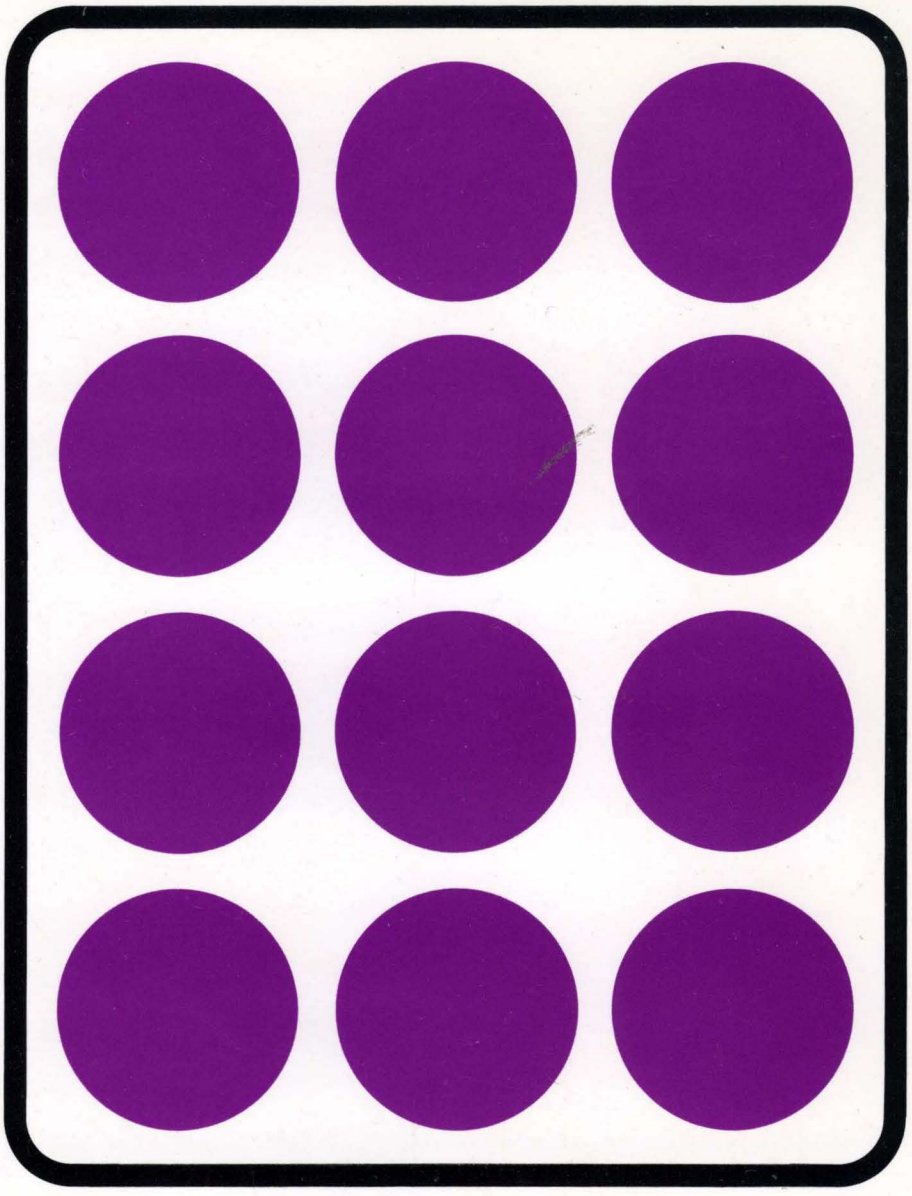
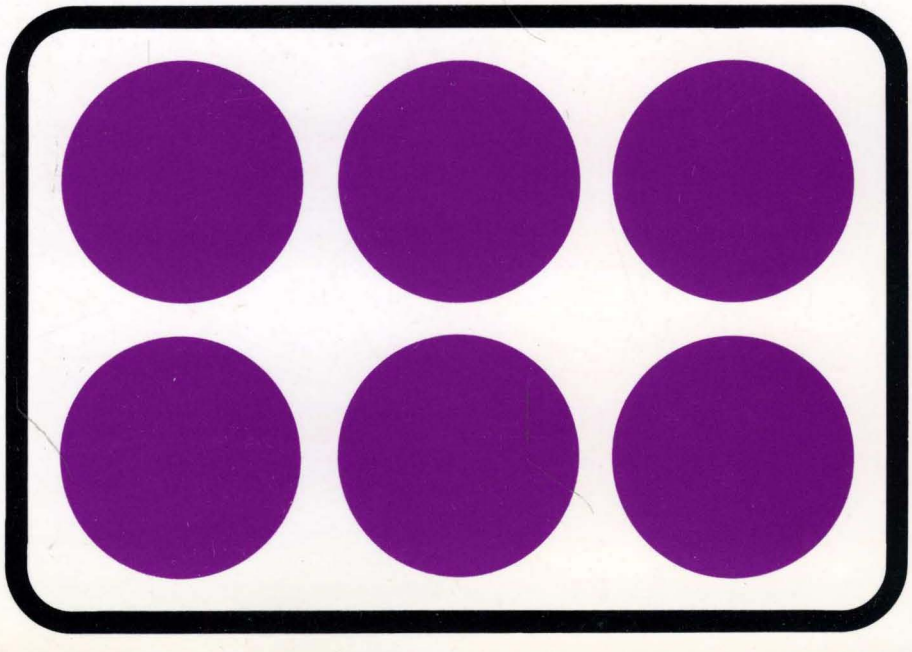


1993 DISK/TREND® REPORT



DISK DRIVE ARRAYS

1993 DISK/TREND® REPORT

DISK DRIVE ARRAYS

March, 1993

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FOREWORD

The is the first in a new series of DISK/TREND Reports on the disk drive array industry. We've been closely watching the early development activity for drive arrays of all types during the 1980's, the intense sales evangelism of the last few years and the widespread market penetration that is now taking place. With at least 100 companies now producing disk drive arrays, it was clear that the time had come for DISK/TREND to undertake the preparation of this report.

Normally, each DISK/TREND Report is completely prepared by our own staff. However, because of the large number of array manufacturers to be interviewed, and the tight timetable to which we had to adhere, we enlisted the assistance of Richard E. "Rick" Brechtlein in the field interviews and in portions of the writing for the report. Rick is a disk drive industry veteran with extensive consulting experience in recent years in the disk array area, and he conducted interviews for us in both Southern California and Texas.

The DISK/TREND Report has now been reporting on the rigid disk drive industry for 17 years, participating in the industry's penchant for rapid change and short product life cycles. Fortunately, the life cycles of the individual DISK/TREND Reports have been longer, by far, than the life cycles of most disk drives. The report on disk drive arrays will be followed by our 1993 report on optical disk drives to be published in July, the report on rigid disk drives in September, and the report on flexible disk drives to be released in November.

We are always willing to help you at any time by providing additional information on the industry which we may have available. Your suggestions for improvements in the DISK/TREND report are always welcome and are sincerely appreciated.

James N. Porter

Robert H. Katzive

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INTRODUCTION

A completely new DISK/TREND Report on disk drive arrays. The preparation of this report has followed the same disciplined ground rules used by DISK/TREND during the last 17 years in the preparation of all of its market studies: Sharply drawn definitions of market classes, product specifications and shipment data; extensive field research to obtain accurate information; and concise organization of all information in the report.

However, in this report we've also added certain types of information you won't find in DISK/TREND Reports on disk drives. Normally, we assume that readers of our other reports know all the terms used in the disk drive industry and are familiar with disk drive applications. But in this report, we make the assumption that disk drive array terms and applications will be new to many readers, so both are explained in detail.

Array System Considerations. If you lack experience with arrays, you will find this nontechnical review useful in understanding what arrays are, the product variations in which they are offered, and when it makes sense to use them. If you are going through the process of deciding whether or not to use a disk drive array, the checklist on system selection and integration is a must, to make sure you cover all the bases. Even if you have experience in the array field, you may find this section of the report helpful.

Let's all speak the same language. The product groups, types of products, market classes, and geographical classifications used in this report have been defined very carefully in the *DISK/TREND array definitions* at the end of the opening summary section. Individual terms used in describing disk drives and arrays have been defined in the *Glossary* section. We suggest you refer to both, as needed.

DISK/TREND on disk. The statistical and specification tables are available on floppy disks, as a separately purchased option to buyers of this report. For easy reference, instructions are included in the last section of this report.

What's a sale worth? As in all DISK/TREND Reports, we report revenues for the sale of array products at the level of the first public sale, at the estimated net transaction price, whether the sale occurs at the captive, PCM/Reseller or OEM/Integrator level -- to accurately record the value of the business to the original seller. An understanding of the relative price levels of captive, PCM/Reseller and OEM/Integrator is important in interpreting DISK/TREND revenue statistics, to avoid an exaggerated impression of the share of the industry's total shipments held by captive drives.

SUMMARY: DISK DRIVE ARRAYS

Industry size

Worldwide revenues for all types of disk drive arrays were $1.5 billion in 1992 and are expected to reach $9.9 billion in 1996, an average annual increase of 63%. Unit shipments of all types of disk drive arrays totaled 95,987 in 1992, and are forecasted at 515,360 for 1996.

Captive disk drive arrays, arrays sold by system manufacturers with their systems, produced $911.8 million of the 1992 revenues, 61.3% of the worldwide total. The 1996 total for captive revenues is projected at $4.8 billion, down to 48.9% of the worldwide total. It should be noted that all array revenues in the DISK/TREND Report are reported at the level of the first public sale by the originating manufacturer, whether originally sold as a complete subsystem, board assembly or software, and whether the sale occurs at the captive end user, PCM/Reseller, or OEM/Integrator levels.

Noncaptive sales of arrays are expected to grow at a faster rate. PCM/Reseller array sales were $485.1 million in 1992, 32.6% of the worldwide total, but are expected to reach $3.9 billion in 1996, providing 39.4% of the worldwide total. OEM/Integrator sales were only $91.1 million in 1992, but are forecasted at $1.2 billion in 1996, moving from 6.1% to 11.7% of worldwide revenues.

The DISK/TREND network/minicomputer/multiuser product group was the largest in 1992, with revenues of $1.2 billion, 81.2% of the worldwide total. That product group is expected to still be the leader in 1996 with $5.9 billion, but with only a 59.5% share, even though the group's projected 451,860 units will provide 87.8% of the 1996 shipment total. Mainframe system arrays are expected to provide 1% of the 1996 unit shipment total, but the significantly higher average prices for arrays used with mainframes will boost their share of the revenue total to 39.2%.

Both array subsystems and boards are expected to grow in their share of unit shipments. Of the 515,360 units of all types of arrays forecasted for 1996 shipment, complete subsystems are expected to generate 62.3% and board assemblies 28.8% of the total. Although software array products held 29.4% of 1992 unit shipments, their share is forecasted to decline to only 8.9% in 1996.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

DISK DRIVE ARRAYS

REVENUE SUMMARY

	DISK DRIVE ARRAY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992		Forecast							
	Revenues		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	494.8	886.7	986.7	1,640.7	1,639.4	2,705.3	2,459.7	3,777.7	3,056.5	4,757.0
PCM/Reseller	308.8	463.9	540.4	809.6	1,317.0	1,890.2	1,772.8	2,585.6	2,055.4	3,116.9
OEM/Integrator	67.4	87.1	211.8	279.6	404.1	548.4	583.0	813.7	692.8	994.4
TOTAL U.S. REVENUES	871.0	1,437.7	1,738.9	2,729.9	3,360.5	5,143.9	4,815.5	7,177.0	5,804.7	8,868.3
Non-U.S. Manufacturers										
Captive	.1	25.1	.1	29.6	1.3	42.4	3.6	62.7	5.7	82.5
PCM/Reseller	10.6	21.2	22.1	37.0	113.3	155.4	331.5	462.4	529.2	782.2
OEM/Integrator	1.6	4.0	8.2	18.5	14.8	38.2	38.3	97.5	62.4	158.8
TOTAL NON-U.S. REVENUES	12.3	50.3	30.4	85.1	129.4	236.0	373.4	622.6	597.3	1,023.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	883.3	1,488.0	1,769.3	2,815.0	3,489.9	5,379.9	5,188.9	7,799.6	6,402.0	9,891.8

Marketing channels

Disk drive array architecture originated in the United States. Most array manufacturers remain in the U.S., and more than 60% of the market for arrays is still located in the U.S. Manufacturers headquartered in the U.S. produced 96.4% of worldwide 1992 revenues, and although their share will fall, they are expected to hold 89.5% of 1996 revenues -- and will also retain 89.9% of the unit shipments.

Enthusiastic missionary selling campaigns, intended to develop new markets for arrays, have been undertaken by the numerous independent manufacturers of controllers and other noncaptive data storage peripherals which have entered the disk drive array business. However, computer system manufacturers of all kinds have also developed arrays, and captive arrays have produced the majority of revenues to date. Internally developed arrays are being sold as captive products with their own systems by many types of system manufacturers, including supercomputer manufacturers such as Cray Research and Thinking Machines, midrange system manufacturers such as Digital Equipment, Tandem Computers, Hewlett-Packard and Data General, and by personal computer manufacturers such as Compaq Computer. Not until 1995 is the share of revenues held by captive manufacturers expected to edge below half of the worldwide total.

PCM/Reseller shipments held a dominant lead in noncaptive shipments in 1992, with 32.6% of revenues for all market channels. 76% of the 1992 PCM/Reseller total of $485.1 million was generated by the sales of only three companies, dominated by the successful mirrored disk subsystems of EMC in the IBM mainframe and AS/400 add-on market. However, by 1996 DISK/TREND Report forecasts anticipate much broader PCM/Reseller penetration of a very diverse market of personal computer and workstation networks, with sales in that year of $3.9 billion, 39.4% of the worldwide total for all market channels.

OEM/Integrator array sales were just getting under way in 1992 for most of the participating companies, with the year's total only $91.1 million. However, the many network server programs which got under way last year using OEM subsystems and boards will triple the 1993 activity, and boost 1996's total to $1.2 billion.

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES
DISK DRIVE ARRAYS
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1992 Revenues $M	1992 Revenues %	1993 Forecast $M	1993 Forecast %	1994 Forecast $M	1994 Forecast %	1995 Forecast $M	1995 Forecast %	1996 Forecast $M	1996 Forecast %
U.S. Manufacturers										
Captive	886.7	59.5%	1,640.7	58.2%	2,705.3	50.2%	3,777.7	48.4%	4,757.0	48.0%
	--		+85.0%		+64.9%		+39.6%		+25.9%	
PCM/Reseller	463.9	31.1%	809.6	28.7%	1,890.2	35.1%	2,585.6	33.1%	3,116.9	31.5%
	--		+74.5%		+133.5%		+36.8%		+20.5%	
OEM/Integrator	87.1	5.8%	279.6	9.9%	548.4	10.1%	813.7	10.4%	994.4	10.0%
	--		+221.0%		+96.1%		+48.4%		+22.2%	
Total U.S. Manufacturers	1,437.7	96.4%	2,729.9	96.8%	5,143.9	95.4%	7,177.0	91.9%	8,868.3	89.5%
	--		+89.9%		+88.4%		+39.5%		+23.6%	
Non-U.S. Manufacturers										
Captive	25.1	1.6%	29.6	1.0%	42.4	.7%	62.7	.8%	82.5	.8%
	--		+17.9%		+43.2%		+47.9%		+31.6%	
PCM/Reseller	21.2	1.4%	37.0	1.3%	155.4	2.8%	462.4	5.9%	782.2	7.9%
	--		+74.5%		+320.0%		+197.6%		+69.2%	
OEM/Integrator	4.0	.6%	18.5	.9%	38.2	1.1%	97.5	1.4%	158.8	1.8%
	--		+362.5%		+106.5%		+155.2%		+62.9%	
Total Non-U.S. Manufacturers	50.3	3.6%	85.1	3.2%	236.0	4.6%	622.6	8.1%	1,023.5	10.5%
	--		+69.2%		+177.3%		+163.8%		+64.4%	
Worldwide Recap										
Captive	911.8	61.3%	1,670.3	59.3%	2,747.7	51.1%	3,840.4	49.2%	4,839.5	48.9%
	--		+83.2%		+64.5%		+39.8%		+26.0%	
PCM/Reseller	485.1	32.6%	846.6	30.1%	2,045.6	38.0%	3,048.0	39.1%	3,899.1	39.4%
	--		+74.5%		+141.6%		+49.0%		+27.9%	
OEM/Integrator	91.1	6.1%	298.1	10.6%	586.6	10.9%	911.2	11.7%	1,153.2	11.7%
	--		+227.2%		+96.8%		+55.3%		+26.6%	
Total All Manufacturers	1,488.0	100.0%	2,815.0	100.0%	5,379.9	100.0%	7,799.6	100.0%	9,891.8	100.0%
	--		+89.2%		+91.1%		+45.0%		+26.8%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

Product groups

In 1992 the networks/minicomputer/multiuser systems product group provided the largest market for disk drive arrays, with revenues of $1.2 billion, holding an 81.2% share of the worldwide total. Extensive participation in this product area by more than ten U.S. systems manufacturers selling internally developed arrays with their own computer systems on a captive basis has provided a large initial sales thrust for the product group, with captive revenues contributing 75% of the 1992 overall total. But while captive sales in the networks/minicomputer/multiuser systems product group are expected to increase through 1996, their share of the group's total is expected to fall to 48.6%.

The big difference in 1996 for the networks/minicomputer/multiuser systems group will be the sales growth of the scores of companies now developing noncaptive network server applications for all types of arrays. The noncaptive 25% share of 1992 worldwide total revenues for the product group is forecasted to reach 51.4% in 1996.

Mainframe system arrays produced only 17.5% of the revenue for all product groups in 1992, but the market entry of significant additional suppliers will boost the 1996 mainframe share to 39.2% of the overall total. So far, EMC has produced most of the revenues for mainframe arrays as the result of the company's sales success with its Symmetrix mirrored disk systems. However, shipments of Storage Technology's overdue Iceberg will probably start by the end of 1993. Furthermore, DISK/TREND assumes that IBM, the leading protagonist in the drama, will introduce a mainframe array in 1994, with the remaining PCM vendors not far behind. All of this activity is expected to boost mainframe array revenues from 1992's $259.8 million to the projected $3.9 billion in 1996.

Although significant to the participating companies in each product group, neither single user arrays or very high performance arrays are expected to produce as much as 1% of the overall 1996 revenue total. The revenue totals in both groups will be modest -- but for different reasons in each product group.

Very high performance arrays, used by supercomputers, imaging systems and high-end workstations, are forecasted to generate revenues of only $72.9 million in 1996, with the total held down by the limited market for supercomputers. Most of the significant supercomputer manufacturers have recently added

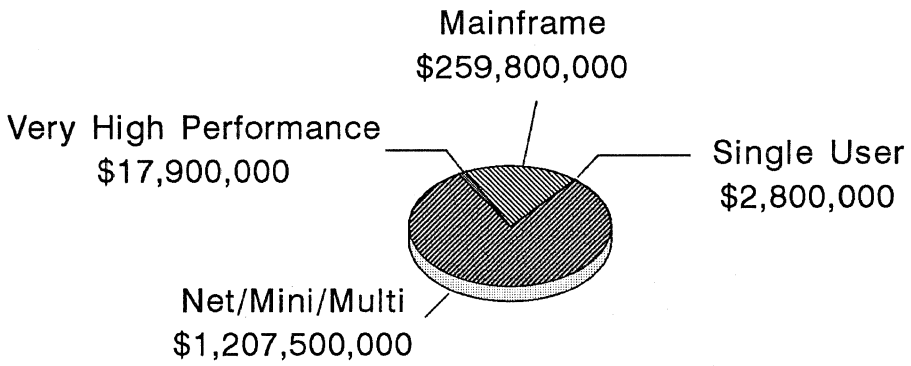
captive array subsystems to their product lines, so that the growth already envisioned in DISK/TREND forecasts is probably all that can be expected from the system manufacturers' product line enhancements. Unfortunately, growth in the supercomputer market is expected to be modest compared to other computer application areas, limiting most growth in data storage requirements for very high performance systems to other applications, including some types of high-end engineering workstations.

The 1996 revenue total for single user arrays is expected to be even lower, at $56.3 million, depressed by very low average unit prices. Usage will be broader than the revenue total suggests, however, with 1996 shipments of 57,110 single user arrays projected. Growth in this product group relies heavily on noncaptive add-on sales of low cost subsystems and boards, mostly RAID-1 mirrored disk arrays. PCM/Reseller sales will predominate, with sales concentrated in a narrow segment of the Macintosh, IBM compatible PC and UNIX workstation market -- serving those single users who think their work is mission critical and have the funds available for highly reliable data storage.

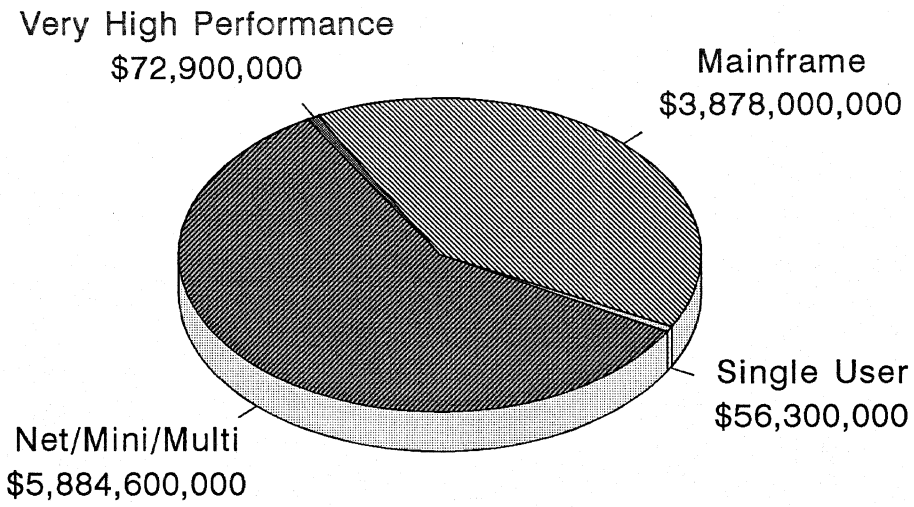
Figure 1

CHANGING PRODUCT MIX

Worldwide Disk Drive Array Revenue



1992



1996

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
DISK DRIVE ARRAYS
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	------1992-----		----------Forecast----------							
ALL MANUFACTURERS	----Revenues---		------1993-----		------1994-----		------1995-----		------1996-----	
	$M	%	$M	%	$M	%	$M	%	$M	%
SINGLE USER SYSTEMS	2.8	.2%	10.8	.4%	22.8	.4%	42.5	.5%	56.3	.6%
	--		+285.7%		+111.1%		+86.4%		+32.5%	
NETWORKS/MINI/MULTIUSER	1,207.5	81.2%	2,360.2	83.9%	4,077.1	75.9%	5,210.4	66.8%	5,884.6	59.5%
	--		+95.5%		+72.7%		+27.8%		+12.9%	
MAINFRAMES	259.8	17.5%	396.4	14.1%	1,221.8	22.7%	2,480.2	31.8%	3,878.0	39.2%
	--		+52.6%		+208.2%		+103.0%		+56.4%	
VERY HIGH PERFORMANCE	17.9	1.1%	47.6	1.6%	58.2	1.0%	66.5	.9%	72.9	.7%
	--		+165.9%		+22.3%		+14.3%		+9.6%	
Total Worldwide Revenue	1,488.0	100.0%	2,815.0	100.0%	5,379.9	100.0%	7,799.6	100.0%	9,891.8	100.0%
	--		+89.2%		+91.1%		+45.0%		+26.8%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

Figure 2

UNIT SHIPMENT SUMMARY

Worldwide Shipments in Thousands of Units

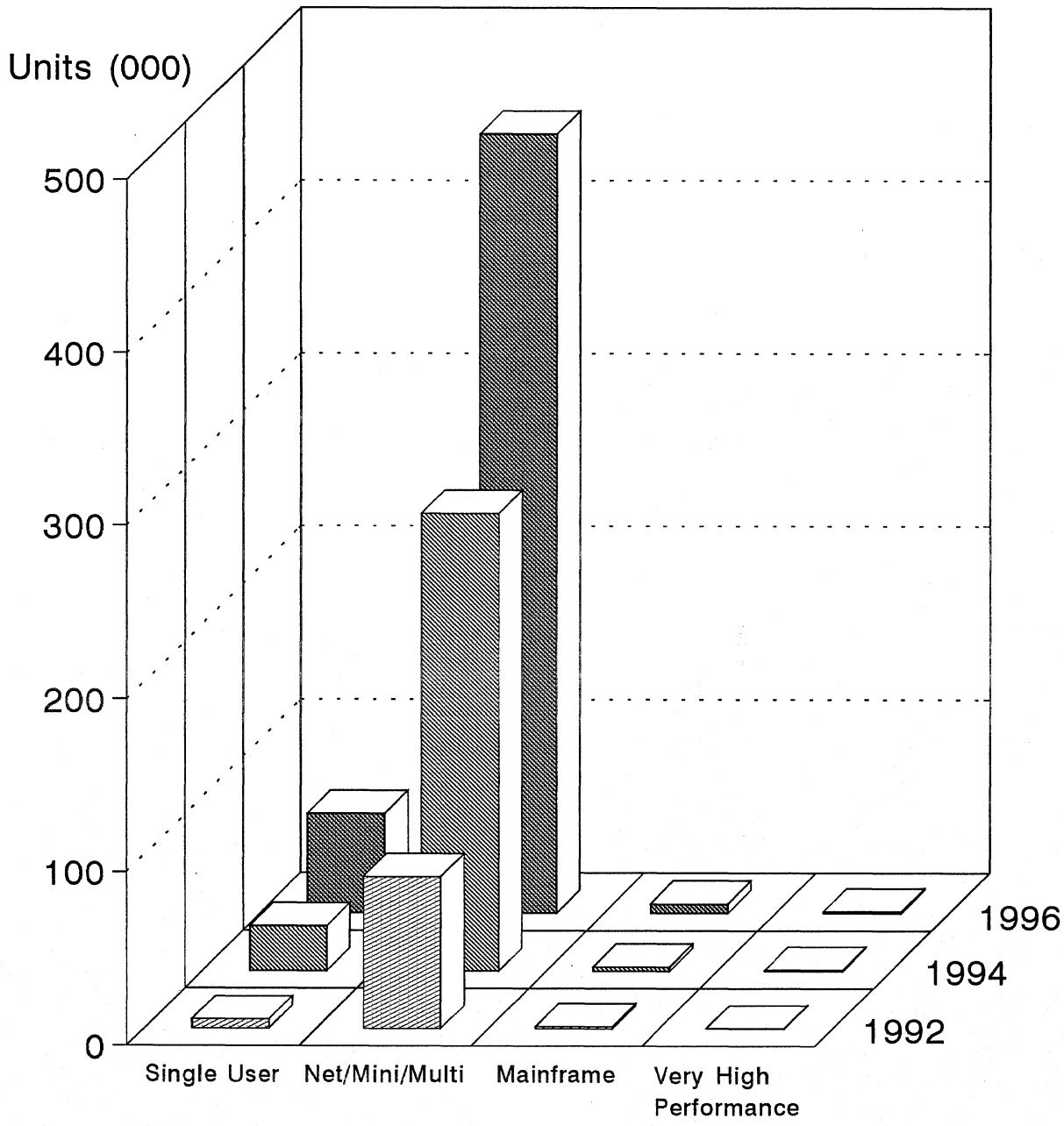


TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
DISK DRIVE ARRAYS
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS	1992		Forecast							
SINGLE UNITS	Shipments		1993		1994		1995		1996	
	Units	%	Units	%	Units	%	Units	%	Units	%
SINGLE USER SYSTEMS	5,400	5.6%	13,725	7.6%	25,900	8.8%	41,920	10.0%	57,110	11.1%
	--		+154.2%		+88.7%		+61.9%		+36.2%	
NETWORKS/MINI/MULTIUSER	89,075	92.9%	165,145	91.4%	265,630	90.2%	371,870	88.9%	451,860	87.8%
	--		+85.4%		+60.8%		+40.0%		+21.5%	
MAINFRAMES	1,248	1.3%	1,430	.8%	2,540	.9%	3,900	.9%	5,400	1.0%
	--		+14.6%		+77.6%		+53.5%		+38.5%	
VERY HIGH PERFORMANCE	264	.2%	555	.2%	720	.1%	870	.2%	990	.1%
	--		+110.2%		+29.7%		+20.8%		+13.8%	
Total Worldwide Shipments	95,987	100.0%	180,855	100.0%	294,790	100.0%	418,560	100.0%	515,360	100.0%
	--		+88.4%		+63.0%		+42.0%		+23.1%	
% U.S. Manufacturers	95.3%		96.0%		95.3%		93.1%		89.9%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

Array product mix

Complete array subsystems have been providing more than half of the total array unit shipments, and the subsystems share is expected to grow to 62.3% in 1996. In the DISK/TREND Report on disk drive arrays, subsystems are defined as one of the three product types used to organize shipment data, and include controllers, disk drives and all supporting elements needed for a specific subsystem such as fans, power supplies, enclosures, etc.

Complete subsystems constitute all of the mainframe array shipments and are expected to provide more than 80% of 1996 array unit shipments for very high performance systems. They are expected to constitute more than half of the total array shipments in 1996 for single user systems and networks/minicomputers/multiuser systems.

Boards are defined in this report as products which include array controller boards only, as well as boards mounted in enclosures, with power supplies, fans and other array elements, but without disk drives. Boards held 70.6% of unit shipments for single user systems in 1992, on the strength of marketing programs for disk controllers with mirroring capability, but the share for boards is expected to shrink to 38.9% in 1996, as complete subsystems grow faster. In the networks/minicomputers/multiuser systems market, boards are expected to double their 1992 share, with 27.9% of the 1996 total, as OEM sales of controller boards to server manufacturers continue to climb.

Although software array products can supply array functionality without requiring special hardware components, the overall software share of 1996 shipments is forecasted to drop to 8.9%, with greatest penetration of single user system markets -- where the usage of processor capacity required for disk array functions will not be noticed by most users, and where the simpler mirrored disk arrays will continue to predominate.

DISK/TREND statistics do not count shipments by the individual RAID level of each array, because so many of today's arrays are capable of operating at multiple levels at the choice of the user, or concurrently. However, it is clear that a very high percentage of the arrays shipped to date are RAID-1 mirrored disk versions. Despite extensive promotion and publicity, dedicated missionary selling activity and naive endorsements by trade publications, manufacturers of

RAID-3 and RAID-5 arrays are just starting to achieve significant market penetration. Most single users and many users of networks/minicomputer/multiuser and mainframe systems have found RAID-1 to be an appropriate product selection during the last few years. RAID-1 subsystems and boards have been readily available, have offered high reliability and have been cost-effective compared to the perceived alternatives.

During the next few years, RAID-3 is destined to continue to be favored for very high performance arrays, the almost unanimous choice for supercomputers and other systems requiring the highest possible data transfer rates. The earlier reliance on multiple individual disk drives, disk drives with multiple head parallel transfer, and RAID-0 striping is being replaced by RAID-3's high data rates combined with enhanced reliability.

RAID-5 is expected to assume an ever-larger role in the networks/minicomputer/multiuser and mainframe array markets, as the availability of appropriate subsystems becomes widespread, unit prices are reduced through product simplification and competition, and the higher quantity of drives at each site makes RAID-1 mirrored disks less attractive. Mirrored disks suffer few price disadvantages compared with RAID-5 when the number of disk drives required for an individual site is only a few. But mirrored disk arrays require 100% drive redundance, while the disk drive redundancy for RAID-5 is in the 20% range, so if all other elements are equal RAID-5 has natural price advantages over RAID-1 when larger numbers of drives are required.

For the record, here are the total number of all types of array models included in the product specifications section of this report, arranged by the highest numerical RAID level claimed for each subsystem, board or software product:

RAID-0/1 combinations	98
RAID-2	--
RAID-0/1/3 combinations	46
RAID-4	--
RAID-0/1/3/4/5 combinations	173

Figure 3

ARRAY TYPE SUMMARY

Worldwide Shipments in Thousands of Units

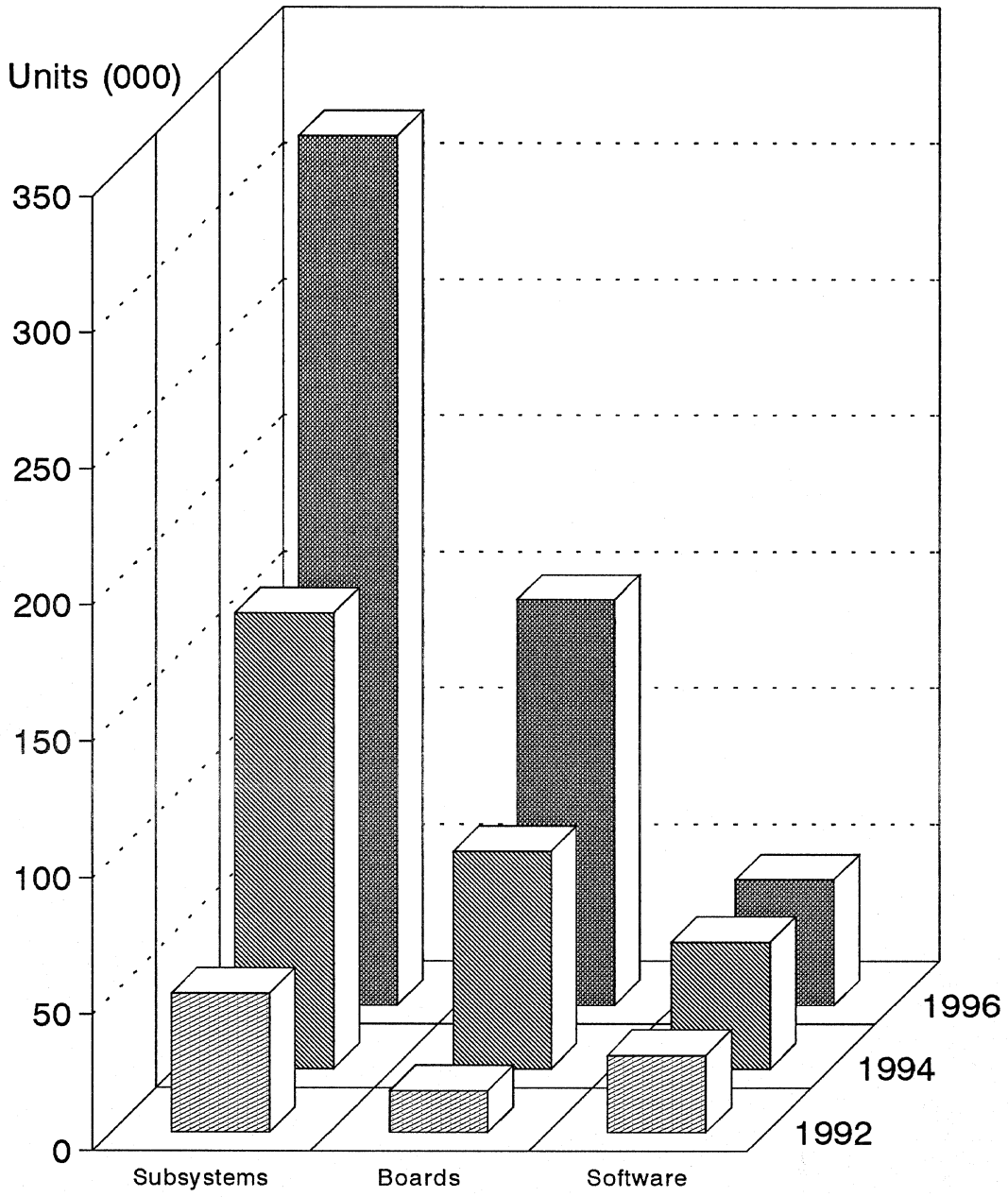


TABLE 5

CONSOLIDATED WORLDWIDE SHIPMENTS
DISK DRIVE ARRAYS
SUMMARY BY ARRAY TYPE

UNIT SHIPMENTS	1992		Forecast							
SINGLE UNITS	Shipments		1993		1994		1995		1996	
	Units	%	Units	%	Units	%	Units	%	Units	%
SUBSYSTEMS	52,483	54.7%	95,660	52.9%	168,710	57.3%	250,095	59.8%	320,790	62.3%
	--		+82.3%		+76.4%		+48.2%		+28.3%	
BOARDS	15,304	15.9%	46,790	25.9%	79,700	27.0%	119,045	28.4%	148,560	28.8%
	--		+205.7%		+70.3%		+49.4%		+24.8%	
SOFTWARE	28,200	29.4%	38,405	21.2%	46,380	15.7%	49,420	11.8%	46,010	8.9%
	--		+36.2%		+20.8%		+6.6%		-6.9%	
Total Worldwide Shipments	95,987	100.0%	180,855	100.0%	294,790	100.0%	418,560	100.0%	515,360	100.0%
	--		+88.4%		+63.0%		+42.0%		+23.1%	

Notes: Percentage figures with plus/minus signs refer to year-to-year growth rates.

Noncaptive market

Noncaptive sales of disk drive arrays produced $576.2 million in revenues in 1992, representing 32,504 disk drive arrays of all types. 1992's noncaptive revenue was only 38.7% of the overall worldwide total for all market channels, but the outlook is for a higher growth rate in future years. While captive disk drive array shipments by many types of system manufacturers are already well established, noncaptive sales are relatively undeveloped, with numerous new array programs by independent manufacturers getting under way during the last year.

In contrast, the DISK/TREND forecast for 1996 noncaptive sales indicates revenues of $5.1 billion, which will represent 51.5% of the overall total for all market channels. The improving expectations for noncaptive array revenues will be the result of a projected 1992-96 average annual growth rate of 76.7%, compared to only 53.4% for captive arrays. In 1996, the shipment total for all types of noncaptive arrays is forecasted at 364,225 units.

In the DISK/TREND statistics for noncaptive array sales the PCM/Reseller channel has an insurmountable lead over OEM/Integrator sales. PCM/Reseller revenues in 1996 are forecasted at $3.9 billion, 39.4% of the overall revenue total for all marketing channels, and 1996 OEM/Integrator revenues are expected to be $1.2 billion, 11.7% of the worldwide overall total. PCM/Reseller sales in the networks/minicomputer/multiuser systems product group will be boosted by rapid shipment growth of complete subsystems. OEM/Integrator sales growth will be helped by high unit sales of boards in the same product group, but at much lower average prices. PCM/Reseller sales will also receive a major gain from the expected availability of several new subsystems in the mainframe add-on market.

The networks/minicomputer/multiuser product group will produce an estimated 60% of 1996 overall noncaptive revenues, a total of $3 billion. The biggest one-year jump in revenues will come in 1993, as many RAID-3 and RAID-5 subsystem suppliers start to realize the rewards of intense sales development programs undertaken in 1992, with subsystem estimated unit shipments increasing 124.2% for the year.

TABLE 6

NONCAPTIVE WORLDWIDE REVENUES
DISK DRIVE ARRAYS
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1992		Forecast							
ALL MANUFACTURERS	Revenues		1993		1994		1995		1996	
	$M	%	$M	%	$M	%	$M	%	$M	%
SINGLE USER SYSTEMS	2.8	.5%	10.8	.9%	22.8	.9%	36.2	.9%	47.2	.9%
	--		+285.7%		+111.1%		+58.8%		+30.4%	
NETWORKS/MINI/MULTIUSER	302.1	52.5%	715.4	62.6%	1,618.2	61.5%	2,481.2	62.8%	3,024.1	60.0%
	--		+136.8%		+126.2%		+53.3%		+21.9%	
MAINFRAMES	259.8	45.1%	396.4	34.7%	962.8	36.6%	1,411.2	35.6%	1,949.6	38.6%
	--		+52.6%		+142.9%		+46.6%		+38.2%	
VERY HIGH PERFORMANCE	11.5	1.9%	22.1	1.8%	28.4	1.0%	30.6	.7%	31.4	.5%
	--		+92.2%		+28.5%		+7.7%		+2.6%	
Total Worldwide Revenues	576.2	100.0%	1,144.7	100.0%	2,632.2	100.0%	3,959.2	100.0%	5,052.3	100.0%
	--		+98.7%		+129.9%		+50.4%		+27.6%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

Figure 4

UNIT SHIPMENT SUMMARY

Worldwide Noncaptive Shipments in Thousands of Units

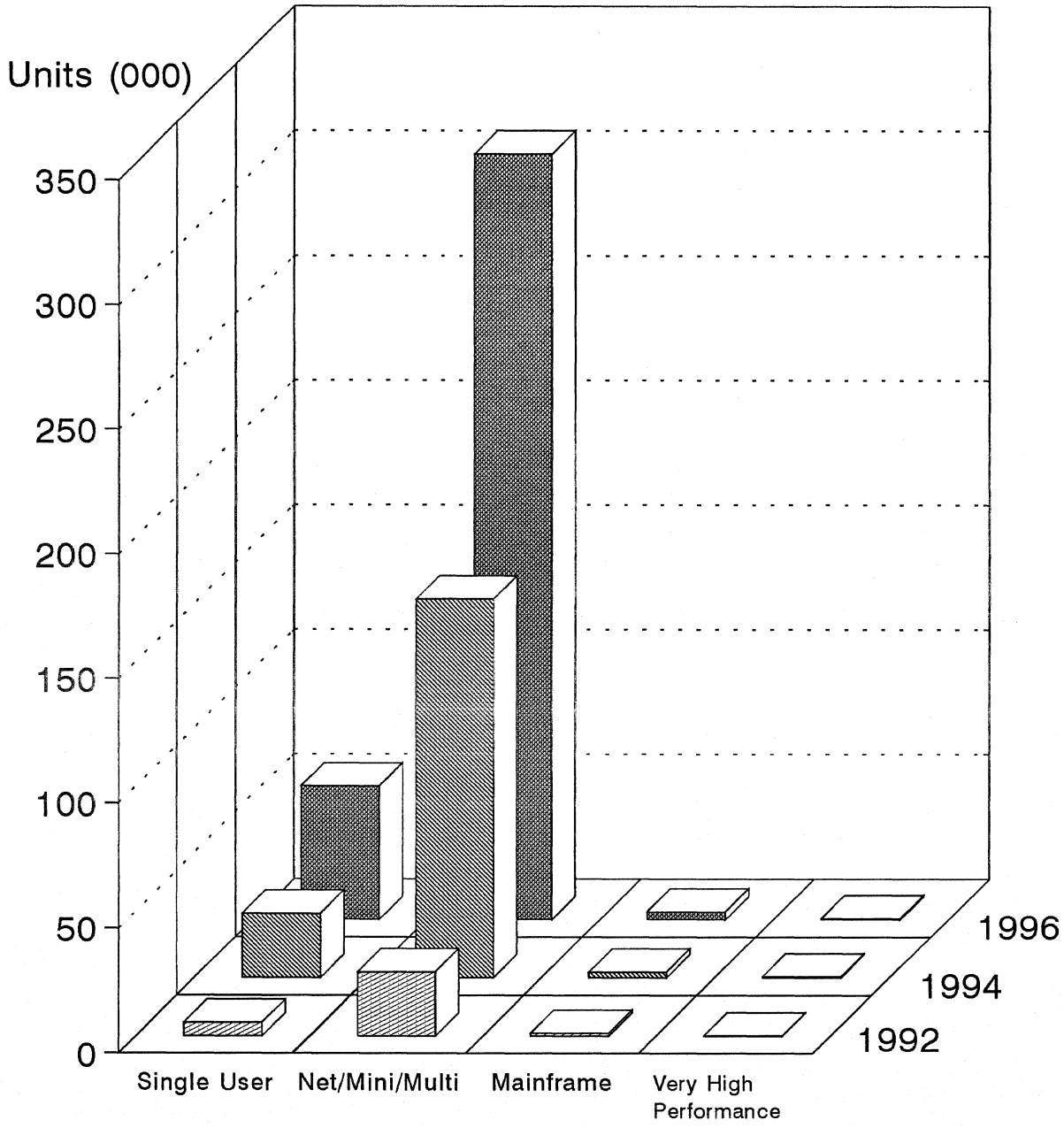


TABLE 7

NONCAPTIVE WORLDWIDE SHIPMENTS
DISK DRIVE ARRAYS
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

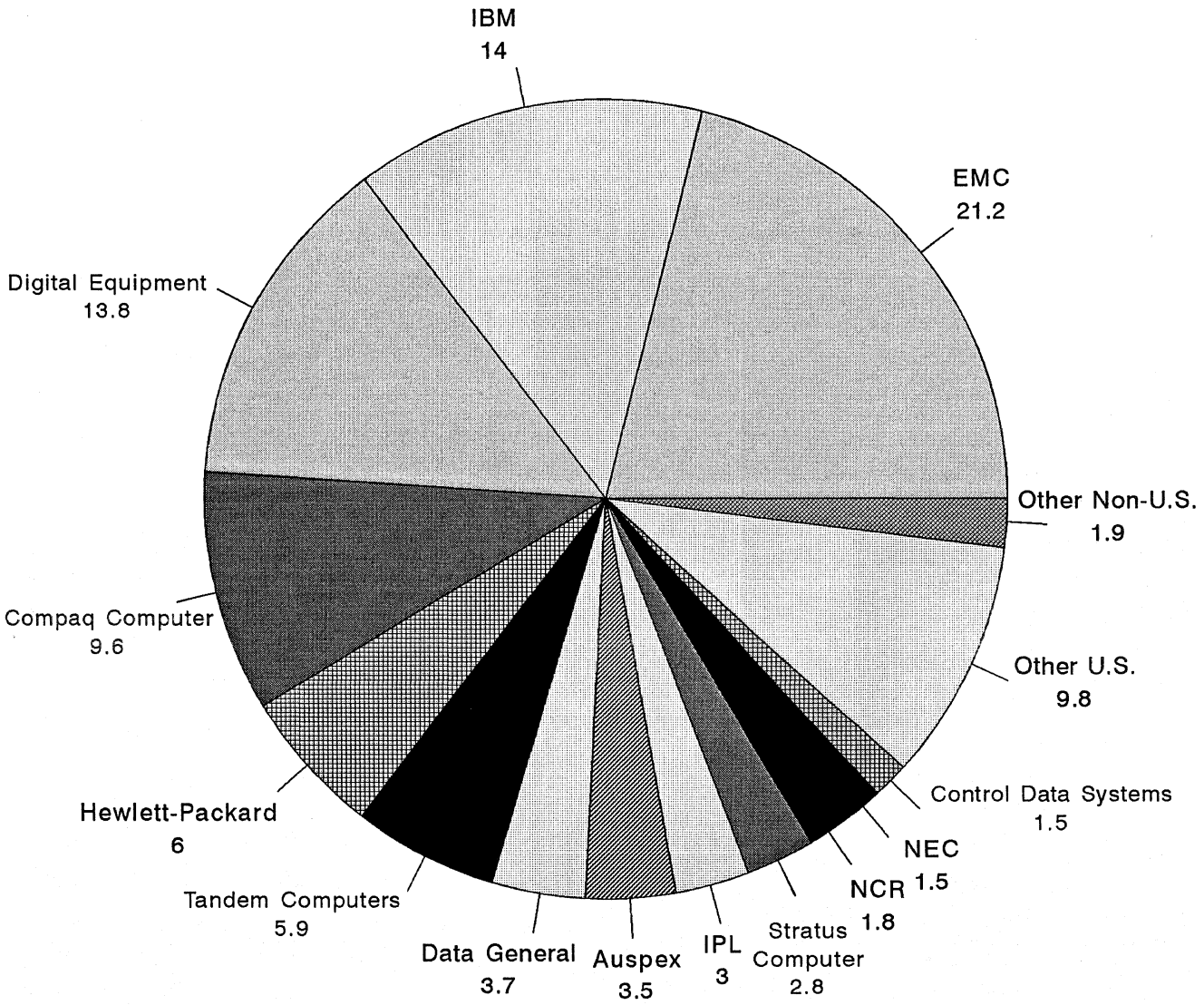
UNIT SHIPMENTS	1992		Forecast							
SINGLE UNITS	Shipments		1993		1994		1995		1996	
	Units	%	Units	%	Units	%	Units	%	Units	%
SINGLE USER SYSTEMS	5,400	16.6%	13,725	14.6%	25,900	14.4%	39,820	14.2%	53,510	14.7%
	--		+154.2%		+88.7%		+53.7%		+34.4%	
NETWORKS/MINI/MULTIUSER	25,642	79.0%	78,570	83.7%	151,910	84.2%	237,130	84.8%	306,980	84.4%
	--		+206.4%		+93.3%		+56.1%		+29.5%	
MAINFRAMES	1,248	3.8%	1,430	1.5%	2,260	1.3%	2,720	.9%	3,180	.8%
	--		+14.6%		+58.0%		+20.4%		+16.9%	
VERY HIGH PERFORMANCE	214	.6%	300	.2%	410	.1%	495	.1%	555	.1%
	--		+40.2%		+36.7%		+20.7%		+12.1%	
Total Worldwide Shipments	32,504	100.0%	94,025	100.0%	180,480	100.0%	280,165	100.0%	364,225	100.0%
	--		+189.3%		+91.9%		+55.2%		+30.0%	
% U.S. Manufacturers	92.0%		94.7%		93.9%		91.4%		87.7%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

Figure 5

1992 ESTIMATED MARKET SHARES

Worldwide Percentage Revenue for All Disk Drive Arrays



1992 Revenues: $1,488,000,000

TABLE 8

1992 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL DISK DRIVE ARRAYS
(Value of non-U.S. currencies estimated at average 1992 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Auspex Systems	--	--	52.3	10.8	--	--	52.3	3.5
Compaq Computer	143.0	15.7	--	--	--	--	143.0	9.6
Control Data Systems	4.5	.5	18.4	3.8	--	--	22.9	1.5
Data General	55.0	6.0	--	--	--	--	55.0	3.7
Digital Equipment	193.5	21.2	--	--	11.4	12.5	204.9	13.8
EMC	--	--	273.6	56.4	41.3	45.3	314.9	21.2
Hewlett-Packard	89.1	9.8	--	--	--	--	89.1	6.0
IBM	209.0	22.9	--	--	--	--	209.0	14.0
IPL	--	--	44.3	9.1	--	--	44.3	3.0
NCR	16.7	1.8	4.4	.9	6.4	7.0	27.5	1.8
Stratus Computer	42.0	4.6	--	--	--	--	42.0	2.8
Tandem Computers	87.2	9.6	--	--	--	--	87.2	5.9
Other U.S.	46.7	5.1	70.9	14.6	28.0	30.7	145.6	9.8
U.S. Total	886.7	97.2	463.9	95.6	87.1	95.6	1,437.7	96.6
NON-U.S. MANUFACTURERS								
NEC	22.5	2.5	--	--	--	--	22.5	1.5
Other Non-U.S.	2.6	.3	21.2	4.4	4.0	4.4	27.8	1.9
Non-U.S. Total	25.1	2.8	21.2	4.4	4.0	4.4	50.3	3.4
WORLDWIDE TOTAL	911.8	100.0	485.1	100.0	91.1	100.0	1,488.0	100.0

Note: 1. Arrays sold in the PCM/Reseller market by other than the original manufacturer are valued at PCM/Reseller prices in the table above, to avoid distortion of total market value.

2. The DISK/TREND estimates of revenue for each disk array manufacturer include net sales of disk drive arrays only and do not represent total revenues for individual companies.

TABLE 9

CURRENT PRODUCT LINES
MANUFACTURERS OF DISK DRIVE ARRAYS

Codes: C = Captive
O = OEM/Integrator
P = PCM/Reseller
SB = Subsystems
BD = Boards
SW = Software

		DISK/TREND PRODUCT GROUP			
U.S. Manufacturers (84)	Type	Single User Arrays	Network/ Minicomputer/ Multiuser Arrays	Mainframe Arrays	Very High Performance Arrays
1776, Inc.	O,P		SW		
Allodyne	O,P		SB		
American Digital Data Assoc.	O,P	SW	BD		
Amperif	P			SB	
Areal Technology	O,P		SB		
Array Technology	O		SB		
ASA Computers	O,P		SB		
AST Research	C		SB		
Astrix	C,O		SB		
ATTO Technology	O,P	BD,SW			
Auspex Systems	O,P		SB		
Blue Lance	P		SB		
Box Hill	C,P		SB		
Cambex	P		SB		
Cambridge Technologies	O		BD,SB		
Chantal	O,P		SW		
Ciprico	O,P		SB		SB
Clearpoint Research	O,P		SB		
Clovis Manufacturing	P		SB		
CMD Technology	O	BD	BD		
Compaq Computer	C		SB		
Concurrent Computer	C		SB		
Conley	O,P		SB		
Control Data Systems	C		BD,SB	SB	
Convex Computer	C				SB
Core International	O,P		SB		
Cray Research	C				SB
Data General	C,O		SB		
Dell Computer	C		SB		
Digi-Data	O		BD		
Digital Equipment Corp.	C,O		SB,SW		
Distributed Processing Tech.	O,P		BD		
DynaTek Automation Systems	P		SB		
ECCS	O,P		SB		
EMC	P		SB	SB	
Encore Computer	C				SB
Gain Systems	O,P		SB		
Hewlett-Packard	C		SB		
IBM	C,O,P		SB,SW		SB
IPL	P		SB		
Legacy Storage Systems	O,P		SB		
Lomas Data Products	O		BD		
Loviel Computer	P	SB,SW			
Maple Systems	P		BD		

U.S. Manufacturers (CONTINUED)	Type	Single User Arrays	Network/ Minicomputer/ Multiuser Arrays	Mainframe Arrays	Very High Performance Arrays
MasPar Computer	C				SB
Mass Microsystems	P	SB	SB		
Maximum Strategy	O,P				SB
Mega Drive Systems	O,P		SB		
Micro Technology	P		SB		
Micronet Technology	O,P		SB		
Micropolis	P		SB		
Morse Technology	O,P		BD		
Mylex	O,P		BD,SB		
NCR	C,O,P		BD,SB,SW		
NetFRAME	O,P		SB		
Northgate Computer Systems	C		SB		
Pacific Micro Data	O		SB		
Perceptive Solutions	O,P		BD,SB		
Peripheral Land, Inc.	P	BD,SB			
Precision Computers	O,P		SB		
Procom Technology	O	BD	SB		
Raidtec	O,P		SB		
Sequoia Systems	C,O		SB		
Silicon Valley Computer	O,P		BD		
Storage Computer	O,P		SB		
Storage Concepts	O,P		SB		SB
Storage Dimensions	O,P	SB	SB		
Storage Solutions	O,P		SB		
Storage Technology	P		SB	SB	
Stratus Computer	C		SB		
Sun Microsystems	C		SW		
System Industries	P		SB,SW		
Tandem Computers	C		SB		
Tangent Computer	C,P		SB		
Thinking Machines	C				SB
Transoft	O,P		BD		
Tricord Systems	C		BD		
UltraStor	O		BD		
Unbound	O		BD,SB		
Unisys	C		SB	SB	
Unitrol Data Protection Sys.	O,P	SW			
Veritas Software	O,P		SW		
Vortex Systems	O		BD		
Winchester Systems	O,P		BD,SB		
Asia/Pacific Rim Manufacturers (7)					
Acer	C		SB		
Fujitsu	C		SB		SB
Hitachi	O		SB		
Infortrend	O		BD		
Laura Technologies	O,P		BD		
NEC	C		BD,SB		
Sanyo Icon	P		SB		
European Manufacturers (7)					
Arco Electronics	P	BD			
Baydel Ltd.	O,P		SB		
Hi-Data	O		BD,SB		
Memorex Telex	P		SB		
Solid Computer	O,P		SB		
TwinCom	O,P		SW		
Zenith Data Systems	C		SW		

DISK/TREND ARRAY DEFINITIONS

Many basic terms have varying meanings within the computer industry. In the DISK/TREND Report on disk drive arrays, the following specific meanings have been used:

Product group classification

Arrays are classified into four product groups according to the type of system attachment for which they are designed. They include:

Single user systems: Intended for use with single personal computers or workstations. Attached processors typically run under DOS, Windows, Macintosh System 7, UNIX, etc.

