1997 DISK/TREND® REPORT

RIGID
DISK
DRIVES

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RIGID DISK DRIVES

June, 1997

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FOREWORD

In mid-1997, the rigid disk drive industry has spent most of the last 12 months trying to make enough drives to satisfy demand -- and not making quite enough, judging from the allocation procedures that most major manufacturers utilized. However, supply and demand seem to be in equilibrium for most types of disk drives as we approach the second half of 1997. In other words, normal. So the industry can settle down to introducing new generations of drives which will make all of the existing products obsolete in a year or two, continue the development of technology improvements which will replace most of the existing components and manufacturing systems, and ponder alternative actions to be taken when the areal density improvement curve for magnetic recording runs out of gas. Definitely another normal year.

This is the second year that the DISK/TREND Report on rigid disk drives has been published in the Spring, instead of the Autumn. The report on disk drive arrays, previously published in the Spring, is now published in October. As usual, the report on optical disk drives will be available in July, and the report on removable data storage will be published in August. If you haven't yet done so, we suggest you visit DISK/TREND's Web site (http://www.disktrend.com), which contains information on current industry events and links to every known Web site in the disk drive industry.

DISK/TREND ON DISK, statistical and specification tables on floppy disks, is again available to subscribers to the DISK/TREND Report. Instructions for using the disks are included at the end of this report.

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

We've had to revise the product groups again

The upward movement in average disk drive capacities is relentless. The impact on the organization of this year's DISK/TREND Report is that we again found it necessary to revise the product groups used at the bottom and at the top of the capacity ranges used for fixed disk drives. We always avoid any unnecessary changes in the way the report is organized, since we know that many companies organize their industry data accordingly, but the rapid realignment of the industry's product lines made the change appropriate. In fact, a few days before this edition of the DISK/TREND Report went to the printer, the industry's first 18 gigabyte 3.5" drive announcement was made.

In the lower capacity ranges of fixed disk drives, we combined the product groups below 500 megabytes into a single "less than 500 megabytes" group. At the high end, the expected introduction of numerous drives during this forecast period has prompted us to split the previous top capacity product group into two new groups: "10-20 gigabytes" and "more than 20 gigabytes". While these product groups make it possible to intelligently organize the data for our forecasts extending through 2000, we fully expect to have to revise the product groups again in a year or two, given the rate at which the industry is making improvements in recording density.

Removable data storage data may appear in two DISK/TREND Reports

We will publish the separate report on removable data storage in August, for the third year. The removable data storage report includes some information also included in this volume on disk cartridge drives and on 1.8" PC Card disk drives -- plus coverage of PCMCIA flash cards, small optical disk drives and floppy drives. In the removable data storage report, the section on disk cartridge drives is substantially the same as the product group in this report on disk cartridge drives, and the data on 1.8" PC Card drives is extracted from several product groups in this report.

Please note how the DISK/TREND Report counts sales revenues

Various market studies report revenues and unit shipments in several ways, and you will find the information in this report much more helpful if you understand the basic ground rules we have followed with the DISK/TREND Report. We report all disk drive revenues at the level of the product's first public sale by the manufacturer, at the estimated transaction price, whether the sale occurs at the captive, PCM/Distributor or OEM/Integrator levels. This is the same method used by individual companies in published financial reports.

SUMMARY: RIGID MAGNETIC DISK DRIVES

Industry size

The aggressive growth pattern established by the rigid disk drive industry is clearly going to continue for the foreseeable future. Key to this growth is the ongoing expansion of the major markets for disk drives, desktop personal computers, notebook computers, and the disk storage subsystems used with mainframes, networks and numerous specialized applications. The long-term growth of these markets isn't slowing down, and neither is the relentless upward movement in the typical disk drive capacities used in each market. Supplementing the traditional uses of these systems, disk storage growth is continually enhanced by new applications, including Internet requirements, data warehousing, remote site mirroring, RAID subsystems, multimedia and video processing, plus the nonstop flow of expanded software applications into the personal computer market.

The continuing expansion of the industry's major markets is making it possible for the disk drive industry to maintain a high growth rate. Worldwide unit shipments reached 105 million drives in 1996, and the 2000 total is projected at 201.2 million units, an average annual increase of 17.7%. The industry's sales revenues were $28.8 billion in 1996, and the 2000 estimate is $75.9 billion, up an average of 27.6% per year. Underlying the enhanced revenue growth is the increasing disk capacity now in demand for numerous applications, an enhancement in demand which is increasing faster than the industry's expected increases in areal density.

PCM/Distributor revenues have increased in recent years, reaching an estimated 27.3% of the 1997 total, pushed up by strong PCM shipments to enterprise systems sites and continuing upgrade and add-on sales to personal computer users. However, it is expected that the personal computer segment of this market will soften somewhat as system manufacturers begin to add much larger disk drives, installed at the factory, to their basic PC models. As this trend continues, the PCM/Distributor share of total industry revenues is expected to decline to 25.2% in 2000. Meanwhile the majority of drives are now shipped in the OEM/Integrator channel, and the OEM revenue share is expected to increase from 50.2% in 1996 to 64.0% in 2000.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

RIGID MAGNETIC DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	3,719.7	5,457.8	3,598.5	5,350.3	3,601.1	5,184.7	3,608.3	5,464.2	4,243.4	6,512.7
Other U.S. Captive	29.0	40.9	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	3,748.7	5,498.7	3,598.5	5,350.3	3,601.1	5,184.7	3,608.3	5,464.2	4,243.4	6,512.7
PCM/Distributor	3,055.2	6,196.3	3,990.1	7,735.2	5,906.7	9,821.6	9,897.1	13,177.3	12,382.7	16,048.2
OEM/Integrator	7,227.6	11,454.5	7,475.7	13,312.1	11,226.7	19,324.0	18,159.9	29,512.2	23,181.8	37,562.0
TOTAL U.S. NONCAPTIVE	10,282.8	17,650.8	11,465.8	21,047.3	17,133.4	29,145.6	28,057.0	42,689.5	35,564.5	53,610.2
TOTAL U.S. REVENUES	14,031.5	23,149.5	15,064.3	26,397.6	20,734.5	34,330.3	31,665.3	48,153.7	39,807.9	60,122.9
Non-U.S. Manufacturers										
Captive	247.5	1,499.5	277.2	1,466.0	327.6	1,550.9	330.2	1,578.2	368.3	1,673.0
PCM/Distributor	597.5	1,155.1	827.6	1,534.2	1,165.5	1,986.3	1,451.2	2,534.5	1,799.8	3,129.8
OEM/Integrator	1,143.6	3,015.0	1,762.4	4,603.1	2,343.9	5,817.6	3,485.6	8,041.6	5,003.4	11,053.8
TOTAL NON-U.S. REVENUES	1,988.6	5,669.6	2,867.2	7,603.3	3,837.0	9,354.8	5,267.0	12,154.3	7,171.5	15,856.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	16,020.1	28,819.1	17,931.5	34,000.9	24,571.5	43,685.1	36,932.3	60,308.0	46,979.4	75,979.5

Marketing channels

In the past year, the number of rigid disk drive manufacturers has again declined, resuming the ten-year trend temporarily interrupted during 1996. Currently, there are 22 active manufacturers of rigid disk drives, a reduction in four from the previous year.

The major deletion from the list was Hewlett-Packard, a long-term disk drive manufacturer, which had produced many different types of rigid disk drives over several decades. By the time the program was discontinued in 1996, H-P's disk drive product line was limited to only a few high-end models. In Japan, Tottori Sanyo has been phasing out the old Areal 2.5" drive product line; in South Korea, Tae Il Media cancelled the 3.5" drive program in a start-up phase; in Singapore, Momentum Peripherals only occasionally assembles some 1.8" drives from the old MiniStor parts inventory acquired in bankruptcy proceedings.

The decline in share of worldwide disk drive revenues held by drives sold in the captive sales channel is continuing. A decade ago, the share of total disk drive revenues held by captive drives was in the 60% range, but in 1996 the captive revenue share was down to 24.3%. In 2000, it is projected to be only 10.8%, as producers of noncaptive drives continue to set the pace with rapid product evolution and growing sales for personal computers and network servers. Sales revenues for the OEM/Integrator channel are forecasted to grow at an average annual rate of 35.7% during the 1996-2000 period, reaching a total of $48.6 billion in 2000. Although declining slightly in share, PCM/Distributor revenues are nevertheless expected to achieve growth, with $19.2 billion in 2000.

An understanding of the relative price levels of captive, PCM/Distributor and OEM/Integrator drives is important in interpreting DISK/TREND revenue statistics, to avoid an exaggerated impression of the share held by captive drives. The price used for each drive is the estimated value at the first time it is sold to a nonaffiliated buyer, at captive end user, PCM/Distributor or OEM/Integrator levels. For example, captive drive revenues for 1996 totaled almost $7.0 billion, 24.3% of the overall revenue total. But 1996 captive unit shipments totaled 7.8 million drives, only 7.4% of the total. The reason for the large difference in the percentages is found in the higher end user prices at which captive drives are sold and the fact that many captive drives are expensive high-end models.

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES
RIGID MAGNETIC DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1996 Revenues		Forecast 1997		Forecast 1998		Forecast 1999		Forecast 2000	
	$M	%	$M	%	$M	%	$M	%	$M	%
U.S. Manufacturers										
IBM Captive	5,457.8	18.9%	5,350.3	15.7%	5,184.7	11.8%	5,464.2	9.0%	6,512.7	8.5%
	-4.2%		-2.0%		-3.1%		+5.4%		+19.2%	
Other U.S. Captive	40.9	.1%	--	--	--	--	--	--	--	--
	-91.5%		--		--		--		--	
PCM/Distributor	6,196.3	21.5%	7,735.2	22.7%	9,821.6	22.4%	13,177.3	21.8%	16,048.2	21.1%
	+18.8%		+24.8%		+27.0%		+34.2%		+21.8%	
OEM/Integrator	11,454.5	39.7%	13,312.1	39.1%	19,324.0	44.2%	29,512.2	48.9%	37,562.0	49.4%
	+.7%		+16.2%		+45.2%		+52.7%		+27.3%	
Total U.S. Manufacturers	23,149.5	80.2%	26,397.6	77.5%	34,330.3	78.4%	48,153.7	79.7%	60,122.9	79.0%
	+1.7%		+14.0%		+30.1%		+40.3%		+24.9%	
Non-U.S. Manufacturers										
Captive	1,499.5	5.2%	1,466.0	4.3%	1,550.9	3.5%	1,578.2	2.6%	1,673.0	2.2%
	-19.4%		-2.2%		+5.8%		+1.8%		+6.0%	
PCM/Distributor	1,155.1	4.0%	1,534.2	4.5%	1,986.3	4.5%	2,534.5	4.2%	3,129.8	4.1%
	+120.8%		+32.8%		+29.5%		+27.6%		+23.5%	
OEM/Integrator	3,015.0	10.6%	4,603.1	13.7%	5,817.6	13.6%	8,041.6	13.5%	11,053.8	14.7%
	+104.0%		+52.7%		+26.4%		+38.2%		+37.5%	
Total Non-U.S. Manufacturers	5,669.6	19.8%	7,603.3	22.5%	9,354.8	21.6%	12,154.3	20.3%	15,856.6	21.0%
	+46.9%		+34.1%		+23.0%		+29.9%		+30.5%	
Worldwide Recap										
Captive	6,998.2	24.3%	6,816.3	20.0%	6,735.6	15.4%	7,042.4	11.7%	8,185.7	10.8%
	-12.9%		-2.6%		-1.2%		+4.6%		+16.2%	
PCM/Distributor	7,351.4	25.5%	9,269.4	27.3%	11,807.9	27.0%	15,711.8	26.1%	19,178.0	25.2%
	+28.1%		+26.1%		+27.4%		+33.1%		+22.1%	
OEM/Integrator	14,469.5	50.2%	17,915.2	52.7%	25,141.6	57.6%	37,553.8	62.2%	48,615.8	64.0%
	+12.6%		+23.8%		+40.3%		+49.4%		+29.5%	
Total All Manufacturers	28,819.1	100.0%	34,000.9	100.0%	43,685.1	100.0%	60,308.0	100.0%	75,979.5	100.0%
	+8.2%		+18.0%		+28.5%		+38.1%		+26.0%	

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

Product mix

The current demand for increased computer disk storage appears to be growing even faster than the disk drive industry's pattern of 60% average annual increases in areal density. In 1990, more than half the drives produced had capacities in the range of 30-60 megabytes, but by 1996 drives in the 1-2 gigabyte range were produced in higher quantities than any other group. The growth pattern for disk storage is now so strong that shipment leadership is expected to advance each year to the next higher DISK/TREND product group, with the result that 2000 shipment leadership will be held by drives in the 10-20 gigabyte capacity range.

The market's appetite for higher disk drive capacities for all of the industry's major application areas is expected to continue beyond the current forecast period. Individual personal computer users are using more disk capacity for Windows and application programs, travelers want to be able to do everything on their notebook computers that they can do with their office PC's, network file servers must be constantly upgraded with more disk capacity, the disk capacity used with mainframe computers is still expanding, and new major disk storage requirements for consumer video servers and other specialized applications are starting to appear. The result is continuous upward movement in the typical capacities of individual disk drives used for most applications.

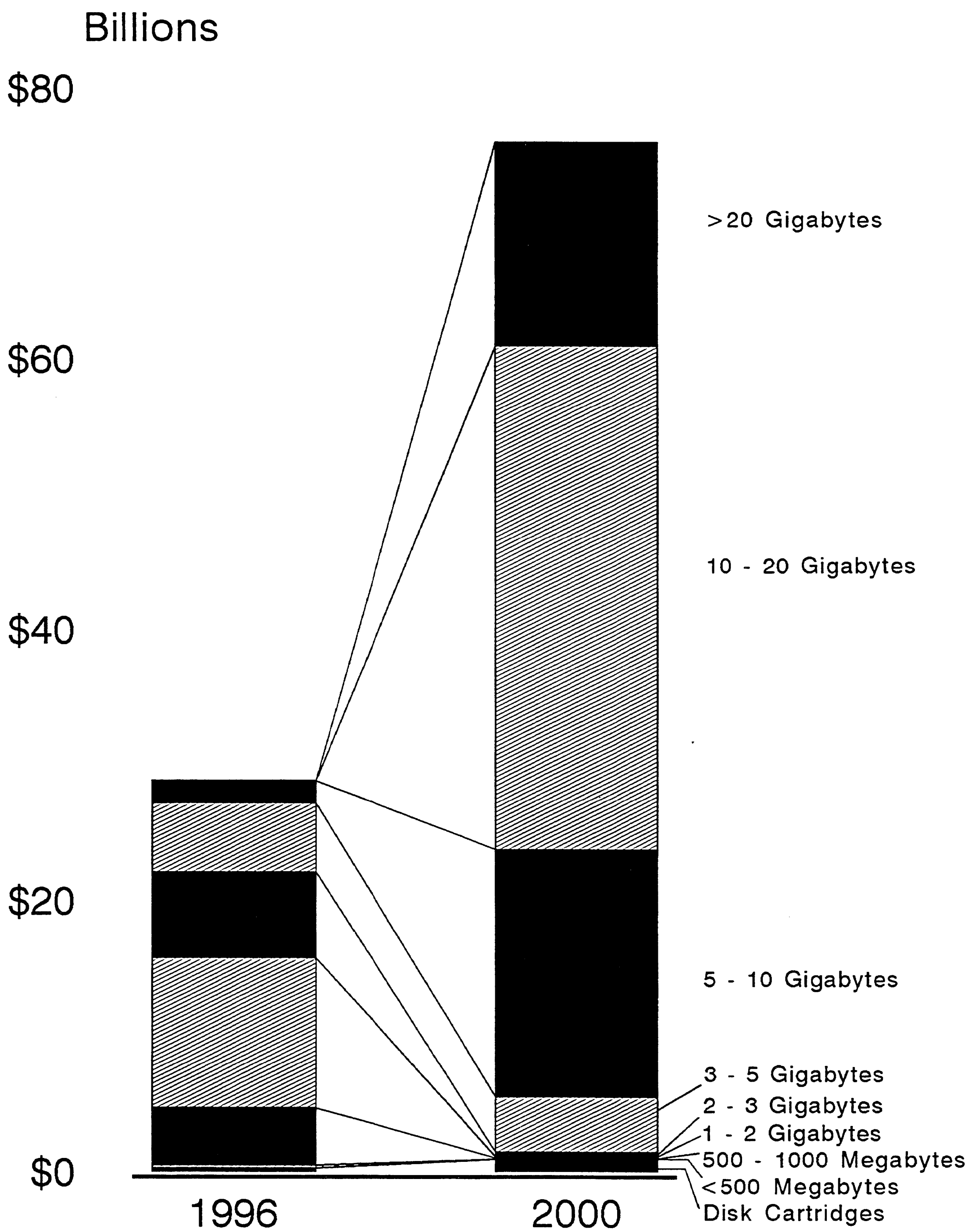
One of the results of continuously increasing areal density has been the obsolescence of all drives with larger disk sizes. After 1996, no significant production of drives with disks larger in diameter than 5.25" is expected. After initially dominating the desktop personal computer market, 3.5" drives benefited from the disk drive industry's widely discussed pattern of 60% annual increases in recording density during the 1990's, and now have large enough capacities to be the predominant choice for network servers and mainframe data storage requirements.

5.25" drives designed for very low manufacturing costs are now being offered in competition with 3.5" drives for personal computer markets at very competitive prices, but it is currently expected that competitors with 3.5" drives will match the larger drives' prices and hold most of the 3.5" business. In 1990, less than 20 million 3.5" drives were shipped, but 168.5 million are projected for

Figure 1

CHANGING PRODUCT MIX

Worldwide Rigid Disk Drive Revenue



2000. A similar pattern of increasing densities has made it possible for 2.5"-3" drives to dominate the notebook computer market, with the one million drives shipped in 1990 expected to grow to 26.2 million in 2000.

Shipments of fixed disk drives in the lower capacity ranges, which once dominated the industry, are rapidly fading away. Next year will be the last year of production of fixed drives with disk diameters of 2.5" or more and with capacities below 1 gigabyte, leaving only 1.8" drives in those capacity ranges. Rapid obsolescence will characterize each capacity range, as average disk capacities continually move up, and as each capacity range peaks in shipments. By 2000, even the 5-10 gigabyte product group will have peaked and will be declining.

2.5"-3" drives enjoy the same benefits of increasing areal density that 3.5" drives are experiencing, and 2.5" drives have actually utilized the highest areal density found in any production drives during the last three years. The share of disk drive industry shipments held by 2.5"-3" drives is expected to increase only slightly during this forecast period, since they are used mostly for notebook computers, which are increasing in shipments only slightly faster than desktop computers. Although the inevitable increases in areal density will probably eventually help 2.5"-3" drives to secure part of the desktop computer disk drive market, significant penetration of that market is not expected through 2000.

1.8" drive manufacturers have been frustrated in their six year campaign to initiate a mass migration to the smaller drives. So far, 1.8" drives have been only slightly successful in the notebook computer market and have had to develop a series of specialized applications with smaller shipment potential. 1997 shipments are estimated at only 355,000, with growth to 765,000 drives projected for 2000.

New products and new market initiatives have generated a greatly increased level of shipments for removable media drives. Established graphics, prepress and security markets have been joined by a range of applications for video and multimedia editing, plus a variety of personal computer applications, to create new sales momentum. 1996 shipments exceeded 1 million drives for the first time, and 2000 shipments are projected to reach 5.5 million drives.

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1996 Revenues $M	1996 Revenues %	Forecast 1997 $M	1997 %	1998 $M	1998 %	1999 $M	1999 %	2000 $M	2000 %
CARTRIDGE DISK DRIVES	237.1	.8%	350.4	1.0%	533.6	1.2%	742.2	1.2%	879.2	1.2%
	+53.2%		+47.8%		+52.3%		+39.1%		+18.5%	
FIXED DISK DRIVES less than 500 Megabytes	219.2	.8%	94.3	.3%	80.7	.2%	63.4	.1%	33.3	--
	-93.1%		-57.0%		-14.4%		-21.4%		-47.5%	
FIXED DISK DRIVES 500 Megabytes - 1 GB	4,207.7	14.6%	542.9	1.6%	91.0	.2%	66.1	.1%	85.1	.1%
	-53.3%		-87.1%		-83.2%		-27.4%		+28.7%	
FIXED DISK DRIVES 1 - 2 Gigabytes	11,057.0	38.4%	5,162.5	15.2%	1,331.8	3.0%	251.1	.4%	82.5	.1%
	+69.3%		-53.3%		-74.2%		-81.1%		-67.1%	
FIXED DISK DRIVES 2 - 3 Gigabytes	6,350.9	22.0%	13,856.4	40.8%	6,421.7	14.7%	1,532.2	2.5%	336.2	.4%
	+36.1%		+118.2%		-53.7%		-76.1%		-78.1%	
FIXED DISK DRIVES 3 - 5 Gigabytes	5,067.2	17.6%	8,259.8	24.3%	17,129.0	39.2%	9,427.8	15.6%	4,060.0	5.3%
	+108.7%		+63.0%		+107.4%		-45.0%		-56.9%	
FIXED DISK DRIVES 5 - 10 Gigabytes	1,661.0	5.8%	5,500.6	16.2%	14,511.9	33.2%	20,976.4	34.8%	18,241.0	24.0%
	+165.3%		+231.2%		+163.8%		+44.5%		-13.0%	
FIXED DISK DRIVES 10 - 20 Gigabytes	--	--	106.5	.3%	3,431.0	7.9%	23,130.1	38.4%	37,143.3	48.9%
	--		--		--		+574.2%		+60.6%	
FIXED DISK DRIVES more than 20 Gigabytes	19.0	--	127.5	.3%	154.4	.4%	4,118.7	6.8%	15,118.9	19.9%
	--		+571.1%		+21.1%		--		+267.1%	
Total Worldwide Revenue	28,819.1	100.0%	34,000.9	100.0%	43,685.1	100.0%	60,308.0	100.0%	75,979.5	100.0%
	+8.2%		+18.0%		+28.5%		+38.1%		+26.0%	

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

Figure 2

UNIT SHIPMENT SUMMARY

Worldwide Shipments in Millions of Units

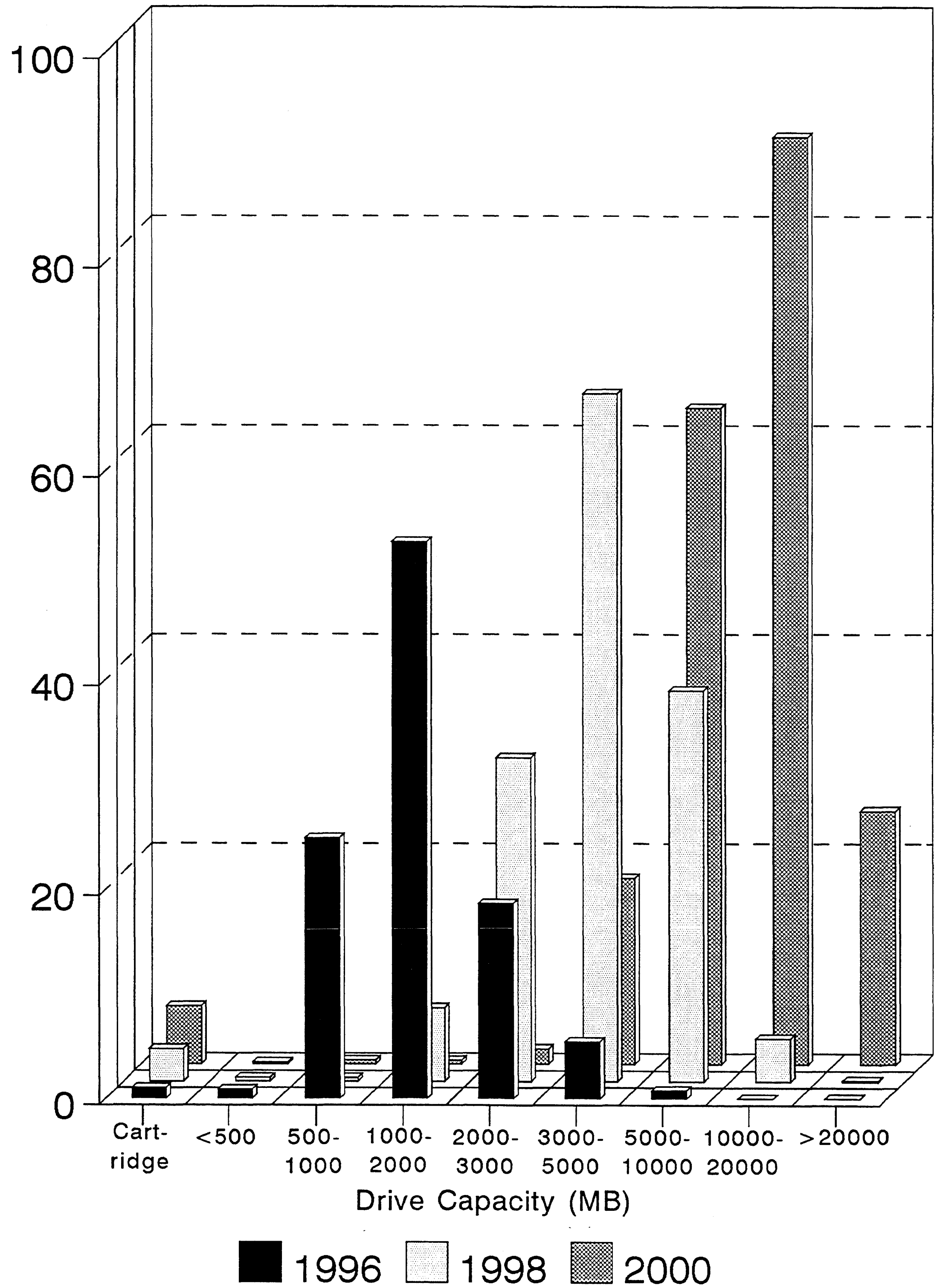


TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1996 Shipments Units	1996 Shipments %	Forecast 1997 Units	1997 %	Forecast 1998 Units	1998 %	Forecast 1999 Units	1999 %	Forecast 2000 Units	2000 %
CARTRIDGE DISK DRIVES	1,044.0 +72.2%	1.0%	1,915.0 +83.4%	1.5%	3,125.0 +63.2%	2.1%	4,510.0 +44.3%	2.6%	5,540.0 +22.8%	2.8%
FIXED DISK DRIVES less than 500 Megabytes	891.0 -95.3%	.8%	398.3 -55.3%	.3%	365.0 -8.4%	.2%	310.0 -15.1%	.2%	185.0 -40.3%	.1%
FIXED DISK DRIVES 500 Megabytes - 1 GB	24,883.3 -41.5%	23.7%	2,852.0 -88.5%	2.3%	360.7 -87.4%	.2%	265.0 -26.5%	.2%	390.0 +47.2%	.2%
FIXED DISK DRIVES 1 - 2 Gigabytes	53,233.5 +155.2%	50.7%	28,979.6 -45.6%	22.9%	7,040.0 -75.7%	4.7%	1,260.0 -82.1%	.7%	360.0 -71.4%	.2%
FIXED DISK DRIVES 2 - 3 Gigabytes	18,665.1 +299.3%	17.8%	60,134.1 +222.2%	47.6%	30,860.0 -48.7%	20.7%	6,880.0 -77.7%	4.0%	1,460.0 -78.8%	.7%
FIXED DISK DRIVES 3 - 5 Gigabytes	5,497.0 +223.6%	5.2%	25,004.5 +354.9%	19.8%	65,745.0 +162.9%	44.1%	40,920.0 -37.8%	23.5%	17,760.0 -56.6%	8.8%
FIXED DISK DRIVES 5 - 10 Gigabytes	793.7 +141.4%	.8%	6,933.5 +773.6%	5.5%	37,300.0 +438.0%	25.0%	68,510.0 +83.7%	39.4%	62,720.0 -8.5%	31.2%
FIXED DISK DRIVES 10 - 20 Gigabytes	-- --	--	60.0 --	--	4,138.0 --	2.8%	48,070.0 --	27.6%	88,611.0 +84.3%	44.0%
FIXED DISK DRIVES more than 20 Gigabytes	10.0 --	--	85.0 +750.0%	.1%	120.0 +41.2%	.1%	3,255.0 --	1.8%	24,165.0 +642.4%	12.0%
Total Worldwide Shipments	105,017.6 +17.3%	100.0%	126,362.0 +20.3%	100.0%	149,053.7 +18.0%	100.0%	173,980.0 +16.7%	100.0%	201,191.0 +15.6%	100.0%
% U.S. Manufacturers	80.7%		76.5%		78.6%		79.7%		79.0%	
Total Capacity (Terabytes)	160,623.4		335,476.0		639,188.0		1,545,060.8		2,829,287.9	

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

Figure 3

DISK DIAMETER SUMMARY

Worldwide Shipments in Millions of Units

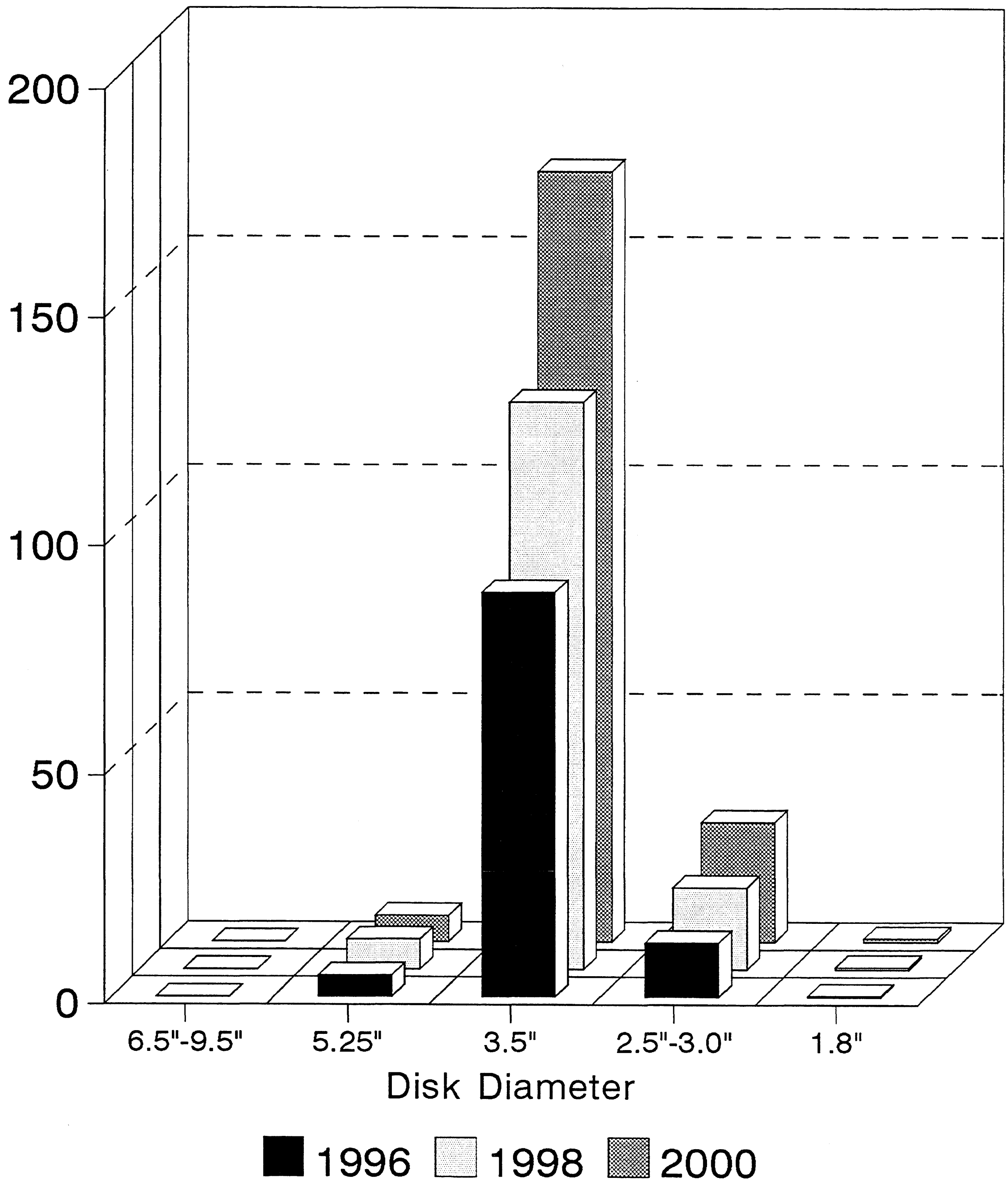


TABLE 5

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
SUMMARY BY DISK DIAMETER

UNIT SHIPMENTS IN THOUSANDS	1996 Shipments		Forecast							
			1997		1998		1999		2000	
	Units	%	Units	%	Units	%	Units	%	Units	%
6.5 - 9.5 INCH	10.0	--	1.0	--	--	--	--	--	--	--
	-18.7%		-90.0%		--		--		--	
5.25 INCH	4,648.9	4.4%	5,689.2	4.5%	6,530.7	4.4%	6,325.0	3.6%	5,705.0	2.8%
	+557.7%		+22.4%		+14.8%		-3.2%		-9.8%	
3.5 INCH	88,356.5	84.1%	105,808.3	83.7%	124,088.0	83.3%	145,275.0	83.5%	168,476.0	83.7%
	+13.6%		+19.8%		+17.3%		+17.1%		+16.0%	
2.5 - 3.0 INCH	11,769.9	11.2%	14,508.5	11.5%	17,925.0	12.0%	21,755.0	12.5%	26,245.0	13.0%
	+10.6%		+23.3%		+23.6%		+21.4%		+20.6%	
1.8 INCH	232.3	.2%	355.0	.3%	510.0	.3%	625.0	.4%	765.0	.4%
	-44.5%		+52.8%		+43.7%		+22.6%		+22.4%	
Total Worldwide Shipments	105,017.6	100.0%	126,362.0	100.0%	149,053.7	100.0%	173,980.0	100.0%	201,191.0	100.0%
	+17.3%		+20.3%		+18.0%		+16.7%		+15.6%	

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

Figure 4

CAPACITY SHIPMENT SUMMARY

Worldwide Shipments in Terabytes

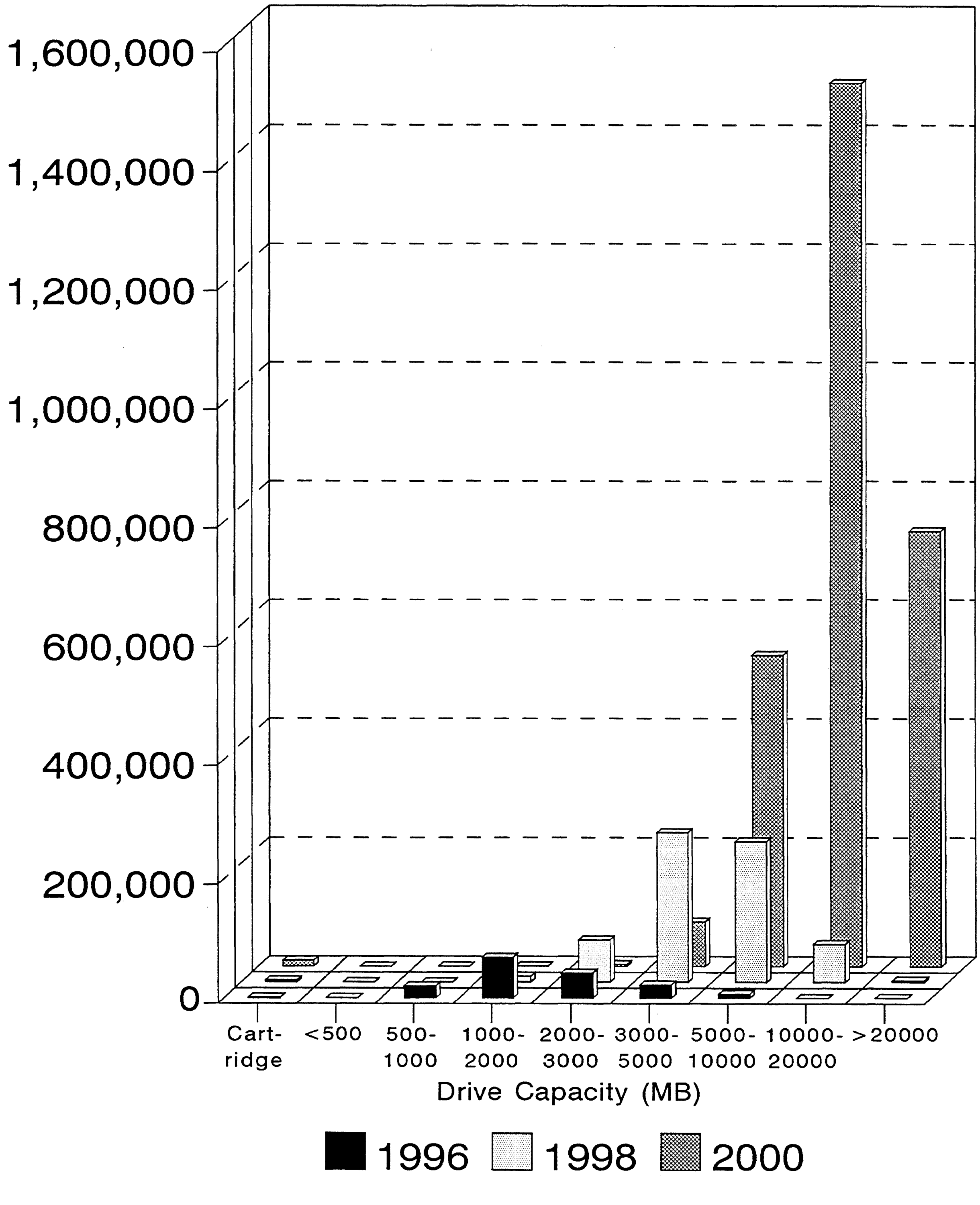


TABLE 6

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPMENTS IN TERABYTES	1996 Shipments		Forecast 1997		Forecast 1998		Forecast 1999		Forecast 2000	
	Tbytes	%	Tbytes	%	Tbytes	%	Tbytes	%	Tbytes	%
CARTRIDGE DISK DRIVES	716.5	.4%	1,853.3	.6%	3,434.5	.5%	6,298.7	.4%	9,686.0	.3%
	+583.7%		+158.7%		+85.3%		+83.4%		+53.8%	
FIXED DISK DRIVES	284.7	.2%	126.4	--	124.9	--	115.0	--	75.7	--
less than 500 Megabytes	-95.8%		-55.6%		-1.1%		-8.0%		-34.2%	
FIXED DISK DRIVES	20,066.3	12.5%	2,239.1	.7%	248.9	--	130.3	--	190.0	--
500 Megabytes - 1 GB	-30.8%		-88.8%		-88.9%		-47.6%		+45.8%	
FIXED DISK DRIVES	68,286.4	42.5%	41,250.3	12.3%	9,899.8	1.5%	1,712.2	.1%	374.1	--
1 - 2 Gigabytes	+178.2%		-39.6%		-76.0%		-82.7%		-78.2%	
FIXED DISK DRIVES	42,011.0	26.2%	138,756.8	41.4%	70,859.8	11.1%	15,495.2	1.0%	3,240.4	.1%
2 - 3 Gigabytes	+313.9%		+230.3%		-48.9%		-78.1%		-79.1%	
FIXED DISK DRIVES	22,150.0	13.8%	99,450.5	29.6%	251,561.9	39.4%	164,049.1	10.6%	74,754.7	2.6%
3 - 5 Gigabytes	+212.3%		+349.0%		+153.0%		-34.8%		-54.4%	
FIXED DISK DRIVES	6,874.5	4.3%	48,718.6	14.5%	236,532.4	37.0%	501,411.2	32.5%	522,868.0	18.5%
5 - 10 Gigabytes	+131.2%		+608.7%		+385.5%		+112.0%		+4.3%	
FIXED DISK DRIVES	--	--	1,092.0	.3%	63,717.6	10.0%	763,939.0	49.4%	1,486,559.0	52.5%
10 - 20 Gigabytes	--		--		--		--		+94.6%	
FIXED DISK DRIVES	234.0	--	1,989.0	.6%	2,808.0	.4%	91,910.0	5.9%	731,539.9	25.9%
more than 20 Gigabytes	--		+750.0%		+41.2%		--		+695.9%	
Total Capacity (Terabytes)	160,623.4		335,476.0		639,188.0		1,545,060.8		2,829,287.9	
	+99.3%		+108.9%		+90.5%		+141.7%		+83.1%	

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

Price per megabyte

The combination of influences which continually forces the average price per megabyte for rigid disk drives to decline is destined to continue. The industry's relentless improvement in areal density underlies much of the annual changes, of course. But other influences, such as the exceptional growth in the personal computer market have accelerated the trend. The rapid migration to higher capacities for personal computers, driven by new software, expanded application programs, multimedia, and storage of data from the Internet, has brought new levels of competition to the markets for personal computer disk drives, each year at higher capacity levels. As higher capacity drive groups are overwhelmed by the personal computer market, high performance disk drives at relatively high prices become minor contributors to the pricing averages.

