) Are your maintenance contracts: (i) automatically renewed_____or (ii) negotiated each renewal cycle?_____

b) What is the length of your normal contract?_____(months)

c) Do you normally invoice (i) monthly_____, (ii) quarterly_____, (iii) semiannually_____, (iv) annually_____, (v) other_____.

d) Do you invoice for exceptions (time and material, etc.) at a different time than your normal cycle? Yes/No _____ If yes, please describe:

_____

_____

_____

_____

e) Who is responsible for maintenance contract:

i) Negotiation _____

ii) Renewal _____

iii) Administration _____

10. a) Has your field service division implemented a field quality assurance program or other formal operational audit? Yes/No _____

b) If yes, please describe: _____

_____

_____

_____

_____

_____

_____

_____

11. What is the average cost breakdown of a typical fault call? (Please respond for products your company services.)

PRODUCT SERVICED	TOTAL COST (dollars)	DIRECT LABOR (percent)	TRAVEL (percent)	PARTS (percent)	OVERHEAD & SUPPORT
Large mainframes					
Medium mainframes					
Small systems					
Peripherals					
Terminals					
Word processors					
Personal computers					
Copiers, facsimile					
Work stations					
PABX, PBX					
Teleprocessing/communications					

D. Personnel

1. Please identify your sources of new employees and rate them on a scale of 1-10. (1 = little or no importance, 10 = highest importance.)

SOURCE OF NEW EMPLOYEES	RATING (1-10)			
	1982	1983	1984	1987
a) Competition				
b) Trade schools				
c) Military schools				
d) Two-year college programs				
e) Four-year colleges				
f) Apprenticeship programs				
g) Other division in company				
h) Employee referrals				
i) Headquarters				
j) Other: _____				

2. Do you provide in-company formal training for:

	YES/NO
a) Indoctrination	
b) Basic training (apprentice level)	
c) Product (technical)	
d) Systems software (system)	
e) Applications software	
f) Management development	
g) Technological upgrading	

3. Do you fully (F) or partially (P) reimburse or otherwise provide financial support for:

	F/P
a) University courses	
b) Out-company seminars in management development	
c) Professional association membership	
d) Purchase of company stock	
e) Professional trade journals	
f) Matching grants to educational institutions	
g) Children's higher education	
h) Out-company training in professional (technical) development	
i) Nonexempt employee relocation	
j) New-hire relocation	
k) Exempt employee relocation	
l) Lease or purchase of automobiles to be used for business	
m) Lease or purchase of company products (micros, minis, personal computers, typewriters, etc.)	
n) Other: _____	
_____	
_____	

4. Do your personnel policies and procedures provide for the following employee benefits and assurances? (Y/N)

FRINGE BENEFITS	EXEMPT		NONEXEMPT	
	1983	BY 1985	1983	BY 1985
a) Life insurance				
b) Hospitalization				
c) Major medical (80% or better)				
d) Limited medical (out patient)				
e) Dental				
f) Eyesight/glasses				
g) Retirement				
h) Disability insurance				
i) Matched savings				
j) Profit-sharing				
k) Paid sick leave				
l) Grievance procedures				
m) Improvement programs for marginal performers				
n) Exit interviews				
o) Appraisal and counseling				
p) Career path definitions				
q) Pay for performance guidelines				

5. Does your company provide incentives for field service employees? (Indicate by check mark.)

INCENTIVES	MANAGEMENT		EXEMPT		NONEXEMPT	
	1983	BY 1985	1983	BY 1985	1983	BY 1985
a) Stock options						
b) Performance bonuses						
c) Suggestion awards						
d) Periodic recognition awards ("FE of the quarter," etc.)						
e) Special projects, foreign assignments, etc.						
f) Award conferences, trips						
g) Competitive scholarships for employees or family						
h) Other: _____						
_____						
_____						

6. a) How many direct labor field service personnel were hired in the following years?

1982 _____

1983 _____ (forecast)

1984 _____ (forecast)

b) How many direct-labor field service personnel left your company in:

1982 _____

1983 _____ (forecast)

c) What percentage of the persons leaving leave for the following reasons:

	1982	1983
i) Voluntary, no reason given	%	%
ii) Left for higher salary, better total compensation		
iii) Released for company reasons		
iv) Promotion in another company		
v) Relocation by another company		
vi) Promoted within own company		
vii) Transferred to foreign subsidiary or other division		
viii) Other _____		
Total	100%	100%

d) Staffing levels:

U.S. EMPLOYEES	1983	1984
i) Total employees in company		
ii) Total in field service division		
iii) Number of direct-labor FEs		
iv) Number of field support engineers		
v) Number of field supervisors		
vi) Number of managers in field		
vii) Line managers at headquarters		
viii) FE staff managers (total)		
ix) FE staff personnel (nonmanagement including administration)		

7. 1983 annual salaries, Peripheral/Terminals field engineers (front-line product field service technicians)

JOB DESCRIPTION	TITLE	(✓) EXEMPT	NUMBER IN U.S.	RANGE		AVERAGE PAID (actual)	AVERAGE GAIN OVER 1982 (percent)
				MAXIMUM	MINIMUM		
a) Entry-level trainee for hardware maintenance		( )					%
b) Entry-level trainee in software maintenance		( )					%
c) Minimum experience level qualified to respond to trouble calls, generally requires assistance		( )					%
d) Qualified field service technician carries territory, requires occasional assistance, renders some aid to lower levels		( )					%
e) Senior-level field service technician: generally gives more assistance than received, assigned field training duties to assist in development of first two categories (above)		( )					%
f) Qualified field service engineer in software support		( )					%
g) Senior level software support in field							
h) Top-level hardware specialist located in field office		( )					%
i) Top-level software specialist located in field office		( )					%

8. 1983 annual salaries, field office staff personnel

JOB DESCRIPTION	TITLE	(✓) EXEMPT	NUMBER IN U.S.	RANGE		AVERAGE PAID (actual)	AVERAGE GAIN OVER 1982 (percent)
				MINIMUM	MAXIMUM		
a) Repair depot, repair technician trainee		( )					%
b) Repair depot, repair technician		( )					%
c) Senior-level repair depot technician		( )					%
d) Office administrator, Jr.		( )					%
e) Office administrator, Sr.		( )					%
f) Field service supervisor may work approximately 50/50 on equipment and management		( )					%
g) First-line manager of field service engineers		( )					%
h) Second-line manager located in field offices		( )					%
i) Staff manager in education and field support		( )					%
j) Staff manager in operations and financial analysis		( )					%
k) Field service administration manager		( )					%
l) Field service personnel manager		( )					%