Networks/Multiuser/Minicomputers: Consists of all midrange systems, to which individual personal computers, workstations or terminals are typically attached. Host platforms include the IBM AS/400, Digital Equipment and other minicomputers, engineering workstation networks and personal computer networks. Software environments include UNIX and its variants as well as other minicomputer operating systems and include network software such as Novell NetWare, Banyan VINES, and Artisoft Lantastic.

Mainframe systems: These are the classic mainframe and supermini system environments.

Very high performance systems: This group includes supercomputers, specialized imaging systems and other systems with requirements for very high data transfer rates.

Product type classification

Within each product group, arrays are classified into three product types for purposes of the DISK/TREND Report. Only products specifically and primarily intended to permit disk drives to operate as an array are included in this classification.

Complete subsystem: Arrays consisting of controller, drives and supporting elements such as fans, power supplies, enclosure, etc., ready for installation.

Board: A board or subsystem providing array capability to a system, but not including disk drives. This category includes products that are boards only, as well as boards mounted in an enclosure, with power supplies, fans and other array elements, but without drives.

Software: A specific software product that provides array functionality without requiring a separate controller. Operating systems that include array functions, such as Novell NetWare SFT III, are not included in this category or counted in the statistics. Sales of software arrays obtained via a technology license with production rights from the licensor are credited to the licensee and not the licensor to avoid distortion of revenue figures.

Market classification

Market class is used here, arbitrarily, to differentiate captive, PCM/Reseller and OEM/Integrator marketing activities.

Captive: Arrays manufactured internally or by a subsidiary of a computer manufacturer, and sold or leased primarily for use with systems offered by the manufacturer. Note that the term is used to describe the products, not the manufacturer; arrays sold to PCM/Reseller or OEM/Integrator market classes are classified accordingly.

Example:

* Arrays sold by Digital Equipment, IBM or Compaq for use with their own systems are considered captive, if internally manufactured.

Noncaptive: Any public sale or lease by any array manufacturer, except sales or leases of internally manufactured arrays by computer system manufacturers primarily for use with their own systems. Both OEM/Integrator and PCM/Reseller shipments are included in the noncaptive sales channel.

Examples:

* Shipments by NCR are noncaptive, except for arrays sold with systems made by the parent company or other subsidiaries.

* Shipments made by Micropolis or Storage Dimensions are noncaptive.

PCM/Reseller: Arrays sold or leased by "plug compatible manufacturers" or their distributing organizations directly to end users for use with systems sold by another manufacturer. Also includes arrays sold in the "aftermarket" -- shipments by array manufacturers to subsystem producers, distributors, retail chains, mail order firms and individual dealers. It includes disk drive arrays to be connected to computer systems of all types, including personal computers, minicomputers and mainframes, or arrays sold as add-on devices by distributors and dealers.

Example:

* Arrays sold by EMC to end users of IBM equipment.

OEM/Integrator: Arrays sold by the original producer to system manufacturers which resell them as part of complete computer systems. Also includes sales to system integrators or value-added resellers which combine finished system components and software to provide complete systems for specific applications. Sales by an array manufacturer to a second manufacturer for resale are included only in shipment totals for the originating manufacturer, except when arrays are produced on a contract manufacturing basis with a design supplied by the manufacturer which finally sells the drive to a third party.

Examples:

* Arrays produced by Maximum Strategy for sale to system manufacturers.

* Software produced by Chantal for sale to system manufacturers.

Geographic classification

Geographic analysis is based upon U.S. and non-U.S. regions. Together, these two regions comprise the worldwide market.

U.S. vs. Worldwide SHIPMENTS: Shipments are classified U.S. or worldwide depending on the country in which the headquarters of the purchasing company is located.

Examples:

* An OEM shipment by a U.S. array manufacturer to a European system manufacturer is included in worldwide totals, even if the array is integrated into a system within the U.S.

* An OEM shipment by a European array manufacturer to a U.S. based system manufacturer is included in U.S. totals, even if the array is integrated into a system in a third country, regardless of the final destination of systems in which the arrays are used.

U.S. vs. Non-U.S. MANUFACTURERS: Manufacturers are classified U.S. or non-U.S., depending on the location of the firm's headquarters, regardless of the location of individual manufacturing plants.

Units of measurement

Assemblies: The basic unit in counting arrays. One assembly consists of the array electronics (or software package) required to operate multiple disk drives as an array. All DISK/TREND array unit totals are counted in assemblies.

Revenue: Based on sales of array assemblies, including bundled drives (if any), as normally sold by individual manufacturers. Add-on drives sold as separate

units are not included in array revenue, nor are replacement parts or service. Sale prices are estimated public sale transaction prices, whether at captive end user, PCM/Reseller or OEM/Integrator levels. All prices are in 1993 constant dollars.

Forecasts: Expected shipments and revenues for current or announced products in new production. Evolutionary improvements within existing disk array architectures are included, but completely new configurations or technologies are not included.

Examples:

* Enhancements such as write latency improvements and revised compression schemes are anticipated in DISK/TREND forecasts.

* Innovations such as arrays for portable systems may require establishment of new DISK/TREND product groups.

ARRAY SYSTEM CONSIDERATIONS

1993 DISK/TREND REPORT

ARRAY SYSTEM CONSIDERATIONS

Disk drive arrays come in a variety of configurations and implementations ranging from inexpensive and simple to costly and complex. This section of the report reviews array characteristics and issues pertaining to their use.

ARRAY CHARACTERISTICS AND CLASSIFICATION

What is an array? A disk drive array is an assembly of disk drives and hardware controllers operated by array management software. The array presents itself to its host system environment as if it were a single physical disk drive. The storage devices that are members of the array can be any type of random access, non volatile storage device with unlimited read/write capabilities, including rigid magnetic disk drives, rewritable optical disk drives and nonvolatile solid state disk drive equivalents.

Array management software can be program code to be executed within the host system environment, or it can be implemented as firmware within the array controller, or as a hybrid combination of the two.

Implementations: For purposes of this report, arrays are considered to be implemented in one of three ways, which represent the forms in which arrays are sold:

* Complete subsystems: Array subsystems include disk drives, controllers with software to operate the array, enclosures, power supplies, fans, cables and possibly other physical elements. The array controller contains the programs necessary to operate the array and appears to the host system as a single drive. The host system is relieved of the need to manage the details of operating the array. Some controllers allow partitioning of the array drives into several types of array (each appearing to the host system as a single drive), all of which can operate concurrently with data routed by the host computer to the array type best able to handle it. Subsystem manufacturers usually include software tools to configure, manage and monitor the array subsystem, frequently for a specific host system and software environment.

* Boards: This category includes array controllers sold individually or with other subsystem elements such as enclosures, fans, power supplies and cabling, but not including disk drives.

* Software: If the array is implemented purely by use of software and without hardware specifically designed to operate an array, then it is a software implementation. Hybrid arrays combining software and hardware functions exist, but are considered as hardware implementations in

this report. Software implementations are relatively inexpensive and usually easy to integrate, but may be slower than hardware implementations and may not provide all the functions a hardware array implementation can provide. Exact performance will depend on processor load, the controllers, disk drives and drivers used with the disk drives, as well as processor performance. Array specific drivers are often provided with software arrays to improve performance. Software array implementations are often specific to the host system and may not be effective at all sites in multihost network environments.

When to use an array -- and when not: Disk drive arrays may provide several kinds of advantages over individual disk drives. Certain array configurations can improve system throughput, and the use of an array can spread data over multiple drives, avoiding unbalanced I/O loads and consequent bottlenecks. Other array configurations can improve data availability by providing a degree of fault tolerance, although the degree of improvement in either case depends upon the specific design of the array subsystem.

Disk drive arrays can provide performance enhancements or fault tolerance enhancements, but these advantages tend to be mutually exclusive, in that optimizing for one usually penalizes the other. There is always an economic penalty compared to nonarray implementations of data storage. If the needs of the system user can be met without improved throughput or improved fault tolerance, there is no need for the additional expenses associated with an array. In short, choosing an array is a balancing act between cost, performance, and data availability.

Arrays should not be viewed as a way of avoiding the need for disk drive backup. While data can be protected against a failure of a drive or other subsystem element, no protection is provided against operator error, disasters, viruses or other external disruptive influences. Furthermore, while arrays may provide for redundancy at the disk drive level, failures elsewhere in a nonredundant system can make the data stored on the array unavailable. Only by duplicating each element of a system, including processors, controllers, cables, ports, fans, power supplies, etc. can the highest probability of data availability be achieved. The need for fault tolerance must be analyzed for each processing node in a network to select the most cost-effective approach.

Choosing the right array for the application: Although some types of disk drive arrays have been used for a number of years, they received prominence after publication of a classification scheme in a technical report by researchers at the University of California in Berkeley in December, 1987 (Technical Report UCB/CSD 87/391). The authors discussed a set of array configurations which they characterized as Redundant Arrays of Inexpensive Disks, RAID by acronym, as compared to a Single Large Expensive Disk (SLED). Five configurations, or RAID levels, ranging from RAID-1 to RAID-5 were defined (an additional level, RAID-6, was proposed later). While not defined by UC, RAID-0 has been generally adopted by the industry as referring to a striped array with no redundancy.

Because the prices of disk drives have declined radically since the RAID acronym was coined, the use of arrays as a means to reduce storage costs is no longer relevant, so the RAID acronym is currently interpreted by many as Redundant Arrays of Independent Disks.

The RAID configurations describe ways of organizing data on the disk drives and organizing the flow of data to and from the drives, but do not cover the details of interfaces or of controller or software operation. The RAID levels merely describe configurations: A higher RAID level does not imply anything regarding relative performance, complexity, cost or reliability, which are functions of specific configurations. Because of their broad industry usage, RAID nomenclature is used throughout this report.

The various configurations and their uses are reviewed briefly below:

* RAID-0: RAID-0 arrays have data striped across the drives that are members of the array. Because each drive is accessed independently, portions of data from an I/O operation can be read or written to each drive simultaneously, minimizing data transfer time. While fast, RAID-0 provides no redundancy in data storage, so if one drive in the array fails, all data in the array becomes unavailable. If the failed drive cannot be repaired, all of the data in the array is irretrievably lost. RAID-0 is best where high performance is desired and fault tolerance is not a consideration. It also offers the lowest cost per megabyte. Some manufacturers have referred to collections of disks without striping as RAID-0 arrays, but this runs counter to industry usage, which would refer to nonstriped, nonredundant groups of drives as JBOD (just a bunch of disks).

* RAID-1 (Mirrored disk drives): In this mode, data is written or read in identical form to two or more drives. This provides fast read performance, because the first drive to respond to an I/O request can provide the data requested, reducing latency. Write performance may be somewhat slower, since both drives have to complete the write operation. The strongest objection to RAID-1 is economic: The cost of the drives at least doubles for any given storage capacity. However, management is relatively simple and controllers or software need not be overly complex, which simplifies integration into a system. RAID-1 is useful where high performance is needed, high data availability is required, and data block sizes are not overly long, but doubles the cost per megabyte since twice as many drives are needed.

* RAID-2: This configuration is rarely used and was included in the Berkeley work primarily to cover a few systems that had been shipped earlier. In RAID-2, bytes are broken into smaller units which are then transmitted in parallel to a set of disk drives. In addition, parity data, computed using Hamming codes, is sent to additional drives used specifically to store parity data. The redundancy of data provides good data availability.

Read performance is good because data is transferred in parallel. Write performance is degraded because of the need to compute parity and then write it to the parity disks. Relative to other array types, RAID-2 is uneconomical because it requires a larger number of drives, and RAID-2 controllers tend to be complex and expensive. RAID-2 performance can be achieved by RAID-3 at lower cost.

* RAID-3: Data is sent to and from the disk drives in parallel, one I/O request at a time. Parity data is stored on a single extra drive provided for this purpose. The disk spindles may be synchronized to transfer data to all drives simultaneously. Because of the high degree of parallelism, data transfers are very fast, although concurrent I/O is not possible. If a single drive fails, data is still available by using the data on the working drives plus the parity drive to reconstruct the data, although the effective data rate will be degraded as a result. RAID-3 is typically used on supercomputers, image manipulation processors and other applications where very high data transfer rates are needed. It is most efficient for long block transfers and is inefficient for short transactions with high I/O request rates. For a given capacity, fewer drives are needed than for RAID-1, as only a single drive for redundancy must be added to the data drives. However, the controller may be more complex and expensive. RAID-3 is best for situations requiring very fast data transfer rates and/or long data blocks.

* RAID-4: In RAID-4, data is striped across the array drives while parity data is accumulated on a separate drive. Data is recoverable if a drive fails. Read performance is similar to RAID-1, but writes are considerably slower than on a single disk because of the need to funnel the parity information through a single drive. RAID-4 has been supplanted by RAID-5, which offers the same read performance but much better write performance.

* RAID-5: Data in a RAID-5 array is striped across the drives in the array, but parity data is also distributed among all of the drives, eliminating some of the write bottleneck. Writes are still slow because of the need to read data from all drives to recompute parity when writing (sometimes called the read-modify-write process). Concurrent I/O transactions can be processed. Data can be recovered in the event of a single drive failure. RAID-5 is efficient for long data records, but is also reasonably efficient for short ones if the array design includes features to improve write performance, or if the application requires a high proportion of reads. It is a good choice for achieving high data availability, with acceptable performance provided that the data block size is small. RAID-5 carries only a modest cost per megabyte penalty compared to a nonarray approach.

* RAID-6: Similar to RAID-5, but with additional parity information written that permits data recovery if two drives fail. This configuration requires extra parity drives, and write performance is theoretically slower than for

an equivalent implementation of RAID-5. It was proposed by UC Berkeley in late 1989. RAID-6 is used by some manufacturers to designate a layered array with RAID-1 and RAID-0 capabilities, but this does not conform to the Berkeley definition.

* Non-Berkeley RAID levels: In addition to the RAID levels defined above, there are a variety of nomenclatures used by specific manufacturers. There is no agreement on the meanings of these; most are meant to imply the ability to operate in more than one mode simultaneously or to imply that a specific design incorporates features of more than one RAID configuration. Others imply attempts to improve RAID-5 performance through vendor specific design features. Terms like RAID-1/0 (or RAID-1+0) have become commonly used to mean a layered array operating simultaneously in both modes, offering the advantages of striping and mirroring.

In meetings of the the RAID Advisory Board, an industry group attempting to create agreement on array nomenclature, test procedures, interface specifications and similar matters, a proposal has been made to classify arrays by their access method rather than by RAID level. While it is unclear that this proposal will be adopted as standard nomenclature, it does provide an alternative way of classifying arrays.

* Parallel access arrays: All of the member disk drives in a parallel access array operate on every I/O transaction handled by the array. RAID-2 and RAID-3 arrays are examples of parallel access arrays. A few RAID-1 arrays fall into this class.

* Independent access arrays: In this category, the disk drives act independently, and may have the ability to be operating upon multiple I/O requests concurrently. RAID-4, RAID-5 and RAID-6 and most RAID-1 implementations fall into this category.

RAID-0 is not included in this set of definitions as the RAID Advisory Board does not consider RAID-0 an array because it does not provide any data redundancy.

Non-RAID approaches: Performance and fault tolerance issues can be addressed without using an array. System designers may choose to employ very fast disk drives, employ controllers with extensive caching and buffering, or use drives with parallel transfer heads to meet speed requirements, or may distribute data files (nonstriped) over many drives. Fault tolerance can be addressed by mirroring (duplexing) whole disk drive subsystems (which in themselves may not be arrays) or by mirroring entire file servers, as does Novell in its SFT III fault tolerant networks.

SYSTEM SELECTION AND INTEGRATION CHECK LIST

The following discussion touches upon significant issues that system integrators and end users should take into account when choosing an array.

Host platform and operating system compatibility: Arrays must operate in the context of attachment to specific hardware platforms and software environments. The possession of a SCSI interface does not automatically guarantee proper operation with every system that has a SCSI port. Usually specific drivers and other software "glue" are necessary. The various release levels and variants of UNIX and other operating systems may have varying ability to correctly operate a given array product. Other concerns:

* Does the system have sufficient memory available to operate the array? Will operating the array slow down other host activities? These are major considerations for software implementations, less so for hardware implementations.

* Are the software and documentation distribution media used to ship array software and documentation supported on the target system? What other devices need to be connected, and can the array controller support those devices?

* For software arrays, can the array device driver provided be co-resident with the system provided device drivers? Are special disk partitions needed?

* Do the cables match? If SCSI is used, does the system SCSI port match the performance characteristics of the array SCSI port? Are the SCSI paths the same width? Single ended or differential? If a board must be plugged into the host system, is there sufficient room, power, cooling available? Are special SCSI terminations needed, or are the drives self-terminated? Do the terminations match the width of the path? Do you need shielded cables to solve EMI problems?

* Can the array use existing drives, if any? Can it support drives of different capacities? Can it support drives from different drive manufacturers or a preferred manufacturer? Does the array packaging limit the total capacity needed? Does drive interface performance match the array controller performance?

* Can the array controller support drives as logical units? Are resources adequately shared between logical units (no starvation if one drive or partition is hyperactive)? Can you boot from the array? Can the array create logical devices on the fly? Which SCSI level is supported? Can the array handle redundant drive controllers and dual ported drives?

* Does the array controller block low level access to the drives? Does the host system need such access and does it know how to use it?

RAID-1 or RAID-0 arrays are the simplest to integrate. Other RAID levels are more complex. Ideally, the array should look exactly like a single disk to the host environment and operate transparently with respect to file systems, applications, data base managers and system utilities once the array is configured.

Types of data used: The form of the data stored may influence the choice of array. Long blocks of data such as images or satellite dumps may best be handled by RAID-3. Short blocks typical of on-line transaction processing may best be handled by RAID-5, especially if the data availability requirements are stringent. If a mixture of performance, availability and ability to handle a variety of data is needed, RAID-1 may be most suitable. If the system handles multiple data types, arrays capable of partitioning the disks into multiple array types should be considered. The array should be capable of handling data block sizes efficiently handled by the host and by the drives.

Data availability: If data availability is an issue, than RAID-0 is inappropriate, since it provides performance but no fault tolerance. RAID-6, though not generally available, theoretically provides superior availability, but at extra cost. Ultimately, data availability may be influenced more by the overall redundancy in the storage subsystem architecture than by the RAID level chosen. If an extremely high level of data availability is mandatory, then dual ported disk drives, redundant controllers, even redundant processors and power feeds will be required. Any element whose failure can make the system nonfault tolerant should be hot plugable. If write cache is used anywhere in the system, then backup power sufficient to keep the system operating until the contents of the write cache are written to disk is needed.

Data availability may be impacted due to performance degradation while data on a failed drive is being recreated. Performance drops of 50% during reconstruction are not unusual, and reconstruction can require time periods ranging from a few minutes to hours depending upon the drive capacity, array loading and other factors. While the data is accessible, it may not be available within the time window needed for satisfactory performance.

Performance: The question of performance revolves around the conditions under which it is measured. It is affected by the mix of reads vs. writes, the mix of sequential vs. random reads and writes, the length of the data blocks and many other factors. Controller and system design features strongly influence performance, especially the presence and configuration of cache. At present, there is no generally accepted way of measuring or specifying performance, requiring array users to exercise caution in interpreting performance specifications. Performance may be optimized by partitioning the array drives into multiple arrays. For instance, an array could be partitioned into a RAID-1 segment and a RAID-5 segment, using the RAID-1 portion for write-intensive I/O mixes and the RAID-5 segment for read-intensive I/O mixes. Some considerations:

* Would a layered array provide better cost/performance benefits than a nonlayered approach?

* Would you benefit from a look-ahead read cache in the array controller? Where is your write cache, if any? Is its size and configuration (write-through, write-back) appropriate to the application?

* Is the RAID level appropriate to the data block sizes, I/O transaction rates and other system factors?

* Does your array support queued commands? Does it need to?

Storage management: An array may be provided with the ability to support other devices, such as tape, robotic libraries, and optical drives that may be used for backup or save/restore operations. While disk drive arrays may provide a high level of insurance against hardware failures, they do not insure against the effects of operator error, fires or natural disasters. Only a rigorously managed backup program can protect data from such events. Some arrays provide for the addition of backup devices operated directly from the array controller and may be convenient where hierarchical storage management is implemented.

The ability to operate the array in several RAID modes simultaneously may be helpful in managing the flow of data. If different array types can be created using different logical partitions, not only can the data be assigned to the RAID mode most efficient in handling it, but backups can be done selectively on partitions as appropriate.

Economics: The economic considerations relevant to arrays are not limited to acquisition costs. For the system integrator there are costs of integration and testing. All array users should recognize that there will be costs of training, spare parts inventories, preventive maintenance and other indirect costs. Also to be considered are the availability and cost of upgrades and expansions for the array. An initially inexpensive array may not be a bargain if it can't be expanded to meet future needs or if it won't work with new software releases. Other considerations:

* If a high degree of fault tolerance is not initially needed, can it be economically added in the future?

* Will an array capable of operating at multiple RAID levels concurrently be a better cost-performance choice than an array which does not have such a capability? How easy is it to migrate data from one RAID level to another?

The most important cost of all may be the cost to the organization if the stored data is not available for the time required to bring the failed system back into service. For some customers, badly degraded availability is almost as costly as complete unavailability, so the array's performance when a component fails may be a critical issue, even though the array continues to operate. Furthermore, once an array element fails, there is no remaining fault tolerance in most array

configurations and the system will crash and may lose data if further failures occur while the original failure remains unrepaired. Many array users keep critical spare parts on site to minimize the window of vulnerability.

Manufacturer support, warranty and maintenance policies and costs vary widely. Array users need to realistically evaluate their internal abilities to support the array with the assistance realistically expected to be available from the manufacturer.

Maintenance: Maintainability issues include the costs and availability of service, the ability of the array to be serviced by an end user in case of a component failure, the ability of the array to identify a failed drive and start up an on-line spare (if available), and the ability to replace drives and other elements of the array subassembly without disrupting operations (hot plugging or hot swapping). Some arrays will automatically recognize a failed drive and rebuild missing data on a spare drive. Others require the operator to physically replace a defective drive and manually initiate the data rebuild. Most arrays will continue to operate while a drive is replaced, and some allow replacement of a power supply, fan or other element without taking the array out of service. If battery backup or a UPS is used, the batteries may need to be changed periodically.

Some arrays make it easy to locate a failed drive, fan or power supply with indicator lights marking the defective element. Since removing the wrong drive when making an array repair will make data unavailable to users, the array design should provide protections against this kind of inadvertent error. Good fault detection systems help to insure the correct replacement parts are used.

It is often necessary to suppress I/O operations to an array member (and sometimes the array) while hot swapping is being done. The array manufacturer usually supplies utilities to do this if a host bus pause operation is required.

Another useful maintenance feature is the ability to run diagnostics in a non-intrusive manner while the system is in normal operation. This can develop useful information for service personnel and may help prevent repeated service calls.

Monitoring and control: Depending upon their design, arrays can be configured by commands from a dedicated control panel, by data from the host sent through the primary data bus, or by data from a remote processor via a separate RS-232 port. Some arrays are factory preset and offer the user little ability to change configuration.

Most arrays are provided with utility software that can be used to configure the array from the host or a remote processor. Some software is easy to use and includes safeguards against the user making disastrous choices. Some requires considerable skill and knowledge to use.

Another desirable feature is the ability to monitor and control the array remotely over a network. Some arrays provide performance monitoring information on request, allowing network supervisors to detect impending drive failures, over-

temperature conditions and other matters requiring remedial action before a failure actually occurs.

Some other considerations:

* What kind of messages or alert signal are generated when an array component fails? Messages to the server? Messages to a master console? Audible alarms? Can alarms be cut off once acknowledged?

* Can the system automatically dial a remote system and notify it of a failure?

Facilities requirements: Some highly fault tolerant arrays require dual AC power feeds from separate circuits. They may also require external uninterruptable power supplies (UPS) to sustain operation in case of power failure.

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TECHNICAL REVIEW

Disk drive arrays come in a variety of configurations and implementations ranging from inexpensive and simple to costly and complex. This section of the report reviews some aspects of significant array technologies and issues pertaining to their use.

ARRAY TECHNOLOGY: STATUS AND POTENTIAL ENHANCEMENTS

Array architecture: The details of array architectures lie in the structure and location of the array management software, which can be host resident, array controller resident, drive controller resident, or scattered throughout the storage subsystem. Implementation can be in pure software, pure firmware, or a combination thereof. While the implementation can influence performance, economics, maintainability and other important factors, architecture is largely independent of implementation details. There are several ways to view array architectures:

* Layered versus nonlayered arrays: A nonlayered array controls array configuration at one point in the array structure, and typically operates as a pure RAID-3, RAID-5, etc. A layered array distributes different array con figurations to different points in the array architecture. For instance, striping may be done in the array driver, while mirroring may be done at the disk controller level. This provides the advantages of both RAID-0 and RAID-1. Similarly, the array controller may stripe for RAID-3 while the disk controller provides a RAID-5 layer.

* Host based versus controller based arrays: If all of the array capability is associated with the host system (usually as a software implementation), rather than with a storage subsystem, then there is great flexibility in configuring and using the array. The host can select its array members from among multiple subsystems, stripe to individual subsystems to improve performance, and provide a level of tolerance for catastrophic disasters that affect a particular subsystem. A host based array can also create arrays with older drives and storage subsystems otherwise incapable of being so operated. The downside is that the use of host resources may be disruptive in computing intensive environments. It may also be difficult for a host based array to take full advantage of the capabilities of intelligent disk drives and controllers because the host may not support the commands needed to do so. Controller based arrays are usually able to optimize storage subsystem performance, but are less able to optimize use of all of the storage resources attached to the host. A host based array may also be difficult to integrate with some operating systems if the operating system is not modular, with well designed software interfaces. In such cases, the controller based array may offer more functionality.

* Modular architecture: This approach, still not fully implemented, incorporates a core array management software module that can be implemented in various forms and places within the storage subsystem, including the host as a virtual device driver, the host bus adaptor, the array controller, or an intelligent device controller servicing multiple drives. The core module communicates through software interfaces appropriate to the location of the core module in the array. Modular architectures allow reuse of program code (which makes development and configuration of midrange and large systems easier), but tend to be too expensive to justify in low end systems. NCR has been among the active investigators of modular array architectures.

* Augmented arrays: Much of the advanced work being done in array design centers around methods to reduce or eliminate write delays associated with the read-modify-write cycles associated with RAID-5 configurations. For some developers, the inclusion of large buffers and algorithms that allow the creation of a few large transactions from the combination of many small ones is a preferred approach. Others use combinations of RAID-3 and RAID-5 technology in which data is placed upon the drives in a RAID-5 format but written to the drives from a large buffer in parallel. An augmented array frequently has a non-Berkeley RAID level defined by its manufacturer.

In some cases the array is bundled into an operating system or OS-like environment. Such implementations usually provide mirroring, duplexing or both. Some, such as Novell's SFT-III, duplex entire servers rather than requiring an array of disk drives. While providing fault tolerance, these approaches don't really qualify as an array product per se and have not been counted in the array statistics in this report.

Hierarchical storage: The more advanced and flexible array controllers provide for the support of tape drive, optical drives and automated libraries, allowing the host system to move inactive data to offline or automated library storage and to stage recalled data to the disk drives for use. Some arrays allow the use of optical disk drives or tape drives as array elements, although not intermixed with magnetic drives. While feasible, the use of removable media makes careful physical volume management mandatory to avoid data corruption.

Packaging: Small array subsystems are usually packaged in tower or rack mount style enclosures. Larger arrays are integrated into floor standing cabinets along with other system elements. Some innovative approaches have emerged, including the modular array packaging of Micropolis and the practice of fitting the entire array, including drives, into the volume of a single 5.25" full height drive by using 2.5" disk drives for the array. As 1.8" diameter drives achieve larger capacities, it is expected that arrays of 1.8" drives will be packaged in the form factor of a 3.5" drive.

The Micropolis approach packages a disk drive, power supply, fan and controller in a module, permitting modules to be stacked to make an array of the desired size. The advantages of this approach include flexibility plus easy installation and expansion.

Arrays announced by Core Technology, Areal Technology, Allodyne and others exemplify the disk drive form factor packaging approach, which is very attractive for arrays to be used with workstations or in servers for small work groups. Disk drives are expected to quadruple the capacity available in today's form factors by the end of 1996, which will make multigigabyte user capacity available in the 5.25" form factor.

In the typical array, the disk drive is mounted on a removable frame, or sled, which may also contain a power supply, fan and other elements associated with the drive. The array is designed to permit removal of the sled without shutting down the array in most cases. Mathematically, service events are less likely in arrays that have common power supplies and fans, since there are fewer components to fail. In practice, service needs depend upon design techniques and avoidance of stress on array components.

Arrays implemented in software require no special packaging, but may influence system packaging as array drives are added or if additional memory is required in the processor to support array operations.

Semiconductors: Specialized semiconductors for use in disk drive arrays have been available from NCR since 1991, and other firms are also beginning to produce specialized chips for this purpose, including drive controllers, array management chips and specialized processors. Over the long haul, basic array controller chips may migrate to the motherboards of low end computing systems, much as graphics controllers, modems and other I/O functions have already done. While this has negative implications for companies providing array controller boards, it is likely that high performance needs of servers and workstations will continue to create a demand for specialized controllers not required in sufficient quantities to justify chip development expense.

Cirrus Logic is among the semiconductor companies that have indicated plans to do an array chip set for the merchant market, joining NCR as a specialized supplier to the array controller market.

Flash memory is expected to have a significant role in future array controllers as a residence for the microcode associated with array management. The ability of flash memory to be updated will make it easy to perform field upgrades of arrays as new software versions are released.

The decreasing cost per megabit of semiconductor memory will tend to increase the likelihood of cache memory being present on array controllers and will tend to expand cache size. Array controllers for even small systems may contain several megabytes of cache, and cache sizes exceeding 50 megabytes are increasingly common.

Disk drives: The trend to higher areal density will continue. The drives that offer 250 megabits per square inch density today are expected to offer a gigabit per square inch by late 1996. The impact of this will be to make a gigabyte available in a single disk 3.5" drive or a double platter 2.5" drive. With the reduced parts count implied, the costs for a gigabyte of storage are expected to steadily decline.

The 3.5" disk drive in the one inch high form factor is expected to become the mainstay product for array producers. Such drives with one gigabyte capacity will be available in 1993 from IBM and others: Capacity expansion to four gigabytes per drive by late 1996 is anticipated.

Disk drive performance is expected to improve. Though only marginal improvements in seek time are expected, 5,400 RPM spindle speeds for high end drives have become common. A few have exceeded 6,000 RPM, and Seagate has announced 7,200 RPM drives. Because of the potential heat generated by drives rotating at the higher speeds, packaging of these drives for easy removability in an array is challenging. Increases in areal density and increases in RPM will combine to produce higher data transfer rates in future disk drives, although the ability of the drive read channel to support these new capabilities will be stretched.

Disk drive arrays require drives with very high MTBF. With multiple drives in a system, the probability of a failure within a given time increases with the number of drives. To minimize service events or the possibility of two drives failing within the same time frame, very high drive MTBF is required, and the disk drive industry has responded by extending MTBF dramatically over the last several years. Hewlett-Packard initiated the MTBF race when it announced drives with 150,000 hours MTBF. Specified MTBF has climbed steadily through 200,000 hours and 500,000 hours to the 800,000 hour (92 years!) MTBF drives announced by IBM in 1993. While MTBF in the 100,000 hour MTBF range is not unusual in large drives for mainframes, it represents a significant accomplishment for makers of small form factor drives.

Arrays can make use of increased drive intelligence. The ability of a drive to test itself is significant in improving the operator's ability to monitor the health of the array. If the drive can collect and report the occurrence and location of soft errors, advance warning of impending failures is possible.

Spindle synchronization has been available for several years on some drives and is useful for RAID-3 implementations.

Interfaces: The interfaces involving arrays are the interface to the host computer, the interface to the drives, the interface to an array control device (which may be the host system) and the interface to the human operator.

Most array host interfaces use SCSI or SCSI-2, some in the fast and/or wide configuration. Arrays for PC based systems, such as Compaq's, frequently use the EISA bus, although there are also arrays for the older ISA bus. Some future

array designs are expected to accommodate the VESA bus. A few arrays with NuBus interfaces are being offered. At the high performance end of the product range, arrays are connected through the HIPPI bus (some using the IPI-3 protocol). Support for SCSI tagged command queuing is becoming important to reduce latency delays and improve concurrent operations in RAID-4 and RAID-5 configurations. As the SCSI-3 command set is defined and implemented it is expected to see wide use in array controllers because it will support advanced commands and high data transfer rates useful in improving array performance. The ability to queue commands at the controller and at the drive provides a significant improvement in array performance.

Drive interfaces are almost all SCSI or SCSI-2, although a few arrays exist that connect to IDE or ESDI interfaces. SCSI-3 and serial SCSI are expected to become common drive interfaces as they enter the market because they support high data transfer rates.

Some arrays use separate RS-232 ports to communicate with a remote computer which functions as the control device for the array. Some systems provide control through the host computer, using utility routines that can be employed through the host console or across a network. These interfaces are expected to remain stable in form.

The human interface provided by arrays varies from very sophisticated and user-friendly to rudimentary and requiring expert experience (plus luck). The long term trend is towards control and monitoring interfaces that can be used at varying levels of skill by authorized users of varying capabilities and which can be used on a server or over a network. An increased use of graphical user interfaces (GUI) is expected.

Cache: The way cache is used in an array subsystem is one of the more significant determinants of performance and fault tolerance. The use of cache is tricky; cache may also exist within the host system or within the disk drives used in the array. Operating with all of these levels of cache active can lead to performance degradation and loss of data under fault conditions if they are not carefully coordinated.

Some array controllers contain cache, while others, such as NCR's, do not, anticipating that system cache or drive level cache will be adequate for performance needs. Most array controllers incorporate cache, usually both read and write cache. Many of the controllers with write cache incorporate battery backup to avoid data loss in the event of power failure. Other designs use nonvolatile semiconductors for write cache and at least one array design, the IBM 9337, employs a separate disk drive as a write cache device.

Write cache in an array controller can be configured as a write-through cache, write-back cache or either. Write-through cache passes write operations directly to the disk drive, notifying the host system that the write is complete after all the drives have reported transaction completion. Write-back cache buffers the writes until the cache is full and then writes to all drives. A 'write complete' status is

given to the host when the data is placed in the cache. Write-through cache is typically employed in data base applications where multiple users need access to the latest possible version of a file. Write-back cache is employed where processor efficiency is of paramount concern.

Software: Array software can range from the expanded disk drivers used for simple disk mirroring on personal computers to the 300,000 plus lines of microcode needed to operate a mainframe array such as the Storage Technology Iceberg subsystem. The design complexities and testing requirements demanded by reliable interfaces to mainframe environments are major factors in determining when a high end product is ready to ship. However, array software add-on packages limited to providing mirroring and striping have been well accepted in systems running under the various types of UNIX and in Sun NFS environments. This success has been achieved primarily because well-defined interfaces between software modules have made array software relatively easy to integrate and support.

Array software is expected to migrate to microcode implementations at both the high end and the low end of array product lines, although array software for mirroring is expected to remain popular because of its relative ease of integration and lack of associated hardware expenses.

Compression: Data compression can help improve the performance of storage subsystems by reducing the number of bytes that must be sent to and from the disk. While the best location within the system to do data compression and decompression remains a subject of controversy, in the long run the argument is expected to be settled in favor of performing compression/decompression in the originating/using system, with data stored or transmitted in compressed form until reaching the processing point at which decompression is needed for processing. In many cases, a dedicated compression/decompression coprocessor will be used to avoid loading the host computer's primary processor with such a compute intensive task. There are many compression algorithms in use, with the choice depending upon the characteristics of the data to be compressed. Typical compression ratios range from 1.5:1 up to 200:1 depending upon the data type and content. There is no single method best for all types of data.

Some compression products for small systems require repartitioning of the disk drives, a feature which may not be compatible with the capabilities of some arrays.

The STC Iceberg, which is intended to operate with mainframes, includes compression as a capability. It is unclear whether this will prove an advantage now that compression is beginning to appear as a feature included in mainframe systems such as the IBM ES/9000 Model 982.

COMPETING TECHNOLOGIES

Besides the mainline technologies discussed above, other data storage technologies may provide competition to arrays in years to come.

Nonarray storage architectures: If minimizing storage costs per megabyte is a primary objective and backup is sufficient for achieving data availability needs, a nonarray architecture will probably be chosen, ranging from a single disk drive at the low end to the strings of disks common in high end systems. However, the emphasis on data availability in networks suggests that nonarray architectures will be less appealing over time. A possible exception is the practice of mirroring complete nodes as opposed to mirroring the drives or mirroring the storage subsystem. This approach, admittedly expensive, has been promoted by Novell and others as an effective way of providing fault tolerance. However, duplexing can result in significant, extended network performance degradation if reconstruction of data from one duplexed server to another is needed.

Holographic storage: It is theoretically possible to store data at very high densities and at very high speeds using crystalline materials as the storage medium and laser scanning devices for input and output to the crystal array. Holographic storage for data is just leaving the pure research stage and entering the development stage. It is expected that there will be no competition to magnetic storage from holographic storage until well past the end of the century.

Holographic storage devices are expected to eventually offer capacities in the range of 200 megabytes to 10 gigabytes, have average access times in the 1 to 10 microsecond range and data transfer rates in the gigabyte per second range.

Solid state arrays: It is possible to fabricate an array using solid state technology rather than disk drives. Although the cost per megabyte is substantially higher than for magnetic storage, if there is a requirement for very high speed or resistance to mechanical stress, solid state arrays may be appropriate.

Because a solid state array is already very fast, performance improvement is not a primary motivation for using an array configuration, especially in large systems. However, fault tolerance is desirable and a legitimate reason for using an array. Mirroring is the simplest, and probably most appropriate method, given the emphasis on speed in high end systems, but if utmost speed is not a requirement, RAID-5 organization could provide fault tolerance while minimizing the cost of expensive semiconductor memory.

At the smaller scale end of the systems world, arrays using flash memory cards may find a niche. Provided that each card maintains its own drive address, the cards could be placed in any PCMCIA slot providing disk drive support -- the exact order of insertion would not matter. However, implementation of arrays using removable media creates a storage management problem -- when the media is re-inserted, there is a risk of synchronizing a recently created volume against an obsolete volume with the resultant loss of recent data.

GLOSSARY

GLOSSARY

In addition to the definitions of individual terms included in this section, the product groups, types of products, market classes, and geographical classifications used in this report are defined in the DISK/TREND Array Definitions, at the end of the opening summary section.

Actuator: The device used to position the movable heads in a drive. Linear actuators use a straight line motion, while rotary actuators turn around a pivot point.

Actuator level cache: A cache segmented to provide separate support to each individual actuator in a drive string, preventing monopolization of the cache by an actuator with an unusually heavy level of activity.

Areal density: A measure of the information stored per unit of area on the surface of a recording medium. Normally computed by multiplying tracks per inch times bits per inch, and expressed as megabits per square inch. (Depending upon the recording code used, bits per inch may not be the same as flux changes per inch.)

Array: A group of storage devices controlled in such a way as to provide higher data transfer rates through parallel operation, higher data availability through redundancy, or both. See RAID. Array functionality is provided by a specialized controller, specialized software or both.

Array processor: The processor in the array controller, separate from the host processor, that performs the local computing and control functions within the array.

Array software, array driver: Programs that operate multiple disk drives as an array directly from the host system without the need for a specialized hardware controller. The software performs typical array functions such as striping, error correction, parity functions, data recovery, etc. An array driver is a smaller piece of code controlling basic data flow functions to the array.

Automatic rebuild: The process by which data from a failed drive in an array is automatically reconstructed upon another drive in the array. Manual rebuild is the same process, but is initiated upon operator command rather than automatically upon detection of a failure. See data reconstruction, rebuilding.

Availability: The probability that data will be available when requested within an acceptable time. If averaged over all data requests, it is the percentage of data requests satisfactorily fulfilled. "Satisfactory" may have different meanings in different applications.

Average access time: The average time elapsed between the time a command to access data is received by a disk drive and the time data begins to be transmitted or received. It usually consists of average head positioning (seek) time, average rotational delay (latency) time and settling time. If the drive uses an embedded controller, there may be an additional controller latency caused by command processing within the drive.

Average positioning time (seek): The average time required to move the head of a disk drive between tracks in response to random positioning requests. Frequently approximated as the time to move the head one third of the distance from inner track to outer track, beginning and ending with the head at rest. The time for the head to settle into its final position after it reaches the desired track is generally included. Often, and erroneously, referred to as "average access time". See average access time.

Average rotational delay (latency): The amount of time required for the disks in a disk drive to rotate through one half of a revolution, thus the average time for the drive to bring the beginning of the requested data block under the heads.

Bandwidth: The amount of data transmitted through a data channel per unit time. Usually expressed in terms of megabytes per second. To understand channel performance, it is useful to know how many signal conductors are included in the data channel.

Bit: The fundamental unit of digital information. As pertaining to digital recording, it is a single recorded information cell.

Bit density (linear density): The number of recorded bits per unit distance as placed upon the tracks of a storage device. Typically given as BPI (bits per inch).

Cache: A portion of memory dedicated to collecting and holding related data until a processing, storage, communications or other module within the system is ready to process it. Cache is usually implemented as fast semiconductor memory, but other forms of memory are sometimes used. The form and architecture of the cache used is a major influence on system performance. See read cache, write cache, segmented cache, multiple threaded cache, actuator level cache.

Check disk, parity disk: Disk in an array that is dedicated to storing redundancy information.

Controller: A physical module that interprets signals sent between the host processor and a peripheral device. The controller is sometimes embedded within the peripheral device, but can also be implemented as a separate PC board or as chips on a host system motherboard.

DASD: Direct Access Storage Device. IBM's term for a disk drive.

Data reconstruction, Data rebuild: The process of recreating data that was stored upon a failed drive or is unavailable from a drive because of component failures. The source of the recreated data is data plus parity information from the operating drives.

Data stripe: A sequence of logically consecutive "stripe units" written to the disk drives in an array. A logical I/O request to a disk array corresponds to a data stripe, which may extend across one, several, or all the drives in the array depending upon the array configuration. See stripe unit.

Data transfer rate, drive: Maximum data rate from the disk drive to the array controller. The rate is a function of the interface transfer rate, bus width, and buffer output rate from the drive. It is usually measured in megabytes per second. The burst rate from the drive is the fastest instantaneous rate between the drive interface and the controller interface. The sustained rate is the rate at which data is extracted from the disks in the drive.

Data transfer rate, host: The rate of data exchange between the host processor and the array. It can be expressed as a burst rate (maximum instantaneous rate) or as a sustained rate (combined effective rate the drives in the array can produce when operating as a group over a period of time). Sustained rate varies as a function of the number of drives in the array and the array configuration.

Degraded operation, degraded mode: The state of operation of an array after a drive has failed. Performance is reduced because of the overhead associated with reconstructing data as requested, rebuilding data on a spare drive, or both.

Disk spanning: A technique that operates several disk drives from a single controller, with the entire set of drives appearing to the host system as a single drive. Data is not striped, nor is there any redundancy, so disk spanning is not recognized as an array technique.

Duplexing: A configuration in which each element of a system or subsystem is duplicated. For instance, in a duplexed RAID-1 array, for each drive pair, each drive has its own controller and host adapter.

Dynamic sparing: A technique that automatically transfers data to a spare drive when the detected error rate for an active drive exceeds a specified threshold.

Exclusive OR: The logical algorithm used to recover data from an array when a drive has failed.

Fault tolerance: The ability to operate normally, albeit at a degraded rate, even though one or more elements of a system have failed.

HIPPI: High performance parallel interface.

Hot spare, hot patch, on-line spare: In an array, a disk drive that is present but normally unused until there is a drive failure, at which time the drive is used to substitute for the failed drive. The data from the failed drive can automatically be rebuilt upon the spare drive, but may require operator intervention in some arrays. See automatic rebuild. By contrast, a cold spare is not installed in the system; it's a shelf item. While widely used among array producers and users, the term "hot spare" is actually a trade mark of Core International.

Hot swap, hot fix: The ability to exchange a defective component without shutting down the equipment of which the component is an element. In arrays, this typically refers to exchanging a drive, but may also apply to exchanges of fans, controllers, wiring or other elements.

Input/Output operations per second (I/O per second): See transaction rate.

Interleaving, data interleaving: The process of distributing a byte of data across several storage devices. Typically used in RAID-2 and RAID-3 configurations.

IPI: Intelligent Peripheral Interface. This is a high performance interface usually used in larger systems. Two variants are in current use: IPI-2 and IPI-3.

JBOD: Just a Bunch of Disks. Term used to refer to a multiple disk drive configuration in which there is no redundancy. Used by some manufacturers to mean a RAID-0 configuration.

Mirroring: A recording technique where data is recorded identically upon two or more disk drives. If a drive fails, operation continues using the other drive. If the drives are accessed for read concurrently, the first drive responding supplies the data. Drives operated in a mirrored mode are defined as a RAID-1 configuration.

MTBDL: Mean Time Between Data Losses. A statistic indicating the elapsed time before half of a group of arrays will experience events that cause data to be lost. Frequently interpreted as the average time between data loss for a single array. For an array with redundancy, this average can exceed 1,000,000 operating hours, but an individual array may fail at any time.

MTBF: Mean Time Between Failures. A statistic indicating the elapsed time a group of devices will operate before half of them experience failure. Frequently interpreted as the average time a single device will operate between failures.

MTDA: Mean Time of Data Availability. This is the average period of time data is available to be used for its intended purpose. See availability.

Multimode operation (Universal RAID): The ability of an array to operate in more than one RAID configuration simultaneously.

Multithreaded cache: A cache which has been segmented and in which each segment is assigned to support one of several simultaneously executing tasks.

Parity: A mathematical technique that adds bits to a data stream containing redundant information allowing reconstruction of the data stream if part of the stream is corrupted or absent. In arrays, single level parity permits data recovery from a single drive failure. Two level parity permits recovery from a two drive failure. Parity information may be held on one drive, as in RAID-3, or spread across all drives in the array, as in RAID-5.

RAID: Redundant Array of Inexpensive Disks. This term was originally coined in 1987 at U.C. Berkeley, as was the initial categorization of RAID configurations. May also stand for Redundant Array of Independent Disks. See also, SLED.

RAID Advisory Board (RAB): The RAB is an association of organizations concerned with sales or purchases of drive arrays and closely related products. RAB activities include the proposal of standards for commonly used nomenclature, array interfaces, test procedures and definitions, and the promotion of array technology throughout the computer industry.

RAID level: A number designating the general configuration of an array. RAID configurations are defined and generally accepted for levels 0 through 5. Higher levels have been used by specific manufacturers to indicate additional features but are not universally accepted. See the Array Considerations section.

Read cache: A cache or cache segment dedicated to accumulating information read from the disk drives. Typically, the read cache will load a track or a few tracks of data on the assumption that the next data requested will be closely related to the initial data requested. The system will search the cache for requested information, initiating further disk accesses only if the desired information is not located in the cache.

Read-modify-write cycle: For RAID-4 and RAID-5 arrays, a write operation requires readback of data from the drives across which the data stripe is to be written, recomputation of the parity data, and rewriting the data and parity.

Read/Write ratio: The ratio of read operations to write operations in a typical host system work load. Important in selecting array configuration, because some configurations are inefficient in write intensive environments. Usually given as "x% reads" in data sheets.

Rebuild: See Reconstruction, Automatic Rebuild.

Reconstruction: The process of recreating the data from a failed disk, rebuild-

ing the information on a new drive from data and parity information on the remaining functional drives. This can occur concurrently with normal operation in most arrays, although the processing overhead will slow the transaction rate.

Recovery period: The time required to reconstruct data from a failed disk drive.

Redundant drive: In a RAID-3 configuration, a drive dedicated to parity data.

SCSI: Small Computer System Interface. SCSI-2 is a more recently defined advanced version. The standard SCSI burst transfer rates for SCSI and SCSI-2 are 5 megabytes/second. Fast SCSI operates at up to 10 megabytes per second. Wide SCSI, with a double width bus, operates at up to 20 megabytes per second. Serial SCSI is a new 20 megabyte per second format using fewer cable wires. SCSI-3 is a proposed new standard adding some new commands, many of which are needed for efficient array performance. SCSI interfaces may operate asynchronously or synchronously. They may be single ended (6 meter cable length limit) or differential (25 meter cable length limit).

Segmented cache: A large block of cache memory divided in such a way that the segments are assigned to individual disk drives, hosts, or processing tasks.

SLED: Single Large Expensive Disk. The alternative to RAID.

Spindle synchronization: A technique for causing the rotational position of all the disks in an array to be identical, facilitating the flow of information in parallel to the drives in the array. Usually used for RAID-3 configurations. Disk drives must be designed specifically to provide spindle synchronization capability.

Storage overhead, array overhead: The percentage of the total capacity of the disks in the array that is used to store redundant information needed to recover data or correct errors. The percentage varies with array configuration and number of disks in the array.

Striping: The process of recording data on several recording devices, distributing blocks of data on each device. The exact striping method depends upon the RAID configuration.

Stripe depth: The amount of data placed on a drive in the array during a transaction, measured in stripe units.

Stripe unit: A unit of data interleaving; the amount of physical data placed upon a disk drive before data flow is switched to the next disk drive in the array. Stripe units normally range from a sector to a track in length and are typically 512 bytes to 64K bytes long.

Throughput: The number of I/O requests completed in a unit of time. Usually expressed as requests per second.

Track density: The number of recording tracks per unit distance, measured perpendicularly to the direction of the recorded track. Usually given as TPI (tracks per inch).

Transaction rate (I/O per second): A transaction is the successful completion of a read or write request for a block of data. A data block access may require multiple reads or writes. Transaction rate is the number of successfully completed transactions per second. Often given with a qualification of workload mix as random requests, sequential requests, or mixed requests, and the read/write ratio.

Virtual disk drive: Virtual drives are not a single physical drive. They appear to the system as a single disk drive, but may in fact be implemented in software, semiconductor memory, or as a collection of drives, or even as a portion of a single drive. They are conceptual constructs, rather than physical entities.

Write cache: A cache or cache segment used to accumulate data before writing to the disk on the theory that a single large write operation is more efficient than several smaller transfers. Can mask the write latency of the drives to the host system. Write cache is usually in semiconductor form, although IBM uses a disk drive in its Model 9337 array.

Write latency: As seen by the host system, the period of time between the initiation of a write transaction and the time at which the storage subsystem has indicated successful completion of write operations. If a write cache is present, write latency is considerably shortened. Depending upon the array configuration, the write latency period may incorporate multiple reads and writes by individual drives in the array. See Read-modify-write cycle.

Write-back cache: Data is accumulated in the cache and the host system is told that the write operation is complete as soon as the cache is loaded. The cache contents are transferred to the disk when the optimum block size is available.

Write-through cache: Data placed in the cache is transferred to the disk when all data relevant to a transaction have been placed in the cache. The host system is notified the write is complete when all drives involved have signaled the completion of the transaction. Typically used for data base applications.

ARRAYS: SINGLE USER SYSTEMS

1993 DISK/TREND REPORT

ARRAYS: SINGLE USER SYSTEMS

Coverage

Examples of disk drive arrays in this group include:

Complete subsystems, with disk drives

Loviel Computer	R1
Mass Microsystems	PersonalArray 1000, 2000
Peripheral Land, Inc.	MiniArray, QuickArray
Storage Dimensions	SA1/2/4 series

Board assembly (no drives)

Arco Electronics	AC1079MC
ATTO Technology	Silicon Express
CMD Technology	SCEA/S
Peripheral Land, Inc.	QuickSCSI, QuickSCSI FS
Procom Technology	ISA SCSI Xelerator

Software arrays

American Digital Data Associates	ADS 2000
ATTO Technology	Express Mirror
Loviel Computer	LARC
Unitrol Data Protection Systems	Immunity

All disk drive arrays used primarily with single personal computers or workstations are included in this product group. Shipments in this product group started in 1990, with early software and board level array products.

The majority of array products offered for single user computer systems are designed for the Macintosh market, with most offering RAID-0 and/or RAID-1 capability. The large data storage requirements for many graphics applications for which Macintosh systems are widely used have created a demand for both the high data rates offered by RAID-0 striping and the reliability provided by RAID-1 mirroring.

Although individual array products offering RAID-3 or RAID-5 capability are included in each of the above subsystem, board and software product types, they remain the exception, and in some cases are intended for high-end graphics and prepress applications. Most of the other products are designed for the very price-sensitive personal computer markets, and use disk mirroring.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	2.7	10.5	21.8	38.0	48.7
All manufacturers	2.8	10.8	22.8	42.5	56.3

The earliest disk drive array products specifically intended for single users appeared in 1990 and 1991, offering RAID-1 and RAID-0/1 for individual computer users who consider their work to be mission critical. Worldwide shipments totaled only 5,400 units in 1992, but are forecasted to reach 13,725 units in 1993. The 1993 revenue total is expected to be a modest $10.8 million, held down by the low average prices which are necessary in this product group.

Shipments which have occurred so far in this product group have included relatively few complete disk drive array subsystems -- only 545 in 1992, growing to an expected 3,080 in 1993, 22.4% of the group's unit total. Many more users have chosen the option of installing a controller board with mirroring capability. Boards and board assemblies are forecasted to provide 61.5% of the 1993 shipment total, for 8,295 units. Software based arrays have accomplished only a small penetration of the market, with a projected 17.1% share of the 1993 worldwide total.

Peripheral Land's 1992 combined total of 3,100 RAID-0/1 subsystems and boards for the Macintosh market gave the company a 57.4 share of the year's worldwide noncaptive unit shipments. Unitrol's RAID-1 software for PC compatible systems held 19.4%, and Procom's RAID-0/1 boards for PC compatible systems earned 13.9% of the worldwide total.