As shipments of noncaptive 3.5" and 2.5" drives decline in the lower capacity product groups, average prices are expected to increase. The reason for this phenomenon is that the only remaining drives in these groups will be 1.8" drives, which have a higher parts count at each capacity level than the larger diameter disk drives and are produced in smaller quantities, and are priced at higher levels. In the 2 gigabyte to 10 gigabyte capacity ranges, where most of the growth in the personal computer market for disk drives will occur during the next few years, the combination of high individual drive capacities, increasing shipments and intense competition is expected to drop the lowest noncaptive price per megabyte from 13 cents in 1996 to 2 cents in 2000.

Severe drops in noncaptive disk drive pricing also affect pricing for captive disk drives. The captive drive producers must respond to prices in the noncaptive market, as noncaptive drives are resold by other system manufacturers at aggressive prices. IBM is easily the largest participant in captive disk drive markets and has aggressively lowered its pricing structures to stay competitive. Also affecting the disk drive prices set by IBM and other captive manufacturers is their continuing movement to newer, smaller drives, at lower costs.

Please note that the data shown in the tables is not merely an average of the price per megabyte of all individual disk drive models offered, but represents the estimated total sales revenues for each product type divided by the total capacity of all drives of that type.

Figure 5

PRICE PER MEGABYTE SUMMARY

Noncaptive Worldwide Shipments ($/MB)

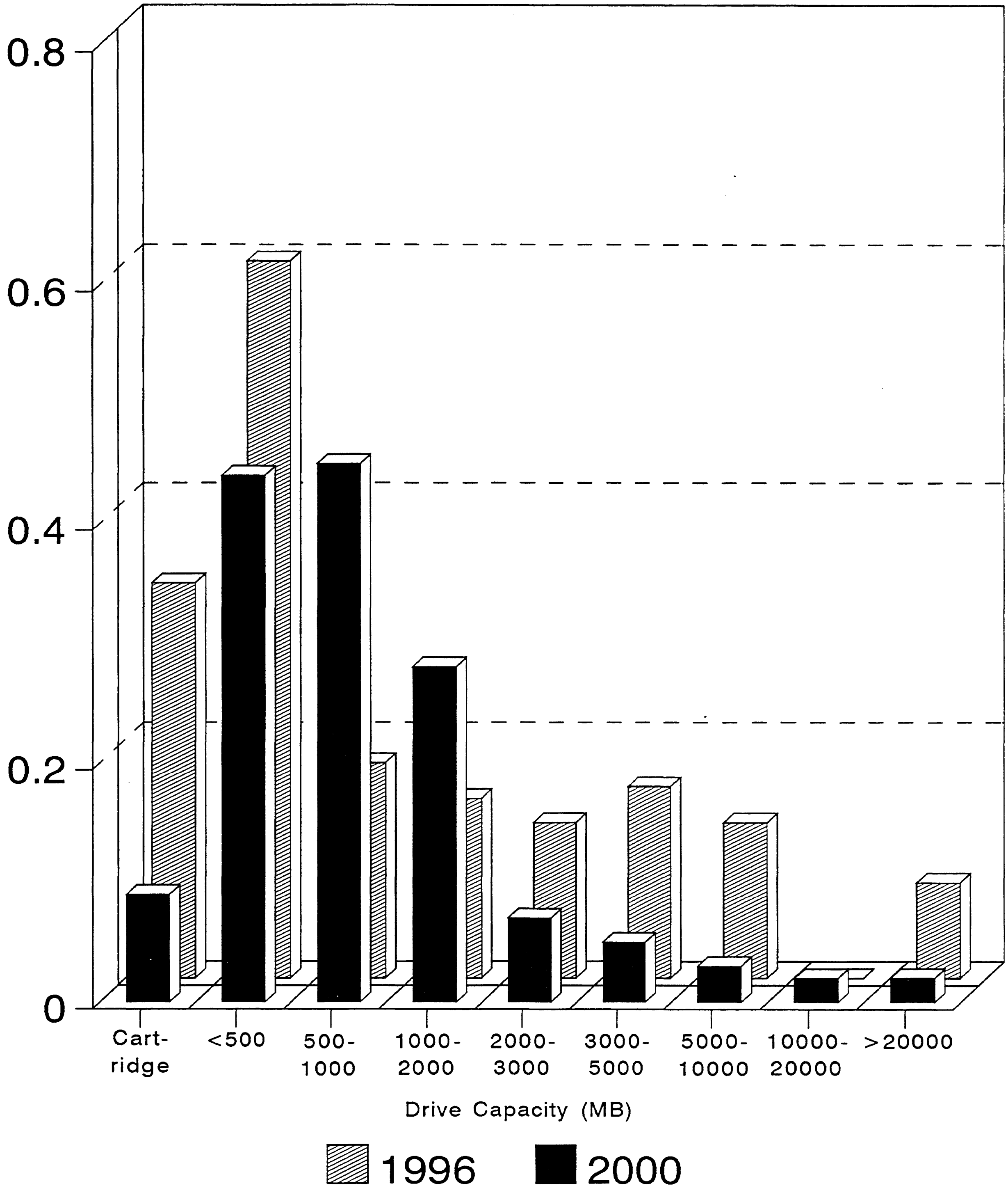


TABLE 7

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

		Forecast			
	1996	1997	1998	1999	2000
CARTRIDGE DISK DRIVES	.33 -77.6%	.19 -42.9%	.16 -17.8%	.12 -24.2%	.09 -23.0%
FIXED DISK DRIVES less than 500 Megabytes	.60 +52.2%	.71 +17.9%	.65 -8.9%	.55 -14.6%	.44 -20.2%
FIXED DISK DRIVES 500 Megabytes - 1 GB	.18 -30.5%	.18 +.6%	.33 +77.6%	.51 +55.0%	.45 -11.7%
FIXED DISK DRIVES 1 - 2 Gigabytes	.15 -29.0%	.11 -22.3%	.11 -4.9%	.12 +13.6%	.28 +126.7%
FIXED DISK DRIVES 2 - 3 Gigabytes	.13 -56.8%	.09 -28.9%	.08 -11.8%	.07 -6.4%	.07 -4.0%
FIXED DISK DRIVES 3 - 5 Gigabytes	.16 -19.3%	.07 -56.2%	.06 -11.4%	.05 -19.3%	.05 -10.0%
FIXED DISK DRIVES 5 - 10 Gigabytes	.13 -32.7%	.08 -38.9%	.05 -31.9%	.04 -28.1%	.03 -17.2%
FIXED DISK DRIVES 10 - 20 Gigabytes	-- --	.07 --	.05 -29.8%	.03 -39.0%	.02 -17.8%
FIXED DISK DRIVES more than 20 Gigabytes	.08 --	.06 -21.1%	.05 -14.2%	.04 -23.1%	.02 -53.6%

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

Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

TABLE 8

CAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

	1996	1997 (Forecast)	1998 (Forecast)	1999 (Forecast)	2000 (Forecast)
CARTRIDGE DISK DRIVES	--	--	--	--	--
	--	--	--	--	--
FIXED DISK DRIVES	1.27	1.01	--	--	--
less than 500 Megabytes	-43.8%	-20.6%	--	--	--
FIXED DISK DRIVES	.65	.50	.63	--	--
500 Megabytes - 1 GB	-22.6%	-23.8%	+25.7%	--	--
FIXED DISK DRIVES	.46	.39	.32	.26	--
1 - 2 Gigabytes	-43.2%	-15.6%	-16.4%	-18.0%	--
FIXED DISK DRIVES	.35	.26	.21	.18	.17
2 - 3 Gigabytes	-73.7%	-25.9%	-20.0%	-11.8%	-9.0%
FIXED DISK DRIVES	.56	.19	.15	.12	.11
3 - 5 Gigabytes	-59.0%	-65.4%	-21.5%	-18.6%	-14.3%
FIXED DISK DRIVES	.84	.35	.18	.09	.07
5 - 10 Gigabytes	-72.0%	-58.3%	-49.7%	-46.0%	-22.0%
FIXED DISK DRIVES	--	.25	.13	.09	.06
10 - 20 Gigabytes	--	--	-46.0%	-34.4%	-36.2%
FIXED DISK DRIVES	--	--	--	.10	.06
more than 20 Gigabytes	--	--	--	--	-37.6%

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

Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

Noncaptive market

The share of rigid disk drive industry revenues produced by noncaptive drives continues to increase. 75.0% of the industry's 1996 worldwide sales total were noncaptive revenues, and the noncaptive share is forecasted to increase to 89.2% in 2000. Today's higher revenue share for noncaptive drives is rooted in the growing noncaptive share of higher capacity drives, at relatively higher prices, which are sold through noncaptive channels, plus the fact that the relative difference between captive drive prices and noncaptive prices is gradually being reduced.

The noncaptive share of worldwide disk drive unit shipments was 92.6% in 1996, and the 2000 share is projected to increase to 94.5%, indicating expected success for noncaptive producers in holding market share while typical captive prices trend downwards.

Independent disk drive manufacturers have quickly exploited technology advances during the last decade which have enabled them to respond with competitive drives for the computer industry's fastest growth sectors: Desktop and portable personal computers, engineering workstations and network file servers. In the process, they led the industry in developing high volume production capability for small drive formats, starting with 5.25", then 3.5", and more recently with 2.5"-3" drives. OEM drives in each of these form factors arrived in the market well before captive drives and set the patterns for the entire industry.

Most segments of the market for noncaptive disk drives are dominated by U.S. based companies, which were able to successfully sell to rapidly growing system manufacturers because they were able to deliver new disk drive configurations early in each product life cycle. Young California and Colorado companies had the right formula for success, as they listened to customers' requests, made management decisions quickly, and moved rapidly to the most cost-effective manufacturing sites. Most of the surviving U.S. start-up companies of the 1980's are now large firms, with multibillion dollar annual sales.

The noncaptive drive leaders now face new challenges, as they adjust to continually lower prices, increasing production and demanding product development requirements. New competitive alignments will also change the picture, forced by acquisitions, vertical integration programs and technology advances.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1996 Revenues $M	1996 Revenues %	Forecast 1997 $M	1997 %	1998 $M	1998 %	1999 $M	1999 %	2000 $M	2000 %
CARTRIDGE DISK DRIVES	237.1 +53.2%	1.1%	350.4 +47.8%	1.3%	533.6 +52.3%	1.4%	742.2 +39.1%	1.4%	879.2 +18.5%	1.3%
FIXED DISK DRIVES less than 500 Megabytes	128.3 -95.0%	.6%	78.6 -38.7%	.3%	80.7 +2.7%	.3%	63.4 -21.4%	.1%	33.3 -47.5%	--
FIXED DISK DRIVES 500 Megabytes - 1 GB	3,470.1 -50.7%	16.0%	335.9 -90.3%	1.2%	71.0 -78.9%	.2%	66.1 -6.9%	.1%	85.1 +28.7%	.2%
FIXED DISK DRIVES 1 - 2 Gigabytes	9,370.5 +108.2%	42.9%	4,441.1 -52.6%	16.5%	927.7 -79.1%	2.5%	172.5 -81.4%	.4%	82.5 -52.2%	.1%
FIXED DISK DRIVES 2 - 3 Gigabytes	4,801.2 +90.1%	22.0%	11,921.0 +148.3%	43.8%	5,208.1 -56.3%	14.2%	904.5 -82.6%	1.7%	155.0 -82.9%	.2%
FIXED DISK DRIVES 3 - 5 Gigabytes	3,048.4 +139.6%	14.0%	6,508.1 +113.5%	23.9%	15,252.4 +134.4%	41.2%	7,736.1 -49.3%	14.6%	3,001.3 -61.2%	4.4%
FIXED DISK DRIVES 5 - 10 Gigabytes	746.3 +31.7%	3.4%	3,360.5 +350.3%	12.4%	11,923.4 +254.8%	32.3%	18,289.6 +53.4%	34.3%	15,578.7 -14.8%	23.1%
FIXED DISK DRIVES 10 - 20 Gigabytes	-- --	--	61.5 --	.2%	2,798.2 --	7.6%	21,590.1 +671.6%	40.6%	34,011.0 +57.5%	50.2%
FIXED DISK DRIVES more than 20 Gigabytes	19.0 --	--	127.5 +571.1%	.4%	154.4 +21.1%	.3%	3,701.1 --	6.8%	13,967.7 +277.4%	20.5%
Total Worldwide Revenues	21,820.9 +17.3%	100.0%	27,184.6 +24.6%	100.0%	36,949.5 +35.9%	100.0%	53,265.6 +44.2%	100.0%	67,793.8 +27.3%	100.0%

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

TABLE 10

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1996 Shipments		Forecast 1997		Forecast 1998		Forecast 1999		Forecast 2000	
	Units	%	Units	%	Units	%	Units	%	Units	%
CARTRIDGE DISK DRIVES	1,044.0	1.1%	1,915.0	1.6%	3,125.0	2.2%	4,510.0	2.8%	5,540.0	2.9%
	+72.2%		+83.4%		+63.2%		+44.3%		+22.8%	
FIXED DISK DRIVES	677.5	.7%	353.3	.3%	365.0	.3%	310.0	.1%	185.0	.1%
less than 500 Megabytes	-96.1%		-47.9%		+3.3%		-15.1%		-40.3%	
FIXED DISK DRIVES	23,302.3	24.0%	2,296.0	2.0%	320.7	.2%	265.0	.2%	390.0	.2%
500 Megabytes - 1 GB	-40.4%		-90.1%		-86.0%		-17.4%		+47.2%	
FIXED DISK DRIVES	50,392.8	51.9%	27,571.3	23.5%	6,095.0	4.4%	1,045.0	.6%	360.0	.2%
1 - 2 Gigabytes	+171.4%		-45.3%		-77.9%		-82.9%		-65.6%	
FIXED DISK DRIVES	16,619.5	17.0%	56,736.1	48.1%	28,200.0	20.2%	5,320.0	3.3%	965.0	.5%
2 - 3 Gigabytes	+325.4%		+241.4%		-50.3%		-81.1%		-81.9%	
FIXED DISK DRIVES	4,556.4	4.7%	22,849.0	19.4%	62,765.0	44.9%	37,630.0	23.0%	15,420.0	8.1%
3 - 5 Gigabytes	+212.9%		+401.5%		+174.7%		-40.0%		-59.0%	
FIXED DISK DRIVES	637.7	.6%	6,043.0	5.1%	35,140.0	25.1%	64,755.0	39.5%	58,520.0	30.9%
5 - 10 Gigabytes	+96.0%		+847.6%		+481.5%		+84.3%		-9.6%	
FIXED DISK DRIVES	--	--	50.0	--	3,845.0	2.7%	47,005.0	28.7%	85,246.0	44.8%
10 - 20 Gigabytes	--		--		--		--		+81.4%	
FIXED DISK DRIVES	10.0	--	85.0	--	120.0	--	3,100.0	1.8%	23,510.0	12.3%
more than 20 Gigabytes	--		+750.0%		+41.2%		--		+658.4%	
Total Worldwide Shipments	97,240.2	100.0%	117,898.7	100.0%	139,975.7	100.0%	163,940.0	100.0%	190,136.0	100.0%
	+19.4%		+21.2%		+18.7%		+17.1%		+16.0%	
% U.S. Manufacturers	81.2%		77.0%		79.2%		80.0%		79.2%	
Total Capacity (Terabytes)	146,632.8		310,408.3		600,281.4		1,477,396.3		2,719,756.7	

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

TABLE 11

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

CAPACITY SHIPMENT SUMMARY

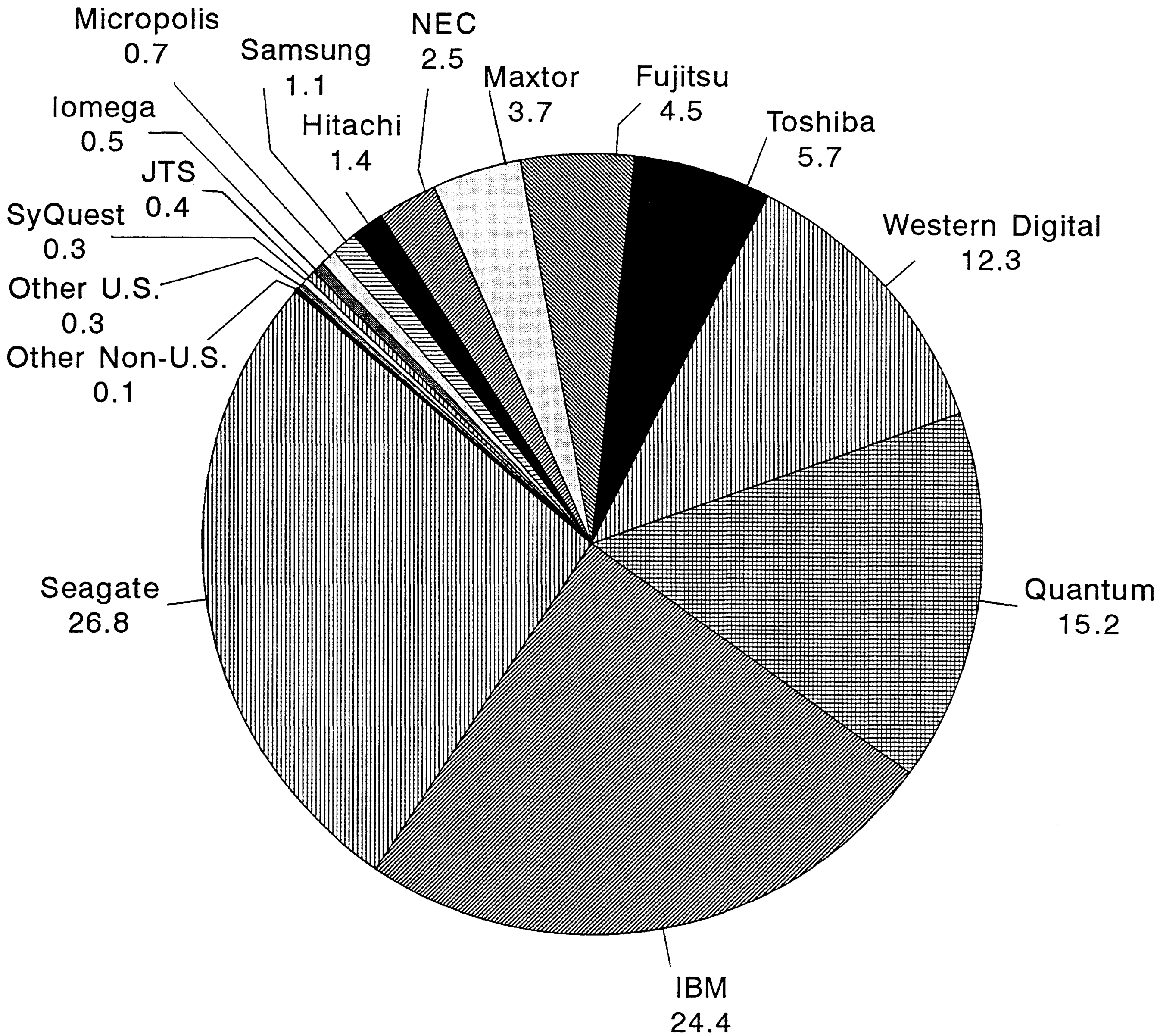
CAPACITY SHIPPED IN TERABYTES	1996 Capacity Units	1996 %	Forecast 1997 Units	1997 %	1998 Units	1998 %	1999 Units	1999 %	2000 Units	2000 %
CARTRIDGE DISK DRIVES	716.5 +583.7%	.5%	1,853.3 +158.7%	.6%	3,434.5 +85.3%	.6%	6,298.7 +83.4%	.4%	9,686.0 +53.8%	.4%
FIXED DISK DRIVES less than 500 Megabytes	213.4 -96.7%	.1%	110.9 -48.0%	--	124.9 +12.7%	--	115.0 -8.0%	--	75.7 -34.2%	--
FIXED DISK DRIVES 500 Megabytes - 1 GB	18,936.4 -29.0%	13.0%	1,822.8 -90.4%	.6%	216.9 -88.1%	--	130.3 -39.9%	--	190.0 +45.8%	--
FIXED DISK DRIVES 1 - 2 Gigabytes	64,598.8 +193.4%	44.1%	39,381.3 -39.0%	12.8%	8,647.3 -78.0%	1.5%	1,415.2 -83.6%	.1%	374.1 -73.6%	--
FIXED DISK DRIVES 2 - 3 Gigabytes	37,591.2 +339.9%	25.6%	131,308.3 +249.3%	42.3%	65,018.8 -50.5%	10.8%	12,068.8 -81.4%	.9%	2,153.7 -82.2%	.1%
FIXED DISK DRIVES 3 - 5 Gigabytes	18,561.7 +196.9%	12.7%	90,453.3 +387.3%	29.1%	239,276.9 +164.5%	40.0%	150,437.6 -37.1%	10.1%	64,820.7 -56.9%	2.4%
FIXED DISK DRIVES 5 - 10 Gigabytes	5,780.8 +95.7%	3.9%	42,579.4 +636.6%	13.8%	221,779.9 +420.9%	36.9%	473,030.7 +113.3%	32.2%	486,837.5 +2.9%	18.0%
FIXED DISK DRIVES 10 - 20 Gigabytes	-- --	--	910.0 --	.3%	58,974.0 --	9.8%	746,330.0 --	50.5%	1,443,249.0 +91.7%	52.9%
FIXED DISK DRIVES more than 20 Gigabytes	234.0 --	.1%	1,989.0 +750.0%	.5%	2,808.0 +41.2%	.4%	87,570.0 --	5.8%	712,370.0 +713.5%	26.2%
Total Capacity (Terabytes)	146,632.8 +100.9%		310,408.3 +111.7%		600,281.4 +93.4%		1,477,396.3 +146.1%		2,719,756.7 +84.1%	
% U.S. Manufacturers	82.7%		78.4%		80.7%		82.6%		80.4%	

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

Figure 6

1996 ESTIMATED MARKET SHARE

Worldwide Percentage Revenues



1996 Revenues: $28,819,100,000

TABLE 12

1996 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES
(Value of non-U.S. currencies estimated at average 1996 rates)

	CAPTIVE		PCM/DISTRIBUTOR		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Hewlett-Packard	40.9	.6	17.1	.2	18.2	.1	76.2	.3
IBM	5,457.8	78.0	187.5	2.6	1,379.5	9.5	7,024.8	24.4
Iomega	--	--	140.5	1.9	6.4	--	146.9	.5
JTS	--	--	83.3	1.1	35.9	.2	119.2	.4
Quantum	--	--	1,634.4	22.2	2,737.6	18.9	4,372.0	15.2
Seagate Technology	--	--	2,781.5	37.8	4,945.2	34.2	7,726.7	26.8
SyQuest Technology	--	--	70.4	1.0	4.7	--	75.1	.3
Western Digital	--	--	1,258.5	17.1	2,274.5	15.7	3,533.0	12.3
Other U.S.	--	--	23.1	.3	52.5	.4	75.6	.3
U.S. Total	5,498.7	78.6	6,196.3	84.3	11,454.5	79.2	23,149.5	80.3
NON-U.S. MANUFACTURERS								
Fujitsu	89.5	1.3	33.5	.5	1,183.1	8.2	1,306.1	4.5
Hitachi	131.8	1.9	124.4	1.7	152.9	1.1	409.1	1.4
Maxtor	--	--	475.3	6.5	596.9	4.1	1,072.2	3.7
Micropolis	--	--	137.8	1.9	58.0	.4	195.8	.7
NEC	367.1	5.2	--	--	339.8	2.3	706.9	2.5
Samsung Electronics	75.0	1.1	227.6	3.1	17.6	.1	320.2	1.1
Toshiba	836.1	11.9	138.9	1.9	657.3	4.5	1,632.3	5.7
Other Non-U.S.	--	--	17.6	.2	9.4	.1	27.0	.1
Non-U.S. Total	1,499.5	21.4	1,155.1	15.7	3,015.0	20.8	5,669.6	19.7
WORLDWIDE TOTAL	6,998.2	100.0	7,351.4	100.0	14,469.5	100.0	28,819.1	100.0

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

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

Codes: 1.8 = 1.8" C = Captive
2 = 2.5"-3" P = PCM
3 = 3.5" O = OEM
5 = 5.25"
8 = 6.5"-9.5"

TABLE 13

CURRENT PRODUCT LINES
MANUFACTURERS OF RIGID MAGNETIC DISK DRIVES

DISK/TREND PRODUCT GROUP		1	2	3	4	5	6	7	8	9
U.S. Manufacturers (12)	Type	Disk Cartridge Drives	Fixed Disk Drives <500 MB	Fixed Disk Drives 500-1 GB	Fixed Disk Drives 1 GB-2 GB	Fixed Disk Drives 2 GB-3 GB	Fixed Disk Drives 3 GB-5 GB	Fixed Disk Drives 5 GB-10 GB	Fixed Disk Drives 10 GB-20 GB	Fixed Disk Drives >20 GB
Avatar Systems	P,O	2								
Gigastorage International	P,O						5	5		
IBM	C,P,O				2	2,3	2,3	2,3		
Integral Peripherals	P,O		1.8	1.8		2				
Iomega	P,O	3								
JTS	P,O				2,3	2,3	3			
Quantum	P,O				3,5	3,5	3,5	3,5	3	
Raymond Engineering	O		3							
Seagate Technology	P,O		2	2	2,3	2,3	3	3,5		5
Sequel	O		5	5						
SyQuest Technology	P,O	3,5								
Western Digital	P,O				2,3	2,3	3			
Asian Manufacturers (7)										
Fujitsu	C,P,O		2,3,5	2,3	2,3,5	3,5	3	3		
Hitachi	C,P,O			2	2,3,5	2,3,8	2,3	3,8		
Maxtor	P,O				3	3	3	3		
Micropolis	P,O					3	3	3		
NEC	C,P,O				3	3	3			
Samsung Electronics	C,P,O				3	3	3	3		
Toshiba	C,P,O			2	2	2	2			
European Manufacturers (3)										
Calluna Technology	P,O		1.8	1.8						
Nomai	P,O	3								
Sagem	O		5							

TECHNICAL REVIEW

Competing technologies

Rapid increases in areal density, resulting in corresponding rapid declines in cost per megabyte, continue to reinforce the position of the rigid magnetic disk drive industry against its challengers. Continuing improvements in drive performance also contribute to making it nearly impossible for any competing storage technology to seriously challenge the rigid magnetic disk drive, except in a few niche applications. Manufacturers continue to provide smaller, faster, more reliable, higher capacity, less expensive disk drives, well supported by a magnetic storage industry supplier infrastructure. During the early 1990's, the disk drive industry was able to increase areal density at a 60% average annual rate, provide thinner disk substrates, greater functionality chips, smaller heads, lower flying heights, smaller motors and many other improvements in disk drive and recording technology. While the annual rate of areal density increase dipped to 45% at mid-decade, it has returned to the 60% range in 1997.

With annual areal density improvements back on the 60% slope, 10 gigabit per square inch areal density by 2000 continues to appear likely, although some technologists expect the rate of increase in areal density to decline towards the end of the decade as increases in data channel rates required by higher linear bit density become harder to achieve. And as areal densities approach 40 gigabits per square inch in the next decade, the decreasing size of the resultant magnetic domains may cause intractable stability problems that require the disk drive industry to switch from longitudinal recording to perpendicular recording (or optical recording using a flying optical head) to further increase areal density.

In a few specialized markets and applications, a limited number of alternatives to magnetic disk recording exist, but only where the substitute technology has been significantly better, faster, smaller, less expensive or demonstrated some other overwhelming advantage in that niche.

Those few technologies which do provide competition to magnetic disk drives in applications where characteristics such as speed, removability, or environmental tolerance give them unique advantages, are discussed in the following sections.

* Semiconductor memory -- applications and trends: Semiconductor memory offers fast response time (typically under 100 microseconds) and high reliability, characteristics that have won it a secondary data storage role in both large and small computer systems. When very fast access to data or programs is required, semiconductor memory can serve as an effective, though expensive, substitute for rigid drives. Larger systems frequently have large auxiliary semiconductor storage units performing as virtual disk drives or as cache between the host processor and disk storage. Personal computer operating systems also allow part of main memory to be designated for use as a fast virtual disk.

  Where only small amounts of mass storage are required, semiconductor memory can be a cost-effective competitor to rigid disk storage, and when added to a disk drive, semiconductor memory can serve as a fast, low power cache that significantly improves system performance. The use of semiconductor memory in a cache can extend portable system battery life, because the disk drive can be shut down after data needed by the current application is loaded into the cache. If the cache memory (and some system memory) is nonvolatile, the system can be turned off and on, returning to the point where operation was halted without expending power on the disk drive.

  Fast semiconductor memory is expensive, ranging from $10/megabyte to over $1000/megabyte depending upon configuration and distribution channel, which limits its use to situations where its high speed or lack of moving parts are vitally necessary to meet system requirements. The least expensive semiconductor memories are volatile, and require the continuous availability of power to avoid loss of data. Nonvolatile semiconductor memory is usually more expensive, usually slower, and usually does not match the capacity per chip of DRAM, the most common form of volatile semiconductor memory. Some companies package semiconductor memory in disk drive form factors with electrical and logical interfaces similar to commonly used disk drive interfaces. For instance, Quantum offers up to 950 megabytes in a full height 5.25" disk drive form factor and up to 268 megabytes in a standard 3.5" form factor. SCSI interfaces are provided.

  The Personal Computer Memory Card International Association (PCMCIA) has standardized the logical and electrical interface for plug-in cards (similar to a credit card) used to expand system memory, emulate a disk drive, or provide other peripheral functions for small portable computers. The associated physical package has been adopted as the PC Card standard. PC Card pin interconnect and packaging standards have been worked out, with the final result being a 68 pin connector and a family of package heights: 3.3 millimeters (Type I), 5 millimeters (Type II) and 10.5 millimeters (Type III). The cards are available with a variety of memory forms, including disk drives, PROM, ROM, SRAM, DRAM, and flash memory. Even smaller form factors for use with industrial equipment, cameras and other consumer applications appeared in 1995 and 1996. Three small form factors (CompactFlash, Miniature Card and Solid State Floppy Disk Card), typically containing flash memory, are contending for acceptance, each backed by a consortium of card manufacturers and equipment manufacturers.

The PCMCIA/PC Card effort has been a major factor in promoting the acceptance of plug-in semiconductor memory as a disk drive alternative, although some disk drives, including 1.8" drives from several sources, have been packaged in PC Card form factors with the capability to be plugged into a PC Card Type III card slot. Most issues regarding software support of the PCMCIA interface have been worked out, but the use of the PCMCIA interface does not fully guarantee functional interchange among older devices that are electrically and physically PCMCIA compliant. In many industrial applications, flash memory cards are used in configurations that are not PCMCIA compliant or only partially compliant, as such applications rarely require the full PCMCIA feature set, and design simplification can significantly reduce costs. Memories up to 240 megabytes are being packaged to fit within the physical envelope of the now discontinued 1.3" Hewlett-Packard Kittyhawk disk drive.

Will semiconductor memory technology improve during the rest of the decade at the same rate exhibited in the last 20 years? As the complexity, packaging problems, and performance requirements of semiconductor memory have increased, so also have the investments in time and capital required to produce succeeding generations of chips. The pace of semiconductor memory price decreases is consequently expected to slow, and high investment costs are already inspiring increasing numbers of companies to pool resources to contain development expenses.

* <u>Volatile semiconductor memories</u>: DRAM is the most commonly employed form of semiconductor memory. It is used in systems of all sizes for general purpose system memory, video memory, and other applications where its volatility is not a major handicap. It is also used on large systems as a supplement to magnetic storage to provide fast mass storage. Access times are in the range of .1 microsecond or less. DRAM chips are readily available in 16 megabit configurations and production of 64 megabit configurations, while small, is growing. Large quantity production of 64 megabit DRAM chips is not expected until late 1997 or 1998.

  SRAM memory chips are in volume production in 1 megabit to 4 megabit configurations. Power requirements are less than DRAM requires and speed is high, permitting SRAM to be used as a memory add-on in portable, power limited equipment. SRAM is sometimes used in removable memory cards that contain a small battery which provides the power needed by SRAM memories to retain data. However, SRAM is more expensive than DRAM and flash memory.

* Nonvolatile semiconductor memories: Flash memory, a form of EEPROM in which a block of memory cells can be erased by an electrical signal, is nonvolatile and can be used as fixed or removable storage. Flash memory can provide adequate mass storage where capacity need be only a few megabytes, power limitations are severe, a hostile environment exists, and product price is not a paramount factor.

  Flash memory is often discussed as a prospective competitor to rotating memory, but its more significant computer applications will be for program storage, peripheral equipment updatable firmware and as a reprogrammable BIOS in computer systems. In this role, flash memory can provide obsolescence protection by allowing periodic code updates, and provide functionality changes in printers, fax machines, modems, and other electronic equipment. Some disk drive producers, including Seagate, Conner, Maxtor and Quantum, formed alliances with flash memory producers to bring flash memory modules organized as low capacity disk drives to market. These alliances proved ineffective, and most have been allowed to lapse.

  While flash memories are rugged, portable, reliable and use little power, they have some functional disadvantages. When rewriting, it is not possible to change only a few bits; an entire block must be erased and rewritten, and this can take from 10 milliseconds to as long as half a second for the equivalent of a disk sector in some flash memories. Whatever is in the cell block must be saved to RAM and restored after the erase/write cycle on the flash memory chip. As a result, read operations can be very fast compared to a magnetic disk drive, but writing may be slower. There is also a limit to the number of times the memory device can be rewritten. At present, most flash memory devices are specified for 100,000 write/erase cycles. Some chips are specified at only 10,000 cycles. Some flash memories still require 12 volt power, but more recent products operate on 5 volts, 3.3 volts, or both.