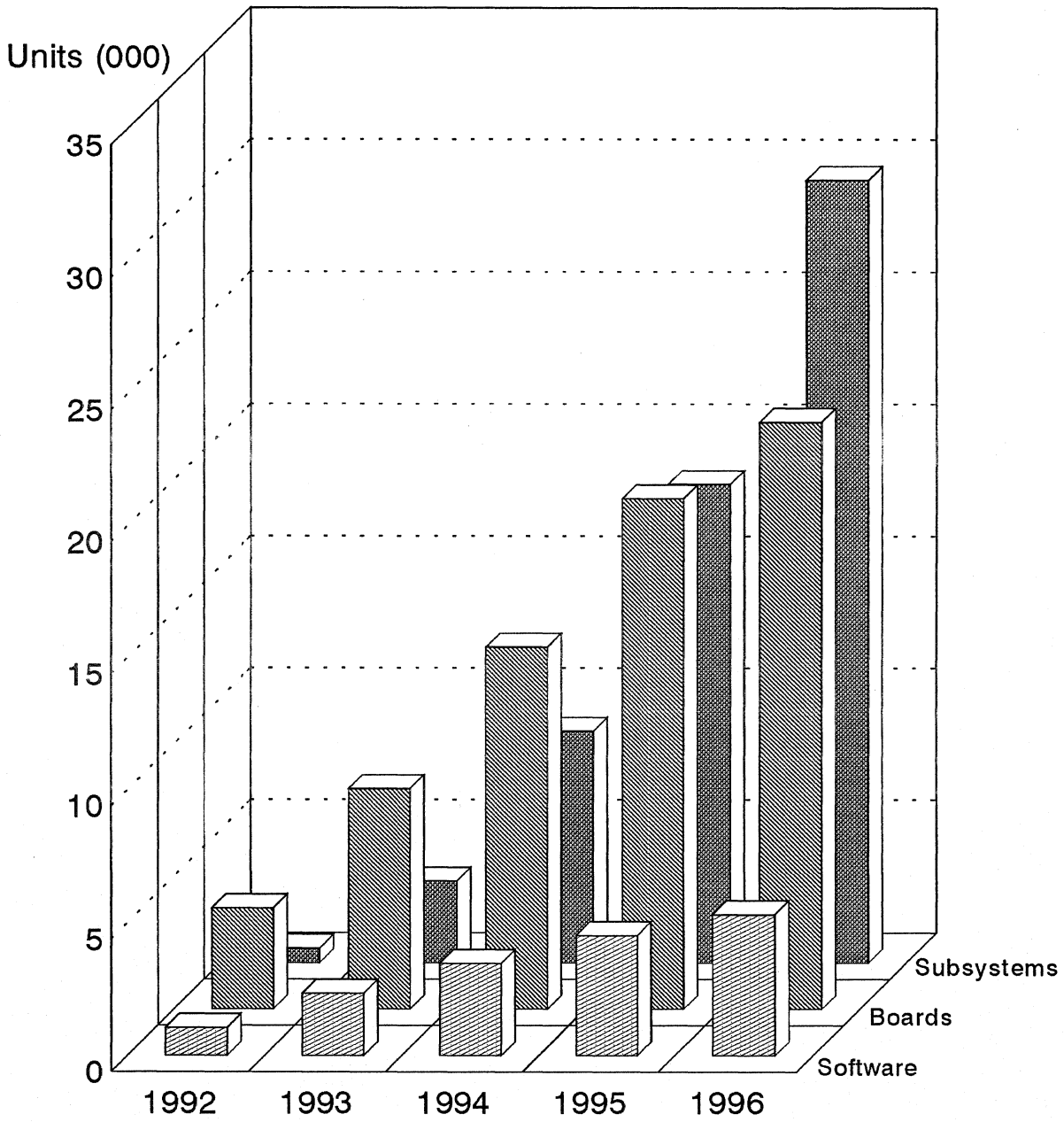
Marketing trends

Total revenues for arrays used with single user systems are expected to reach $56.3 million in 1996 -- substantial growth, but the group's worldwide revenue is nevertheless expected to remain the smallest of the DISK/TREND four array product groups. The group's low average unit prices will increase slightly due to the larger share expected for subsystems and the forecasted start of captive shipments, but not enough to boost the 1996 revenue total higher than this level. On the other hand, total shipments of single user arrays are forecasted

Figure 6

Single User System Arrays

Worldwide Shipments by Array Type



to reach 57,110 units in 1996, an average increase for the 1994-96 period of 62.3% per year.

Complete subsystems are expected to grow faster than other types of arrays in the 1993-96 period, increasing an average of 118.2% per year. In 1996, total shipments of 29,600 array subsystems are projected, followed by 22,200 boards. Because of the relatively small capacity of single user arrays, it is believed that the majority will remain RAID-1 types for the next few years, with some migration to RAID-5 arrays, as 1.8" and 2.5" drives with higher capacities are packaged in very small array enclosures.

The single user array market remains an add-on market served primarily by independent peripheral vendors specializing in the Macintosh and IBM compatible personal computer markets. Array manufacturers headquartered in the U.S. have led in development of the growth markets for single user array subsystems and boards and are expected to hold 86.5% of 1996 worldwide revenues. The PCM/Reseller channel is expected to remain dominant in sales of arrays for single user systems, and is forecasted to lead in 1996 unit shipments for all types of arrays.

Technical trends

A few manufacturers have already taken advantage of the availability of 2.5" drives to offer multiple disk complete array subsystems in the form factor of full size 5.25" disk drives. The capacity of these arrays will increase, as the capacity of 2.5" drives increases over the years. The capacity of individual 2.5" drives will probably reach at least 300 megabytes in 1993, and should exceed 500 megabytes or more within a few years. RAID-5 arrays with adequate capacity for many sophisticated single user applications will be cost-effective with high capacity 2.5" drives packaged in small enclosures.

1.8" drives with over 100 megabytes capacity will also be available in 1993, and these drives open additional packaging opportunities because they will be available in the PCMCIA type III configuration, a plug-in card only 10.5 millimeters thick. These drives, which are expected to offer capacities of at least 200 megabytes within a few years, provide the opportunity to produce a disk drive array in the 3.5" disk drive form factor, probably with one inch height. The

removable card-mounted drives will make it possible to upgrade drives when higher capacities become available and make replacement of failed drives easy.

Forecasting assumptions

1. The market for single user arrays will continue to grow, but will generate purchases from only a small segment of Macintosh, PC compatible and UNIX workstation users.

2. Complete subsystems will increase to at least half of the unit shipments for the product group, due to convenience of installation and use, plus availability of new small arrays using 2.5" and 1.8" disk drives.

3. U.S. manufacturers will continue to dominate the worldwide market for single user arrays, due to aggressive product development and continuously changing competitive conditions.

TABLE 10

SINGLE USER SYSTEMS

REVENUE SUMMARY

	DISK DRIVE ARRAY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	--	--	5.0	6.3	6.8	9.1
PCM/Reseller	2.0	2.7	7.0	10.0	13.1	20.5	17.7	27.4	21.5	32.9
OEM/Integrator	--	--	.4	.5	1.1	1.3	3.4	4.3	5.2	6.7
TOTAL U.S. REVENUES	2.0	2.7	7.4	10.5	14.2	21.8	26.1	38.0	33.5	48.7
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	.1	.1	.3	.3	.6	.8	2.5	3.4	3.9	5.6
OEM/Integrator	--	--	--	--	.2	.2	.9	1.1	1.6	2.0
TOTAL NON-U.S. REVENUES	.1	.1	.3	.3	.8	1.0	3.4	4.5	5.5	7.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2.1	2.8	7.7	10.8	15.0	22.8	29.5	42.5	39.0	56.3
OEM Average Price ($000)		--		1.266		.833		.966		.887

TABLE 11

SINGLE USER SYSTEMS

UNIT SHIPMENT SUMMARY

	DISK DRIVE ARRAY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1992 Shipments		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	--	--	1,680	2,100	2,700	3,600
PCM/Reseller	3,250	4,300	8,330	11,080	15,140	20,950	20,570	29,130	25,340	36,510
OEM/Integrator	50	50	325	395	1,300	1,600	3,450	4,290	5,650	7,230
TOTAL U.S. SHIPMENTS	3,300	4,350	8,655	11,475	16,440	22,550	25,700	35,520	33,690	47,340
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	950	1,050	2,000	2,250	2,740	3,150	4,090	5,100	5,335	7,190
OEM/Integrator	--	--	--	--	180	200	1,000	1,300	1,930	2,580
TOTAL NON-U.S. SHIPMENTS	950	1,050	2,000	2,250	2,920	3,350	5,090	6,400	7,265	9,770
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	4,250	5,400	10,655	13,725	19,360	25,900	30,790	41,920	40,955	57,110
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	4	5	14	19	34	45	65	86	106	144

TABLE 12

SINGLE USER SYSTEMS

WORLDWIDE REVENUES ($M)

BREAKDOWN BY ARRAY TYPE

	1992 Revenues			Forecast											
				1993			1994			1995			1996		
	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software
U.S. MANUFACTURERS															
Captive	--	--	--	--	--	--	--	--	--	6.3	--	--	9.1	--	--
PCM/Reseller	1.5	1.2	--	7.3	2.4	.3	16.8	3.6	.1	22.9	4.4	.1	28.5	4.3	.1
OEM/Integrator	--	--	--	--	.5	--	.2	1.1	--	2.0	2.3	--	3.2	3.4	.1
TOTAL U.S. REVENUES	1.5	1.2	--	7.3	2.9	.3	17.0	4.7	.1	31.2	6.7	.1	40.8	7.7	.2
NON-U.S. MANUFACTURERS															
PCM/Reseller	--	--	.1	--	--	.3	.4	--	.4	2.8	.1	.5	4.9	.2	.5
OEM/Integrator	--	--	--	--	--	--	--	.2	--	.4	.7	--	.9	1.1	--
TOTAL NON-U.S. REVENUES	--	--	.1	--	--	.3	.4	.2	.4	3.2	.8	.5	5.8	1.3	.5
WORLDWIDE RECAP															
Captive	--	--	--	--	--	--	--	--	--	6.3	--	--	9.1	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	+44.4%	--	--
PCM/Reseller	1.5	1.2	.1	7.3	2.4	.6	17.2	3.6	.5	25.7	4.5	.6	33.4	4.5	.6
	--	--	--	+386.7%	+100.0%	+500.0%	+135.6%	+50.0%	-16.7%	+49.4%	+25.0%	+20.0%	+30.0%	--	--
OEM/Integrator	--	--	--	--	.5	--	.2	1.3	--	2.4	3.0	--	4.1	4.5	.1
	--	--	--	--	--	--	--	+160.0%	--	--	+130.8%	--	+70.8%	+50.0%	--
Total Revenues	1.5	1.2	.1	7.3	2.9	.6	17.4	4.9	.5	34.4	7.5	.6	46.6	9.0	.7
	--	--	--	+386.7%	+141.7%	+500.0%	+138.4%	+69.0%	-16.7%	+97.7%	+53.1%	+20.0%	+35.5%	+20.0%	+16.7%
ANNUAL SHARE, BY TYPE	53.7%	42.9%	3.4%	67.7%	26.9%	5.4%	76.4%	21.5%	2.1%	81.0%	17.6%	1.4%	82.9%	16.0%	1.1%

TABLE 13

SINGLE USER SYSTEMS

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY ARRAY TYPE

	1992 Shipments			Forecast											
				1993			1994			1995			1996		
	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software
U.S. MANUFACTURERS															
Captive	--	--	--	--	--	--	--	--	--	2,100	--	--	3,600	--	--
PCM/Reseller	545	3,755	--	3,080	7,900	100	8,400	12,250	300	12,700	15,950	480	19,000	16,890	620
OEM/Integrator	--	50	--	--	395	--	150	1,100	350	1,500	2,300	490	3,200	3,400	630
TOTAL U.S. SHIPMENTS	545	3,805	--	3,080	8,295	100	8,550	13,350	650	16,300	18,250	970	25,800	20,290	1,250
NON-U.S. MANUFACTURERS															
PCM/Reseller	--	--	1,050	--	--	2,250	200	120	2,830	1,400	300	3,400	2,900	510	3,780
OEM/Integrator	--	--	--	--	--	--	--	200	--	400	750	150	900	1,400	280
TOTAL NON-U.S. SHIPMENTS	--	--	1,050	--	--	2,250	200	320	2,830	1,800	1,050	3,550	3,800	1,910	4,060
WORLDWIDE RECAP															
Captive	--	--	--	--	--	--	--	--	--	2,100	--	--	3,600	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	+71.4%	--	--
PCM/Reseller	545	3,755	1,050	3,080	7,900	2,350	8,600	12,370	3,130	14,100	16,250	3,880	21,900	17,400	4,400
	--	--	--	+465.1%	+110.4%	+123.8%	+179.2%	+56.6%	+33.2%	+64.0%	+31.4%	+24.0%	+55.3%	+7.1%	+13.4%
OEM/Integrator	--	50	--	--	395	--	150	1,300	350	1,900	3,050	640	4,100	4,800	910
	--	--	--	--	+690.0%	--	--	+229.1%	--	--	+134.6%	+82.9%	+115.8%	+57.4%	+42.2%
Total Shipments	545	3,805	1,050	3,080	8,295	2,350	8,750	13,670	3,480	18,100	19,300	4,520	29,600	22,200	5,310
	--	--	--	+465.1%	+118.0%	+123.8%	+184.1%	+64.8%	+48.1%	+106.9%	+41.2%	+29.9%	+63.5%	+15.0%	+17.5%
ANNUAL SHARE, BY TYPE	10.1%	70.6%	19.3%	22.4%	60.5%	17.1%	33.9%	52.8%	13.3%	43.3%	46.0%	10.7%	51.9%	38.9%	9.2%

TABLE 14

SINGLE USER SYSTEMS

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drive Arrays

	1992 Net Shipments									
	To United States Destinations					Worldwide				
	Units				%	Units				%
Drive Manufacturers	Subsys.	Boards	Softwre	Total		Subsys.	Boards	Softwre	Total	
Peripheral Land	150	2,100	--	2,250	52.9	300	2,800	--	3,100	57.5
Unitrol	--	--	950	950	22.4	--	--	1,050	1,050	19.4
Procom	--	650	--	650	15.3	--	750	--	750	13.9
Core International	200	--	--	200	4.7	240	--	--	240	4.4
Arco Electronics	--	145	--	145	3.4	--	205	--	205	3.8
Perceptive Solutions	--	50	--	50	1.2	--	50	--	50	.9
Other U.S.	5	--	--	5	.1	5	--	--	5	.1
Other Non-U.S.	--	--	--	--	--	--	--	--	--	--
TOTAL	355	2,945	950	4,250	100.0	545	3,805	1,050	5,400	100.0

ARRAYS: NETWORKS, MINICOMPUTERS, MULTIUSER SYSTEMS

1993 DISK/TREND REPORT

ARRAYS: NETWORK/MINICOMPUTER/MULTIUSER SYSTEMS

Coverage

Examples of disk drive arrays in this group include:

Complete subsystems, with disk drives

Acer	AF 500, AF 3000
Allodyne	ALLO-510, ALLO-910
Areal Technology	AA5190, AA9180
Array Technology	PentARRAY 5000, 5020
ASA Computers	Array Option 1-7
AST Research	AST 3/5
Astrix	Array Server II
Auspex Systems	NS 5XXX
Baydel	DAR-3xx
Blue Lance	Datarray
Box Hill	RAID Box
Cambex	Array/6000 Certainty
Cambridge Technologies	Raidpro
Ciprico	NA6610, NA6700, NA6710
Clearpoint Research	FA-1700, FA-400
Clovis Manufacturing	G-2 Intellistor
Compaq Computer	Systempro/XL series, Prosignia series
Conley	SR1, SR2
Core International	CPR series, MA-800 MicroArray
Data General	CLARiiON 7906, CLARiiON 7910
Dell Computer	DSA
Digital Equipment	SHA21, RM HSC95, SZ200
DynaTek Automation	RDR 2.0, RDR 5.0I, XPR 1000
ECCS	DFT-1, DFT-5, MDFT-1
EMC	Harmonix HX5
Fujitsu	F7956B1, F7956C1
Gain Systems	Superserver
Hewlett-Packard	1350SA, 420SA, C2252-HA
Hi-Data	2000, 3000
IBM	9337, 3514, 7051, 9570
IPL	7637-20, 7936
Legacy Storage Systems	HFD NetSpan, SL, XE
Mass Microsystems	PersonalArray, MASSterArray
Mega Drive Systems	MR/5, MR/20, MR/245
Memorex-Telex	3936-40
Micro Technology	Failsafe 26, Failsafe 44
Micronet Technology	Raven 30, Micro Mirror
Micropolis	RAIDION 680, RAIDION LT
Mylex	IDA S 2000
NCR	6298-2000
NEC	N1137-32/33/34, N7759-89
NetFRAME	NF250 FT, NF450 FT
Northgate Computer Systems	Disk Array

Complete subsystems, with disk drives (continued)

Pacific Micro Data	MAST VII
Perceptive Solutions	Prism
Procom Technology	LANforcer
Raidtec	FlexArray, FlexArray IX
Sanyo Icon	MRX-100, MRX-300, MRX-500FT
Sequoia Systems	DS310, DS4003
Solid Computer	WSR425, WSR805
Storage Computer	CLx, D3x, D5x, R3x,R5x
Storage Concepts	Concept 51, Concept 550
Storage Dimensions	LANStor-CDA, SA1-1000F2
Storage Solutions	CM-01, CM-02
Storage Technology	Alpine 9600
Stratus Computer	D600 (K121)
System Industries	318, 333, 341, 344, 360
Tangent Computer	Multiserver-2, Raid5server
Unbound	RAIDSTOR-T3, MacRAID-T3
Unisys	MasCab-2,QCIC/PBAY
Vortex Systems	Mirror Plus
Winchester Systems	Flashdisk 2

Board assembly (no drives)

American Digital Data Associates	ADS 1000, ADS 3000
Cambridge Technologies	CDA 3003-ISA
CMD Technology	CRD-5000
Control Data	47008
Digi-Data	Model Z
Distributed Processing Technology	Smart Cache
Hi-Data	510, 520, 550
Infortrend	IS-1000
Laura Technologies (Tentime)	PowerCache SC
Lomas Data Products	LDP Cache IIP
Maple Systems	MC2068, MC4000, MC4200
Morse Technology	KP 8050
Mylex	DAC-960
NCR	ADP-92, ADP-93
Perceptive Solutions	dataSHADOW
Silicon Valley Computer	ADP 104
Transoft	DataDock T2000
UltraStor	124F, 144F
Unbound	RAIDSTOR
Winchester Systems	Flashserver

Software arrays

1776, Inc.	76SC4, 76SC4-HS, 76SC4-DA
Chantal	Paragon 3.0
Digital Equipment	QL-YEA9-J, Volume Shadowing 6.0
IBM	OASAS I V2.0
NCR	Disk Array Plus
Sun Microsystems	Online: DiskSuite 1.0

Software arrays (continued)

System Industries	eaSIshadow
TwinCom	Dual Mirror, Network Mirror
Veritas Software	VxVM
Zenith Data Systems	OASYS I

This product group includes arrays intended primarily for use with networks, minicomputers and multiuser systems. While mirrored disk implementations have been available for many years, the group has seen an explosion of product introductions of RAID-3 and RAID-5 arrays since the early pioneering efforts in the mid-1980s. Arrays have originated with system manufacturers, disk drive manufacturers, independent peripherals resellers and controller manufacturers, network server manufacturers and startup companies founded for the sole purpose of producing disk drive arrays.

The complete subsystems included in this product group cover a broad range of capabilities, from highly redundant fault tolerant superservers exemplified by those of NetFRAME and Array Technology, to small arrays of 2.5" drives packaged in the form factor of a 5.25" drive, such as those introduced within the last year by Core International and Areal Technology. Most of the subsystems are somewhere between these extremes, with a wide variation in physical size, price and redundancy of critical components.

A strong majority of the complete subsystems in this product group offer either RAID-3 or RAID-5 capability, or both -- and most of these are relative newcomers to the field. A very high share of array subsystems shipped until now have been RAID-1 mirrored disk implementations. Many of the RAID-1 shipment leaders have offered RAID-1 subsystems on a captive basis with midrange minicomputers, such as Digital Equipment, Tandem Computers and Stratus Computer, with superservers from Auspex and NetFRAME, and with plug compatible subsystems for the IBM AS/400 add-on market from EMC and IPL.

A high percentage of the array board assemblies also now provide RAID-3 and/or RAID-5 capability. This report groups boards, array assemblies complete with everything except disk drives, and all levels in between in the board assembly product group. Customers for the board manufacturers typically include computer system manufacturers and independent server manufacturers, which

assemble the completed array subsystem, plus sophisticated computer users with a do-it-yourself urge. Array software is also typically purchased by the same buyers. Although the majority of array software offerings are still RAID-0/1 or RAID-1, RAID-5 software is available from multiple vendors.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	1,158.7	2,277.5	3,935.3	4,951.3	5,458.6
All manufacturers	1,207.5	2,360.2	4,077.1	5,210.4	5,884.6

Despite the participation of 79 companies and 1992 sales revenue of $1.2 billion, the network/minicomputer/multiuser market for disk drive arrays is still in its early growth period. The product group includes only a small number of companies with array products which have clearly been successful already. However, it also includes many companies with array products with excellent prospects for the future.

Captive array subsystems have dominated this product group to date, and are expected to provide one third of the 1993 total worldwide shipments for the group and 64.7% of the revenues. Strong shipments by Compaq Computer, successful recent array products by Data General, IBM, Hewlett-Packard and Digital Equipment, and established mirrored disk programs by Tandem Computers and Stratus Computer have all contributed to the high captive array shipments. RAID-1 software products from Digital Equipment and Sun Microsystems have also contributed to the captive total for unit shipments, but more modestly to the captive revenue totals, due to lower average prices.

PCM/Reseller sales of complete subsystems are expected to provide 65.7% of 1993's total noncaptive array revenues. These sales will be distributed among more than 30 companies, representing shipments of 24,665 subsystems. Most of these firms are providing arrays for use with personal computer and UNIX workstation file servers, but a few are active in the IBM AS/400 add-on market.

OEM/Integrator shipments of board assemblies without disk drives are expected to reach 33,380 units in 1993, but at a much lower contribution to total

revenues. OEM/Integrator sales of boards and partial array assemblies to numerous systems manufacturers and network server manufacturers are now available from more than 15 manufacturers.

Mylex led the network/minicomputer/multiuser group in worldwide noncaptive unit shipments for 1992, with 19.0% of the total, all board assemblies. NCR held 12.6%, with a combination of subsystems, boards and software products (although it should be noted that NCR's presence in the industry is larger than this figure would suggest due to the firm's sale of array chip sets, which are not counted as completed array products in this report). IPL secured third place with 10.8%, composed entirely of complete subsystems for the AS/400 market.

Marketing trends

Worldwide revenues for all types of network/minicomputer/multiuser arrays are forecasted to grow from $2.4 billion in 1993 to $5.9 billion in 1996, an average annual increase of 38.3%. 1993's worldwide unit shipments of 165,145 are projected to reach 451,860 in 1996, an average increase of 40.8% per year. The average revenue increase will be slightly lower due to declining average unit prices.

Shipments of disk drive arrays for this product group are currently dominated by companies headquartered in the United States, which held 95.9% of 1992 worldwide revenues for all types of arrays. Although the number of non-U.S. participants is expected to increase from today's 14 companies (several with operations mostly in the U.S.), revenue for U.S. companies for 1996 is expected to decline only to 92.8% of the worldwide total. The next three years will see continuous improvements in disk array architecture, electronics, packaging and marketing techniques -- all areas of strength for most of the U.S. companies participating in development of the array market.

The nature of the disk drive array business is expected to see several major changes during the next three years. Noncaptive array shipments and revenues will pass up captive shipments and revenues. Complete subsystems and board assemblies will increase their share of the industry total, at the expense of software products, and the 1996 product mix will contain a much higher percentage of RAID-5 and other advanced array implementations than today.

Complete subsystems sold through the PCM/Reseller channel will provide shipments of a forecasted 116,450 units in 1996, boosted by intense competition among the numerous manufacturers and resellers, combined with continuing product improvements. 1996 captive shipments of complete subsystems are expected to be only slightly behind, with 112,410 arrays, but due to much higher average unit prices, will generate total revenues of $2.8 billion for system manufacturers.

OEM/Integrator shipments of array board assemblies are expected to top 113,830 units in 1996. This growth will be fueled by the demand for array controllers and partially assembled arrays from system manufacturers and network server manufacturers lacking the resources or time to develop their own array technology.

Although sales of noncaptive software array products are expected to continue their growth through 1996, the rate of growth will be modest, and captive software arrays are expected to top out by 1996. It is believed the typical end users will prefer to acquire and use complete array product offers, to avoid the nuisance and complexity of separately purchasing software, drives, cabinets, etc. Individual software packages will continue to be most interesting to users who already have computer systems using multiple disk drives.

Technical trends

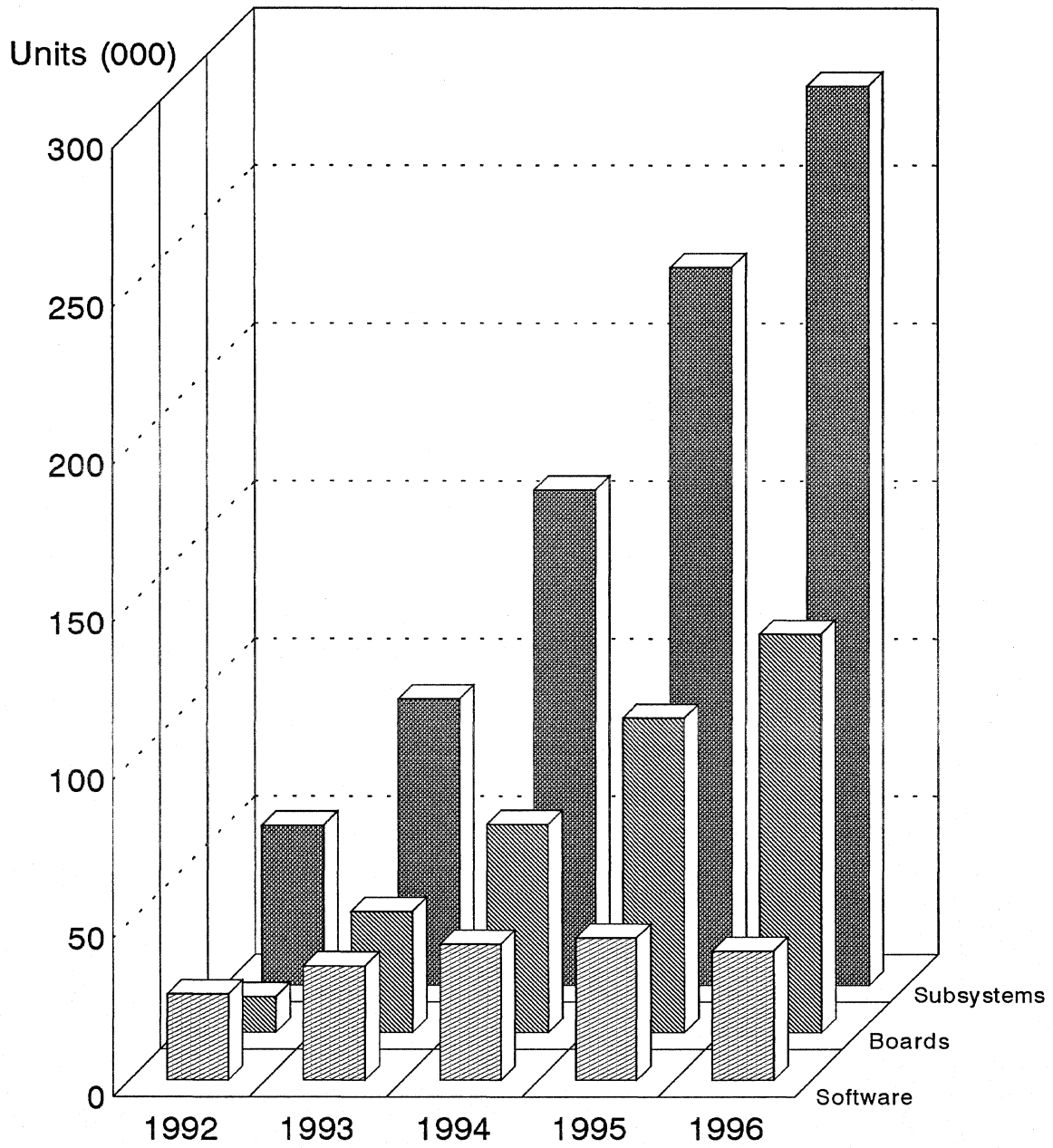
The possibilities that disk drive array functions may be embedded in future operating systems or in chips mounted on system motherboards provide the major area of uncertainty for today's disk drive array manufacturers. Operating systems that include array functions are not included in the DISK/TREND Report shipment and revenue totals.

Limited array capabilities already have been included in some existing operating systems for minicomputers and mainframes by Digital Equipment and IBM. These operating system options allow users to mirror disks available on a system, or as with Novell's SFT III network system, to mirror complete file servers on a network. There has been widespread speculation on the possibility of RAID-1, RAID-3 and RAID-5 capabilities being included in future versions of DOS, Win-

Figure 7

Networks/Minicomputer/Multiuser System Arrays

Worldwide Shipments by Array Type



dows NT, OS and other operating systems being developed by the new wave of software joint ventures formed by several of the industry's major computer manufacturers.

It is considered likely that some of the new operating systems expected to appear during the next few years will contain disk array features. However, their probable effect on the market for hardware based arrays and separate software array packages is expected to be modest, and has been anticipated in this year's DISK/TREND Report forecasts.

Any software based array must use a portion of the processor's capabilities to perform its tasks, and in a heavily used system the penalty is an impact on system performance. This is probably not significant to many single user systems, but in the network/minicomputer/multiuser market represented by this product group it would be undesirable. Hardware based arrays will continue to have the performance advantage, and through intelligent planning manufacturers of hardware based arrays will probably be able to make them as convenient to use as array features provided within operating systems.

The existing hardware based arrays are expected to benefit from a continuous stream of improvements in architecture, to improve performance; in packaging, through smaller disk drives and reduced chip sets; and in user convenience, improved through internal software changes. The most pressing challenge, especially for manufacturers of RAID-5 arrays, will be to reduce price per megabyte, in comparison to other storage alternatives.

Much of the future growth for RAID-5 in low-end configurations will depend on better price comparisons with mirrored disk arrays. And larger RAID-5 arrays must minimize their price disadvantage compared to individual disks, which are becoming more reliable every month. As with other electronics industry products, most of the contribution to lower costs will probably come from higher shipment volume and new designs which lower the hardware parts count.

The impact on high-end network superservers will be higher capacity in smaller cabinets, with steadily improving price per megabyte. Midrange arrays, which today usually sacrifice some fault tolerance for lower price tags, will combine higher reliability with even lower prices. The smallest arrays will be offered in even smaller physical packages, with new disk drives and reduced

chip sets making possible complete arrays in the physical size of a typical 3.5" disk drive.

Forecasting assumptions

1. Networks for personal computer and workstation applications will continue to grow at a high rate.

2. U.S. manufacturers will continue to dominate the worldwide array market, due to aggressive product development and continuously changing competitive conditions.

3. Complete subsystems and boards will continue to achieve higher growth than software array products by providing users with the convenience of complete array subsystems and typically higher performance.

TABLE 15

NETWORKS/MINI/MULTIUSER

REVENUE SUMMARY

	DISK DRIVE ARRAY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	490.1	881.7	969.9	1,617.3	1,445.4	2,428.3	1,757.2	2,693.4	1,888.7	2,819.4
PCM/Reseller	167.6	242.6	299.2	449.8	722.9	1,038.7	1,039.5	1,533.4	1,146.6	1,741.3
OEM/Integrator	27.6	34.4	159.9	210.4	344.0	468.3	517.5	724.5	623.1	897.9
TOTAL U.S. REVENUES	685.3	1,158.7	1,429.0	2,277.5	2,512.3	3,935.3	3,314.2	4,951.3	3,658.4	5,458.6
Non-U.S. Manufacturers										
Captive	.1	23.7	.1	27.5	1.3	30.6	3.6	35.8	5.7	41.1
PCM/Reseller	10.5	21.1	21.8	36.7	47.7	74.6	83.0	129.0	147.3	230.6
OEM/Integrator	1.6	4.0	8.2	18.5	13.9	36.6	36.2	94.3	59.1	154.3
TOTAL NON-U.S. REVENUES	12.2	48.8	30.1	82.7	62.9	141.8	122.8	259.1	212.1	426.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	697.5	1,207.5	1,459.1	2,360.2	2,575.2	4,077.1	3,437.0	5,210.4	3,870.5	5,884.6
OEM Average Price ($000)		3.8		5.0		6.1		6.3		6.0

TABLE 16

NETWORKS/MINI/MULTIUSER

UNIT SHIPMENT SUMMARY

	DISK DRIVE ARRAY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1992 Shipments		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	30,818	61,593	43,915	84,430	64,875	111,000	82,000	130,100	89,745	138,070
PCM/Reseller	8,696	14,346	19,958	30,540	43,375	64,100	64,400	96,730	75,125	115,550
OEM/Integrator	6,843	9,770	34,190	45,335	59,725	80,410	89,100	123,300	110,365	157,230
TOTAL U.S. SHIPMENTS	46,357	85,709	98,063	160,305	167,975	255,510	235,500	350,130	275,235	410,850
Non-U.S. Manufacturers										
Captive	200	1,840	250	2,145	510	2,720	1,720	4,640	3,105	6,810
PCM/Reseller	643	1,294	1,255	2,140	3,150	5,250	6,015	9,900	10,990	17,400
OEM/Integrator	50	232	160	555	605	2,150	2,115	7,200	5,340	16,800
TOTAL NON-U.S. SHIPMENTS	893	3,366	1,665	4,840	4,265	10,120	9,850	21,740	19,435	41,010
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	47,250	89,075	99,728	165,145	172,240	265,630	245,350	371,870	294,670	451,860
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	47	89	146	254	319	519	564	891	859	1,343

TABLE 17

NETWORKS/MINI/MULTIUSER

WORLDWIDE REVENUES ($M)

BREAKDOWN BY ARRAY TYPE

	1992 Revenues			Forecast											
	1993			1994			1995			1996					
	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software
U.S. MANUFACTURERS															
Captive	775.9	.7	105.1	1,501.1	.6	115.6	2,310.0	1.0	117.3	2,592.0	1.2	100.2	2,750.0	1.4	68.0
PCM/Reseller	233.5	8.2	.9	433.8	12.9	3.1	1,020.3	13.3	5.1	1,515.2	12.5	5.7	1,722.9	12.7	5.7
OEM/Integrator	19.8	13.0	1.6	153.2	54.3	2.9	351.0	114.3	3.0	561.6	160.1	2.8	711.2	184.2	2.5
TOTAL U.S. REVENUES	1,029.2	21.9	107.6	2,088.1	67.8	121.6	3,681.3	128.6	125.4	4,668.8	173.8	108.7	5,184.1	198.3	76.2
NON-U.S. MANUFACTURERS															
Captive	23.5	--	.2	27.3	--	.2	29.8	.5	.3	32.9	2.3	.6	36.2	3.8	1.1
PCM/Reseller	21.0	.1	--	36.3	.4	--	71.4	3.2	--	124.8	4.2	--	226.5	4.1	--
OEM/Integrator	2.9	1.1	--	16.7	1.8	--	31.5	5.1	--	84.0	10.3	--	132.5	21.8	--
TOTAL NON-U.S. REVENUES	47.4	1.2	.2	80.3	2.2	.2	132.7	8.8	.3	241.7	16.8	.6	395.2	29.7	1.1
WORLDWIDE RECAP															
Captive	799.4	.7	105.3	1,528.4	.6	115.8	2,339.8	1.5	117.6	2,624.9	3.5	100.8	2,786.2	5.2	69.1
	--	--	--	+91.2%	-14.3%	+10.0%	+53.1%	+150.0%	+1.6%	+12.2%	+133.3%	-14.3%	+6.1%	+48.6%	-31.4%
PCM/Reseller	254.5	8.3	.9	470.1	13.3	3.1	1,091.7	16.5	5.1	1,640.0	16.7	5.7	1,949.4	16.8	5.7
	--	--	--	+84.7%	+60.2%	+244.4%	+132.2%	+24.1%	+64.5%	+50.2%	+1.2%	+11.8%	+18.9%	+.6%	--
OEM/Integrator	22.7	14.1	1.6	169.9	56.1	2.9	382.5	119.4	3.0	645.6	170.4	2.8	843.7	206.0	2.5
	--	--	--	+648.5%	+297.9%	+81.2%	+125.1%	+112.8%	+3.4%	+68.8%	+42.7%	-6.7%	+30.7%	+20.9%	-10.7%
Total Revenues	1,076.6	23.1	107.8	2,168.4	70.0	121.8	3,814.0	137.4	125.7	4,910.5	190.6	109.3	5,579.3	228.0	77.3
	--	--	--	+101.4%	+203.0%	+13.0%	+75.9%	+96.3%	+3.2%	+28.7%	+38.7%	-13.0%	+13.6%	+19.6%	-29.3%
ANNUAL SHARE, BY TYPE	89.3%	1.9%	8.8%	92.0%	3.0%	5.0%	93.6%	3.4%	3.0%	94.3%	3.7%	2.0%	94.9%	3.9%	1.2%

TABLE 18

NETWORKS/MINI/MULTIUSER

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY ARRAY TYPE

	1992 Shipments			Forecast 1993			1994			1995			1996		
	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software	Subsys.	Boards	Software
U.S. MANUFACTURERS															
Captive	37,338	255	24,000	54,895	335	29,200	77,000	510	33,490	96,000	700	33,400	110,000	870	27,200
PCM/Reseller	9,716	3,395	1,235	22,585	4,600	3,355	53,700	5,300	5,100	84,180	6,250	6,300	101,350	7,100	7,100
OEM/Integrator	645	7,510	1,615	9,235	32,980	3,120	19,500	57,110	3,800	35,100	84,250	3,950	50,800	102,330	4,100
TOTAL U.S. SHIPMENTS	47,699	11,160	26,850	86,715	37,915	35,675	150,200	62,920	42,390	215,280	91,200	43,650	262,150	110,300	38,400
NON-U.S. MANUFACTURERS															
Captive	1,540	--	300	1,765	--	380	1,980	230	510	2,190	1,200	1,250	2,410	2,100	2,300
PCM/Reseller	1,285	9	--	2,080	60	--	4,200	1,050	--	7,800	2,100	--	15,100	2,300	--
OEM/Integrator	22	210	--	155	400	--	450	1,700	--	2,100	5,100	--	5,300	11,500	--
TOTAL NON-U.S. SHIPMENTS	2,847	219	300	4,000	460	380	6,630	2,980	510	12,090	8,400	1,250	22,810	15,900	2,300
WORLDWIDE RECAP															
Captive	38,878	255	24,300	56,660	335	29,580	78,980	740	34,000	98,190	1,900	34,650	112,410	2,970	29,500
	--	--	--	+45.7%	+31.4%	+21.7%	+39.4%	+120.9%	+14.9%	+24.3%	+156.8%	+1.9%	+14.5%	+56.3%	-14.9%
PCM/Reseller	11,001	3,404	1,235	24,665	4,660	3,355	57,900	6,350	5,100	91,980	8,350	6,300	116,450	9,400	7,100
	--	--	--	+124.2%	+36.9%	+171.7%	+134.7%	+36.3%	+52.0%	+58.9%	+31.5%	+23.5%	+26.6%	+12.6%	+12.7%
OEM/Integrator	667	7,720	1,615	9,390	33,380	3,120	19,950	58,810	3,800	37,200	89,350	3,950	56,100	113,830	4,100
	--	--	--	--	+332.4%	+93.2%	+112.5%	+76.2%	+21.8%	+86.5%	+51.9%	+3.9%	+50.8%	+27.4%	+3.8%
Total Shipments	50,546	11,379	27,150	90,715	38,375	36,055	156,830	65,900	42,900	227,370	99,600	44,900	284,960	126,200	40,700
	--	--	--	+79.5%	+237.2%	+32.8%	+72.9%	+71.7%	+19.0%	+45.0%	+51.1%	+4.7%	+25.3%	+26.7%	-9.4%
ANNUAL SHARE, BY TYPE	56.8%	12.8%	30.4%	55.0%	23.2%	21.8%	59.1%	24.8%	16.1%	61.2%	26.8%	12.0%	63.2%	27.9%	8.9%

TABLE 19

NETWORKS/MINI/MULTIUSER

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drive Arrays

	1992 Net Shipments									
	To United States Destinations					Worldwide				
	Units				%	Units				%
Drive Manufacturers	Subsys.	Boards	Softwre	Total		Subsys.	Boards	Softwre	Total	
Mylex	--	1,980	--	1,980	12.2	--	4,860	--	4,860	19.0
NCR	8	2,800	80	2,888	17.8	18	3,145	80	3,243	12.6
IPL	1,280	--	--	1,280	7.9	2,770	--	--	2,770	10.7
EMC	1,575	--	--	1,575	9.7	2,100	--	--	2,100	8.2
Micropolis	1,300	--	--	1,300	8.0	1,900	--	--	1,900	7.4
Perceptive Solutions	--	150	--	150	.9	--	1,350	--	1,350	5.3
Legacy Storage	600	--	--	600	3.7	1,200	--	--	1,200	4.7
Micronet Technology	900	--	--	900	5.5	1,100	--	--	1,100	4.3
Other U.S.	2,045	1,353	2,068	5,467	33.7	2,473	1,559	2,770	6,820	26.6
Other Non-U.S.	53	40	--	92	.6	107	210	--	299	1.2
TOTAL	7,761	6,323	2,148	16,232	100.0	11,668	11,124	2,850	25,642	100.0

ARRAYS: MAINFRAME SYSTEMS

1993 DISK/TREND REPORT

ARRAYS: MAINFRAME SYSTEMS

Coverage

Examples of disk drive arrays in this group include:

Complete subsystems, with disk drives

Amperif	Viking 6400
Control Data Systems	5830
EMC	Symmetrix 4204, 4800, 5500
Storage Technology	Iceberg 9200
Unisys	M9740, M9760, USR 4000

All disk drive arrays intended primarily for use with mainframe computer systems are included in this product group. Operating systems that include array functions, such as the ability to mirror individual disk volumes, are not included in this report or counted in the statistics, but array software sold as add-on products are recognized in the report. The earliest activity in the group was represented by the Control Data Systems shipments of its early RAID-3 disk drive array in 1989.

EMC's shipments of the firm's Symmetrix series of subsystems with RAID-1 mirrored disk capability for the IBM mainframe plug compatible market have been the dominant products in the group to date. However, it is clear that Storage Technology's Iceberg was the winner in the first round of public relations campaigns for mainframe disk drive arrays -- which has been all the more embarrassing for STC with each announcement of further shipment delays. The current estimate for Iceberg's first commercial shipment is sometime in the second half of 1993. Amperif also hopes to start shipments for the IBM plug compatible array market in 1993, with distribution arrangements through Memorex-Telex and Comparex.

The company not named in the above list of announced array products is IBM. Although IBM has introduced several arrays for personal computer and workstation networks, office minicomputers and very high performance applications, the company hasn't yet made its move in the mainframe array market. However, there is a general expectation in the computer industry that IBM will be the major player in this field, with the first product announcements probably timed for next year.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	259.8	396.4	1,132.8	2,126.2	3,293.6
All manufacturers	259.8	396.4	1,221.8	2,480.2	3,878.0

Total revenues for arrays used with mainframe computer systems have already reached substantial levels, mostly as the result of EMC's success with the Symmetrix subsystem with RAID-1 mirrored disk capability. 1992's total of $259.8 million is expected to increase to $396.4 million in 1993. 1992 shipments were only 1,248 subsystems, but the revenue total was swollen because the overall average price exceeded $200,000. Worldwide shipments in 1993 are forecasted at 1,430 subsystems. All shipments to date have been by U.S. manufacturers.

Complete subsystems are the only type of arrays which have been shipped in this product group. Mainframe users are not likely to constitute a market for board level arrays, nor have individual software array products been sold in significant quantities.

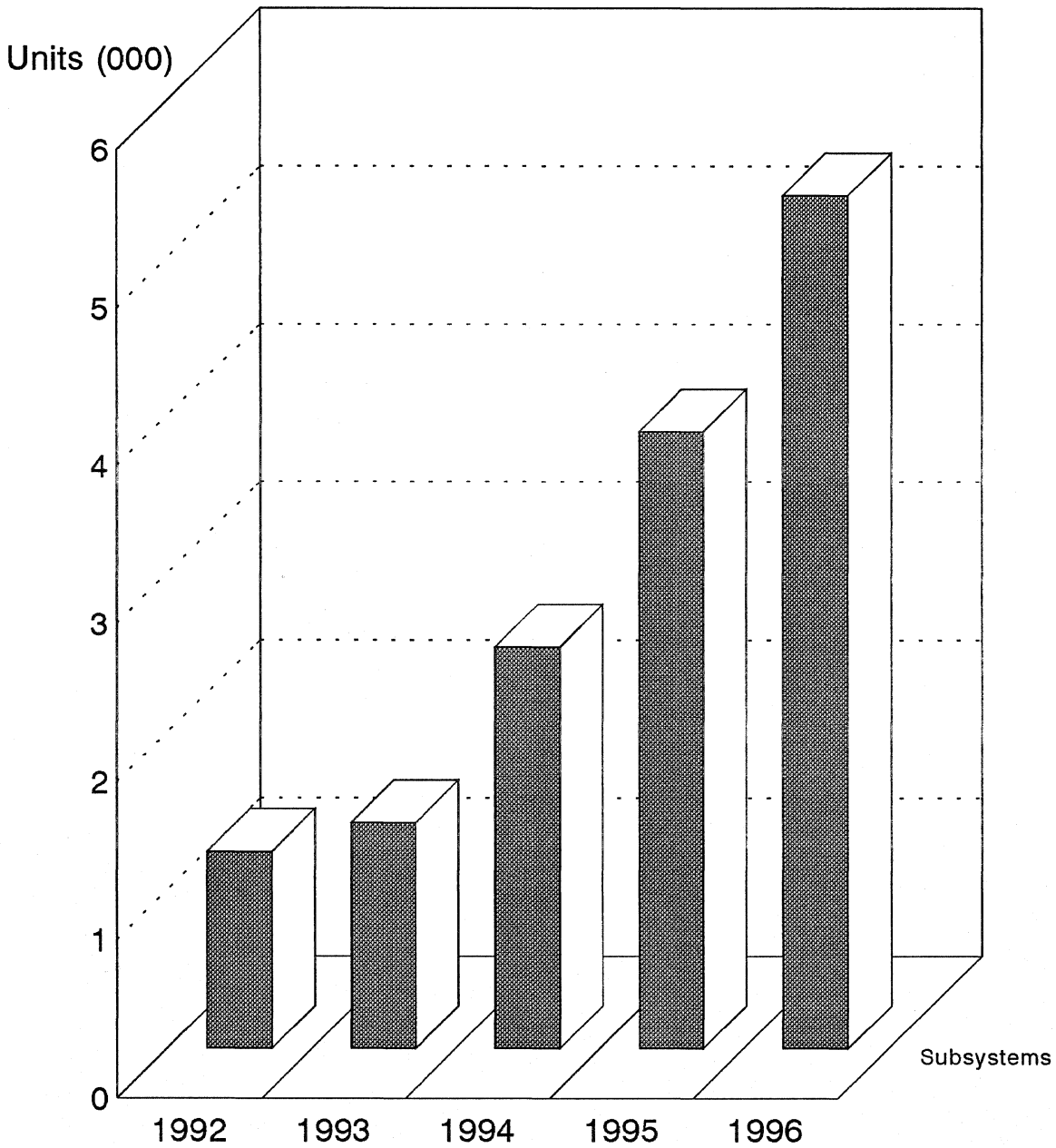
Despite Storage Technology's delayed introduction of the Iceberg, this report assumes that limited shipments for the world's most famous disk drive array will start this year. Although it appears that IBM will not have any comparable array offering available this year, it has already started its counterattack with the recent announcement that a hardware based data compression capability will be offered with selected processor models later in 1993. Since the Iceberg subsystem is expected to provide part of its operating cost-effectiveness with built-in data compression, IBM's system data compression may obviate part of the Iceberg's price per megabyte story. However, the Iceberg is expected to retain enough sales appeal to provide an attractive market, especially with no comparable arrays yet in the market.

Although most of the array subsystems in this group have been shipped in the plug compatible add-on market, an OEM market has also come into existence. For example, EMC has announced OEM contracts with both Unisys and Groupe Bull. DISK/TREND estimates for 1992 noncaptive unit shipments, includ-

Figure 8

Mainframe System Arrays

Worldwide Shipments by Array Type



ing both PCM/Reseller and OEM/Integrator channels, indicate that EMC captured 90.4% of the worldwide total.

Marketing trends

The industry's major uncertainty regarding this array product group is when IBM will enter the arena, and with what. We are estimating that IBM's long-awaited array introduction for mainframes will occur in mid-1994, and will include a family of arrays intended for use with both midrange and high-end IBM mainframes. IBM will almost certainly make use of new high capacity 3.5" drives, probably in the 3 gigabyte range, and is expected to offer user selectable RAID-1 and enhanced RAID-5 capability.

Due to the expected market entry of IBM and additional plug compatible peripherals suppliers, revenues for mainframe system arrays are expected to increase sharply. 1994's worldwide revenue total is forecasted to jump 208.2%, to $1.2 billion, and the 1996 total is projected at $3.9 billion. Shipments for 1996 are forecasted at 5,400 units. The overall average price will rise to over $700,000 per array unit, driven up by increased captive shipments at higher average prices and by the larger storage capacity of expected new high models.

Storage Technology's Iceberg is the first announced RAID-5 array subsystem intended for the mainframe market, and it is expected that some of the other arrays from independent peripherals suppliers for mainframe applications to be introduced during the next few years will also utilize RAID-5 implementations optimized to overcome the normal write latency problems associated with that type of array. Although the mirrored disk configurations which have dominated mainframe applications so far are probably not going to decline in shipments, much of the future growth will probably go to enhanced RAID-5 arrays, because of the outlook for lower price per megabyte.

Technical trends

For the most part, add-on data storage peripherals in the mainframe market must exist within the limitations defined by IBM for channels, operating systems, disk controllers and storage architecture. IBM's mainframes provide the principal PCM market, and many of today's competitive mainframe computers use storage

devices compatible with IBM's own subsystems. Anything new IBM does in the area affects everything in the competitive product offering.

For these reasons, much of the product development planning by independent peripherals suppliers will be affected by the details of IBM's eventual mainframe array product line. Which array type(s) will be offered? What will be the interrelationship with data compression at the system level? Will existing types of disk controllers be replaced with something new? What will be the relationship to IBM's System Managed Storage programs?

Until the answers to these questions and others is known, the long-term patterns for the development of disk drive array technology for mainframe applications are uncertain.

Forecasting assumptions

1. IBM will introduce arrays with RAID-1/5 capability for use with multiple mainframe models in mid-1994.

2. Iceberg will start commercial shipments at modest levels in the second half of 1993.

3. Non-U.S. manufacturers will initiate shipments in 1994 of array subsystems for captive mainframe applications and for IBM compatible PCM markets.

TABLE 20

MAINFRAMES

REVENUE SUMMARY

	DISK DRIVE ARRAY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992		Forecast							
	Revenues		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	175.0	250.0	674.5	1,045.0	1,134.0	1,890.0
PCM/Reseller	139.2	218.6	234.2	349.8	580.0	830.0	714.0	1,023.0	885.5	1,340.5
OEM/Integrator	29.0	41.2	32.2	46.6	36.0	52.8	38.8	58.2	41.6	63.1
TOTAL U.S. REVENUES	168.2	259.8	266.4	396.4	791.0	1,132.8	1,427.3	2,126.2	2,061.1	3,293.6
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	9.0	--	24.0	--	38.4
PCM/Reseller	--	--	--	--	65.0	80.0	246.0	330.0	378.0	546.0
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL NON-U.S. REVENUES	--	--	--	--	65.0	89.0	246.0	354.0	378.0	584.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	168.2	259.8	266.4	396.4	856.0	1,221.8	1,673.3	2,480.2	2,439.1	3,878.0
OEM Average Price ($000)		120.8		115.1		120.0		125.2		130.1

TABLE 21

MAINFRAMES

UNIT SHIPMENT SUMMARY

	DISK DRIVE ARRAY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1992 Shipments		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	175	250	710	1,100	1,260	2,100
PCM/Reseller	564	907	665	1,025	1,160	1,660	1,190	1,705	1,265	1,915
OEM/Integrator	240	341	280	405	300	440	310	465	320	485
TOTAL U.S. SHIPMENTS	804	1,248	945	1,430	1,460	2,100	1,500	2,170	1,585	2,400
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	30	--	80	--	120
PCM/Reseller	--	--	--	--	130	160	410	550	540	780
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	--	--	--	--	130	190	410	630	540	900
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	804	1,248	945	1,430	1,765	2,540	2,620	3,900	3,385	5,400
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	--	1	1	2	3	5	6	9	9	14

TABLE 22

MAINFRAMES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY ARRAY TYPE

	1992 Revenues Subsys.	Forecast --1993-- Subsys.	--1994-- Subsys.	--1995-- Subsys.	--1996-- Subsys.
U.S. MANUFACTURERS					
Captive	--	--	250.0	1,045.0	1,890.0
PCM/Reseller	218.6	349.8	830.0	1,023.0	1,340.5
OEM/Integrator	41.2	46.6	52.8	58.2	63.1
TOTAL U.S. REVENUES	259.8	396.4	1,132.8	2,126.2	3,293.6
NON-U.S. MANUFACTURERS					
Captive	--	--	9.0	24.0	38.4
PCM/Reseller	--	--	80.0	330.0	546.0
TOTAL NON-U.S. REVENUES	--	--	89.0	354.0	584.4
WORLDWIDE RECAP					
Captive	--	--	259.0	1,069.0	1,928.4
	--	--	--	+312.7%	+80.4%
PCM/Reseller	218.6	349.8	910.0	1,353.0	1,886.5
	--	+60.0%	+160.1%	+48.7%	+39.4%
OEM/Integrator	41.2	46.6	52.8	58.2	63.1
	--	+13.1%	+13.3%	+10.2%	+8.4%
Total Revenues	259.8	396.4	1,221.8	2,480.2	3,878.0
	--	+52.6%	+208.2%	+103.0%	+56.4%
ANNUAL SHARE, BY TYPE	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 23

MAINFRAMES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY ARRAY TYPE

	1992 Shipments Subsys.	Forecast --1993-- Subsys.	--1994-- Subsys.	--1995-- Subsys.	--1996-- Subsys.
U.S. MANUFACTURERS					
Captive	--	--	250	1,100	2,100
PCM/Reseller	907	1,025	1,660	1,705	1,915
OEM/Integrator	341	405	440	465	485
TOTAL U.S. SHIPMENTS	1,248	1,430	2,350	3,270	4,500
NON-U.S. MANUFACTURERS					
Captive	--	--	30	80	120
PCM/Reseller	--	--	160	550	780
TOTAL NON-U.S. SHIPMENTS	--	--	190	630	900
WORLDWIDE RECAP					
Captive	--	--	280	1,180	2,220
	--	--	--	+321.4%	+88.1%
PCM/Reseller	907	1,025	1,820	2,255	2,695
	--	+13.0%	+77.6%	+23.9%	+19.5%
OEM/Integrator	341	405	440	465	485
	--	+18.8%	+8.6%	+5.7%	+4.3%
Total Shipments	1,248	1,430	2,540	3,900	5,400
	--	+14.6%	+77.6%	+53.5%	+38.5%
ANNUAL SHARE, BY TYPE	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 24

MAINFRAMES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drive Arrays

	1992 Net Shipments									
	To United States Destinations					Worldwide				
	Units				%	Units				%
Drive Manufacturers	Subsys.	Boards	Softwre	Total		Subsys.	Boards	Softwre	Total	
EMC	754	--	--	754	93.8	1,128	--	--	1,128	90.4
Other U.S.	50	--	--	50	6.2	120	--	--	120	9.6
Other Non-U.S.	--	--	--	--	--	--	--	--	--	--
TOTAL	804	--	--	804	100.0	1,248	--	--	1,248	100.0

ARRAYS: VERY HIGH PERFORMANCE SYSTEMS

1993 DISK/TREND REPORT

ARRAYS: VERY HIGH PERFORMANCE SYSTEMS

Coverage

Examples of disk drive arrays in this group include:

Complete subsystems, with disk drives

Ciprico	AS6610, AS6700, AS6710
Convex Computer	DAR-001
Cray Research	DA-60, DA-62
Encore Computer	RAID 5
Fujitsu	K6490
IBM	9570 series
MasPar Computer	DA-4116A, DA-4124A
Maximum Strategy	Gen 4, HIPPI-S2
Storage Concepts	Concept 151, Concept 71 FCS
Thinking Machines	CM-5

Arrays offered for use with very high performance computer systems include complete disk drive subsystems, now the dominant array type in this product group, plus arrays sold as board assemblies, which may include cabinets and other components.