  Flash memories using 1 to 64 megabit chips are currently in production, manufactured by Intel, AMD, SanDisk, Samsung, Atmel, Seeq Technology, Toshiba and other firms, and more 64 megabit chips are currently being introduced. Most flash memory cards have capacities under 10 megabytes, but average capacities are increasing. Flash disk cards, some with capacities in excess of 100 megabytes, that mimic the 512 byte sector organization of a magnetic disk drive and include an IDE interface, appear as a disk drive to the host system. "Linear flash" appears as additional system RAM memory. Both are available in card and module packages.

  The price range for flash memory remained at about $40 to $60 per megabyte in 1992 and 1993 due to production roadblocks, but declined to the $30 to $40 per megabyte range in 1994 and 1995. Early 1997 flash memory OEM prices remain in the range of 7 to 15 dollars per megabyte, still much higher than magnetic disk drives, but should decline as memory chips using multiple bit storage cells enter the market in late 1997. Where less than 20 megabytes of storage are required and the rate of rewrites is not too high, flash memory can be economically attractive as a competitor to rigid disk drives.

Ferroelectric memories (FRAM) use the electrically reversible polarization of ferroelectric materials to form a capacitor, which is required in the circuitry of semiconductor memories. Proper design can produce a nonvolatile memory cell that can be fabricated with conventional planar processes but has smaller dimensions than cells made with silicon dioxide capacitor dielectrics. Submicrosecond access times are possible. The number of write/erase cycles possible exceeds a trillion cycles for the best materials, and a billion cycles may eventually be routinely achieved. Operating speed is equivalent to that of typical DRAM, but not quite as fast as conventional SRAM. FRAM does not have the limitations on write speed characteristic of flash memory. The fabrication techniques required to construct ferroelectric chips are substantially the same as used for CMOS, which is a well understood technology, although some process changes are needed to accommodate the different materials used.

Ramtron, which has long been the most visible developer of ferroelectric memory technology, has licensed it to NMB Semiconductor Company, ITT and Seiko, and more recently added Rohm, IBM, Toshiba, Samsung and SGS-Thompson as licensees. Ramtron and Hitachi are jointly developing 256 kilobit, 1 megabit and 4 megabit ferroelectric memory chips. Ramtron also has a joint development effort with Fujitsu aimed at production of 1 megabit chips, to be followed eventually by 16 megabit chips. National Semiconductor also has a ferroelectric memory development effort. Ramtron currently offers chips from 4 to 64 kilobits, and with its licensees hopes to produce 256 kilobit chips in the near future. The chips are currently being sold for a variety of applications, including electronic games.

Rohm began producing 4 kilobit, 16 kilobit, and 64 kilobit chips in 1996, some of which will be resold by Ramtron. Hitachi began production of 256 kilobit chips in 1996, and plans to produce 4 megabit chips in 1998, and 16 megabit chips in 1999. NEC has also discussed 4 megabit chips. Symetrix, another U.S. based startup, also has joint FRAM developments with Japanese partners.

Supporters of ferroelectric memories project that in the 1998 time frame, chips with 1 to 4 megabit capacity could be available selling at $30 to $60 per megabyte. 16 megabit chips, possibly available as samples in 1998, could sell in the $15 to $25 per megabyte range. Additional packaging and system costs will be incurred to fabricate the equivalent of a disk drive.

Ferroelectric and flash memories will contend for acceptance in portable computers, consumer equipment, "smart cards" and in industrial applications where loss of memory due to a power lapse is a critical problem. Ferroelectric memory will probably compete with magnetic drives in applications where the environment is stressful and rapid access is required. This includes military, industrial, and some high value commercial applications, but does not embrace the broader classes of nonvolatile memory requirements served by rotating memory. Development of ferroelectric memory technology is lagging that of flash memory, and it isn't clear that both can succeed.

* Holographic storage: Holographic storage is a type of storage in which an array of bits is stored in an optically sensitive medium as a pattern scattered throughout the volume of the medium. A scanned laser generated writing (object) beam and reference beam create an interference pattern throughout the storage element, which in turn modifies the index of refraction throughout the storage medium in a similar pattern. Many bit pattern images can be stored in a single piece of storage media, limited largely by the need to maintain an adequate signal to noise ratio. As images are added, there is some tendency for interference between them. The location of the image is determined by the angle at which the reference beam impinges upon the storage medium. When the medium is illuminated by the reference beam only, the data can be projected upon a detector.

  Storage media can be fixed or removable, and both write-once and rewritable forms are possible. Current media designs employ crystals fabricated from iron doped lithium niobate, barium titanate, strontium barium niobate and organic polymer materials. In general, the materials are not interchangeable. While some of these materials permit degradation of stored data due to the effect of read operations, temperature cycling can make the data permanent while still permitting further writing operations. Acousto-optical modulators are used to scan the laser beams. The deflected object beam used for writing is directed through a spatial light modulator (SLM) to create the bit stream to be stored. The SLM is typically a liquid crystal array with the bit pattern imaged upon it. A CCD sensor array is used as an output detector for data readback.

  Because holographic storage systems have no moving mechanical parts, they have applications in military, industrial, and other applications where ruggedized storage is essential. If practical, holographic storage can virtually eliminate the current limitations on throughput caused by mechanical drives, and must be considered as having the potential to compete with magnetic and optical rotating disk drives for selected applications after the turn of the century.

  Early attempts to develop holographic storage for use in computer memories were unsuccessful due to technical difficulties (many due to a lack of suitable components), such as a tendency of read operations to degrade the stored data, and inability to meet cost and performance constraints. But the very high storage densities and fast access times theoretically achievable have encouraged continuing research and development efforts by many organizations worldwide, and many of the early problems have been reduced or eliminated.

One of the more ambitious holographic storage programs was conducted by MCC (Microelectronics and Computing Corporation), a research consortium sponsored by major U.S. technology firms. Supporters of the MCC effort included DEC, NCR, Eastman Kodak, General Dynamics and E-Systems. MCC demonstrated working prototypes of write-once holographic memories in a 5.25" form factor in 1992 and established a subsidiary corporation, Tamarack Storage Devices, to commercialize the technology. MCC's devices targeted capacities in the range of 200 megabytes to 10 gigabytes, average access times in the 1 to 10 microsecond range and data transfer rates in the gigabyte per second range.

While Tamarack's efforts did not result in a salable product, other companies and universities are working as a consortium on the HDSS (Holographic Data Storage System) to develop prototype holographic storage equipment or required components by the year 2000. Much of this effort is funded by a $32 million program jointly funded by NSIC (National Storage Industry Consortium) and DARPA (Defense Advanced Research Project Agency), which is associated with the U.S. Department of Defense. The goal of HDSS is a capacity of at least a trillion bits and at least a one gigabit per second data transfer rate. A second consortium started in 1994, designated PRISM (Photo Refractive Information Storage Materials) is concentrating upon development of suitable holographic media. Both write-once and rewritable media are anticipated. The consortium is focusing upon creating a storage device with a terabyte of memory (using several media units), one gigabit per second data transfer rate and an access time of less than one millisecond within a single medium unit. A mechanical transport mechanism will switch storage crystals, with a typical transport time of 30 milliseconds anticipated. Packaging of the device within a standard 5.25" form factor is expected. Current cubic storage density is under 50 megabytes/cubic centimeter, but the target is storage media with 10 gigabytes/cubic centimeter capability.

Among the organizations participating in the HDSS consortium are IBM, Optitek, GTE, Eastman Kodak, Rochester Photonics, SDL and several universities, including Stanford, Carnegie Mellon, the University of Arizona and the University of Dayton. PRISM members include IBM, Optitek, GTE, Hughes, Rockwell, SRI and Stanford University. Nonconsortium organizations are also developing holographic memories, including Holoplex and NTT. Consortium members do not expect to have salable products available until at least 1999, although a few evaluation prototypes may be completed sooner. Rockwell and Holoplex have created operating prototypes with limited storage capabilities for evaluating the technology.

Research related to nonholographic three-dimensional optical storage continues, but many of the same temperature and material problems must be overcome. For instance, the University of California at Irvine disclosed an experimental device capable of storing 6.5 trillion bits in an organically doped plastic module the size of a sugar cube. Two different lasers are needed to write and read data, and the device must be operated at cryogenic temperatures to avoid data loss.

* Optical disk drives: Optical drives range from 2.5" units with 140 megabyte capacity to 14" drives with up to 25 gigabytes of capacity. In recent years, optical recording has increased its areal density at "only" an average 40% per year compared to the average 60% annual growth exhibited by rigid disk drives and has become increasingly disadvantaged compared to rigid disk drives from a storage density standpoint. With track densities of 18,000 to 34,000 tracks per inch and linear bit densities of 25,000 to 90,000 bits per inch or more, some optical disk drives remain capable of higher areal densities than magnetic disk drives now in use, although yet unannounced magnetic disk drives exceeding 3 gigabits per square inch areal density are expected to close the gap. However, the performance of optical disk drives compared to rigid disk drives is markedly inferior due to their longer seek times and latencies.

  Optical disk drives have the potential to become more significant challenges to rigid disk drives, as TeraStor, Quinta and other firms developing very high capacity magneto-optic drives introduce expected products in 1998. Neither firm has yet announced details of its designs, but near-rigid disk drive performance with initial capacities of 10 to 20 gigabytes per disk surface is anticipated. This new class of optical drives achieves its capacity through the use of hybrid heads, actuators and electronics using technology developed for rigid drives. The heads (which, in the case of TeraStor, employ unconventional imaging technology developed at Stanford University to produce very small bit size) fly only microinches from the media. Coupled with shorter wavelength red lasers and optimized media, the new optical drives are expected to achieve areal densities substantially in excess of those obtainable today with conventional rigid disk drive designs, achieving an anticipated 10 gigabits per square inch in 1998.

  Development of blue diode lasers capable of room temperature operation could further improve areal density, but suitable devices are not expected to be available for several years. However, the red lasers now appearing in newer conventional optical drives are expected to improve typical areal density over the next year. The ultimate limit of optical areal density may be much higher than today's practice. In mid-1992, Bell Laboratories reported they had written data in the laboratory at 45 billion bits per square inch using fiber optics to replace conventional optical elements.

  Although the areal density of optical drives is high, the volumetric density is inferior to that of magnetic drives because optical media is thick, head assemblies are large, only one disk is typically present, and typically only one head is present in the drive. Very high capacity drives, such as the anticipated TeraStor design, may eliminate much of optical's volumetric disadvantage, especially if the technology proves suitable for fixed media applications. Current optical drive technologies cannot provide performance equivalent to current magnetic disk technology, nor can optical drives yet compete on a product cost basis. Therefore, conventional optical disk drives will continue to be preferred only where removability of the media is an advantage, such as use in an automated library or for security concerns. The very high capacity, high performance optical drives anticipated in 1998 may well define a new niche in the storage performance hierarchy, located between rigid disk drives and conventional optical drives.

Even in some removable applications, high capacity 3.5" magnetic cartridge drives compete strongly with 230 megabyte and 640 megabyte 3.5" optical drives, offering better performance, lower price and higher capacity. Magnetic disk cartridge products such as the 1 gigabyte Iomega "Jaz" and SyQuest 1.5 gigabyte "SyJet" drives compare well against 3.5" optical drives. Optical drives seem more likely to complement rigid magnetic disk drives rather than replace them, serving as vehicles for backup, software distribution, and off-line or library storage.

Manufacturers of optical disk media now claim that their disks will provide archival lives which equal or exceed those of magnetic media, with 10 to 30 years being commonly encountered specifications for archival life of the media. Lifetime is limited by the gradual appearance of defects on the recording layer due to the corrosive effects of water and oxygen on the metal films used in the recording layers of the media. The termination point of media lifetime occurs when the error correction capability of the drive can no longer cope with the gradually increasing media defect density. Media using organic dyes as the recording material have no metallic films and may offer improved stability.

Because optical drives have removable media, large automated libraries using optical drives can provide random access to many disks, making the use of large-scale optical storage attractive for users such as governmental agencies, banks, insurance companies and other organizations with massive records that must be easily accessed. Library systems coupled with storage management software and operating system support make optical storage practical in the larger system environments typical of networks.

* Nonreversible optical disks: The first optical disk recording systems to enter the market were "nonreversible" or "write-once" systems. The initial products manufactured were 12" in diameter, but the trend is to 12 centimeter diameter drives. 12 centimeter (4.72") CD-ROM compatible write-once drives for professional use were introduced by Yamaha in 1989 and

by Sony in 1990, and lower cost 12 centimeter write-once drives from Philips, Sony and JVC entered the market in 1992. 12 centimeter CD-R drives became the dominant form of write-once drives in 1994 as a result of the displacement of 5.25" write-once drives by multifunction and rewritable optical disk drives. CD-R drives are now being displaced by CD-RW drives offering rewritability, but the transition will be gradual until CD-RW drive prices approach CD-R prices and production ramps are implemented. CD-RW and CD-R drive capacity and performance do not compete against rigid drives and they pose no significant competitive threat. DVD-R and DVD-RAM drives, anticipated in the 1997-1998 time frame, will offer competitive capacity, but inferior performance compared to rigid drives and are not expected to be significant competition.

The market for "pure" write-once optical disk drive systems is limited to the niches which emphasize nonreversibility. In some applications, the ability of write-once optical disk storage systems to maintain an audit trail or indicate whether or not stored data has been modified is perceived as a significant benefit.

Virtually no displacement of magnetic disk drives by nonreversible optical storage will occur in the foreseeable future, and the growth of write-once technology is being capped by competition from rewritable or multifunctional optical drive technology.

* Rewritable optical disks: As cost-effective rewritable drives with improved performance become available, the possibility for eventual inroads into the market for magnetic disk drives exists. Some rewritable optical drives have reached performance levels typical of small rigid magnetic drives in the mid-1980s, but cost, capacity, power consumption and packaging improvements have lagged.

  Magneto-optical (MO) recording has been evolving for more than twenty years, and rewritable phase change optical recording emerged as a competitor in 1990. Magneto-optical drives now entering production can finally overwrite in place: In older designs, a complete sector must be erased before the sector can be rewritten. Phase change media can be directly overwritten, but limits the number of write erase cycles, typically to a few hundred thousand. MO media can be rewritten indefinitely, although it is subject to thermal fatigue effects observed after 10-20 million write-erase cycles.

  Some rewritable drives have exceeded 4,000 RPM spin rates and Fujitsu has announced a 5,400 RPM model. However, average seek times are having difficulty moving below 20 milliseconds, and it remains to be seen if the performance of the TeraStor and Quinta designs can approach the best magnetic drive technology. Improved head design, shorter wavelength, higher power lasers and other improvements will gradually permit closing the performance gap.

Today's 5.25" MO drives typically offer 1.3 gigabytes per side. MOST, Sony, Nikon, Olympus and others have already introduced such drives, while Pinnacle Micro has announced both 1.3 gigabyte per side and 2.3 gigabyte per side drives. 2.6 gigabyte per side media issues are currently under consideration in several standards technical subcommittees, with related drives expected in 1998. However, the low shipment volumes of 5.25" MO drives leave them open to competition from lower cost 120 millimeter format writable and rewritable drives expected to be shipping in large quantities in the 1998-1999 time frame, including anticipated MO drives using 120 millimeter media.

ISO standard 3.5" drives now offer over 640 megabytes per surface. 3.5" drives are expected to move to the 1.3 gigabyte per surface mark towards the end of the decade, and Fujitsu has demonstrated an experimental 4 gigabyte 3.5" drive.

Sony's 140 megabyte 2.5" drive production began in late 1994, but the drive did not receive wide acceptance due to its relatively high price, power consumption and excessively large package.

The first rewritable phase change drive was introduced by Matsushita Electric in 1990, and was backward compatible with previous write-once drives from the same firm. The PD drive, a 650 megabyte rewritable phase change drive with CD-ROM read capability began shipping in 1995 from Matsushita and NEC. While inferior to rigid magnetic drives in performance, it has won a limited role as an auxiliary storage and data exchange and backup device. Companies producing CD format drives began shipping rewritable drives (CD-RW) using phase change media in late 1996. If produced at a low enough price, such drives could achieve significant market penetration as auxiliary storage. While unlikely to displace rigid disk drives because of limitations in performance and reliability, they are expected to slowly displace write-once CD-R drives.

Potentially the least expensive to manufacture is erasable dye-based technology. While developers have not been able to demonstrate an adequately high number of write/erase cycles for general use, there are applications, such as backup, where this is not a major disadvantage. Recordable CD format drives (CD-R) using write-once dye based media have been in production since 1992.

Individual firms working on other proposed reversible optical recording technologies have yet to overcome technical problems that include slow completion of the reversal cycle, degradation of stored data with the passage of time, sensitivity to ambient light, limitations on the number of reversals which may be accomplished before degradation, temperature sensitivity, expensive optical or laser components, poor shelf life, and low recording density.

* Read-only optical disks: The read-only optical disk category is dominated by the CD-ROM, which has capacities of 550 to 680 megabytes, depending upon the format used, but slow access times. Performance has gradually improved, with data transfer rates increasing from 150 KB/second (1X) through 2X, 3X, 4X, 6X to 24X or more, even though most systems are incapable of using rates higher than 8X (1.2 MB/second). DVD-ROM drives, with capacity per surface of 4.7 gigabytes, began shipments in late 1996. If multiple layer media is used, 8.5 gigabytes per surface is possible. Write-once (DVD-R) and rewritable (DVD-RAM) versions of DVD drives are also anticipated, but they will probably appear in the marketplace in volume in 1998 or later as additional technical, infrastructure, copyright and other legal issues must be resolved.

  Because they do not have recording capability, no significant displacement of magnetic disk drives by read-only optical drives is anticipated. They will retain a specialized role as a form of electronic publishing and will appear on computer systems as an adjunct to a rigid disk drive rather than as a replacement device. Rewritable CD or DVD format drives could take the place of some rigid disk drives in an auxiliary storage or data exchange and distribution role.

* High capacity flexible disk drives: The 5.25" Bernoulli disk drives offered by Iomega reached 230 megabytes in capacity and competed for a while with removable 5.25" rigid cartridge disk drives, but are now phasing out. Iomega and its several licensees are producing the highly successful 3.5" 100 megabyte "Zip" drive, and this technology is potentially extendible to the 200 megabyte range and beyond.

  The 3.5" "Floptical" drives with capacity in the 20 megabyte range produced initially by Insite Peripherals and for a while by Iomega achieved limited acceptance, especially in the aftermarket. The floptical 20 megabyte drive has been displaced by a 120 megabyte version manufactured by Matsushita-Kotobuki Electronics and others, and initially used by Compaq Computer in selected personal computer applications. Like the 20 megabyte version, these drives are backward compatible with 1.44 megabyte floppy drives. 130 megabyte floppy drives, also backward compatible are expected to be available in 1997 from Swan Instruments and Mitsumi Electric.

  Unfortunately, none of the 3.5" high capacity flexible disk drive formats are compatible with each other, although some provide read and write backward compatibility with one and two megabyte 3.5" floppy disks. Aggressively priced, high capacity floppy drives are expected to compete in the low end of magnetic and optical disk drive markets, and against tape drives for backup applications. With over six million shipped, Iomega's high capacity 3.5" "Zip" drives have proven successful in the marketplace, competing with various low-end rigid disk cartridge drive and optical disk drive formats for specific applications.

Disk drive enhancements

Continuous and rapid improvement in product technology has characterized the highly competitive rigid disk drive industry since 1956, when IBM shipped RAMAC, the first moving head rigid magnetic disk drive. IBM provided disk drive product development leadership until the late 1970s, at which time IBM was displaced from its leading position by aggressive competitors manufacturing small diameter drives. IBM reemerged as a product leader in the late 1980's, with new families of 2.5", 3.5" and 5.25" drives. IBM has maintained a leading position in early implementation of high recording densities in new drive models. The "Scorpion" series of high-end 3.5" disk drives set the pattern for the current generation of high-end 3.5" drives, and IBM's 2.5" drives have offered the industry's highest areal densities in most of the recent years. Other manufacturers followed IBM's lead and moved to higher areal densities based on magnetoresistive heads (first used by IBM in 1991) and improved data channels. In early 1997, Hitachi briefly captured the areal density lead with a 2.5" drive operating at 2 gigabits per square inch areal density, before IBM moved ahead with a 2.5" drive at 2.6 gigabits per square inch.

The critical areas of technological change for rigid disk drives are discussed below.

* <u>Areal density</u>: Areal density has increased rapidly since the early 1990s. Drives using MR heads and having areal densities exceeding 560 million bits per square inch went into production in 1994, and leading edge drives achieved over 900 megabits per square inch in late 1995. 2 gigabits per square inch was reached in early 1997, and drives exhibiting over 3 gigabits per square inch are anticipated by late 1997. 10 gigabits per square inch is expected by the year 2000. Increasing areal density reduces the number of disks and heads needed to achieve a given capacity in a specific form factor, which in turn lowers product costs.

  TPI in excess of 6,000 is common and many of the newest small drives operate at over 7,000 TPI. IBM's "Dolce" 2.5" drive operates at 9,000 TPI, while the 3.5" "Hercules" operates at 8,600 TPI. IBM has shown the feasibility in the laboratory of creating media with very narrow tracks with submicron dimensions. However, considerable work will have to be done to develop heads capable of working with such narrow track widths. Hitachi's 2.3 gigabit per square inch demonstration featured 17,000 TPI, a figure that may not be seen in a production drive for a while, but Hitachi's

2 gigabit per square inch 2.5" drive achieved 11,000 TPI. New materials and designs being developed to improve vibration suppression damping in head gimbal assemblies and positioning mechanisms should assist in reaching higher track densities.

IBM's 1989 1 gigabit per square inch demonstration operated at 158,000 bits per inch, which was exceeded slightly by Hitachi at 165,000 BPI. IBM's new 2.5" "Dolce" operates at 160,900 BPI, a bit more than IBM's 1989 laboratory demo. Many of today's small drives operate with bit densities above 80,000 BPI, and an increasing number have BPI in excess of 100,000 BPI. The areal densities of newer 2.5" drives exceed the areal densities of 3.5" drives.

Another factor increasing disk capacity is the ability of more intelligent drives to dispense with much of the sector formatting information, reducing overhead and increasing the available area for user data.

* Limits to areal density: Today's rigid disk drives all use longitudinal recording, making use of magnetic domains oriented parallel to the surface of the recording medium. As areal density increases and bit sizes decrease, the stability of the stored data declines due to interdomain interference until it reaches the superparamagnetic limit (expected to be reached at 35 to 40 gigabits per square inch between 2000 and 2005), at which further increases in longitudinal recording density are not possible. Higher linear densities could theoretically be resolved by recording heads if magnetization were oriented in a plane perpendicular to the recording surface or by using smaller cylindrical domains that are isolated from each other by nonmagnetic material, and TPI could also be sharply increased, provided that head to disk spacing is minimized. As areal densities of longitudinal recording approach the superparamagnetic limit, interest in perpendicular recording and the use of isolated domains is likely to increase because it appears to be able to support higher areal densities than longitudinal recording, perhaps extending to the 100 gigabits per square inch range.

  The use of hybrid optical/magnetic recording systems (which produce inherently cylindrical domains) also appears to offer a way around the superparamagnetic limit, although the increased complexity of the heads required may add enough mass to limit average seek times and available laser power may not be high enough to sustain writing at very high RPM, at least in initial designs for this type of drive. TeraStor claims that its yet formally unannounced drive will be able to operate reliably at areal density close to the superparamagnetic limit for longitudinal recording and is expected to offer considerably higher areal density as laser wavelength decreases in future years, permitting ever smaller bit sizes.

* Head flying height: Because head flying height determines the achievable areal density, reductions are of critical importance. Head flying height is in

the 2 microinch range for an increasing number of drives, and several firms are designing drives in which there is no measurable flying height.

As flying height decreases, maintaining a constant flying height becomes critical to reliable performance. Developers of conventional sliders have added slots to the outer rails or contoured the edges of the rails to improve flying height stability, while others have adopted negative pressure sliders, a design that forms a partial vacuum under the head. The head can stably fly very close to the disk surface, although there is a risk of debris accumulating in the negative pressure cavity on the underside of the head.

The virtual elimination of flying height requires a new level of sophistication in the preparation of disk substrates, plated layers, thin overcoatings, heads and test equipment. For instance, it appears that glass, exotic aluminum alloys or other alternative substrates may be necessary to obtain the required smoothness, rigidity and flatness for the lowest flying and glide heights. Determining reliable processes for manufacturing, coating, texturing and testing disk media using alternative substrates are major challenges, as are the needs for accurate, repeatable test instrumentation capable of dealing with decreasing flying height and bit sizes.

Several approaches to contact recording have been tried. Censtor developed an unusual low mass, low contact area head design in which the head is normally in contact with the disk. While wear does occur, the rate of wear of the critical parts of the head is low enough to permit head lifetimes to exceed expected drive lifetimes. The head area and loading is small enough to control stiction effects, and the in-contact thin film head is capable of operating at 200,000 to 300,000 BPI. VISqUS Technology, acquired by Conner Peripherals in 1991, developed a "waterskiing" technique in which the friction of head/disk contact is controlled by floating a head on a continually refreshed liquid bearing surface, but this technique did not prove successful in practice.

IBM's "tail dragging" approach suspended a small head from a larger flying head. The large area of the flying head keeps the head at a stable height and orientation while positioning the smaller active head at the surface of the disk. The tail dragger has evolved into a series of virtual contact heads, variously called "Tri-pad" or "Proximity recording heads" by various manufacturers. These heads, which fly at 1.5 microinches or less, are the most commonly used type. They are employed for both inductive thin film and magnetoresistive heads.

* <u>Recording heads</u>: Monolithic ferrite heads patterned after IBM's 3350 designs dominated early Winchester disk drive designs. In following years, PCM disk drives using heads with 3370 contours (minisliders) designed to compete against IBM's 3370, 3375, 3380, and other new drives with ferrite heads became common. The avalanche of small diameter disk

drives from multiple OEM sources since the early 1980's has required smaller head contours and continues to drive the demand for higher performance smaller heads. These pressures have driven the development of composite, metal-in-gap ferrite heads, inductive thin film heads, and magnetoresistive thin film heads, but ferrite heads are all but phased out as areal density increases forced the transition to inductive thin film heads and, more recently, to magnetoresistive heads. A transition to heads using "Giant" magnetoresistance, also known as spin valve heads, is expected to be well under way by the end of the decade. 1984 saw the beginning of thin film head shipments for small diameter OEM disk drives. Production is large and increasing as more vendors master the process and gain control of process yields.

Sliders have continued to decline in size under the pressure to make ever smaller HDAs. After several years of dominance, the 70% form factor microslider (70% of the volume of a minislider) has been replaced by the 50% form factor nanoslider, which is now in wide use in 3.5", 2.5", and 1.8" disk drives. The 30% form factor picoslider is now supplied by several manufacturers for use in 2.5" drives, but 50% sliders are expected to be used with the majority of drives for several years in the future. A limited use of sub-30% sliders began in 1996. As the form factor decreases in size, the difficulties in connecting MR heads, which have more leads, will begin to mount.

As spacing between disks diminished, use of smaller sliders became mandatory. Additional advantages of the small sliders include less mass to inhibit rapid positioner movement or to cause damaging head/disk interference. The smaller size also relieves stiction problems, although some new drive designs also utilize ramp loaded heads, eliminating the possibility of stiction and reducing power requirements for starting drive motors. The very low flying heights now required also required improvements in head wear resistance. A diamond like carbon overcoating for the head first used by IBM is now used by many producers to improve head life and reduce stiction.

Head suspensions have become a challenging design area as slider form factors continue to shrink and MR heads, which require more wires, become increasingly prevalent. Expected improvements include the incorporation of connecting leads and head bonding pads within the structure of the suspension itself. While stainless steel remains the current material of choice for suspensions, other materials such as ceramics or silicon are being investigated.

Magnetoresistive heads are now in use in both high performance and low cost disk drive designs. While internally generated noise, vulnerability to electrostatic discharge and low yield still remain challenges, MR heads are now available from at least 9 vendors, with many also produced by drive manufacturers such as IBM, Quantum, Fujitsu and Seagate.

IBM introduced the first 3.5" disk drives using MR heads in 1991, using them in 2.5" disk drives in 1993, as well as in the 3390-9. A few drive manufacturers introduced drives with MR heads in 1994, and others have followed. Seagate, Fujitsu, Quantum and Hitachi are among the companies that have announced drives using MR heads.

In August, 1993, IBM published information suggesting that advanced MR heads using "giant magnetoresistance" (GMR), which enhances head sensitivity and improves signal to noise ratios, will be a key factor in moving recording density beyond 1 gigabit per square inch to 10 gigabits per square inch areal density by the end of the decade. IBM has demonstrated recording at 3 gigabits per square inch in the laboratory. Giant magnetoresistance is moving out of the laboratory stage at IBM and other firms, and drives with GMR heads are expected in 1998. There appear to be several possible methods of constructing multilayer heads exhibiting enhanced magnetoresistance, with the more promising designated as the multilayer granular alloy approach and the spin valve, also a multilayer structure. The challenge is to fabricate a structure highly responsive to the lower field strengths typically seen by read heads as bit size declines.

MR heads are usually fabricated in an assembly including an inductive thin film head for writing and the MR head for readback of data. The width of the write head is usually greater than the width of the read head to provide some protection against off track positioning and noise from adjacent tracks. Because these head assemblies are complex and yields are not yet high, except for IBM, the near term use of MR heads is expected to be limited to situations requiring their unique capabilities, and it is not clear that the supply of MR heads can be ramped fast enough to meet anticipated demand in the next few years.

* Recording disks: Disk media production processes have undergone continuing refinement to achieve ever-thinner applications of more uniform recording layers. Progress in improving media surface lubricants and protective overcoatings has been equally impressive, if at times uneven. Fluorocarbon based lubricants are typically used in current drive designs. Carbon and silicon dioxide overcoatings have been getting thinner, to reduce head-recording layer separation. The thinnest are now down to about .2 microinch. Hydrogenated carbon is the most favored overcoat material. The emergence of virtual contact recording has created pressure to improve the durability of the thin overcoatings.

  Substrate smoothness has been a critical issue for several years as flying heights have diminished. Aluminum substrates require a layer, usually plated, of very smooth material to serve as a surface for the deposition of the magnetic recording layer. A typical layer is 300 to 400 microinches thick, and is textured to provide protection against stiction. The depth of the texturing is decreasing as flying heights decrease, but the texturing patterns are becoming more complex, increasing the sophistication and expense of texturing equipment. The "bump" type of laser texturing currently employed is expected to be replaced by finer geometric patterns that do not perturb the position of a low flying head. Zoned recording and the expansion of the active recording area closer to the outer edge of the disk are also increasing the complexity of the texturing process. The increasing complexity of the processes required to create good aluminum substrates are encouraging the use of glass and glass/ceramic hybrid materials as substrates, as the surfaces tend to be inherently smooth and texturing can be added in the process of making the basic substrate.

The oxide coated media of early disk drives has been displaced by thin film media, because oxide coated media was unable to satisfy increasing areal density requirements. Even IBM, a longtime oxide champion, abandoned oxide coated media after 1989.

Plating was the primary method used to produce early generations of thin film disks, but plating has been supplanted by sputtering as the preferred production technique for disk magnetic surfaces. The sputtering process is more capable of producing the higher coercivities, thin layers and tight tolerances required by disk drives operating at high areal densities and low flying heights. Media producers also find the sputtering process easier to control and capable of substantially higher yields than the plating process. Plating retains a role in the preparation of aluminum substrates, being used to place a nickel-phosphorus alloy passivating and smoothing layer on the substrate before the magnetic layer is applied by sputtering.

Media with coercivity in the 2,000 oersted range is routinely produced, and some companies have demonstrated fabrication of media up to 2,500 oersted coercivity on production quality sputtering systems. Media with coercivities exceeding 2,000 oersteds is expected to increasingly appear in new high end and mobile system drive designs.

As areal density moves above the 5 gigabit per square inch level, media design will become more complex, with more specialized layers sputtered onto the surface to provide higher linear bit density and faster bit switching. Process designers will be challenged to maintain current process yields and media costs as complexity increases. The decreasing bit size will also require a reduction in the number and size of surface defects in order to keep yields at an appropriate level.

Most high capacity 2.5" disk drives, such as those of IBM and Toshiba, use glass or glass/ceramic as a substrate material, and some 1.8" drives have also used glass media. (3.5" and larger drives have continued to use aluminum substrates.) Glass substrates are potentially smoother and flatter (especially in very thin substrates) than aluminum, have fewer impurities that can cause defects, and can be made very thin. These characteristics allow for lower flying heights and the inclusion of more disks in a stack, both highly desirable features. However, glass is more difficult to laser texture. Because glass is more resistant to damage from shock induced head slap, glass substrates are attractive in drives for mobile systems. However, because of lower production volume, glass disks still cost significantly more than aluminum substrates and industry production capacity is limited at present. Aluminum is likely to remain the substrate of choice for some years for 3.5" and larger media, and the use of 30% sliders, which are less likely to damage media as the result of head slap, may make aluminum a stronger contender in the sub 3.5" drive arena as well.

In 1993, Seagate Technology and Corning announced that Seagate had agreed to use Corning's canasite glass/ceramic substrates in volume production. Technical problems involving degradation of the magnetic coating by substrate contamination have delayed the use of canasite in production drives. Other alternative substrate materials have been proposed, including carbon, plastic, titanium, aluminum-boron-carbide and silicon carbide, but none of these have yet won industry acceptance.

Disk substrate thickness is declining in order to allow placement of more disks in small diameter drive HDAs. In 1989, 50 mil substrates were standard practice for 3.5" diameter drives, but 31.5 mil substrates have assumed the lead position since IBM introduced them in the "Lightning" 3.5" drive in 1989. 2.5" drive substrates, now predominantly at 25 and 35 mils, will also migrate to thinner disks, probably 15 mils, but that is likely to take several years.

* Performance: Significant improvements in data transfer rates and average access times are expected during the next few years. Important factors in initiating these improvements will be the increase in disk rotation rate, (which both decreases latency and increases data transfer rate) and increases in linear bit density (which also increases data transfer rate at a given RPM), albeit at the expense of a higher performance read/write channel.

  3,600 RPM was the standard drive specification for many years, but drive RPM began an upward trend in 1989 when Imprimis announced a family of high capacity 5.25" drives operating at 5,400 RPM. Seagate pioneered 7,200 RPM drives in late 1992 with the "Barracuda" series, and extended its leadership in late 1996 with the 10,000 RPM "Cheetah". Some firms are considering using motors in the 10,000 to 15,000 RPM range. The heat, runout, power consumption and bearing wear problems generated by higher spin rates present a significant challenge to both disk drive and system designers, who are expected to begin adopting hydrodynamic motor bearings (in which a thin viscous film substitutes for ball bearings) as spin rates move above 12,000 RPM.

  As RPM and track density increase, it becomes increasingly difficult to maintain head position relative to the recording track. The higher servo bandwidths required probably cannot be accommodated by pivoting the actuator arm around its bearing, and compound actuators are expected to appear, perhaps as early as 1999, as companies begin acquiring manufacturing experience with the technique. Suspension mounted microactuators capable of moving the head over a range of a few tracks for purposes of track following or fine motion positioning are expected to be the solutions of choice for most companies. Micro-voice coil motors and piezoelectric elements appear to be the most commonly considered solutions at the present time.

The availability of high speed data channels that connect the heads to the drive controller may be a factor that paces the rate of performance advances. While the electronics used to write data is fairly straightforward, the ever increasing write speeds required are causing parasitic head inductances/capacitances/resistance and bit switching time in media to require attention as potential performance obstacles. Readback circuitry can be quite complex and is usually the limiting factor in establishing the bandwidth of the data channel, a situation complicated by the declining signal to noise ratio observed as bit density increases. While the majority of drive read channels currently use peak detection and have bandwidths under 100 megabits per second, advanced drives employ PRML (Probable Response, Maximum Likelihood) channels and have moved past 100 megahertz in read channel bandwidth. One of the fastest read channels is offered by Silicon Systems, which specifies operation at up to 200 megahertz. As areal densities approach 10 gigabits per second, channel data rates are expected to require 400 to 500 megahertz data channels. While PRML channels are fast, they also require significant power, making them less desirable in small drives destined for use in notebook computers, although aggressive power management strategies can minimize the average power required.

Average seek times have now dipped down to the 6-7 millisecond range for the fastest drives, and sub-10 millisecond seek times are becoming more common in high performance 3.5" drives. Higher energy magnetic materials used in actuators and lower mass heads are contributing to the improved performance. In some cases, special alloys permitting lighter positioning mechanisms that help reduce seek time are being considered. Some drives are specified with read seek times that are a millisecond or two faster than the write seek time as a result of drive intelligence permitting usable readback signals to be acquired before the head has fully settled after a seek.

The requirements of digital audio and digital video based systems require a different view of performance. While data processing systems can specify performance in terms of average response times and throughput, multimedia oriented systems require specification of the maximum sustained performance in terms of throughput and response times so that system designers can obtain the smooth flow of audio/video content required by end users. The continuity of output requirement has implications as to how intelligent drive controllers manage potentially disruptive operations such as periodic recalibration, head degaussing, and other internal, and usually invisible, housekeeping functions. Drives employing embedded servo tracking schemes may have an inherent advantage in providing an uninterrupted data flow.

* Form factor: Sub-3.5" drives are an increasingly significant part of the market as manufacturers of notebook computers require small footprint, low height, low power drive designs. Drive height has steadily declined, and competition in providing higher capacity and thinner sub-3.5" disk diameter drives is keen. 15 to 19 millimeter heights are available for new low-end drives for desktop computers, so that half of an existing "half high" disk drive bay can be free for other peripheral devices. 3.0" drives for use in notebook computers are now in production. They are seen by many notebook producers as a good compromise between size, capacity and power drain. 2.5" drives are already available in the 8.5 to 12.7 millimeter high range, to allow maximum volume for batteries in notebook computers. 1.8" drives conforming to the 10.5 millimeter PCMCIA Type III height requirement are in production. Maxtor announced 1.8" drives in the 5 millimeter high PCMCIA Type II card format in 1995, but the product was never put into production, and Maxtor subsequently withdrew from the 1.8" drive market.

  Despite the move to smaller form factors, 5.25" drives are not dead yet. In 1995 Gigastorage International announced a single platter 1.1 gigabyte 5.25" drive, and in 1996 Quantum announced "Bigfoot", a family of one and two platter 5.25" drives with capacities of a 1.2 and 2.2 gigabytes, (since expanded to three platters and over 6 gigabytes) taking advantage of minimal parts count and the larger surface area of the disk to obtain a lower cost per megabyte. Depending on the ferocity of the competitive response, such drives may have the potential to be shipped in significant numbers over the next few years.

  Technologically, form factor reduction is being driven by improvements in areal density, smaller heads, thinner media, greater IC functionality, and higher energy magnetic materials that permit fabrication of smaller motors and actuators without reducing performance. One of the most critical factors is the reduction in the surface area required to mount electronics needed by the drive. An increasing degree of functional integration in chips is needed and is being provided. In some drive designs, fewer than 7 chips are needed and drive designs requiring only 5 chips (or less) on the circuit board are expected to be common in the future.

* Power reduction: Another aspect of form factor reduction is the need to operate the drive at low power to conserve battery life in portable systems or to meet the requirements of energy efficient desktop systems. Smaller form factor drives typically need less power to rotate the disks and move the heads. Portable systems require the drive to have several operating

modes to conserve power when not in use. Typically, the drive does not spin when data is not being transferred and other power consuming functions may also be shut down when the drive is inactive. A related need is for the drive to quickly come up to operating speed when needed. A few designs incorporate ramp loaded heads, enabling removal of the heads from disk contact when the drive spins down. The removal of head drag on the disk enables the drive to spin up faster with less power demand and lessens the danger of a stiction caused malfunction.

The voltage required by the drive is also a factor. After 1996, some drives for portable systems may be capable of operating within specification over a range of voltage from 3 to 5 volts. 3 volt operation permits the drive to be operated directly from a battery supply without incurring the cost and power dissipation of a voltage regulator. While concerns exist about the performance of drives operating at 3 volt levels, the performance requirements of the portable computers most likely to employ 3 volt drives may not demand the highest levels of disk drive performance. 3 volt chips and chip sets are gradually becoming available, with various functions such as controllers and read/write channels available from Cirrus Logic, IMP, Allegro, Zilog and others.

* Interfaces and controllers: All of the current small disk drives have intelligent embedded controllers and are able to communicate directly with a host system data bus or host bus adaptor. Embedded SCSI and PC/AT (IDE) controllers are widely used in drives for personal computer applications, and embedded SCSI is also used with the majority of drives used with workstations, servers and equivalent applications. SCSI is also used as an interface to other types of peripheral products, including tape drives, optical drives, libraries, scanners and others. Ultra-SCSI drives are now entering the market.

While the IDE interface (more formally known as the ATA, or AT Attachment interface in standards committees) was originally limited to rigid drives with 528 megabytes or less, the Enhanced IDE (EIDE) specification sponsored by Western Digital and other firms supports drives with capacities to 8.4 gigabytes, provides 1 or 2 data channels, and also accommodates other devices such as CD-ROMs and tape drives. Higher data transfer rates in processor I/O mode and DMA mode are also supported, allowing IDE to substitute for SCSI if only a few peripheral devices are needed in a system. Enhanced IDE incorporates ATA-2, the second generation ATA specification establishing the higher data transfer rates and additional transfer modes. Shipments of disk drives incorporating EIDE and ATA-2 began in 1994.

SCSI interfaces are most frequently encountered in workstations, file servers (especially those using disk drive arrays) and Apple Macintosh and IBM personal computers. IDE interfaces far outnumber SCSI interfaces in the IBM compatible personal computer market. For 1.8" and smaller drives, the standards for pin connections used for ATA (AT Attachment) cards that fit physically into PCMCIA sized slots and connectors exist but various manufacturers have implemented them in ways leading to incompatibility between cards. However, some companies have agreed to informal interchange standards: In September of 1993, IBM, Maxtor, Seagate, SanDisk and Toshiba announced that mass storage cards using the PCMCIA interface and supplied by those companies would be interchangeable and would also comply with the ATA standard.

The SCSI interface continues to evolve, with the SCSI-2 command set now in general use. SCSI-3 (Ultra-SCSI), the next version, is now incorporated in many high end rigid drives. (However, SCSI is implemented in different ways by different peripheral manufacturers, and is not the ironclad standard that many would prefer.) SCSI has been upgraded to accommodate 20 megahertz bus clock rates, permitting 20 megabyte per second byte wide transfers (Fast-20) or 40 megabyte per second transfers (Fast-40) if two bytes are transmitted at a time.

Serial interfaces are a new family of small drive interfaces. Three interface designs are vying for drive maker and OEM acceptance: SSA (Serial Storage Architecture), Fibre Channel Arbitrated Loop (FC-AL) and the IEEE sponsored P1394 interface, more familiarly known as Firewire. The serial interface proposals have some common features, including SCSI command sets, ability to hot plug drives, smaller and less expensive connectors and cables, and data transfer rates exceeding IDE and SCSI rates, but differ in their efficiency with different size data blocks, number of drives or other devices, physical size of storage subsystem and other factors.

SSA, originally supported by IBM, Conner, Micropolis, Dell, Adaptec and many others was earliest to appear in drives and controllers, and seemed destined for a major role in large and midrange systems. However, with the acquisition of Conner by Seagate Technology and the sale of the Micropolis disk drive operation to Singapore Technologies, wide industry support for SSA vanished, and the market has been reluctant to perceive SSA as truly "open" and not an IBM marketing ploy. Fibre Channel now appears to be the serial interface of choice for most system producers, and an increasing amount of support from chip and controller producers has materialized. Fibre Channel has been championed by Seagate, Quantum, and many supporters of open systems, while Apple and video equipment producers have been the most visible supporters of P1394, which is expected to find its primary role in home based systems and/or multimedia applications. The choice of serial interface used will be made by the system integrator dependent upon the application and processing platform selected.

Intelligent interfaces and embedded controllers provide disk drive suppliers with a chance to add value, but more importantly allow engineers to design the drive to meet various needs while maintaining a common interface to the host system. Embedded intelligent interfaces (usually implemented with microcode) permit varying bit density by zones over the band of recording tracks and advanced data coding transparent to the host system. Other features, such as on-board error monitoring and diagnostics, error correction, exclusive-OR computations, digital servos, segmented caching, zero latency read/write and multiport buffering can be included and also made transparent to the host system. However, there is a balance between overall system performance and the design of the intelligent controller. For instance, the use of too large a buffer can slow data retrieval if all of the buffer contents must be examined to service each request for data from the system. Intelligent controllers can also provide indications of impending drive failure to a system, permitting an orderly replacement of the drive with minimum disruption to operations.

* Digital servos: Digital servos are increasingly popular as VLSI density improves, track density increases, and smaller disk drive form factors make printed circuit board space a scarcer commodity. The ability to incorporate programmable servo functions in a single chip or chip set provides both functional and economic advantages. Typical servo control chips employ digital signal processors coupled with a standard microprocessor. Digital servo chips may include motor power control functions as well as servo functions.

* Encoding and error correction: Effective linear bit density can be improved beyond the raw flux change density by the use of appropriate data encoding schemes. Run-length-limited codes such as 1,7 RLL are the most often used currently, but the Probable Response Maximum Likelihood (PRML) code introduced by IBM is becoming more widely used as it becomes well understood by the rest of the industry and appropriate chips become available from independent semiconductor vendors.

  In-line error correction of the read-back data stream are expected to become increasingly common, because as areal density becomes higher, the size of a media defect required to cause an error becomes smaller and the number of error causing defects per unit area increases. The Reed-Solomon codes used in optical disk drives to perform error correction are migrating to the rigid disk drive world, permitting the reliable use of media that would otherwise have to be discarded. The effective improvement in media yield provides an incentive to adopt error correction techniques. However, the error correction process will become increasingly stressed due to the need to increase speed to keep up with higher data transfer rates.

* Internal processing: If other in-line processing of data within the drive is performed, data compression within the drive might also be incorporated as an internal drive capability. In addition to improving capacity, the inter-

nal data transfer rate may be improved. The degree of compression obtainable is highly influenced by the format of the data and the degree of processing allowable by real time requirements on drive performance. In any event, the compression algorithms used will be restricted to lossless compression techniques. Another type of internal drive processing is exemplified by Western Digital's SPX drives, which interface to CD-ROM drives and provide much of the buffering and interface function required by the CD-ROM drive, thereby providing greatly improved performance and a lower cost for the optical drive. Seagate also offers augmented drives, in this case drives that perform the exclusive OR logical function required for disk drive arrays. These drives are expected to find usage in arrays operating from serial interfaces.

* Storage management software: As rigid disk drives move to higher capacity levels and are attached in large numbers to individual systems and network file servers, the ability of system managers to control and monitor the flow, availability, and residence time of data in data storage subsystems is becoming increasingly important. While such software is not an integral part of the drive, its presence, availability and usability are becoming important influences in determining market acceptance rates for high capacity, high performance 3.5" drives in networked systems.

* Multiple spindle arrays: A single high capacity drive can be replaced with an array of smaller capacity drives having aggregate equivalent capacity and a file organization that appears to the host system to be similar to that of the larger drive. Data, plus parity information, is typically striped, mirrored, or both, across each drive in the array. In some array configurations, the drives operate with the drive rotation rate and phase synchronized to minimize the skew between related bits. Disk drive arrays are usually implemented with specialized controllers and software, but some arrays achieve low cost by using software to control array functionality and minimize hardware content. This approach lowers cost, but performance usually suffers. Arrays are available for a variety of systems, ranging from PC's serving as file servers to mainframes and supercomputers.

  The term RAID (Redundant Array of Independent Disks) denotes multiple drive configurations generically, with specific configurations ranging from multiple, uncoordinated disk drives to striped, synchronized drives defined within the RAID designation as RAID-0, RAID-1, RAID-2, etc., through RAID-6. The RAID nomenclature, which derives from papers published by the University of California, Berkeley, has been formally defined only up to the RAID-6 level, but various firms offer advanced redundant architectures informally defined with RAID designations of their own invention. The RAID Advisory Board, an industry association, has developed a standardized nomenclature for disk drive arrays. Attention is shifting away from the specific RAID architecture to the degree of data availability provided by the overall storage subsystem, including the array components.

The multispindle array can offer significant advantages compared to drives limited by a single actuator. Depending upon the way the array is configured and upon the degree of sophistication of associated subsystems, it can provide fault tolerance, very high data transfer rates, or volumetric efficiencies, compared to single drives. Options such as cache and multiple data paths can also improve performance. Disk arrays, except for the RAID-0 (striping only) type, improve fault tolerance. However, optimizing for performance means less than optimum reliability and cost, while optimizing for fault tolerance or cost may degrade performance significantly.

Several companies provide array products that operate simultaneously in several RAID modes, providing users with operational flexibility. Arrays are more costly than single large disks, and require that each drive in the array have superior reliability to provide an acceptable service rate for the array. Furthermore, while arrays can improve the fault tolerance of the system, data availability is not assured unless every portion of the system is made redundant so that a failure of a controller, a power supply or a cable cannot disable the array.

Disk array markets have grown to a significant size. While product complexity and proliferation, lack of standardization, customer confusion and ignorance of array capabilities could be expected to suppress market development, the array market is actually on a healthy growth pattern and has already passed the $9 billion level.

DEFINITIONS

Many basic terms have varying meanings within the computer industry, depending upon the role of the person speaking. In this report, such terms are used in the way most disk drive manufacturers use them.

Market classification

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

Captive: Disk drives 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; drives sold to PCM/Distributor or OEM/Integrator market classes are classified accordingly. Most DISK/TREND statistics separate data between IBM captive and "other captive", but the term still pertains to the disk drives involved, not the manufacturer.

Examples:

* Drives sold by IBM, Hitachi or Fujitsu with computer systems to end users are considered captive, if internally manufactured.

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

Examples:

* Shipments by Toshiba are noncaptive, except for drives sold with computers made by the parent company or other subsidiaries.

* Shipments made by Seagate or Western Digital are noncaptive.

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

Examples:

* Disk drives sold by Quantum or Maxtor through distributors or major retailers to computer end users.

* On an arbitrary basis, disk drives manufactured by Seagate, Fujitsu or Hitachi and resold in the PCM/Distributor market by other companies are included in PCM/Distributor totals, to avoid distortion of total PCM activity.

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

Examples:

* Drives produced by Seagate or Western Digital for sale to system manufacturers.

* Drives sold by Quantum Corporation to system manufacturers but manufactured to Quantum designs by Matsushita-Kotobuki Electronics.

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. disk drive manufacturer to a European system manufacturer is included in worldwide totals, even if the drive is integrated into a system within the U.S.

* An OEM shipment by a Japanese drive manufacturer to a U.S. based system manufacturer is included in U.S. totals, even if the drive is integrated into a system in Taiwan, regardless of the final destination of systems in which the drives are used.

U.S. vs. Non-U.S. MANUFACTURERS: Disk drive 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.

Example:

* Seagate is considered a U.S. manufacturer, even though the firm manufactures disk drives in non-U.S locations.

Units of measurement

Spindles: The basic unit in counting disk drives. One spindle or spindle disk assembly consists of the disk drive mechanism required to utilize a single disk or disk stack. All DISK/TREND unit totals are counted in spindles. In order to avoid distortion of shipment information for fixed disk drives used with mainframe systems, certain plug compatible models have been arbitrarily counted on the basis that two or more physical spindles are equivalent to a single IBM spindle.

Revenue: Based on sales of disk drives alone, as normally sold by individual manufacturers. Controllers sold as separate units are not included in disk drive revenue, nor are spare parts or service. When individual disk drive models include integral control functions, such as may be required for the first drive on a string of drives, the actual value of the complete unit is used. Sale prices are estimated public sale transaction prices, whether at captive end user, PCM/Distributor or OEM/Integrator levels. All prices are in 1997 constant dollars.

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

Examples:

* Product enhancements such as double density versions of existing single density configurations and revised encoding schemes are anticipated in DISK/TREND forecasts.

* Innovations such as nonstandard size disks or new physical configurations may require establishment of new DISK/TREND product groups.

Application classification

Shipments of disk drives are classified by the following computer applications:

Very high performance systems: Disk drives which are attached directly to the processor or to a terminal associated with a supercomputer or a high-end imaging system.

Mainframe systems: Disk drives attached directly to the processor or to a server associated with a mainframe or superminicomputer.

Networks/midrange computers: Drives attached to network file servers, minicomputers, video-on-demand servers and other midrange multiuser systems. Examples: IBM System AS/400, Hewlett-Packard 3000, Compaq Systempro, Data General CLARiiON series.

Personal computers: Drives used with a desktop or portable personal computer intended primarily for nonconsumer applications. Examples: Dell Dimension, Apple Macintosh, Compaq DeskPro, Toshiba Satellite series.

Workstations: Attached to single user high end workstations used for engineering, graphics, order processing/shipping, document storage and imaging, point-of-sale, medical, CAD/CAM/CAE, factory production control, law enforcement, military, and other applications.

Consumer and hobby computers: Used in general purpose or dedicated applications systems sold primarily to consumers for nonbusiness purposes. Examples: All computers intended for home use and all computer games. Multimedia systems for home use are also included in this category.

Other applications: Any application not included above, including nonconventional uses such as intelligent fax machines, copiers, intelligent personal communication devices, automotive navigation systems, digital cameras, factory data collection equipment, etc.

DISK CARTRIDGE DRIVES

DISK CARTRIDGE DRIVES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

SyQuest Technology	SQ5200C

3.5" disk diameter

Iomega	Jaz
Nomai	MCD-I, 750.c
SyQuest Technology	EZFlyer 230, SyJet

2.5" disk diameter

Avatar Systems	2250

All types of disk drives using removable media in the form of rigid disk cartridges have been included in this section. Until 1995, 5.25" disk drives provided the majority of shipments in the disk cartridge drive product group. However, SyQuest's 3.5" drives have been available since 1992, with capacities up to 1.5 gigabytes available in drives currently in production, and total shipments of 3.5" drives passed up the 5.25" form factor in 1995.

In response to the Iomega initial market success with the Zip 100 megabyte high capacity 3.5" floppy drive, SyQuest introduced in 1995 the "EZ" single head 3.5" rigid disk cartridge drive designed for very low cost, with capacity initially at 135 megabytes, followed by the 230 megabyte EZFlyer in mid-1996. The capacity range of rigid disk cartridge drives was significantly increased in December, 1995, with the Iomega introduction of the 1 gigabyte Jaz 3.5" drive, using a two disk cartridge. In response, SyQuest offered the SyJet, a 3.5" drive with a capacity of 1.5 gigabytes using a two disk cartridge, with deliveries starting in December, 1996. The race to offer higher capacities in 3.5" rigid disk cartridge drives is destined to continue, exploiting the availability of advanced heads, disks and other critical components being continually developed for fixed disk drives. There is also the possibility that the capacity leadership now held by 3.5" drives may be surpassed by 5.25" rigid disk cartridge drives, if SyQuest is able to obtain the financial resources needed to start production of the company's planned Rocket series of 5.25" drives, starting with a 4.7 gigabyte model.

Avatar Systems' 2.5" disk cartridge drives, including models combining removable disk drives with floppy drives, have been available in limited production quantities since 1993, with volume production of the current 250 megabyte models under way at the company's new Thailand plant. SyQuest also initiated a 2.5" disk cartridge drive program, with initial shipments in 1993, but has since discontinued the product. In addition, SyQuest placed considerable emphasis on development of an 80 megabyte drive in a PCMCIA Type III PC Card format, using 1.8" disks in a cartridge which could be removed from the removable drive. However, the 1.8" project was dropped in early 1996.

Market status

Although total shipments of disk cartridge drives did not reach the expected level in 1996, the increase was substantial. 1996 unit shipments topped 1 million drives for the first time, up 73.2%. 1997 shipments are forecasted to exceed 1.9 million drives in 1997, an increase of 83.4%. Sales revenues for 1996 were $237.1 million, and 1996 is expected to reach $350.4 million, new highs for the product group. The current shipment growth in this product group continues to be derived mostly from 3.5" drives, with a modest assist from 2.5" disk drives. The role of 5.25" drives continues to diminish, limited by capacities that are too low and prices that are too high, until the arrival of new high-end models, expected next year.

Rigid disk cartridge drives do not exist in an isolated market. They share the market for removable media disk drives with high capacity flexible disk drives and optical disk drives, and frequently compete for the same applications. For years the most aggressive competition for SyQuest's rigid disk cartridge drives was provided by the Iomega 5.25" high capacity Bernoulli floppy disk drive. Iomega's Bernoulli drives also increased in capacity over the years, up to 230 megabytes, with the result that SyQuest and Iomega have competed directly in both the Macintosh and IBM personal computer markets for the same graphics and desktop publishing applications. Until 1995, SyQuest's disk cartridge drives held a clear lead in these markets, due to a successful strategy of concentrating on the Macintosh market, the leader in desktop publishing. SyQuest's EZ drive series, initially with 135 and now with 230 megabytes, was intended for many of the same markets as Iomega's successful Zip high capacity floppy drive, currently at 100 megabytes with a higher capacity version expected. SyQuest's disastrous financial results during the last two years illustrate the difficulty in competing against a high capacity floppy drive optimized for low production cost with a rigid disk equivalent.

There is also a vigorous contest between 3.5" rigid disk cartridge drives and 3.5" magneto-optic drives, but the 3.5" rigid disk cartridge drives appear to be holding their own in this contest. Shipments of both types of drives are increasing, but rigid disk cartridge drives remain at higher shipment levels, due to lower prices and continuing increases in the disk capacities available. 3.5" MO drives, however, have made progress in displacing 5.25" rigid disk cartridge drives in some professional and business applications, with higher capacities and increasingly competitive prices.

Although SyQuest's initial growth in disk cartridge drive shipments was built on the company's original 3.9" drives, the 44 megabyte 5.25" model introduced in 1987 became the dominant "prepress" interchange standard, for graphics, typography and other original material used in printing, as projects move from designers, art departments and advertising agencies to typographers and printers. But despite upgrading from 44 megabytes to 88 megabytes in 1991, and 200 megabytes in 1994, the overall market growth for 5.25" rigid disk cartridge drives slowed down, as customers' appetites for even higher capacities became stronger. 5.25" drive shipments started declining in 1995 and in 1997 are projected at only 55,000 drives.

The first 2.5" disk cartridge drive shipments began in 1993. SyQuest's previously announced 2.5" drive was dropped, but Avatar Systems introduced a 2.5" rigid disk cartridge drive, with capacity now up to 250 megabytes, intended for a variety of personal computer and specialized system applications. In the meantime, SyQuest's 1.8" drive in the PCMCIA Type III form factor was one of the most unusual disk drive designs to date. It used a disk cartridge which could be removed from the drive, which, like all drives in a PCMCIA card format, was removable from the host system. SyQuest had hoped that the 1.8" low media cost would be instrumental in applications requiring multiple media units, and make it possible for SyQuest to gradually migrate the "prepress" disk cartridge interchange market from its 5.25" and 3.5" drives to its 1.8" drives, as continuing improvements in the areal density of rigid disk drives made it possible to increase drive capacity. The program was discontinued by SyQuest in early 1996, in light of the modest growth experienced by the industry for 1.8" disk drives and shifting company priorities.

For the first time in memory, SyQuest Technology lost its leadership in shipments of disk cartridge drives in 1996. Iomega's Jaz drive captured 53.2% of the worldwide unit shipments of rigid disk cartridge drives in 1996, with an estimated 555,000 drives. SyQuest's 429,000 drives provided 41.4% of the 1996 total. In 1996, all disk cartridge drives were shipped in noncaptive market channels, primarily in the PCM/Distributor channel.

Marketing trends

The current DISK/TREND forecast for this product group expects shipments to top 5.5 million drives in 2000, with sales revenues at $879.2 million. Despite the expected availability of higher capacities for all types of disk drives in the product group, 3.5" drives are destined to maintain dominance, with 89.2% of the 2000 total. Expanding on the traditional prepress, graphics and security markets, most of the growth is expected to be derived from expanded business and professional applications, such as multimedia development, video editing and a variety of technical workstations, with only modest penetration of consumer markets.

It must be noted that all shipment forecasts for rigid disk cartridge drives must be regarded as somewhat speculative, due to the current volatile nature of the industry structure, competitive product offerings and the status of the individual competitors. The market is currently beginning a transition to increased OEM/Integrator sales, as specialized system manufacturers add higher capacity 3.5" drives to their product lines. It is clear that the drives will increase in capacity, but the timing of capacity improvements for rigid disk cartridge drives is uncertain, depending less on technical feasibility than on competitive tactics. By the end of the forecast period, it is also possible that major improvements in optical disk recording densities could provide major new competitive threats. The financial viability of certain disk drive manufacturers will also control their ability to produce planned new drives, with SyQuest being the largest question mark. After more than two years of losses, it may be difficult to maintain the industry's pace of product introductions.

Technical trends

The basic recording technologies now in use for products in this group will continue to predominate for years. The smaller drives in quantity production embody the mechanical design lessons accumulated during years of production of larger removable disk drives, and will be able to exploit the rapid advances in recording technology from other segments of the disk drive industry. The 3.5" and 2.5" disk cartridge drives now available may be expected to increase continually in capacity during the coming years, following closely the rapid improvements in areal density expected with fixed disk drives.

Iomega's Jaz drive provides an illustration of the benefits which accrue to this product group from the much higher production levels now achieved with fixed disk drives manufactured for the desktop personal computer market. The current Jaz drive uses two 540 megabyte disks in each cartridge -- the same type of disks which were manufactured for the highest volume fixed disk drives produced in 1995. As recording capacities increase at the expected 60% per year, disks, heads and semiconductors manufactured for the industry's highest volume fixed disk drives will become available to the manufacturers of disk cartridge drives at low costs. With these components available, it is to be expected that capacities available in 3.5" disk cartridge drives will track the same upward trend, probably following fixed disk drives by a year or two.

Forecasting assumptions

1. Significant shipment increases of 3.5" and 2.5" disk cartridge drives will continue, with further increases in drive capacity available, with successful sales to both system manufacturers and the aftermarket.
2. Production for 5.25" disk cartridge drives will increase starting in 1998, with introduction of high capacity models.

TABLE 14

CARTRIDGE DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	158.6	211.0	205.9	289.7	313.6	434.4	427.3	591.9	498.0	690.3
OEM/Integrator	9.3	11.8	35.3	41.7	63.2	74.8	99.2	117.7	126.6	150.4
TOTAL U.S. NONCAPTIVE	167.9	222.8	241.2	331.4	376.8	509.2	526.5	709.6	624.6	840.7
TOTAL U.S. REVENUES	167.9	222.8	241.2	331.4	376.8	509.2	526.5	709.6	624.6	840.7
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	4.8	14.3	7.0	19.0	9.6	24.4	13.0	32.6	16.5	38.5
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL NON-U.S. REVENUES	4.8	14.3	7.0	19.0	9.6	24.4	13.0	32.6	16.5	38.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	172.7	237.1	248.2	350.4	386.4	533.6	539.5	742.2	641.1	879.2
OEM Average Price ($000)		.203		.173		.164		.159		.151

TABLE 15

CARTRIDGE DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996		Forecast							
	Shipments		1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	685.0	929.0	1,130.0	1,580.0	1,825.0	2,530.0	2,575.0	3,570.0	3,100.0	4,300.0
OEM/Integrator	44.0	58.0	205.0	240.0	385.0	455.0	625.0	740.0	840.0	995.0
TOTAL U.S. NONCAPTIVE	729.0	987.0	1,335.0	1,820.0	2,210.0	2,985.0	3,200.0	4,310.0	3,940.0	5,295.0
TOTAL U.S. SHIPMENTS	729.0	987.0	1,335.0	1,820.0	2,210.0	2,985.0	3,200.0	4,310.0	3,940.0	5,295.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	19.0	57.0	35.0	95.0	55.0	140.0	80.0	200.0	105.0	245.0
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	19.0	57.0	35.0	95.0	55.0	140.0	80.0	200.0	105.0	245.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	748.0	1,044.0	1,370.0	1,915.0	2,265.0	3,125.0	3,280.0	4,510.0	4,045.0	5,540.0
Total Capacity (Terabytes)	549.4	716.5	1,340.7	1,853.3	2,504.5	3,434.5	4,600.7	6,298.7	7,110.7	9,686.0
Cumulative Shipments (Units in millions)										
IBM	--	--	--	--	--	--	--	--	--	--
Non-IBM	3.2	5.1	4.6	7.0	6.9	10.1	10.2	14.6	14.2	20.1
WORLDWIDE TOTAL	3.3	5.1	4.7	7.1	6.9	10.2	10.2	14.7	14.3	20.2

TABLE 16

CARTRIDGE DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues			Forecast 1997			1998			1999			2000		
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS															
PCM/Distributor	26.0	185.0	--	11.0	263.7	15.0	16.7	378.2	39.5	23.5	508.0	60.4	24.6	594.3	71.4
OEM/Integrator	--	11.1	.7	--	37.1	4.6	5.9	62.4	6.5	8.4	97.9	11.4	9.0	128.5	12.9
TOTAL U.S. REVENUES	26.0	196.1	.7	11.0	300.8	19.6	22.6	440.6	46.0	31.9	605.9	71.8	33.6	722.8	84.3
NON-U.S. MANUFACTURERS															
PCM/Distributor	--	14.3	--	--	19.0	--	--	24.4	--	--	32.6	--	--	38.5	--
TOTAL NON-U.S. REVENUES	--	14.3	--	--	19.0	--	--	24.4	--	--	32.6	--	--	38.5	--
WORLDWIDE RECAP															
PCM/Distributor	26.0	199.3	--	11.0	282.7	15.0	16.7	402.6	39.5	23.5	540.6	60.4	24.6	632.8	71.4
	-62.9%	+145.1%	--	-57.7%	+41.8%	--	+51.8%	+42.4%	+163.3%	+40.7%	+34.3%	+52.9%	+4.7%	+17.1%	+18.2%
OEM/Integrator	--	11.1	.7	--	37.1	4.6	5.9	62.4	6.5	8.4	97.9	11.4	9.0	128.5	12.9
	--	+296.4%	--	--	+234.2%	+557.1%	--	+68.2%	+41.3%	+42.4%	+56.9%	+75.4%	+7.1%	+31.3%	+13.2%
Total Revenues	26.0	210.4	.7	11.0	319.8	19.6	22.6	465.0	46.0	31.9	638.5	71.8	33.6	761.3	84.3
	-62.9%	+150.2%	--	-57.7%	+52.0%	--	+105.5%	+45.4%	+134.7%	+41.2%	+37.3%	+56.1%	+5.3%	+19.2%	+17.4%
ANNUAL SHARE, BY DIAMETER	11.0%	88.8%	.2%	3.1%	91.4%	5.5%	4.2%	87.2%	8.6%	4.3%	86.1%	9.6%	3.8%	86.7%	9.5%

TABLE 17

CARTRIDGE DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments			Forecast 1997			1998			1999			2000		
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS															
PCM/Distributor	81.0	848.0	--	55.0	1,460.0	65.0	85.0	2,265.0	180.0	125.0	3,155.0	290.0	135.0	3,810.0	355.0
OEM/Integrator	--	55.0	3.0	--	220.0	20.0	30.0	395.0	30.0	45.0	640.0	55.0	50.0	880.0	65.0
TOTAL U.S. SHIPMENTS	81.0	903.0	3.0	55.0	1,680.0	85.0	115.0	2,660.0	210.0	170.0	3,795.0	345.0	185.0	4,690.0	420.0
NON-U.S. MANUFACTURERS															
PCM/Distributor	--	57.0	--	--	95.0	--	--	140.0	--	--	200.0	--	--	245.0	--
TOTAL NON-U.S. SHIPMENTS	--	57.0	--	--	95.0	--	--	140.0	--	--	200.0	--	--	245.0	--
WORLDWIDE RECAP															
PCM/Distributor	81.0	905.0	--	55.0	1,555.0	65.0	85.0	2,405.0	180.0	125.0	3,355.0	290.0	135.0	4,055.0	355.0
	-69.3%	+174.0%	--	-32.1%	+71.8%	--	+54.5%	+54.7%	+176.9%	+47.1%	+39.5%	+61.1%	+8.0%	+20.9%	+22.4%
OEM/Integrator	--	55.0	3.0	--	220.0	20.0	30.0	395.0	30.0	45.0	640.0	55.0	50.0	880.0	65.0
	--	+450.0%	+50.0%	--	+300.0%	+566.7%	--	+79.5%	+50.0%	+50.0%	+62.0%	+83.3%	+11.1%	+37.5%	+18.2%
Total Shipments	81.0	960.0	3.0	55.0	1,775.0	85.0	115.0	2,800.0	210.0	170.0	3,995.0	345.0	185.0	4,935.0	420.0
	-69.3%	+182.1%	+50.0%	-32.1%	+84.9%	--	+109.1%	+57.7%	+147.1%	+47.8%	+42.7%	+64.3%	+8.8%	+23.5%	+21.7%
ANNUAL SHARE, BY DIAMETER	7.8%	92.1%	.1%	2.9%	92.8%	4.3%	3.7%	89.7%	6.6%	3.8%	88.7%	7.5%	3.3%	89.2%	7.5%
TOTAL CAPACITY (Terabytes)	16.2	699.8	.5	11.0	1,821.0	21.3	92.0	3,290.0	52.5	340.0	5,872.5	86.3	869.5	8,711.5	105.0

TABLE 18

CARTRIDGE DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS Business and professional, single user	483.4	46.3	997.2	18.0
WORKSTATIONS Engineering and office, single user	470.8	45.1	4,210.4	76.0
CONSUMER, GAME AND HOBBY COMPUTERS	64.7	6.2	83.1	1.5
OTHER APPLICATIONS	25.1	2.4	249.3	4.5
Total	1,044.0	100.0	5,540.0	100.0

TABLE 19

CARTRIDGE DISK DRIVES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1996	Forecast 1997	1998	1999	2000
Captive					
5.25"	--	--	--	--	--
3.5"	--	--	--	--	--
2.5"	--	--	--	--	--
Captive Average	--	--	--	--	--
PCM/Distributor					
5.25"	1.60	1.00	.24	.09	.03
3.5"	.29	.17	.14	.11	.08
2.5"	--	.91	.87	.83	.80
PCM/Distributor Average	.33	.19	.15	.11	.09
OEM/Integrator					
5.25"	--	--	.24	.09	.03
3.5"	.33	.15	.13	.10	.08
2.5"	1.38	.92	.86	.82	.79
OEM/Integrator Average	.35	.17	.14	.11	.08

Note: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

TABLE 20

CARTRIDGE DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	5.25"	3.5"	2.5"	Total		5.25"	3.5"	2.5"	Total	
Iomega	--	447.0	--	447.0	59.8	--	555.0	--	555.0	53.2
SyQuest Technology	53.0	227.0	--	280.0	37.4	81.0	348.0	--	429.0	41.1
Nomai	--	19.0	--	19.0	2.5	--	57.0	--	57.0	5.5
Other U.S.	--	--	2.0	2.0	.3	--	--	3.0	3.0	.3
Other Non-U.S.	--	--	--	--	--	--	--	--	--	--
TOTAL	53.0	693.0	2.0	748.0	100.0	81.0	960.0	3.0	1044.0	100.0

FIXED DISK DRIVES, LESS THAN 500 MEGABYTES

1997 DISK/TREND REPORT

FIXED DISK DRIVES, LESS THAN 500 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Fujitsu	M2262H/HA
Sequel	XT-4380, XT-8380
Sagem	MSA 252-200

3.5" disk diameter

Fujitsu	MK2681S/T**
Raymond Engineering	8440, 84300

2.5" disk diameter

Fujitsu	M2635T/S***
Seagate Technology	ST9420AG****
Toshiba	MK-1824****

1.8" disk diameter

Calluna Technology	CT-170MC*****, CT-390MC*****
Integral Peripherals	8085*****, 8340PA*****

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.
*****PCMCIA Type III (10.5 mm height).

Although numerous manufacturers shipped fixed disk drives with less than 300 megabytes capacity using 14" disks in the 1970's and with 8" disks in the late 1970's and early 1980's, followed by 5.25" disks in the 1980's, the industry's continuing improvement in recording densities has forced the withdrawal of drives with larger disks from the market. In the last few years, 3.5" and 2.5" drives also found rapidly shrinking markets below 500 megabytes, due to the current demand for the higher capacities required for most applications, and the continually dropping prices for disk drives with higher capacities. 1997 is expected to be the last year of significant shipments for 5.25", 3.5" and 2.5" disk drives in this product group, and 1.8" disk drives are the only group forecasted to remain in production through 2000.

Market status

The peak shipment year for disk drives with capacities less than 500 megabytes was 1994, with shipments of 51 million units. Since that year, shipments have dropped sharply, as the personal computer industry's ravenous appetite for disk storage capacity was so great that leadership in disk drive shipments moved rapidly up to high capacities. Only 891 thousand drives with capacities less than 500 megabytes were shipped in 1996, and a further decline of 55.3% is forecasted for 1997, with shipments of only 398.3 thousand drives. Although shipments of both 3.5" and 2.5" drives declined sharply in 1996, 3.5" shipments dropped faster, allowing 2.5" drives to take a short-lived leadership in unit shipments, with 39.9% of the product group's unit shipment total. However, shipments of both drive diameters are continuing to drop rapidly in 1997, and 1.8" drives are expected to constitute 74% of 1997 shipments.

The disk drive industry's ability to continue the rapid transition to high capacities at low cost has been matched by the market's demand for more disk capacity on personal computers, in order to utilize improved operating systems and application programs, and to add new storage for a variety of applications, including graphics, games, multimedia, and downloads from the Internet. The result has been falling shipments and a rapid decline in revenues for drives with less than 500 megabytes capacity. Total sales revenues for the product group are expected to drop from $219.2 million in 1996 to only $94.3 million in 1997.

In 1996, 97.6% of the drives in the less than 500 megabyte capacity range were used for business personal computers or home computers, a transition which occurred during the last few years. Until 1992, the majority of disk drives in this product group were used with workstations and midrange computer systems. In 1994, a surge of increased usage for personal computers created a movement to new product lines from most drive manufacturers, with low cost and reduced parts count becoming prime objectives. By next year, the continuing movement to higher capacities for 3.5" and 2.5" drives used for personal computer, home computer and notebook computer applications will leave 1.8" drives with all of the remaining shipments for the product group. In 2000, business personal computers and home computers will still consume the majority of drives in this product group, but a variety of specialized applications will utilize about 40% of the shipments.

With the decline of shipments for drives larger than 1.8", Integral Peripherals moved into leadership in noncaptive drive unit shipments for 1996, with 209.6 thousand drives, 30.9% of the worldwide total. Seagate Technology held second place with a combination of 2.5" and 3.5" drives, at 23.2%, and Fujitsu was third with 12.7%.

Marketing trends

As shipments of 5.25", 3.5" and 2.5" drives with capacities less than 500 megabytes reach the end of life in 1997, 1.8" drives are expected to be the only survivors in this product group, starting in 1998.