The majority of arrays in this product group are provided on a captive basis by supercomputer manufacturers, and the majority of those arrays are currently RAID-3 complete subsystems. However, four companies with arrays in this product group are now also offering RAID-5 configurations. The firm with the most impressive array specification is Thinking Machines, the massively parallel supercomputer manufacturer which pioneered the disk drive array configuration which became known as RAID-2. In late 1992, however, Thinking Machines replaced the old array with a new model -- a RAID-3 array with the theoretical capability to attach 3,072 3.5" drives, for a total available capacity of 3.2 terabytes.

In addition to the arrays offered by supercomputer manufacturers, a few independent array manufacturers offer RAID-3 subsystems which are sold on an OEM basis to manufacturers of specialized very high performance systems and storage subsystems used in a variety of high-end technical workstation and imaging applications.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	16.5	45.5	54.0	61.5	67.4
0ll manufacturers	17.9	47.6	58.2	66.5	72.9

Total revenues for arrays used with very high performance computer systems were only $17.9 million in 1992, but are expected to increase 160% in 1993, to $47.6 million. Shipments will double in the same period, increasing to 555 units in 1993.

Complete array subsystems will provide 78.5% of 1993's shipments, a total of 435 units. Current disk drive array shipments are being boosted by new captive array subsystems introduced by Cray Research, Thinking Machines and Encore Computer at the end of 1992. Reflecting the supercomputer market's requirement for very high data transfer rates, most of the arrays offered are RAID-3 types.

The lead in noncaptive shipments for 1992 was held by Maximum Strategy with 65.9% of the worldwide unit total, mostly boards. Ciprico held the rest of the noncaptive total with 34.1%, all subsystems.

Marketing trends

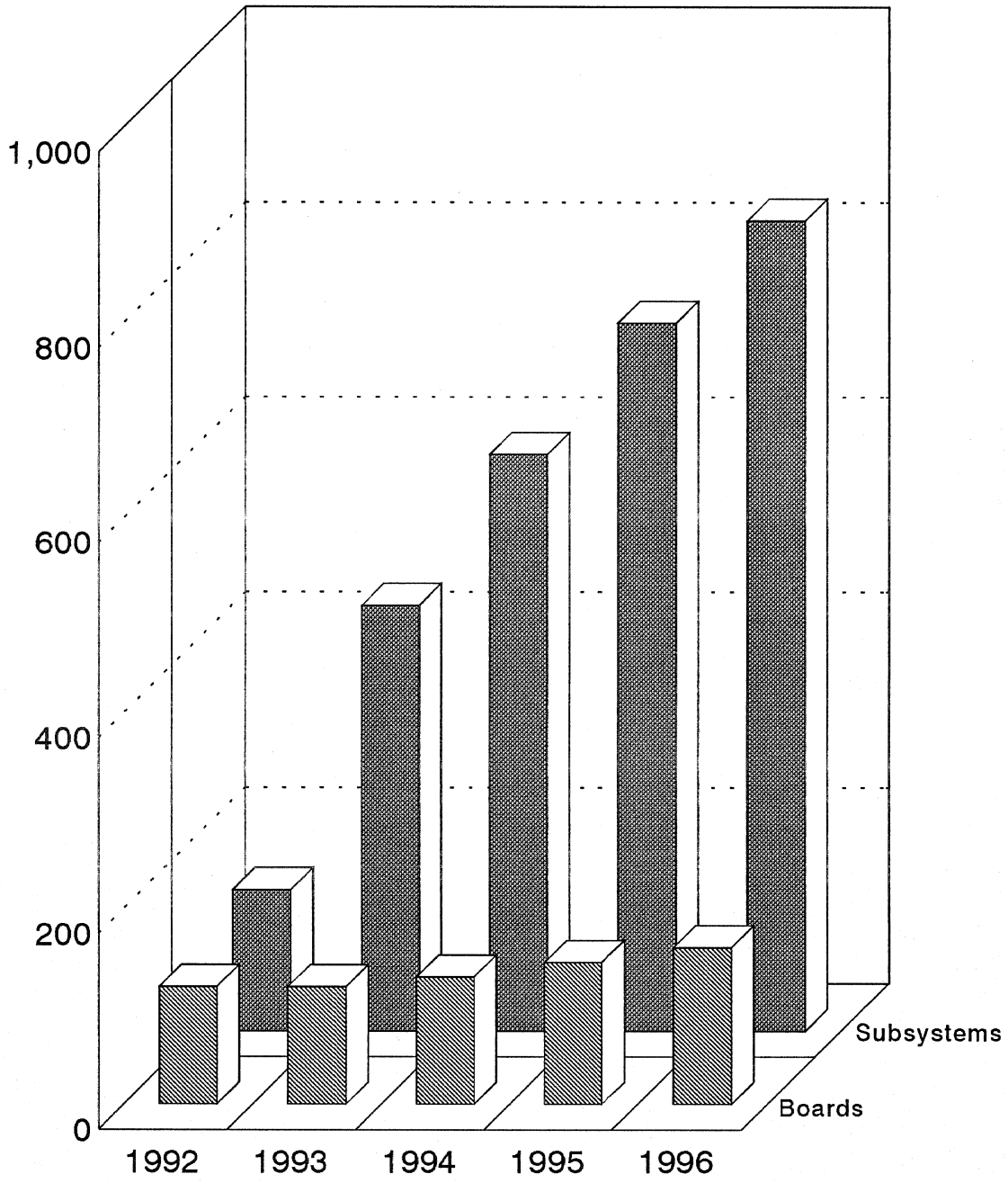
Growth in unit shipments for arrays used with very high performance systems in the 1994-96 period is forecasted at a modest average annual increase of 21.4%. The 1996 unit total is expected to be 990 arrays, only 0.1% of the total for all disk drive array product groups. The limited potential in unit shipment growth for this product group is a reflection of the limitations on the overall growth potential for the principal market, supercomputers. 1996 total revenues for the product group are projected at $72.9 million.

The major portion of the projected shipment increases for this product group through 1996 are expected to come from complete subsystems, which will almost double in unit shipments and will provide an estimated 83.9% of 1996's total unit shipments. Captive disk drive array subsystem shipments will continue

Figure 9

Very High Performance System Arrays

Worldwide Shipments by Array Type



to grow, and are expected to maintain leadership in both unit shipments and in revenues in 1996.

However, noncaptive array subsystem shipments are expected to increase at a faster rate, rivaling the captive subsystem total in 1996. PCM/Reseller shipments are forecasted to start in 1994 from both U.S. and non-U.S. manufacturers, with modest shipments targeted at specialized workstation and imaging markets. It is expected that OEM/Integrator shipments of board assemblies will continue to grow gradually, responding to continuing demand from the same specialized workstation and imaging markets, plus small supercomputer manufacturers.

Technical trends

Several leading supercomputer companies have recently introduced the disk drive array architecture that they plan to utilize for the next several years, and RAID-3 is the clear winner. For these applications, there is no question that transfer rate is the key requirement, and the ability of RAID-3 array configurations to meet that requirement will keep them in the lead.

For other applications, however, there is probably enough demand for multimode arrays capable of operating in various combinations of RAID-0, RAID-1, RAID-3 and RAID-5 to justify products with these capabilities. A few manufacturers already offer arrays which include RAID-5 capability and more are likely to follow.

It is believed that most of the improvements in arrays used with very high performance systems through 1996 will involve gradual refinements made possible by improved components. Reduced count chip sets and semiconductors with higher data rates will help with both packaging, costs and performance. 3.5" disk drives with ever-higher capacities, improved performance and lower cost per megabyte will also provide gains in packaging, costs and performance.

Forecasting assumptions

1. RAID-3 implementations will remain the dominant type of array for very high performance systems.

2. The primary application for arrays in this product group will continue to be supercomputers, a market which will grow at a modest rate.

3. Complete array subsystems will continue to dominate shipments in this product group.

TABLE 25

VERY HIGH PERFORMANCE

REVENUE SUMMARY

	DISK DRIVE ARRAY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	4.7	5.0	16.8	23.4	19.0	27.0	23.0	33.0	27.0	38.5
PCM/Reseller	--	--	--	--	1.0	1.0	1.6	1.8	1.8	2.2
OEM/Integrator	10.8	11.5	19.3	22.1	23.0	26.0	23.3	26.7	22.9	26.7
TOTAL U.S. REVENUES	15.5	16.5	36.1	45.5	43.0	54.0	47.9	61.5	51.7	67.4
Non-U.S. Manufacturers										
Captive	--	1.4	--	2.1	--	2.8	--	2.9	--	3.0
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	--	--	--	.7	1.4	1.2	2.1	1.7	2.5
TOTAL NON-U.S. REVENUES	--	1.4	--	2.1	.7	4.2	1.2	5.0	1.7	5.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	15.5	17.9	36.1	47.6	43.7	58.2	49.1	66.5	53.4	72.9
OEM Average Price ($000)		53.7		73.7		70.3		63.3		58.4

TABLE 26

VERY HIGH PERFORMANCE

UNIT SHIPMENT SUMMARY

	DISK DRIVE ARRAY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1992 Shipments		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	26	30	162	225	190	270	230	330	270	385
PCM/Reseller	--	--	--	--	20	20	35	40	45	55
OEM/Integrator	198	214	264	300	325	370	365	420	390	455
TOTAL U.S. SHIPMENTS	224	244	426	525	535	660	630	790	705	895
Non-U.S. Manufacturers										
Captive	--	20	--	30	--	40	--	45	--	50
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	--	--	--	10	20	20	35	30	45
TOTAL NON-U.S. SHIPMENTS	--	20	--	30	10	60	20	80	30	95
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	224	264	426	555	545	720	650	870	735	990
Cumulative Shipments (Single units)										
WORLDWIDE TOTAL	224	264	650	819	1,195	1,539	1,845	2,409	2,580	3,399

TABLE 27

VERY HIGH PERFORMANCE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY ARRAY TYPE

	1992 Revenues		Forecast 1993		1994		1995		1996	
	Subsys.	Boards	Subsys.	Boards	Subsys.	Boards	Subsys.	Boards	Subsys.	Boards
U.S. MANUFACTURERS										
Captive	5.0	--	23.4	--	27.0	--	33.0	--	38.5	--
PCM/Reseller	--	--	--	--	1.0	--	1.8	--	2.2	--
OEM/Integrator	4.6	6.9	12.5	9.6	15.6	10.4	16.5	10.2	16.3	10.4
TOTAL U.S. REVENUES	9.6	6.9	35.9	9.6	43.6	10.4	51.3	10.2	57.0	10.4
NON-U.S. MANUFACTURERS										
Captive	1.4	--	2.1	--	2.8	--	2.9	--	3.0	--
OEM/Integrator	--	--	--	--	1.4	--	2.1	--	2.5	--
TOTAL NON-U.S. REVENUES	1.4	--	2.1	--	4.2	--	5.0	--	5.5	--
WORLDWIDE RECAP										
Captive	6.4	--	25.5	--	29.8	--	35.9	--	41.5	--
	--	--	+298.4%	--	+16.9%	--	+20.5%	--	+15.6%	--
PCM/Reseller	--	--	--	--	1.0	--	1.8	--	2.2	--
	--	--	--	--	--	--	+80.0%	--	+22.2%	--
OEM/Integrator	4.6	6.9	12.5	9.6	17.0	10.4	18.6	10.2	18.8	10.4
	--	--	+171.7%	+39.1%	+36.0%	+8.3%	+9.4%	-1.9%	+1.1%	+2.0%
Total Revenues	11.0	6.9	38.0	9.6	47.8	10.4	56.3	10.2	62.5	10.4
	--	--	+245.5%	+39.1%	+25.8%	+8.3%	+17.8%	-1.9%	+11.0%	+2.0%
ANNUAL SHARE, BY TYPE	61.6%	38.4%	79.9%	20.1%	82.2%	17.8%	84.8%	15.2%	85.8%	14.2%

TABLE 28

VERY HIGH PERFORMANCE

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY ARRAY TYPE

	1992 Shipments		Forecast 1993		1994		1995		1996	
	Subsys.	Boards	Subsys.	Boards	Subsys.	Boards	Subsys.	Boards	Subsys.	Boards
U.S. MANUFACTURERS										
Captive	30	--	225	--	270	--	330	--	385	--
PCM/Reseller	--	--	--	--	20	--	40	--	55	--
OEM/Integrator	94	120	180	120	240	130	275	145	295	160
TOTAL U.S. SHIPMENTS	124	120	405	120	530	130	645	145	735	160
NON-U.S. MANUFACTURERS										
Captive	20	--	30	--	40	--	45	--	50	--
OEM/Integrator	--	--	--	--	20	--	35	--	45	--
TOTAL NON-U.S. SHIPMENTS	20	--	30	--	60	--	80	--	95	--
WORLDWIDE RECAP										
Captive	50	--	255	--	310	--	375	--	435	--
	--	--	+410.0%	--	+21.6%	--	+21.0%	--	+16.0%	--
PCM/Reseller	--	--	--	--	20	--	40	--	55	--
	--	--	--	--	--	--	+100.0%	--	+37.5%	--
OEM/Integrator	94	120	180	120	260	130	310	145	340	160
	--	--	+91.5%	--	+44.4%	+8.3%	+19.2%	+11.5%	+9.7%	+10.3%
Total Shipments	144	120	435	120	590	130	725	145	830	160
	--	--	+202.1%	--	+35.6%	+8.3%	+22.9%	+11.5%	+14.5%	+10.3%
ANNUAL SHARE, BY TYPE	54.6%	45.4%	78.5%	21.5%	82.0%	18.0%	83.4%	16.6%	83.9%	16.1%

TABLE 29

VERY HIGH PERFORMANCE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drive Arrays

	1992 Net Shipments									
	To United States Destinations					Worldwide				
	Units				%	Units				%
Drive Manufacturers	Subsys.	Boards	Softwre	Total		Subsys.	Boards	Softwre	Total	
Maximum Strategy	20	115	--	135	68.2	21	120	--	141	65.9
Ciprico	63	--	--	63	31.8	73	--	--	73	34.1
Other U.S.	--	--	--	--	--	--	--	--	--	--
Other Non-U.S.	--	--	--	--	--	--	--	--	--	--
TOTAL	83	115	--	198	100.0	94	120	--	214	100.0

ARRAY SPECIFICATIONS

1993 DISK/TREND REPORT

DISK DRIVE ARRAY SPECIFICATIONS

Coverage

This section includes most disk drive arrays which are now in new production or announced, arranged alphabetically by manufacturer. In a few cases, products are listed for which only preliminary announcements have been made because these are considered significant indicators of industry direction. Specifications are based upon data provided by manufacturers and are subject to change. In general, if data for specification items was unavailable or not applicable, it is indicated by "--".

Specifications on array models sold by computer system manufacturers, but purchased on an OEM basis from others, have been included in some cases, for identification purposes. Also included are plug compatible arrays sold by major mainframe PCM vendors such as Memorex-Telex, but which are manufactured by other firms. Not listed in some cases are captive arrays which are similar to OEM/Integrator models made by the same manufacturer.

Array type

Arrays are classified by implementation as:

Software: Implemented as program code executing in a host system.

Board: Controllers, or array subassemblies without drives.

Subsystem: Complete array subassemblies including disk drives.

Host platform and environment

The host platform is the equipment to which the array is capable of being attached. Environment refers to the operating systems and network software with which the array is compatible and supported. If the array will connect to any host system offering a SCSI port, platform is indicated as "SCSI host". Where the array can be connected to the large number of IBM PC compatible computers available, "PC compatible" is indicated.

RAID level

All Berkeley RAID levels supported by the array are given. If the manufactur-

er has used a non-Berkeley designation, it is indicated in quotes. Also shown is the manner in which the RAID mode is selected; by commands through the host interface channel, by an operator panel, through a separate control port, or by presetting at the factory.

Array capacity

If multiple capacities are shown for minimum or maximum array capacity, they correspond to the listed RAID modes. The order in which they are given matches the order in which the RAID modes are listed. User available capacity for each mode is provided. If only one capacity is given for minimum or maximum capacity, then it is the available user capacity for the lowest RAID mode listed. Where a variety of drives are used by the manufacturer, array capacity is shown as "drive dependent".

Drives per array

The minimum and maximum number of drives available for user data in the array. Where indeterminate, as in the case of a software array, "--" is used.

Concurrent host channels

Where more than one channel between the host and the array is available, the standard number of channels and maximum number of channels is given.

Array interface to host and drives

All standard interfaces supported are named for the host to array interface and the array controller to drives interface.

Cache size and function

If the array contains a cache, the minimum and maximum available sizes are given. Also indicated is whether the cache is used for read operations, write operations or both. If no cache is used, then these fields are designated by "--".

Redundancy

If the array offers dual redundant controllers that address a common drive set or dual controllers that mirror drive sets, then the controller redundancy will be indicated by "Yes", "Optional", or "Duplexed", depending upon the manufacturers offerings and array configuration.

If the array is equipped with multiple fans providing sufficient cooling capacity so that the array can continue operation if a fan fails, then fan redundancy is indicated as "Yes", or "Optional" if the additional fan is an option.

If the array is equipped with multiple power supplies so that the array will continue operation if any power supply in the array fails, then power supply redundancy is indicated as "Yes", or "Optional" if the additional power supply is an option.

Spare drive

If the array has no capability to support a spare drive to replace a failed drive with the system in operation, then "None" is indicated. If no spare drive is provided, but a failed drive can be hot swapped, than "Manual" is indicated. If a spare drive is provided and it is automatically used by the system in the event of an array drive failure, then "Auto" is indicated.

Also, if drive data rebuilding is done in the background, "background" is indicated. If rebuilding is done in foreground, preempting use of the array, then "foreground" is indicated.

Transfer rate

The burst transfer rates between host and array controller, and between array controller and drives are given.

Drives

Where the manufacturer has indicated specific drives used in an array, the drive formatted capacity, average seek time, and average rotational latency are given. If a range of values is specified, the lowest and highest are given. An example for drive capacity: 300-1000. In many cases, manufacturers support a

wide variety of drives. In this case, the drive parameters are given as "Drive dependent" and the drive models are identified as "Various".

Array size

Where appropriate, the dimensions of the array are given. If a variety of sizes is available, "Varies" is indicated. In many cases, the array is packaged as part of a complete computer system, in which case system overall dimensions are used.

Power

Power required is given in watts or KVA, identified appropriately. Also indicated is whether the array has internal power backup in the form of battery backup for the cache or an internal UPS for the array. If neither is present, then "None" is indicated.

Accuracy

All information in this section has been cross-checked for accuracy. However, it is anticipated that some errors may be included, since many manufacturers' published specifications do not cover all of the items listed, and numerous verbal inquiries have been required.

1993 DISK/TREND product groups for disk drive arrays

Product groups for the 1993 DISK/TREND Report on disk drive arrays include:

Single user system arrays

Networks/minicomputer/multiuser system arrays

Mainframe system arrays

Very high performance system arrays

MANUFACTURER	1776, INC.	1776, INC.	1776, INC.	ACER	ACER
ARRAY MODEL	76SC4	76SC4-DA	76SC4-HS	AF 500	AF 510
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive	Captive
ARRAY CONFIGURATION: Type	Software	Software	Software	Subsystem	Subsystem
Host platform, software environment	ISA, EISA, MCA UNIX	ISA, EISA, MCA UNIX	ISA, EISA, MCA UNIX	Acer NetWare, VINES, SCO UNIX	Acer NetWare, VINES, SCO UNIX
RAID level Configured by:	0/1 Host	0/1 Host	0/1 Host	0/1/5 Host	0/1/5 Host
Array capacity (Gbytes) MIN MAX	NA Drive dependent	NA Drive dependent	NA Drive dependent	3.2/1.6/2.6* 36.8/18.4/29.4	3.2/1.6/2.6* 36.8/18.4/29.4
Minimum drives per array	2	2	2	3	3
Maximum drives per array	21	18	18	35	35
Concurrent host channels	1	2	1	1	1
Array interface to host	NA	NA	NA	EISA	EISA
Drive interface	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.192, 2.016	.192, 2.016	.192, 2.016		
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write		
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes N/A N/A	Yes N/A N/A	Yes N/A N/A	No No No	No No No
Spare drive (None/Auto/Manual)	Manual	Manual	Manual	Manual-backgrnd	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	9 Drive dependent	9 Drive dependent	9 Drive dependent	33 10	33 10
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	Drive dependent	521, 1050	521, 1050
Nominal disk diameter, height	Drive dependent	Drive dependent	Drive dependent	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	10	10
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	6.7	6.7
Drive models	Various	Various	Various	Fujits. M2624FA Quantum 1050S	Fujits. M2624FA Quantum 1050S
ARRAY SIZE: Inches: H x W x D	N/A	N/A	N/A	22.9 x 7 x 20	22.9 x 7 x 20
POWER: Power backup	N/A	N/A	N/A	350 watts None	350 watts None
FIRST CUSTOMER SHIPMENT	1990	1990	1990	4Q92	2Q93
COMMENTS		Adds support for a second host system concurrently active	Adds support for a second host system in idle mode	*With 1050 MB drives	*With 1050 MB drives

MANUFACTURER	ACER	ACER	ALLODYNE	ALLODYNE	AMERICAN DIGITAL DATA ASSOCIATES
ARRAY MODEL	AF 1000	AF 3000	ALLO-510	ALLO-910	ADS 2000
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Single User
MARKET	Captive	Captive	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Software
Host platform, software environment	Acer NetWare, VINES, SCO UNIX	Acer NetWare, VINES, SCO UNIX	SCSI host	SCSI host	SCSI host UNIX
RAID level Configured by:	0/1/5 Host	0/1/5 Host	3/5	3/5	0/1 Host
Array capacity (Gbytes) MIN MAX	3.2/1.6/2.6* 36.8/18.4/29.4	3.2/1.6/2.6* 36.8/18.4/29.4	Drive dependent	Drive dependent	Drive dependent Drive dependent
Minimum drives per array	3	3	5	9	3
Maximum drives per array	35	35	5	9	14
Concurrent host channels	1	1	1	1	1, 2
Array interface to host	EISA	EISA	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	IDE	IDE	SCSI-2
Cache size (min, max: MB)			.25, 1	.25, 1	None
Cache function (Read, Write)			Read, Write	Read, Write	None
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	No No No	Host dependent Host dependent Host dependent	Host dependent Host dependent Host dependent	Yes No No
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Auto
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	33 10	33 10	10 2.5	10 2.5	N/A Drive dependent
DRIVES: Formatted capacity/drive(MB)	521, 1050	521, 1050	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	Drive dependent	Drive dependent	Drive dependent
Average positioning time (msec)	10	10	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	6.7	6.7	Drive dependent	Drive dependent	Drive dependent
Drive models	Fujits. M2624FA Quantum 1050S	Fujits. M2624FA Quantum 1050S	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	22.9 x 7 x 20	24.6 x 14 X 16	5 x 5.75 x 8	5 x 10 x 8	Varies
POWER: Power backup	350 watts None	430 watts UPS optional	40 watts Cache battery	60 watts Cache battery	N/A None
FIRST CUSTOMER SHIPMENT	2Q93	10/92	11/92	12/92	6/92
COMMENTS	*With 1050 MB drives	*With 1050 MB drives	Write back cache	Write back cache	1776 Inc. RAID UNIX software

MANUFACTURER	AMERICAN DIGITAL DATA ASSOCIATES	AMERICAN DIGITAL DATA ASSOCIATES	AMPERIF	ARCO ELECTRONICS	AREAL TECHNOLOGY
ARRAY MODEL	ADS 1000	ADS 3000	Viking 6400	AC1079MC	AA5180
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Mainframe	Single User	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	PCM	PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Board	Board	Subsystem	Board	Subsystem
Host platform, software environment	PC compatible NetWare, DOS, UNIX	SCSI host Various	IBM mainframe MVS/VM	PC compatible DOS, OS/2, NetWare	SCSI host DOS, UNIX, NetWare
RAID level Configured by:	0/1/4/5 Host	0/3/5 Host	5 Panel	1 Preset	3/5 Host
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	Drive dependent Drive dependent	14 442	Drive dependent Drive dependent	.72 .72
Minimum drives per array	5	2	6	2	5
Maximum drives per array	35	5	144	2	5
Concurrent host channels	1, 2	1	16	1	1
Array interface to host	SCSI-2	SCSI-2	IBM	Micro Channel	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	IDE	IDE
Cache size (min, max: MB)	None	None	64, 2048	--	1
Cache function (Read, Write)	None	None	Read, Write	--	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes No No	Yes No No	Yes Yes Yes	No No No	Host dependent Host dependent Host dependent
Spare drive (None/Auto/Manual)	Auto	Auto	Auto-background	Manual-backgrnd	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 Drive dependent	20 Drive dependent	4.5, 17 5.5	1.4 Drive dependent	10 15
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	3000 and up	Drive dependent	183
Nominal disk diameter, height	Drive dependent	Drive dependent	5.25", 82.6 mm	2.5", 17.5 mm	2.5", 15 mm
Average positioning time (msec)	Drive dependent	Drive dependent	11.5	Drive dependent	15
Average rotational delay (msec)	Drive dependent	Drive dependent	5.6	Drive dependent	10.1
Drive models	Various	Various	Various	Various	Areal A180
ARRAY SIZE: Inches: H x W x D	Varies	Varies	Drive dependent	3.5 x 11.5	3.25 x 5 x 8
POWER: Power backup	N/A None	N/A None	Drive dependent Cache battery	6 watts+ drives None	25 watts None
FIRST CUSTOMER SHIPMENT	1/92	1/93	4/93	10/92	1Q93
COMMENTS	UltraStor controller	Digi-Data controller		2 2.5" drives mount on card	Allodyne controller

MANUFACTURER	AREAL TECHNOLOGY	ARRAY TECHNOLOGY	ARRAY TECHNOLOGY	ASA COMPUTERS	ASA COMPUTERS
ARRAY MODEL	AA9180	PentARRAY 5020	PentARRAY 5000	Array Option 1	Array Option 2
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	SCSI host DOS, UNIX, NetWare	Various Sun UNIX, RS/6000	Various Sun UNIX, RS/6000	ASA NetWare	ASA NetWare
RAID level Configured by:	3/5 Host	0/1/3/5	0/1/3/5	0/1/4/5 Host	0/1/4/5
Array capacity (Gbytes) MIN MAX	1.46 1.46	2 40	2 80	.34/.17/.34/.34 1.7/.86/1.4/1.4	.4/.2/.4/.4 2/1/1.6/1.6
Minimum drives per array	5	1	1	2	2
Maximum drives per array	9	20	20	10	10
Concurrent host channels	1	2	2	1	1, 2
Array interface to host	SCSI-2	SCSI-2	SCSI-2	EISA	EISA
Drive interface	IDE	SCSI	SCSI	SCSI-2	SCSI-2
Cache size (min, max: MB)	1	2, 2	2, 2	4, 64	4, 64
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Host dependent Host dependent Host dependent	Yes Yes Yes	Yes Yes Yes	No Yes Yes	Yes Yes Yes
Spare drive (None/Auto/Manual)	Manual-backgrnd	Auto-background	Auto-background	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 15	10 5	10 5	33 10	33 10
DRIVES: Formatted capacity/drive(MB)	183	2000	2000-4000	170	200
Nominal disk diameter, height	2.5", 15 mm	5.25", 82.6 mm	5.25", 82.6 mm	3.5", 25.4 mm	3.5", 25.4 mm
Average positioning time (msec)	15	Drive dependent	Drive dependent	17	12
Average rotational delay (msec)	10.1	Drive dependent	Drive dependent	7.8	6.7
Drive models	Areal A180	Drive dependent	Drive dependent	Conner 30170E	Seagate ST3283A
ARRAY SIZE: Inches: H x W x D	3.25 x 5 x 8	38 x 21 x 33	55 x 22 x 36		
POWER: Power backup	25 watts None	4.8 KVA Battery	4.8 KVA Battery	400 watts None	400 watts None
FIRST CUSTOMER SHIPMENT	1Q93	8/93	5/92	1993	1993
COMMENTS	Allodyne controller			UPS advised	UPS advised

MANUFACTURER	ASA COMPUTERS	ASA COMPUTERS	ASA COMPUTERS	ASA COMPUTERS	ASA COMPUTERS
ARRAY MODEL	Array Option 3	Array Option 4	Array Option 5	Array Option 6	Array Option 7
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	ASA NetWare	ASA NetWare	ASA NetWare	ASA NetWare	ASA NetWare
RAID level Configured by:	0/1/4/5 Host	0/1/5 Host	0/1/5 Host	0/1/5 Host	0/1/5 Host
Array capacity (Gbytes) MIN MAX	1.1/.52/1.1/1.1 5.2/2.6/4.2/4.2	.68/.34/.68 3.4/1.7/2.8	.85/.43/.85 4.2/2.2/3.4	1.1/.52/1.1 5.2/2.6/4.2	2.1/1.1/2.1 10.1/5/8.4
Minimum drives per array	2	2	2	2	2
Maximum drives per array	10	10	10	10	10
Concurrent host channels	1, 3	3, 5	3, 5	3, 5	3, 5
Array interface to host	EISA	EISA	EISA	EISA	EISA
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	4, 64	4, 64	4, 64	4, 64	4, 64
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	No Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
Spare drive (None/Auto/Manual)	Auto-background	Auto-background	Auto-background	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	33 10	33 10	33 10	33 10	33 10
DRIVES: Formatted capacity/drive(MB)	525	340	425	525	1050
Nominal disk diameter, height	3.5", 25.4 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	10.5	12	12	10.5	9
Average rotational delay (msec)	5.56	6.66	6.66	6.7	4.76
Drive models	Seagate ST3610N	Seagate ST3385N	Seagate ST3550N	Seagate ST3610N	Seagate ST31200N
ARRAY SIZE: Inches: H x W x D					
POWER: Power backup	400 watts None	400 watts None	400 watts None	400 watts None	400 watts None
FIRST CUSTOMER SHIPMENT	1993	1993	1993	1993	1993
COMMENTS	UPS advised	UPS advised	UPS advised	UPS advised	UPS advised

MANUFACTURER	AST RESEARCH	AST RESEARCH	ASTRIX	ASTRIX	ASTRIX
ARRAY MODEL	AST 3/5 ARRAY CM	AST 3/5 ARRAY CS	Array PC	FT Server	Array Server I
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	Captive	Captive, OEM	Captive, OEM	Captive, OEM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	AST ManhattanSM NetWare, SCO UNIX	AST Premium CS NetWare, SCO UNIX	Astrix NetWare, DOS	Astrix NetWare, DOS	Astrix NetWare, DOS
RAID level Configured by:	0/1/5/6* Host	0/1/5/6* Host	0/1/3/5	0/1	0/1/3/5
Array capacity (Gbytes) MIN MAX	2.65 16	2.65 16	.51 .51	.76/.38 .76/.38	1.5 1.5
Minimum drives per array	3	3	4	2	4
Maximum drives per array	8	8	4	2	4
Concurrent host channels	3 or 5	3 or 5	1	1	1
Array interface to host	SCSI-2	SCSI-2	EISA	EISA	EISA
Drive interface	SCSI-2	SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2
Cache size (min, max: MB)	4, 4	4, 4	.256, .512	.256, .512	.256, .512
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	Yes No No	No No No	No No No	No No No
Spare drive (None/Auto/Manual)	Auto	Auto	Manual, Auto	None	Manual, Auto
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	7.5 2.01	7.5 2.01	33 5	33 5	33 5
DRIVES: Formatted capacity/drive(MB)	890, 1225	890, 1225	127	340	340
Nominal disk diameter, height	3.5"	3.5"	3.5", 25.4 mm	3.5", 25.4 mm	3.5", 25.4 mm
Average positioning time (msec)	10.5, 10	10.5, 10	15	8.5	8.5
Average rotational delay (msec)	5.56, 6.7	5.56, 6.7	8.5	4.76	4.76
Drive models	H-P C2246 Quantum 1225S	H-P C2246 Quantum 1225S	Maxtor 7120S	Maxtor LXT 340	Maxtor LXT 340
ARRAY SIZE: Inches: H x W x D	26 x 19 x 15	26 x 19 x 15	26 x 7 x 16.5		26 x 7 x 16.5
POWER: Power backup	300 watts None	300 watts None	300 watts UPS	300 watts UPS	300 watts UPS
FIRST CUSTOMER SHIPMENT	12/92	1/92	12/92	1990	12/92
COMMENTS	*RAID 6= striping and mirroring Uses modified Mylex controll.	*RAID 6= striping and mirroring Uses modified Mylex controll.	Complete server UltraStor controller	Complete server DPT controller	Complete server UltraStor controller

MANUFACTURER	ASTRIX	ATTO TECHNOLOGY	ATTO TECHNOLOGY	ATTO TECHNOLOGY	AUSPEX SYSTEMS
ARRAY MODEL	Array Server II	Express Mirror	Express Stripe	Silicon Express	NS 3XXX
DISK/TREND GROUP	Net/Mini/Multi	Single User	Single User	Single User	Net/Mini/Multi
MARKET	Captive, OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Software	Software	Board	Subsystem
Host platform, software environment	Astrix NetWare, DOS	Macintosh	Macintosh	Macintosh	NFS (Sun)
RAID level Configured by:	0/1/3/5	1	0	0/1/3/4/5	0/1
Array capacity (Gbytes) MIN MAX	12.5 12.5	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	2 20
Minimum drives per array	10	2	2	2	2
Maximum drives per array	10	4	4	4	10
Concurrent host channels	1	1	1	1	1
Array interface to host	EISA	SCSI	SCSI	NuBus	VME
Drive interface	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI
Cache size (min, max: MB)	.256, .512				16, 192*
Cache function (Read, Write)	Read, Write				Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	Option No No	No No No	Option No No	No No No
Spare drive (None/Auto/Manual)	Manual, Auto	None	None	None	None
ARRAY PERFORMANCE: Boot from array?	Yes				Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	33 5	10 Drive dependent	10 Drive dependent	10 Drive dependent	30 2
DRIVES: Formatted capacity/drive(MB)	1250	Drive dependent	Drive dependent	Drive dependent	2000
Nominal disk diameter, height	3.5", 41.3 mm	Drive dependent	Drive dependent	Drive dependent	5.25", 82.6 mm
Average positioning time (msec)	12	Drive dependent	Drive dependent	Drive dependent	11.5
Average rotational delay (msec)	8.3	Drive dependent	Drive dependent	Drive dependent	5.5
Drive models	Toshiba	Various	Various	Various	H-P C3010
ARRAY SIZE: Inches: H x W x D	26.5 x 16.5 x 30	N/A	N/A	N/A	42 x 21 x 32
POWER: Power backup	300 watts External UPS	N/A	N/A	N/A	Cache battery*
FIRST CUSTOMER SHIPMENT	1/93	1/92	11/92	1/92	12/90
COMMENTS	Complete server UltraStor controller	Requires ATTO Silicon Express controller Can support 4 controllers	Requires ATTO Silicon Express controller Can support 4 controllers	Supports command tag queing, disc., asynch. I/O, scatter-gather	*Optional nonvolatile memory battery backed 1 MB

MANUFACTURER	AUSPEX SYSTEMS	BAYDEL LTD.	BAYDEL LTD.	BAYDEL LTD.	BLUE LANCE
ARRAY MODEL	NS 5XXX	DAR-3xx	DAR-5xx	DAT-3xx	Datarray
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	NFS (Sun)	SCSI host UNIX, others	SCSI host UNIX, others	SCSI host UNIX, others	Various NetWare, SCO UNIX
RAID level Configured by:	0/1	3 Preset	3 Preset	3 Preset	0/1/5 Host
Array capacity (Gbytes) MIN MAX	2 60	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	2	2 + parity	2 + parity	2 + parity	7
Maximum drives per array	60	28 + 7 parity	28 + 7 parity	28 + 7 parity	28
Concurrent host channels	1, 3	1	1	1	1
Array interface to host	VME	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2
Drive interface	SCSI	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2
Cache size (min, max: MB)	16, 384*	1, 64	1, 64	1, 64	--
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No Option	Option No Option	Option No Yes	Option No Option	No No No
Spare drive (None/Auto/Manual)	None	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	RAID 1 only
Transfer rate: host (MB/Sec) drive (MB/Sec)	30 2	10 5	10 5	10 5	Drive dependent Drive dependent
DRIVES: Formatted capacity/drive(MB)	2000	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	5.25", 82.6 mm	3.5", 41.3 mm	5.25"	3.5", 41.3 mm	Drive dependent
Average positioning time (msec)	11.5	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	5.5	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	H-P C3010	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	76 x 24 x 39		26 x 9 x 27	26 x 9 x 27	25 x 9 x 30
POWER: Power backup	Cache battery*	250 watts Battery option		250 watts Battery option	None
FIRST CUSTOMER SHIPMENT	2/90	1992	1993	1991	1992
COMMENTS	*Optional nonvolatile memory, battery backed 1-3 MB	Subsystems without drives are available	Subsystems without drives are available	Subsystems without drives are available	Many available configurations. Also available without drives and controllers Chantal softw.

MANUFACTURER	BOX HILL	CAMBEX	CAMBRIDGE TECHNOLOGIES	CAMBRIDGE TECHNOLOGIES	CAMBRIDGE TECHNOLOGIES
ARRAY MODEL	RAID Box	ARRAY/6000 Certainty	CDA 3003-ISA	Raidpak	Raidpro
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive, PCM	PCM	OEM	OEM	OEM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Board	Subsystem	Subsystem
Host platform, software environment	Sun, H-P, other UNIX	RS/6000, AIX	PC-ISA Bus Various	PC-ISA Bus Various	PC-ISA Bus Various
RAID level Configured by:	5 Preset	0/1/3/5	3/5 Preset	3/5 Preset	3/5 Preset
Array capacity (Gbytes) MIN MAX	4 12	8 96	Drive dependent Drive dependent	.6 1.2	.34 1.2
Minimum drives per array	3	5	3	3	3
Maximum drives per array	5	60	3	6	6
Concurrent host channels	1	2	1	1	1
Array interface to host	SCSI-2	SCSI-2	ISA-Bus	ISA-Bus	ISA-Bus, SCSI-2
Drive interface	SCSI-2	SCSI-2	IDE	IDE	IDE
Cache size (min, max: MB)	--	--	2, 4	2, 4	8, 32
Cache function (Read, Write)	--	--	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes Yes	Yes Yes Yes	No No No	No No No	No No No
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual	No	No	Auto
ARRAY PERFORMANCE: Boot from array?	--	--	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 10	20 10	4 Drive dependent	4 5	4 5
DRIVES: Formatted capacity/drive(MB)	760-3600	1600	Drive dependent	212.6	212.6
Nominal disk diameter, height	Drive dependent	3.5", 41.3 mm	Drive dependent	3.5", 25.4 mm	3.5", 25.4 mm
Average positioning time (msec)	Drive dependent	10	Drive dependent	14	14
Average rotational delay (msec)	Drive dependent	5.6	Drive dependent	8.21	8.21
Drive models	Various	--	Various	WDAC 2200 Caviar	WDAC 2200 Caviar
ARRAY SIZE: Inches: H x W x D	Varies	66 x 24 x 34	4 x 14	3.5 x 3 x 6*	18.6 x 8.6 x 17.5
POWER: Power backup	450 watts None		8 watts None	8 watts None	8 watts None
FIRST CUSTOMER SHIPMENT	1991	12/92	3/92	1/93	1/93
COMMENTS		Dual AC feed Supported under HACMP/6000		*Drive package	

MANUFACTURER	CHANTAL	CIPRICO	CIPRICO	CIPRICO	CIPRICO
ARRAY MODEL	Paragon 3.0	NA6610	NA6700	NA6710	AS6610
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Very High Perf.
MARKET	OEM, PCM	PCM	PCM	PCM	OEM
ARRAY CONFIGURATION: Type	Software	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	PC compatible NetWare, UNIX	Various NetWare	Various NetWare	Various NetWare	Various
RAID level Configured by:	0/1/5 Host	3 Preset	3 Preset	3 Preset	3 Preset
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	2	5	5	9	5
Maximum drives per array	16	5	5	9	5
Concurrent host channels	1, 4	1	1	1	1
Array interface to host	SCSI, SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI, SCSI-2	ESDI	SCSI-2	SCSI-2	ESDI
Cache size (min, max: MB)	N/A	.512	N/A	N/A	.512
Cache function (Read, Write)	N/A	Read	N/A	N/A	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	N/A N/A N/A	No No No	No No Yes	No No Yes	No No No
Spare drive (None/Auto/Manual)	Auto-background	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	No				
Transfer rate: host (MB/Sec) drive (MB/Sec)	Host dependent Drive dependent	5 5	20 15	20 20	20 9
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	N/A	Varies	7 x 17 x 22	Varies	Varies
POWER: Power backup	N/A	650 watts --	200 watts --	300 watts --	650 watts --
FIRST CUSTOMER SHIPMENT	1/91	1991	1Q93	1Q93	1990
COMMENTS	Earlier versions shipped in 1990				

MANUFACTURER	CIPRICO	CIPRICO	CLEARPOINT RESEARCH	CLEARPOINT RESEARCH	CLOVIS MANUFACTURING
ARRAY MODEL	AS6700	AS6710	FA-1700	FA-4000	G2
DISK/TREND GROUP	Very High Perf.	Very High Perf.	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM	OEM	OEM, PCM	PCM, OEM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Various	Various	DEC, various SCSI hosts	DEC, Sun, various SCSI hosts	RS/6000, WangVS NetWare, VINES
RAID level Configured by:	3 Preset	3 Preset	0/3/5 Host	0/3/5 Host	0/1 Panel
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	Drive dependent Drive dependent	1.7 11.9	4 56	.32 18
Minimum drives per array	5	9	5 (+ 1 spare)	5 (+ 1 spare)	2
Maximum drives per array	5	9	5 (+ 1 spare)	35 (+ 7 spares)	6
Concurrent host channels	1	1	1	1	1
Array interface to host	SCSI-2	SCSI-2	SCSI-2, DSSI	SCSI-2, DSSI	SCSI, SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI, SCSI-2
Cache size (min, max: MB)	N/A	N/A	256, 256	512, 512	4, 16
Cache function (Read, Write)	N/A	N/A	Read	Read	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No Yes	No No Yes	No No Yes	No No Yes	No Yes No
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual-backgrnd	Auto-background	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?			--	--	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	20 15	20 20	20 10	20 10	10 10
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	426	1050	370-3000
Nominal disk diameter, height	Drive dependent	Drive dependent	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 5.25"
Average positioning time (msec)	Drive dependent	Drive dependent	14	10.5	9
Average rotational delay (msec)	Drive dependent	Drive dependent	6.8	5.6	5.6
Drive models	Various	Various	Seagate ST1481N	DEC DSP3105	Various
ARRAY SIZE: Inches: H x W x D	7 x 17 x 22	7 x 17 x 22	5.2 x 19 x 22*	5.2 x 19 x 22*	Varies
POWER: Power backup	200 watts --	300 watts --	2.3 KVA --	3.45 KVA --	300 watts UPS
FIRST CUSTOMER SHIPMENT	1Q93	1992	4Q92	4Q92	1991
COMMENTS			*Rack/tabletop	*Rack/tabletop	Available without drives

MANUFACTURER	CLOVIS MANUFACTURING	CMD TECHNOLOGY	CMD TECHNOLOGY	COMPAQ COMPUTER	COMPAQ COMPUTER
ARRAY MODEL	G3	SCEA/S	CRD-5000	Systempro 486-680e	Systempro 486-1020e
DISK/TREND GROUP	Net/Mini/Multi	Single User	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	OEM	OEM	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Board	Board	Subsystem	Subsystem
Host platform, software environment	RS/6000, WangVS NetWare, VINES	SCSI host NetWare, UNIX, DOS, Wind. NT*	SCSI host NetWare, UNIX, DOS, Wind. NT*	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.
RAID level Configured by:	1/3/5 Panel	1 Panel	0/3/5 Host,Panel,Port	0/1/4/5 Host	0/1/4/5 Host
Array capacity (Gbytes) MIN MAX	2 28	Drive dependent Drive dependent	Drive dependent Drive dependent	.68/.34/-/- 3.7/1.9/2/2	1/.3/-/- 4.1/2/3/3
Minimum drives per array	2	2	5	2	2
Maximum drives per array	35	8	28	8	8
Concurrent host channels	1	1	1, 3	1	1
Array interface to host	SCSI, SCSI-2	SCSI-2	SCSI-2	EISA	EISA
Drive interface	SCSI, SCSI-2	SCSI-2	SCSI-2	IDE	IDE
Cache size (min, max: MB)	0, 128	--	8, 32	4*	4*
Cache function (Read, Write)	Read, Write	--	Write	Write	Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	No No No	Yes No No	With duplexing No No	With duplexing No No
Spare drive (None/Auto/Manual)	Auto-background	Auto-background	Auto-background	None	None
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	40 10	10 Drive dependent	10 Drive dependent	33 8	33 8
DRIVES: Formatted capacity/drive(MB)	500-2000	Drive dependent	Drive dependent	340	510.4
Nominal disk diameter, height	3.5", 41.3 mm	Drive dependent	Drive dependent	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	9	Drive dependent	Drive dependent	12	12
Average rotational delay (msec)	5.6	Drive dependent	Drive dependent	6.7	6.7
Drive models	Various	Various	Various	Conner	Conner
ARRAY SIZE: Inches: H x W x D	Varies	5.75 x 8.12	3.25 x 5.75 x 8.12	23.8 x 7.6 x 20.3	23.8 x 7.6 x 20.3
POWER: Power backup	350 watts UPS	2 watts None	25 watts Cache battery	360 watts Cache battery	360 watts Cache battery
FIRST CUSTOMER SHIPMENT	1993	2/93	4/93	12/89	12/89
COMMENTS		*Many software systems supported	*Many software systems supported	*Mirrored 2 MB cache Cache added 5/92	*Mirrored 2 MB cache Cache added 5/92

MANUFACTURER	COMPAQ COMPUTER	COMPAQ COMPUTER	COMPAQ COMPUTER	COMPAQ COMPUTER	COMPAQ COMPUTER
ARRAY MODEL	Systempro 486-2040e	Systempro 486/50-1020	Systempro 486/50-2040	Prosignia 486 DX2/66-1020	Prosignia DX2/66-2100
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	Captive	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.
RAID level Configured by:	0/1/4/5 Host	0/1/4/5 Host	0/1/4/5 Host	0/1/4/5 Host	0/1/4/5 Host
Array capacity (Gbytes) MIN MAX	2/1/1.5/1.5 4.1/2/3/3	1/.5/-/- 4.1/2/3/3	2/1/1.5/1.5 4.1/2/3/3	1/.5/-/- 3.1/1.5/2/2	2.1/1.05/-/- 14.7/7.4/11/11
Minimum drives per array	4	2	4	2	2
Maximum drives per array	8	8	8	6	14
Concurrent host channels	1	1	1	1	1
Array interface to host	EISA	EISA	EISA	EISA	EISA
Drive interface	IDE	IDE	IDE	IDE	SCSI-2
Cache size (min, max: MB)	4*	4*	4*	4*	4*
Cache function (Read, Write)	Write	Write	Write	Write	Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	With duplexing No No	With duplexing No No	With duplexing No No	No No No	With duplexing No No
Spare drive (None/Auto/Manual)	None	None	None	None	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	33 2	33 2	33 2	33 2	33 10
DRIVES: Formatted capacity/drive(MB)	510.4	510.4	510.4	510.4	1050
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	12	12	12	12	10.5
Average rotational delay (msec)	6.7	6.7	6.7	6.7	5.5
Drive models	Conner	Conner	Conner	Conner	Various
ARRAY SIZE: Inches: H x W x D	23.8 x 7.6 x 20.3	23.8 x 7.6 x 20.3	23.8 x 7.6 x 20.3	21.9 x 9 x 17.3	21.9 x 9 x 17.3
POWER: Power backup	360 watts Cache battery	360 watts Cache battery	360 watts Cache battery	240 watts Cache battery	240 watts Cache battery
FIRST CUSTOMER SHIPMENT	12/89	12/89	12/89	9/92	5/93
COMMENTS	*Mirrored 2 MB cache Cache added 5/92	*Mirrored 2 MB cache Cache added 5/92	*Mirrored 2 MB cache Cache added 5/92	*Mirrored 2 MB cache	*Mirrored 2 MB cache

MANUFACTURER	COMPAQ COMPUTER	COMPAQ COMPUTER	COMPAQ COMPUTER	COMPAQ COMPUTER	COMPAQ COMPUTER
ARRAY MODEL	Prosignia 486/33-1020	Prosignia 486/33-1100	Prosignia P5/60-1100	Prosignia P5/66-2100	Systempro/XL 486/50-1100
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	Captive	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.
RAID level Configured by:	0/1/4/5 Host	0/1/4/5 Host	0/1/4/5 Host	0/1/4/5 Host	0/1/4/5 Host
Array capacity (Gbytes) MIN MAX	1/.5/1/1 3.1/1.8/2/2	1.1/.6/-/- 7.4/3.7/5.6/5.6	1.1/.6/-/- 7.4/3.7/5.6/5.6	2.1/1/-/- 14.7/7.4/11/11	1.1/.6/-/- 7.4/3.7/5.6/5.6
Minimum drives per array	2	2	2	2	2
Maximum drives per array	6	14	14	14	14
Concurrent host channels	1	1	1	1	1
Array interface to host	EISA	EISA	EISA	EISA	EISA
Drive interface	IDE	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	4*	4*	4*	4*	4*
Cache function (Read, Write)	Write	Write	Write	Write	Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	With duplexing No No	With duplexing No No	With duplexing No No	With duplexing No No
Spare drive (None/Auto/Manual)	None	Auto-background	Auto-background	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	33 2	33 10	33 10	33 10	33 10
DRIVES: Formatted capacity/drive(MB)	510.4	550	550	1050	550
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	12	10.5	10.5	10.5	10.5
Average rotational delay (msec)	6.7	5.5	5.5	5.5	5.5
Drive models	Conner	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	21.9 x 9 x 17.3	21.9 x 9 x 17.3	21.9 x 9 x 17.3	21.9 x 9 x 17.3	23.8 x 7.6 x 20.3
POWER: Power backup	240 watts Cache battery	240 watts Cache battery	240 watts Cache battery	240 watts Cache battery	360 watts Cache battery
FIRST CUSTOMER SHIPMENT	9/92	5/93	5/93	5/93	5/93
COMMENTS	*Mirrored 2 MB cache	*Mirrored 2 MB cache	*Mirrored 2 MB cache	*Mirrored 2 MB cache	*Mirrored 2 MB cache

MANUFACTURER	COMPAQ COMPUTER	COMPAQ COMPUTER	COMPAQ COMPUTER	COMPAQ COMPUTER	CONCURRENT COMPUTER
ARRAY MODEL	Systempro/XL 486/50-2100	Systempro/XL P5/66-1100	Systempro/XL P5/66-2100	Proliant	D-251
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	Captive	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.	Compaq UNIX, NetWare, OS/2,VINES,oth.	Concurrent UNIX (RTU)
RAID level Configured by:	0/1/4/5 Host	0/1/4/5 Host	0/1/4/5 Host	0/1/4/5 Host	0/1
Array capacity (Gbytes) MIN MAX	2.1/1/-/- 14.7/7.4/11/11	1.1/.6/-/- 7.4/3.7/5.6/5.6	2.1/1/-/- 14.7/7.4/11/11	.33 7.35	2.8 45
Minimum drives per array	2	2	2	1	2
Maximum drives per array	14	14	14	7	32
Concurrent host channels	1	1	1	1	2, 8
Array interface to host	EISA	EISA	EISA	EISA	VME
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI	IPI-2
Cache size (min, max: MB)	4*	4*	4*	4*	.5, .5
Cache function (Read, Write)	Write	Write	Write	Write	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	With duplexing No No	With duplexing No No	With duplexing No No	With duplexing No No	Yes No No
Spare drive (None/Auto/Manual)	Auto-background	Auto-background	Auto-background	Auto-background	Auto
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	33 10	33 10	33 10	33 10	20 7.5
DRIVES: Formatted capacity/drive(MB)	1050	550	1050	330, 550, 1050	1341
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	5.25"
Average positioning time (msec)	10.5	10.5	10.5	10.5	11.5
Average rotational delay (msec)	5.5	5.5	5.5	5.5	5.56
Drive models	Various	Various	Various	Various	Seagate ST81154K
ARRAY SIZE: Inches: H x W x D	23.8 x 7.6 x 20.3	23.8 x 7.6 x 20.3	23.8 x 7.6 x 20.3	21.9 x 9 x 17.3	5.25 x 19 x 25
POWER: Power backup	360 watts Cache battery	360 watts Cache battery	360 watts Cache battery	240 watts Cache battery	20 watts+drives UPS
FIRST CUSTOMER SHIPMENT	5/93	5/93	5/93	5/93	11/92
COMMENTS	*Mirrored 2 MB cache	*Mirrored 2 MB cache	*Mirrored 2 MB cache	*Mirrored 2 MB cache Optional SCSI array controller	Supports concurrent mirroring, striping and dual porting