Worldwide total unit shipments (000)	1996	1997	1998	1999	2000
5.25"	2.9	.3	--	--	--
	--	.1%	--	--	--
3.5"	300.2	66.0	375.0	--	----
	33.7%	16.6%	--	--	--
2.5"	355.7	37.0	--	--	--
	39.9%	9.3%	--	--	--
1.8" PCMCIA Type III	232.3	295.0	365.0	310.0	185.0
	26.1%	74.0%	100.0%	100.0%	100.0%
Total	891.0	398.3	365.0	310.0	185.0

The rapid movement to higher capacities for 3.5" and 2.5" drives, combined with more demanding software and enhanced user appetite for new applications, have prompted both manufacturers and users of notebook computers and desktop personal computers to abandon the 3.5" and 2.5" disk drives in this product group.

Drives with disks 1.8" or less enjoyed increasing shipments in the less than 500 megabyte range in 1995 (including closeout shipments of 1.3" drives), but shipments declined 44.5% in 1996, as some of the specialized applications for which these drives have been used were displaced by newer systems. In 1997, shipments are again increasing, but 1998 is expected to be the last year of growth for 1.8" drives in this product group, as capacities move up. It is a lonely product area, with only two active drive manufacturers, after other manufacturers of 1.8" drives dropped out of the field due to a smaller available overall market for 1.8" drives than they expected. 1998's peak shipments of 365,000 1.8" drives are expected to decline to 310,000 1.8" drives in 1999, with the drop continuing down to 185,000 in 2000.

Clearly, the market currently available to 1.8" drives has been limited to the manufacturers of a few notebook computer models, plus the manufacturers of a variety of pen-based computers, electronic typewriters, security applications and other specialized applications. The limiting factor continues to be the price at each capacity level, compared to 2.5" drives, and the movement in the notebook computer market to disk capacities above those in this product group. The price comparison is easily seen in the relative price per megabyte levels for 2.5" and 1.8" drives. In 1997, the average OEM/Integrator price per megabyte for 1.8" drives in this product group is estimated at 74 cents, while the average for 2.5" drives is 49 cents.

Technical trends

The inevitable disk drive improvements in recording density made drives with capacities less than 500 megabytes the industry's volume leader in 1994, because the personal computer industry needed 3.5" and 2.5" drives with capacities in the group's range, and the disk drive industry was able to produce them cheaply and reliably. Advances in recording density had made it possible to manufacture the drives routinely with a minimum parts count, using only one disk and two recording heads.

The same market forces will determine the computer industry's potential future interest in 1.8" drives. As noted above, demand for the existing generation of 1.8" Type III PC Card drives in this capacity range is expected to peak in 1998, as the industry's recording densities move up. The remaining development programs for 1.8" drives will be aimed at two related objectives. Initially, cost reduction targets will stimulate efforts to utilize a single 1.8" disk to achieve 300-500 megabyte capacities, and this will probably become practical in the next year or two. When single 1.8" disks can achieve this capacity, drive manufacturers might decide to introduce 5 millimeter thick Type II PC Card drives, which will be limited to a single disk. The packaging challenges for Type II drives will be difficult, but much of the work has already been done by drive manufacturers which deferred product introductions until the format could offer enough disk capacity to enjoy a broad market.

At one time, it was expected that the manufacturers of 1.8" drives would undertake the investment required to move to 5 millimeter thick Type II PC Card drives. However, the notebook computer market has demanded higher capacities than it is currently practical to offer in 1.8" PC Card formats in the next few years, and with other 1.8" drive markets significantly smaller in size, drive manufacturer's plans for Type II cards have apparently been postponed for now.

Forecasting assumptions

1. Significant shipments of 5.25", 3.5" and 2.5" drives will end in 1997, as desktop personal computers and notebook computers move to higher disk drive capacities.
2. Shipments of 1.8" drives will peak in 1998, due to a transition to higher capacities, with negligible penetration of notebook computer markets, plus a variety of workstation and industrial applications. Although production of Type II PC Card drives will be technically possible during this forecast period, it is not expected that they will be introduced.

TABLE 21

FIXED DISK DRIVES, LESS THAN 500 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	12.6	21.0	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	12.6	21.0	--	--	--	--	--	--	--	--
PCM/Distributor	21.6	35.4	21.6	28.8	26.0	35.0	21.9	28.2	12.0	15.7
OEM/Integrator	27.5	51.4	20.6	38.7	19.9	37.6	15.3	28.6	8.0	14.2
TOTAL U.S. NONCAPTIVE	49.1	86.8	42.2	67.5	45.9	72.6	37.2	56.8	20.0	29.9
TOTAL U.S. REVENUES	61.7	107.8	42.2	67.5	45.9	72.6	37.2	56.8	20.0	29.9
Non-U.S. Manufacturers										
Captive	8.8	69.9	--	15.7	--	--	--	--	--	--
PCM/Distributor	3.4	8.5	1.6	4.1	2.2	5.4	2.0	4.0	.9	1.8
OEM/Integrator	2.5	33.0	.9	7.0	1.8	2.7	1.7	2.6	.8	1.6
TOTAL NON-U.S. REVENUES	14.7	111.4	2.5	26.8	4.0	8.1	3.7	6.6	1.7	3.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	76.4	219.2	44.7	94.3	49.9	80.7	40.9	63.4	21.7	33.3
OEM Average Price ($000)		.192		.212		.217		.201		.175

TABLE 22

FIXED DISK DRIVES, LESS THAN 500 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996		Forecast							
	Shipments		1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	30.0	50.0	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	30.0	50.0	--	--	--	--	--	--	--	--
PCM/Distributor	109.0	191.3	90.0	120.0	115.0	155.0	105.0	135.0	65.0	85.0
OEM/Integrator	139.2	261.8	95.0	175.0	90.0	170.0	75.0	140.0	45.0	80.0
TOTAL U.S. NONCAPTIVE	248.2	453.1	185.0	295.0	205.0	325.0	180.0	275.0	110.0	165.0
TOTAL U.S. SHIPMENTS	278.2	503.1	185.0	295.0	205.0	325.0	180.0	275.0	110.0	165.0
Non-U.S. Manufacturers										
Captive	18.0	163.5	--	45.0	--	--	--	--	--	--
PCM/Distributor	21.1	47.9	7.0	18.0	10.0	25.0	10.0	20.0	5.0	10.0
OEM/Integrator	15.9	176.5	5.0	40.3	10.0	15.0	10.0	15.0	5.0	10.0
TOTAL NON-U.S. SHIPMENTS	55.0	387.9	12.0	103.3	20.0	40.0	20.0	35.0	10.0	20.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	333.2	891.0	197.0	398.3	225.0	365.0	200.0	310.0	120.0	185.0
Total Capacity (Terabytes)	102.5	284.7	61.9	126.4	77.3	124.9	74.4	115.0	49.4	75.7
Cumulative Shipments (Units in millions)										
IBM	18.8	27.5	18.8	27.5	18.8	27.5	18.8	27.5	18.8	27.5
Non-IBM	137.3	257.5	137.5	257.9	137.7	258.3	137.9	258.6	138.1	258.8
WORLDWIDE TOTAL	156.1	285.1	156.3	285.5	156.6	285.8	156.8	286.1	156.9	286.3

TABLE 23

FIXED DISK DRIVES, LESS THAN 500 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues				Forecast 1997				Forecast 1998	Forecast 1999	Forecast 2000
	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	1.8"	1.8"	1.8"
U.S. MANUFACTURERS											
IBM Captive	--	--	21.0	--	--	--	--	--	--	--	--
PCM/Distributor	.6	5.7	10.7	18.4	--	--	--	28.8	35.0	28.2	15.7
OEM/Integrator	1.0	5.8	12.7	31.9	--	--	3.9	34.8	37.6	28.6	14.2
TOTAL U.S. REVENUES	1.6	11.5	44.4	50.3	--	--	3.9	63.6	72.6	56.8	29.9
NON-U.S. MANUFACTURERS											
Captive	--	36.6	33.3	--	--	15.7	--	--	--	--	--
PCM/Distributor	--	2.8	2.3	3.4	--	--	--	4.1	5.4	4.0	1.8
OEM/Integrator	2.1	16.7	12.4	1.8	.4	3.0	1.4	2.2	2.7	2.6	1.6
TOTAL NON-U.S. REVENUES	2.1	56.1	48.0	5.2	.4	18.7	1.4	6.3	8.1	6.6	3.4
WORLDWIDE RECAP											
Captive	--	36.6	54.3	--	--	15.7	--	--	--	--	--
	--	-85.5%	-85.6%	--	--	-57.1%	--	--	--	--	--
PCM/Distributor	.6	8.5	13.0	21.8	--	--	--	32.9	40.4	32.2	17.5
	-76.9%	-98.3%	-89.7%	+65.2%	--	--	--	+50.9%	+22.8%	-20.3%	-45.7%
OEM/Integrator	3.1	22.5	25.1	33.7	.4	3.0	5.3	37.0	40.3	31.2	15.8
	-65.9%	-98.4%	-94.0%	-60.4%	-87.1%	-86.7%	-78.9%	+9.8%	+8.9%	-22.6%	-49.4%
Total Revenues	3.7	67.6	92.4	55.5	.4	18.7	5.3	69.9	80.7	63.4	33.3
	-68.9%	-96.8%	-90.0%	-43.7%	-89.2%	-72.3%	-94.3%	+25.9%	+15.5%	-21.4%	-47.5%
ANNUAL SHARE, BY DIAMETER	1.7%	30.9%	42.2%	25.2%	.4%	19.8%	5.6%	74.2%	100.0%	100.0%	100.0%

TABLE 24

FIXED DISK DRIVES, LESS THAN 500 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments				Forecast 1997				Forecast 1998	Forecast 1999	Forecast 2000
	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	1.8"	1.8"	1.8"
U.S. MANUFACTURERS											
IBM Captive	--	--	50.0	--	--	--	--	--	--	--	--
PCM/Distributor	.5	45.0	69.0	76.8	--	--	--	120.0	155.0	135.0	85.0
OEM/Integrator	1.0	45.0	83.0	132.8	--	--	30.0	145.0	170.0	140.0	80.0
TOTAL U.S. SHIPMENTS	1.5	90.0	202.0	209.6	--	--	30.0	265.0	325.0	275.0	165.0
NON-U.S. MANUFACTURERS											
Captive	--	95.5	68.0	--	--	45.0	--	--	--	--	--
PCM/Distributor	--	20.0	15.0	12.9	--	--	--	18.0	25.0	20.0	10.0
OEM/Integrator	1.4	94.6	70.7	9.8	.3	21.0	7.0	12.0	15.0	15.0	10.0
TOTAL NON-U.S. SHIPMENTS	1.4	210.1	153.7	22.7	.3	66.0	7.0	30.0	40.0	35.0	20.0
WORLDWIDE RECAP											
Captive	--	95.5	118.0	--	--	45.0	--	--	--	--	--
	--	-82.8%	-84.6%	--	--	-52.9%	--	--	--	--	--
PCM/Distributor	.5	65.0	84.0	89.7	--	--	--	138.0	180.0	155.0	95.0
	-77.3%	-98.2%	-88.0%	+66.1%	--	--	--	+53.8%	+30.4%	-13.9%	-38.7%
OEM/Integrator	2.4	139.6	153.7	142.6	.3	21.0	37.0	157.0	185.0	155.0	90.0
	-74.5%	-98.6%	-93.8%	-60.9%	-87.5%	-85.0%	-75.9%	+10.1%	+17.8%	-16.2%	-41.9%
Total Shipments	2.9	300.1	355.7	232.3	.3	66.0	37.0	295.0	365.0	310.0	185.0
	-75.2%	-97.9%	-91.0%	-44.5%	-89.7%	-78.0%	-89.6%	+27.0%	+23.7%	-15.1%	-40.3%
ANNUAL SHARE, BY DIAMETER	.3%	33.8%	39.9%	26.0%	.1%	16.6%	9.3%	74.0%	100.0%	100.0%	100.0%
TOTAL CAPACITY (Terabytes)	.9	110.8	113.2	59.8	.1	22.9	10.8	92.6	125.0	115.0	75.7

TABLE 25

FIXED DISK DRIVES, LESS THAN 500 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS Business and professional, single user	808.1	90.7	75.8	41.0
WORKSTATIONS Engineering and office, single user	7.1	.8	13.0	7.0
CONSUMER, GAME AND HOBBY COMPUTERS	61.5	6.9	35.1	19.0
OTHER APPLICATIONS	14.3	1.6	61.1	33.0
Total	891.0	100.0	185.0	100.0

TABLE 26

FIXED DISK DRIVES, LESS THAN 500 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1996	Forecast 1997	Forecast 1998	Forecast 1999	Forecast 2000
Captive					
5.25"	--	--	--	--	--
3.5"	1.11	1.01	--	--	--
2.5"	1.41	--	--	--	--
1.8"	--	--	--	--	--
Captive Average	1.27	1.01	--	--	--
PCM/Distributor					
5.25"	6.00	--	--	--	--
3.5"	.34	--	--	--	--
2.5"	.49	--	--	--	--
1.8"	.93	.76	.66	.56	.44
PCM/Distributor Average	.59	.76	.66	.56	.44
OEM/Integrator					
5.25"	3.87	4.20	--	--	--
3.5"	.42	.40	--	--	--
2.5"	.51	.49	--	--	--
1.8"	.92	.74	.63	.53	.43
OEM/Integrator Average	.60	.67	.63	.53	.43

Note: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

TABLE 27

FIXED DISK DRIVES, LESS THAN 500 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	5.25"	3.5"	2.5"	1.8"	Total		5.25"	3.5"	2.5"	1.8"	Total	
Integral Peripherals	--	--	--	125.9	125.9	44.1	--	--	--	209.6	209.6	30.9
Seagate Technology	--	10.0	77.0	--	87.0	30.5	--	20.0	137.0	--	157.0	23.2
Fujitsu	--	--	--	--	--	--	1.4	73.1	11.7	--	86.2	12.7
Western Digital	--	29.0	--	--	29.0	10.2	--	60.0	--	--	60.0	8.9
Other U.S.	1.3	5.0	--	--	6.3	2.2	1.5	10.0	15.0	--	26.5	3.9
Other Non-U.S.	--	19.0	9.0	9.0	37.0	13.0	--	41.5	74.0	22.7	138.2	20.4
TOTAL	1.3	63.0	86.0	134.9	285.2	100.0	2.9	204.6	237.7	232.3	677.5	100.0

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

1997 DISK/TREND REPORT

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Sequel	XT-8760SH

3.5" disk diameter

Fujitsu	M1612TAU**

2.5" - 3" disk diameter

Fujitsu	M2713TAM****
Hitachi	DK212A-81***, DK222A-81****
Seagate Technology	ST9840A****
Toshiba	MK-0803FMAT*****, MK-1928****

1.8" disk diameter

Calluna Technology	CT-520RM*****
Integral Peripherals	8510PA*****

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.
*****Maximum 10.5 mm height, or less.

Until recent years, drives in this group consisted mostly of PCM, IBM and other captive 14" drives intended for use with mainframe systems. Control Data's 9" FSD was the pioneer among disk drives less than 10.5", but in the mid-1980's several 8" drives with capacities above 500 megabytes entered the market. Maxtor's introduction of a 768 megabyte 5.25" drive precipitated a flurry of products from many of the same companies already competing in lower capacity 5.25" drive markets, but most of these drives were pushed out of the market in the early 1990's by a wave of 3.5" drive introductions.

In 1990, Maxtor was also the first company to offer a 3.5" drive in this product group, but the firm was quickly followed by numerous competitors. During 1993-94, most 3.5" drive manufacturers added 1" high models, and in 1995 most of the surviving participants added drives using a single 3.5" disk. During the past year, most of the 3.5" drives in this capacity range have been discontinued, displaced by the industry's relentless movement to higher capacities.

Toshiba, which provided much of the product leadership in 2.5" drives during the early 1990's, announced 520 megabyte 2.5" models in 1993, the first 2.5" drives in this capacity range. In 1994, IBM's Bolero series achieved up to 720 megabytes using two disks in a 12.5 millimeter high drive, and the IBM Sonata series used only one disk for 540 megabytes, also with a 12.5 millimeter drive height. A new type of disk drive competitor for the notebook computer market appeared in 1995, with the JTS introduction of the 3" Nordic drive, a model intended to offer lower prices than 2.5" drives of the same capacity. The transition to higher capacities has also affected the 2.5"-3" drive group, with many manufacturers dropping drive models in this capacity range during the last year, as the notebook computer market continually moves to higher disk capacities.

The 1.8" PC Card drives, announced in 1996 but with first shipments delayed until 1997, are the only new group of products in the 500 megabytes to 1 gigabyte range.

Market status

The speed with which this product group has fallen from industry leadership has been faster than originally expected. As recently as 1995, drives in the 500 megabytes to 1 gigabyte range were the leading product group, with 42.5 million units, 47.5% of the industry's worldwide unit shipments. In 1996, worldwide shipments fell to 24.9 million drives, and the 1997 total is forecasted at only 2.8 million drives. 1995's worldwide sales revenue for the product group was $9 billion, but the 1996 total dropped to $4.2 billion, and only $542.9 million is forecasted for 1997.

Shipments of 3.5" drives for desktop personal computer markets were the dominant contributing factor in the product group's 1995 sales success. Faster PC processors, improved operating systems and application programs, data downloaded from the Internet and wider personal computer usage all contributing to 1995's notable increase in drive shipments in the 500 megabyte - 1 gigabyte range. Just in time to exploit the new demand, the industry's incessant increases in areal density made possible 3.5" drives in this capacity range with only one or two disks, for which production could be quickly ramped to high levels, at low unit cost. With the availability of 1" high drives in this capacity range starting in 1992, shipments ramped up rapidly starting in 1994. The same phenomenon started to occur with 2.5" drives in 1995, as drives with 12.5 or 12.7 millimeter heights became available in the product lines of most 2.5" disk drive manufacturers. 1995 shipments of 2.5" drives in this capacity range jumped 393.9%, reaching 6.3 million units, with the majority 12.7 millimeters or less in height.

But the growth period for both 3.5" and 2.5" drives was over in 1996, as the inevitable upward trend in the market's demand for disk capacity continues for both desktop personal computers and for notebook computers. Worldwide unit shipments of 3.5" drives fell 42.7% in 1996, with a drop of another 92.5% projected for 1997, reducing shipments to only 1.5 million units. 1997 shipments of 2.5" drives are forecasted to decline to 1.2 million units. In addition to the capacity limitations of this product group, sales have been hurt by the price per megabyte now available with drives intended to desktop and notebook computer markets. The average OEM/Integrator price per megabyte for 3.5" drives is down to 15 cents in 1997, with 2.5" drives at 21 cents -- but equivalent drives with higher capacities are available at less than half these prices.

The combination of business personal computers and consumer computer applications consumed 99.9% of the disk drives shipped in this product group in 1996, with network servers, midrange systems and workstations utilizing only 0.1% of total shipments. The mix of applications will undergo marked changes by 2000, as 3.5" and 2.5" drive shipments disappear, leaving the product group to 1.8" drives. In 2000, business and home personal computers are expected to hold 60.0% of worldwide shipments, with workstations at 12.0%, and a variety of specialized applications at 28.0%.

Seagate moved into leadership in noncaptive drive shipments for the product group in 1996, with 30.2% of the worldwide total, predominantly with 3.5" models. Western Digital was again in second place with 27.6% of the total, all 3.5" drives, and Quantum dropped to third place with 24.7%, also mostly 3.5" drives.

Marketing trends

The computer industry continually enhances software and broadens applications, increasing the demand for on-line data storage. As disk drive areal densities also continually increase, making possible rapid drive capacity improvements, last year's disk drive models have already reached premature old age. The downhill sales pattern for disk drive product groups which have peaked in shipments is now a standard industry pattern. Worldwide unit shipments of drives in the 500 megabytes to 1 gigabyte range will continue to fall through 1999, as 5.25", 3.5" and 2.5" models disappear, bottoming out at a projected 265,000 units in 1999. Only 1.8" drives are expected to continue in production, with continually increasing shipments, reaching a forecasted worldwide total of 390,000 in 2000.

Worldwide total unit shipments (000)	1996	1997	1998	1999	2000
5.25"	1.3	1,0	.7	--	--
	--	--	.2%	--	--
3.5"	20,778.8	1,568.0	--	--	--
	83.5%	55.0.	--	--	--
2.5"-3"	4,103.2	1,223.0	215.0	--	--
	16.5%	42.9%	59.6%	--	--
1.8" PCMCIA Type III	--	60.0	145.0	265.0	390.0
	--	2.1%	40.2%	100.0%	100.0%
Total	24,883.3	2,852.0	360.7	265.0	390.0

Manufacturers of desktop personal computers have settled into a pattern of immediate movement to new disk capacity levels as soon as they become available, a phenomenon which will result in the withdrawal of all 3.5" drives in this product group during 1997. The notebook computer market which consumes most of the current generation of 2.5" drives follows the same pattern, with a timetable a bit slower. The last shipments of 2.5" drives are expected in 1998. The anticipated market for 1.8" drives in this capacity range will follow a different set of rules. The 1.8" market will probably consist of a variety of specialized applications, similar to the pattern already established by lower capacity 1.8" drives.

Technical trends

No effort by disk drive manufacturers will be expended to develop new drives in this capacity range larger than 1.8" models. Most of the 2.5" drives currently available have been the result of development of "product families" originally initiated for lower capacity ranges, which have evolved into drives with capacities in this product group and higher. The product family concept makes it possible to quickly move to new higher capacity models as new critical components, such as heads, disks and semiconductors, become available. Usually, only a small percentage of the drive's components are changed for a new model, achieving a fast manufacturing start, and reducing costs to a minimum level. The current intent of most of these development programs is to produce drives in capacity ranges higher than this product group.

The development programs for 1.8" drives will follow similar product family strategies, except that the main product planning targets will frequently be in this product group, considering the drive capacity ranges now practical with the industry's current areal density levels. This capacity range is still a demanding target for 1.8" drive development programs, with the same head, disk and semiconductor limitations which exist with larger diameter drives, but complicated by the special considerations developers of 1.8" drives must place on power requirements and shock and vibration specifications.

Forecasting assumptions

1. No 5.25", 3.5" or 2.5" drives in this capacity range will be manufactured after 1998.
2. Shipments of 1.8" drives will start in 1996, and maintain a pattern of continuous growth through 2000.

TABLE 28

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	238.4	354.5	89.6	134.4	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	238.4	354.5	89.6	134.4	--	--	--	--	--	--
PCM/Distributor	431.5	1,197.4	24.0	58.0	--	--	3.8	5.1	5.5	7.7
OEM/Integrator	666.4	1,613.8	70.5	157.0	8.0	10.9	12.0	20.4	18.9	29.4
TOTAL U.S. NONCAPTIVE	1,097.9	2,811.2	94.5	215.0	8.0	10.9	15.8	25.5	24.4	37.1
TOTAL U.S. REVENUES	1,336.3	3,165.7	184.1	349.4	8.0	10.9	15.8	25.5	24.4	37.1
Non-U.S. Manufacturers										
Captive	96.8	383.1	18.0	72.6	5.0	20.0	--	--	--	--
PCM/Distributor	58.3	135.7	6.2	19.0	6.7	12.9	7.8	13.0	8.1	15.0
OEM/Integrator	255.6	523.2	23.7	101.9	16.7	47.2	16.3	27.6	19.8	33.0
TOTAL NON-U.S. REVENUES	410.7	1,042.0	47.9	193.5	28.4	80.1	24.1	40.6	27.9	48.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,747.0	4,207.7	232.0	542.9	36.4	91.0	39.9	66.1	52.3	85.1
OEM Average Price ($000)		.153		.147		.214		.246		.215

TABLE 29

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996		Forecast							
	Shipments		1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	680.0	1,010.0	280.0	420.0	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	680.0	1,010.0	280.0	420.0	--	--	--	--	--	--
PCM/Distributor	3,100.0	8,593.0	190.0	460.0	--	--	15.0	20.0	25.0	35.0
OEM/Integrator	4,598.3	11,023.5	515.8	1,151.0	25.6	35.7	50.0	85.0	90.0	140.0
TOTAL U.S. NONCAPTIVE	7,698.3	19,616.5	705.8	1,611.0	25.6	35.7	65.0	105.0	115.0	175.0
TOTAL U.S. SHIPMENTS	8,378.3	20,626.5	985.8	2,031.0	25.6	35.7	65.0	105.0	115.0	175.0
Non-U.S. Manufacturers										
Captive	135.0	571.0	30.0	136.0	10.0	40.0	--	--	--	--
PCM/Distributor	310.0	738.0	22.0	85.0	25.0	50.0	30.0	50.0	35.0	65.0
OEM/Integrator	1,470.9	2,947.8	130.0	600.0	70.0	235.0	65.0	110.0	90.0	150.0
TOTAL NON-U.S. SHIPMENTS	1,915.9	4,256.8	182.0	821.0	105.0	325.0	95.0	160.0	125.0	215.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	10,294.2	24,883.3	1,167.8	2,852.0	130.6	360.7	160.0	265.0	240.0	390.0
Total Capacity (Terabytes)	8,209.4	20,066.3	914.7	2,239.1	80.0	248.9	77.2	130.3	115.3	190.0
Cumulative Shipments (Units in millions)										
IBM	3.6	5.5	3.9	5.9	3.9	5.9	3.9	5.9	3.9	5.9
Non-IBM	37.5	78.8	38.4	81.2	38.5	81.6	38.7	81.9	38.9	82.2
WORLDWIDE TOTAL	41.2	84.3	42.3	87.2	42.5	87.5	42.6	87.8	42.9	88.2

TABLE 30

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues			Forecast 1997				1998			1999	2000
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	1.8"	5.25"	2.5"	1.8"	1.8"	1.8"
U.S. MANUFACTURERS												
IBM Captive	--	45.1	309.4	--	--	134.4	--	--	--	--	--	--
PCM/Distributor	--	1,170.1	27.3	--	58.0	--	--	--	--	--	5.1	7.7
OEM/Integrator	2.0	1,414.0	197.8	2.0	113.4	41.6	--	1.4	--	9.5	20.4	29.4
TOTAL U.S. REVENUES	2.0	2,629.2	534.5	2.0	171.4	176.0	--	1.4	--	9.5	25.5	37.1
NON-U.S. MANUFACTURERS												
Captive	--	60.5	322.6	--	12.6	60.0	--	--	20.0	--	--	--
PCM/Distributor	--	96.5	39.2	--	2.0	10.0	7.0	--	2.7	10.2	13.0	15.0
OEM/Integrator	.6	238.6	284.0	--	19.2	70.2	12.5	--	26.2	21.0	27.6	33.0
TOTAL NON-U.S. REVENUES	.6	395.6	645.8	--	33.8	140.2	19.5	--	48.9	31.2	40.6	48.0
WORLDWIDE RECAP												
Captive	--	105.6	632.0	--	12.6	194.4	--	--	20.0	--	--	--
	--	-86.3%	-46.2%	--	-88.1%	-69.2%	--	--	-89.7%	--	--	--
PCM/Distributor	--	1,266.6	66.5	--	60.0	10.0	7.0	--	2.7	10.2	18.1	22.7
	--	-39.6%	-28.3%	--	-95.3%	-85.0%	--	--	-73.0%	+45.7%	+77.5%	+25.4%
OEM/Integrator	2.6	1,652.6	481.8	2.0	132.6	111.8	12.5	1.4	26.2	30.5	48.0	62.4
	-62.3%	-56.0%	-55.4%	-23.1%	-92.0%	-76.8%	--	-30.0%	-76.6%	+144.0%	+57.4%	+30.0%
Total Revenues	2.6	3,024.8	1,180.3	2.0	205.2	316.2	19.5	1.4	48.9	40.7	66.1	85.1
	-62.3%	-54.4%	-49.7%	-23.1%	-93.2%	-73.2%	--	-30.0%	-84.5%	+108.7%	+62.4%	+28.7%
ANNUAL SHARE, BY DIAMETER	.1%	72.0%	27.9%	.4%	37.9%	58.2%	3.5%	1.5%	53.8%	44.7%	100.0%	100.0%

Note: 2.5 inch totals include 3 inch drives

TABLE 31

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments			Forecast 1997				Forecast 1998			Forecast 1999	Forecast 2000
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	1.8"	5.25"	2.5"	1.8"	1.8"	1.8"
U.S. MANUFACTURERS												
IBM Captive	--	100.0	910.0	--	--	420.0	--	--	--	--	--	--
PCM/Distributor	--	8,457.0	136.0	--	460.0	--	--	--	--	--	20.0	35.0
OEM/Integrator	1.0	10,016.5	1,006.0	1.0	890.0	260.0	--	.7	--	35.0	85.0	140.0
TOTAL U.S. SHIPMENTS	1.0	18,573.5	2,052.0	1.0	1,350.0	680.0	--	.7	--	35.0	105.0	175.0
NON-U.S. MANUFACTURERS												
Captive	--	121.0	450.0	--	36.0	100.0	--	--	40.0	--	--	--
PCM/Distributor	--	568.0	170.0	--	15.0	50.0	20.0	--	15.0	35.0	50.0	65.0
OEM/Integrator	.3	1,516.3	1,431.2	--	167.0	393.0	40.0	--	160.0	75.0	110.0	150.0
TOTAL NON-U.S. SHIPMENTS	.3	2,205.3	2,051.2	--	218.0	543.0	60.0	--	215.0	110.0	160.0	215.0
WORLDWIDE RECAP												
Captive	--	221.0	1,360.0	--	36.0	520.0	--	--	40.0	--	--	--
	--	-80.2%	-41.9%	--	-83.7%	-61.8%	--	--	-92.3%	--	--	--
PCM/Distributor	--	9,025.0	306.0	--	475.0	50.0	20.0	--	15.0	35.0	70.0	100.0
	--	-27.2%	-1.3%	--	-94.7%	-83.7%	--	--	-70.0%	+75.0%	+100.0%	+42.9%
OEM/Integrator	1.3	11,532.8	2,437.2	1.0	1,057.0	653.0	40.0	.7	160.0	110.0	195.0	290.0
	-69.8%	-49.3%	-32.9%	-23.1%	-90.8%	-73.2%	--	-30.0%	-75.5%	+175.0%	+77.3%	+48.7%
Total Shipments	1.3	20,778.8	4,103.2	1.0	1,568.0	1,223.0	60.0	.7	215.0	145.0	265.0	390.0
	-69.8%	-42.7%	-34.7%	-23.1%	-92.5%	-70.2%	--	-30.0%	-82.4%	+141.7%	+82.8%	+47.2%
ANNUAL SHARE, BY DIAMETER	--	83.6%	16.4%	--	55.1%	42.9%	2.0%	.2%	59.7%	40.1%	100.0%	100.0%
TOTAL CAPACITY (Terabytes)	1.0	17,106.6	2,958.7	.8	1,262.1	945.0	31.2	.5	172.0	76.4	130.3	190.0

Note: 2.5 inch totals include 3 inch drives.

TABLE 32

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS				
Business and professional, single user	21,698.2	87.2	183.3	47.0
WORKSTATIONS				
Engineering and office, single user	24.9	.1	46.8	12.0
CONSUMER, GAME AND HOBBY COMPUTERS	3,160.2	12.7	50.7	13.0
OTHER APPLICATIONS	--	--	109.2	28.0
Total	24,883.3	100.0	390.0	100.0

TABLE 33

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1996	1997 (Forecast)	1998 (Forecast)	1999 (Forecast)	2000 (Forecast)
Captive					
5.25"	--	--	--	--	--
3.5"	.82	.59	--	--	--
2.5"	.63	.49	.62	--	--
1.8"	--	--	--	--	--
Captive Average	.65	.49	.62	--	--
PCM/Distributor					
5.25"	--	--	--	--	--
3.5"	.16	.14	--	--	--
2.5"	.29	.25	.22	--	--
1.8"	--	.67	.55	.68	.64
PCM/Distributor Average	.16	.17	.42	.68	.64
OEM/Integrator					
5.25"	2.60	2.50	2.63	--	--
3.5"	.17	.15	--	--	--
2.5"	.27	.21	.20	--	--
1.8"	--	.59	.52	.46	.40
OEM/Integrator Average	.19	.18	.31	.46	.40

Notes: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

2.5 inch totals include 3 inch drives.

TABLE 34

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	5.25"	3.5"	2.5"	Total		5.25"	3.5"	2.5"	Total	
Seagate Technology	--	2300.0	98.0	2398.0	25.3	--	6458.0	568.0	7026.0	30.2
Western Digital	--	2380.0	--	2380.0	25.1	--	6430.0	--	6430.0	27.6
Quantum	--	2625.0	70.0	2695.0	28.4	--	5580.0	175.0	5755.0	24.7
Maxtor	--	545.0	--	545.0	5.7	--	992.0	--	992.0	4.3
Toshiba	--	--	280.0	280.0	3.0	--	--	900.0	900.0	3.9
Fujitsu	--	202.0	155.7	357.7	3.8	.3	465.1	242.2	707.6	3.0
NEC	--	210.0	--	210.0	2.2	--	505.0	--	505.0	2.2
Hitachi	--	--	382.0	382.0	4.0	--	--	451.0	451.0	1.9
IBM	--	--	215.0	215.0	2.3	--	--	390.0	390.0	1.7
Other U.S.	.8	3.5	6.0	10.3	.1	1.0	5.5	9.0	15.5	.1
Other Non-U.S.	--	6.2	--	6.2	.1	--	122.2	8.0	130.2	.6
TOTAL	.8	8271.7	1206.7	9479.2	100.0	1.3	20557.8	2743.2	23302.3	100.0

Note: 2.5 inch totals include 3 inch drives.

FIXED DISK DRIVES, 1 - 2 GIGABYTES

1997 DISK/TREND REPORT

FIXED DISK DRIVES, 1 - 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Fujitsu	F6429H
Quantum	1.2 Bigfoot***

3.5" disk diameter

Fujitsu	MPA3017AT**, M1623TAU**
Hitachi	DK315C-14*, DK326C-10**
IBM	DJAA-31270**, DJAA-31700**
JTS	C1300-2AF***, C1700-3AF***
Maxtor	81280A2**, 81750A2**
NEC	D3845**, DSE1700A/S**
Quantum	1.0 Pioneer SG**, 1.6 Fireball ST
Samsung Electronics	WN31273A**, WNR-31601A**
Seagate Technology	ST31276A**, ST31720A**
Western Digital	AC21000**, AC21600**

2.5" - 3" disk diameter

Fujitsu	M2724TAM****
Hitachi	DK213A-18***, DK225A-14****
IBM	DDLA-21620*****, DTNA-21800****
JTS	N1080-2AR*****, N1620-3AR****
Seagate Technology	ST91430AG****, ST91685AG***
Toshiba	MK-1003MAV****, MK-1403MAV****
Western Digital	PhD1400*****

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.
*****Maximum 10.5 mm height, or less.

There are still drives in this product group that were designed for mainframe computers, but shipments are now negligible. IBM's 3380 was the core of this group during the first half of the 1980's, after painful delays in the product's introduction. However, IBM's 3380 series moved to higher capacities in 1985, and the product group has seen little application in mainframe computer markets in the last decade. During this period, the industry has seen successive generations of 8"-10.5" drives, then 5.25" drives, and current dominance by 3.5" drives.

Although 1" high 3.5" drives provided more than 95% of 1995 shipments for this product group, shipments of 3.5" drives have peaked and are now declining. The first 2.5" drives with more than 1 gigabyte capacity appeared in the product lines of 7 manufacturers in 1995, but shipments of 2.5" drives in this capacity range also peaked in 1996. Most of the product changes anticipated for the 3.5" and 2.5" drives in this product group will be centered on reducing the number of platters in each model to the minimum, to reduce costs. Many of the 3.5" drives already use only one disk. Most of the 2.5" drives have been reduced to 12.7 millimeters in height or less, and two disks will be normal in most 2.5" models during the next year or two. IBM's "Dolce" 2.5" family introduced in 1997 is only 9.5 millimeters in height, and probably will stimulate competitive product entries with the same height.

Competing for the traditional 2.5" drive markets is the 3" drive family originally announced by JTS, with the intention of capturing notebook computer sales by using the additional recording area offered by 3" disks to reduce prices at each capacity level. Western Digital has also announced 3" drive models, but most activity for 3" drives is expected to occur in capacity ranges above those offered by this product group. The industry is also seeing the reincarnation of the 5.25" disk form factor, first with a new drive from Gigastorage International, designed to provide very low cost disk storage for personal computers, followed by the Quantum Bigfoot, a single disk 5.25" drive with 1.2 gigabyte capacity and also designed to provide a pricing edge.

Market status

As expected, the 1-2 gigabyte product group assumed industry leadership in 1996, and, as also expected, shipments are dropping rapidly in 1997. 1996 worldwide unit shipments of 52.2 million drives were up 155.2% from the previous year. The 1997 total is forecasted at less than $29 million, down 45.6%. Sales revenues in 1996 reached $11.1 billion, but the worldwide total for 1997 is projected at only $5.2 billion.

1-2 gigabyte drives have had their moment of glory, and can now follow the path pioneered by the lower capacity product groups, as the industry's movement to higher areal densities rapidly obsoletes yesterday's shipment leaders.