MANUFACTURER	CONCURRENT COMPUTER	CONLEY	CONLEY	CONTROL DATA SYSTEMS	CONTROL DATA SYSTEMS
ARRAY MODEL	SD-22	SR1	SR2	47008	5830
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Mainframe
MARKET	Captive	OEM, PCM	OEM, PCM	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Board,Subsystem	Subsystem
Host platform, software environment	Concurrent UNIX (RTU)	Sun, Macintosh, misc. SCSI hosts	Sun, Macintosh, misc. SCSI hosts	SGI, MIPS UNIX	SGI, MIPS,CYBER UNIX-NOX,VE-NOS
RAID level Configured by:	0/1	0/1/3/5	0/1/3/5	0/3 Host	0/3 Host
Array capacity (Gbytes) MIN MAX	1.7 27	4 78	4 78	2.4 64	2.4 64
Minimum drives per array	2	3	3	2	2
Maximum drives per array	32	10	10	32	32
Concurrent host channels	2, 8	7	7	2	4, 8
Array interface to host	VME	SCSI-2	SCSI-2	VME	IPI-3
Drive interface	IPI-2	SCSI	SCSI	IPI-2	IPI-2
Cache size (min, max: MB)	.5, .5	.512, 40	.512, 40	None	None
Cache function (Read, Write)	Read	Read, Write	Read, Write	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes No No	Yes Yes Yes	Yes Yes Yes	Yes No No	Yes No No
Spare drive (None/Auto/Manual)	Auto	Manual-backgrnd	Manual-backgrnd	Manual-back/for	Manual-back/for
ARRAY PERFORMANCE: Boot from array?	Yes	No	No	No	No
Transfer rate: host (MB/Sec) drive (MB/Sec)	20 6	Drive dependent Drive dependent	Drive dependent Drive dependent	25 7.5	25 7.5
DRIVES: Formatted capacity/drive(MB)	850	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	8"	3.5" or 5.25"	3.5" or 5.25"	5.25"	5.25", 8"
Average positioning time (msec)	15	Drive dependent	Drive dependent	11	11/18
Average rotational delay (msec)	8.3	Drive dependent	Drive dependent	5.55	5.55/8.3
Drive models	Seagate ST41800K	Various	Various	Seagate ST41201K,41800K	Seagte.ST81154K 41201K, 41800K
ARRAY SIZE: Inches: H x W x D	5.25 x 19 x 25	28 x 9 x 22	28 x 9 x 22	7 x 19	60 X 40 X 30
POWER: Power backup	20 watts+drives UPS	250 watts None	250 watts None	85 watts(Board) None	2.8 KVA UPS
FIRST CUSTOMER SHIPMENT	5/91	11/91	11/91	8/91	6/89
COMMENTS	Supports concurrent mirroring, striping and dual porting				

MANUFACTURER	CONVEX COMPUTER	CORE INTERNATIONAL	CORE INTERNATIONAL	CORE INTERNATIONAL	CORE INTERNATIONAL
ARRAY MODEL	DAR-001	CPR-100	CPR-200	CPR-400	CPR-500
DISK/TREND GROUP	Very High Perf.	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	ConvexC3 series Convex OS	Various PCs, Workstations, Networks	Various PCs, Workstations, Networks	Various PCs, Workstations, Networks	Various PCs, Workstations, Networks
RAID level Configured by:	0/1/5 Host	3/5 Host	3/5 Host	3/5 Host	3/5 Host
Array capacity (Gbytes) MIN MAX	40 80	1.3 1.6	2.6 3.3	4 5	5.2 6.5
Minimum drives per array	16	5	5	5	5
Maximum drives per array	32	6	6	6	6
Concurrent host channels	4	1	1	1	1
Array interface to host	Proprietary	SCSI	SCSI	SCSI	SCSI
Drive interface	IPI-2	ESDI	ESDI	ESDI	ESDI
Cache size (min, max: MB)	Configurable	--, 8	--, 8	--, 8	--, 8
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
Spare drive (None/Auto/Manual)	None	Auto	Auto	Auto	Auto
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	36 25/9.34	5 2.5	20 2.5	20 3	20 3
DRIVES: Formatted capacity/drive(MB)	3338/3050*	332	663	1000	1300
Nominal disk diameter, height	5.25", 8"	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm
Average positioning time (msec)	11/12	17	14	14	13.5
Average rotational delay (msec)	5.56/6.87	8.3	8.3	8.3	8.3
Drive models	Elite III, Sabre VII	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	70 x 25.1 x 39.3	36 x 8 x 25	36 x 8 x 25	36 x 8 x 25	36 x 8 x 25
POWER: Power backup	N/A None	795 watts None	795 watts	795 watts None	795 watts
FIRST CUSTOMER SHIPMENT	2Q92	4/91	4/91	4/91	4/91
COMMENTS	*Drives use 2 parallel heads				

MANUFACTURER	CORE INTERNATIONAL	CORE INTERNATIONAL	CORE INTERNATIONAL	CORE INTERNATIONAL	CRAY RESEARCH
ARRAY MODEL	LA-2000	LA-4000	MA-500 MicroArray	MA-800 MicroArray	DA-60
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Very High Perf.
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	NetWare, UNIX, OS/2, DOS	NetWare, UNIX, OS/2, DOS	Various PCs, Workstations, Networks	Various PCs, Workstations, Networks	Cray Unicos
RAID level Configured by:	3/5 Host	3/5 Host	3/5 Host	3/5 Host	3 Host
Array capacity (Gbytes) MIN MAX	2 2	3 4	.510 14.56	.842 23.58	7.84 62.72
Minimum drives per array	5	5	5	5	5
Maximum drives per array	5	5	5	5	40
Concurrent host channels	1	1	1	1	1
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	IPI-2
Drive interface	IDE	IDE	IDE	IDE	IPI-2
Cache size (min, max: MB)	2, 8	2, 8	2, 8	2, 8	--
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes Yes	No Yes Yes	No No No	No No No	-- -- --
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual-backgrnd	Auto-background	Auto-background	Manual
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	5	5	5	5	80 20
DRIVES: Formatted capacity/drive(MB)	540	1000	130	213	1960
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	2.5", 19 mm	2.5", 19 mm	8", 8.44"
Average positioning time (msec)	12	10	17	12	12
Average rotational delay (msec)	6.8	5.6	8.3	8.3	8.3
Drive models	Fujitsu	Micropolis	Toshiba	Toshiba	Seagate Sabre 6 PTD 9 head
ARRAY SIZE: Inches: H x W x D	8.25 x 12.5 x 18	8.25 x 12.5 x 18	3.25 x 5.75 x 8	3.25 x 5.75 x 8	60.75 x 24 x 40.8
POWER: Power backup	530 watts None	530 watts None	N/A None	N/A None	275 watts/drive None
FIRST CUSTOMER SHIPMENT	2/93	2/93	8/92	1Q93	12/92
COMMENTS					DCA-3 channel adapter controls up to 8 DA-60 array groups

MANUFACTURER	CRAY RESEARCH	DATA GENERAL	DATA GENERAL	DATA GENERAL	DELL COMPUTER
ARRAY MODEL	DA-62	CL 2025D, 2025R CL 2060D, 2060R CLARiiON	CLARiiON 7910 AViiON 7911	CLARiiON 7906 AViiON 7907	DSA
DISK/TREND GROUP	Very High Perf.	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	OEM	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Cray Unicos	Sun, H-P RS/6000,Unisys, ICL, UNIX	DG AViiON, DG Eclipse, UNIX, AOS/VS	DG AViiON, DG Eclipse, UNIX, AOV/VS	Dell Lanman 2.2,Dell UNIX, NetWare
RAID level Configured by:	3 Host	0/1/3/5 Host, Panel	0/1/3/5 Host, Panel	0/1/3/5 Host, Panel	0/1/4/5 Host
Array capacity (Gbytes) MIN MAX	10.92 87.36	2.5/1.2/2/2 24/12/19.2/19.2	6/3/5/5 24/12/20/20	2.5/1.2/2/2 10/5/8/8	4 14
Minimum drives per array	5	5	5	5	4
Maximum drives per array	40	20	20	20	14
Concurrent host channels	1	2	2	2	1, 2
Array interface to host	IPI-2	SCSI-2	SCSI-2	SCSI-2	Proprietary
Drive interface	IPI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	--	--	--	--	1
Cache function (Read, Write)	--	--	--	--	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	-- -- --	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes No No
Spare drive (None/Auto/Manual)	Manual	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	No	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	32 8.1	10 10	10 10	10 10	16 10
DRIVES: Formatted capacity/drive(MB)	2730	500, 1200	1200	500	1050
Nominal disk diameter, height	8", 4.75"	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	12	12/11.4	12	11.4	9.5
Average rotational delay (msec)	6.87	6.82/6.95	6.82	6.95	5.56
Drive models	Seagate Sabre 7 PTD	Various	Various	Various	DEC 3105
ARRAY SIZE: Inches: H x W x D	60.75 x 24 x 40.8	25 x 14 x 27.5	25 x 14 x 27.5	25 x 14 x 27.5	24 x 7.5 x 22.3
POWER: Power backup	167 watts/drive None	590 watts None	590 watts	590 watts None	Host dependent None
FIRST CUSTOMER SHIPMENT	12/92	11/92	9/92	9/92	3/93
COMMENTS	DCA-3 channel adapter controls up to 8 DA-62 array groups	Concurrent RAID levels	Concurrent RAID levels	Concurrent RAID levels	ISA bus, RAID 1/0 version shipped 11/92

MANUFACTURER	DIGI-DATA	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
ARRAY MODEL	Model Z	DECraid+	HSC65 SDI	HSC65 SDI/SCSI	HSC95 SDI
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM	Captive	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Board	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Various	VAX, VMS	VAX, ALPHA,MIPS VMS, ULTRIX	VAX, ALPHA VMS	VAX, ALPHA,MIPS VMS, ULTRIX
RAID level Configured by:	0/3/5 Port	0/1/0+1 --	0/1 Host	0/1 Host	0/1 Host
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	2 96	1 40	1 40/21	1 96
Minimum drives per array	5	5	1	1	1
Maximum drives per array	5	48	20	20/20	48
Concurrent host channels	7 max.	1	1, 3	1, 3	1, 8
Array interface to host	SCSI-2	Digital prop.	Digital prop.	Digital prop.	Digital prop.
Drive interface	SCSI-2	SDI	SDI	SDI, SCSI-2	SDI
Cache size (min, max: MB)	--	--, 128	64, 64	64, 64	64, 64
Cache function (Read, Write)	--	Read	Read	Read	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	Yes -- Yes	Yes No No	Yes No No	Yes No No
Spare drive (None/Auto/Manual)	None	Auto	Auto (option)	Auto (option)	Auto (option)
ARRAY PERFORMANCE: Boot from array?	Yes	--	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	20 10	4 4	4 2.8	4 2.8, 10	4 2.8
DRIVES: Formatted capacity/drive(MB)	Drive dependent	1000-2000	1000, 2000	1000, 2000	1000, 2000
Nominal disk diameter, height	Drive dependent	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm
Average positioning time (msec)	Drive dependent	12.5-12.9	12.5	12.5	12.5
Average rotational delay (msec)	Drive dependent	8.3	8.3	8.3	8.3
Drive models	Various	RA72, RA73	RA72, RA73	RA72, RA73	RA72, RA73
ARRAY SIZE: Inches: H x W x D	3.25 x 5.75 x 8*	81 x 22 x 38	41.7 x 21.3 x 35	41.7 x 21.3 x 35	41.7 x 21.3 x 35
POWER: Power backup	26 watts	1470 watts --	785 watts None	785 watts None	785 watts None
FIRST CUSTOMER SHIPMENT	4/92	6/92	9/92	3/93	9/92
COMMENTS	*Without drives	Software-based subsystem			

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
ARRAY MODEL	HSC95 SDI/SCSI	RM HSC95 SDI/SCSI	RM HSC95 SCSI	SHA11	SHA21
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	Captive	Captive	OEM	OEM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	VAX, ALPHA,MIPS VMS, ULTRIX	VAX, ALPHA VMS	VAX, ALPHA VMS	Various SCO, NetWare	VAX, ALPHA, VMS SCO, NetWare
RAID level Configured by:	0/1 Host	0/1 Host	0/1 Host	0/1/0+1/3/5 --	0/1/0+1/3/5 Host
Array capacity (Gbytes) MIN MAX	1 40/27.3	1 40/29.4	1.05 58.8	2 35	8 56
Minimum drives per array	1	1	1	5	5
Maximum drives per array	20/26	20/28	56	35	35
Concurrent host channels	1, 8	1, 8	1, 8	1	1
Array interface to host	Digital prop.	Digital prop.	Digital prop.	SCSI	SCSI-2
Drive interface	SDI, SCSI-2	SDI, SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	64, 64	64, 64	64, 64	--	--
Cache function (Read, Write)	Read	Read	Read	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes No No	Yes No Yes	Yes No Yes	Yes Yes Yes	Yes Yes Yes
Spare drive (None/Auto/Manual)	Auto (option)	Auto (option)	Auto (option)	None-manual	No-manual
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	--	--
Transfer rate: host (MB/Sec) drive (MB/Sec)	4 2.8, 10	4 2.8, 10	4 10	10-20 5	20 20
DRIVES: Formatted capacity/drive(MB)	1000, 2000	1000, 2000	1050	425-1050	1600
Nominal disk diameter, height	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	12.5	12.5	9.5	14-9.5	10
Average rotational delay (msec)	8.3	8.3	5.6	6.6-5.6	5.6
Drive models	RA72, RA73	RA72, RA73	RZ26	RZ25, RZ26	DSP3160
ARRAY SIZE: Inches: H x W x D	41.7 x 21.3 x 35	67 x 31 x 34.5	67 x 31 x 34.5	24 x 14 x 15	24 x 14 x 15
POWER: Power backup	785 watts None	785 watts Battery	785 watts Battery	131 watts Battery	131 watts Battery
FIRST CUSTOMER SHIPMENT	3/93	3/93	3/93	11/92	4/93
COMMENTS					

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DISTRIBUTED PROCESSING TECHNOLOGY	DYNATEK AUTOMATION SYSTEMS
ARRAY MODEL	Striping Driver QL-YEA9-J*	SZ200	Volume Shadowing, Version 6.0	Smart Cache Plus Mirroring Option	IIR 500
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	Captive	Captive, OEM	OEM, PCM	PCM
ARRAY CONFIGURATION: Type	Software	Subsystem	Software	Board	Subsystem
Host platform, software environment	VAX, VMS	VAX, ALPHA, VMS SCO, NetWare	VAX	PC compatible NetWare, VINES, LAN Mgr., UNIX	PC compatible NetWare, SCO UNIX
RAID level Configured by:	0 --	0/1/0+1/3/5 --	1 --	1 Host	0/1/4/5 Host
Array capacity (Gbytes) MIN MAX	-- --	2 35	-- 464	Drive dependent Drive dependent	.6/.3/.4/.4 .6/.3/.4/.4
Minimum drives per array	--	5	1	2	3
Maximum drives per array	--	35	130 x 3	6	3
Concurrent host channels	--	1	1, 130	1	1
Array interface to host	DSSI, SCSI	SCSI	DSSI, SCSI	SCSI-2	EISA
Drive interface	DSSI, SCSI	SCSI-2	DSSI, SCSI	SCSI, SCSI-2	SCSI-2
Cache size (min, max: MB)	--	--	DSSI, SCSI	.512, 16	--
Cache function (Read, Write)	--	--	--	Read, Write	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	-- -- --	Yes Yes Yes	-- -- --	No No No	No No No
Spare drive (None/Auto/Manual)	--	No-manual	--	None	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	--	--	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	Drive dependent Drive dependent	10-20 5	Drive dependent Drive dependent	Drive dependent Drive dependent	33 10
DRIVES: Formatted capacity/drive(MB)	Drive dependent	425-1050	Drive dependent	Drive dependent	200
Nominal disk diameter, height	Drive dependent	3.5", 41.3 mm	Drive dependent	Drive dependent	3.5", 41.3 mm
Average positioning time (msec)	Drive dependent	14-9.5	Drive dependent	Drive dependent	16
Average rotational delay (msec)	Drive dependent	6.5	Drive dependent	Drive dependent	8.3
Drive models	Various	RZ25, RZ26	Various	Various	IBM WDS-3200
ARRAY SIZE: Inches: H x W x D	--	24 x 14 x 15	--	--	3.25 x 5.75 x 8
POWER: Power backup	-- --	131 watts Battery	-- --	Drive dependent --	60 watts None
FIRST CUSTOMER SHIPMENT	12/89	11/92	1990	2/92	1993
COMMENTS					

MANUFACTURER	DYNATEK AUTOMATION SYSTEMS	DYNATEK AUTOMATION SYSTEMS	DYNATEK AUTOMATION SYSTEMS	DYNATEK AUTOMATION SYSTEMS	DYNATEK AUTOMATION SYSTEMS
ARRAY MODEL	RDR 2.0	RDR 3.5T	RDR 4.0F	RDR 5.0I	RDR 5.0T
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	PCM	PCM	PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	RS/6000 NetWare, OS/2	RS/6000 NetWare, OS/2	RS/6000 NetWare, OS/2	RS/6000 NetWare, OS/2	RS/6000 NetWare, OS/2
RAID level Configured by:	0/1/3/5 Host	0/1/3/5 Host	0/1/3/5 Host	0/1/3/5 Host	0/1/3/5 Host
Array capacity (Gbytes) MIN MAX	1.5/.8/1/1 2.6/1.3/2.1/2.1	2.6/1.3/1.8/1.8 4.4/2.2/3.5/3.5	3/1.5/2/2 5/2.5/4/4	3.6/1.8/2.4/2.4 6/3/4.8/4.8	3.6/1.8/2.4/2.4 6/3/4.8/4.8
Minimum drives per array	3	3	3	3	3
Maximum drives per array	5	5	5	5	5
Concurrent host channels	1	1	1	1	1
Array interface to host	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2
Drive interface	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2
Cache size (min, max: MB)					--
Cache function (Read, Write)					--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Per drive Per drive	No Per drive Per drive	No Per drive Per drive	No Per drive Per drive	No Per drive Per drive
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	Host dependent	Host dependent	Host dependent	Host dependent	Host dependent
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 5	10 5	10 5	10 5	10 5
DRIVES: Formatted capacity/drive(MB)	520	877	1000	1200	1200
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	12	12.5	10	12	12.5
Average rotational delay (msec)	6.8	8.3	6.82	6.95	8.3
Drive models	Fujitsu M2624	Toshiba MK-438FB	Fujitsu M2694	IBM 0663-E15	Toshiba MK-538FB
ARRAY SIZE: Inches: H x W x D	19 x 12 x 20	19 x 12 x 20	19 x 12 x 20	19 x 12 x 20	19 x 12 x 20
POWER: Power backup	250 watts None	250 watts None	250 watts None	250 watts None	250 watts None
FIRST CUSTOMER SHIPMENT	2Q92	2Q92	2Q92	2Q92	2Q92
COMMENTS					

MANUFACTURER	DYNATEK AUTOMATION SYSTEMS	DYNATEK AUTOMATION SYSTEMS	ECCS	ECCS	ECCS
ARRAY MODEL	XPR 1000	XPR 400	DFT-1	DFT-5	FFT-1
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	SCSI host Various	SCSI host Various	SCSI host UNIX, NetWare, VINES	NCR 3000 UNIX, NetWare	SCSI host UNIX, NetWare, VINES
RAID level Configured by:	0/1/3/5 Panel	0/1/3/5 Panel	1 Preset	5 Preset	1 Preset
Array capacity (Gbytes) MIN MAX	3.6/1.8/2.4/2.4 12/6/9.6/9.6	1.5/.8/1/1 5.2/2.6/4.2/4.2	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	3	3	2	5	2
Maximum drives per array	10	10	8	5	6
Concurrent host channels	1	1	1	1	1, 3
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	--	--	--	--	--
Cache function (Read, Write)	--	--	--	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Per drive Per drive	Yes Per drive Per drive	No No No	No No No	No Yes Yes
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	No	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 10	10 10	10 10	10 10	20 10
DRIVES: Formatted capacity/drive(MB)	1200	520	200-860	200-860	1000-3000
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 5.25"	3.5", 5.25"	3.5"
Average positioning time (msec)	12	12	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	6.95	6.8	Drive dependent	Drive dependent	Drive dependent
Drive models	IBM 0663-E15	Fujitsu M2624	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	33 x 17.5 x 22	33 x 17.5 x 22	10.56 x 7.50 x 11.8	29 x 13 x 30	8.75 x 19 x 22
POWER: Power backup	500 watts None	500 watts None	150 watts None	250 watts None	250 watts None
FIRST CUSTOMER SHIPMENT	1993	1993	10/92	7/92	3/93
COMMENTS			ECCS controller	NCR controller	ECCS controller

MANUFACTURER	ECCS	EMC	EMC	EMC	EMC
ARRAY MODEL	MDFT-1	Harmonix HX3	Harmonix HX5	Symmetrix 4204	Symmetrix 4424
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Mainframe	Mainframe
MARKET	OEM, PCM	PCM	PCM	PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	SCSI host UNIX, NetWare, VINES	AS/400	AS/400	IBM mainframes	IBM mainframes
RAID level Configured by:	1 Preset	0/1	0/1	1 Preset	1 Preset
Array capacity (Gbytes) MIN MAX	1.0 1.0	3.4 6.8	3.4 6.8	4 8	8 48
Minimum drives per array	2	2	2	4	8
Maximum drives per array	2	9	5	4	24
Concurrent host channels	1	1	1		
Array interface to host	SCSI-2	IPI-3	IPI-3	BMX	BMX
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI	SCSI
Cache size (min, max: MB)	--	32, 128	4, 128	64, 1500	256
Cache function (Read, Write)	--	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	No Yes Yes	No Yes Yes	No Yes Yes	Yes Yes Yes
Spare drive (None/Auto/Manual)	None	Auto-background	Auto-background	Auto	Auto
ARRAY PERFORMANCE: Boot from array?	Yes				
Transfer rate: host (MB/Sec) drive (MB/Sec)	5 5	10 10	10 10	3.0/4.5 Drive dependent	3.0/4.5 Drive dependent
DRIVES: Formatted capacity/drive(MB)	1000	857	1714	1000	1000, 2000
Nominal disk diameter, height	3.5", 25.4 mm	3.5", 41.3 mm	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm
Average positioning time (msec)	Drive dependent	10.5	11.5	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	6.7	5.6	Drive dependent	Drive dependent
Drive models	Seagate	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	3.82 x 5.75 x 8	5.25 x 17.5 x 28	6.75 x 17.5 x 28		
POWER: Power backup	25 watts None	.26 KVA None	.35 KVA None		
FIRST CUSTOMER SHIPMENT	1993	12/92	4/92	8/90	8/90
COMMENTS	ECCS controller	Remote diagnostics	Remote diagnostics	Remote diagnostics	Remote diagnostics

MANUFACTURER	EMC	EMC	ENCORE COMPUTER	FUJITSU	FUJITSU
ARRAY MODEL	Symmetrix 4800	Symmetrix 5500	RAID 5	F7956B1 Willow	F7956C1 Cottonwood
DISK/TREND GROUP	Mainframe	Mainframe	Very High Perf.	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	PCM	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	IBM mainframes	IBM mainframes All OS	Encore UMAX-5	Workstations UNIX	Workstations UNIX
RAID level Configured by:	1 Preset	1 Preset	3/5 Host	3 Preset	3 Preset
Array capacity (Gbytes) MIN MAX	10 90	60 360	6 32	2.0 8.2	2.0 4.1
Minimum drives per array	8	32	6	11	6
Maximum drives per array	32	128	16	22	12
Concurrent host channels	8	32	1, 15	2	2
Array interface to host	BMX/ESCON	BMX/ESCON	VME-proprietary	SCSI-2	SCSI-2
Drive interface	SCSI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	256, 368	.768, 3584	64, 572	--	--
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	No No No	No No No
Spare drive (None/Auto/Manual)	Auto	Auto-background	Manual-backgrnd	Auto	Auto
ARRAY PERFORMANCE: Boot from array?			Yes	No	No
Transfer rate: host (MB/Sec) drive (MB/Sec)	3.0/4.5 Drive dependent	3.0/4.5 Drive dependent	50 10	10 3	10 3
DRIVES: Formatted capacity/drive(MB)	1000,2000,3000	1000,2000,3000	1050, 1986	500	500
Nominal disk diameter, height	5.25", 82.6	5.25", 82.6 mm	5.25", 82.6 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	Drive dependent	Drive dependent	15/11	12	12
Average rotational delay (msec)	Drive dependent	Drive dependent	8.3/5.56	6.8	6.8
Drive models	Various	Various	Seagate Wren 7 Elite 2	M2628SC Picobird-4	M2628SC Picobird-4
ARRAY SIZE: Inches: H x W x D		74.9 x 68.7 x 36.4	5.25 x 19 x 15	28 x 10 x 30	21 x 22 x 24
POWER: Power backup		1.34-6.60 KVA Battery	N/A Internal UPS	620 watts --	860 watts --
FIRST CUSTOMER SHIPMENT	1Q92	1Q93	5/93	2Q92	1Q93
COMMENTS		Remote diagnostics UPS included. Version for Unisys avail.	Interphase 4220 controller		

MANUFACTURER	FUJITSU	GAIN SYSTEMS	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
ARRAY MODEL	F6490A/B D1A	Superserver	1350SA C2427-JK	420SA C2425-JK	C2252-B C2254-B
DISK/TREND GROUP	Very High Perf.	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	OEM, PCM	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	VP2000 UNIX, proprietary	IBM compatible NetWare, UNIX	H-P-9000 works. HP-UX	H-P 9000 works.	H-P 9000, 3000
RAID level Configured by:	3 Preset	0/1/5	0/1/3/5 Host	0/1/3/5 Host	0
Array capacity (Gbytes) MIN MAX	15 120	Drive dependent Drive dependent	4.1 8.1	1.4 2.5	2.7 5.4
Minimum drives per array	10	2	5	5	2
Maximum drives per array	80	16	6	6	5
Concurrent host channels	2, 4, 8	1	1	1	1
Array interface to host	IBM, prop.	SCSI, SCSI-2	SCSI-2	SCSI-2	HP-FL
Drive interface	IPI-2	SCSI, SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	--	--	.128	.128	.128
Cache function (Read, Write)	--	--	Read, Write	Read, Write	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	Option Yes Yes	No No Yes	No No No	No Yes No
Spare drive (None/Auto/Manual)	Auto	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	None
ARRAY PERFORMANCE: Boot from array?	No	Yes	No	No	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	36 4.5	10 5	10 2.88	10 2.58	5 2.88
DRIVES: Formatted capacity/drive(MB)	1890	Drive dependent	1355	422	1355
Nominal disk diameter, height	8", 5.25"	3.5"	5.25"	3.5", 41.3 mm	5.25"
Average positioning time (msec)	12	Drive dependent	13.5	13	13.5
Average rotational delay (msec)	6.9	Drive dependent	7.5	8.3	7.5
Drive models	M2671PA Swallow-7	Various	H-P Coyote III	H-P Wolverine	H-P Coyote III
ARRAY SIZE: Inches: H x W x D	66 x 22 x 32	Varies	14.6 x 7.5 x 15.25	14.6 x 7.5 x 15.25	10.5 x 16.7 x 26.1
POWER: Power backup	2.2 KVA --	750 watts None	310 watts None	155 watts None	200 watts None
FIRST CUSTOMER SHIPMENT	3Q90	1993	1/92	1/92	1Q92
COMMENTS		Purchased controller			

MANUFACTURER	HEWLETT-PACKARD	HI-DATA	HI-DATA	HI-DATA	HI-DATA
ARRAY MODEL	C2252-HA C2254-HA	510	520	550	2000
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	OEM	OEM	OEM	OEM
ARRAY CONFIGURATION: Type	Subsystem	Board	Board	Board	Subsystem
Host platform, software environment	H-P 9000, 3000	Various Various	Various Various	Various Various	SCSI host
RAID level Configured by:	3	3/"53"* Host	3/"53"* Host	3/"53"* Host	3/"35"/"53"
Array capacity (Gbytes) MIN MAX	2.7 5.4	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	2	5	5	5	5
Maximum drives per array	5	35	75	75	75
Concurrent host channels	1	1	1, 2	1, 2	1, 2
Array interface to host	HP-FL	SCSI-2	SCSI-2	Fibre	SCSI, SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI, SCSI-2
Cache size (min, max: MB)	.128	2.5	5	10	5
Cache function (Read, Write)	Read	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes No	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Option Yes Option
Spare drive (None/Auto/Manual)	Manual-backgrnd	Auto-foreground	Auto-foreground	Auto-foreground	Auto-backgrnd*
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	5 2.88	10 5	20 10	50 20	20
DRIVES: Formatted capacity/drive(MB)	1355	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	5.25"	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average positioning time (msec)	13.5	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	7.5	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	H-P Coyote III	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	10.5 x 16.7 x 26.1	Array size dependent	Array size dependent	Array size dependent	7 x 19 x 17.7**
POWER: Power backup	200 watts None	25 watts+drives Dual AC	25 watts+drives Dual AC	25 watts+drives Dual AC	25 watts+drives None
FIRST CUSTOMER SHIPMENT	1Q92	1990	3/92	3/93	1992
COMMENTS		Tabletop or rack mount available. *RAID 53 is combined RAID 5 and RAID 3	Tabletop or rack mount available. *RAID 53 is combined RAID 5 and RAID 3	Tabletop or rack mount available. *RAID 53 is combined RAID 5 and RAID 3	*Option **Controller module Rack mount package

MANUFACTURER	HI-DATA	HITACHI	IBM	IBM	IBM
ARRAY MODEL	3000	DF100-17 DF100-34	3514-001	3514-004	7051-840 Power Network Dataserver
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM	OEM	Captive	Captive,OEM,PCM	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	SCSI host	-- --	PS/2	PS/2	RS/6000 AIX, NFS
RAID level Configured by:	3/"35"/"53"	3/4/5*	5 Preset	5 Preset	0/1 Host
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	17.2 68.8	.769 2.79	1.97 6.9	10/5 48/24
Minimum drives per array	5	8	3	3	10
Maximum drives per array	75	32	8	8	40
Concurrent host channels	1, 2	1	1	1	1, 3
Array interface to host	SCSI, SCSI-2	SCSI-2	SCSI-2	SCSI-2	Proprietary
Drive interface	SCSI, SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	5	--	2.75, 4.0	2.75, 4.0	16, 384
Cache function (Read, Write)	Read, Write	--	Read, Write*	Read, Write*	Read, Option.W
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Option Yes Option	No Yes Yes	No No Yes	No No Yes	No Yes Yes
Spare drive (None/Auto/Manual)	Auto-backgrnd*	Manual	Manual	Manual	Option
ARRAY PERFORMANCE: Boot from array?	Yes		Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	20	10 10	10 2	10 10	55 10
DRIVES: Formatted capacity/drive(MB)	Drive dependent	2870	400	1200	2000, 2400
Nominal disk diameter, height	Drive dependent	5.25", 82.6 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5" (2/module)
Average positioning time (msec)	Drive dependent	12.8	11.5	9.4 RD/11.4 WR	11, 9.8
Average rotational delay (msec)	Drive dependent	5.6	6.95	6.95	6.95
Drive models	Various	DK517C-37	Turbo	Corsair-2E	Corsair-1 Corsair-2
ARRAY SIZE: Inches: H x W x D	3.8 x 25.4 x 17.1**	27.6 x 22.4 x 31.5	24 x 13.5 x 31.5	24 x 13.5 x 31.5	76.8 x 24 x 38.8
POWER: Power backup	25 watts+drives None	1.3 KVA	.660 KVA None	.660 KVA None	1.82 KVA None
FIRST CUSTOMER SHIPMENT	1992	4Q92	11/92	11/92	3/93
COMMENTS	*Option **Controller module Tabletop package	*FCS of RAID 5 8/93	PS/2 *Drive used for write cache	PS/2 *Drive used for write cache	RS/6000 server incorporates RS/6000 340R Auspex controller

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
ARRAY MODEL	7051-800 Power Network Dataserver	9337-010	9337-020	9337-040	9337-110
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	Captive	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Expansion Unit	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	RS/6000 AIX, NFS	AS/400 9405	AS/400 9405	AS/400 9406	AS/400 9405
RAID level Configured by:	0/1 Host	0	0	0	5
Array capacity (Gbytes) MIN MAX	10/5 96/48	1.080 3.790	1.940 6.790	7.868 13.769	1.620 3.250
Minimum drives per array	10	2	2	4	4
Maximum drives per array	80	7	7	7	7
Concurrent host channels	1, 3	1	1	1	1
Array interface to host	Proprietary	IBM 6500 10P	IBM 6500 10P	IBM 6500 10P	IBM 6500 10P
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	--	2	2	2	2
Cache function (Read, Write)	Read	Read, Write*	Read, Write*	Read, Write*	Read, Write*
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes Yes	No No Yes	No No Yes	No No Yes	No No Yes
Spare drive (None/Auto/Manual)	Option	--	--	--	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	55 10	10 5	10 5	10 5	10 5
DRIVES: Formatted capacity/drive(MB)	2000, 4000	542	970	1967	542
Nominal disk diameter, height	3.5" (2/module)	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	11, 9.8	9.8	9.8	9.2 RD/10.7 WR	9.8
Average rotational delay (msec)	6.95, 5.6	6.7	6.7	5.6	6.7
Drive models	Corsair-1, Allicat-S20	Corsair-1	Corsair-1	Allicat	Corsair-1
ARRAY SIZE: Inches: H x W x D	76.8 x 24.0 x 38.8	8.75 x 19 x 28.2	8.75 x 19 x 28.2	8.75 x 19 x 28.2	8.75 x 19 x 28.2
POWER: Power backup	2.4 KVA None	.660 KVA None	.660 KVA None	.660 KVA None	.660 KVA None
FIRST CUSTOMER SHIPMENT	3/93	3Q92	3Q92	1993	4Q92
COMMENTS	Expansion unit for 7051-840	AS/400 Read ahead cache *Drive used for write cache	AS/400 Read ahead cache *Drive used for write cache	AS/400 Read ahead cache *Drive used for write cache	AS/400 Read ahead cache *Drive used for write cache

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
ARRAY MODEL	9337-120	9337-140	Oasas I V2.0	PS/2 Server 295	9570-1xx (5.25)
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Very High Perf.
MARKET	Captive	Captive	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Software	Subsystem	Subsystem
Host platform, software environment	AS/400 9405	AS/400 9406	PS/2 OS/2 2.0	PS/2 Server 295 OS/2, NetWare	RS/6000, ES9000 MVS (ES9000), AIX
RAID level Configured by:	5	5	0/1/5 Host	0/1/5 Host	3 Port, Host
Array capacity (Gbytes) MIN MAX	2.910 5.820	5.901 11.802	Drive dependent Drive dependent	.8/.4/.6 16/8/12.8	10.5 168
Minimum drives per array	4	4	3	2	5 (4 + parity)
Maximum drives per array	7	7	8	16	160
Concurrent host channels	1	1	--	1, 4	1
Array interface to host	IBM 6500 10P	IBM 6500 10P	SCSI	Parallan	HIPPI (IPI-3)
Drive interface	SCSI-2	SCSI-2	SCSI	SCSI-2	IPI-2
Cache size (min, max: MB)	2	2	--	--	10, 20
Cache function (Read, Write)	Read, Write*	Read, Write*	--	--	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No Yes	No No Yes	-- -- --	Yes No Option	No Yes Yes
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	--	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 5	10 5	Drive dependent Drive dependent	10 2, 5	27.5-55 4.4
DRIVES: Formatted capacity/drive(MB)	970	1967	100-1000	400, 1000	1500
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	3.5"	3.5", 41.3 mm	5.25"
Average positioning time (msec)	9.8	9.2 RD/10.7 WR	Drive dependent	11.5, 9.4	12
Average rotational delay (msec)	6.7	5.6	Drive dependent	6.95, 6.95	5.58
Drive models	Corsair-1	Allicat	Various	Turbo, Corsair-1	9345
ARRAY SIZE: Inches: H x W x D	8.75 x 19 x 28.2	8.75 x 19 x 28.2	--	26.9 x 23 x 13.3	29.5 x 38.5 x 62
POWER: Power backup	.660 KVA None	.660 KVA None	--	None	3.4 KVA None
FIRST CUSTOMER SHIPMENT	4Q92	1993	2/93	10/92	11/91
COMMENTS	AS/400 Read ahead cache *Drive used for write cache	AS/400 Read ahead cache *Drive used for write cache	PS/2 Integra software	PS/2 Can span mult. SCSI channels. Support external UPS. Parallan contr.	Maximum Strategy controller

MANUFACTURER	IBM	IBM	INFORTREND	IPL	IPL
ARRAY MODEL	9570-2xx (3.5)	9570-2xx (5.25)	IS-1000	7637-10	7637-20
DISK/TREND GROUP	Very High Perf.	Very High Perf.	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	Captive	OEM	PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Board	Subsystem	Subsystem
Host platform, software environment	RS/6000, ES9000 MVS (ES9000), AIX	RS/6000, ES9000 MVS (ES9000), AIX	PC compatible DOS, OS/2, NetWare, NT	AS/400	AS/400
RAID level Configured by:	0/1/3/5 Port, Host	3 Port, Host	0/1/4/5 Host	0/1	0/1
Array capacity (Gbytes) MIN MAX	13.5 220	10.5 168	Drive dependent Drive dependent	.942 1.884	1.71 3.42
Minimum drives per array	10	5 (4 + parity)	2	2	2
Maximum drives per array	160	160	21	4	4
Concurrent host channels	1	2	1	1	1
Array interface to host	HIPPI (IPI-3)	HIPPI (IPI-3)	EISA	IPI	IPI
Drive interface	IPI-2	IPI-2	SCSI, SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	10, 20	10, 20	4, 16	16, 128	16, 128
Cache function (Read, Write)	Read	Read	Read, Write	Read	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes Yes	No Yes Yes	No No No	No No No	No No No
Spare drive (None/Auto/Manual)	Auto-background	Auto-background	Auto-background	None	None
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes		
Transfer rate: host (MB/Sec) drive (MB/Sec)	27.5-55 5	27.5-55 4.4	33 10	6.0 5.0	6.0 5.0
DRIVES: Formatted capacity/drive(MB)	1700	1500	Drive dependent	471	857
Nominal disk diameter, height	3.5", 41.3 mm	5.25"	Drive dependent	3.5"	3.5", 41.3 mm
Average positioning time (msec)	9.4 RD/11 WR	12	Drive dependent	5.5	9.8
Average rotational delay (msec)	5.6	5.58	Drive dependent	6.95	6.95
Drive models	Allicat P10	9345	Various	IBM	IBM
ARRAY SIZE: Inches: H x W x D	29.5 x 38.5 x 62	29.5 x 38.5 x 62	.625 x 5 x 13.375	5 x 19 x 26.5	5 x 19 x 26.5
POWER: Power backup	2.95-1.4 KVA None	3.4 KVA None	20 watts None	330 KVA --	330 KVA --
FIRST CUSTOMER SHIPMENT	3/93	11/91	1993	4/92	3/92
COMMENTS		Maximum Strategy controller			

MANUFACTURER	IPL	LAURA TECHNOLOGIES	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS
ARRAY MODEL	7936	PowerCache SC	SL	XE	HFD
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Board	Subsystem	Subsystem	Subsystem
Host platform, software environment	AS/400	PC compatible UNIX, DOS, OS/2 NetWare	Misc. networks NetWare, NT, OS/2, UNIX	Misc. networks NetWare, NT, OS/2, UNIX	Misc. networks NetWare, NT, OS/2, UNIX
RAID level Configured by:	0/1	1 Host	0/1/5	0/1/5	0/1/5
Array capacity (Gbytes) MIN MAX	.6 1.8	Drive dependent Drive dependent	.420 6.300	.420 10.500	.420 6.330
Minimum drives per array	2	2	2	2	2
Maximum drives per array	4	6	8	12	8
Concurrent host channels	1	1	4	4	4
Array interface to host	IPI	ISA	ISA,EISA,MCA	ISA,EISA,MCA	ISA,EISA,MCA
Drive interface	SCSI-2	SCSI	SCSI,SCSI-2	SCSI,SCSI-2	SCSI,SCSI-2
Cache size (min, max: MB)	--	.512, 16	--	--	--
Cache function (Read, Write)	--	Read, Write*	--	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	Duplexing No No	Yes (option) Yes Yes (option)	Yes (option) Yes Yes (option)	Yes (option) Yes Yes (option)
Spare drive (None/Auto/Manual)	None	None	Auto-background	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?		Yes			
Transfer rate: host (MB/Sec) drive (MB/Sec)	6 2.5	1 10	10 10	10 10	10 10
DRIVES: Formatted capacity/drive(MB)	300	Drive dependent	420-2100	420-2100	420-2100
Nominal disk diameter, height	3.5", 41.3 mm	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average positioning time (msec)	12.5	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	6.95	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	IBM	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	6.66 x 19 x 28.25	--	17.5 x 7.75 x 18.5	27.5 x 9 x 21.75	17.5 x 7.75 x 18.5
POWER: Power backup	330 KVA --	-- --	250-750 watts	250-750 watts	250-750 watts
FIRST CUSTOMER SHIPMENT	9/90	2Q93	6/92	1991	1991
COMMENTS		*User configur-able cache	Optical & tape drive options. Software-based subsystem. RAID-5 optional	Optical & tape drive options. Software-based subsystem. RAID-5 optional	Optical & tape drive options. Software-based subsystem. RAID-5 optional

MANUFACTURER	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LOMAS DATA PRODUCTS	LOVIEL COMPUTER	LOVIEL COMPUTER
ARRAY MODEL	HFD/XE	HFD NetSpan	LDP CACHE IIP	LARC	R1
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Single User	Single User
MARKET	OEM, PCM	OEM, PCM	OEM	PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Board	Software	Subsystem
Host platform, software environment	Misc. networks NetWare, NT, OS/2, UNIX	Misc. networks NetWare, NT, OS/2, UNIX	ISA, EISA	Macintosh	Macintosh
RAID level Configured by:	0/1/5	0/1/5	0/1	0/1/4/5 Host	0/1/3/5 Host
Array capacity (Gbytes) MIN MAX	.420 10.500	1.260 10.500	.1 16	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	2	6	2	2	2
Maximum drives per array	12	12	4	15	5
Concurrent host channels	4	4	1	1	1
Array interface to host	ISA,EISA,MCA	ISA,EISA,MCA	SCSI, SCSI-2	Drive dependent	SCSI, SCSI-2
Drive interface	SCSI,SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	Drive dependent	SCSI, SCSI-2
Cache size (min, max: MB)	--	--	1, 16	--	--
Cache function (Read, Write)	--	--	Read, Write	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes (option) Yes Yes (option)	Yes (option) Yes Yes (option)	No -- --	-- -- --	Yes Yes Yes
Spare drive (None/Auto/Manual)	Auto-background	Auto-background	Manual-foregrnd	Manual	Manual
ARRAY PERFORMANCE: Boot from array?			Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 10	10 10	Host dependent 5	Drive dependent Drive dependent	20, 10 5
DRIVES: Formatted capacity/drive(MB)	420-2100	420-2100	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Any SCSI	Any SCSI
ARRAY SIZE: Inches: H x W x D	27.5 x 9 x 21.75	27.5 x 9 x 21.75	--	8 x 17.75 x 20	28 x 9 x 22
POWER: Power backup	250-750 watts	250-750 watts	-- --	-- --	750 watts None
FIRST CUSTOMER SHIPMENT	1991	3/92	1989	1993	1992
COMMENTS	Optical & tape drive options. Software-based subsystem. RAID-5 optional	Optical & tape drive options. Software-based subsystem. Inc. DAT tape. RAID-5 optional			NCR controller

MANUFACTURER	MAPLE SYSTEMS	MAPLE SYSTEMS	MAPLE SYSTEMS	MAPLE SYSTEMS	MAPLE SYSTEMS
ARRAY MODEL	MC1175	MC2068	MC2078	MC4000	MC4200
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	PCM	PCM	PCM	PCM
ARRAY CONFIGURATION: Type	Board	Board	Board	Board	Board
Host platform, software environment	PC compatible NetWare	PC compatible NetWare	PC compatible NetWare	PC compatible NetWare	PC compatible NetWare
RAID level Configured by:	0/1 Host	0/1 Host	0/1 Host	0/1 Host	0/1 Host
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	2	2	2	2	2
Maximum drives per array	2	2	2	7	7
Concurrent host channels	1	1	1	1	1
Array interface to host	ISA	ISA	VESA local bus	ISA	VESA local bus
Drive interface	ESDI	IDE	IDE	SCSI	SCSI
Cache size (min, max: MB)	.064	.512, 8	2, 32	2, 32	2, 32
Cache function (Read, Write)	Read	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	No No No	No No No	No No No	No No No
Spare drive (None/Auto/Manual)	No	No	No	No	No
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	4 3	4 3	Host dependent 3	4 10	Host dependent 10
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	3.9 x 8	4.25 x 9	4.25 x 10	4.25 x 9	4.25 x 10
POWER: Power backup	4 watts None	1.5 watts None	1.5 watts None	2.5 watts None	2.5 watts None
FIRST CUSTOMER SHIPMENT	7/91	10/92	3/93	2/93	5/93
COMMENTS	Requires NetWare V3.1x	Requires NetWare V3.1x UPS support	Requires NetWare V3.1x UPS support	Requires NetWare V3.1x UPS support	Requires NetWare V3.1x UPS support

MANUFACTURER	MASPAR COMPUTER	MASPAR COMPUTER	MASPAR COMPUTER	MASPAR COMPUTER	MASPAR COMPUTER
ARRAY MODEL	DA-4004A	DA-4108A	DA-4116A	DA-4124A	DA-4216A
DISK/TREND GROUP	Very High Perf.	Very High Perf.	Very High Perf.	Very High Perf.	Very High Perf.
MARKET	Captive	Captive	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Maspar UNIX	Maspar UNIX	Maspar UNIX	Maspar UNIX	Maspar UNIX
RAID level Configured by:	3 Preset	3 Preset	3 Preset	3 Preset	3 Preset
Array capacity (Gbytes) MIN MAX	5.5 5.5	11 11	22 22	33 33	22 22
Minimum drives per array	4 + parity	8 + parity	16 + 2 parity	24 + 3 parity	16 + 2 parity
Maximum drives per array	4 + parity	8 + parity	16 + 2 parity	24 + 3 parity	16 + 2 parity
Concurrent host channels	1	1	1	1	2
Array interface to host	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary
Drive interface	ESDI	ESDI	ESDI	ESDI	ESDI
Cache size (min, max: MB)	2	4	4	4	8
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	No No No	No No No	No No No	No No No
Spare drive (None/Auto/Manual)	Auto-background	Auto-background	Auto-background	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?	No	No	No	No	No
Transfer rate: host (MB/Sec) drive (MB/Sec)	8 9.8	16 18	16 18	16 18	32 36
DRIVES: Formatted capacity/drive(MB)	1321	1321	1321	1321	1321
Nominal disk diameter, height	5.25"	5.25"	5.25"	5.25"	5.25"
Average positioning time (msec)	14	14	14	14	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Drive models	Hitachi DK516-15	Hitachi DK516-15	Hitachi DK516-15	Hitachi DK516-15	Hitachi DK516-15
ARRAY SIZE: Inches: H x W x D	57.75 x 23 x 32.5	57.75 x 23 x 32.5	57.75 x 23 x 32.5	57.75 x 23 x 32.5	57.75 x 23 x 32.5
POWER: Power backup	2000 watts None	2000 watts None	4000 watts None	4000 watts None	4000 watts None
FIRST CUSTOMER SHIPMENT	12/90	12/90	12/90	12/90	12/90
COMMENTS	Optional hot standby disk	Optional hot standby disk	Optional hot standby disk	Optional hot standby disk	2 optional hot standby disks

MANUFACTURER	MASS MICROSYSTEMS	MASS MICROSYSTEMS	MASS MICROSYSTEMS	MASS MICROSYSTEMS	MAXIMUM STRATEGY
ARRAY MODEL	PersonalArray 1000	PersonalArray 2000	MASSterArray 2000	MASSterArray 4000	HIPPI-S2
DISK/TREND GROUP	Single User	Single User	Net/Mini/Multi	Net/Mini/Multi	Very High Perf.
MARKET	PCM	PCM	PCM	PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Macintosh	Macintosh	Macintosh	Macintosh	Various
RAID level Configured by:	0/1	0/1	0/1/3/5	0/1/3/5	3 Preset
Array capacity (Gbytes) MIN	2	2	5	5	43
MAX					345
Minimum drives per array	2	2	5	5	40
Maximum drives per array	2	2	5	5	320
Concurrent host channels	1	1	1	1	1, 2
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	HIPPI
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	ESDI
Cache size (min, max: MB)	256 per drive	256 per drive	256 per drive	256 per drive	N/A
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	N/A
Redundancy: Controller (Yes/No)	No	No	No	No	No
Fan (Yes/No)	No	No	Yes	Yes	No
Power supply (Yes/No)	No	No	Yes	Yes	No
Spare drive (None/Auto/Manual)	Manual	Manual	Manual-backgrnd	Manual-backgrnd	Auto
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	No
Transfer rate: host (MB/Sec)	10	10	10	10	72-144
drive (MB/Sec)	10	10	10	10	2.75
DRIVES: Formatted capacity/drive(MB)	510	1005	510	1005	1350
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	5.25", 82.6 mm
Average positioning time (msec)	10.5 RD/12 WR	10.5 RD/12 WR	10.5 RD/12 WR	10.5 RD/12 WR	14
Average rotational delay (msec)	5.5	5.6	5.5	5.6	8.3
Drive models	Seagate ST3610	Seagate ST11200	Seagate ST3610	Seagate ST11200	Hitachi DK-516
ARRAY SIZE: Inches: H x W x D	9.5 x 4.25 x 13	9.5 x 4.25 x 13	15.5 x 15.5 x 15.5	15.5 x 15.5.x 15.5	78 x 42.5 x 38
POWER: Power backup	None	None	None	None	3600 watts
FIRST CUSTOMER SHIPMENT	3/93	3/93	3/93	3/93	4/91
COMMENTS	Raidtec controller	Raidtec controller	Raidtec controller	Raidtec controller	

MANUFACTURER	MAXIMUM STRATEGY	MAXIMUM STRATEGY	MAXIMUM STRATEGY	MAXIMUM STRATEGY	MAXIMUM STRATEGY
ARRAY MODEL	MCP-10	MCR-40	S2P	S2R	Strategy Gen 4
DISK/TREND GROUP	Very High Perf.	Very High Perf.	Very High Perf.	Very High Perf.	Very High Perf.
MARKET	OEM	OEM	OEM	OEM	OEM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	IBM RS/6000 AIX	IBM RS/6000 AIX	Various	Various	IPI-3 compatible
RAID level Configured by:	3 Preset	3 Preset	3 Preset	3 Preset	1/3/5 Config. by host
Array capacity (Gbytes) MIN MAX	10.8 10.8	10.8 43.2	5.5* 10.8*	5.5* 43.2*	12 60
Minimum drives per array	10	10	10	10	10
Maximum drives per array	10	40	10	40	40
Concurrent host channels	1, 2	1 to 4	1, 2	1 to 4	2
Array interface to host	Micro Channel	Micro Channel	VME-2E	VME-2E	HIPPI
Drive interface	ESDI	ESDI	ESDI	ESDI	IPI-2
Cache size (min, max: MB)	N/A	N/A	N/A	N/A	N/A
Cache function (Read, Write)	N/A	N/A	N/A	N/A	N/A
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	No No No	No No No	No No No	No No No
Spare drive (None/Auto/Manual)	Auto	Auto	Auto	Auto	Auto
ARRAY PERFORMANCE: Boot from array?	No	No	No	No	No
Transfer rate: host (MB/Sec) drive (MB/Sec)	18 2.75	18 2.75	18* 2.75	18* 2.75	90 5.52
DRIVES: Formatted capacity/drive(MB)	1350	1350	1350	1350	1520
Nominal disk diameter, height	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm
Average positioning time (msec)	14	14	14	14	11.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	5.5
Drive models	Hitachi DK-516	Hitachi DK-516	Hitachi DK-516	Hitachi DK-516	Seagate Elite ST41800K
ARRAY SIZE: Inches: H x W x D	14 x 19 x 33	70 x 25 x 41	14 x 19 x 33	70 x 25 x 41	70 x 25 x 41
POWER: Power backup	700 watts	2000 watts	700 watts	2000 watts	3000 watts
FIRST CUSTOMER SHIPMENT	7/91	7/91	8/90	11/90	9/92
COMMENTS			*Depends upon disk drive used	*Depends upon disk drive used	

MANUFACTURER	MEGA DRIVE SYSTEMS	MEGA DRIVE SYSTEMS	MEGA DRIVE SYSTEMS	MEGA DRIVE SYSTEMS	MEGA DRIVE SYSTEMS
ARRAY MODEL	MR/5	MR/10	MR/20	MR/35	MR/70
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	SCSI host Various	SCSI host Various	SCSI host Various	SCSI host Various	SCSI host Various
RAID level Configured by:	0/1/3/5/35x* Panel	0/1/3/5/35x* Panel	0/1/3/5/35x* Panel	0/1/3/5/35x* Panel	0/1/3/5/35x* Panel
Array capacity (Gbytes) MIN MAX	1.6 10	1.6 20	1.6 40	1.6 70	3.1 140
Minimum drives per array	3	3	3	3	6
Maximum drives per array	5	10	20	35	70
Concurrent host channels	1	1, 2	1, 2	1, 2	1, 2
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2
Cache size (min, max: MB)	0, 64	0, 64	0, 64	0, 64	0, 64
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
Spare drive (None/Auto/Manual)	Auto-background	Auto-background	Auto-background	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	20 10	20 10	20 10	20 10	20 10
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	3.5", 22-14.3mm	3.5", 22-14.3mm	3.5", 22-14.3mm	3.5", 22-14.3mm	3.5", 22-14.3mm
Average positioning time (msec)	9, 15	9, 15	9, 15	9, 15	9, 15
Average rotational delay (msec)	4.3, 6.9	4.3, 6.9	4.3, 6.9	4.3, 6.9	4.3, 6.9
Drive models	Various	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	8 x 8 x 20	8 x 16 x 20	14 x 16 x 20	36 x 19 x 20	72 x 19 x 20
POWER: Power backup	150 watts Cache battery	250 watts Cache battery	350 watts Cache battery	500 watts Cache battery	1000 watts Cache battery
FIRST CUSTOMER SHIPMENT	4Q92	4Q92	1Q93	1Q93	2Q93
COMMENTS	*Proprietary mode	*Proprietary mode	*Proprietary mode	*Proprietary mode	*Proprietary mode