Incessant growth in the personal computer market's craving for more disk storage capacity generated the rapid growth of shipments in this capacity range through 1996. 3.5" drives were the primary beneficiaries of storage demand for desktop personal computers, with 44.3 million drives shipped in 1996, up 117.1% over the previous year. The notebook computer market also saw a similar upward swing in demand for disk storage, with the result that 1995's shipments of 409,600 2.5" drives jumped to 6.4 million in 1996. Worldwide shipments of 3.5" drives are projected to drop to 23.5 million in 1997, with 2.5" drives down to 4.4 million. The advent of single disk 5.25" drives in 1996 provided a new competitive threat to 3.5" drives in the desktop PC market, but only 2.5 million 5.25" drives were shipped in 1996, a modest market entry. 5.25" shipments are expected to decline to 1.1 million units in 1997, following the product group's overall shipment trend.

Average unit prices have continued to fall quickly as high volume personal computer applications have largely displaced the product group's traditional workstation, midrange and mainframe computer markets. Although the first 3.5" drives with more than 1 gigabyte capacity did not ship until 1991, by 1996 3.5" drives provided 98% of total unit shipments for this product group. The average OEM/Integrator price per megabyte for 3.5" drives in this capacity class was 74 cents in 1993, but fell to 50 cents in 1994. By 1995, it was down to 20 cents, and the average for 1997 is projected at 10 cents.

97.7% of the drives in this product group were used in business personal computer and consumer computer applications in 1996, reflecting the disappearance of the mainframe, network server and midrange applications which once dominated the capacity range. However, as shipments of drives used for desktop and notebook personal computers continues to decline, the mix of applications for which the product group is utilized will continue to evolve. By 2000, the majority of 1-2 gigabyte drive shipments are projected to be 1.8" models, and only 65% will be used for any type of personal computer, with 16% used with various workstations and 19% used with other specialized applications.

Seagate became the leader in noncaptive unit shipments for 1996, with 26.6% of the worldwide total, mostly 3.5" drives. Quantum was second with 24.6%, mostly 3.5" drives, but with over 2.5 million 5.25" models. Western Digital remained in third position with 19%, all 3.5" drives.

Marketing trends

There is no doubt that this product group will receive the disk drive industry's standard reward for past shipment leaders -- quick oblivion. Final shipments of 5.25" drives are projected for 1998, 3.5" drives in 1999 and 2.5" drives in 2000. By then, the only remaining products in the group are expected to be 1.8" drives, production of which will become practical by 1999 due to the industry's expected areal density increases and development of critical components.

Worldwide total unit shipments (000)	1996	1997	1998	1999	2000
5.25"	2,525.9 4.7%	1,051.8 3.6%	330.0 4.7%	-- --	-- --
3.5"	44,339.6 83.3%	23,527.3 81.2%	4,020.0 57.1%	155.0 12.3%	-- --
2.5"-3"	6,368.0 12.0%	4,400.5 15.2%	2,690.0 38.2%	1,055.0 83.7%	170.0 47.2%
1.8"	-- --	-- --	-- --	50.0 4.0%	190.0 52.8%
Total	53,233.5	28,979.6	7,040.0	1,260.0	360.0

1998 shipments of 1-2 gigabyte drives are expected to drop an average of 76.4% per year in the 1998-2000 period, with each of the existing product types sustaining a continuous decline. The quick reaction of the personal computer industry to availability of drives at higher capacities at the right price is, of course, the reason.

The expected availability of 1.8" disk drives is projected to keep this product group active through 2000. Although first shipments of 1.8" drives are forecasted to start in 1999, the actual timing is subject to several influences, and shipments could actually start earlier. The first shipments of 1.8" drives in the 500 megabyte range is starting in 1997, with modest areal densities, by today's standards. If the market reception of those drives is favorable enough, drive manufacturers active in the 1.8" product area could move above the 1 gigabyte level within a year, taking advantage of head, disk and semiconductor component technology already developed for larger diameter drives.

Technical trends

During the last few years, developing disk drives for the 1-2 gigabyte range became a sophisticated exercise in applied engineering, in which nothing new had to be invented, but many leading edge components had to be available in large quantities, assembled with great precision, and delivered in a reliable, low-cost mechanism. In 1997, the industry's landmark new drives are now typically designed for much higher capacity levels, and some of the highest areal densities are now utilized in 2.5" drives in this product group.

Much of the interesting technical developments in the product group during the last year have involved miniaturization of 2.5" drives, with leadership currently held by the IBM "Dolce" drives, with only 9.5 millimeter height. Those 2.5" drive mechanisms will now evolve into drives with capacities above those in this product group, and the remaining challenges in product development for 1-2 gigabyte drives will primarily involve 1.8" drives. It is expected that the existing Type III PCMCIA card formats will continue to be used for disk drives in this capacity range, and that the challenges facing designers of these drives will not involve development of new mechanical designs, but the utilization of higher areal densities. Fortunately, the development already undertaken to produce critical components for drives using larger disks will greatly simplify the task.

Forecasting assumptions

1. The last shipments of low-cost 5.25" drives will occur in 1998, due to demand for higher capacities for personal computers.
2. Shipments of 3.5" drives will end in 1999, displaced by higher capacity drives in the personal computer market.
4. 2.5" drives shipments will continue to decline, with last shipments in 2000, impacted by the continuing movement to higher disk capacities for notebook computers.
5. The first shipments of 1.8" drives will occur in 1999.

TABLE 35

FIXED DISK DRIVES, 1 - 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	654.4	946.6	143.1	218.3	93.4	145.3	41.4	63.0	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	654.4	946.6	143.1	218.3	93.4	145.3	41.4	63.0	--	--
PCM/Distributor	1,198.4	2,737.8	510.8	1,179.9	71.6	169.3	1.1	2.9	1.9	4.0
OEM/Integrator	2,133.0	4,251.0	1,007.9	2,071.1	284.1	542.1	69.2	115.2	23.0	34.1
TOTAL U.S. NONCAPTIVE	3,331.4	6,988.8	1,518.7	3,251.0	355.7	711.4	70.3	118.1	24.9	38.1
TOTAL U.S. REVENUES	3,985.8	7,935.4	1,661.8	3,469.3	449.1	856.7	111.7	181.1	24.9	38.1
Non-U.S. Manufacturers										
Captive	108.8	739.9	59.0	503.1	28.3	258.8	--	15.6	--	--
PCM/Distributor	202.8	529.5	91.3	257.0	4.2	20.3	.9	6.0	4.6	7.7
OEM/Integrator	635.7	1,852.2	313.4	933.1	66.7	196.0	19.6	48.4	22.3	36.7
TOTAL NON-U.S. REVENUES	947.3	3,121.6	463.7	1,693.2	99.2	475.1	20.5	70.0	26.9	44.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	4,933.1	11,057.0	2,125.5	5,162.5	548.3	1,331.8	132.2	251.1	51.8	82.5
OEM Average Price ($000)		.192		.164		.155		.165		.224

TABLE 36

FIXED DISK DRIVES, 1 - 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996		Forecast							
	Shipments		1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1,240.0	1,790.0	295.0	450.0	225.0	350.0	115.0	175.0	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	1,240.0	1,790.0	295.0	450.0	225.0	350.0	115.0	175.0	--	--
PCM/Distributor	6,943.0	15,949.7	3,365.0	7,795.0	525.0	1,240.0	8.0	20.0	7.0	15.0
OEM/Integrator	11,371.1	23,135.2	6,310.0	13,090.0	1,850.0	3,600.0	430.0	725.0	105.0	160.0
TOTAL U.S. NONCAPTIVE	18,314.1	39,084.9	9,675.0	20,885.0	2,375.0	4,840.0	438.0	745.0	112.0	175.0
TOTAL U.S. SHIPMENTS	19,554.1	40,874.9	9,970.0	21,335.0	2,600.0	5,190.0	553.0	920.0	112.0	175.0
Non-U.S. Manufacturers										
Captive	150.0	1,050.7	115.0	958.3	65.0	595.0	--	40.0	--	--
PCM/Distributor	1,081.4	2,768.8	570.0	1,540.0	25.0	115.0	5.0	35.0	15.0	30.0
OEM/Integrator	2,982.4	8,539.1	1,765.5	5,146.3	390.0	1,140.0	100.0	265.0	85.0	155.0
TOTAL NON-U.S. SHIPMENTS	4,213.8	12,358.6	2,450.5	7,644.6	480.0	1,850.0	105.0	340.0	100.0	185.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	23,767.9	53,233.5	12,420.5	28,979.6	3,080.0	7,040.0	658.0	1,260.0	212.0	360.0
Total Capacity (Terabytes)	30,638.9	68,286.4	17,788.6	41,250.3	4,375.4	9,899.8	895.3	1,712.2	206.8	374.1
Cumulative Shipments (Units in millions)										
IBM	3.7	5.4	4.0	5.9	4.3	6.2	4.4	6.4	4.4	6.4
Non-IBM	38.6	78.4	50.7	106.9	53.6	113.6	54.1	114.7	54.4	115.0
WORLDWIDE TOTAL	42.4	83.9	54.8	112.8	57.9	119.9	58.6	121.1	58.8	121.5

TABLE 37

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues			Forecast 1997			1998			1999			2000	
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	3.5"	2.5"	1.8"	2.5"	1.8"
U.S. MANUFACTURERS														
IBM Captive	--	436.6	510.0	--	--	218.3	--	--	145.3	--	63.0	--	--	--
PCM/Distributor	143.8	2,578.5	15.5	52.0	1,104.3	23.6	15.0	150.6	3.7	1.2	1.7	--	.8	3.2
OEM/Integrator	234.5	3,323.1	693.4	84.6	1,619.9	366.6	26.2	272.9	243.0	9.0	99.5	6.7	13.1	21.0
TOTAL U.S. REVENUES	378.3	6,338.2	1,218.9	136.6	2,724.2	608.5	41.2	423.5	392.0	10.2	164.2	6.7	13.9	24.2
NON-U.S. MANUFACTURERS														
Captive	25.2	352.1	362.6	3.9	291.7	207.5	--	163.1	95.7	15.6	--	--	--	--
PCM/Distributor	--	456.4	73.1	--	208.7	48.3	--	6.6	13.7	.7	5.3	--	1.6	6.1
OEM/Integrator	4.9	1,263.7	583.6	1.7	590.6	340.8	--	66.7	129.3	3.3	35.3	9.8	10.1	26.6
TOTAL NON-U.S. REVENUES	30.1	2,072.2	1,019.3	5.6	1,091.0	596.6	--	236.4	238.7	19.6	40.6	9.8	11.7	32.7
WORLDWIDE RECAP														
Captive	25.2	788.7	872.6	3.9	291.7	425.8	--	163.1	241.0	15.6	63.0	--	--	--
	-91.0%	-45.2%	+270.5%	-84.5%	-63.0%	-51.2%	--	-44.1%	-43.4%	-90.4%	-73.9%	--	--	--
PCM/Distributor	143.8	3,034.9	88.6	52.0	1,313.0	71.9	15.0	157.2	17.4	1.9	7.0	--	2.4	9.3
	--	+107.8%	--	-63.8%	-56.7%	-18.8%	-71.2%	-88.0%	-75.8%	-98.8%	-59.8%	--	-65.7%	--
OEM/Integrator	239.4	4,586.8	1,277.0	86.3	2,210.5	707.4	26.2	339.6	372.3	12.3	134.8	16.5	23.2	47.6
	--	+53.3%	--	-64.0%	-51.8%	-44.6%	-69.6%	-84.6%	-47.4%	-96.4%	-63.8%	--	-82.8%	+188.5%
Total Revenues	408.4	8,410.4	2,238.2	142.2	3,815.2	1,205.1	41.2	659.9	630.7	29.8	204.8	16.5	25.6	56.9
	+42.5%	+42.7%	+716.3%	-65.2%	-54.6%	-46.2%	-71.0%	-82.7%	-47.7%	-95.5%	-67.5%	--	-87.5%	+244.8%
ANNUAL SHARE, BY DIAMETER	3.7%	76.2%	20.1%	2.8%	74.0%	23.2%	3.1%	49.6%	47.3%	11.9%	81.7%	6.4%	31.1%	68.9%

Note: 2.5 inch totals include 3 inch drives.

TABLE 38

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments			Forecast 1997			1998			1999			2000	
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	3.5"	2.5"	1.8"	2.5"	1.8"
U.S. MANUFACTURERS														
IBM Captive	--	940.0	850.0	--	--	450.0	--	--	350.0	--	175.0	--	--	--
PCM/Distributor	958.0	14,933.5	58.2	400.0	7,285.0	110.0	120.0	1,100.0	20.0	10.0	10.0	--	5.0	10.0
OEM/Integrator	1,562.7	18,910.9	2,661.6	650.0	10,710.0	1,730.0	210.0	2,040.0	1,350.0	75.0	630.0	20.0	90.0	70.0
TOTAL U.S. SHIPMENTS	2,520.7	34,784.4	3,569.8	1,050.0	17,995.0	2,290.0	330.0	3,140.0	1,720.0	85.0	815.0	20.0	95.0	80.0
NON-U.S. MANUFACTURERS														
Captive	1.8	548.9	500.0	.3	558.0	400.0	--	375.0	220.0	40.0	--	--	--	--
PCM/Distributor	--	2,524.8	244.0	--	1,355.0	185.0	--	45.0	70.0	5.0	30.0	--	10.0	20.0
OEM/Integrator	3.4	6,481.5	2,054.2	1.5	3,619.3	1,525.5	--	460.0	680.0	25.0	210.0	30.0	65.0	90.0
TOTAL NON-U.S. SHIPMENTS	5.2	9,555.2	2,798.2	1.8	5,532.3	2,110.5	--	880.0	970.0	70.0	240.0	30.0	75.0	110.0
WORLDWIDE RECAP														
Captive	1.8	1,488.9	1,350.0	.3	558.0	850.0	--	375.0	570.0	40.0	175.0	--	--	--
	-88.4%	-23.9%	+335.5%	-83.3%	-62.5%	-37.0%	--	-32.8%	-32.9%	-89.3%	-69.3%	--	--	--
PCM/Distributor	958.0	17,458.3	302.2	400.0	8,640.0	295.0	120.0	1,145.0	90.0	15.0	40.0	--	15.0	30.0
	--	+191.7%	--	-58.2%	-50.5%	-2.4%	-70.0%	-86.7%	-69.5%	-98.7%	-55.6%	--	-62.5%	--
OEM/Integrator	1,566.1	25,392.4	4,715.8	651.5	14,329.3	3,255.5	210.0	2,500.0	2,030.0	100.0	840.0	50.0	155.0	160.0
	--	+103.5%	--	-58.4%	-43.6%	-31.0%	-67.8%	-82.6%	-37.6%	-96.0%	-58.6%	--	-81.5%	+220.0%
Total Shipments	2,525.9	44,339.6	6,368.0	1,051.8	23,527.3	4,400.5	330.0	4,020.0	2,690.0	155.0	1,055.0	50.0	170.0	190.0
	--	+117.1%	--	-58.4%	-46.9%	-30.9%	-68.6%	-82.9%	-38.9%	-96.1%	-60.8%	--	-83.9%	+280.0%
ANNUAL SHARE, BY DIAMETER	4.7%	83.4%	11.9%	3.6%	81.3%	15.1%	4.7%	57.2%	38.1%	12.3%	83.8%	3.9%	47.3%	52.7%
TOTAL CAPACITY (Terabytes)	3,248.6	57,184.5	7,853.3	1,352.9	33,973.1	5,924.3	424.4	5,817.5	3,658.0	222.0	1,453.0	37.2	230.5	143.6

Note: 2.5 inch totals include 3 inch drives.

TABLE 39

FIXED DISK DRIVES, 1 - 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	585.6	1.1	--	--
PERSONAL COMPUTERS Business and professional, single user	47,803.7	89.8	194.4	54.0
WORKSTATIONS Engineering and office, single user	638.8	1.2	57.6	16.0
CONSUMER, GAME AND HOBBY COMPUTERS	4,205.4	7.9	39.6	11.0
OTHER APPLICATIONS	--	--	68.4	19.0
Total	53,233.5	100.0	360.0	100.0

TABLE 40

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1996	Forecast 1997	1998	1999	2000
Captive					
5.25"	9.33	7.80	--	--	--
3.5"	.39	.39	.33	.30	--
2.5"	.52	.37	.31	.25	--
1.8"	--	--	--	--	--
Captive Average	.45	.38	.32	.26	--
PCM/Distributor					
5.25"	.11	.10	.09	--	--
3.5"	.13	.10	.09	.08	--
2.5"	.22	.19	.14	.13	.11
1.8"	--	--	--	--	.43
PCM/Distributor Average	.13	.10	.09	.11	.28
OEM/Integrator					
5.25"	.11	.10	.09	--	--
3.5"	.14	.10	.09	.08	--
2.5"	.22	.16	.13	.11	.11
1.8"	--	--	--	.44	.38
OEM/Integrator Average	.15	.11	.11	.12	.21

Notes: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

2.5 inch totals include 3 inch drives.

TABLE 41

FIXED DISK DRIVES, 1 - 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	5.25"	3.5"	2.5"	Total		5.25"	3.5"	2.5"	Total	
Seagate Technology	--	5144.9	--	5144.9	23.0	--	13314.9	106.0	13420.9	26.6
Quantum	1260.0	4963.0	--	6223.0	27.8	2515.0	9865.0	--	12380.0	24.6
Western Digital	--	4510.0	--	4510.0	20.2	--	9595.0	--	9595.0	19.0
Fujitsu	--	817.3	116.2	933.5	4.2	.4	3354.5	569.5	3924.4	7.8
Maxtor	--	1658.0	35.7	1693.7	7.6	--	3016.0	66.7	3082.7	6.1
IBM	--	330.0	1780.0	2110.0	9.4	--	470.0	2550.0	3020.0	6.0
Toshiba	--	--	380.0	380.0	1.7	--	--	1400.0	1400.0	2.8
NEC	--	570.0	--	570.0	2.5	--	1350.0	--	1350.0	2.7
Samsung Electronics	--	312.6	--	312.6	1.4	--	1272.8	--	1272.8	2.5
JTS	--	300.0	4.5	304.5	1.4	--	599.5	6.5	606.0	1.2
Other U.S.	--	--	21.7	21.7	.1	5.7	--	57.3	63.0	.1
Other Non-U.S.	1.0	--	173.0	174.0	.8	3.0	13.0	262.0	278.0	.6
TOTAL	1261.0	18605.8	2511.1	22377.9	100.0	2524.1	42850.7	5018.0	50392.8	100.0

Note: 2.5 inch totals include 3 inch drives.

FIXED DISK DRIVES, 2 - 3 GIGABYTES

1997 DISK/TREND REPORT

FIXED DISK DRIVES, 2 - 3 GIGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Fujitsu	F6429K
Quantum	2.5 Bigfoot, 2.1 Bigfoot CY

3.5" disk diameter

Fujitsu	M2932*, M1638TAU**
Hitachi	DK328C-21**
IBM	DORS-32160**, DAQA-32160**
Maxtor	82560A4**, 82100A4**
Micropolis	4525A**
NEC	D3896**, DSE2550A**
Quantum	2.1 Pioneer SG**, 2.1 Fireball SE**
Samsung Electronics	WN32160A**, WN32542A**
Seagate Technology	ST-52160N***, ST32531A**
Western Digital	AC22000**, WDE2170**

2.5-3" disk diameter

Hitachi	DK225A-21****
IBM	DLGA-22690***, DTNA-22160***
Integral Peripherals	32160*****
JTS	C2000-3AF***, N2160-3AR****
Seagate Technology	ST92255AG***, ST92130AG****
Toshiba	MK-2103MAV****
Western Digital	PhD 2160*****

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.
*****Maximum 10.5 mm height, or less.

The disk drive industry has a relatively short history in this capacity range. There was a brief period of activity in the mid-1980's, with a few drives designed for the mainframe market, but these were soon supplanted by drives with capacities above this range. Disk drives with individual spindles containing capacities above 2 gigabytes first appeared in 1985 with IBM's 3380-E, the double capacity model in the 3380 series. Most of the 6.5", 8", 9.5" and 10.5" drives which followed were intended for mainframe and supermini applications similar to IBM's, and most used standard industry technology.

5.25" drives above 2 gigabytes were shipped for the first time in 1991, and were once available from seven manufacturers, now down to two. The early 5.25" drives offered in this capacity range were intended for midrange and mainframe systems, with only one remaining. The 5.25" drives now in the market are sold as low cost substitutes for 3.5" drives in the personal computer market.

The initial 3.5" drives in this product group were intended for midrange and mainframe computer system applications. In 1997, the midrange system markets for 3.5" disk drives are almost gone, dwarfed by the rapid growth of demand for higher disk capacities in the desktop personal computer market, and the newer generation of low cost 3.5" drive families. Ten disk drive manufacturers now participate in the very competitive contest to secure customers among the leading personal computer makers for 3.5" 1" high drives. Seven disk drive manufacturers also now offer 2.5" drives in this capacity range, targeting the inevitable enlargement of demand for disk capacity for notebook computers which always follows each upward step in capacities used with desktop personal computers.

Market status

In 1997, the 2-3 gigabyte product group is currently undergoing the interesting experience known as product leadership of the disk drive industry, shortly before dropping to half-size in the following year. After shipping 4.7 million drives in 1995, the product group increased 299.3% in 1996 to 18.7 million drives. As the group peaks in 1997, total shipments for the year are forecasted to reach 60.1 million drives. Due to the changing nature of the disk drive products and applications for this product group, sales revenues have also been on a growth trend, but with a different pattern, from $4.7 million in 1995, to $6.4 million in 1996, to a projected $13.9 million in 1997.

As market requirements evolve, the transitional nature of the current applications for drives in this product group is reflected in the changing product mix. Shipments of 5.25", 6.5", 8", and 9.5" drives for mainframe systems have faded, with final production expected this year. At the same time many network server and midrange system requirements are transitioning to higher capacities, and existing applications with the same capacity requirements are moving to drives which are physically smaller and lower in price. The first significant shipments of

2-3 gigabyte 3.5" drives did not occur until 1993, but 1997 shipments of 3.5" drives are expected to top 50 million units, as desktop personal computers become the dominant application for the product group.

The reemergence of significant shipments of 5.25" drives in 1996 was the result of new programs by Quantum and Gigastorage International to divert sales from standard 3.5" drives designed for personal computers to new low-cost 5.25" models. A moderate level of success for these efforts was achieved, but market penetration will be limited by the reluctance of other drive manufacturers to surrender customers to the new 5.25" drives, and their expected feisty response at the bargaining table. In this capacity range, Quantum remains the only 5.25" participant with drives intended for personal computer applications, since Gigastorage production was suspended due to financial problems.

Shipments of 2-3 gigabyte drives in the 2.5"-3" group have undergone rapid increases since the first availability of production shipments in 1996. 1997 shipments are projected to exceed 7 million drives, with seven drive manufacturers now active. The upward transition to higher disk capacities for notebook computers is inevitable, and the level of sales success to be achieved by individual drive manufacturers during 1997 will be controlled primarily by product availability. The first significant availability of 3" drives is expected to occur in this product group during 1997, with shipments by JTS, Western Digital and Integral Peripherals, providing the first phase of a significant challenge to the dominance of 2.5" drives in the notebook computer market.

Once the product group's major application, mainframe computer storage utilized only 0.6% of the product group's 1996 shipments, while network and midrange applications dropped to 18.2%. Underlining the ongoing changes in this capacity range, the mainframe applications will be nonexistent in 2000, and network/midrange requirements will be only 1.0% of the total. Drives used with workstations will decline from 4.4% in 1996 to 2.0% in 2000. Business personal computer applications utilized 72.8% of 1996's drives and consumer computers only 4.0%, but in 2000 business personal computers are expected to require 80.0% of drive shipments, and consumer computers will take 17.0%.

Long the leader in this capacity range, Seagate Technology continued to hold the lead in noncaptive shipments in 1996, with 34.3% of the worldwide total, all 3.5" drives. Quantum's 24.9% earned second place with a combination of 5.25" and 3.5" drives, and Western Digital advanced to third place with 17.5%, all 3.5" drives.

Marketing trends

After peaking in 1997, total shipments of 2-3 gigabyte drives are forecasted to decline at an annual average of 68.4% during the 1998-2000 period, with 2000 shipments down to 1.5 million drives. Sales revenues are expected to decline at an annual rate of 69.3% during the same period, with 2000 revenue for the product group down to $336.2. The personal computer industry's migration to higher disk drive capacities than those offered by this product group will affect drives using all disk diameters, but 2.5"-3" drives are expected to have one additional year of modest shipment growth in 1998.

Worldwide total unit shipments (000)	1996	1997	1998	1999	2000
6.5"-9.5"	9.0	1.0	--	--	--
	.1%	--	--	--	--
5.25"	1,709.3	2,950.1	1,720.0	230.0	--
	9.1%	4.9%	5.6%	3.3%	--
3.5"	16,056.8	50,150.0	21,860.0	3,235.0	450.0
	86.0%	83.4%	70.8%	47.0%	30.8%
2.5"-3	890.0	7,033.0	7,280.0	3,415.0	1,010.0
	4.8%	11.7%	23.6%	49.6%	69.2%
Total	18,665.1	60,134.1	30,860.0	6,880.0	1,460.0

Since peak demand for disk capacities in the notebook computer market frequently lags a year behind the capacities used in desktop personal computers, shipments of 2-3 gigabyte 2.5"-3" drives are not expected to peak until 1998. The same trend will keep 2.5"-3" drive shipments in the lead for the product group for the remainder of the forecast period.

Technical trends

For disk drives with the highest production levels, the most important technical specification is cost. For that reason, low manufacturing cost has become the prime product development objective for the majority of 2-3 gigabyte drives, a design objective at least as important as performance and reliability. The major product development emphasis has been placed on development of 3.5" and 2.5" drives which can be manufactured efficiently at high production rates, utilizing designs with a low parts count.

Areal density improvements are the largest influence on designers' ability to reduce drive costs. The well publicized 60% annual rate of improvement in areal density has not been consistently achieved, but remains a reasonable overall expectation for the balance of the current decade. Quantum has announced the first 3.5" drive for desktop personal computer applications with 2 gigabytes on a single disk, for delivery in late 1997, and in 1998 2.5" drives using one disk with similar capacities for the notebook computer market will probably be introduced.

Most of the technology development needed for future drives in the 2-3 gigabyte capacity range will not be specifically targeted to this product group. Development of semiconductors with the very high data rates required will be undertaken for all disk drives. Miniaturization of heads and head assemblies will be applicable to most disk drives in the second half of the 1990's. The movement to advanced magnetoresistive head designs and improvement in disk substrates and disk surfaces will also find general application.

Forecasting assumptions

1. All shipments of drives larger than 5.25" will end in 1997, and the remaining network/midrange disk drive market in this capacity range will be served by newer 3.5" high performance drives in this product group designed for low parts count.
2. Low cost 5.25" drives will stay in production through 1999, but sales growth will be held down by competitive action and declining markets.
3. 3.5" drive shipments will peak in 1997, then drop rapidly as personal computer markets move to higher disk drive capacities.
4. 2.5" drives will increase shipments through 1999, then decline through 2000, as notebook computer markets transition to drives with higher capacities.

TABLE 42

FIXED DISK DRIVES, 2 - 3 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	841.2	1,232.1	793.5	1,190.3	486.5	742.3	266.1	413.2	70.9	112.3
Other U.S. Captive	29.0	40.9	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	870.2	1,273.0	793.5	1,190.3	486.5	742.3	266.1	413.2	70.9	112.3
PCM/Distributor	705.6	1,258.9	1,721.9	3,412.6	655.8	1,268.1	63.0	123.3	4.6	7.7
OEM/Integrator	2,121.1	2,875.8	3,012.6	5,568.3	1,372.7	2,447.2	261.2	432.9	57.1	89.5
TOTAL U.S. NONCAPTIVE	2,826.7	4,134.7	4,734.5	8,980.9	2,028.5	3,715.3	324.2	556.2	61.7	97.2
TOTAL U.S. REVENUES	3,696.9	5,407.7	5,528.0	10,171.2	2,515.0	4,457.6	590.3	969.4	132.6	209.5
Non-U.S. Manufacturers										
Captive	33.1	276.7	186.8	745.1	127.0	471.3	63.1	214.5	20.3	68.9
PCM/Distributor	114.2	214.6	375.2	717.3	154.7	303.9	27.2	59.0	6.2	12.7
OEM/Integrator	177.3	451.9	887.0	2,222.8	448.3	1,188.9	102.9	289.3	16.4	45.1
TOTAL NON-U.S. REVENUES	324.6	943.2	1,449.0	3,685.2	730.0	1,964.1	193.2	562.8	42.9	126.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	4,021.5	6,350.9	6,977.0	13,856.4	3,245.0	6,421.7	783.5	1,532.2	175.5	336.2
OEM Average Price ($000)		.295		.211		.183		.172		.161

TABLE 43

FIXED DISK DRIVES, 2 - 3 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996 Shipments		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1,210.0	1,772.0	1,420.0	2,130.0	1,120.0	1,710.0	695.0	1,080.0	205.0	325.0
Other U.S. Captive	20.0	28.0	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	1,230.0	1,800.0	1,420.0	2,130.0	1,120.0	1,710.0	695.0	1,080.0	205.0	325.0
PCM/Distributor	2,549.3	4,614.3	8,294.0	16,503.0	3,500.0	6,775.0	395.0	775.0	30.0	50.0
OEM/Integrator	6,737.0	9,583.0	14,215.0	26,555.0	7,580.0	13,620.0	1,530.0	2,560.0	350.0	550.0
TOTAL U.S. NONCAPTIVE	9,286.3	14,197.3	22,509.0	43,058.0	11,080.0	20,395.0	1,925.0	3,335.0	380.0	600.0
TOTAL U.S. SHIPMENTS	10,516.3	15,997.3	23,929.0	45,188.0	12,200.0	22,105.0	2,620.0	4,415.0	585.0	925.0
Non-U.S. Manufacturers										
Captive	45.0	245.6	310.0	1,268.0	250.0	950.0	140.0	480.0	50.0	170.0
PCM/Distributor	383.6	723.7	1,790.0	3,395.0	850.0	1,650.0	165.0	350.0	40.0	80.0
OEM/Integrator	666.4	1,698.5	4,105.0	10,283.1	2,355.0	6,155.0	590.0	1,635.0	105.0	285.0
TOTAL NON-U.S. SHIPMENTS	1,095.0	2,667.8	6,205.0	14,946.1	3,455.0	8,755.0	895.0	2,465.0	195.0	535.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	11,611.3	18,665.1	30,134.0	60,134.1	15,655.0	30,860.0	3,515.0	6,880.0	780.0	1,460.0
Total Capacity (Terabytes)	25,987.0	42,011.0	69,567.9	138,756.8	35,992.7	70,859.8	7,927.0	15,495.2	1,734.0	3,240.4
Cumulative Shipments (Units in millions)										
IBM	1.9	2.8	3.3	5.0	4.4	6.7	5.1	7.7	5.3	8.1
Non-IBM	15.6	24.0	44.4	82.0	58.9	111.2	61.7	117.0	62.3	118.1
WORLDWIDE TOTAL	17.6	26.9	47.7	87.0	63.4	117.9	66.9	124.8	67.7	126.2

TABLE 44

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues				Forecast 1997				Forecast 1998			Forecast 1999			Forecast 2000	
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																
IBM Captive	--	--	1,169.1	63.0	--	--	800.3	390.0	--	428.3	314.0	--	242.8	170.4	64.5	47.8
Other U.S. Captive	--	--	40.9	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	--	128.1	1,130.8	--	--	201.6	3,188.8	22.2	40.6	1,207.1	20.4	4.9	110.7	7.7	5.1	2.6
OEM/Integrator	--	208.3	2,648.6	18.9	--	329.4	4,635.8	603.1	223.4	1,692.4	531.4	26.7	162.0	244.2	9.8	79.7
TOTAL U.S. REVENUES	--	336.4	4,989.4	81.9	--	531.0	8,624.9	1,015.3	264.0	3,327.8	865.8	31.6	515.5	422.3	79.4	130.1
NON-U.S. MANUFACTURERS																
Captive	91.2	18.7	49.1	117.7	11.0	--	113.5	620.6	--	44.6	426.7	--	7.1	207.4	--	68.9
PCM/Distributor	1.2	--	188.0	25.4	--	--	657.5	59.8	--	254.2	49.7	--	37.9	21.1	5.8	6.9
OEM/Integrator	.9	1.1	289.9	160.0	--	.1	1,567.5	655.2	--	566.7	622.2	--	85.3	204.0	14.7	30.4
TOTAL NON-U.S. REVENUES	93.3	19.8	527.0	303.1	11.0	.1	2,338.5	1,335.6	--	865.5	1,098.6	--	130.3	432.5	20.5	106.2
WORLDWIDE RECAP																
Captive	91.2	18.7	1,259.1	180.7	11.0	--	913.8	1,010.6	--	472.9	740.7	--	249.9	377.8	64.5	116.7
	+38.2%	-91.8%	-31.9%	--	-87.9%	--	-27.4%	+459.3%	--	-48.2%	-26.7%	--	-47.2%	-49.0%	-74.2%	-69.1%
PCM/Distributor	1.2	128.1	1,318.8	25.4	--	201.6	3,846.3	82.0	40.6	1,461.3	70.1	4.9	148.6	28.8	10.9	9.5
	--	-26.8%	+160.2%	--	--	+57.4%	+191.7%	+222.8%	-79.9%	-62.0%	-14.5%	-87.9%	-89.8%	-58.9%	-92.7%	-67.0%
OEM/Integrator	.9	209.4	2,938.5	178.9	--	329.5	6,203.3	1,258.3	223.4	2,259.1	1,153.6	26.7	247.3	448.2	24.5	110.1
	+28.6%	+311.4%	+63.9%	--	--	+57.4%	+111.1%	+603.4%	-32.2%	-63.6%	-8.3%	-88.0%	-89.1%	-61.1%	-90.1%	-75.4%
Total Revenues	93.3	356.2	5,516.4	385.0	11.0	531.1	10,963.4	2,350.9	264.0	4,193.3	1,964.4	31.6	645.8	854.8	99.9	236.3
	+39.9%	-21.4%	+33.0%	--	-88.2%	+49.1%	+98.7%	+510.6%	-50.3%	-61.8%	-16.4%	-88.0%	-84.6%	-56.5%	-84.5%	-72.4%
ANNUAL SHARE, BY DIAMETER	1.5%	5.6%	87.0%	5.9%	.1%	3.8%	79.2%	16.9%	4.1%	65.4%	30.5%	2.1%	42.2%	55.7%	29.8%	70.2%

Note: 8 inch totals include 6.5 - 9.5 inch drives, and 2.5 inch totals include 3 inch drives.

TABLE 45

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments				Forecast 1997				1998			1999			2000	
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																
IBM Captive	--	--	1,682.0	90.0	--	--	1,480.0	650.0	--	1,060.0	650.0	--	680.0	400.0	200.0	125.0
Other U.S. Captive	--	--	28.0	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	--	650.0	3,964.3	--	--	1,120.0	15,295.0	88.0	260.0	6,420.0	95.0	35.0	700.0	40.0	35.0	15.0
OEM/Integrator	--	1,057.0	8,461.0	65.0	--	1,830.0	22,295.0	2,430.0	1,460.0	9,630.0	2,530.0	195.0	1,045.0	1,320.0	70.0	480.0
TOTAL U.S. SHIPMENTS	--	1,707.0	14,135.3	155.0	--	2,950.0	39,070.0	3,168.0	1,720.0	17,110.0	3,275.0	230.0	2,425.0	1,760.0	305.0	620.0
NON-U.S. MANUFACTURERS																
Captive	7.0	1.1	77.5	160.0	1.0	--	237.0	1,030.0	--	110.0	840.0	--	20.0	460.0	--	170.0
PCM/Distributor	1.0	--	647.7	75.0	--	--	3,170.0	225.0	--	1,420.0	230.0	--	240.0	110.0	40.0	40.0
OEM/Integrator	1.0	1.2	1,196.3	500.0	--	.1	7,673.0	2,610.0	--	3,220.0	2,935.0	--	550.0	1,085.0	105.0	180.0
TOTAL NON-U.S. SHIPMENTS	9.0	2.3	1,921.5	735.0	1.0	.1	11,080.0	3,865.0	--	4,750.0	4,005.0	--	810.0	1,655.0	145.0	390.0
WORLDWIDE RECAP																
Captive	7.0	1.1	1,787.5	250.0	1.0	--	1,717.0	1,680.0	--	1,170.0	1,490.0	--	700.0	860.0	200.0	295.0
	+150.0%	-90.8%	+137.5%	--	-85.7%	--	-3.9%	+572.0%	--	-31.9%	-11.3%	--	-40.2%	-42.3%	-71.4%	-65.7%
PCM/Distributor	1.0	650.0	4,612.0	75.0	--	1,120.0	18,465.0	313.0	260.0	7,840.0	325.0	35.0	940.0	150.0	75.0	55.0
	--	--	+437.2%	--	--	+72.3%	+300.4%	+317.3%	-76.8%	-57.5%	+3.8%	-86.5%	-88.0%	-53.8%	-92.0%	-63.3%
OEM/Integrator	1.0	1,058.2	9,657.3	565.0	--	1,830.1	29,968.0	5,040.0	1,460.0	12,850.0	5,465.0	195.0	1,595.0	2,405.0	175.0	660.0
	+400.0%	--	+222.7%	--	--	+72.9%	+210.3%	+792.0%	-20.2%	-57.1%	+8.4%	-86.6%	-87.6%	-56.0%	-89.0%	-72.6%
Total Shipments	9.0	1,709.3	16,056.8	890.0	1.0	2,950.1	50,150.0	7,033.0	1,720.0	21,860.0	7,280.0	230.0	3,235.0	3,415.0	450.0	1,010.0
	+200.0%	--	+248.8%	--	-88.9%	+72.6%	+212.3%	+690.2%	-41.7%	-56.4%	+3.5%	-86.6%	-85.2%	-53.1%	-86.1%	-70.4%
ANNUAL SHARE, BY DIAMETER	--	9.2%	86.1%	4.7%	--	4.9%	83.5%	11.6%	5.6%	70.9%	23.5%	3.3%	47.1%	49.6%	30.9%	69.1%
TOTAL CAPACITY (Terabytes)	26.1	4,393.7	35,668.8	1,922.4	2.9	7,581.9	115,607.6	15,564.4	4,420.4	50,518.6	15,920.8	591.1	7,417.3	7,486.8	1,021.5	2,218.9

Note: 8 inch totals include 6.5 - 9.5 inch drives, and 2.5 inch totals include 3 inch drives.