MANUFACTURER	MEGA DRIVE SYSTEMS	MEGA DRIVE SYSTEMS	MEMOREX TELEX	MICRO TECHNOLOGY	MICRO TECHNOLOGY
ARRAY MODEL	MR/140	MR/245	3936-40	FailSafe 26	FailSafe 44
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	PCM	PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	SCSI host Various	SCSI host Various	AS/400	VAX-CI cluster VMS	VAX-CI cluster VMS
RAID level Configured by:	0/1/3/5/35x* Panel	0/1/3/5/35x* Panel	1	5+* Preset	5+* Preset
Array capacity (Gbytes) MIN MAX	6.2 280	10.9 490	1.7 3.4	22 22	44 44
Minimum drives per array	12	21	2	13	13
Maximum drives per array	140	245	4	13	13
Concurrent host channels	1, 2	1, 2	1	2 (dual ports)	2 (dual ports)
Array interface to host	SCSI-2	SCSI-2	IPI-3	DEC CI Bus	DEC CI Bus
Drive interface	SCSI, SCSI-2	SCSI, SCSI-2	SCSI	SCSI-2	SCSI-2
Cache size (min, max: MB)	0, 64	0, 64	8, 16	N/A	N/A
Cache function (Read, Write)	Read, Write	Read, Write	Read	N/A	N/A
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	Yes Yes Yes	No No No	Yes Yes Yes	Yes Yes Yes
Spare drive (None/Auto/Manual)	Auto-background	Auto-background	Manual	Auto/Manual-bac	Auto/Manual-bac
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	20 10	20 10	5.7 5	10 4.8	10 10
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	857	1050	1900
Nominal disk diameter, height	3.5", 22-14.3mm	3.5", 22-14.3mm	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm
Average positioning time (msec)	9, 15	9, 15	8.8	15	12.9
Average rotational delay (msec)	4.3, 6.9	4.3, 6.9	5.6	8.3	8.3
Drive models	Various	Various	Seagate Elite	Seagate Wren 7	Seagate Wren 9
ARRAY SIZE: Inches: H x W x D	72 x 38 x 20	78 x 57 x 20	5.06 x 17.03 x 27	62 x 35 x 37	62 x 35 x 37
POWER: Power backup	2000 watts Cache battery	3500 watts Cache battery	.4 KVA None	4600 watts None**	4600 watts None**
FIRST CUSTOMER SHIPMENT	2Q93	2Q93	8/92	4/92	4/92
COMMENTS	*Proprietary mode	*Proprietary mode	Mfg. by Formation	*RAID 5 plus synch. spindles dual parity **Dual AC feed	*RAID 5 plus synch. spindles dual parity **Dual AC feed

MANUFACTURER	MICRONET TECHNOLOGY	MICRONET TECHNOLOGY	MICRONET TECHNOLOGY	MICRONET TECHNOLOGY	MICROPOLIS
ARRAY MODEL	Micro Mirror	Rapid Access	Raven 30	Raven 40	RAIDION 680
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Macintosh	PC 386, 486 DOS	Macintosh	Macintosh Quadra 900/950	SCSI host NetWare
RAID level Configured by:	1 Preset	1 Preset	1 Preset	1 Preset	1/5
Array capacity (Gbytes) MIN MAX	.48 5.56	1.06 77.8	.642 4.060	.642 5.560	.340, .680 10.54
Minimum drives per array	2	2	2	2	2, 3
Maximum drives per array	2	28	2	2	32
Concurrent host channels	1	4	2	2	1, 4
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Cache size (min, max: MB)	N/A	N/A	N/A	N/A	.256 per drive
Cache function (Read, Write)	N/A	N/A	N/A	N/A	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes Yes	Yes Yes Yes	Yes Yes Yes	No Yes Yes	Yes-duplexing Yes-per drive Yes per drive
Spare drive (None/Auto/Manual)	Manual-foregrnd	Manual-backgrnd	None	None	Auto*
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	No
Transfer rate: host (MB/Sec) drive (MB/Sec)	4 2.2, 4.8	4.8, 10 2.2, 4.8	3.8, 4.4 .68, .72	4.0, 9.2 .68, 1.5	4 15
DRIVES: Formatted capacity/drive(MB)	240, 2780	530, 2780	321, 2030	321, 2780	340
Nominal disk diameter, height	3.5", 5.25"	3.5", 5.25"	3.5", 5.25"	3.5", 5.25"	5.25"
Average positioning time (msec)	8, 15	8, 14	5.7, 7	4, 7.5	15
Average rotational delay (msec)	4.8, 6.8	4.8, 6.8	4.8, 8.3	4.8, 8.3	8.3
Drive models	Various	Various	Various	Various	RM 340
ARRAY SIZE: Inches: H x W x D	6.5 x 7.75 x 12*	6.5 x 7.75 x 12*	6.5 x 7.75 x 12*	4.5 x 5 x 9.25*	5.5 x 11 x 13.8**
POWER: Power backup	105 watts None	100, 300 watts None	105, 210 watts None	300 watts None	50 watts/drive None
FIRST CUSTOMER SHIPMENT	3/90	10/91	3/90	11/91	11/91
COMMENTS	*Size may vary depending upon drives supplied	*Size may vary depending upon drives supplied	*Size may vary depending upon drives supplied	*Size may vary depending upon drives supplied	*Optional online spare **Per module

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
ARRAY MODEL	RAIDION 1340	RAIDION 2060	RAIDION 2680	RAIDION 3500	RAIDION 4200
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	PCM	PCM	PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	SCSI host NetWare	SCSI host NetWare	SCSI host NetWare	SCSI host NetWare	SCSI host NetWare
RAID level Configured by:	1/5	1/5	1/5	1/5	1/5
Array capacity (Gbytes) MIN MAX	.670, 1.340 20.77	1.030, 2.060 31.93	1.340, 2.860 41.54	1.750, 3.500 54.25	2.100, 4.200 65.10
Minimum drives per array	2, 3	2, 3	2, 3	2, 3	2, 3
Maximum drives per array	32	32	32	32	32
Concurrent host channels	1, 4	1, 4	1, 4	1, 4	1, 4
Array interface to host	SCSI	SCSI	SCSI	SCSI	SCSI
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256 per drive	.256 per drive	.256 per drive	.256 per drive	.512 per drive
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes-duplexing Yes-per drive Yes per drive	Yes-duplexing Yes-per drive Yes per drive	Yes-duplexing Yes-per drive Yes per drive	Yes-duplexing Yes-per drive Yes per drive	Yes-duplexing Yes-per drive Yes per drive
Spare drive (None/Auto/Manual)	Auto*	Auto*	Auto*	Auto*	Auto*
ARRAY PERFORMANCE: Boot from array?	No	No	No	No	No
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 20-32	 20	10 23	10 24-38	10 32-40
DRIVES: Formatted capacity/drive(MB)	667	1036	1341	1750	2100
Nominal disk diameter, height	5.25"	5.25"	5.25"	5.25"	5.25"
Average positioning time (msec)	16	14.5	14.5	14.5	10
Average rotational delay (msec)	8.3	8.3	8.3	8.3	5.6
Drive models	RM 670	RM 1030	RM 1340	RM 1750	RM 2100
ARRAY SIZE: Inches: H x W x D	5.5 x 11 x 13.8**	5.5 x 11 x 13.8**	5.5 x 11 x 13.8**	5.5 x 11 x 13.8**	5.5 x 11 x 13.8**
POWER: Power backup	50 watts/drive None	50 watts/drive None	50 watts/drive None	50 watts/drive None	50 watts/drive None
FIRST CUSTOMER SHIPMENT	11/91	11/91	11/91	4/92	10/92
COMMENTS	*Optional online spare **Per module	*Optional online spare **Per module	*Optional online spare **Per module	*Optional online spare **Per module	*Optional online spare **Per module

MANUFACTURER	MICROPOLIS	MORSE TECHNOLOGY	MYLEX	MYLEX	MYLEX
ARRAY MODEL	RAIDION LT	KP 8050	DAC-960-1/2	DAC-960-3	DAC-960-5
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	OEM, PCM	OEM	OEM	OEM
ARRAY CONFIGURATION: Type	Subsystem	Board	Board	Board	Board
Host platform, software environment	SCSI host NetWare, OS/2	PC compatible NetWare	PC compatible NetWare, OS/2 SCO UNIX 3.24	PC compatible NetWare, OS/2 SCO UNIX 3.24	PC compatible NetWare, OS/2 SCO UNIX 3.24
RAID level Configured by:	0/1/5 Host	1 Preset	0/1/5/6*/7* Host	0/1/5/6*/7* Host	0/1/5/6*/7* Host
Array capacity (Gbytes) MIN MAX	.5 28	1 4	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	2	2	2	2	2
Maximum drives per array	28	8	7/14	21	20
Concurrent host channels	1, 4	1, 2	1, 2	1	1
Array interface to host	SCSI	EISA	EISA	EISA	EISA
Drive interface	SCSI-2	IDE	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.512 per drive	.064, .512	4, 64	4, 64	4, 64
Cache function (Read, Write)	Read, Write	Read	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes-duplexing Yes-per drive Yes per drive	No No No	Yes-up to 4 Yes-per drive Yes-per drive	Yes-up to 4 Yes-per drive Yes-per drive	Yes-up to 4 Yes-per drive Yes-per drive
Spare drive (None/Auto/Manual)	Auto*	Manual-backgrnd	Auto-backgrnd	Auto-backgrnd	Auto-backgrnd
ARRAY PERFORMANCE: Boot from array?	No	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 10	22 Drive dependent	33 20	33 20	33 20
DRIVES: Formatted capacity/drive(MB)	560-1050	543	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	3.5", 41.3 mm	5.25"	3.5", 5.25"	3.5", 5.25"	3.5", 5.25"
Average positioning time (msec)	10	12	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	5.6	6.7	Drive dependent	Drive dependent	Drive dependent
Drive models	Micropolis	Various	Hewlett-Packard Seagate,Fujitsu	Hewlett-Packard Seagate,Fujitsu	Hewlett-Packard Seagate,Fujitsu
ARRAY SIZE: Inches: H x W x D	2.2 x 8.4 x 9.9	11.25 x 4.25	4.25 x 10	4.25 x 10	4.25 x 10
POWER: Power backup	50 watts/drive None	10 watts None	50 watts+drives None	50 watts+drives None	50 watts+drives None
FIRST CUSTOMER SHIPMENT	1993	12/92	1/93	1/93	5/92
COMMENTS	*Optional online spare	Requires NetWare V3.11	*RAID 6,7 is combined RAID 1,0	*RAID 6,7 is combined RAID 1,0	*RAID 6,7 is combined RAID 1,0

MANUFACTURER	MYLEX	NCR	NCR	NCR	NCR
ARRAY MODEL	IDA S 2000	6292-4000	6298-2000	6298-3000	ADP-92-01
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	Captive, OEM	Captive, OEM	Captive, OEM	Captive,OEM,PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Board
Host platform, software environment	PC compatible NetWare, OS/2 SCO UNIX 3.24	NCR 3300, 3400 UNIX, NetWare	NCR 3400, 3500, other UNIX	NCR 3400, 3500, other UNIX	Various UNIX, OS/2, NetWare
RAID level Configured by:	0/1/5/6*/7* Host	0/1/5 Host	0/1/3/5 Host	0/1/3/5 Host	0/1/3/5 Host
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	2.1/1.05/1.7 2.1/1.05/1.7	2.1/1.1/1.7/1.7 8.5/4.3/6.8/6.8	5.2/2.6/4.2/4.2 21/12/16.8/16.8	Drive dependent Drive dependent
Minimum drives per array	2	5	5	5	1/2/3/3
Maximum drives per array	21	5	20	20	35
Concurrent host channels	1	1	1	1	1
Array interface to host	EISA	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI	SCSI, SCSI-2	SCSI, SCSI-2	SCSI-2
Cache size (min, max: MB)	4, 64	--	--	--	--
Cache function (Read, Write)	Read, Write	--	--	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	No No No	Yes Yes Yes	Yes Yes Yes	Yes No No
Spare drive (None/Auto/Manual)	Auto-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	Yes	No	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	33 20	10 5	20 5	20 10	10 5
DRIVES: Formatted capacity/drive(MB)	Drive dependent	426	426	1050	Drive dependent
Nominal disk diameter, height	3.5", 5.25"	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	Drive dependent
Average positioning time (msec)	Drive dependent	14.6	14.6	10.5	Drive dependent
Average rotational delay (msec)	Drive dependent	6.8	6.8	5.6	Drive dependent
Drive models	Hewlett-Packard Seagate,Fujitsu	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	30.5 x 13 x 22	13.75 x 7.25 x 16.6	29 x 12 x 28	29 x 12 x 28	5.1 x 14.4
POWER: Power backup	400 watts None	115 watts None	618 watts None	618 watts None	15 watts None
FIRST CUSTOMER SHIPMENT	1/93	1991	1992	1992	1991
COMMENTS	*RAID 6,7 is combined RAID 1,0. 486 DX-2/66. Disk array server.	ADP-92-01 controller	ADP-92-02 controller	ADP-92-02 controller	Uses 25 MHz 68020 chip

MANUFACTURER	NCR	NCR	NCR	NCR	NCR
ARRAY MODEL	ADP-92-02	ADP-92-06	ADP-93-01	ADP-93-02	ADP-93-04
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive,OEM,PCM	OEM, PCM	OEM, PCM	Captive,OEM,PCM	OEM
ARRAY CONFIGURATION: Type	Board	Board	Board	Board	Board
Host platform, software environment	Various UNIX, OS/2, NetWare	Various UNIX, OS/2, AIX NetWare	Various UNIX, OS/2, AIX NetWare	Various UNIX, OS/2, AIX NetWare	Various UNIX, OS/2, AIX NetWare
RAID level Configured by:	0/1/3/5 Host	0/1/3/5 Host	0/1/3/5 Host	0/1/3/5 Host	0/1/3/5 Host
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	1/2/3/3	1/2/3/3	1/2/3/3	1/2/3/3	1/2/3/3
Maximum drives per array	35	35	35	35	35
Concurrent host channels	1	1	1	1	1
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	--	--	--	--	--
Cache function (Read, Write)	--	--	--	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Supported Supported	Yes No No	Yes No No	Yes Supported Supported	Yes No No
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	20 5	20 5	20 10	20 10	20 10
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	9.8 x 13.7	4.8 x 14.4	5.1 x 14.4	9.75 x 8.5	5.1 x 14.4
POWER: Power backup	15 watts None	15 watts None	30 watts None	30 watts None	30 watts None
FIRST CUSTOMER SHIPMENT	1992	1992	1993	1992	1993
COMMENTS	Uses 25 MHz 68020 chip	Uses 25 MHz 68020 chip ISA/EISA form factor	Uses 40 MHz 68030 chip Multiple SCSI initiator support	Uses 40 MHz 68030 chip Multiple SCSI initiator support	Uses 40 MHz 68030 chip Multiple SCSI initiator support

MANUFACTURER	NCR	NEC	NEC	NEC	NEC
ARRAY MODEL	Disk Array Plus	N1137-32	N1137-33	N1137-34	N7759-89
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive,OEM,PCM	Captive	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Software	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	NCR 3xxx:UNIX AT&T Starserver Various:NetWare	OPA A-VX	OPA A-VX	OPA A-VX	UP4800 UNIX
RAID level Configured by:	0/1/5 Host	3 Preset	3 Preset	3 Preset	3 Preset
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	.7 .7	1.3 1.3	1.7 1.7	1.7 1.7
Minimum drives per array	N/A	5	5	5	5
Maximum drives per array	N/A	5	5	5	5
Concurrent host channels	1, 2	1	1	1	1
Array interface to host	N/A	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	Host dependent	--	--	--	--
Cache function (Read, Write)	Read	--	--	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	N/A N/A N/A	-- -- --	-- -- --	-- -- --	-- -- --
Spare drive (None/Auto/Manual)	Manual-backgrnd	None	None	None	None
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	No
Transfer rate: host (MB/Sec) drive (MB/Sec)	Host dependent Drive dependent	5 5	5 5	5 5	5 5
DRIVES: Formatted capacity/drive(MB)	Drive dependent	165	331	425	425
Nominal disk diameter, height	Drive dependent	3.5", 25.4 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	Drive dependent	16.5	14	14	14
Average rotational delay (msec)	Drive dependent	8.3	8.3	8.3	8.3
Drive models	Various	D3865	D3872	D3881	D3881
ARRAY SIZE: Inches: H x W x D	N/A	17.8 x 7.7 x 14.5	17.8 x 7.7 x 14.5	17.8 x 7.7 x 14.5	27.6 x 13.6 x 30
POWER: Power backup	N/A	-- --	-- --	-- --	-- --
FIRST CUSTOMER SHIPMENT	6/92	2Q92	2Q92	2Q92	4Q92
COMMENTS	Online tuning. Single volume. Can span multiple drives and adapters				

MANUFACTURER	NEC	NETFRAME	NETFRAME	NORTHGATE COMPUTER SYSTEMS	NORTHGATE COMPUTER SYSTEMS
ARRAY MODEL	OP-450-5103 SCSI Mirroring Module	NF250 FT	NF450 FT	External Disk Array	Internal Disk Array
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	OEM, PCM	OEM, PCM	Captive	Captive
ARRAY CONFIGURATION: Type	Board	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	EISA PC	NetFRAME Sun, NetWare, UNIX, OS/2	NetFRAME Sun, NetWare, UNIX, OS/2	Northgate DOS, OS/2, UNIX NetWare	Northgate DOS, OS/2, UNIX NetWare
RAID level Configured by:	1 Preset	0/1 Host	0/1 Host	0/1/5	0/1/5
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	3.2/1.6 33.6/16.8	3.2/1.6 88.6/44.3	.400 60	.400 10
Minimum drives per array	2	2	2	1	1
Maximum drives per array	6	20	56	5	10
Concurrent host channels	1	1, 3	1, 8	1	1
Array interface to host	EISA	NetFRAME	NetFRAME	SCSI-2	SCSI-2
Drive interface	SCSI	SCSI-2	SCSI-2	SCSI	SCSI
Cache size (min, max: MB)	4, 16	1, 3	1,8	16, 64	16, 64
Cache function (Read, Write)	Read, Write	Read	Read	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	-- -- --	Duplexing Yes No	Duplexing Yes Yes	No No Yes	No No Yes
Spare drive (None/Auto/Manual)	--	Manual-backgrnd	Manual-backgrnd	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?		Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	33 10	12.5 5	12.5 5	33 Drive dependent	33 Drive dependent
DRIVES: Formatted capacity/drive(MB)	Drive dependent	1300	1300	400 to 3400	400 to 3400
Nominal disk diameter, height	3.5", 5.25"	5.25", 82.6 mm	5.25", 82.6 mm	3.5", 5.25"	3.5", 41.3 mm
Average positioning time (msec)	Drive dependent	13.5	13.5	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	8.3	8.3	Drive dependent	Drive dependent
Drive models	Varies	Hitachi DK516C H-P*	Hitachi DK516C H-P*	Various	Various
ARRAY SIZE: Inches: H x W x D	EISA standard	26 x 19 x 19	42 x 19 x 19		
POWER: Power backup	-- --	500 watts None	1500 watts None	Varies None	Varies None
FIRST CUSTOMER SHIPMENT	6/92	2/92	2/92	1992	1992
COMMENTS	Requires EISA SCSI host adapter OP-450-6301	*Optional drives 200 MB-1.6 GB Requires Novell software	*Optional drives 200 MB-1.6 GB Requires Novell software	Mylex controller	Mylex controller

MANUFACTURER	PACIFIC MICRO DATA	PERCEPTIVE SOLUTIONS	PERCEPTIVE SOLUTIONS	PERIPHERAL LAND, INC.	PERIPHERAL LAND, INC.
ARRAY MODEL	MAST VII	dataSHADOW	Prism	MiniArray	MiniArray 040
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Single User	Single User
MARKET	OEM	OEM, PCM	OEM, PCM	PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Board	Subsystem	Subsystem	Subsystem
Host platform, software environment	ISA, EISA, MCA NetWare, UNIX, DOS, OS/2, oth	PC compatible UNIX, PTPLANS	SCSI host	Macintosh NuBus	Macintosh Quad. (900/950)
RAID level Configured by:	0/1/3/5 *	1 Host	0/3/5 Host, Port	0/1	0/1
Array capacity (Gbytes) MIN MAX	1 9.6	Drive dependent Drive dependent	Drive dependent Drive dependent	.660 2, 6	.660 4.2
Minimum drives per array	3	2	2	2	2
Maximum drives per array	7	28	6	2	4
Concurrent host channels	1, 2	1	1, 2	1	1
Array interface to host	SCSI-2	ISA, EISA	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	ESDI, SCSI, IDE	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	4, 64	1, 16	4, 64	--	--
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes Yes	N/A N/A N/A	Option Yes Option	No No No	No No No
Spare drive (None/Auto/Manual)	*	Manual-backgrnd	Auto-background	Manual	Manual
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 Various	4-7 2-5	20 10	5	8.4
DRIVES: Formatted capacity/drive(MB)	525, 1600	Drive dependent	Drive dependent	330-2600	660-4200
Nominal disk diameter, height	3.5", 41.3 mm	Drive dependent	3.5"	3.5", 41.3 mm	3.5", 5.25"
Average positioning time (msec)	Various	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	Various	Drive dependent	Drive dependent	--	Drive dependent
Drive models	Various	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	20 x 14.5 x 12	N/A	11 x 7 x 9	Drive dependent	Drive dependent
POWER: Power backup	45 watts None	N/A None	150 watts None	Drive dependent --	Drive dependent --
FIRST CUSTOMER SHIPMENT	2/93	1Q90	4Q93	6/92	6/92
COMMENTS	*Depends on controller used Also sold without drives		Available without drives		

MANUFACTURER	PERIPHERAL LAND, INC.	PERIPHERAL LAND, INC.	PERIPHERAL LAND, INC.	PERIPHERAL LAND, INC.	PRECISION COMPUTERS
ARRAY MODEL	MiniArray FS	QuickArray	QuickSCSI	QuickSCSI FS	486-50 EISA
DISK/TREND GROUP	Single User	Single User	Single User	Single User	Net/Mini/Multi
MARKET	PCM	PCM	PCM	PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Board	Board	Subsystem
Host platform, software environment	Macintosh Quad. NuBus (700/900/950)	Macintosh PDS	Macintosh NuBus	Macintosh NuBus	NetWare, UNIX, DOS OS/2
RAID level Configured by:	0/1	0/1	0/1	0/1	0/1/4/5 Host
Array capacity (Gbytes) MIN MAX	1 4	4 11.2	Drive dependent 2	Drive dependent 2	2 4
Minimum drives per array	4	4	2	6	2
Maximum drives per array	4	4	6	1	5
Concurrent host channels	1	1	1	1	1
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	--	--	--	--	--
Cache function (Read, Write)	--	--	--	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	No No No	No No No	No No No	No Yes Option
Spare drive (None/Auto/Manual)	Manual	Manual	Manual	Manual	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10	16	7.5 Drive dependent	10 Drive dependent	20 10
DRIVES: Formatted capacity/drive(MB)	1000	1000	Drive dependent	Drive dependent	1052
Nominal disk diameter, height	3.5", 5.25"	3.5", 5.25"	Drive dependent	Drive dependent	3.5", 41.3 mm
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	10.5
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	5.56
Drive models	Various	Various	Various	Various	Hewlett-Packard
ARRAY SIZE: Inches: H x W x D	Drive dependent	Drive dependent			33.75 x 10.83 x 23.75
POWER: Power backup	Drive dependent --	Drive dependent --	Drive dependent --	Drive dependent --	225 watts None
FIRST CUSTOMER SHIPMENT	2Q93	3Q93	4/91	2Q93	11/92
COMMENTS					UltraStor controller

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	RAIDTEC	RAIDTEC	SANYO ICON
ARRAY MODEL	ISA SCSI Xelerator	LANforcer	FlexArray	FlexArray IX	MRX-100
DISK/TREND GROUP	Single User	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	PCM
ARRAY CONFIGURATION: Type	Board	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	PC compatible DOS, Windows, NetWare, OS/2	PC compatible DOS, Windows, NetWare, OS/2	NetWare, UNIX, Xenix, OS/2	IBM, Sun, Mac DOS, NetWare, OS/2, UNIX, DEC	SCSI host NetWare, UNIX, DOS, OS/2, Pick
RAID level Configured by:	0/1* Host	0/1* Host	0/1/3/5	0/1/3/5	0/1/5 Port
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	6/3 6/3	Drive dependent Drive dependent	Drive dependent Drive dependent	3.2 14.8
Minimum drives per array	2	6	2	2	2
Maximum drives per array	7	6	6	6	4
Concurrent host channels	1	1	1	1	1, 12
Array interface to host	SCSI, SCSI-2	SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2
Drive interface	SCSI, SCSI-2	SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI-2
Cache size (min, max: MB)	--	.256 per drive	--	--	32, 128
Cache function (Read, Write)	--	Read, Write	--	--	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	-- -- --	No Yes Yes	No Yes Yes	No Yes Yes	Yes No No
Spare drive (None/Auto/Manual)	Manual-foregrnd	Manual-foregrnd	Manual-backgrnd	Manual-backgrnd	Manual
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	No
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 10	10 10	10 Drive dependent	10 Drive dependent	10 2.75/3.03/4.8
DRIVES: Formatted capacity/drive(MB)	Drive dependent	1000	Drive dependent	Drive dependent	1320-2000
Nominal disk diameter, height	Drive dependent	3.5", 41.3 mm	3.5"	3.5"	5.25", 82.6 mm
Average positioning time (msec)	Drive dependent	12	Drive dependent	Drive dependent	12-14
Average rotational delay (msec)	Drive dependent	6.6	Drive dependent	Drive dependent	8.3-5.6
Drive models	Various	Seagate ST11200N	Various	Various	Hitachi
ARRAY SIZE: Inches: H x W x D	4.75 x 10.72 x 0.875	15.5 x 15.5 x 16	15.75 x 15.6 x 15.6	15.75 x 15.6 x 15.6	25.5 x 9 x 27
POWER: Power backup	3.8 watts None	0.3 KVA None	230 watts None	230 watts None	600 watts None
FIRST CUSTOMER SHIPMENT	12/92	4/93	3Q92	1Q93	10/92
COMMENTS	*Supports concurrent RAID 0 and RAID 1	*Supports concurrent RAID 0 and RAID 1			Expandable to 300 GB

MANUFACTURER	SANYO ICON	SANYO ICON	SANYO ICON	SEQUOIA SYSTEMS	SEQUOIA SYSTEMS
ARRAY MODEL	MRX-300	MRX-500	MRX-500FT	DS310	DS4003
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	PCM	PCM	Captive, OEM	Captive, OEM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	SCSI host NetWare, UNIX, DOS, OS/2, Pick	SCSI host NetWare, UNIX, DOS, OS/2, Pick	SCSI host NetWare, UNIX, DOS, OS/2, Pick	Sequoia series 400 Wilt Topix	Sequoia series 40 Wilt Topix
RAID level Configured by:	0/1/5 Port	0/1/5 Port	0/1/5 Port	1 Preset	1 Preset
Array capacity (Gbytes) MIN MAX	3.2 40.6	3.2 60.9	3.2 40.6	9 Drive dependent	8 Drive dependent
Minimum drives per array	2	2	2	2	2
Maximum drives per array	14	21	14	6	10
Concurrent host channels	1, 12	1, 12	1, 12	2	2
Array interface to host	SCSI, SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	VME	VME
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI	SCSI-2
Cache size (min, max: MB)	32, 128	32, 128	32, 128	1	4
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes No No	Yes No No	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
Spare drive (None/Auto/Manual)	Manual	Manual	Manual	Manual-backgrnd	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	No	No	No	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 2.75/3.03/4.8	10 2.75/3.03/4.8	10 2.75/3.03/4.8	5 4	20 10
DRIVES: Formatted capacity/drive(MB)	1320-2000	1320-2000	1320-2000	905	880
Nominal disk diameter, height	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm	5.25"	3.5"
Average positioning time (msec)	12-14	12-14	12-14	13	10
Average rotational delay (msec)	8.3-5.6	8.3-5.6	8.3-5.6	8.3	5.6
Drive models	Hitachi	Hitachi	Hitachi	Various	Various
ARRAY SIZE: Inches: H x W x D	38.5 x 25.5 x 35	54 x 25.5 x 35	54 x 25.5 x 35	10.5 x 19 x 30	8 x 19 x 24
POWER: Power backup	1440 watts None	1440 watts None	1440 watts None	500 watts Battery	300 watts Battery
FIRST CUSTOMER SHIPMENT	10/92	10/92	10/92	1989	1992
COMMENTS	Expandable to 300 GB	Expandable to 300 GB	Expandable to 300 GB		

MANUFACTURER	SILICON VALLEY COMPUTER	SOLID COMPUTER	SOLID COMPUTER	STORAGE COMPUTER	STORAGE COMPUTER
ARRAY MODEL	ADP 104 ADP 108 Goldcard II	WSR425	WSR805	CLx	D3x
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Board	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	PC AT, PS/2 DOS, UNIX	SCSI host NetWare, UNIX	SCSI host NetWare, UNIX	Most PC & UNIX networks, plus midrange syst.	Most PC & UNIX Networks, plus midrange syst.
RAID level Configured by:	0/1 Preset	0/1/3/5 Host	0/1/3/5 Host	"7" Preset	"7" Preset
Array capacity (Gbytes) MIN MAX	20 8000	5.3/2.7/4.2/4.2 5.3/2.7/4.2/4.2	10/5/8/8 10/5/8/8	2 189	2 23
Minimum drives per array	2	5	5	3	3
Maximum drives per array	4	5	5	48	12
Concurrent host channels	1	1	1	1 to 12	1 or 2
Array interface to host	16 bit ISA Bus	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	IDE	SCSI-2	SCSI-2	SCSI-1/2	SCSI-1/2
Cache size (min, max: MB)	.016, .032	--	--	16-256	1-64
Cache function (Read, Write)	Read	Read	Read	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	-- -- --	No No No	No No No	Yes Yes Yes	No Yes Yes
Spare drive (None/Auto/Manual)	Auto	Manual-backgrnd	Manual-backgrnd	Auto	Auto
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	3 max. 9 max.	10 10	10 10	10 or 20 Drive dependent	10 or 20 Drive dependent
DRIVES: Formatted capacity/drive(MB)	Drive dependent	1050	2000	Drive dependent	Drive dependent
Nominal disk diameter, height	Drive dependent	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 5.25"	3.5", 5.25"
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Any IDE drives	Fujitsu Seagate	Fujitsu Seagate	Various	Various
ARRAY SIZE: Inches: H x W x D	Requires 2 3.5" x 1.5" slots	16 x 9 x 17	16 x 9 x 17	14 x 16.5 x 15.5	14 x 16.5 x 15.5
POWER: Power backup	-- None	-- None	-- None	2160 KVA --	1440 KVA --
FIRST CUSTOMER SHIPMENT	9/92	1992	1992	4Q92	2Q92
COMMENTS		Digi-Data controller	Digi-Data controller	UPS required	UPS required

MANUFACTURER	STORAGE COMPUTER	STORAGE COMPUTER	STORAGE COMPUTER	STORAGE CONCEPTS	STORAGE CONCEPTS
ARRAY MODEL	D5x	R3x	R5x	Concept 51-S	Concept 550
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Most PC & UNIX networks, plus midrange syst.	Most PC & UNIX networks, plus midrange syst.	Most PC & UNIX networks, plus midrange syst.	RS/6000, Sun AIX, VME UNIX,	SCSI host Various
RAID level Configured by:	"7" Preset	"7" Preset	"7" Preset	3 Host, Preset	3 Host
Array capacity (Gbytes) MIN MAX	2 44	2 36	2 68	3 48	1.5 6
Minimum drives per array	3	3	3	2	2
Maximum drives per array	12	18	18	36	8
Concurrent host channels	1, 2	1 to 4	1 to 4	2	1
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-1/2	SCSI-1/2	SCSI-1/2	ESDI	ESDI
Cache size (min, max: MB)	1-64	4-256	4-256	.25, 1	None
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	None
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes Yes	No Yes Yes	No Yes Yes	No No No	No No No
Spare drive (None/Auto/Manual)	Auto	Auto	Auto	No	No
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	No	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 or 20 Drive dependent	10 or 20 Drive dependent	10 or 20 Drive dependent	18.24 2.75	10 3
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	Drive dependent	1320	1320
Nominal disk diameter, height	3.5", 5.25"	3.5", 5.25"	3.5", 5.25"	5.25", 82.6 mm	5.25", 82.6 mm
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	14	14
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	8.3	8.3
Drive models	Various	Various	Various	Hitachi DK516-15	Hitachi DK516-15
ARRAY SIZE: Inches: H x W x D	14 x 16.5 x 15.5	14 x 19 x 28.5	14 x 19 x 28.5	8.75 x 19 x 30	28.5 x 11.25 x 30
POWER: Power backup	1440 KVA --	2160 KVA --	2160 KVA --	800 watts None	450 watts None
FIRST CUSTOMER SHIPMENT	2Q92	1Q92	1Q92	3/92	2/91
COMMENTS	UPS required	UPS required	UPS required		Rack mount or desk side tower

MANUFACTURER	STORAGE CONCEPTS	STORAGE CONCEPTS	STORAGE CONCEPTS	STORAGE CONCEPTS	STORAGE DIMENSIONS
ARRAY MODEL	Concept 51	Concept 151	Concept 510	Concept 71 FCS	SA1-1000F2 SA2-2000F4
DISK/TREND GROUP	Net/Mini/Multi	Very High Perf.	Very High Perf.	Very High Perf.	Single User
MARKET	OEM, PCM	OEM	OEM	OEM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	DEC, Sun, PC VMS, VME UNIX, DOS	VME Bus, PC-AT Proprietary	VME Bus, Q-Bus, PC-AT Proprietary	Any fiber channel host Proprietary	Macintosh
RAID level Configured by:	3 Host, Preset	0/3 Host	3 Host	0/3 Host	0
Array capacity (Gbytes) MIN MAX	3 108	35.6 324	3 7.5	12 96	1 2
Minimum drives per array	2	18	2	5	2*
Maximum drives per array	72	27	5	48	7
Concurrent host channels	2	2	2	1	1
Array interface to host	Proprietary	Proprietary	Proprietary	FSC, IPI-3	SCSI-2
Drive interface	ESDI	ESDI	ESDI	IPI-2	SCSI-2
Cache size (min, max: MB)	.25, 1	2.3, 3.5	.25, 1	1, 4	--
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read, Write	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	No No No	No No No	Yes Yes Yes	No No No
Spare drive (None/Auto/Manual)	No	No	No	No	None
ARRAY PERFORMANCE: Boot from array?	No	No	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	20 2.75	20 2.75	12 3	100 5.22	10 10
DRIVES: Formatted capacity/drive(MB)	1320	1320	760	1760	500
Nominal disk diameter, height	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	14	14	Drive dependent	12	14
Average rotational delay (msec)	8.3	8.3	Drive dependent	5.58	6.8
Drive models	Hitachi DK516-15	Hitachi DK516-15	Various	IBM	DEC DSP3105
ARRAY SIZE: Inches: H x W x D	8.75 x 19 x 30	30.5 x 19 x 30	5.25 x 19 x 27	7 x 19 x 19.5	5.5 x 7.6 x 14.4
POWER: Power backup	800 watts None	2400 watts None	Drive dependent None	Drive dependent Cache battery	250 watts
FIRST CUSTOMER SHIPMENT	4/89	7/92	1/91	4/93	1993
COMMENTS					*4 for 2000F4

MANUFACTURER	STORAGE DIMENSIONS	STORAGE DIMENSIONS	STORAGE DIMENSIONS	STORAGE DIMENSIONS	STORAGE DIMENSIONS
ARRAY MODEL	SA1-2000F2 SA2-4000F4	SA2-2610F2 SA4-5220F4	SA2-4060F2 SA4-8120F4	SA2-5600F2 SA4-11200F4	SA2-5600W2 SA2-11200W4
DISK/TREND GROUP	Single User	Single User	Single User	Single User	Single User
MARKET	PCM	PCM	PCM	PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Macintosh	Macintosh	Macintosh	Macintosh	Macintosh
RAID level Configured by:	0	0	0	0	0
Array capacity (Gbytes) MIN MAX	2 4	2.6 5.2	4.06 8.12	5.6 11.2	5.6 11.2
Minimum drives per array	2*	2*	2*	2*	2*
Maximum drives per array	7	7	7	7	15
Concurrent host channels	1	1	1	1	1
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	--	--	--	--	--
Cache function (Read, Write)	--	--	--	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	No No No	No No No	No No No	No No No
Spare drive (None/Auto/Manual)	None	None	None	None	None
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 10	10 10	10 10	10 10	20 10
DRIVES: Formatted capacity/drive(MB)	1000	1305	2030	2800	2800
Nominal disk diameter, height	3.5", 41.3 mm	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm	5.25", 82.6 mm
Average positioning time (msec)	10	11.5	11	11	11
Average rotational delay (msec)	5.6	5.56	5.56	5.56	5.56
Drive models	DEC DSP3105	Seagate Elite 1	Seagate Elite 2	Seagate Elite 3	Seagate Elite 3
ARRAY SIZE: Inches: H x W x D	5.5 x 7.6 x 14.4	5.5 x 15.4 x 14.4	5.5 x 15.4 x 14.4	5.5 x 7.6 x 14.4	5.5 x 15.4 x 14.4
POWER: Power backup	250 watts	250 watts	250 watts	250 watts	250 watts
FIRST CUSTOMER SHIPMENT	1993	1993	1993	1992	1992
COMMENTS	*4 for 4000F4	*4 for 5220F4	*4 for 8120F4	*4 for 11200F4	*4 for 11200W4

MANUFACTURER	STORAGE DIMENSIONS	STORAGE DIMENSIONS	STORAGE DIMENSIONS	STORAGE SOLUTIONS	STORAGE SOLUTIONS
ARRAY MODEL	LANStor-CDA-02	LANStor-CDA-04	LANStor-CDA-06	CM-01 (1000) CM-01 (2000) CM-01 (8000)	CM-02 (1000) CM-02 (2000) CM-02 (8000)
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	PC compatible NetWare	PC compatible NetWare	PC compatible NetWare	EISA, MCA NetWare, OS/2	Various
RAID level Configured by:	0/5 Host	0/5 Host	0/5 Host	0/5	0/5
Array capacity (Gbytes) MIN MAX	2.1 2.6	4.2 5.25	6.4 8	2.1/1.6 10/8	2.1/1.6 10/8
Minimum drives per array	5	5	5	3	3
Maximum drives per array	5 + spare*	5 + spare*	5 + spare*	5	5
Concurrent host channels	1	1	1	1	1
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	1	1	1	2.5, 2.5	2.5, 2.5
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	Read	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes Yes	No Yes Yes	No Yes Yes	No No Yes	No No Yes
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd	Manual-backgrnd
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 5	10 5	10 5	10 5	20 10
DRIVES: Formatted capacity/drive(MB)	525	1050	1600	Drive dependent	Drive dependent
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm
Average positioning time (msec)	14	10.5	10	Drive dependent	Drive dependent
Average rotational delay (msec)	6.8	5.56	5.56	Drive dependent	Drive dependent
Drive models	Seagate ST1581N	Seagate ST11200N	DEC DSP3160	Drive dependent	Drive dependent
ARRAY SIZE: Inches: H x W x D	7 x 17 x 21	7 x 17 x 21	7 x 17 x 21	18.3 x 8.1 x 14.5	18.3 x 8.1 x 14.5
POWER: Power backup	250 watts None	250 watts None	250 watts None	245 watts None	245 watts None
FIRST CUSTOMER SHIPMENT	1992	1992	1993	6/92	1/93
COMMENTS	NCR controller *Nonoperating spare	NCR controller *Nonoperating spare	NCR controller *Nonoperating spare		

MANUFACTURER	STORAGE TECHNOLOGY	STORAGE TECHNOLOGY	STRATUS COMPUTER	SUN MICROSYSTEMS	SYSTEM INDUSTRIES
ARRAY MODEL	Alpine 9600	Iceberg 9200	D600 (K121)	Online: DiskSuite 1.0	318
DISK/TREND GROUP	Net/Mini/Multi	Mainframe	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	PCM	Captive	Captive	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Software	Subsystem
Host platform, software environment	AS/400 OS/400	IBM mainframe MVS/XA-ESA, VM/XA-ESA	Stratus VOS/FTX	Sun SPARC Solaris	DEC, Sun Various UNIX
RAID level Configured by:	5 Panel	5+	1 Preset	0/1 Host	3 RS232C port
Array capacity (Gbytes) MIN MAX	10.2 25.7	100* 400*	.319 Varies by syst.	Drive dependent Drive dependent	1.8 12.6
Minimum drives per array	10	32	2	2	4 + parity
Maximum drives per array	24	128/string	Varies by syst.	128	28 + parity
Concurrent host channels	4	12	2, 10	--	1
Array interface to host	IPI	IBM	Proprietary	--	SCSI-2
Drive interface	SCSI	ESDI	SCSI	--	SCSI-2
Cache size (min, max: MB)	0	64, 512		--	16, 64
Cache function (Read, Write)	0	Read, Write		--	Read, Write*
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Option -- --	Option Yes Yes (hot fix)
Spare drive (None/Auto/Manual)	Auto	Auto	Manual-backgrnd	Auto-background	None
ARRAY PERFORMANCE: Boot from array?	--	--		Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	Host dependent 5	4.5 2.8*	5 Drive dependent	Drive dependent Drive dependent	10 5
DRIVES: Formatted capacity/drive(MB)	1342	1450	319/665/1460	Drive dependent	450
Nominal disk diameter, height	5.25", 82.6 mm	5.25", 82.6 mm	5.25"	Drive dependent	3.5", 41.3 mm
Average positioning time (msec)	13.5		Drive dependent	Drive dependent	10-14
Average rotational delay (msec)	7.5		Drive dependent	Drive dependent	5.5-8.3
Drive models	H-P C3005	H-P Coyote III	D602, D603, D604	Various	Various
ARRAY SIZE: Inches: H x W x D	62.1 x 32 x 36.3	72.0 x 27.7 x 32.0	Varies	--	7 x 17 x 25
POWER: Power backup	2.6 KVA Battery	3.3 KVA	Drive dependent None	-- --	150 watts Internal UPS
FIRST CUSTOMER SHIPMENT	9/92	1993	3/91	9/91	12/91
COMMENTS	Mfg. by Array Technology	*Assumes 2.6x data compression			*Write back cache

MANUFACTURER	SYSTEM INDUSTRIES	SYSTEM INDUSTRIES	SYSTEM INDUSTRIES	SYSTEM INDUSTRIES	SYSTEM INDUSTRIES
ARRAY MODEL	333	341	344	360	eaSIshadow
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	PCM	PCM	PCM	PCM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Software
Host platform, software environment	DEC, Sun Various UNIX	DEC, Sun Various UNIX	DEC, Sun Various UNIX	DEC, Sun Various UNIX	DEC VAX VMS
RAID level Configured by:	3 RS232C port	3 RS232C port	3 RS232C port	3 RS232C port	1 Host
Array capacity (Gbytes) MIN MAX	3.3 23.1	4.1 28.7	4.4 30.8	6 42	Drive dependent Drive dependent
Minimum drives per array	4 + parity	4 + parity	4 + parity	4 + parity	2
Maximum drives per array	28 + parity	28 + parity	28 + parity	28 + parity	--
Concurrent host channels	1	1	1	1	--
Array interface to host	SCSI-2	SCSI-2	SCSI-2	SCSI-2	--
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	--
Cache size (min, max: MB)	16, 64	16, 64	16, 64	16, 64	--
Cache function (Read, Write)	Read, Write*	Read, Write*	Read, Write*	Read, Write*	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Option Yes Yes (hot fix)	Option Yes Yes (hot fix)	Option Yes Yes (hot fix)	Option Yes Yes (hot fix)	Yes -- --
Spare drive (None/Auto/Manual)	None	None	None	None	None
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	No
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 5	10 5	10 5	10 5	-- --
DRIVES: Formatted capacity/drive(MB)	825	1025	1100	1500	Drive dependent
Nominal disk diameter, height	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	3.5", 41.3 mm	Drive dependent
Average positioning time (msec)	10-14	10-14	10-14	10-14	Drive dependent
Average rotational delay (msec)	5.5-8.3	5.5-8.3	5.5-8.3	5.5-8.3	Drive dependent
Drive models	Various	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	7 x 17 x 25	7 x 17 x 25	7 x 17 x 25	7 x 17 x 25	--
POWER: Power backup	150 watts Internal UPS	150 watts Internal UPS	150 watts Internal UPS	150 watts Internal UPS	--
FIRST CUSTOMER SHIPMENT	8/92	10/92	2/93	3Q93	1989
COMMENTS	*Write back cache	*Write back cache	*Write back cache	*Write back cache	

MANUFACTURER	TANDEM COMPUTERS	TANGENT COMPUTER	TANGENT COMPUTER	TANGENT COMPUTER	THINKING MACHINES
ARRAY MODEL	4500	Multiserver-2	Driveserver-2	Raid5server	CM-5 Scalable Disk Array
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Very High Perf.
MARKET	Captive	Captive, PCM	Captive, PCM	Captive, PCM	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	Tandem Nonstop	Tangent NetWare, UNIX, OS/2, NT, Other	Tangent NetWare, UNIX, OS/2, NT, Other	Tangent NetWare, UNIX, OS/2, NT, Other	CM-5 systems UNIX NFS
RAID level Configured by:	1 Host	0/1/"6" Host	0/1/"6" Host	0/1/4/5 Host	3 Host
Array capacity (Gbytes) MIN MAX	2 6	Drive Dependent	Drive Dependent	Drive Dependent	7.2 3238.0
Minimum drives per array	2	2	2	1	8
Maximum drives per array	6	10	10	35	3072
Concurrent host channels	2	1,4	1,4	1	384
Array interface to host	SCSI over fiber	EISA	EISA	EISA	Proprietary(NI)
Drive interface	SCSI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	0, 56	.512, 16	.512, 16	--	3, 1536
Cache function (Read, Write)	Read, Write	Read, Write	Read, Write	--	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	Duplexing Option Option	Duplexing Option Option	Option Option Option	Optional Optional Optional
Spare drive (None/Auto/Manual)	Auto-background	Manual-backgrnd	Manual-backgrnd	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	1900 2400	33 10	33 10	33 10	4224 10
DRIVES: Formatted capacity/drive(MB)	1000	Drive dependent	Drive dependent	Drive dependent	1200
Nominal disk diameter, height	5.25", 82.6 mm	3.5", 5.25"	3.5", 5.25"	3.5", 5.25"	3.5", 41.3 mm
Average positioning time (msec)	15	Drive dependent	Drive dependent	Drive dependent	9.4
Average rotational delay (msec)	8.3	Drive dependent	Drive dependent	Drive dependent	7
Drive models	Various	Seagate	Seagate	Seagate	IBM Corsair IIE
ARRAY SIZE: Inches: H x W x D	10.5 x 25 x 36	Varies	Varies	Varies	
POWER: Power backup	180 watts Dual AC	None	None	None	Varies
FIRST CUSTOMER SHIPMENT	4Q91	1993	1993	1993	10/92
COMMENTS			External mount version of Multiserver-2	UltraStor controller	Scalable

MANUFACTURER	TRANSOFT	TRANSOFT	TRICORD SYSTEMS	TWINCOM	TWINCOM
ARRAY MODEL	DataDock T1000	DataDock T2000	PowerRaid/ Enhanced IIOP	Dual Mirror	Multi Mirror
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM, PCM	Captive	OEM, PCM	OEM, PCM
ARRAY CONFIGURATION: Type	Board	Board	Board	Software	Software
Host platform, software environment	PC, Macintosh UNIX	PC, Macintosh UNIX	PowerFrame Sup. UNIX, OS/2, LAN Mgr,VINES,NetW.	Various Most UNIX versions	Various Most UNIX versions
RAID level Configured by:	0/1/3/5 Host	0/1/3/5 Host	0/1 Host	1 Preset	1 Preset
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	Drive dependent Drive dependent	0.425 42/21	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	5	20	2	2	2
Maximum drives per array	5	20	14	2	32
Concurrent host channels	1	1	--	1, 2	1, 4
Array interface to host	SCSI-2	SCSI-2	Proprietary	Host dependent	Host dependent
Drive interface	SCSI-2	SCSI-2	SCSI-2	Drive dependent	Drive dependent
Cache size (min, max: MB)	--		--	Host dependent	Host dependent
Cache function (Read, Write)	--		--	--	--
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No No No	Yes-up to 4 Yes Yes	Yes Yes Yes	-- -- --	-- -- --
Spare drive (None/Auto/Manual)	Manual-backgrnd	Manual-backgrnd	Auto-background	Auto/Manual	Auto/Manual
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	20 5	20 5	133 10	Host dependent Drive dependent	Host dependent Drive dependent
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	425-3000	Drive dependent	Drive dependent
Nominal disk diameter, height	Drive dependent	Drive dependent	3.5", 5.25"	Drive dependent	Drive dependent
Average positioning time (msec)	Drive dependent	Drive dependent	11	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	D400F, D1000F, D1700F, D3000H	Any supported by OS	Any supported by OS
ARRAY SIZE: Inches: H x W x D	14 x 7.5 x 16.5	28.5 x 12.5 x 28	--	--	--
POWER: Power backup	None	None	-- UPS	-- --	-- --
FIRST CUSTOMER SHIPMENT	4Q92	4Q92	6/92	1986	1989
COMMENTS	NCR ADP-92 controller	NCR ADP-92 controller	Board mounts on subsystem motherboard	Mirrors system disk	Mirrors multiple pairs

MANUFACTURER	TWINCOM	ULTRASTOR	ULTRASTOR	UNBOUND	UNBOUND
ARRAY MODEL	Network Mirror	124F	144F	MacRAID T-3	RAIDSTOR
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
ARRAY CONFIGURATION: Type	Software	Board	Board	Subsystem	Board
Host platform, software environment	Various Most UNIX versions	PC compatible UNIX, NetWare, OS/2, DOS	SCSI host UNIX, NetWare, OS/2, DOS	Mac Quadra	SCSI host
RAID level Configured by:	1 Preset	0/1/4/5 Host	0/1/3/4/5 Host	0/3/5 Host, Preset	0/3/5 Host, Preset
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	5 50	7.5 70
Minimum drives per array	2	1	1	5	5
Maximum drives per array	32	35	35	35	35
Concurrent host channels	1, 4	1	1	1, 5	1
Array interface to host	Host dependent	EISA Bus	SCSI-2	NuBus	SCSI-2
Drive interface	Drive dependent	SCSI, SCSI-2	SCSI, SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	Host dependent	--*	--*	8, 72	8, 72
Cache function (Read, Write)	--	--	--	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	-- -- --	No No No	No No No	No Yes Yes	No Yes Yes
Spare drive (None/Auto/Manual)	Auto/Manual	Auto-back.,fore	Auto-back.,fore	Auto-background	Auto-background
ARRAY PERFORMANCE: Boot from array?	Yes	Yes	Yes	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	Host dependent Drive dependent	33 max. 10 max.	20 max. 10 max.	10 Drive dependent	20 Drive dependent
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Any supported by OS	Various	Various	Various	Various
ARRAY SIZE: Inches: H x W x D	--	4.5 x 13	1.625 x 5.75 x 8	3.25 x 5.75 x 8	3.25 x 5.75 x 8
POWER: Power backup	-- --	15 watts	15 watts	25 watts*	25 watts None
FIRST CUSTOMER SHIPMENT	1992	2/92	12/92	8/92	4/92
COMMENTS	Mirrors over a network	*1 MB buffer	*1 MB buffer Supports command tag queing	Digi-Data controller *Plus drive power	Digi-Data controller

MANUFACTURER	UNBOUND	UNISYS	UNISYS	UNISYS	UNISYS
ARRAY MODEL	RAIDSTOR-T3	MasCab-2	QCIC/PBAY	M9740	M9760
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi	Mainframe	Mainframe
MARKET	OEM	Captive	Captive	Captive	Captive
ARRAY CONFIGURATION: Type	Subsystem	Subsystem	Subsystem	Subsystem	Subsystem
Host platform, software environment	SCSI host	Unisys UNIX	Unisys UNIX	Unisys 2200 1100 O/S	Unisys 2200 1100 O/S
RAID level Configured by:	0/3/5 Host, Preset	0/1 Host	0/1 Host	0/1 Host	0/1 Host
Array capacity (Gbytes) MIN MAX	7.5 70	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent
Minimum drives per array	5	2	2	4	4
Maximum drives per array	35	33	96	16	32
Concurrent host channels	1	5	16	2	4
Array interface to host	SCSI-2	EISA	Proprietary	EMCFIPS61	EMCFIPS61
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Cache size (min, max: MB)	8, 72	--	--	16, 64	128, 3072
Cache function (Read, Write)	Read, Write	--	--	Read, Write	Read, Write
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	No Yes Yes	Option No No	Option No No	Yes Yes Yes	Yes Yes Yes
Spare drive (None/Auto/Manual)	Auto-background	Manual	Manual	None	Auto-Option
ARRAY PERFORMANCE: Boot from array?	Yes	No	No	Yes	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	20 Drive dependent	10 10	10 10	4.5 3	4.5 5
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Nominal disk diameter, height	Drive dependent	3.5", 5.25"	3.5", 5.25"	8"	5.25"
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average rotational delay (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Hitachi	Various
ARRAY SIZE: Inches: H x W x D	3.25 x 5.75 x 8	26.5 x 12 x 17	22.75 x 19 x 30	52.5 x 20 x 30	22.75 x 20 x 30
POWER: Power backup	25 watts*	300 w. + drives None	500 watts None	400 w. + drives Cache battery	400 w. + drives Cache battery
FIRST CUSTOMER SHIPMENT	4/92	5/92	4/92	4Q90	2Q92
COMMENTS	Digi-Data controller *Plus drive power	Veritas software	Veritas software		

MANUFACTURER	UNISYS	UNITROL DATA PROTECTION SYSTEMS	VERITAS SOFTWARE	VORTEX SYSTEMS	WINCHESTER SYSTEMS
ARRAY MODEL	USR 4000	Immunity	VxVM	Mirror Plus	Flashdisk 2
DISK/TREND GROUP	Mainframe	Single User	Net/Mini/Multi	Net/Mini/Multi	Net/Mini/Multi
MARKET	Captive	PCM, OEM	OEM, PCM	OEM	PCM
ARRAY CONFIGURATION: Type	Subsystem	Software	Software	Board	Subsystem
Host platform, software environment	Unisys A,V,2200 series MCP, 051100	IBM PC Compat. PC/MS-DOS, most LANs, Windows	Various SCO UNIX, UNIX SVR4.X	Various OS/2, VINES	DEC, most workstations
RAID level Configured by:	0/1 Host	1 Preset	0/1 Host	1	1 Preset
Array capacity (Gbytes) MIN MAX	Drive dependent Drive dependent	Drive dependent Drive dependent	Drive dependent Drive dependent	.660 8	1 90
Minimum drives per array	5	2	--	2	2
Maximum drives per array	5	2	--	4	70
Concurrent host channels	2	1, 2	--	1	5
Array interface to host	SCSI	IDE, SCSI	Various	SCSI	SCSI-2
Drive interface	SCSI-2	IDE, SCSI	SCSI, ESDI, IDE	SCSI	ESDI
Cache size (min, max: MB)	--	1, host depend.	--	--	16, 560
Cache function (Read, Write)	--		--	--	Read
Redundancy: Controller (Yes/No) Fan (Yes/No) Power supply (Yes/No)	Yes Yes Yes	-- -- --	-- -- --	-- -- --	No Option Option
Spare drive (None/Auto/Manual)	Manual	Manual-foregrnd	Manual-backgrnd	Manual-backgrnd	Manual
ARRAY PERFORMANCE: Boot from array?	Yes	--	--	--	Yes
Transfer rate: host (MB/Sec) drive (MB/Sec)	10 10	-- Drive dependent	Drive dependent Drive dependent	20 Drive dependent	5 2.750
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent	Drive dependent	331-2000	1300
Nominal disk diameter, height	3.5", 5.25"	--	Drive dependent	Drive dependent	5.25", 82.6 mm
Average positioning time (msec)	Drive dependent	--	Drive dependent	Drive dependent	14
Average rotational delay (msec)	Drive dependent	--	Drive dependent	Drive dependent	8.3
Drive models	Various	Various	Drive dependent	Drive dependent	Varies
ARRAY SIZE: Inches: H x W x D	7 x 19 x 30	--	--		*
POWER: Power backup	400 watts None	-- --	-- --	-- --	100 UPS option
FIRST CUSTOMER SHIPMENT	1Q93	1990	1991	1992	6/92
COMMENTS		Error logging to good disk. Duplexing adapter avail. Network support	Can mirror logical disks Device driver independent		*Varies with tabletop, rack, pedestal units

MANUFACTURER	WINCHESTER SYSTEMS	ZENITH DATA SYSTEMS			
ARRAY MODEL	Flashserver	OASYS I			
DISK/TREND GROUP	Net/Mini/Multi	Net/Mini/Multi			
MARKET	OEM	Captive			
ARRAY CONFIGURATION: Type	Board	Software			
Host platform, software environment	Most servers	EISA NetWare, UNIX, SCO, MS LAN Mgr			
RAID level	0/1	5			
Configured by:	Host	Host			
Array capacity (Gbytes) MIN	Drive dependent	.6			
MAX	Drive dependent	6			
Minimum drives per array	2	3			
Maximum drives per array	70	7			
Concurrent host channels	5	1, 2			
Array interface to host	EISA, ISA	SCSI-2			
Drive interface	SCSI-2	SCSI-2			
Cache size (min, max: MB)	4, 160	--			
Cache function (Read, Write)	Read, Write	--			
Redundancy: Controller (Yes/No)	No	No			
Fan (Yes/No)	Option	No			
Power supply (Yes/No)	Option	No			
Spare drive (None/Auto/Manual)	Manual-backgrnd	Auto-background			
ARRAY PERFORMANCE: Boot from array?	Yes	Yes			
Transfer rate: host (MB/Sec)	33	10			
drive (MB/Sec)	Drive dependent	10			
DRIVES: Formatted capacity/drive(MB)	Drive dependent	Drive dependent			
Nominal disk diameter, height	Drive dependent	3.5", 1.6"			
Average positioning time (msec)	Drive dependent	10.5			
Average rotational delay (msec)	Drive dependent	7			
Drive models	Various	Any SCSI			
ARRAY SIZE: Inches: H x W x D	*	Internal to server			
POWER:	Drive dependent	384 watts			
Power backup	Drive dependent	UPS option			
FIRST CUSTOMER SHIPMENT	1Q93	1992			
COMMENTS	*Varies with tabletop, rack, pedestal units	Tower mounted 2-server subsystem Integra software			

MANUFACTURER PROFILES

1993 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing disk drive arrays, or those which are expected to enter the market, are listed in this section. DISK/TREND normally estimates the annual volume of disk drive array sales by manufacturers. Because few companies had a high level of disk drive array sales in 1992, this figure is reported explicitly only for firms with major 1992 sales. "1992 total net sales" covers the fiscal year ending in 1992 for each firm unless noted otherwise, or for the parent company if the disk drive array manufacturer is a subsidiary. The fiscal year of listed firms ends on December 31, 1992, unless otherwise noted.

Except for Canadian firms, manufacturers located in the United States that have majority owners headquartered in other countries are grouped in the geographical area in which the owner's home office is located. Canadian array manufacturers are grouped with the U.S. companies for convenience.

Exchange rates

The exchange rates used in converting the financial data of non-U.S. manufacturers to dollars are given below. The average exchange rate for 1992 is used, as cited by the Federal Reserve Bulletin.

Country	Currency	Currency units/U.S. dollar
Canada	Canadian dollar	1.2
France	French franc	5.29
Germany	Deutschmark	1.56
Japan	Yen	127.0
Taiwan	Taiwan dollar	25.16
United Kingdom	Pound	.568

Use caution in making year to year comparisons of revenue and income figures, as they are significantly impacted by exchange rate changes.

U.S. Manufacturers

1776, INC.
8632 S. Sepulveda Blvd.
Los Angeles, CA 90045

1776, Inc. was founded in December, 1986, for the purpose of providing specialized large data storage hardware systems. In 1989, the company completed a change to become a software supplier to the users of SCO UNIX. Its current products include "1776 Disk Array Software" which is specifically designed for the Intel-architecture microcomputer UNIX environment.

A second product of 1776, Inc., is "Multi-Host", which offers a unique method of using microcomputers in mission critical applications. Multi-Host combines the high performance and fault tolerance of "1776 Disk Array Software" together with the ability for a second host computer to back up the primary UNIX system.

1776, Inc. markets its software products directly to OEMs and through distributors. The company has been successful in installations with numerous major companies currently utilizing UNIX applications.

ALLODYNE, INC.
200 Brown Road, Suite 102
Fremont, CA 94539

Founded in April, 1991, Allodyne has developed an innovative array controller using ASICs of its own design. The firm is working with disk drive producers to create array products, including Areal Technology, with whom it jointly developed an array using IDE interface 2.5" drives. This array, which can attach to host SCSI ports, contains five drives within the form factor of a full height 5.25" drive. A larger nine drive configuration is also available. The array operates in RAID-3 or RAID-5 mode, and efficiently handles large data blocks by operating in a combined RAID-3/RAID-5 mode, avoiding excessive read-modify-write cycles. Tagged command queing and a battery backed cache are included. The array is capable of hot swapping and rebuilds in background mode. As of early 1993, Allodyne was actively seeking additional potential strategic partners for development or product marketing.

AMERICAN DIGITAL DATA ASSOCIATES
434 Cloverleaf Drive
Baldwin Park, CA 91706

ADDA was founded in 1983 to develop, manufacture and sell a family of PC mother boards for the systems integration market. The company has broadened its product line over the years and now offers a range of products from the low-end X-Terminal to high-end super servers. ADDA sells a series of 386 and 486 based systems, with emphasis on the UNIX system user.

In January 1992, ADDA introduced its first RAID product, the model ADS 1000. It featured RAID levels 0, 1, 4 and 5 through the utilization of an UltraStore RAID controller bundled with various disk drives. In June, 1992, the company introduced it's second RAID offering. The product featured UNIX support for RAID levels 0 and 1 through, the packaging of the RAID software module from 1776, Inc., coupled with various disk drives. In January 1993, ADDA introduced it's model ADS 3000 which supports RAID levels 0, 3 and 5 using the Digi-Data controller, combined with various high performance disk drives.

ADDA markets its products world wide through a network of VARs and supplements them in the domestic U.S. markets with regional distributors.

AMPERIF CORPORATION
9232 Eton Avenue
Chatsworth, CA 91311-4296

Amperif Corporation was founded in 1976 for the purpose of providing high capacity, high performance disk subsystems to the mainframe computer marketplace. In December, 1992, Amperif announced its new VIKING model disk array RAID level 5 subsystem. This high end subsystem is targeted at the response-driven on-line transaction processing (OLTP) market segment. With host systems interface data transfer rates targeted at 200 megabytes/second and a completely fault tolerant packaging configuration, the Amperif subsystem is being positioned against the Storage Technology Iceberg product offering.

To insure the ultimate in fault tolerance, the Amperif design is highly modular and has redundant hardware in virtually every area considered to be susceptible to a failure mode. In its maximum configuration, the VIKING has 52 large logic boards and supports up to 144 individual 5.25" high capacity, high performance disk drives. Amperif's packaging puts each replaceable assembly into its own "Customer Removable Module". This approach will allow the VIKING to be maintained by the customer despite the sophistication of the product's design and system level functionality.

The VIKING design uses parallel redundant data and control paths, fully mirrored cache ranging in size from 64 megabytes to 2048 megabytes and RAID level 5 support for each bank of six disk drives. Since most of the logic paths in the design are redundant, a comparison of the output of each data stream is made to ensure data integrity is always maintained. The VIKING provides up to 16 simultaneous channel/storage paths for single or multiple subsystem images (control unit addresses) with addressability for up to 256 logical volumes. The end user data capacity ranges from 45 gigabytes to 350 gigabytes in a maximum configuration. The cache is not only a global resource for all 16 concurrent host paths, but is fully mirrored to ensure access to any data that may be in the cache should one half fail.

Distribution arrangements for the VIKING product have been announced in North America with Memorex-Telex and in Europe with Comparex.

AREAL TECHNOLOGY
2075 Zanker Road
San Jose, CA 95131

Founded in 1988, Areal became an early producer of 2.5" disk drives and was the first to incorporate glass media in the 2.5" form factor, thereby achieving unusually high drive capacity. The firm has been working with Allodyne to develop a disk drive array family and now markets arrays containing five or nine 2.5" drives. The five drive array fits within the normal form factor of a full height 5.25" disk drive. 180 megabyte drives are currently offered, but it is expected that Areal will also use higher capacity drives in the array as they become available.

Areal anticipates that significant sales of the array will occur through distribution and also hopes to develop OEM interest in the array products.

ARRAY TECHNOLOGY CORPORATION (Subsidiary of Tandem Computers, Inc.)
4775-B Walnut Street
Boulder, CO 80301

Array Technology was originally started in 1987 with funding from Seagate Technology to develop high performance arrays, and was later sold to the management group. With the need for further funding, Array Technology was sold to Tandem Computers in April, 1990, and is now operated as a wholly owned subsidiary of Tandem.

Array Technology has specialized in designing RAID-0/1/3/5 arrays with a high degree of fault tolerance. Arrays sold under its own name use up to 20 high capacity 5.25" drives and are marketed for the UNIX workstation market. OEM agreements with NCR and Storage Technology have been announced. Array Technology is currently manufacturing the Alpine array for sale by a Storage Technology subsidiary in the IBM AS/400 market.

ASA COMPUTERS
2354 Calle Del Mundo
Santa Clara, CA 95054

ASA is a supplier of complete systems usable as file servers. The firm began as a PC assembly operation and a distributor of computer components, and gradually evolved into a system integrator and manufacturer. Besides the "Stallion" line of file servers, the firm also offers Sun workstation clones. ASA systems support RAID-0/1/5 or RAID-0/1/4/5, depending upon which controller is used. RAID-0 and -1 functionality is provided by Novell NetWare.

AST RESEARCH, INC.
16215 Alton Parkway
Irvine, Ca.92713-9658

1992 total net sales: $944,079,000 (FY ending 6/27/92) Net Income: $68,504,000

AST Research was founded in 1987 to develop, manufacture and market high-performance computer systems for large corporations, small businesses and individual users. The AST product mix is broad, offering performance oriented computer systems for a wide range of applications.

AST Research's sales strategy centers on selling products through networks of VADs, VARs, national distributors, systems integrators, and large retailers. In 1991, AST made a significant move into mass merchandising with the introduction of the "Advantage!" line of personal computers developed specifically for distribution through electronics "superstore" chains.

In early 1992, AST introduced its first disk array product, offered on its Premium CS line of computer systems. Along with a RAID level 0, 1, and 5 capability, the product also features a "RAID-6" implementation. The AST RAID-6 offers the features of both RAID level 0 striping and RAID level 1 mirroring capability. In late 1992, AST began offering this RAID subsystem on its new Manhattan SM series of high performance computer systems.

ASTRIX COMPUTER CORPORATION (Subsidiary of Four D Corporation)
1546 Centre Point Drive
Milpitas, CA 95035

Astrix, founded in 1989, manufactures fault tolerant servers and workstations incorporating disk drive arrays. A European marketing headquarters is located in Katowice, Poland.

The company purchases the controllers used to fabricate the array subsystems. The servers operate in RAID-5 mode, while the workstations can operate as RAID-5 or RAID-1/0 depending upon the controller used. Marketing is through VARs or direct. The servers include an integral UPS to provide protection from power failures.

ATTO TECHNOLOGY
1576 Sweet Home Road
Amherst, NY 14228

Atto, founded in 1988, is today a producer of solid state disk drives, external cache subsystems, and SCSI host adapters for PC compatible and Macintosh computers. Atto has also developed mirroring and striping software for use with its controllers on the Macintosh personal computers. Up to 4 drives may be

striped or mirrored. Because there has been relatively little competition for disk arrays on Apple products until recently, Atto has had an opportunity to hold significant market share in the Macintosh array segment as the market develops.

Shipments of mirroring software began in early 1992, while striping capability was added in late 1992.

AUSPEX SYSTEMS, INC.
2952 Bunker Hill Lane
Santa Clara, CA 95054

Auspex is a manufacturer of UNIX based network servers that employ a sophisticated architecture and a high speed internal VME bus to obtain unusually high performance. RAID-0 and RAID-1 are supported, with only two drives assigned to a SCSI channel for optimized response. Auspex systems employ multiple processor/controller boards dedicated to controlling the array and can provide duplexing and drive spanning as well as mirroring and striping. Drives can be partitioned and array functions assigned to specific partitions. While Auspex could probably add other RAID levels to its arrays, the firm prefers to restrict itself to RAID-1 and RAID-0 in order to optimize system performance.

Providing server services for networks of Sun Microsystem workstations is a major objective of Auspex, and the company has also licensed the controller used by IBM in the recently announced 7051 RS/6000 file server.

AUSTIN COMPUTER SYSTEMS, INC.
10300 Metric Boulevard
Austin, TX 78758

Austin Computer Systems, established in 1984, manufactures a variety of 386 and 486 based EISA and ISA bus computers. In late 1992, the firm introduced a RAID-5 file server for NetWare applications, using a controller from UltraStor.

BLUE LANCE
1700 West Loop South, Suite 1100
Houston, TX 77027

Blue Lance is a system integrator and software development firm specializing in Novell network management tools. Purchased hardware and software elements are integrated into array subsystems (less drives) which are sold through other VARs and integrators who add the disk drives. Blue Lance also sells a limited number of subsystems. The firm has a strong customer base for custom services in the metropolitan Houston area.

BOX HILL SYSTEMS CORP.
161 Avenue of the Americas, Suite 903
New York, NY 10013

Privately held Box Hill was founded in 1987 as a producer of storage subsystems for the UNIX based systems market. The current array product is a RAID-5 configuration with support for several popular minicomputers.

BUSLOGIC INC.
4151 Burton Drive
Santa Clara, CA 95054

BusLogic was founded in 1988, but until 1992, the BusLogic product line was limited to Ethernet controllers, SCSI host adapter boards and SCSI drivers rather than arrays. Upon the purchase of Chantal in 1992, now the Chantal Systems Division, Buslogic began to shift its strategy to include array support in future products and to include Chantal in joint promotion of board and software packages. While current controllers do not include specific support for arrays, future controllers are expected to have some degree of array functionality.

CAMBEX CORPORATION
360 Second Avenue
Waltham, MA 02154

1992 total net sales: $52,083,000 (FY ending 8/31/92) Net income: $9,847,000

Founded in 1968 to supply add-in semiconductor memory systems for the IBM mainframe market, Cambex has grown to become a leading supplier in that field. In recent years, the firm has established the Enterprise Systems Division to address its traditional market for central and expanded IBM mainframe memory systems and the Open Systems Division, which offers storage software products as well as disk, tape and semiconductor memory hardware products for the IBM RS/6000 workstation market.

Cambex shipped its ARRAY/6000 subsystem with RAID-0/1/3/5 capability in December, 1992. Designed for RS/6000 applications, the ARRAY/6000 provides a high level of redundancy for all component parts and offers up to 96 gigabytes capacity, using 1.6 megabyte 3.5" drives.

CAMBRIDGE TECHNOLOGIES
9265 Activity Road
San Diego, CA 92126

Cambridge Technologies was founded in October, 1991, to design, manufacture and market a line of RAID disk array PCBs and subsystems. The compa-

ny's first product was its model CDA 3003-ISA, which was designed to manage an array of three IDE interface disk drives while providing higher data availability, disk fault tolerance and higher performance.

The CDA 3003-ISA utilizes a proprietary technique of implementing several features of various RAID levels simultaneously. The CDA 3003-ISA is a plug replacement product for previous generations of Western Digital WD1003 disk controllers. By utilizing this design approach, the CDA 3003-ISA is fully compatible with existing BIOS and Operating Systems and therefore requires no special software drivers for proper system operation. Also featured is an RS-232 serial port, the ability to provide remote status and transparent data compression. The CDA 3003-ISA was followed by RAIDPAK, a disk subsystem featuring up to three Western Digital disk drives packaged in a 5.25" footprint box along with the CDA 3003-ISA RAID controller board and associated cables and hardware.

The company also now offers a version called the RAIDPRO subsystem which can support up to six Western Digital disk drives for a total capacity up to 1.2 gigabytes. The RAIDPRO also features automatic hot swapable disk drives as well as a choice of interface options. The company markets its products primarily to OEMs and VARs and is in the process of setting up nationwide distributors to handle its product lines.

CHANTAL SYSTEMS (A Division of BusLogic)
7220 Trade Street
San Diego, CA 92121

Chantal Systems was founded in 1978 to provide software products for the UNIX and the Novell NetWare environments. Its early product NetCal, is a Novell NetWare work group scheduler product. In June of 1990, Chantal introduced its first RAID software product, the PARAGON Disk Array Software (DAS) for the UNIX world and in November of 1991 followed with a Novell NetWare version of PARAGON. An updated version of PARAGON with greatly improved RAID-5 performance and other improvements was introduced in February, 1993. The PARAGON software is a RAID 0,1 or 5 implementation aimed at 386 and 486 class computer platforms. Its CORNERSTONE software product is a subset of the PARAGON RAID package and functions as a standard SCSI device driver under UNIX and Novell NetWare environments. Chantal Systems markets its products worldwide through a network of OEMs, resellers and distributors, with approximately 40% of its RAID software revenue coming from its European operations. Approximately 70% of its revenue is derived from the Novell market with the remainder coming from the UNIX area.

In the Novell NetWare environment, up to 4 SCSI host adapters and up to 28 SCSI disk drives of various capacities and performance may be connected. With a UNIX platform up to 3 host adapters and 21 SCSI disk drives are supported. The PARAGON RAID software is compatible with systems utilizing the EISA, ISA and Micro Channel bus architectures.

As a division of BusLogic, Chantal is continuing to function as an autonomous business unit.

CIPRICO, INC.
2800 Campus Drive
Plymouth, MN 55441

1992 total net sales: $13,414,692 (FY ending 9/30/92) Net income: $426,958

Ciprico was established in 1978, and produces disk drive arrays, adapters, and disk and tape drive controller boards for the workstation, network server and very high performance storage markets. Products are sold directly to system manufacturers and through a variety of resellers to end users. Ciprico introduced its first disk drive array in 1990, and succeeding product generations have expanded the firm's product line of RAID-3 arrays for SCSI based host platforms. Current models utilize 5 to 9 drives, with capacity dependent upon a variety of possible drive models.

CLEARPOINT RESEARCH CORPORATION
35 Parkwood Drive
Hopkinton, MA 01748

Clearpoint was founded in 1982 as a manufacturer and distributor of add-in solid state memory, and later added disk drive and tape drive subsystems for the DEC market. In September, 1992, the company announced its Freedom disk drive array series, RAID-0/3/5 subsystems intended for DEC, Sun, IBM and H-P system markets. However, poor business results caught up with the firm in late February, 1993, and Clearpoint dismissed most of its employees and closed most of its facilities. It is not yet clear whether the firm will be able to maintain an ongoing operation and whether it will attempt to remain in the disk drive array business.

CLOVIS MANUFACTURING COMPANY, INC.
187 Billerica Road
Chelmsford, MA 01824

Clovis was founded in 1987 by former Wang employees, and has since specialized in add-on products for Wang systems. An array operating in RAID modes 1, 3, and 5 is currently available. The mirroring mode is compatible with Novell NetWare, SCO UNIX, DOS, OS/2 and Banyan VINES.

CMD TECHNOLOGY INC.
1 Vanderbilt
Irvine, CA 92718

CMD Technology was founded in 1986 to develop and market SCSI adapters for the DEC marketplace. Over the intervening years the company has expanded its product line to address other SCSI based systems opportunities, and its products can now be found on a variety of UNIX, Novell, Windows NT and MS-DOS platforms.

In January 1993, the company introduced its first RAID disk array product, the model CRD-5000. Offering the user a choice of RAID level 0, 3 or 5, the CRD-5000 provides support for up to 28 individual disk drives and can service up to 3 host channels simultaneously. Utilizing the FAST SCSI-2 bus, the CDR-5000 can transfer data to the host system at up to 10 megabytes/second. In order to further enhance the overall system performance, up to 32 megabytes of write cache can be implemented in the subsystem configuration. The company sells worldwide through OEMs, VARs and other resellers.

COMPAQ COMPUTER CORPORATION
20555 SH 249
Houston, Texas 77070

1992 total net sales: $4,099,758,000 Net Income: $213,152,000

Compaq is a major participant in the IBM PC compatible computer market, offering a broad product line ranging from notebook computers to multiprocessor systems intended for use as servers.

Compaq was the first to offer disk drive arrays (other than mirroring) on personal computers. The company's first arrays were shipped in 1989, and currently has shipped more arrays than any other supplier. Compaq designs its own array controllers and supports them with storage subsystem management tools that can be operated over a network. All of the Compaq arrays are sold with Compaq computers and attach directly to the host processor EISA bus. RAID levels 0,1,4, and 5 are supported. An unusual feature of the Compaq arrays is that only write cache is provided. The processor makes use of cache elsewhere in the system for read operations. The write cache is mirrored, and includes battery backup.

CONCURRENT COMPUTER CORPORATION
2 Crescent Place
Oceanport, NJ 07757

1992 total net sales: $221,572,000 (FY ending 6/30/92) Net Income: $60,147,000

Concurrent started life as Interdata, a supplier of minicomputers, in 1966.

The firm was subsequently purchased by Perkin-Elmer and operated as a subsidiary before regaining its independence and its current name in 1984. The firm specializes in high performance minicomputers and networked systems running under the UNIX operating system.

RAID-0/1 arrays implemented in software are available for Concurrent's systems using IPI interfaced disk drives.

CONLEY CORPORATION
16 West 22nd Street
New York, NY 10010

Conley offers a RAID-0/1/3/5 array subsystem for a variety of personal computer networks and UNIX applications. Fault tolerance is stressed in systems design, with a high level of redundancy in various types of hardware used in array design.

CONTROL DATA SYSTEMS, INC.
4201 Lexington Avenue North
Arden Hills, MN 55126

1992 total net sales: $516,979,000 (FY ending 1/2/93. Includes first two quarters as part of Ceridian Corporation.) Net Income: ($134,034,000)

The existing Control Data Systems organization resulted from the continuing breakup of the previous Control Data Corporation, for many years a major manufacturer of mainframe and very high performance computers, and once the leading disk drive manufacturer. After the disk drive operations were sold to Seagate Technology in 1989, the parent company's name was changed to Ceridian Corporation. Ceridian spun off the computer business into newly formed Control Data Systems, Inc., effective July 31, 1992. Control Data Systems current products include mainframe computers, UNIX-based servers and workstations, peripherals, system software and application hardware. The firm is undergoing a planned transition from a mainframe computer manufacturer to an open systems integrator. Since 1986, Control Data has had an agreement with Silicon Graphics, under which it sells SGI workstations and servers, and this arrangement was expanded in 1992 with an equity investment by Silicon Graphics in Control Data Systems.

Since the mid-1980s, CDC had been developing a high-end disk drive array subsystem, and this program was not included in the sale of the disk drive business to Seagate, but was later included in the products turned over to Control Data Systems. Existing array products are RAID-0/3 configurations, used with both mainframes and UNIX networks, with the ability to utilize up to 32 high performance 5.25" and 8" drives.

CONVEX COMPUTER CORPORATION
3000 Waterview Parkway
Richardson, TX 75080

1992 total net sales: $231,819,000 Net income: $2,788,000

CONVEX Computer Corporation is a leading manufacturer of air-cooled supercomputers that address the needs of scientific, engineering and technical users. CONVEX systems are used to solve complex problems in such diverse areas as seismic processing, reservoir simulation, computational chemistry, computer-aided engineering, image processing, aerospace simulations and molecular biology.

The company was founded in 1982 and by 1985 had introduced its first supercomputer, the C1 which sold for $300,000. In March, 1992, CONVEX and Hewlett-Packard announced extensive business and technology agreements which included a 5% ownership position in CONVEX by Hewlett-Packard. Part of this agreement included an announcement that CONVEX would adopt Hewlett-Packard's PA-RISC (Precision Architecture Reduced-Instruction Set Computing) technologies in its massively parallel processing (MPP) supercomputer under development. In October, 1992, CONVEX introduced the Meta Series, a cluster system that links CONVEX supercomputers with Hewlett-Packard's PA-RISC processing nodes.

In the second quarter of 1992, the company introduced a RAID level 0, 1 or 5 disk subsystem offering up to 80 gigabytes of data on-line to the user. The array utilizes parallel head, IPI-2 disk drives which yield a sustained host bus data transfer rate of over 36 megabytes/second. Each array subsystem can support up to 32 disk drives and utilizes 4 host I/O channels as a standard configuration.

CONVEX has systems installed in 44 countries around the world. It has 58 direct sales and service offices to support over 600 current customers.

CORE INTERNATIONAL
7171 North Federal Highway
Boca Raton, FL 33487

Core began in 1979 as a manufacturer of peripherals and became an early marketer of disk drives for the IBM 5100 desktop computer series, which preceded the PC. The company became a supplier of peripherals for the IBM PC market during most of the 1980s, and in 1987 introduced an early mirrored disk capability for the Novell market. Aiwa Co., Ltd., a Japanese manufacturer of consumer electronics products which is controlled by Sony, purchased a 23% minority interest in Core International in 1992.

Since 1991 Core has participated in the array market for personal computers, workstations and networks with RAID-3/5 subsystems. The firm's innovative

"MicroArray" uses 2.5" drives packaged with array controller in the form factor of a full size 5.25" drive.

CRAY RESEARCH, INC.
655A Lone Oak Drive
Eagan, MN 55121

1992 total net sales: $797,578,000 Net Income: ($14,875,000)

Cray Research was founded in 1972 and claims two thirds of the worldwide market for supercomputers. With over 5,400 employees, the company has transitioned through several generations of supercomputers, with continually increasing performance demands on the disk drives used with most of their installations. Cray Research's current RAID-3 capability is based on utilization of the DCA-3 disk array channel adapter, which is a RAID-3 controller capable of handling 40 IPI-2 parallel transfer drives. The high performance option using DD-60 drives has a potential capacity of over 62 gigabytes and sustained transfer rate of 80 megabytes per second. The high capacity option using DD-62 drives offers over 87 megabytes capacity and a peak transfer rate of 32 megabytes per second.

DATA GENERAL CORPORATION
4400 Computer Drive
Westboro, MA 01580

1992 total net sales: $1,115,947,000 (FY ending 9/26/92) Net income: ($62,512,000)

Founded in 1968, Data General became a leading minicomputer manufacturer, but suffered the same softening of the market for classic minicomputers that hit the entire market segment in the mid-1980s. But despite declines in its traditional market, Data General appears headed for recovery on the strength of the AViiON line of RISC servers and workstations using UNIX. First introduced in 1989, the AViiON product line generated revenues exceeding $300 million in the 1992 fiscal year. Overall, the company's range of products currently includes data base servers, communications and network servers, workstations, desktop and portable systems, mass storage and many related software products.

Data General's 1990 introduction of RAID-0/1/3/5 subsystems for the AViiON product family resulted in a successful product for captive sales, which has already been superseded by later generations, and the 1992 establishment of a new Data General organization to pursue noncaptive array markets. The CLARiiON Business Unit is responsible for development of array markets with other system manufacturers and independent peripherals suppliers and integrators. The first results of this program are CLARiiON agreements with Groupe Bull for its UNIX systems and with ERI, a systems integrator active in the Sun Microsystems UNIX server market.

DATA TECHNOLOGY CORPORATION (Subsidiary of Qume Corporation)
1515 Centre Pointe Drive
Milpitas, CA 95035

1992 total net sales: $229,781,000 (FY ending 2/29/92) Net Income: ($14,435,000)

The existing Qume Corporation was formed as the result of the purchase of Qume, the pioneer manufacturer of daisywheel printers, from Alcatel in 1988 by Data Technology, with the subsequent change in the name of the parent company to Qume Corporation. Qume's product lines include video display and printer products, while the data storage products are the responsibility of Data Technology Corporation, which was reestablished as a Qume subsidiary in a 1992 reorganization. DTC's product line consists primarily of high performance disk controllers, plus SCSI and EISA host adapters. The DTC-3292 controller board offers RAID-1 mirroring capability.

DELL COMPUTER CORPORATION
9505 Arboretum Blvd.
Austin, TX 78758

1993 total net sales: $2,013,924,000 (FY ending 1/31/93) Net Income: $101,642,000

Dell Computer, founded in 1984 to sell PCs via mail order has become legendary in the computer industry. In November of 1992, the company began shipping its first disk array product, the model DAS which offers RAID-0 and RAID-1 capabilities. In March, 1993, the subsystem will be upgraded to support RAID levels 4 and 5. Since the Dell DAS is a captive array subsystem and is not offered as a stand-alone product, the upgrade will be accomplished by software only changes to the Dell computer system. Ranging in capacity from 4 to 14 gigabytes, the DAS comes with 1 gigabyte high performance 3.5" disk drives.

DIGI-DATA CORPORATION
8589 Dorsey Run Road
Jessup, MD 20794

Digi-Data has been active since 1962 as a manufacturer of tape cassette and cartridge drives, with an emphasis on military markets. In recent years the firm's product line has been broadened to cover a variety of commercial applications for tape drives for the Digital Equipment, Data General, Hewlett-Packard and IBM markets. Since April, 1992, Digi-Data has also been actively promoting its RAID-0/3/5 array, sold as a board-level product for a variety of host environments.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

1992 total net sales: $13,930,872,000 (FY ending 6/27/92) Net Income: ($2,795,507,000)

Digital Equipment is a veteran disk drive manufacturer, with production starting more than 20 years ago, during the firm's early days as a minicomputer manufacturer. Digital has been phasing out older large diameter disk drives during the last few years, and has aggressively developed high capacity 3.5" and 5.25" drives, for both captive and OEM sales.

For several years, Digital has offered a variety of disk mirroring capabilities, in both hardware implementations with drive controllers and in software RAID-0 and RAID-1 implementations. Late in 1992, Digital announced new RAID-0/1/3/5 arrays, which will also be offered in OEM markets.

DISTRIBUTED PROCESSING TECHNOLOGY
140 Candace Drive
Maitland, FL 32751

DPT has designed and sold board level controllers for the personal computer and network markets since 1977. An early producer of SCSI controllers, the firm pioneered in development of cache usage with controller boards. DPT's "disk mirroring module" attaches to its ISA and EISA "SmartCache Plus" controller boards, providing RAID-1 capability.

DYNATEK AUTOMATION SYSTEMS, INC.
15 Tangiers Road
Toronto, Ontario M3J 2B1
Canada

DynaTek, a privately owned firm established in 1985, is a system integrator specializing in packaged SCSI-based storage systems operable with a broad variety of hardware platforms. In addition to disk drive arrays, DynaTek provides automated library systems and a variety of disk and tape drive subsystems. The firm markets primarily to VARs and other types of dealer/integrator on a worldwide basis.

DynaTek offers several array products ranging from RAID-5 configurations that fit within the standard 5.25" full height form factor to larger tower mounted installations operating in RAID 0, 1, 3 and 5 modes.

ECCS, INC.
1 Sheila Drive, Building 6A
Tinton Falls, NJ 07724

ECCS is a systems integrator and VAR specializing in UNIX-based systems and subsystems. The company was founded in 1980. Array products include RAID-1 and RAID-5 arrays. The RAID-1 units can be operated in a combined RAID-0/1 mode which the company designates as RAID-10, in which data is striped across a set of SCSI controllers, which in turn control mirrored disks.

EMC CORPORATION
171 South Street
Hopkinton, MA 01748

1992 total net sales: $349,101,000 (FY ending 1/2/93) Net Income: $28,735,000

Established in 1979, EMC has become a born-again growth company in the last three years, based on rapid growth since 1990 in the market for its Symmetrix family of cached disk storage systems offering mirrored disk capability for IBM and other mainframe computers, supplemented by the Harmonix subsystem family sold in the AS/400 market. The company also sells tape drive add-on products and a variety of solid state disk and main memory upgrades for several systems. Aided by IBM's lack of equivalent disk subsystems and Storage Technology's delays with its Iceberg program, EMC has become the leading supplier of high performance mirrored disk subsystems for the mainframe market.

ENCORE COMPUTER CORPORATION
6901 West Sunrise Blvd.
Fort Lauderdale, FL 33313-4499

Encore Computer Corporation was founded in 1963 to design, manufacture, market and service open computing solutions with mainframe performance for complex real time on-line transaction processing applications. The Encore 90 family of computers combines parallel processing and real time computing facilities by implementing a hardware and software architecture and provides open systems and standards while delivering very high performance solutions.

The 90 Series of computers focus on a massively expandable systems configuration in order to solve complex computing problems. This configuration flexibility enables connection of multiple CPUs, I/O subsystems and intelligent communications controllers, providing the processing power formerly found only in the largest of mainframe type computer environments. Encore's fiber optic memory channels maintain I/O bandwidths in excess of 53 megabytes/second per I/O channel.

In mid-1993, Encore will be launching a RAID level 3 and 5 I/O subsystem which will incorporate the Interphase Cougar 4220 SCSI-2 host bus adapter module in the high performance data I/O path. This RAID offering will initially range in size from 6 to 32 gigabytes in capacity, utilizing 5.25" SCSI-2 disk drives, and supporting up to 15 I/O channels simultaneously with up to 572 megabytes of read/write cache. It has the capability of supporting host data transfer rates of 50 megabytes/second. As of December 1992 the company had over 25,000 systems installed worldwide and had sales and service available in 40 cities.

FORMATION, INC.
121 Whittendale Drive
Moorestown, NJ 08057

Since 1970, Formation has provided mass storage and network interconnect products to system integrators, system manufacturers, VARs and distributors. In network markets, Formation has become a specialist in air traffic control systems, tape drive and disk drive subsystems and controllers for IBM mainframes and midrange systems. Formation has not yet announced a disk drive array product, but has indicated that it is developing a RAID-3/5 system for applications requiring high availability.

GAIN SYSTEMS
6025-D Unity Drive
Norcross, GA 30071

Gain Systems is a system integrator producing personal computers, servers and complete disk drive array subsystems. The firm also sells subsystems less drives in a few cases. Gain arrays provide redundance in fans, power supplies and, optionally, controllers.

HEWLETT-PACKARD COMPANY
3000 Hanover Street
Palo Alto, CA 94303

1992 total net sales: $16,410,000,000 (FY ending 10/31/92) Net Income: $549,000,000

Hewlett-Packard has an extensive manufacturing operation for disk drives at Boise, Idaho, established in 1977, supplemented in mid-1983 with a facility in Bristol, England. H-P has made disk cartridge, disk pack, and fixed Winchester disk drives at Boise, which is also the firm's development and manufacturing facility for disk controllers. After a long history of large diameter disk drive production, H-P has successfully transitioned to 5.25" and 3.5" high capacity drives, with both types used extensively with H-P computer systems. The OEM disk drive program has also proved to be successful for H-P. In 1989, H-P startled the

industry by announcing 150,000 hour MTBF and a five year warranty for its 5.25" drives, an action which substantially improved H-P's visibility in the OEM market. H-P's credentials as an OEM disk drive producer were significantly enhanced with its announcement of the first 1.3" drive in 1992, with several mobile computer markets targeted.

Since early 1992, H-P has offered a family of RAID-0/1/3/5 arrays for UNIX workstation and multiuser applications, using both 5.25" and 3.5" H-P disk drives. H-P has had a long-standing array development activity, and the company is expected to become a significant competitor in several disk drive array markets.

INTEGRA TECHNOLOGIES, INC.
3130 De La Cruz Boulevard
Santa Clara, CA 95054

The existing Integra organization started life as Pacstor, Inc., founded in 1987 by John Kevill, one of the disk drive industry's pioneers and the originator of many of the industry's more adventurous development programs. After moderate success in early market development for its RAID-5 system with customers primarily in the banking business, Pacstor was acquired in 1990 by Integra Technologies. While maintaining the same technical staff, Integra has de-emphasized sale of its own subsystems, and the firm's current focus is to provide disk drive array technology on a licensed basis to system vendors at the OEM level. IBM and Zenith Data Systems currently offer software based arrays licensed from Integra and others are expected in 1993.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1992 total net sales: $64,523,000,000 Net income: ($4,965,000,000)

In July, 1990, IBM created the new Storage Systems Products Division, encompassing the previous General Products Division, which held responsibility for more than twenty years for disk and tape drives for mainframe applications, and Low End Disk Operations, established during the 1980's to coordinate IBM's worldwide development and manufacturing operations for disk drives used in personal computers and midrange systems. In early 1992, SSPD became Adstar, one of IBM's new wholly owned subsidiary companies. IBM manufactures 10.8", 5.25", 3.5" and 2.5" fixed disk drives at several factories in the United States, Europe and Japan.

During the last year and a half, IBM has established several disk drive array programs, using both internally developed and purchased technology. One of the most interesting arrays introduced by the industry to date is the IBM RAID-0/5 array developed at Rochester and sold as the 9337 for AS/400 applications and as the 3514 for PS/2 applications. This array overcomes the usual RAID-5 write

latency problems by utilizing a dedicated disk drive as a "write assist disk" -- in effect a write cache. Programs using externally developed technology include the Oasas RAID-0/1/5 software array licensed from Integra, the PS/2 Server 295 RAID-0/1/5 using a Parallan controller, the 7051 RS/6000 RAID-0/1 using an Auspex controller, and the 9570 very high performance "HIPPI" array using a Maximum Strategy controller. It is expected that IBM will undertake internal development of arrays for most of its own requirements during the next few years.

Of major importance to the industry is IBM's eventual choice of array technology for use with mainframe computers. EMC has developed a rapidly growing business during the last two years based on its Symmetrix 5.25" disk subsystems with mirrored disk capability, by displacing a large number of IBM 3390 drives. Storage Technology's Iceberg RAID-5 array with enhanced features has been delayed at least until the second half of 1993, much to STC's financial embarrassment. It's not clear to the outside world what IBM's mainframe array strategy will be, but there have been hints dropped by IBM executives that it won't be ready until 1994. In the meantime, early in 1993 IBM revealed plans to offer data compression capability for part of the mainframe product line later in the year, possibility reducing the appeal of competitive products such as the Iceberg.

IPL SYSTEMS, INC.
60 Hickory Drive
Waltham, MA 02154

1992 total net sales: $53,572,000 Net income: $3,053,000

IPL's primary market focus is tape and disk drive subsystems, plus memory upgrades, sold into the IBM AS/400 market. Founded in 1973, IPL distributes AS/400 data storage products through large independent distributors in the U.S. and Europe. IPL's 9336 RAID-0/1 using 5.25" drives and the 9337 RAID-0/1 using 3.5" drives have become a major portion of the firm's sales into the AS/400 market.

LEGACY STORAGE SYSTEMS, INC.
43 Riviera Drive
Markham, Ontario L3R 5J6
Canada

Legacy Storage Systems is the name adopted in June, 1991, for the firm which resulted from the merger of two earlier Canadian companies. Although Legacy offers several tape and disk drive subsystems, it is now concentrating on development of its disk drive array product line. RAID-0/1/5 arrays, which also include tape drive options, are offered for a variety of PC, NetWare and UNIX network applications.

LOMAS DATA PRODUCTS, INC.
420 Maple Street #2
Marlboro, MA 01752

A diversified small electronics design and manufacturing company founded in 1980, Lomas started making PC bus products in 1987. The firm product line includes caching SCSI controllers with mirroring capability. Sales are mostly to system manufacturers, with a concentration in producers of voice mail systems.

LOVIEL COMPUTER CORPORATION
5599 West 78th Street
Edina, MN 55439

Loviel is an independent manufacturer of disk and tape drive equipment for the personal computer market. The firm produces RAID-0/1/3/5 array subsystems, using NCR controllers, plus software arrays, for Mackintosh applications, concentrating on the prepress and imaging markets

MAPLE SYSTEMS, INC.
2380 Qume Drive, #B
San Jose, CA 95131

Maple Systems supplies SCSI controllers that are capable of supporting mirroring when used with Novell NetWare version 3.11. The controllers include cache of up to 32 megabytes and are available with host interfaces to the ISA bus and the VESA local bus. The controllers also will provide orderly storage subsystem shutdown upon receipt of loss of power signals from a UPS.

MASPAR COMPUTER CORPORATION
749 North Mary Avenue
Sunnyvale, CA 94086

MasPar provides massively parallel processors capable of very high performance to support applications such as real time image processing, simulations, complex design tasks and fast access to large data bases. The company was founded in March, 1988, and is still privately held. MasPar does not make its own arrays, but uses Maximum Strategy RAID-3 arrays to provide its systems with fast I/O and a degree of fault tolerance.

MASS MICROSYSTEMS, INC. (Subsidiary of Ramtek Corporation)
810 West Maude Avenue
Sunnyvale, CA 94086

Mass Microsystems was founded in 1987 and rapidly became a major factor in the add-on market for Macintosh storage peripherals. After several manage-

ment changes and major changes in the product line during 1992, Mass Microsystems agreed in December to a merger, in which it will emerge as a wholly owned subsidiary of Ramtek Corporation, after the expected closing of the merger in March, 1993. Mass Microsystems has introduced a family of RAID-0/1 and RAID-0/1/3/5 arrays for the Mac market using a Raidtec controller, with first deliveries expected in March, 1993.

MAXIMUM STRATEGY, INC.
2185 Old Oakland Road
San Jose, CA 95131

Founded in September, 1986, Maximum Strategy has succeeded in becoming a supplier of array subsystems to a number of major system manufacturers, including IBM, MasPar, Cray and others. While the firm's first products, shipped in 1987 for use by Walt Disney animators, were RAID-0 configurations, most recent shipments have been of RAID-3 arrays. Maximum Strategy has had a long-term product development relationship with IBM. In 1991, the firm announced an array attaching to the IBM RS/6000 system, and in 1992 began shipping a RAID-3 HIPPI interface array controller to IBM for use in the IBM 9570 disk array subsystem. This relationship is expected to continue in the future.

Maximum Strategy arrays emphasize performance. The Gen 4 array subsystem, first shipped in 1992, provides HIPPI host interfaces and an IPI-2 drive interface, as well as partitioning to allow simultaneous RAID-1/3/5 operation. Other arrays attach to the VME bus or the Micro Channel bus.

MEGA DRIVE SYSTEMS
489 S. Robertson Blvd.
Beverly Hills, CA 90211

Mega Drive Systems was founded in 1988 to provide high performance data storage solutions to fulfill users' requirements for the accurate and reliable processing of large amounts of information. Mega Drive's strategy has been to capitalize on its removable adaptation of Winchester hard drive technology by providing a family of highly reliable, small form factor rugged mass storage subsystems with high capacity and performance as well as security characteristics. In October, 1992, Mega Drive introduced its new MR series of disk array subsystems, offering RAID 0, 1, 3 and 5 levels.

Mega Drive's MR RAID subsystems use an intelligent disk controller to interface on the SCSI bus as a single device. The hardware based architecture operates in a manner that is fully transparent to the host operating system. The various models of the MR RAID series are available in desktop, deskside and rack mount configurations. Based on the model chosen, it can employ from 5 to 245 disk drives per system. Depending on the type of disk drive used in the configuration, the MR RAID model will provide from 1.6 to 490 gigabytes of high per-

formance mass storage. Mega Drive Systems markets its removable data storage subsystems principally to VARs, systems integrators, OEMs and large end users.

MICRONET TECHNOLOGY
20 Mason Street
Irvine, CA 92718

Micronet Technology was founded in 1989 to supply high performance disk storage subsystems to the Apple Mac market. In March of 1990 it introduced its first disk array RAID-1 product, the Raven 30, which was followed by the MICRO MIRROR, the RAPID ACCESS series and the Raven 40 by November, 1991. The RAPID ACCESS series was designed for the PC-based NetWare LAN environment.

Today, approximately 75% of the business for Micronet array products comes from the Apple market with the remaining 25% from the newer RAPID ACCESS series for the PC DOS marketplace. Micronet Technology sells its products through a series of resellers and dealers in the Apple market and through VARs with their PC DOS products.

MICROPOLIS CORPORATION
21123 Nordhoff Street
Chatsworth, CA 91311

1992 total net sales: $396,579,000 Net income: $19,557,000

Known as the originator of what were then considered high capacity 5.25" flexible disk drives, Micropolis started production of 8" Winchester disk drives in 1979 and subsequently became a factor in the 5.25" marketplace after the usual Winchester early production problems, and is currently striving to increase production of high-end 3.5" drives.

After an abortive disk drive array development project in the late 1980s, Micropolis entered the array market in 1991 with its RAIDION family of RAID subsystems. Beginning with the Model 680, with 10 gigabytes of storage and either RAID Level 1 or 5 functionality, the product line has grown to six models which range up to 65 gigabytes. The current RAIDION array family is built around the Micropolis RM family of high performance 5.25" Winchester drives.

MICRO TECHNOLOGY
5065 East Hunter Ave.
Anaheim, CA 92807

Micro Technology was founded in 1983 to design, manufacture, market and service storage subsystems for the DEC VMS, UNIX and network attached

computing environments. Today the company's product line encompasses on-line high-capacity storage arrays, tape backup, archival storage products as well as fault tolerant subsystems.

The company expanded into the fault tolerant storage arena with its acquisition of SF2, Inc., a Sunnyvale, California, company that pioneered and commercially delivered the first independent RAID-5 array to the DEC marketplace. As a result of this acquisition, the company now holds 24 patents pending or issued in fault tolerant RAID technology and networking. Micro Technology markets its products worldwide and in addition to its sales offices, the company has 34 service centers in the domestic U.S. and 13 service centers overseas. The company is privately held, but has indicated that sales for the fiscal year ending April 4, 1992, were $105,000,000.

MORSE TECHNOLOGY, INC.
17531 Railroad Street
City of Industry, CA 91748

Morse Technology, Inc. was founded originally to develop, manufacture and market PC motherboards. Over the years, its product line has expanded to include computer monitors and host bus adapter cards. In December 1992 the company introduced its model KP 8050, an IDE hard drive accelerator controller for the EISA bus which offers RAID-1 support. The model KP 8050 is a dual-function controller which, along with its utility software, allows the user to determine whether an application needs hardware caching, as is the case with file servers or "Super Buffering" which significantly speeds up software caching performance running under Microsoft Windows.

The KP 8050 is a 32 bit IDE accelerator that uses bus mastering and includes fault tolerance features, including disk duplexing for different channels or disk mirroring for the same channel. The design utilizes the Intel 82355 BMIC chip which speeds up multitasking in the Windows environment and also optimizes network performance under Novell NetWare and SCO UNIX.

The company markets its products worldwide through a network of VARs, Systems Integrators and OEMs. The company has manufacturing and support facilities in Amsterdam, Holland, and Taipei, Taiwan, as well as its corporate headquarters in Los Angeles.

MYLEX CORPORATION
34551 Ardenwood Boulevard
Fremont, CA 94537

1992 total net sales: $48,769,500 Net income: $3,000,000

Mylex produces a variety of controller boards for graphics and storage devices as well as Ethernet adapters, system motherboards and disk drive array

controllers and subsystems. The firm also produces its own multiprocessor server. Mylex estimates that its arrays could account for over 50% of its revenues at year end.

While array activity in 1992 was nominal, Mylex has succeeded in obtaining OEM contracts for array controllers from AST, Northgate and others, and appears poised to become a major supplier of disk drive array hardware in 1993. Mylex controllers attach to the host EISA bus and can be used with many PC compatible systems. Mylex controllers provide RAID levels 0, 1, and 5, plus combined striping and mirroring which Mylex designates as "Mylex RAID", or Mylex RAID-6/7. Operating system support includes Novell NetWare 3.11 and SCO UNIX 3.2 V4. In the future, Mylex expects its array controllers will also operate with Windows NT, Solaris, UNIX SV R4 and others.

NCR (Subsidiary of AT&T)
1700 South Patterson Road
Dayton, OH 45479

1992 total net sales: $64,904,000,000 Net income: $3,807,000,000

NCR was founded in 1884 as the National Cash Register company and evolved to become one of the leading mainframe and minicomputer suppliers, although the firm was unable to keep up with IBM and Digital Equipment. AT&T purchased NCR in 1991 to improve its capabilities in combining communication and computing technologies.

NCR coordinates its array activities through its Peripheral Products Division in Wichita, Kansas. The firm produces array controllers which it uses in its own arrays and also sells on an OEM basis to other array producers. NCR also introduced in 1991 a specialized array chip set (produced by NCR Microelectronics Division) which it uses internally and also sells to OEMs. Additionally, NCR offers Disk Array Plus, software that provides array functionality without the need for specialized hardware. The software was being generated by AT&T in its Naperville, Illinois, facility and was assigned to NCR after the 1991 acquisition. As a result, a software array development program using technology licensed from Integra was displaced by the Naperville effort.

Disk Array Plus operates at RAID levels 0, 1, and 5. NCR hardware array implementations operate at RAID levels 0, 1, 3 and 5, and can do so concurrently. NCR array controllers do not provide cache on the controller, relying upon the processor to provide caching functions. However, they do support communication with multiple hosts.

In 1991, NCR established a customer relationship with Array Technology for arrays that NCR might elect to use in specific NCR systems.

NETFRAME SYSTEMS, INC.
1545 Barber Lane
Milpitas, CA 95035

1992 total net sales: $39,051,000 (FY ending 1/1/93) Net Income: $3,249,000

NetFRAME manufactures and sells specialized, high performance multiprocessor computers for use as network servers. Novell NetWare and OS/2 LAN Manager are currently supported, and operation under UNIX SVR4 and Windows NT is anticipated in the future. The company began operation in 1987 as Carlton G. Amdahl Associates, acquired its present name in 1988, and shipped its first systems in 1989. Olivetti is a major customer and distributes NetFRAME products worldwide.

NetkFRAME provides a disk controller for its systems that is optimized for striping and mirroring, but relies upon the operating system to actually provide the array function. The storage subsystem architecture allows for redundant buses, redundant I/O processors, and redundant power and cooling. At present, NetFRAME has two systems in its product line that make use of disk arrays and anticipates healthy growth for these in 1993.

NORTHGATE COMPUTER SYSTEMS, INC.
7075 Flying Cloud Drive
Eden Prairie, MN 55344

1992 total net sales: $124,467,000 Net Income: ($15,529,000)

Founded in 1968, Northgate in recent years has been a manufacturer of IBM compatible personal computers, and during the past year has been impacted by the PC price wars, with reduced sales and heavy losses. In 1991 Northgate introduced the OmniArray, using a Ciprico controller. In late 1992 that product was replaced by the Northgate Disk Array, a RAID-0/1/5 subsystem based on Mylex products.

PACIFIC MICRO DATA, INC.
3002 Dow Ave.
Tustin, CA 92680

Pacific Micro Data was founded in 1988 as a systems integrator to offer RAID 0, 1 and 5 solutions to the Novell, UNIX, DOS and OS/2 markets. Its first product, the MAST VI, is no longer marketed and has been replaced by the MAST VII. Supporting standards and open systems are the cornerstones of Pacific Micro Data's price/performance strategy.

The MAST VII combines nonproprietary SCSI-2 disk drives, tape drives, host adapters, and RAID technology (software and hardware) in its subsystems. The

RAID subsystem monitors temperature and fan RPM by an audible alarm which can be disabled in the event of a subsystem failure. The MAST VII enclosure is designed to contain 3.5" SCSI devices and supports hot disk drive power-on replacement. Depending on the users requirements, the MAST VII can be configured using the following devices:

DISK DRIVES:	Micropolis, Digital Equipment, Fujitsu
TAPE DRIVES:	Hewlett-Packard, Archive
HOST ADAPTERS:	Adaptec, BusLogic
RAID TECHNOLOGIES:	Chantal, Mylex, UltraStor

PARALLAN COMPUTER, INC.
1310 Villa Street
Mountain View, CA 94041

Parallan, founded in 1988 as a server developer and producer, established development relationships with both Microsoft and IBM early in its life. By 1990, the firm had introduced its first systems, providing server services to PC networks running DOS, Windows and OS/2. The server includes an array operating in RAID-5 mode, and also incorporates redundant processors, data buses, controllers and power supplies, providing a high degree of fault tolerance .

In 1992, IBM acquired a minority interest in Parallan and became Parallan's exclusive distributor for its server, which has since been announced by IBM as the PS/2 Server 295. Over a period of years, IBM is expected to become the primary manufacturer as well as the exclusive distributor of other products designed by Parallan.

PERCEPTIVE SOLUTIONS
2700 Flora Street
Dallas, TX 75201

Perceptive Solutions was founded in 1988 to develop, manufacture and market intelligent mass storage controllers, disk array subsystems, and related storage-enhancement products for microcomputers, workstations, and file servers. The company's product lines cover the full spectrum of intelligent controller technology, from a low-cost quickCACHE IDE to the universal hyperSTORE 1600 family. Options such as the dataSHADOW RAID-1 drive mirroring add fault-tolerance and the hyperDRIVER device drivers provide greater on-line capacity and support optical disk drives.

Perceptive Solutions' current plans are to introduce a new family of disk array products later in 1993. The Prism drive array will provide RAID level 0, 3 and 5 support and will be offered as a completely packaged subsystem in a small footprint utilizing 3.5" high performance disk drives. Perceptive Solutions sells its products through several different channels. Domestic U.S. distribution includes

a number of regional distributors and direct sales to VARs and systems integrators. Selected products are also sold through a number of direct marketers and retailers, such as CompUSA.

PERIPHERAL LAND INC.
47421 Bayside Parkway
Fremont, CA 94538

PLI got its start in 1985 with the introduction of an early SCSI adapter which allowed SCSI disk drives to be used with the Macintosh without voiding the warranty. Since that time the firm's product line of add-on peripherals has been expanded to include SyQuest removable cartridge drives, CD-ROMs, magneto-optical drives, Floptical drives, fixed hard disk drives, DAT tape drives and a variety of SCSI host adapters. Since mid-1992, PLI has offered SCSI adapters with RAID-0/1 capability for a variety of Macintosh models.