TABLE 46

FIXED DISK DRIVES, 2 - 3 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	112.0	.6	--	--
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	3,397.0	18.2	14.6	1.0
PERSONAL COMPUTERS Business and professional, single user	13,588.2	72.8	1,168.0	80.0
WORKSTATIONS Engineering and office, single user	821.3	4.4	29.2	2.0
CONSUMER, GAME AND HOBBY COMPUTERS	746.6	4.0	248.2	17.0
OTHER APPLICATIONS	--	--	--	--
Total	18,665.1	100.0	1,460.0	100.0

TABLE 47

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1996	Forecast 1997	1998	1999	2000
Captive					
8"	4.49	3.79	--	--	--
5.25"	6.03	--	--	--	--
3.5"	.32	.24	.18	.16	.14
2.5"	.33	.27	.22	.19	.17
Captive Average	.35	.26	.20	.18	.16
PCM/Distributor					
8"	.41	--	--	--	--
5.25"	.07	.07	.06	.05	--
3.5"	.12	.09	.08	.06	.06
2.5"	.15	.12	.09	.08	.07
PCM/Distributor Average	.12	.09	.08	.07	.06
OEM/Integrator					
8"	.31	--	--	--	--
5.25"	.07	.07	.06	.05	--
3.5"	.13	.08	.07	.06	.05
2.5"	.14	.11	.09	.08	.07
OEM/Integrator Average	.13	.09	.08	.07	.07

Notes: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

8 inch totals include 6.5 - 9.5 inch drives.

2.5 inch totals include 3 inch drives.

TABLE 48

FIXED DISK DRIVES, 2 - 3 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	8"	5.25"	3.5"	2.5"	Total		8"	5.25"	3.5"	2.5"	Total	
Seagate Technology	--	--	4198.0	--	4198.0	40.6	--	--	5698.0	--	5698.0	34.3
Quantum	--	845.0	1320.0	--	2165.0	20.9	--	1690.0	2445.0	--	4135.0	24.9
Western Digital	--	--	1950.0	--	1950.0	18.9	--	--	2915.0	--	2915.0	17.5
IBM	--	--	855.0	45.0	900.0	8.7	--	--	1230.0	65.0	1295.0	7.8
Maxtor	--	--	596.0	--	596.0	5.8	--	--	1087.0	--	1087.0	6.5
Toshiba	--	--	--	161.0	161.0	1.6	--	--	--	575.0	575.0	3.5
Fujitsu	--	--	158.6	--	158.6	1.5	--	1.2	534.5	--	535.7	3.2
Other U.S.	--	--	73.3	--	73.3	.7	--	17.0	137.3	--	154.3	.9
Other Non-U.S.	--	--	134.4	--	134.4	1.3	2.0	--	222.5	--	224.5	1.4
TOTAL	--	845.0	9285.3	206.0	10336.3	100.0	2.0	1708.2	14269.3	640.0	16619.5	100.0

Notes: 8 inch totals include 6.5 - 9.5 inch drives.

2.5 inch totals include 3 inch drives.

FIXED DISK DRIVES, 3 - 5 GIGABYTES

FIXED DISK DRIVES, 3 - 5 GIGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Gigastorage International	B5300A**
Quantum	4.3 Bigfoot CY

3.5" disk diameter

Fujitsu	M2934*, MPA3043AT**
Hitachi	DK306-45, DK328H-43**
IBM	DCHS-34550**, DHEA-34860**
JTS	C3000-3AF**
Maxtor	83201A6**, 84320A5**
Micropolis	4540A**, 4743**
NEC	DVF4400S**, D5S3100A/S**
Quantum	4.3 Fireball SE, 4.5 Atlas III
Samsung Electronics	WN34003A/U**, VG-33402A**
Seagate Technology	ST34340A**, ST34501**, ST34371**
Western Digital	AC34000**, WDE4360**

2.5"-3" disk diameter

Hitachi	DK226A-32****
IBM	DPLA-24480***, DTCA-24090****
Toshiba	MK-3303MAN***

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.
*****Maximum 10.5 mm height, or less.

For many years the capacity range above 3 gigabytes was the exclusive territory of disk drives intended for mainframe computer applications. The first disk drive in the product group was IBM's 3,781 megabyte 3380K, with 14" disks, introduced in 1987, which in turn was made obsolete by IBM's 3390 series, using 10.8" disks, initially introduced in 1989. In 1991, the IBM 3390 series moved to capacities above 5 gigabytes. The various drives using 6.5"-10.5" disks in this capacity range since the late 1980's were intended mostly for mainframe and supermini applications similar to IBM's, and all are now out of production.

5.25" drives above 3 gigabytes appeared for the first time in 1992, and for a few years were offered by most manufacturers active in the markets for high-end disk drives. This product activity was short-lived, as some 5.25" drive manufacturers quickly moved to higher capacities and others developed 3.5" drives for this capacity range. Production of 5.25" drives in the 3-5 gigabyte range for high-end applications has been phased out, and new models intended for low-cost desktop personal computers have been introduced.

IBM utilized magnetoresistive heads and PRML encoding with the firm's Starfire 4.3 gigabyte 1.625" high drives announced in late 1993, the first 3.5" drives to pioneer the over 3 gigabyte range. After a difficult production start for these drives during 1994-95, IBM announced 4.5 gigabyte 1" high Scorpion 3.5" drives in late 1995. During 1995-96, IBM was joined by all of the other disk drive manufacturers active in the high capacity disk drive field in offering 3.5" drives with more than 3 gigabyte capacities, most of which also offer 1" high 4.5 gigabyte models. The industry had a difficult start-up period with these drives, but production increased to significant levels in 1996. The pioneering high-end 3.5" drives in this product group intended for mainframe, midrange and network file server applications have been joined in 1997 by a new generation of lower cost drives intended for the desktop personal computer market.

Despite the initial high degree of technical difficulty, IBM shipped the first 2.5" drive in the 3-5 gigabyte range in late 1996. Hitachi was close behind, with a 2.5" drive in the first half of 1997 which was the first disk drive to utilize areal densities above the 2 gigabit per square inch level.

Market status

The 3-5 gigabyte capacity range is now undergoing a rapid transformation from exclusive concentration on high-end disk drives designed for mainframe, midrange and network file server applications to mass production of low-cost drives for the desktop personal computer and notebook computer markets. It is an environment in which all of the major disk drive manufacturers have introduced 3.5" drives intended for high production levels in competitive personal computer markets, and the first wave of 2.5" drive introductions for notebook computers has occurred.

1996 worldwide shipments for the product group were 5.5 million drives, an increase of 223.6% over the previous year, and 1997 shipments are projected to top 25 million drives, up 354.9%. However, due to the expected changes in product mix, average unit prices are falling sharply, depressing the gain in sales revenues. For example, the average OEM/Integrator price for 3.5" drives in 1996 was 16 cents per megabyte, but will fall to an estimated 7 cents in 1997. Worldwide total sales revenues increased 108.7% in 1996, at $5.1 billion, but the 1997 increase is estimated at only 63%, at $8.3 billion.

Until 1996, mainframe and midrange system markets provided almost all of the growth for shipments in this product group, but that started to change in 1996, with the advent of 3-5 gigabyte drives designed for personal computer applications. In 1996, mainframe systems were the application which consumed 16.1% of the product group's shipments, but zero shipments are forecasted for this application in 2000. Networks/midrange systems received 38.4% of 1996 unit shipments, but the 2000 share for this application is expected to be only 3.0%. Workstations received 6.5% of 1996 shipments, but will be down to an estimated 2.0% in 2000. Obviously, the big growth area is business personal computers, which grew from less than 1% of 1995 shipments to 38.5% of 1996 shipments, and are projected to account for 88.0% of the 2000 total. Consumer computers, which received only 0.4% of 1996 shipments, are forecasted to use 7.0% of the total for 2000.

Seagate Technology, the leader in 3-5 gigabyte high performance drives, continued to dominate noncaptive shipments for this product group in 1996, capturing 50.8% of the 1996 total, with all 3.5" drives. Quantum held second place with 22.8%, and IBM remained in third place with 10.0%.

Marketing trends

The 3-5 gigabyte product group is destined to become next year's leader in overall unit shipments. The DISK/TREND Report forecast for the product group's 1998 total shipments is 65.7 million drives, an increase of 162.9%. However, there's no stopping the continuing upward trend in average capacities per drive, and by 1999 this product group's moment of glory will be over. 1999 worldwide shipments are projected at 40.9 million drives, down 37.8%, and the 2000 projection is 17.8 million drives, a reduction of 56.6%. After peaking in 1998 with $17.1 billion in sales revenues, the total for the product group is forecasted to fall to $4.1 billion in 2000.

The changing nature of the products produced and the markets served by this product group can be clearly seen in the evolution of typical unit prices during the forecast period. In 1995, when products in the group were still mostly high performance drives, the average OEM/Integrator unit price was $842. In 1997, with drives for the personal computer market clearly in the lead, the average OEM/Integrator price is down to an estimated $282, and by 2000 it is projected to fall to $196. The 5.25" and the 2.5"-3" drives offered throughout the current forecast period are all intended for competitive, high volume markets and are priced accordingly, with normal price declines.

Worldwide total unit shipments (000)	1996	1997	1998	1999	2000
5.25"	3.5 .1%	825.0 3.3%	2,740.0 4.2%	1,860.0 4.5%	420.0 2.4%
3.5"	5,443.5 99.0%	22,559.5 90.2%	58,585.0 89.1%	30,360.0 74.2%	9,700.0 54.6%
2.5"-3"	50.0 .9%	1,620.0 6.5%	4,420.0 6.7%	8,700.0 21.3%	7,640.0 43.0%
Total	5,497.0	25,004.5	65,745.0	40,920.0	17,760.0

Following the expected 1998 peak in shipments of 3-5 gigabyte 3.5" drives, it is expected that the shipment pattern already observed in all of the lower capacity product groups will be repeated -- with a decline in shipments after the peak almost as rapid as the period of increases which preceded it. The shipment peak for 2.5"-3" drives is expected to stretch out a bit longer. 2.5"-3" high volume shipments are actually just starting in 1997, and the peak is not expected until 1999, with only a modest decline in 2000. Although 2.5"-3" drives with capacities much higher than those of this product group will be available by then, it has become normal for disk drive capacities utilized with notebook computers to lag behind those featured with desktop personal computers by a year or two.

Technical trends

It is expected that high performance disk drives which remain in this product group will be improved, but that the highest priority will be placed on improvements designed to lower product costs for drives destined for the personal computer market. Well before the end of the this forecast period, 3.5" drives for both high-end and low-end applications will be available with only one disk, reducing parts count to a minimum. Such drives will be priced significantly lower than today's models, with higher reliability, and they may provide performance enhancements not yet in today's production drives. One such enhancement will probably be rotation speeds in the 10,000 RPM range, offering major improvement to today's latencies and transfer rates.

The same type of product development effort will be devoted to the 2.5"-3" drives targeted at the notebook computer market. With low product cost as the overriding objective, these programs will stress attempts to achieve the lowest possible drive parts count consistent with areal densities which can be manufactured with high yields. The industry's highest areal densities have been utilized in 2.5" drives developed by IBM since 1994. During the past year, 2.5" drives in this product group have achieved the highest areal densities in the disk drive industry, with the current leadership held by IBM's "Toccata" series, at 2.5 gigabits per square inch.

Forecasting assumptions

1. Production of high-end 3.5" drives in this capacity range will continue through 2000, but a high proportion of 3.5" drives will be designed for lower cost personal computer applications. Total 3-5 gigabyte 3.5" drive shipments will peak in 1998.
2. Shipments of low-cost 5.25" drives intended to compete with 3.5" drives for personal computer applications will continue through 2000.
3. The early 2.5" drive models currently available in this product group will be supplemented with additional 2.5"-3" drive introductions during 1997-98, resulting in continuing shipment growth through 2000.

TABLE 49

FIXED DISK DRIVES, 3 - 5 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1,355.8	1,997.9	1,134.9	1,649.0	1,007.4	1,505.5	792.5	1,206.7	429.4	669.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	1,355.8	1,997.9	1,134.9	1,649.0	1,007.4	1,505.5	792.5	1,206.7	429.4	669.0
PCM/Distributor	425.2	614.2	1,031.0	2,035.7	2,118.3	4,325.8	855.5	1,744.6	278.7	566.4
OEM/Integrator	1,814.7	2,152.1	1,900.3	3,375.4	4,439.9	8,040.9	2,392.5	4,223.9	978.5	1,677.6
TOTAL U.S. NONCAPTIVE	2,239.9	2,766.3	2,931.3	5,411.1	6,558.2	12,366.7	3,248.0	5,968.5	1,257.2	2,244.0
TOTAL U.S. REVENUES	3,595.7	4,764.2	4,066.2	7,060.1	7,565.6	13,872.2	4,040.5	7,175.2	1,686.6	2,913.0
Non-U.S. Manufacturers										
Captive	--	20.9	13.4	102.7	85.2	371.1	121.8	485.0	106.5	389.7
PCM/Distributor	169.0	191.9	154.0	258.9	511.2	846.7	207.6	365.9	51.9	104.1
OEM/Integrator	30.7	90.2	317.1	838.1	759.6	2,039.0	512.2	1,401.7	234.5	653.2
TOTAL NON-U.S. REVENUES	199.7	303.0	484.5	1,199.7	1,356.0	3,256.8	841.6	2,252.6	392.9	1,147.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	3,795.4	5,067.2	4,550.7	8,259.8	8,921.6	17,129.0	4,882.1	9,427.8	2,079.5	4,060.0
OEM Average Price ($000)		.667		.281		.231		.203		.193

TABLE 50

FIXED DISK DRIVES, 3 - 5 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996		Forecast							
	Shipments		1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	647.0	930.0	1,384.0	2,015.0	1,555.0	2,325.0	1,520.0	2,315.0	950.0	1,480.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	647.0	930.0	1,384.0	2,015.0	1,555.0	2,325.0	1,520.0	2,315.0	950.0	1,480.0
PCM/Distributor	694.0	1,036.0	3,400.0	6,840.0	7,890.0	16,120.0	4,110.0	8,385.0	1,400.0	2,845.0
OEM/Integrator	2,517.0	3,137.5	6,295.0	11,495.0	19,200.0	34,825.0	11,825.0	20,910.0	5,100.0	8,740.0
TOTAL U.S. NONCAPTIVE	3,211.0	4,173.5	9,695.0	18,335.0	27,090.0	50,945.0	15,935.0	29,295.0	6,500.0	11,585.0
TOTAL U.S. SHIPMENTS	3,858.0	5,103.5	11,079.0	20,350.0	28,645.0	53,270.0	17,455.0	31,610.0	7,450.0	13,065.0
Non-U.S. Manufacturers										
Captive	--	10.6	20.0	140.5	150.0	655.0	245.0	975.0	235.0	860.0
PCM/Distributor	135.6	163.1	621.0	1,032.0	1,830.0	3,040.0	920.0	1,625.0	260.0	520.0
OEM/Integrator	64.8	219.8	1,314.0	3,482.0	3,275.0	8,780.0	2,455.0	6,710.0	1,190.0	3,315.0
TOTAL NON-U.S. SHIPMENTS	200.4	393.5	1,955.0	4,654.5	5,255.0	12,475.0	3,620.0	9,310.0	1,685.0	4,695.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	4,058.4	5,497.0	13,034.0	25,004.5	33,900.0	65,745.0	21,075.0	40,920.0	9,135.0	17,760.0
Total Capacity (Terabytes)	16,574.3	22,150.0	52,132.4	99,450.5	129,866.8	251,561.9	84,589.9	164,049.1	38,462.0	74,754.7
Cumulative Shipments (Units in millions)										
IBM	1.0	1.5	2.4	3.6	4.0	5.9	5.5	8.2	6.4	9.7
Non-IBM	4.8	6.3	16.4	29.3	48.8	92.7	68.3	131.3	76.5	147.6
WORLDWIDE TOTAL	5.9	7.9	18.9	32.9	52.8	98.6	73.9	139.5	83.0	157.3

TABLE 51

FIXED DISK DRIVES, 3 - 5 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues			Forecast 1997			1998			1999			2000		
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS															
IBM Captive	--	1,990.6	7.3	--	1,513.6	135.4	--	1,281.2	224.3	--	834.7	372.0	--	258.6	410.4
PCM/Distributor	.4	613.8	--	96.6	1,930.6	8.5	196.6	4,107.2	22.0	111.8	1,595.2	37.6	26.2	511.1	29.1
OEM/Integrator	.3	2,139.0	12.8	59.7	3,143.5	172.2	314.5	7,331.4	395.0	203.2	3,268.3	752.4	39.3	1,054.5	583.8
TOTAL U.S. REVENUES	.7	4,743.4	20.1	156.3	6,587.7	316.1	511.1	12,719.8	641.3	315.0	5,698.2	1,162.0	65.5	1,824.2	1,023.3
NON-U.S. MANUFACTURERS															
Captive	--	20.9	--	--	55.8	46.9	--	70.1	301.0	--	52.6	432.4	--	9.1	380.6
PCM/Distributor	--	191.9	--	--	243.9	15.0	--	807.8	38.9	--	314.2	51.7	--	69.7	34.4
OEM/Integrator	--	90.2	--	--	636.2	201.9	--	1,650.0	389.0	--	744.0	657.7	--	175.4	477.8
TOTAL NON-U.S. REVENUES	--	303.0	--	--	935.9	263.8	--	2,527.9	728.9	--	1,110.8	1,141.8	--	254.2	892.8
WORLDWIDE RECAP															
Captive	--	2,011.5	7.3	--	1,569.4	182.3	--	1,351.3	525.3	--	887.3	804.4	--	267.7	791.0
	--	+74.0%	--	--	-22.0%	--	--	-13.9%	+188.2%	--	-34.3%	+53.1%	--	-69.8%	-1.7%
PCM/Distributor	.4	805.7	--	96.6	2,174.5	23.5	196.6	4,915.0	60.9	111.8	1,909.4	89.3	26.2	580.8	63.5
	-88.6%	+115.4%	--	--	+169.9%	--	+103.5%	+126.0%	+159.1%	-43.1%	-61.2%	+46.6%	-76.6%	-69.6%	-28.9%
OEM/Integrator	.3	2,229.2	12.8	59.7	3,779.7	374.1	314.5	8,981.4	784.0	203.2	4,012.3	1,410.1	39.3	1,229.9	1,061.6
	-96.6%	+151.6%	--	--	+69.6%	--	+426.8%	+137.6%	+109.6%	-35.4%	-55.3%	+79.9%	-80.7%	-69.3%	-24.7%
Total Revenues	.7	5,046.4	20.1	156.3	7,523.6	579.9	511.1	15,247.7	1,370.2	315.0	6,809.0	2,303.8	65.5	2,078.4	1,916.1
	-94.3%	+108.9%	--	--	+49.1%	--	+227.0%	+102.7%	+136.3%	-38.4%	-55.3%	+68.1%	-79.2%	-69.5%	-16.8%
ANNUAL SHARE, BY DIAMETER	--	99.7%	.3%	1.9%	91.2%	6.9%	3.0%	89.1%	7.9%	3.3%	72.3%	24.4%	1.6%	51.3%	47.1%

Note: 2.5 inch totals include 3 inch drives.

TABLE 52

FIXED DISK DRIVES, 3 - 5 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments			Forecast 1997			Forecast 1998			Forecast 1999			Forecast 2000		
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS															
IBM Captive	--	920.0	10.0	--	1,805.0	210.0	--	1,915.0	410.0	--	1,540.0	775.0	--	530.0	950.0
PCM/Distributor	2.0	1,034.0	--	510.0	6,300.0	30.0	1,040.0	14,990.0	90.0	650.0	7,560.0	175.0	165.0	2,530.0	150.0
OEM/Integrator	1.5	3,096.0	40.0	315.0	10,565.0	615.0	1,700.0	31,465.0	1,660.0	1,210.0	16,100.0	3,600.0	255.0	5,380.0	3,105.0
TOTAL U.S. SHIPMENTS	3.5	5,050.0	50.0	825.0	18,670.0	855.0	2,740.0	48,370.0	2,160.0	1,860.0	25,200.0	4,550.0	420.0	8,440.0	4,205.0
NON-U.S. MANUFACTURERS															
Captive	--	10.6	--	--	70.5	70.0	--	125.0	530.0	--	105.0	870.0	--	20.0	840.0
PCM/Distributor	--	163.1	--	--	982.0	50.0	--	2,885.0	155.0	--	1,390.0	235.0	--	350.0	170.0
OEM/Integrator	--	219.8	--	--	2,837.0	645.0	--	7,205.0	1,575.0	--	3,665.0	3,045.0	--	890.0	2,425.0
TOTAL NON-U.S. SHIPMENTS	--	393.5	--	--	3,889.5	765.0	--	10,215.0	2,260.0	--	5,160.0	4,150.0	--	1,260.0	3,435.0
WORLDWIDE RECAP															
Captive	--	930.6	10.0	--	1,875.5	280.0	--	2,040.0	940.0	--	1,645.0	1,645.0	--	550.0	1,790.0
	--	+283.8%	--	--	+101.5%	--	--	+8.8%	+235.7%	--	-19.4%	+75.0%	--	-66.6%	+8.8%
PCM/Distributor	2.0	1,197.1	--	510.0	7,282.0	80.0	1,040.0	17,875.0	245.0	650.0	8,950.0	410.0	165.0	2,880.0	320.0
	-42.9%	+206.8%	--	--	+508.3%	--	+103.9%	+145.5%	+206.3%	-37.5%	-49.9%	+67.3%	-74.6%	-67.8%	-22.0%
OEM/Integrator	1.5	3,315.8	40.0	315.0	13,402.0	1,260.0	1,700.0	38,670.0	3,235.0	1,210.0	19,765.0	6,645.0	255.0	6,270.0	5,530.0
	-81.0%	+214.4%	--	--	+304.2%	--	+439.7%	+188.5%	+156.7%	-28.8%	-48.9%	+105.4%	-78.9%	-68.3%	-16.8%
Total Shipments	3.5	5,443.5	50.0	825.0	22,559.5	1,620.0	2,740.0	58,585.0	4,420.0	1,860.0	30,360.0	8,700.0	420.0	9,700.0	7,640.0
	-69.3%	+222.6%	--	--	+314.4%	--	+232.1%	+159.7%	+172.8%	-32.1%	-48.2%	+96.8%	-77.4%	-68.1%	-12.2%
ANNUAL SHARE, BY DIAMETER	.1%	99.1%	.8%	3.3%	90.3%	6.4%	4.2%	89.2%	6.6%	4.5%	74.3%	21.2%	2.4%	54.7%	42.9%
TOTAL CAPACITY (Terabytes)	10.5	21,985.5	154.0	3,503.0	90,439.5	5,508.0	11,877.9	223,772.0	15,912.0	8,063.1	122,056.0	33,930.0	1,820.7	40,846.0	32,088.0

Note: 2.5 inch totals include 3 inch drives.

TABLE 53

FIXED DISK DRIVES, 3 - 5 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	5.5	.1	--	--
MAINFRAME SYSTEMS General purpose	885.1	16.1	--	--
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	2,110.8	38.4	532.8	3.0
PERSONAL COMPUTERS Business and professional, single user	2,116.3	38.5	15,628.8	88.0
WORKSTATIONS Engineering and office, single user	357.3	6.5	355.2	2.0
CONSUMER, GAME AND HOBBY COMPUTERS	22.0	.4	1,243.2	7.0
OTHER APPLICATIONS	--	--	--	--
Total	5,497.0	100.0	17,760.0	100.0

TABLE 54

FIXED DISK DRIVES, 3 - 5 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1996	Forecast 1997	1998	1999	2000
Captive					
8"	--	--	--	--	--
5.25"	--	--	--	--	--
3.5"	.56	.19	.15	.12	.11
2.5"	.23	.18	.15	.12	.10
Captive Average	.56	.19	.15	.12	.10
PCM/Distributor					
8"	--	--	--	--	--
5.25"	.06	.04	.04	.04	.03
3.5"	.17	.07	.07	.05	.04
2.5"	--	.08	.06	.05	.04
PCM/Distributor Average	.16	.07	.07	.05	.04
OEM/Integrator					
8"	--	--	--	--	--
5.25"	.06	.04	.04	.03	.03
3.5"	.16	.07	.06	.05	.04
2.5"	.10	.08	.06	.05	.04
OEM/Integrator Average	.16	.07	.06	.05	.04

Notes: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

2.5 inch totals include 3 inch drives.

TABLE 55

FIXED DISK DRIVES, 3 - 5 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

1996 Net Shipments

Drive Manufacturers	To United States Destinations Units (000) 8"	5.25"	3.5"	2.5"	Total	%	Worldwide Units (000) 8"	5.25"	3.5"	2.5"	Total	%
Seagate Technology	--	--	2036.0	--	2036.0	59.7	--	--	2315.0	--	2315.0	50.8
Quantum	--	--	600.0	--	600.0	17.6	--	--	1040.0	--	1040.0	22.8
IBM	--	--	280.0	25.0	305.0	8.9	--	--	415.0	40.0	455.0	10.0
Western Digital	--	--	270.0	--	270.0	7.9	--	--	360.0	--	360.0	7.9
Fujitsu	--	--	51.9	--	51.9	1.5	--	--	192.9	--	192.9	4.2
Other U.S.	--	--	--	--	--	--	--	3.5	--	--	3.5	.1
Other Non-U.S.	--	--	148.5	--	148.5	4.4	--	--	190.0	--	190.0	4.2
TOTAL	--	--	3386.4	25.0	3411.4	100.0	--	3.5	4512.9	40.0	4556.4	100.0

Note: 2.5 inch totals include 3 inch drives.

FIXED DISK DRIVES, 5 - 10 GIGABYTES

1997 DISK/TREND REPORT

FIXED DISK DRIVES, 5 - 10 GIGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Gigastorage International	B5512A**
Quantum	6.4 Bigfoot CY**
Seagate Technology	ST410800N/W

3.5" disk diameter

Fujitsu	MPA3052T**, M2949S*
Hitachi	DK308-90, DK318H-91*
IBM	DHEA-36480**, DCHS-39100*
Maxtor	87000A8**, 85120A8**
Micropolis	4550A**, 3391*
Quantum	8.4 Fireball SE**, 9.1 Atlas III**
Samsung Electronics	VG-35102A**
Seagate Technology	ST36450A**, ST19171N/FC*

2.5"-3" disk diameter

IBM	DPLA-25120***

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.

Established as a separate DISK/TREND product group for the first time last year, the 5-10 gigabyte capacity range didn't exist as a disk drive industry product area until IBM introduced the 3390-3 in 1991, using 10.8" disks, with 5,676 megabytes capacity. The 3390-3 stayed in production until 1995, and during most of that period it was IBM's primary disk drive for the mainframe computer systems market. IBM's introduction in Autumn, 1994, of the company's first disk drive array subsystem for mainframe applications under the recycled RAMAC name effectively replaced IBM's older large diameter disk drives with arrays of lower capacity 3.5" drives.

A major share of the sales activity in this capacity range during the last two years has been generated by 9 gigabyte 5.25" drives, led by the Seagate Elite 9. These drives appeared in mid-1994, and have been widely used in arrays and other storage subsystems for mainframe, midrange and network file server applications, offering the most competitive price per megabyte available. IBM skipped

5.25" drives in this range and preannounced an 8.7 gigabyte 3.5" drive in late 1994, later changing the specification to 9.1 gigabytes when the drive went into production in late 1995. Six manufacturers now offer high performance 9.1 gigabyte 3.5" drives, with an additional entrant expected during 1997.

In 1997, the increasing disk drive capacity appetite of the desktop personal computer market has prompted seven drive manufacturers to add drives intended for PC applications, at appropriate performance and price levels, with capacities ranging from 5 to 8.5 gigabytes. All of these manufacturers have introduced 1" high 3.5" drives with IDE interfaces, and Quantum has expanded its Bigfoot family to include a 6.4 gigabyte model.

Another indication that the 5-10 gigabyte product group may now expect expanded product horizons was IBM's mid-1997 introduction of the industry's highest capacity 2.5" drive, a 17 millimeter high 5.1 gigabyte model in its "Prelude" family.

Market status

Total 1996 worldwide shipments of 5-10 gigabyte drives were 793.7 thousand units, but major changes are under way for this product group in 1997, and the year's shipments are forecasted to reach 6.9 million drives. 1996 shipments consisted entirely of high performance drives used primarily with mainframe and midrange computers, network file servers, and a variety of specialized applications requiring high-end disk drives. 1997 shipments also include these markets, but much of the sales increase is due to higher demand for increased capacity disk used with high-end personal computers. Total sales revenues for the product group in 1996 were $1.7 billion, with 1997 expected to climb to $5.5 billion.

About 40% of the high performance drives in this product group shipped in 1996 were 5.25" models, mostly Seagate's Elite 9, with the balance consisting of 9.1 gigabyte 3.5" drives, with shipments dominated by Seagate and IBM. The high performance drive scene is changing in 1997, with a sharp decline in shipments of 5.25" drives, impacted by Seagate's movement to the Elite 23 gigabyte version and rapid growth in 3.5" drive shipments by both Seagate and IBM, supplemented with growing high performance 3.5" drive programs by Fujitsu, Quantum and Micropolis.

The largest boost in 1997 shipments is expected from the new generation of drives targeted at the personal computer market, with new models from most major drive manufacturers. The mix of applications for this product group will be completely changed by the end of the current forecast period, as personal computers become the dominant market. 56.6% of the product group's 1996 shipments were used with mainframe computers, but the share for mainframes will drop to 0.1% in 2000. A sharp drop in the network/midrange share of the product groups shipments is also expected, from 38.1% in 1996 to 5.0% in 2000, despite an increase in actual unit shipments. Personal computers are expected to rise from less than 1% in 1996 to 89.8% in 2000, and consumer computers are predicted to climb from zero in 1996 to 4.0% of the 2000 total.

Seagate Technology continued to hold a commanding lead in noncaptive unit shipments in 1996, with 75.2% of the worldwide total, including both 3.5" and 5.25" drives, followed by second place Micropolis, with 11.5%.

Marketing trends

Drive shipments in the 5-10 gigabyte capacity range are not expected to peak for another two years, but there will be major changes in product mix on the way to that climax. Total unit shipments are projected to increase 438% in 1998, reaching the 37.3 million level, on the way to the 1999 peak of 68.5 million drives.

Worldwide total unit shipments (000)	1996	1997	1998	1999	2000
6.5"-8"	1.0	--	--	--	--
	.1%	--	--	--	--
5.25"	315.0	721.0	1,295.0	2,980.0	1,910.0
	39.7%	10.4%	3.5%	4.3%	3.0%
3.5"	477.7	6,102.5	32,895.0	58,240.0	50,585.0
	60.2%	88.0%	88.2%	85.0%	80.7%
2.5"-3"	--	110.0	3,110.0	7,290.0	10,225.0
	--	1.6%	8.3%	10.6%	16.3%
Total	793.7	6,933.5	37,300.0	68,510.0	62,720.0

Both 3.5" and 5.25" drives are expected to reach peak shipments in 1999, with the market completely dominated by desktop personal computer applications. 2.5"-3" shipments are not expected to peak before 2000, following the usual pattern of notebook computers in reaching shipment peaks at each capacity level a year or two later than desktop personal computers. By 2000, 2.5"-3" drives are expected to provide 16.3% of the product group's total shipments.

The fact that separate high performance and low cost 3.5" disk drive types will coexist in this product group during the 1997-99 period means that the price per megabyte calculations which apply to noncaptive drive shipments during those years will be composite figures. The average price per megabyte for all OEM/Integrator drives was 18 cents in 1995, when most of the drives shipped were 5.25" models. The average OEM/Integrator price dropped to 12 cents in 1996, when 60% of the drives were high performance 3.5" models. And, as the product mix shifts to drives for personal computer applications, with rapidly increasing shipments, the average will continue to fall. The OEM/Integrator average price in 1997 is estimated at 7 cents, falling to 3 cents in 2000.

Technical trends

During the last few years, the most challenging product development problems for the disk drive industry were presented by the capacities in this product group. As the industry moves up in recording density and drive performance objectives, it is always necessary to solve new problems in numerous technical areas, including the head/disk interface, track density/head positioning, semiconductor data rates, new encoding methods, magnetic/electrical interference, new interface requirements, and a myriad of other electronic and mechanical engineering considerations. In addition, there is the challenge of developing and securing reliable supplies of many new components, never previously in quantity production.

Most of the current challenges in developing and manufacturing 5-10 gigabyte drives are much more manageable, and the areas of great difficulty are now found with new development programs for drives in higher capacity ranges. Starting in 1997, many of the new high performance drives for the 5-10 gigabyte range will be depopulated models derived from development programs initiated for higher capacity targets. The completely different development activities targeted at low cost 3.5" and 2.5" drives will also have a major impact on this product group in future years. The basic objective for such programs will be efficient manufacturing.

Forecasting assumptions

1. New personal computer applications will increase 5.25" drive shipments through 1999, the peak year, then decline, as personal computer disk capacities move up.
2. Shipments of 3.5" drives with 5-10 gigabyte capacities will peak in 1999, dominated by shipments of low cost models for personal computer applications starting in 1997.
3. The first 2.5" drive shipments in this product group will occur in 1997, with continuing increases through 2000.