PRECISION COMPUTERS, INC.
1111 SE Stephens
Portland, OR 97214

Precision Computers is a systems integrator offering complete subsystems for IBM compatible personal computers. The equipment is provided with Hewlett-Packard disk drives and UltraStor controllers.

PROCOM TECHNOLOGY
2181 Dupont Drive
Irvine, CA 92715

Procom Technology was founded in 1986 to provide external 5.25" flexible disk drive products to the IBM PS/2 market. The company next expanded its product line into the Apple Mac market with a family of hard disk drive subsystems. Subsequent ventures led them into the removable media hard disk drive arena with SyQuest drives, DAT tape subsystems and TEAC tape cassette subsystems. The company designs its own ISA, EISA and SCSI-2 host bus adapters for its market requirements.

In late 1992, Procom introduced its first RAID product, the "XCELERATOR". This RAID controller makes it possible for the host to configure the board to look like a standard SCSI-2 host bus adapter or it can be user defined to function as a RAID-0, RAID-1 or both simultaneously. In early 1993, the company will be announcing its next RAID offering, which will be a complete subsystem using up to six 3.5" one gigabyte disk drives. The company markets worldwide through a network of VARs, VADs and other resellers.

RAIDTEC CORPORATION
1111 Alderman Drive
Alpharetta, GA 30201

Raidtec offers RAID-0/1/3/5 arrays for Novell NetWare, UNIX and other platforms. The Raidtec arrays are SCSI-based subsystems using 3.5" drives, and offer hot replacement of key components. Raidtec is also supplying the array controller used by Mass Microsystems in that firm's arrays introduced in early 1993.

R SQUARED
11211 East Arapahoe Road
Englewood, CO 80112

R Squared is a system integrator operating throughout the U.S., with a concentration on mass storage products for UNIX systems operated by major commercial and government users. Among R Squared's product offerings are high capacity disk drives, tape backup systems, and tape library systems. The firm announced a RAID-3/5 array in 1992, which is expected to be initially delivered in April, 1993, utilizing an array controller from Digi-Data.

SEQUOIA SYSTEMS, INC.
400 Nickerson Road
Marlborough, MA 01752

1992 total net sales: $62,588,000 (FY ending 6/30/92) Net income: ($3,940,000)

Sequoia was founded in 1981 as a manufacturer of fault tolerant on-line transaction processing systems. The company's strategy has been to offer OLTP systems based as much as possible on industry standard hardware and software, consisting of multiple processors that share memory and are managed by a single operating system. Disk drives are mirrored, with newer systems using high capacity 3.5" drives. Although Sequoia established a series of development and marketing alliances with major computer companies, including Hewlett-Packard, Samsung and Toshiba, it has experienced financial problems during the last year, resulting in key management changes.

SILICON VALLEY COMPUTER
441 North Whisman Road
Mountain View, CA 94043

Silicon Valley Computer was founded in 1982. The firm manufactures PC motherboards, PC/AT compatible systems and IDE controllers, and distributes disk drives. In December, 1992, Silicon Valley announced an IDE disk controller with RAID-1 mirroring capability.

SOLBOURNE COMPUTER, INC.
1900 Pike Road
Longmont, CO 80501

Solbourne got its start in 1986 as a manufacturer of SPARC workstations. However, since 1989 the company has become primarily a producer of SPARC multiprocessor servers for networks using Oracle financial applications. Solbourne provides an optional mirrored disk capability with its BoSS disk subsystems.

STORAGE COMPUTER CORPORATION
11 Riverside Street
Nashua, NH 03062

Storage Computer's array development activities started in 1984 as a project within Cab-Tek, Inc., a privately held company that manufactures computer printer accessories. Starting as what is now known as RAID-3, Storage Computer's program experimented with various array configurations, finally evolving into "RAID-7", an asynchronous subsystem with extensive cache which is designed to overcome performance limitations of other RAID implementations. The company's subsystem uses either 3.5" or 5.25" drives and is designed with a high level of redundancy. The company was established as a separate entity in 1992, and array shipments started in mid-1992.

STORAGE CONCEPTS, INC.
1622 Deere Avenue
Irvine, CA 92714

Storage Concepts was founded in May, 1984, to develop and market a series of high speed parallel disk subsystems. These products were developed to support real time image processing, super and near-supercomputer data storage and specialized government and military applications, as well as addressing the mass storage requirements for general purpose computer applications.

The fundamental design of the company's disk storage controllers is differentiated in the marketplace by its unique dual-bus architecture. Disk subsystems offered by the company have the traditional host interface to the CPU, but in addition they offer a proprietary bus, the Differential Fast Bus (DFB), a 16 bit data bus that can accommodate data throughput up to 25 megabytes/second. A second proprietary bus, the Enhanced Differential Fast Bus (EDFB), a 32 bit data bus, allows the user to read and write to the disk drive at speeds up to 50 megabytes/second. The company's Matrix Array family of disk array subsystems was first introduced in April, 1989, with the model Concept 51. Since that time the company has added five more models to the family, the latest being the

Concept 71 FCS, a fiber channel based offering to the very high performance computer market. The Matrix Array product line offers up to 108 gigabytes of data storage.

The company sells direct, supplemented with manufacturers sales representatives. In 1991, the company opened a direct sales and support office in the U.K. for support of its European based business. In other parts of the world the company sells through local distributors and systems integrators.

STORAGE DIMENSIONS INC.
1656 McCarthy Boulevard
Milpitas, CA 93035

Storage Dimensions, founded in 1985, was purchased by Maxtor in 1987 and operated as a Maxtor subsidiary until late 1992, when the company was purchased from Maxtor by its managers and an investment group. Maxtor retains 30% ownership. SDI revenues are estimated to exceed $85 million annually.

The SDI product line includes storage subsystems containing disk drives, tape drives and optical drives for attachment to workstations, personal computers and file servers. They are available for a variety of host platforms, including Sun, IBM, Apple, Compaq and Novell.

SDI's disk drive arrays are available in RAID-5 configurations for PC compatible hosts with either the ISA, EISA or Microchannel bus. RAID-0 arrays are available for the Macintosh, with a wide selection of drive capacities.

STORAGE SOLUTIONS, INC.
417 Shippan Avenue
Stamford, CT 06902

Storage Solutions, founded in 1989, is an independent supplier of disk drive and tape drive subsystems for various personal computer networks. Since mid-1992, the firm has been shipping a RAID-0/5 array. In SSI's array each drive's individual enclosure contains its own power supply, to facilitate usage in the array or as independent drives.

STORAGE TECHNOLOGY CORPORATION
2270 South 88th Street
Louisville, CO 80027

1992 total net sales: $1,056,965,000 (FY ending 12/25/92) Net income: $15,494,000

Storage Technology's "Iceberg" array for mainframe applications is easily the most famous disk drive array program so far, despite the fact that deliveries are

embarrassingly late. After great success in the second half of the 1970's as the leader in plug compatible disk drives, STC's shipments dropped in 1982-1983, as IBM 3380 shipments started in earnest. STC's volume shipments of 3380 equivalent drives didn't start until early 1984, too late to save the company from failures in its other new business areas. The firm's management had launched expensive programs to build mainframe computers and optical disk drives -- and had acquired firms in other areas, with extensive bank borrowing. In October, 1984, the bankers wouldn't wait, and the company was thrown into Chapter 11. After a series of complex negotiations with creditors, the firm emerged from bankruptcy in mid-1987.

Orders for STC's innovative 1/2" tape cartridge library system provided several years of growth, and were instrumental in restoring STC's position in the storage products industry. However, shipments of drives equivalent to IBM's 3380K did not start until 1989, and the firm never regained its earlier share of the IBM disk drive plug compatible market. In 1990, the firm began discussing new products incorporating disk drive arrays to be sold into the PCM marketplace. The Alpine midrange array for the AS/400 market manufactured for Storage Technology by Array Technology has been shipping since late 1992. The high-end Iceberg array project, which uses purchased 5.25" drives, was to be available in the first half of 1992, but the schedule has slipped, and commercial availability of Iceberg is not expected until the second half of 1993 at the earliest.

STRATUS COMPUTER, INC.
55 Fairbanks Boulevard
Marlboro, MA 01752

1992 total net sales: $486,266,000 (FY ending 1/3/93) Net income: $56,945,000

Stratus Computer was founded in 1980 to produce fault tolerant minicomputers, which are used primarily for on-line transaction processing, communications control, distributed computing, and other applications in which high system availability is essential. Stratus has progressed through multiple generations of systems, with the latest systems employing RISC processors. IBM's System/88 is produced by Stratus on a contract manufacturing basis, and the company also has OEM arrangements with Olivetti, Ericsson Telecom and NEC. The Stratus D600 Peripheral Subsystem utilizes disk drive controllers which provide mirrored RAID-1 capability, using standard industry disk drives with capacities from 319 megabytes to 1.4 gigabytes.

SUN MICROSYSTEMS, INC.
2550 Garcia Avenue
Mountain View, CA 94043

1992 total net sales: $3,588,885,000 (FY ending 6/30/92) Net Income: $173,313,000

Sun is a major producer of workstations and network servers based upon UNIX and Sun's own networking software. The firm was founded in 1982 and rapidly became a significant factor in workstation and server markets. The firm's SPARCstation and SPARCserver platforms are targets for many third party software providers.

As an adjunct to its version of UNIX, Sun offers "Online: DiskSuite", a software-based file system that provides for very large file systems (up to one terabyte) to be created under UNIX and which also provides mirroring and striping. Sun licenses DiskSuite for both its desktop systems and its servers.

SYSTEMS INDUSTRIES
1855 Barber Lane
Milpitas, CA 95035

1992 total net sales: $59,746,000 (FY ending 7/25/92) Net income: ($23,556,000)

Systems Industries was founded in 1968. The company's first products were systems for automating scientific instruments, but in the process of development, it was discovered that the minicomputers typically used had inadequate amounts of mass storage available.

Systems Industries began selling storage subsystems for DEC and Data General computers in 1971 and exited the instrument activity in 1976. Since then, SI has been a supplier of storage subsystems for minicomputers, selling primarily to DEC end users. The company's sales have declined from those of the late eighties, and the firm is broadening its product line in order to improve its position. New products include automated tape library subsystems and disk drive arrays.

In 1989, SI began marketing "eaSIshadow", a software product allowing DEC processors running under VMS 5.0 or above to operate drives in a mirrored mode. The array product line was augmented in 1992 with a RAID-3 array that attaches to a host SCSI-2 channel on DEC or Sun systems. SI purchases the array controller for these arrays.

TANDEM COMPUTERS INC.
19333 Vallco Parkway
Cupertino, CA 95014

1992 total net sales: $2,036,917,000 (FY ending 9/30/92) Net income: ($41,184,000)

Since its start in 1974, Tandem has become the largest manufacturer of fault tolerant on-line transaction processing systems, and has expanded its product coverage to include fault tolerant UNIX software based systems and large network systems. In 1992, the company also introduced systems using RISC processors and for the first time offered data storage systems using large capacity 5.25" disk drives. Tandem's target customers are mainly large companies and government installations with mission critical applications requiring computer systems with high standards of availability.

In 1990, Tandem acquired Array Technology Corporation, which produces array subsystems, including the Storage Technology Alpine array now being marketed in the IBM AS/400 market. Tandem does not currently use Array Technology RAID subsystems with its own OLTP systems, but continues to employ the mirrored disk implementations which have been its storage mainstay for many years. The 4500 disk subsystem introduced in late 1991 utilizes up to six disk drive modules, each containing up to six disk drives, to provide up to 37.3 gigabytes in a single cabinet.

TANGENT COMPUTER, INC.
197 Airport Boulevard
Burlingame, CA 94010

Tangent is a system manufacturer that produces servers working under OS/2 and UNIX, and servers for Novell networks. Its product line includes a six drive array option operating in RAID-5 mode.

THINKING MACHINES CORPORATION
245 First Street
Cambridge, MA 02142

Thinking Machines was established in 1983 to design and manufacture parallel processing supercomputers. The company's pioneering "DataVault" disk drive array using a Hamming Code error correcting scheme became known as RAID-2 when the U.C. Berkeley RAID nomenclature system was published in 1987. Unfortunately, RAID-2 was not as efficient in utilizing available disk drive resources as later array configurations, and the DataVault is no longer in production. It was superseded in 1992 by the CM-5 Scalable Disk Array, a RAID-3 array architecture with the ability to attach 3,072 3.5" drives, each with 1.2 gigabytes capacity, for a theoretical total array capacity of 3.2 terabytes.

TRANSOFT CORPORATION
31 Parker Way
Santa Barbara, CA 93101

Transoft was founded in 1986 as the result of a merger between two software companies, Mibek and Apolyonics. The company integrates NCR array controllers with other mechanical and electrical subassemblies, shipping most of its output to VARs and OEMs serving the Macintosh market. The firm markets in the U.S., Europe and Asia, notably Taiwan.

TRICORD SYSTEMS, INC.
3750 Annapolis Lane
Plymouth, MN 55447

Tricord started in 1987 with venture capital funding to develop and manufacture network superservers for the enterprise computing market. Additional investment was received from Kubota, and Tricord has licensed Kubota Computer to manufacture and sell Tricord products in the Japanese domestic market. The PowerFrame server series is designed for field upgradability and includes duplexing for most components to achieve a high level of fault tolerance. In the past Tricord has resold Ciprico RAID-3 arrays, but since June, 1992, has supplied its own RAID-0/1 capability for Tricord file servers, first as an option, and as standard equipment on all servers since the beginning of 1993.

ULTRASTOR CORPORATION
15 Hammond Drive
Irvine, CA 92718

UltraStor Corporation was founded in 1989 to develop and market a family of "ULTRA" high performance disk controllers aimed at rapidly growing disk intensive systems such as multiuser, networking, CAD/graphics and desktop publishing. The company's family of disk controllers and adapters currently support the popular SCSI devices, IDE interface drives, as well as higher performance ESDI interface disk drives.

In October, 1991, the company introduced its first RAID product, the Model ULTRA 124F, an EISA/SCSI Array Controller for the OEM and systems integrator markets, offering support for RAID levels 0, 1, 4 and 5. Each RAID controller provides from 3 to 5 independent channels and can support from 1 to 35 disk drives per controller, and can support data transfer burst rates on the EISA bus up to 33 megabytes/second and sustain a transfer rate of 20 megabytes/second in a RAID-5 mode. In October, 1992, the company introduced the ULTRA 144F RAID level 0, 1, 4 and 5 disk array controller which can support many host computer platform (supermicros, minicomputers, PC's, etc.) which use SCSI host interfaces.

UltraStor sells its products worldwide through OEMs and VARs, and maintains an office in the U.K., as well as its corporate headquarters in California.

UNBOUND, INC.
17951 Lyons Circle
Huntington Beach, CA 92647

UNBOUND, Inc. was founded in 1984 to develop, manufacture and market DEC-compatible computer systems. Two systems were produced: The CUBE and the Varistor. The CUBE was noted for its modularity and expansion capability and is still marketed today. In 1987 the company introduced its first tape and disk subsystems for the DEC marketplace. These subsystems interfaced with the PDP-11, VAX and MicroVAX offerings by DEC. The latest product offering is a subsystem which interfaces to SDI clustered VAX machines. In 1988, the company expanded its market area with the introduction of removable and lockable drive subsystems for the workstation marketplace with offerings for SUN, DEC, Mac, PCs and other host platforms which incorporate the SCSI bus interface.

In 1991, the firm introduced a family of high performance SCSI RAIDSTOR-F5 disk array subsystems. This product family offers RAID 0, 3 and 5 level support with data storage ranging from 7.5 to 70 gigabytes, utilizing high performance 5.25" Winchester disk drives from various drive manufacturers. The company sells its products through a network of distributors and VARs as well as to the OEM market.

UNISYS CORPORATION
P.O. Box 500
Blue Bell, PA 19424

1992 total net sales: $8,421,900,000 Net income: $361,200,000

With roots deep in the history of the computer business, Unisys is a manufacturer of mainframes, minicomputers, and networking equipment. The company was formed from the merger of Burroughs and Sperry-Univac in 1986. With the decline of the mainframe market in recent years, Unisys has been focussing on networking, information distribution, software and services. Financial services, airlines, travel and telecommunications are areas of Unisys market strength.

The company offers RAID-1 and RAID-0 arrays on its UNIX-based systems. In smaller UNIX-based systems, the arrays are implemented using software modules added to the UNIX operating system, while a subsystem with RAID-1 capability purchased from EMC is offered with Unisys mainframe systems.

UNITROL DATA PROTECTION SYSTEMS INC.
815 Hornby Street
Vancouver, British Columbia V6Z 2E6
Canada

Unitrol offers a software implementation of a RAID-1 array. The software operates on any IBM compatible PC running DOS or Windows. The firm sells through dealers and VARs, but is trying to develop an OEM customer base as well. Unitrol's array can also operate with disk drives employing removable cartridges, allowing creation of instant backups as file contents change. It is also possible to logically partition the disks and mirror only selected partitions.

The firm also offers IDE drive controllers that are configured to allow duplexing with its mirroring software.

VERITAS SOFTWARE CORPORATION
4800 Great America Parkway
Santa Clara, CA 95054

An offshoot of Tolerant Systems, a UNIX based systems manufacturer, Veritas was established in 1988. The company has developed storage management software add-ons to the UNIX operating system, including a module permitting disks to operate in mirrored and striped modes. At present, the Veritas modules operate with UNIX SVR4 and SCO UNIX. The company has licensed the use of its technology to system manufacturers that include UNIX SVR4 with their systems. The SCO UNIX version is sold through distribution. Veritas modules appear on a very large proportion of the UNIX SVR4 based systems currently marketed, but the firm is still trying to improve its presence in the SCO UNIX market.

Veritas has had a long standing joint development program with UNIX System Laboratories (recently acquired by Novell), and similar relationships with IBM relating to nonarray software products. The firm is also working on joint developments with a number of other firms active or entering the array market.

VERMONT RESEARCH CORPORATION
Precision Park
North Springfield, VT 05150

Vermont Research was a pioneer disk drive manufacturer, and probably the first company to use an embedded servo head positioning system in a disk drive. In the Autumn of 1992, VRC announced a RAID-0/3/5 high performance array subsystem with extensive fault tolerance features. However, the company decided to withdraw the announced array product, in favor of concentrating on its solid state memories and other product developments.

VORTEX SYSTEMS, INC.
800 Vinial Street
Pittsburgh, PA 15212

Vortex is an independent supplier of data storage subsystems for computer network applications, founded in 1987. After initial concentration on optical disk drive backup subsystems, Vortex introduced a SCSI controller with mirroring capability in 1992, for Banyan VINES and OS/2 markets.

WINCHESTER SYSTEMS, INC.
400 West Cummings Park
Woburn, MA 01801

Winchester Systems has been marketing its add-on storage subsystems since 1981. Early products were mostly disk drive subsystems, but DAT tape subsystems have been a larger part of the company's business in recent years. The company's Flashdisk 2 RAID-1 subsystem has been offered since mid-1992, with up to 90 gigabytes capacity for DEC and most engineering workstation applications. The Flashserver RAID-0/1 board is designed to use SCSI drives with EISA computers.

ZITEL CORPORATION
630 Alder Drive
Milpitas, CA 95035

1992 total net sales: $45,602,000 (FY ending 9/30/92) Net income: $1,531,000

Zitel, which began operation in 1981, is best known as a manufacturer of large solid state memory add-ons for Unisys mainframes and minicomputers, especially those used in on-line transaction processing. Zitel has also developed products for a number of OEM customers, including IBM. In 1991, the firm began selling a memory subsystem incorporating both solid state memory used as a large, fast cache and a high performance disk drive.

While Zitel does not market array products at present, it has done so in the past, beginning with a RAID-2 array sold to Ford Aerospace in 1988. The firm remains interested in high performance arrays and may re-enter the market in the future, probably in conjunction with a selected strategic partner.

Asia/Pacific Rim Manufacturers

ACER CO.
347 Wu Lin Fung Chen Road
Lung Tan Hsiang
Taoyuan
Taiwan

1991 total net sales: $473,887,000 (FY ending 12/91) Net income: ($24,126,000)

Founded in 1981, Acer is known for its personal computers and related products. The firm is now one of Taiwan's largest companies. Acer's U.S. subsidiary, Acer America is located in San Jose, at the facilities of Altos, which Acer acquired.

While Acer has had an internal development program focussed on RAID-0/1, its server class products equipped with an array option currently use controllers purchased from third parties that offer RAID-0/1/5 combinations. All of Acer's array sales are for subsystems attached to Acer computers. The majority of Acer's array sales have been to customers outside the U.S., a pattern that is expected to continue.

FUJITSU LTD.
6-1, Marunouchi 2-chome
Chiyoda-ku, Tokyo 100

1992 total net sales: $27,101,945,000 (FY ending 3/92) Net income: $96,142,000

Fujitsu derives about 70% of its sales from the computer industry and is known as the leading manufacturer of computers for the Japanese domestic market. Fujitsu is also a major exporter to the worldwide computer market. Since 1982, the company has been among the leaders in worldwide disk drive revenues, and skillfully managed a transition from older removable disk drives to a product line consisting mainly of fixed disk drives in all capacity ranges and in several disk diameters. Fujitsu is manufacturing some of its high performance drives at a major facility near Portland, Oregon, which is now in full operation. Some low end 3.5" drives are produced in Thailand. Intellistor, located in Longmont, Colorado, is a Fujitsu subsidiary developing small diameter disk drives and disk drive arrays. Fujitsu also has a 44% ownership position in Amdahl.

Since the second half of 1990, Fujitsu has been offering a RAID-3 array originally developed by Intellistor. All shipment of the array have so far been limited to Japan.

HITACHI, LTD.
4-6 Kanda-Surugadai
Chiyoda-ku, Tokyo 101

1992 total net sales: $61,146,024,000 (FY ending 3/92) Net income: $1,004,811,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major manufacturer of computer systems. The firm currently makes a wide range of Winchester technology fixed disk drives for both captive and noncaptive markets. In addition to significant OEM sales of smaller capacity fixed disk drives, Hitachi also sells IBM compatible 3390 equivalent drives through Hitachi Data Systems (formerly National Advanced Systems, before acquisition by Hitachi), and in 1983 started selling plug compatible drives for distribution in the European PCM market through BASF, and currently through Comparex.

Hitachi has been shipping a RAID-3 array since late 1992, and plans to add RAID-5 capability this Autumn.

INFORTREND, INC.
32-3 Dong Men Street
Baan Chyau, Taipei
Taiwan

Infortrend is a startup company working on an array controller offering RAID-0, RAID-1, RAID-4, and RAID-5. The controller has an EISA host bus and SCSI-2 drive ports, and is intended for use on IBM PC compatible platforms. The firm expects to market the controller on an OEM basis.

LAURA TECHNOLOGIES
Tentime Division
106 South 54th Street
Chandler, AZ 85226

Laura Technologies is an Australia based conglomerate. It was founded in 1970 and originally was a management services and real estate investment company. In 1991, the firm bought Conan Corporation, which produced SCSI controllers, and established the brandname "Tentime" as the divisional name.

Laura Technology products include SCSI adaptors, autochanger software drivers for SCO Unix, optical drive subsystems, and DAT tape storage subsystems. Support for mirroring is available as an option for the SCSI controllers.

NEC CORPORATION
5-33-1, Shiba
Minato-ku, Tokyo 108

1992 total net sales: $29,715,354,000 Net income: $120,283,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about 49% of the firm's total revenues. Current disk drive production involves fixed disk drives, from large to small configurations, for both captive and OEM markets. Fixed disk drives include 14", 9", 8", 5.25", 3.5" and 1.8" disk diameters. NEC was the first of the major Japanese drive producers to produce small form factor rigid disk drives offshore, with the establishment of a factory in the Philippines.

NEC has been shipping a SCSI controller board with mirroring capability in the U.S. personal computer market, and is expected to start shipments in 1993 of a RAID-3 array with NEC supercomputers.

SANYO ICON (Subsidiary of Sanyo Electric Co., Ltd.)
18301 Von Karman
Irvine, CA 92715

1991 total net sales: $12,723,520,000 (FY ending 11/91) Net income: $132,575,000

Sanyo Electric Co. is a multinational Japanese corporation, employing over 56,000 people in 100 different subsidiary companies in 27 countries. In North America, Sanyo Electric operates 27 of these subsidiaries and maintains 52 regional offices. The company's products include audio and video equipment, information systems and electronic devices, home appliances, batteries and industrial and commercial equipment.

Sanyo Icon became a Sanyo subsidiary in 1984. The company is part of the Information Systems Group, whose charter is to design, develop, manufacture and internationally market two separate product lines. The first is a line of high performance mass storage peripheral systems for local area networks, and the second is a line of high performance computer systems specifically designed for the PICK, UNIX and MS-DOS markets.

In October, 1992, Sanyo Icon introduced its LANser MRX (Multiple RAID eXtended) family of high performance disk array subsystems. This product line complemented its LANser Intelligent Disk Subsystems products which were introduced in 1990 as Sanyo Icon's first offering for LAN markets.

With the LANser MRX product, Sanyo Icon offers RAID 0, 1 or 5 capabilities in various physical packaging configurations. The LANser MRX line has fast internal bus structure (80 megabytes/second) and will support up to 12 file servers. Individual configurations can be expanded to support up to 105 individual disk drives, providing the user an available data base of over 300 gigabytes. The

Model MRX500FT will expand the fault tolerance capability by providing a duplexed environment. All four current LANser MRX models, the MRX100, MRX300, MRX500 and MRX500FT feature a separate control console that provides on-line network diagnostics.

Sanyo Icon markets its LANser MRX disk array products through a series of Value Added Systems Integrators (VASIs) in the U.S. Overseas, all Sanyo Icon products are sold through a distributor network in Canada, Europe, South Africa, South America, Australia and the Pacific Rim. Sanyo Electric markets the products in Japan.

European Manufacturers

ARCO ELECTRONICS INC. (Subsidiary of ARCO Electronic Control Ltd., Israel)
2750 North 29th Avenue, Suite 316
Hollywood, FL 33020

ARCO was founded in 1987 and is a supplier of LAN controllers and storage subsystems for personal computers. The firm is a subsidiary of ARCO Electronic Control, an Israeli company specializing in industrial electronics, and timers. In late 1992, ARCO began shipping a RAID-1 array including a board with two mirrored 2.5" drives mounted on the board. The board, which has a Microchannel interface, can also attach to two external drives instead of drives mounted on the board.

BAYDEL LTD.
Brook Way
Leatherhead
Surrey KT22 7NA
United Kingdom

RAID-3 array controllers and subsystems are among the products of Baydel. Controllers are supplied on an OEM or PCM basis to firms in the U.S. and in Europe, while most complete subsystems are sold in Europe. Most European sales are through distributors in the U.K., Germany and Switzerland. The array attaches to a host SCSI port, and includes a cache ranging from 4 to 64 megabytes in capacity.

The firm was founded in 1972 by engineers from IBM's Hursley research establishment, and initially designed and fabricated peripheral equipment for the IBM and DEC systems market. Add-on products for the PC market have been part of the product line in 1988. Controllers supporting mirroring and caching were first developed in 1979, but the first RAID-3 units were shipped in 1991.

GROUPE BULL
121, avenue de Malakoff
75116 Paris
France

Groupe Bull is the parent organization of an intricate grouping of companies active in the computer industry. Included are Compagnie des Machines Bull, the successor to a long line of French computer organizations, and now the parent company for all Bull computer programs. Also included are the organizations previous known in the United States as Honeywell Information Systems and Zenith Data Systems.

Computer operations except for personal computers are the responsibility of Bull Systems Products, which early in 1993 announced deals with Data General

to resell the DG Clariion RAID-0/1/3/5 array subsystems for UNIX applications and with EMC to resell the Symmetrix 4800 RAID-1 subsystems for mainframe applications. Zenith Data Systems has been reselling Integra RAID-5 software arrays for personal computer applications.

HI-DATA LIMITED
61 Reading Road, Unit 8
Pangbourne, Berkshire RG8 7HY
United Kingdom

Hi-Data manufactures and sells array controllers and subsystems capable of operating at RAID level 3 and in hybrid RAID-3/RAID-5 modes Hi-Data calls RAID-53 and RAID-35. Redundant fans and power supplies are provided in the Hi-Data subsystems. A second array controller can be provided as an option to provide controller redundancy. Hot sparing and hot swapping are also supported.

Because the array market in Europe is less active than in the U.S., Hi-Data has opened a sales and support office in Woburn, MA, and has been promoting its presence in the market through participation in small exhibitions and through other public relations activities.

MEMOREX TELEX CORPORATION (Subsidiary of Memorex Telex N.V.)
4343 S. 118th East Avenue
Tulsa, OK 74146

The pioneer magnetic media and plug compatible disk drive producer originally known as Memorex Corporation was acquired by Burroughs in late 1981, and Burroughs placed all disk drive development and manufacturing responsibility for the entire company in the Memorex organization. In late 1986, however, Burroughs sold the disk drive sales and service operations of Memorex to a group of Memorex executives, retaining only the rigid disk development and manufacturing operations. Telex was acquired by Memorex in early 1988 and the firm adopted its new name. Plug compatible disk drive subsystems now sold and serviced by Memorex Telex use various drive mechanisms manufactured by Fujitsu and Seagate. Memorex, now headquartered in Europe, includes PCM marketing operations, the Memorex Communications Division, and the flexible media operations. The firm is under financial stress, and in mid-1991 announced that it would enter a "pre-packaged bankruptcy" arrangement in the Fall of 1991. The associated restructuring was completed in February, 1992.

Memorex-Telex has been offering a RAID-1 subsystem in the AS/400 add-on market during the past year, using an array manufactured by Formation.

SOLID COMPUTER GMBH
Bruckmannring 32
D-8042 Oberschlessheim
Germany

Solid Computer is a system integrator and manufacturer offering SPARC workstation clones and a variety of controller cards for Sun and other systems. Also in the product line are solid state disk drives, optical disk drive subsystems, tape subsystems and servers. The firm has announced an array subsystem capable of operating at RAID levels 0, 1, 3, and 5, which began shipping in late 1992. While most sales have been in Europe, a U.S. subsidiary, Solid Computer Corporation is beginning to develop business domestically. The subsidiary is located in Norcross, GA.

TWINCOM INTERNATIONAL
Slotlaan 15
4902 AD Oosterhout
The Netherlands

TwinCom is offering mirroring software for UNIX systems in Europe and in U.S. markets. The software can operate RAID-1 arrays locally or over a network. Sales are made through distribution and on an OEM basis. A U.S. marketing and support office is located in Shreveport, Louisiana.

TwinCom's product is derived from mirroring software developed 12 years ago for a Dutch pharmaceutical company. It was ported to UNIX in 1983, and first became generally available in 1986 as a system drive mirroring product. Support for multiple pairs became available in 1989 and for networks in 1992.

DISK/TREND ON DISK

1993 DISK/TREND REPORT

DISK/TREND ON DISK

Introduction

DISK/TREND ON DISK is a licensed set of floppy disks available for separate purchase that contain the statistical tables and specification tables from the annual DISK/TREND Reports. The disk files have been prepared in a format usable on IBM or IBM-compatible computers running under the MS-DOS or PC-DOS operating system. A system with a hard disk is highly recommended, but a system with two floppy disks can be used if necessary. All DISK/TREND ON DISK files contain data only -- manipulation of data is the user's responsibility. Because some of the files can be very large, system memory of 640K or more is recommended.

Two types of diskette files are supplied for each DISK/TREND disk drive report. The first type contains the statistical tables in ASCII format. File names are keyed to the table numbers in the report for easy identification. The second type contains the specification section in a Lotus 1-2-3 data base format. Multiple disks of each type are provided where the files are too numerous or too large to fit on a single floppy disk. The color of the label of the floppy disk is similar to the color used on the cover of the corresponding report for ease in identification.

Because the statistical tables are provided in ASCII format, they can be used with any spreadsheet program that can import ASCII text files. However, the specification tables have been prepared specifically in Lotus 1-2-3 format to allow them to be searchable using Lotus 1-2-3 data base commands. If you are using a spreadsheet program other than Lotus 1-2-3 that can translate Lotus WK1 formatted files to its own format, it may be able to import the specification tables without difficulty.

A file translation program, AutoImport, is available from DISK/TREND to assist in converting the data supplied to the formats of several popular spreadsheet programs. One copy of AutoImport is provided automatically at no extra charge to DISK/TREND subscribers who have purchased an original copy of DISK/TREND ON DISK but is provided only in the first year DISK/TREND ON DISK is purchased. Updates to AutoImport may be provided in following years at DISK/TREND's discretion. Extra copies of AutoImport may be purchased at any

time. If you have not purchased DISK/TREND ON DISK, but would find AutoImport useful with other file translation tasks, it may be purchased independently from DISK/TREND or White Crane Systems, Inc.

The authors of this manual assume that you are familiar with personal computers, Lotus 1-2-3 or other spreadsheets, and MS-DOS, and do not cover their operation in this manual. This manual deals specifically with how to load and use the files supplied on the floppy disks.

Note: Please read the license on the following page.

DISK/TREND ON DISK

Information License

DISK/TREND supplies diskettes containing selected information from the 1993 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1993 DISK/TREND Report volume.

YOU MAY:

1. Install and use the information on a single computer system, provided that you or the organization by which you are employed has purchased at least one copy of the DISK/TREND report volume associated with the information.

2. Make backup copies of the information for your own use. Such backup copies may be used only on the computer on which the information is installed. You must reproduce the copyright notice on any copies.

3. Reproduce the information, but not the associated programs or documentation, contained in the Product for use within internal documents distributed within the organization by which you are employed.

YOU MAY NOT:

1. Install, or allow the use of, the information on more than a single computer system.

2. Transfer the information through or within a computer network.

3. Distribute the information or any portion thereof in any form outside the organization by which you are employed or modify the information for purposes of distribution.

4. Transfer this license to another party.

AUTOIMPORT

Use of AutoImport is subject to license terms and conditions of White Crane Systems, Inc.

Trademarks

IBM is a trademark of International Business Machines Corporation.
Lotus and Lotus 1-2-3 are trademarks of Lotus Development Corporation.
MS-DOS is a trademark of Microsoft Corporation.
AutoImport is a trademark of White Crane Systems, Inc.

1993 DISK/TREND REPORT

Getting started

The first thing you should do is to make working copies of the original DISK/TREND diskettes. Place the originals in a safe location and use only the working copies for day-to-day operations. This procedure will help to protect your data from inadvertent destruction or loss due to a malfunction of the computer or its operator. We also recommend that you place a write protect tab on the working copies (after you create them) for the same reason. Use the hard disk or another floppy disk copy for day-to-day manipulations of the files.

The statistical tables are provided in ASCII text format. This allows you to use any word processor to edit the file prior to importing it into Lotus 1-2-3. Appropriate editing removes any material you don't wish to work with and allows you to add figures or text to the data tables. You may also embed the data in internal documents or reports you are preparing for use within your company.

To convert the statistical tables to a spreadsheet you may use the AutoImport utility software, which is probably quicker and easier than the typical text file import and conversion procedure provided with spreadsheet programs. One copy of AutoImport is provided automatically at no extra charge to each DISK/TREND subscriber who has purchased an original copy of DISK/TREND ON DISK and is provided in the first year DISK/TREND ON DISK is purchased. Updates to AutoImport may be provided in following years at DISK/TREND's discretion. Extra copies of AutoImport may be purchased at any time.

DISK/TREND ON DISK is normally shipped on 1.2 megabyte 5.25" floppy disks, but is also available on 1.44 megabyte 3.5" disks if requested.

STATISTICAL TABLES

Loading and Installation

1. Place the floppy disk marked "Tables" in a floppy disk drive able to read your size disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the Lotus 1-2-3 system disk in drive A. Use the DOS 'DIR' command to examine the file directory on the "Tables" disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

   TYPE A:READ.ME (Use the appropriate drive letter if not A)

   If you wish to print the instructions, turn on your printer and type:

   TYPE A:READ.ME>PRN

2. Do this step if you have a hard disk. Log into the hard disk directory in which Lotus 1-2-3 normally stores worksheet files. Using the DOS 'COPY' command, copy all the statistical table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?T*.*

   Several utility files should also be copied. The command is:

   COPY A:*.PRN (if you are using the Lotus 1-2-3 data parsing commands)
   COPY A:*.MSK (if you are using AutoImport)

   The utility files named FORMLIN?.PRN are specifically for usage with Lotus 1-2-3 data parsing if you prefer not to use AutoImport for file translation.

   Installing AutoImport: If you have a hard disk, create a directory named AIMP (You could use other names if you prefer). Now place AutoImport disk 1 in drive A and type: A:INSTALL C:\AIMP and then ENTER. Follow any instructions appearing on the screen until installation is complete. To make AutoImport accessible from any directory, place C:\AIMP in your AUTOEXEC.BAT file's 'PATH' statement. See your MS-DOS instruction manual for information about this step.

   If you are using a floppy-only system, copy the AutoImport disks and use only the copies in following steps. In a floppy-only system, AutoImport disk 1 should be in drive A when AutoImport is in use for file translation.

3. If you are using AutoImport (highly recommended) for translation of files to spreadsheet format, do the translation at this point. See the following section on using AutoImport for details.

4. Now you are ready to start your spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the spreadsheet system disk in drive A. If you are using a rigid disk system, place a copy of the spreadsheet system disk in floppy drive A if required by the security provisions of your spreadsheet program. Now start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the appropriate file retrieval command to select a file. An example of a Lotus 1-2-3 command is:

   /FR<filename>

   The file names are in the format XTYY.WK1, where:

   X= Type of data
   F (Flexible disk drive data)
   R (Rigid disk drive data)
   O (Optical disk drive data)
   A (Disk drive array data)

   YY= Table number, as shown in the appropriate report volume

   Examples:
   File RT10.WK1 is Rigid Disk Drive Report Table 10
   File FT2.WK1 is Flexible Disk Drive Report Table 2
   File OT1.WK1 is Optical Disk Drive Report Table 1
   File AT3.WK1 is Disk Drive Array Report Table 3

   The file selected will be loaded as a worksheet. If this is the first time the file has been loaded, you may want to create your own formulas linking the cells of the spreadsheet. See your spreadsheet reference manual for details on numerical manipulations and graphics.

If you don't use AutoImport

If you don't use AutoImport but still want to translate ASCII files to your spreadsheet format, you will have to use spreadsheet tools such as the Lotus 1-2-3 Data Parse commands. They allow the user to convert a table which has been imported in the form of a block of text to a form in which the individual numbers and labels can be manipulated as spreadsheet elements or used to prepare graphics. Let's take Lotus 1-2-3 as an example. Before proceeding, it would be useful to read the Lotus reference manual on this subject if you are not a regular user of the Data Parse commands.

The trickiest and most time-consuming part of using the Data Parse com-

mands is setting up the format line. Several utility files have been provided on the tables disk to make this process easier. These are used with various table formats encountered in the DISK/TREND Reports and correspond with the precomputed masks provided for use with AutoImport:

o FORMLINA.PRN	Used with Tables 1 and 2 and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.
o FORMLINB.PRN	Used with Tables 3 and 4.
o FORMLINF.PRN	Used with Tables 5 through 12.
o FORMLIND.PRN	Used with Application tables.
o FORMLINE.PRN	Used with Drive Height, Drive Capacity and Track Density tables in Flexible Disk Drive Report.

There are no FORMLIN format files for disk diameter tables or market share tables, as these are variable in format. You will have to construct the format line directly, but after you have seen how it is done for the other tables, this should not be too big a job.

After you have used spreadsheet tools to translate a file, you will understand why we recommend AutoImport for this function.

Using AutoImport

Using AutoImport is a two-step process. Step one is creation of a translation mask for each format used in files to be converted. The typical DISK/TREND Report uses 5 to 7 standard mask designs (which have been precomputed and included on your Statistical Tables disk) plus additional masks that are dependent upon table content, as some table types have variable numbers of columns. You will have to create your own masks for such tables, but this can be done easily as shown below.

Step two is the translation process. Once the mask has been created, it can be used with any table matching the mask format. See the tables below which relate table types to specific masks.

MASK TABLE

Mask File Name	Rigid Report	Flexible Report	Optical Report	Array Report
MASKA	<-------- Table 1--------->		Tables 1,2	Table 1
	<-------------- Product Group Revenue ------------------>			
	<-------------- Product Group Shipment ------------------>			
MASKB	<-------- Table 2 -------->		Tables 3,4	Table 2
MASKC	Tables 3,4,6,9, 10,11	Tables 3,4	Tables 5 to 12	Tables 3 to 7
MASKD	<-- All Product Group Application Tables ---->			N/A
MASKE	N/A	Drive Height, Track Density, Drive Capacity	Write-Once/ Erasable Analysis	N/A
MASKF	N/A	Applications Summary	N/A	N/A
MASKG	*	Product Group Market Share	*	*
MASKH	Tables 7,8	N/A	N/A	N/A
MASKI	Product Group Price/Megabyte	N/A	N/A	N/A

N/A = Not applicable to this report

* Variable format depending upon number of disk diameters in the product group.

TABLE NUMBER TO MASK CROSS-REFERENCE

Table Number	1992 Rigid Report	1992 Flexible Report	1992 Optical Report	1993 Array Report
1	MASKA	MASKA	MASKA	MASKA
2	MASKB	MASKB	MASKA	MASKB
3	MASKC	MASKC	MASKB	MASKC
4	MASKC	MASKC	MASKB	MASKC
5	MASKC	--	MASKC	MASKC
6	MASKC	--	MASKC	MASKC
7	MASKH	MASKF	MASKC	MASKC
8	MASKH	MASKA	MASKC	--
9	MASKC	MASKA	MASKC	--
10	MASKC	MASKE	MASKC	MASKA
11	MASKC	MASKD	MASKC	MASKA
12	--	MASKG	MASKC	--
13	--	MASKA	--	--
14	MASKA	MASKA	--	--
15	MASKA	MASKE	--	MASKA
16	--	MASKE	--	MASKA
17	--	MASKD	MASKA	--
18	MASKD	MASKG	MASKA	--
19	MASKI	MASKA	--	--
20	--	MASKA	--	MASKA
21	MASKA	--	MASKD	MASKA
22	MASKA	--	--	--
23	--	MASKE	MASKA	--
24	--	MASKE	MASKA	--
25	MASKD	MASKD	--	MASKA
26	MASKI	MASKG	--	MASKA
27	--	MASKA	--	--
28	MASKA	MASKA	--	--
29	MASKA	--	MASKE	--
30	--	--	MASKD	
31	--	MASKD	--	
32	MASKD	MASKG	MASKA	
33	MASKI		MASKA	
34	--		MASKD	
35	MASKA		MASKA	
36	MASKA		MASKA	
37	--		MASKA	
38	--		MASKA	
39	MASKD		--	
40	MASKI		--	
41	--		MASKE	
42	MASKA		MASKA	
43	MASKA		MASKA	
44	--		--	
45	--		--	
46	MASKD		MASKE	
47	MASKI		MASKA	

Cross reference (continued)

Table Number	1992 Rigid Report	1992 Flexible Report	1992 Optical Report
48	--		MASKA
49	MASKA		--
50	MASKA		--
51	--		MASKE
52	--		
53	MASKD		
54	MASKI		
55	--		
56	MASKA		
57	MASKA		
58	--		
59	--		
60	MASKD		
61	MASKI		
62	--		
63	MASKA		
64	MASKA		
65	--		
66	--		
67	MASKD		
68	MASKI		
69	--		
70	MASKA		
71	MASKA		
72	--		
73	--		
74	--		
75	MASKD		
76	MASKI		
77	--		

-- indicates that the format of this table is variable. Create a mask using AutoImport if a spreadsheet is needed.

Translation using precomputed masks

1. First, copy the files you wish to translate to the AIMP directory from DISK/TREND ON DISK floppy disk. Go to the AIMP directory, insert the floppy disk in drive A and type the following commands:

   COPY A:?T*.*
   COPY A:*.MSK

   These commands copy the data files and mask files you need.

   If you are using a two floppy disk system, copy the files you want to translate to a second floppy disk along with the mask files. Make sure that no more than half of the floppy disk is filled, because you will need space for the converted files.

2. Now start AutoImport. When the opening screen appears, select the "TRANSLATE" menu item using the arrow keys or just type "T". (The AutoImport menu system works just like the menus in Lotus 1-2-3.)

3. When the next screen appears, enter the name of the mask to use on the top line where the highlighted space is. If a standard mask is being used, see the mask table above to choose the mask file name to enter. If you used a mask previously, the system defaults to the last mask named. Press "ENTER".

4. Select the output file name. Type /OFT (Output:File:Type-in)

   Enter the name of the file. The file name form recommended is ?Tnn, where ? is the type of report (R, F, or O), T is just that, and nn is the DISK/TREND Report table number matching the file being translated. You should not enter the file name extension as the system adds it automatically for you. Press "ENTER".

   Examples: RT4 FT12 OT14 AT20

5. Enter the input file name using the same file naming convention as above. Type /IT (Input:Type-in)

   Enter the name of the file, including the extension, which will be of the form yy? where yy is the year of the report and ? is the report type as above.

   Examples: RT4.93R FT12.93F OT14.93O AT19.93A

6. The default spreadsheet type to which the translation is made is Lotus 1-2-3 version 2.x. If you wish to translate to a different spreadsheet format you may choose it by typing /TS (Task:Spreadsheet)and then selecting your preference from the menu of choices displayed.

7. You are ready to translate. Type "G" for "GO" or select "GO" using the arrow keys. You will see the file being translated scroll by as the translation proceeds.

8. If you want to do more translations, repeat from step 3.

9. When you are done translating, leave AutoImport by typing /Q (Quit) to return to the AutoImport main menu and then /E (Exit) to leave AutoImport and return to DOS. It will save you some keystrokes if you copy your new spreadsheet files to your spreadsheet directory. If you are using a two floppy system, just remove the AutoImport disk from drive A and substitute your spreadsheet disk.

Mask Generation

1. Start AutoImport as above. When the opening screen appears, select "Mask" using the arrow keys or type "M".

2. Name the file you will use as the template to create the mask. The file name will be of the form ?Tnn.yy?, where ? is the type of report (R, F, or O, A), nn is the table number and yy is the report year.

   Example: AT10.93A

   To name the file, type /FIT (File:Input:Type-in). When the highlighted blank space appears, fill it in with the file name and press 'Enter'. The contents of the file will now appear on the screen.

3. Next define the header lines. These are lines that are translated to the spreadsheet as a single cell of text. Place the cursor at the top of the header area, normally at the left top of the report table. Now type /LH (Line:Header). Using the down arrow key, expand the highlighted area until it extends to just above the first row of numerical data. Press 'Enter'. If there are any footnotes at the bottom, the lines in which they appear can be treated the same way by locating the header at the left margin of the first footnote line, typing /LH, extending the highlight area over the note and pressing 'Enter'.

4. Next, locate the longest left margin label (excluding the header lines) in the table. Position the cursor so that it is at the left margin of the line containing the longest label. Type /AY (Auto:Yes). This step actually creates the mask. Check to be sure all figures have been delineated properly. If not, see below.

   In a few cases, the automatic feature may be confused by a table layout and all values will not be picked for conversion. In these unusual cases, you may be able to get the overlooked values included by repeating this step on another line.

   Another unusual case can occur in which the right-hand part of a label is somehow included in a value occurring in the next column to the right. Deal with this rare case as follows:

   o Place cursor in left margin of offending line. Type /CW to adjust width and then use arrow keys to move right column margin clear of the column of values.

   o Set cursor on last position of column to the right of the left margin labels. Type /DCO to delete this one column from the mask.

   o Now place the cursor in the first space to the right of the left margin

label column. Type /C and then adjust the column width to encompass all places in the values column you have been working with. This will restore the mask column, also.

5. Save the mask in a mask file. Type /FMS (File:Mask:Save). Fill in the name of the mask file.

   Example: AT10MSK

6. Save the output file. Type /FOT (File:Output:Type-in). Now enter the file name.

   Example: AT10. You don't need to enter the file extender.

7. To make more masks, repeat from step 2. To quit the mask function, type /Q (quit). This returns you to the AutoImport main menu. To leave AutoImport, type /E.

Other AutoImport Functions

AutoImport can do much more than the functions described above, which are those concerned with a basic understanding of how to create spreadsheets from DISK/TREND ON DISK files. See the separate AutoImport manual provided for details of these other functions.

SPECIFICATION TABLES

Loading

1. Place the floppy disk marked "Specifications" in a floppy disk drive able to read your size disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the spreadsheet system disk in drive A. Use the DOS "DIR" command to examine the file directory on the "Tables" disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

   TYPE A:READ.ME (Use the appropriate drive letter if not A)

   If you wish to print the instructions, turn on your printer and type:

   TYPE A:READ.ME>PRN

2. Do this step if you have a hard disk. Log into the hard disk directory in which your spreadsheet normally stores worksheet files. Using the DOS "COPY" command, copy all the specification table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?S*.*

3. Now you are ready to start Lotus 1-2-3 or other spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the Lotus spreadsheet system disk in drive A. If you are using a rigid disk system, place the spreadsheet system disk in floppy drive A. If your spreadsheet is not Lotus 1-2-3, you will have to translate the data from Lotus 1-2-3 to your format. Almost all spreadsheet packages of recent vintage are able to do this translation. After translation, if needed, start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the spreadsheet File Retrieve command to select a file. The equivalent Lotus 1-2-3 command is:

   /FR<filename>

   The file names are in the format XSYZZ.WK1 or XSYZZ.WKS, depending upon which version of Lotus 1-2-3 you are using. X,Y, and Z are:

   X= F (Flexible disk drive data)
   O (Optical disk drive data)
   R (Rigid disk drive data)
   A (Disk drive array data)

Y= Table number. Usually, there is only one table, but if the specification file is so large as to need multiple disks to hold it, there may be several.

ZZ= Year of report.

Example: AS193 Disk drive array specification table

Note that the specification tables load directly as a data base. You can use the data base functions of Lotus 1-2-3 to sort, count or otherwise manipulate the data for purposes of special analysis. Other spreadsheets may have similar capabilities.

Using the specification data base

Introduction: If you have not used the Lotus 1-2-3 /DATA QUERY commands, it will be helpful for you to review the sections of the Lotus 1-2-3 reference manual that pertain to their use before proceeding further.

The specification data base fits into a worksheet format of 25 to 30 columns, depending upon whether rigid, optical or floppy drives are involved, and a row count of up to 500 rows. Each row represents a specific record, and is equivalent to a single column in the Specifications section of the DISK/TREND report. Each column represents a specific specification parameter, and is equivalent to one row of the DISK/TREND report.

The data base has been set up for data extraction using Lotus 1-2-3 commands. The Input, Output and Criterion ranges have been predefined, but you, the user, will have to decide how you want the extracted data manipulated and place the appropriate Lotus functions, such as @COUNT, in the appropriate cells. Some rows between the bottom of the input range and the top of the output range have been left empty so that you can do this easily. When the data base is first loaded, you will see the top of the input range, showing the first column (manufacturer name) for the first several manufacturers. Use the arrow keys to find other manufacturers or specific product specifications. If you are not using Lotus 1-2-3, use the equivalent procedure for your spreadsheet.

Operating tips

Expanding the input or output ranges: The predefined output range is of a nominal size, and a search with broad parameters may result in overflowing the output range. In such a case, merely extend the output range (add more rows) using the Lotus 1-2-3 /DQEO command. Similarly, it is possible to extend the input range to add more products, but be sure you move the output range so that there is no overlap.

Memory overflow: If you should receive a memory overflow message while manipulating the specification data, it is usually because:

- There are other "pop-up" programs resident in the memory of your computer. These should be removed.
- You have selected too large an output range. Use a smaller output range or delete some of the columns that contain data not relevant to your analysis. If you delete data, be sure that if you save your spreadsheet you use a different file name, otherwise you will overwrite the original file with the modified spreadsheet.
- If you receive a memory overflow message while loading the data base, the data base is too large for your computer's available memory. You probably will have to remove other resident programs and reload Lotus 1-2-3 and the data base. If your computer doesn't have 640K memory, you will probably get this message.

Saving time

The specification data base is large and takes significant time to recompute or perform other operations. If you are interested in drives that belong to only a few product groups, it will probably save you time in the long run if you extract only those groups you are interested in into a new worksheet and use that for the analysis. Use spreadsheet FILE EXTRACT and FILE COMBINE commands for this purpose.

Another way to save time is to use the SORT capabilities of your spreadsheet to organize the data the way you find it most useful. The most commonly done sorts are by manufacturer name and by DISK/TREND product group, but it would also be possible to sort by average seek time, price, and so on.

Make sure that when you save a worksheet using the FILE SAVE command

that you save it in a new file name. If you save it in the file name from which it was loaded, the original copy will be overwritten. If a file is overwritten unintentionally, it can take a long time to recreate.

If you are interested in only a subset of product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and then use the second file for analysis. The smaller file will take less time to process.

Technical support

Just about all of your questions regarding the use of DISK/TREND ON DISK should be answered in this manual or in the Lotus 1-2-3 reference manual. However, if you need to contact us to resolve any points of confusion, report errors, or otherwise receive comfort:

Call us at: **415-961-6209**

Ask for Technical Support for DISK/TREND ON DISK

In order to make this process efficient, when you call--

1. Tell us what is on the diskette label.

2. Have your computer up and displaying the data or operation that is the subject of your call.

3. Have this manual and the Lotus 1-2-3 reference manual handy.

If you have questions about AutoImport as it is used with DISK/TREND ON DISK, contact DISK/TREND at the number above. Questions about other functions of AutoImport should be referred to White Crane Systems.

Apple Macintosh compatibility: While DISK/TREND on DISK has been prepared for use on IBM PC compatible computers, users have reported that they are able to translate files into Macintosh format using Apple Computer software. The specific software reported used is Apple File Exchange.

Special data

The specification data base contains one category of information not present in the hard copy report. This is the country code field, representing the continental region in which the headquarters of the drive producer is located. A key is located at the top of the adjacent column to the right.

In order to make it easier to do sorting or extraction analysis on the data, the contents of certain fields have been modified and are not exactly the same as in the printed report tables. Some affected fields have been converted to purely numeric fields as described below. Where multiple values existed, the value representing the highest level of performance or capability has been retained.

Comments and asterisks in the affected fields have been eliminated. A '0' means that no data was available. Asterisks are retained in the comment field so that you will have an indication that one or more characteristics of the drive was referenced to a comment. Check the printed report table for details.

The affected fields are:

Group:	Numeric conversion: Now you can extract a range of groups.
Host_chans:	Numeric conversion: You can sort or extract on a value or range of values for number of host channels.

A country code field has been added in the last column of the data base.
The code explanation is:

1 = U.S. manufacturer
2 = Asian manufacturer
3 = European manufacturer
4 = South American or other manufacturer

Codes are based upon the location of the manufacturer's headquarters.

First ship date has been modified so that the last two characters will always represent the year of shipment. An entry of ??89 in the criterion field for the First Ship Date column will cause all products first shipped in 1989 to be extracted.