TABLE 56

FIXED DISK DRIVES, 5 - 10 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	617.3	905.7	1,401.4	2,113.3	1,503.4	2,223.0	1,437.0	2,172.7	1,371.8	2,114.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	617.3	905.7	1,401.4	2,113.3	1,503.4	2,223.0	1,437.0	2,172.7	1,371.8	2,114.0
PCM/Distributor	95.3	122.6	390.5	643.5	2,116.2	2,865.4	3,325.5	4,351.4	2,723.3	3,314.2
OEM/Integrator	455.6	498.6	1,346.0	1,957.9	3,856.2	6,444.6	5,850.9	10,103.6	5,026.9	8,817.1
TOTAL U.S. NONCAPTIVE	550.9	621.2	1,736.5	2,601.4	5,972.4	9,310.0	9,176.4	14,455.0	7,750.2	12,131.3
TOTAL U.S. REVENUES	1,168.2	1,526.9	3,137.9	4,714.7	7,475.8	11,533.0	10,613.4	16,627.7	9,122.0	14,245.3
Non-U.S. Manufacturers										
Captive	--	9.0	--	26.8	82.1	365.5	117.5	514.1	116.7	548.3
PCM/Distributor	45.0	60.6	192.3	258.9	381.7	632.4	491.0	861.0	332.6	627.3
OEM/Integrator	41.8	64.5	220.3	500.2	888.0	1,981.0	1,302.4	2,973.6	1,181.8	2,820.1
TOTAL NON-U.S. REVENUES	86.8	134.1	412.6	785.9	1,351.8	2,978.9	1,910.9	4,348.7	1,631.1	3,995.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,255.0	1,661.0	3,550.5	5,500.6	8,827.6	14,511.9	12,524.3	20,976.4	10,753.1	18,241.0
OEM Average Price ($000)		1.163		.576		.338		.278		.265

TABLE 57

FIXED DISK DRIVES, 5 - 10 GIGABYTES

UNIT SHIPMENT SUMMARY

DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)

	1996 Shipments		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	105.0	155.0	590.0	875.0	1,165.0	1,720.0	2,010.0	3,040.0	2,155.0	3,315.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	105.0	155.0	590.0	875.0	1,165.0	1,720.0	2,010.0	3,040.0	2,155.0	3,315.0
PCM/Distributor	83.0	107.0	778.0	1,328.0	6,345.0	8,615.0	11,455.0	14,910.0	10,125.0	12,330.0
OEM/Integrator	378.5	418.5	2,265.0	3,418.0	11,510.0	19,360.0	21,215.0	36,650.0	19,075.0	33,465.0
TOTAL U.S. NONCAPTIVE	461.5	525.5	3,043.0	4,746.0	17,855.0	27,975.0	32,670.0	51,560.0	29,200.0	45,795.0
TOTAL U.S. SHIPMENTS	566.5	680.5	3,633.0	5,621.0	19,020.0	29,695.0	34,680.0	54,600.0	31,355.0	49,110.0
Non-U.S. Manufacturers										
Captive	--	1.0	--	15.5	105.0	440.0	165.0	715.0	190.0	885.0
PCM/Distributor	34.6	46.6	323.0	451.0	985.0	1,640.0	1,610.0	2,825.0	1,210.0	2,285.0
OEM/Integrator	38.3	65.6	370.0	846.0	2,495.0	5,525.0	4,555.0	10,370.0	4,370.0	10,440.0
TOTAL NON-U.S. SHIPMENTS	72.9	113.2	693.0	1,312.5	3,585.0	7,605.0	6,330.0	13,910.0	5,770.0	13,610.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	639.4	793.7	4,326.0	6,933.5	22,605.0	37,300.0	41,010.0	68,510.0	37,125.0	62,720.0
Total Capacity (Terabytes)	5,577.0	6,874.5	30,915.4	48,718.6	144,135.4	236,532.4	301,806.7	501,411.2	311,247.5	522,868.0
Cumulative Shipments (Units in millions)										
IBM	.2	.3	.8	1.2	2.0	2.9	4.0	5.9	6.1	9.3
Non-IBM	.9	1.0	4.6	7.1	26.0	42.7	65.0	108.1	100.0	167.5
WORLDWIDE TOTAL	1.1	1.4	5.4	8.3	28.0	45.6	69.0	114.1	106.2	176.9

TABLE 58

FIXED DISK DRIVES, 5 - 10 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues			Forecast 1997			1998			1999			2000		
	8"	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS															
IBM Captive	--	--	905.7	--	2,089.9	23.4	--	2,049.7	173.3	--	1,713.0	459.7	--	1,488.7	625.3
PCM/Distributor	--	64.6	58.0	97.1	546.4	--	152.4	2,696.0	17.0	403.6	3,908.9	38.9	175.6	3,107.7	30.9
OEM/Integrator	--	324.2	174.4	202.8	1,727.9	27.2	227.8	5,726.0	490.8	626.1	8,579.3	898.2	296.4	7,440.8	1,079.9
TOTAL U.S. REVENUES	--	388.8	1,138.1	299.9	4,364.2	50.6	380.2	10,471.7	681.1	1,029.7	14,201.2	1,396.8	472.0	12,037.2	1,736.1
NON-U.S. MANUFACTURERS															
Captive	9.0	--	--	--	26.8	--	--	99.6	265.9	--	101.1	413.0	--	81.6	466.7
PCM/Distributor	--	25.0	35.6	--	258.9	--	--	604.8	27.6	--	797.6	63.4	--	544.6	82.7
OEM/Integrator	--	13.6	50.9	--	500.2	--	--	1,658.0	323.0	--	2,191.0	782.6	--	1,766.7	1,053.4
TOTAL NON-U.S. REVENUES	9.0	38.6	86.5	--	785.9	--	--	2,362.4	616.5	--	3,089.7	1,259.0	--	2,392.9	1,602.8
WORLDWIDE RECAP															
Captive	9.0	--	905.7	--	2,116.7	23.4	--	2,149.3	439.2	--	1,814.1	872.7	--	1,570.3	1,092.0
	--	--	--	--	+133.7%	--	--	+1.5%	--	--	-15.6%	+98.7%	--	-13.4%	+25.1%
PCM/Distributor	--	89.6	93.6	97.1	805.3	--	152.4	3,300.8	44.6	403.6	4,706.5	102.3	175.6	3,652.3	113.6
	--	-62.4%	--	+8.4%	+760.4%	--	+57.0%	+309.9%	--	+164.8%	+42.6%	+129.4%	-56.5%	-22.4%	+11.0%
OEM/Integrator	--	337.8	225.3	202.8	2,228.1	27.2	227.8	7,384.0	813.8	626.1	10,770.3	1,680.8	296.4	9,207.5	2,133.3
	--	+3.1%	--	-40.0%	+888.9%	--	+12.3%	+231.4%	--	+174.8%	+45.9%	+106.5%	-52.7%	-14.5%	+26.9%
Total Revenues	9.0	427.4	1,224.6	299.9	5,150.1	50.6	380.2	12,834.1	1,297.6	1,029.7	17,290.9	2,655.8	472.0	14,430.1	3,338.9
	--	-24.5%	--	-29.8%	+320.6%	--	+26.8%	+149.2%	--	+170.8%	+34.7%	+104.7%	-54.2%	-16.5%	+25.7%
ANNUAL SHARE, BY DIAMETER	.5%	25.8%	73.7%	5.5%	93.7%	.8%	2.6%	88.5%	8.9%	4.9%	82.5%	12.6%	2.6%	79.2%	18.2%

Note: 8 inch totals include 6.5 - 8 inch drives, and 2.5 inch totals include 3 inch drives.

TABLE 59

FIXED DISK DRIVES, 5 - 10 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments			Forecast 1997			1998			1999			2000		
	8"	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS															
IBM Captive	--	--	155.0	--	845.0	30.0	--	1,495.0	225.0	--	2,360.0	680.0	--	2,290.0	1,025.0
PCM/Distributor	--	48.0	59.0	258.0	1,070.0	--	515.0	8,050.0	50.0	1,160.0	13,620.0	130.0	705.0	11,510.0	115.0
OEM/Integrator	--	241.0	177.5	463.0	2,875.0	80.0	780.0	17,115.0	1,465.0	1,820.0	31,775.0	3,055.0	1,205.0	28,185.0	4,075.0
TOTAL U.S. SHIPMENTS	--	289.0	391.5	721.0	4,790.0	110.0	1,295.0	26,660.0	1,740.0	2,980.0	47,755.0	3,865.0	1,910.0	41,985.0	5,215.0
NON-U.S. MANUFACTURERS															
Captive	1.0	--	--	--	15.5	--	--	100.0	340.0	--	135.0	580.0	--	125.0	760.0
PCM/Distributor	--	16.2	30.4	--	451.0	--	--	1,560.0	80.0	--	2,615.0	210.0	--	1,980.0	305.0
OEM/Integrator	--	9.8	55.8	--	846.0	--	--	4,575.0	950.0	--	7,735.0	2,635.0	--	6,495.0	3,945.0
TOTAL NON-U.S. SHIPMENTS	1.0	26.0	86.2	--	1,312.5	--	--	6,235.0	1,370.0	--	10,485.0	3,425.0	--	8,600.0	5,010.0
WORLDWIDE RECAP															
Captive	1.0	--	155.0	--	860.5	30.0	--	1,595.0	565.0	--	2,495.0	1,260.0	--	2,415.0	1,785.0
	--	--	--	--	+455.2%	--	--	+85.4%	--	--	+56.4%	+123.0%	--	-3.2%	+41.7%
PCM/Distributor	--	64.2	89.4	258.0	1,521.0	--	515.0	9,610.0	130.0	1,160.0	16,235.0	340.0	705.0	13,490.0	420.0
	--	-49.0%	--	+301.9%	--	--	+99.6%	+531.8%	--	+125.2%	+68.9%	+161.5%	-39.2%	-16.9%	+23.5%
OEM/Integrator	--	250.8	233.3	463.0	3,721.0	80.0	780.0	21,690.0	2,415.0	1,820.0	39,510.0	5,690.0	1,205.0	34,680.0	8,020.0
	--	+26.0%	--	+84.6%	--	--	+68.5%	+482.9%	--	+133.3%	+82.2%	+135.6%	-33.8%	-12.2%	+40.9%
Total Shipments	1.0	315.0	477.7	721.0	6,102.5	110.0	1,295.0	32,895.0	3,110.0	2,980.0	58,240.0	7,290.0	1,910.0	50,585.0	10,225.0
	--	-3.1%	--	+128.9%	--	--	+79.6%	+439.0%	--	+130.1%	+77.0%	+134.4%	-35.9%	-13.1%	+40.3%
ANNUAL SHARE, BY DIAMETER	.1%	39.8%	60.1%	10.4%	88.1%	1.5%	3.5%	88.3%	8.2%	4.3%	85.1%	10.6%	3.0%	80.8%	16.2%
TOTAL CAPACITY (Terabytes)	8.5	2,863.3	4,002.7	4,848.9	43,306.5	563.2	8,430.5	210,325.0	17,777.0	22,350.0	429,743.8	49,317.5	16,235.0	426,825.5	79,807.5

Note: 8 inch totals include 6.5 - 8 inch drives, and 2.5 inch totals include 3 inch drives.

TABLE 60

FIXED DISK DRIVES, 5 - 10 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	.8	.1	62.7	.1
MAINFRAME SYSTEMS				
General purpose	449.2	56.6	62.7	.1
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	302.4	38.1	3,136.0	5.0
PERSONAL COMPUTERS				
Business and professional, single user	5.6	.7	56,322.6	89.8
WORKSTATIONS				
Engineering and office, single user	35.7	4.5	627.2	1.0
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	2,508.8	4.0
OTHER APPLICATIONS	--	--	--	--
Total	793.7	100.0	62,720.0	100.0

TABLE 61

FIXED DISK DRIVES, 5 - 10 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1996	Forecast 1997	1998	1999	2000
Captive					
8"	1.05	--	--	--	--
5.25"	--	--	--	--	--
3.5"	.83	.35	.18	.09	.07
2.5"	--	.15	.14	.10	.07
Captive Average	.83	.34	.17	.09	.07
PCM/Distributor					
8"	--	--	--	--	--
5.25"	.15	.05	.04	.04	.02
3.5"	.11	.08	.05	.03	.03
2.5"	--	--	.06	.04	.03
PCM/Distributor Average	.13	.07	.05	.04	.03
OEM/Integrator					
8"	--	--	--	--	--
5.25"	.14	.06	.04	.04	.02
3.5"	.10	.08	.05	.03	.03
2.5"	--	.06	.05	.04	.03
OEM/Integrator Average	.12	.07	.05	.03	.03

Notes: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

8 inch totals include 6.5 - 8 inch drives.

2.5 inch totals include 3 inch drives.

TABLE 62

FIXED DISK DRIVES, 5 - 10 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	8"	5.25"	3.5"	Total		8"	5.25"	3.5"	Total	
Seagate Technology	--	279.0	158.0	437.0	80.3	--	299.0	188.0	487.0	75.2
Micropolis	--	21.7	38.5	60.2	11.1	--	26.0	48.2	74.2	11.5
Other U.S.	--	--	34.5	34.5	6.3	--	--	48.5	48.5	7.5
Other Non-U.S.	--	--	12.7	12.7	2.3	--	--	38.0	38.0	5.9
TOTAL	--	300.7	243.7	544.4	100.0	--	325.0	322.7	647.7	100.0

FIXED DISK DRIVES, 10 - 20 GIGABYTES

FIXED DISK DRIVES, 10 - 20 GIGABYTES

Coverage

Examples of disk drives in this group include:

3.5" disk diameter

Quantum	18.2 Atlas III*

*Maximum 41.3 mm height, or less.

The 10-20 gigabyte product group appears for the first time in this year's edition of the DISK/TREND Report. It's a product group with very limited previous activity. The only disk drive ever available in this capacity range was the IBM 17 gigabyte 3390-9, using 10.8" disks, with shipments from 1993 to 1995.

In 1997, a new wave of 18.2 gigabyte 3.5" drives is expected to be announced, and it's probable that some will actually be delivered this year. So far, the only announced disk drive in the product group is the Quantum Atlas III, for which production deliveries are not scheduled until the first quarter of 1998. Many in the industry have anticipated IBM's "Marlin" drive, and it is currently expected to be available in the second half of 1997. Other manufacturers are also expected to introduce 18.2 gigabyte models this year.

Market status

In mid-1997, there are no current disk drive shipments in the 10-20 gigabyte range. However, shipments of 18.2 gigabyte 3.5" drives are expected to commence in the second half of 1997, by IBM and probably by other manufacturers. The current DISK/TREND forecast for 1997 worldwide unit shipments is 60 thousand drives, in a mixture of captive and noncaptive sales channels. 1997 worldwide sales revenues for the product group are estimated at $106.5 million.

Following the example of other disk drive capacity ranges, the high performance disk drive requirements of mainframe, midrange and network file server applications will provide the initial stimulus for development and production of 10-20 gigabyte drives. Most of the 1997 introductions will be refinements of drive mechanisms currently used with 9.1 gigabyte drives, to utilize heads, disks and semiconductors designed for higher recording density.

Marketing trends

Despite the modest start predicted for this product group in 1997, the forecast for subsequent years is dramatically different, following the industry's classic pattern of rapid build-up of shipments as typical recording capacities increase. By 2000, drive shipments in this capacity range are expected to lead the industry. The DISK/TREND Report projection is 4.1 million drives in 1998, 48.1 million in 1999, and 88.6 million in 2000. Worldwide 2000 sales revenues are forecasted at $37.1 billion, almost half of the expected total for all rigid disk drives.

Although high performance drives are expected to remain a significant factor in the 10-20 gigabyte range through 2000, the first drives designed for personal computer applications are expected in 1998, establishing production totals on a much higher level. In 2000, mainframe system applications are forecasted to utilize only 0.4% of the product group's shipments; networks/midrange applications, 6.1%; and workstations, 0.7%. By that time, business personal computers are predicted to use 89.0% of the drives, and consumer computers, 3.7% of the total.

The advent of a large scale personal computer market for 10-20 gigabyte disk drives will create a rapid increase in shipments of 3.5" drives, reaching 79.3 million in 2000. Low-cost 5.25" drives designed for personal computers are also expected, with 2000 shipments of a modest 2.8 million. Starting in 1999, 2.5"-3" drives for notebook computer applications are expected, with shipments rising to 6.5 million in 2000.

Worldwide total unit shipments (000)	1996	1997	1998	1999	2000
5.25"	--	--	210.0	975.0	2,750.0
	--	--	5.1%	2.0%	3.1%
3.5"	--	60.0	3,928.0	46,145.0	79,351.0
		100.0%	94.9%	96.0%	89.6%
2.5"-3"	--	--	--	950.0	6,510.0
	--	--	--	2.0%	7.3%
Total	--	60.0	4,138.0	48,070.0	88,611.0

In the mainframe and file server applications which will initially provide the markets for 10-20 gigabyte drives, price per megabyte is a principal driving influence. The initial 18.2 gigabyte drives to be offered in this product group will offer a significant improvement in the price per megabyte available with the 5-10 gigabyte drives which now dominate these applications. The 1997 average OEM/Integrator price per megabyte for the initial 18.2 gigabyte high performance drives in the product group is estimated at 6 cents. In subsequent years, when the group's shipments are dominated by drives for desktop personal computer applications, the OEM/Integrator average is expected to drop to 2 cents.

Technical trends

The disk drive industry's leading edge product development programs are currently targeted on the drives soon to be introduced in this product group. Although the highest areal densities are now used in 2.5" drives at lower capacity levels, the new 18.2 gigabyte 3.5" models have a broad range of technical challenges. These drives typically utilize 9 or 10 disks, spinning at either 7,200 or 10,000 RPM, while operating at areal densities close to the industry's highest level -- creating some of the world's more difficult mechanical engineering challenges. These designs also generate exceptionally high internal data rates, stimulating development of new schemes for head electrical connections and semiconductors. And, of course, the MTBF of drives in today's high performance applications must be better than any other type of disk drive. The work on high performance drives for this capacity range will not cease with the successful initial start of 18.2 gigabyte drive shipments. The first wave will all be 1.625" high models, but 1" high drives using half the number of disks are to be expected. The current forecast anticipates such drives, exemplified by IBM's "Stingray" program, with first shipments probably in 1999.

Forecasting assumptions

1. 5.25" drive shipments will start in 1998, and continue to increase through 2000, with all shipments generated by personal computer markets.
2. Shipments of 3.5" drives with 5-10 gigabyte capacities will start in 1997, for high performance applications, but drives for personal computer applications will dominate shipments after 1998, with the product group assuming leadership in industry shipments in 2000.
3. The first 2.5" drives in this product group will ship in 1999, with a significant increase in shipments in 2000.

TABLE 63

FIXED DISK DRIVES, 10 - 20 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	36.0	45.0	510.4	568.6	829.1	1,258.8	1,680.0	2,547.8
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	36.0	45.0	510.4	568.6	829.1	1,258.8	1,680.0	2,547.8
PCM/Distributor	--	--	16.9	19.5	514.6	633.0	4,281.9	5,262.8	6,040.1	7,704.1
OEM/Integrator	--	--	30.0	42.0	1,131.7	1,662.1	7,846.4	12,447.7	11,618.1	19,175.3
TOTAL U.S. NONCAPTIVE	--	--	46.9	61.5	1,646.3	2,295.1	12,128.3	17,710.5	17,658.2	26,879.4
TOTAL U.S. REVENUES	--	--	82.9	106.5	2,156.7	2,863.7	12,957.4	18,969.3	19,338.2	29,427.2
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	64.2	27.8	281.2	111.2	584.5
PCM/Distributor	--	--	--	--	95.2	140.3	632.4	1,029.2	1,007.0	1,644.6
OEM/Integrator	--	--	--	--	162.8	362.8	1,330.1	2,850.4	2,441.6	5,487.0
TOTAL NON-U.S. REVENUES	--	--	--	--	258.0	567.3	1,990.3	4,160.8	3,559.8	7,716.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	--	--	82.9	106.5	2,414.7	3,431.0	14,947.7	23,130.1	22,898.0	37,143.3
OEM Average Price ($000)	--		1.200		.761		.459		.397	

TABLE 64

FIXED DISK DRIVES, 10 - 20 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996 Shipments		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	8.0	10.0	225.0	263.0	570.0	860.0	1,795.0	2,715.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	8.0	10.0	225.0	263.0	570.0	860.0	1,795.0	2,715.0
PCM/Distributor	--	--	13.0	15.0	850.0	1,045.0	9,525.0	11,670.0	15,240.0	19,480.0
OEM/Integrator	--	--	25.0	35.0	1,525.0	2,270.0	17,095.0	27,295.0	29,220.0	48,276.0
TOTAL U.S. NONCAPTIVE	--	--	38.0	50.0	2,375.0	3,315.0	26,620.0	38,965.0	44,460.0	67,756.0
TOTAL U.S. SHIPMENTS	--	--	46.0	60.0	2,600.0	3,578.0	27,190.0	39,825.0	46,255.0	70,471.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	30.0	30.0	205.0	135.0	650.0
PCM/Distributor	--	--	--	--	95.0	140.0	1,215.0	2,005.0	2,185.0	3,650.0
OEM/Integrator	--	--	--	--	175.0	390.0	2,860.0	6,035.0	6,165.0	13,840.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	--	270.0	560.0	4,105.0	8,245.0	8,485.0	18,140.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	--	--	46.0	60.0	2,870.0	4,138.0	31,295.0	48,070.0	54,740.0	88,611.0
Total Capacity (Terabytes)	--	--	837.2	1,092.0	43,926.0	63,717.6	499,263.0	763,939.0	921,570.0	1,486,559.0
Cumulative Shipments (Units in millions)										
IBM	--	--	--	--	.2	.3	.8	1.1	2.6	3.8
Non-IBM	--	--	--	--	2.6	3.9	33.4	51.1	86.3	137.0
WORLDWIDE TOTAL	--	--	--	--	2.9	4.2	34.2	52.2	88.9	140.9

TABLE 65

FIXED DISK DRIVES, 10 - 20 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues	Forecast 1997 3.5"	1998 5.25"	1998 3.5"	1999 5.25"	1999 3.5"	1999 2.5"	2000 5.25"	2000 3.5"	2000 2.5"
U.S. MANUFACTURERS										
IBM Captive	--	45.0	--	568.6	--	1,167.9	90.9	--	2,260.5	287.3
PCM/Distributor	--	19.5	40.0	593.0	158.0	5,096.8	8.0	390.6	7,248.4	65.1
OEM/Integrator	--	42.0	58.2	1,603.9	234.6	12,043.2	169.9	654.0	17,513.3	1,008.0
TOTAL U.S. REVENUES	--	106.5	98.2	2,765.5	392.6	18,307.9	268.8	1,044.6	27,022.2	1,360.4
NON-U.S. MANUFACTURERS										
Captive	--	--	--	64.2	--	179.4	101.8	--	204.3	380.2
PCM/Distributor	--	--	--	140.3	--	1,019.0	10.2	--	1,580.6	64.0
OEM/Integrator	--	--	--	362.8	--	2,743.9	106.5	--	4,638.7	848.3
TOTAL NON-U.S. REVENUES	--	--	--	567.3	--	3,942.3	218.5	--	6,423.6	1,292.5
WORLDWIDE RECAP										
Captive	--	45.0	--	632.8	--	1,347.3	192.7	--	2,464.8	667.5
	--	--	--	--	--	+112.9%	--	--	+82.9%	+246.4%
PCM/Distributor	--	19.5	40.0	733.3	158.0	6,115.8	18.2	390.6	8,829.0	129.1
	--	--	--	--	+295.0%	+734.0%	--	+147.2%	+44.4%	+609.3%
OEM/Integrator	--	42.0	58.2	1,966.7	234.6	14,787.1	276.4	654.0	22,152.0	1,856.3
	--	--	--	--	+303.1%	+651.9%	--	+178.8%	+49.8%	+571.6%
Total Revenues	--	106.5	98.2	3,332.8	392.6	22,250.2	487.3	1,044.6	33,445.8	2,652.9
	--	--	--	--	+299.8%	+567.6%	--	+166.1%	+50.3%	+444.4%
ANNUAL SHARE, BY DIAMETER	--	100.0%	2.9%	97.1%	1.7%	96.3%	2.0%	2.8%	90.1%	7.1%

Note: 2.5 inch totals include 3 inch drives.

TABLE 66

FIXED DISK DRIVES, 10 - 20 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments	Forecast 1997 3.5"	1998 5.25"	1998 3.5"	1999 5.25"	1999 3.5"	1999 2.5"	2000 5.25"	2000 3.5"	2000 2.5"
U.S. MANUFACTURERS										
IBM Captive	--	10.0	--	263.0	--	760.0	100.0	--	2,355.0	360.0
PCM/Distributor	--	15.0	85.0	960.0	390.0	11,260.0	20.0	1,020.0	18,275.0	185.0
OEM/Integrator	--	35.0	125.0	2,145.0	585.0	26,280.0	430.0	1,730.0	43,641.0	2,905.0
TOTAL U.S. SHIPMENTS	--	60.0	210.0	3,368.0	975.0	38,300.0	550.0	2,750.0	64,271.0	3,450.0
NON-U.S. MANUFACTURERS										
Captive	--	--	--	30.0	--	95.0	110.0	--	180.0	470.0
PCM/Distributor	--	--	--	140.0	--	1,980.0	25.0	--	3,470.0	180.0
OEM/Integrator	--	--	--	390.0	--	5,770.0	265.0	--	11,430.0	2,410.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	560.0	--	7,845.0	400.0	--	15,080.0	3,060.0
WORLDWIDE RECAP										
Captive	--	10.0	--	293.0	--	855.0	210.0	--	2,535.0	830.0
	--	+400.0%	--	--	--	+191.8%	--	--	+196.5%	+295.2%
PCM/Distributor	--	15.0	85.0	1,100.0	390.0	13,240.0	45.0	1,020.0	21,745.0	365.0
	--	--	--	--	+358.8%	--	--	+161.5%	+64.2%	+711.1%
OEM/Integrator	--	35.0	125.0	2,535.0	585.0	32,050.0	695.0	1,730.0	55,071.0	5,315.0
	--	--	--	--	+368.0%	--	--	+195.7%	+71.8%	+664.7%
Total Shipments	--	60.0	210.0	3,928.0	975.0	46,145.0	950.0	2,750.0	79,351.0	6,510.0
	--	--	--	--	+364.3%	--	--	+182.1%	+72.0%	+585.3%
ANNUAL SHARE, BY DIAMETER	--	100.0%	5.1%	94.9%	2.0%	96.1%	1.9%	3.1%	89.6%	7.3%
TOTAL CAPACITY (Terabytes)	--	1,092.0	2,520.0	61,197.6	15,600.0	735,439.0	12,900.0	46,750.0	1,295,399.0	101,100.0

Note: 2.5 inch totals include 3 inch drives.

TABLE 67

FIXED DISK DRIVES, 10 - 20 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	88.6	.1
MAINFRAME SYSTEMS				
General purpose	--	--	354.4	.4
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	--	--	5,405.3	6.1
PERSONAL COMPUTERS				
Business and professional, single user	--	--	78,863.8	89.0
WORKSTATIONS				
Engineering and office, single user	--	--	620.3	.7
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	3,278.6	3.7
OTHER APPLICATIONS	--	--	--	--
Total	--	--	88,611.0	100.0

TABLE 68

FIXED DISK DRIVES, 10 - 20 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1996	Forecast 1997	1998	1999	2000
Captive					
10"	--	--	--	--	--
5.25"	--	--	--	--	--
3.5"	--	.24	.13	.09	.05
2.5"	--	--	--	.06	.05
Captive Average	--	.24	.13	.08	.05
PCM/Distributor					
10"	--	--	--	--	--
5.25"	--	--	.03	.02	.02
3.5"	--	.07	.04	.02	.02
2.5"	--	--	--	.03	.02
PCM/Distributor Average	--	.07	.04	.02	.02
OEM/Integrator					
10"	--	--	--	--	--
5.25"	--	--	.03	.02	.02
3.5"	--	.06	.04	.02	.02
2.5"	--	--	--	.02	.02
OEM/Integrator Average	--	.06	.04	.02	.02

Notes: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

2.5 inch totals include 3 inch drives.

FIXED DISK DRIVES, MORE THAN 20 GIGABYTES

FIXED DISK DRIVES, MORE THAN 20 GIGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Seagate Technology	ST423451N/W/FC

This is a product group without a past. Currently, Seagate Technology's 5.25" Elite 23, a 23 gigabyte descendant of the company's successful Elite 9, is the only disk drive available with more than 20 megabytes capacity. The Elite 23, which entered the market in the second half of 1996, offers the industry's best price per megabyte to date for high performance drives. It is expected to be widely used in established mainframe, network server and midrange applications, plus new video server and imaging markets.

For the next year, the Elite family may be the only participants in this product group. The principal event to anticipate will be the introduction of higher capacities, probably at least twice the existing 23 gigabytes, when Seagate feels enough competitive heat to justify the action. Long term, however, the main event in this product group will be the 3.5" drives expected, probably in 1999, which will rapidly become the major participants in the more than 20 gigabyte market. IBM's "Manta" project is expected to result in a high performance 36 gigabyte 3.5" drive, offering four times the capacity of the existing mainstream high performance "Scorpion" series. Also in 1999, it is anticipated that lower cost 3.5" drives for personal computer application will move above the 20 gigabyte threshold in 1999, and 2.5" drives for notebook computer markets will arrive in 2000, with similar capacities.

Market status

Seagate's shipments of 10 thousand Elite 23 drives were the only sales activity in this product group in 1996, generating an estimated $19 million in sales revenues. In 1997, the Elite 23 is still the only game in town, but shipments are forecasted to increase to 85 thousand drives, producing $127.5 million in sales revenues.

Most of the past drive shipments in this product group have been used for mainframe computer and other enterprise systems storage subsystem applications. Although the product group is expected to supply a majority of the disk drives used for mainframe and high-end server applications in 2000, the expected 1999 introduction of drives for personal computers will provide an overwhelming increase in shipments of those drives by 2000. The proportion of the product group's 2000 shipments used for high performance applications will drop to modest size: Mainframe systems, 3.0%; networks/midrange systems, 6.4%; workstations, 0.4%; and very high performance systems, 0.1%. On the other hand, business personal computers will consume 87.0% of shipments, and consumer computers, 3.1%.

Marketing trends

High performance applications are expected to generate continued growth for shipments of the existing 5.25" drives in this product group through 1998, but the introduction of 36 gigabyte 3.5" drives in 1999 will probably put the brakes on subsequent 5.25" drive shipment growth, except for the initiation of low-end 5.25" drive shipments for personal computer applications in 2000. The wave of 3.5" drives for the personal computer market will boost the total 3.5" share of 2000 drive shipments to an estimated 97.1%. The start of 2.5"-3" drive shipments in 2000 will provide only an estimated 1.1% of that year's total.

Worldwide total unit shipments (000)	1996	1997	1998	1999	2000
5.25"	10.0	85.0	120.0	110.0	440.0
	100.0%	100.0%	100.0%	3.4%	1.8%
3.5"	--	--	--	3,145.0	23,455.0
	--	--	--	96.6%	97.1%
2.5"-3"	--	--	--	--	270.0
	--	--	--	--	1.1%
Total	10.0	85.0	120.0	3,255.0	24,165.0

Table 73, which summarizes DISK/TREND data on mainframe disk drive applications, is included in this product group because the majority of the drives used for mainframe data storage will be models with more than 20 gigabytes capacity by the end of the forecast period. Capacities in that table are grouped according to the logical IBM volumes available with each drive, following the patterns established during the IBM 3380/3390 drive era, now past, but still meaningful to users.

Technical trends

It currently appears that IBM has been successful in reestablishing the 60% annual rate of increase in disk drive areal density, after slipping to a 45% average in 1995-96. At that rate, IBM may not quite achieve the frequently stated density objective of 10 gigabits per square inch, but it should be capable of fulfilling the product introduction assumptions which have been made for this product group: 3.5" high performance and personal computer drives in 1999 and 2.5" drives for notebook computers in 2000.

Comparable areal density improvements should also make it possible for Seagate to boost the capacity of the 5.25" Elite series to at least four times the current 23 gigabytes, reaching 100 gigabytes -- if the market wants that much capacity in a single drive. The industry has been confronted with questions, doubts and concerns for at least 30 years about the maximum capacity per drive that makes sense. In the next few years, the customers will probably set the capacity limit per drive, not the technology.

Forecasting assumptions

1. IBM and other drive manufacturers will be successful in improving areal density utilized in high-end drives by an average of 60% per year.
2. High-end 3.5" drives with 36 gigabytes capacity will be produced by at least one manufacturer in 1999, and more than one manufacturer will start shipments of 3.5" drives for personal computer markets in 1999.
3. Shipments of high performance 5.25" drives will increase through 1998, then decline, while the first production of 5.25" drives for personal computers will start in 2000.
4. The first shipments of 2.5" drives will start in 2000.

TABLE 69

FIXED DISK DRIVES, MORE THAN 20 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	242.2	349.8	691.3	1,069.6
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	242.2	349.8	691.3	1,069.6
PCM/Distributor	19.0	19.0	67.5	67.5	90.6	90.6	917.1	1,067.1	2,818.6	3,738.1
OEM/Integrator	--	--	52.5	60.0	51.0	63.8	1,613.2	2,022.2	5,324.7	7,574.4
TOTAL U.S. NONCAPTIVE	19.0	19.0	120.0	127.5	141.6	154.4	2,530.3	3,089.3	8,143.3	11,312.5
TOTAL U.S. REVENUES	19.0	19.0	120.0	127.5	141.6	154.4	2,772.5	3,439.1	8,834.6	12,382.1
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	67.8	13.6	81.6
PCM/Distributor	--	--	--	--	--	--	69.3	163.8	372.0	678.1
OEM/Integrator	--	--	--	--	--	--	200.4	448.0	1,086.2	1,977.1
TOTAL NON-U.S. REVENUES	--	--	--	--	--	--	269.7	679.6	1,471.8	2,736.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	19.0	19.0	120.0	127.5	141.6	154.4	3,042.2	4,118.7	10,306.4	15,118.9
OEM Average Price ($000)		--		1.500		1.276		1.170		.585

TABLE 70

FIXED DISK DRIVES, MORE THAN 20 GIGABYTES

UNIT SHIPMENT SUMMARY

DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)

	1996 Shipments		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	90.0	130.0	385.0	595.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	90.0	130.0	385.0	595.0
PCM/Distributor	10.0	10.0	45.0	45.0	70.0	70.0	740.0	860.0	4,593.0	6,100.0
OEM/Integrator	--	--	35.0	40.0	40.0	50.0	1,380.0	1,730.0	9,095.0	12,955.0
TOTAL U.S. NONCAPTIVE	10.0	10.0	80.0	85.0	110.0	120.0	2,120.0	2,590.0	13,688.0	19,055.0
TOTAL U.S. SHIPMENTS	10.0	10.0	80.0	85.0	110.0	120.0	2,210.0	2,720.0	14,073.0	19,650.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	25.0	10.0	60.0
PCM/Distributor	--	--	--	--	--	--	55.0	130.0	606.0	1,105.0
OEM/Integrator	--	--	--	--	--	--	170.0	380.0	1,840.0	3,350.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	--	--	--	225.0	535.0	2,456.0	4,515.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	10.0	10.0	80.0	85.0	110.0	120.0	2,435.0	3,255.0	16,529.0	24,165.0
Total Capacity (Terabytes)	234.0	234.0	1,872.0	1,989.0	2,574.0	2,808.0	68,880.0	91,910.0	501,657.0	731,540.0
Cumulative Shipments (Units in millions)										
IBM	--	--	--	--	--	--	--	.1	.4	.7
Non-IBM	--	--	--	--	.2	.2	2.5	3.3	18.6	26.9
WORLDWIDE TOTAL	--	--	--	--	.2	.2	2.6	3.4	19.1	27.6

TABLE 71

FIXED DISK DRIVES, MORE THAN 20 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues	Forecast						
		--1997--	--1998--	-------1999-------		------------2000------------		
	5.25"	5.25"	5.25"	5.25"	3.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS								
IBM Captive	--	--	--	--	349.8	--	997.8	71.8
PCM/Distributor	19.0	67.5	90.6	79.6	987.5	160.1	3,572.6	5.4
OEM/Integrator	--	60.0	63.8	44.9	1,977.3	217.3	7,279.0	78.1
TOTAL U.S. REVENUES	19.0	127.5	154.4	124.5	3,314.6	377.4	11,849.4	155.3
NON-U.S. MANUFACTURERS								
Captive	--	--	--	--	67.8	--	81.6	--
PCM/Distributor	--	--	--	--	163.8	--	675.4	2.7
OEM/Integrator	--	--	--	--	448.0	--	1,953.2	23.9
TOTAL NON-U.S. REVENUES	--	--	--	--	679.6	--	2,710.2	26.6
WORLDWIDE RECAP								
Captive	--	--	--	--	417.6	--	1,079.4	71.8
	--	--	--	--	--	--	+158.5%	--
PCM/Distributor	19.0	67.5	90.6	79.6	1,151.3	160.1	4,248.0	8.1
	--	+255.3%	+34.2%	-12.1%	--	+101.1%	+269.0%	--
OEM/Integrator	--	60.0	63.8	44.9	2,425.3	217.3	9,232.2	102.0
	--	--	+6.3%	-29.6%	--	+384.0%	+280.7%	--
Total Revenues	19.0	127.5	154.4	124.5	3,994.2	377.4	14,559.6	181.9
	--	+571.1%	+21.1%	-19.4%	--	+203.1%	+264.5%	--
ANNUAL SHARE, BY DIAMETER	100.0%	100.0%	100.0%	3.0%	97.0%	2.5%	96.4%	1.1%

Note: 2.5 inch totals include 3 inch drives.

TABLE 72

FIXED DISK DRIVES, MORE THAN 20 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments	Forecast						
		--1997--	--1998--	-------1999-------		------------2000------------		
	5.25"	5.25"	5.25"	5.25"	3.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS								
IBM Captive	--	--	--	--	130.0	--	535.0	60.0
PCM/Distributor	10.0	45.0	70.0	70.0	790.0	185.0	5,905.0	10.0
OEM/Integrator	--	40.0	50.0	40.0	1,690.0	255.0	12,550.0	150.0
TOTAL U.S. SHIPMENTS	10.0	85.0	120.0	110.0	2,610.0	440.0	18,990.0	220.0
NON-U.S. MANUFACTURERS								
Captive	--	--	--	--	25.0	--	60.0	--
PCM/Distributor	--	--	--	--	130.0	--	1,100.0	5.0
OEM/Integrator	--	--	--	--	380.0	--	3,305.0	45.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	--	535.0	--	4,465.0	50.0
WORLDWIDE RECAP								
Captive	--	--	--	--	155.0	--	595.0	60.0
	--	--	--	--	--	--	+283.9%	--
PCM/Distributor	10.0	45.0	70.0	70.0	920.0	185.0	7,005.0	15.0
	--	+350.0%	+55.6%	--	--	+164.3%	+661.4%	--
OEM/Integrator	--	40.0	50.0	40.0	2,070.0	255.0	15,855.0	195.0
	--	--	+25.0%	-20.0%	--	+537.5%	+665.9%	--
Total Shipments	10.0	85.0	120.0	110.0	3,145.0	440.0	23,455.0	270.0
	--	+750.0%	+41.2%	-8.3%	--	+300.0%	+645.8%	--
ANNUAL SHARE, BY DIAMETER	100.0%	100.0%	100.0%	3.4%	96.6%	1.8%	97.2%	1.0%
TOTAL CAPACITY (Terabytes)	234.0	1,989.0	2,808.0	3,850.0	88,060.0	22,000.0	703,650.0	5,890.0

Note: 2.5 inch totals include 3 inch drives.

TABLE 73

WORLDWIDE SHIPMENTS OF IBM CAPTIVE AND PLUG COMPATIBLE FIXED DISK DRIVES

USED WITH MAINFRAME COMPUTER APPLICATIONS

	DISK DRIVE SHIPMENTS, BY SHIPMENT DESTINATION (000 SPINDLES)									
	1996 Shipments		FORECAST							
			1997		1998		1999		2000	
	US	WW	US	WW	US	WW	US	WW	US	WW
3390-3 type (5676 MB)										
PCM	1.5	2.5	--	--	--	--	--	--	--	--
3390-9 type (17028 MB)										
PCM	.7	1.0	--	--	--	--	--	--	--	--
Disk subsystems with array capability (Average available capacity per drive)										
IBM (2838 MB)	170.0	265.0	28.0	45.0	--	--	--	--	--	--
PCM (2838 MB)	58.0	90.0	20.0	30.0	--	--	--	--	--	--
IBM (5676 MB)	61.0	95.0	210.0	330.0	48.0	75.0	--	--	--	--
PCM (5676 MB)	53.0	80.0	138.0	210.0	80.0	120.0	16.0	25.0	--	--
PCM (8514 MB)	95.0	145.0	95.0	145.0	56.0	85.0	20.0	30.0	--	--
IBM (11352 MB)	--	--	--	--	150.0	220.0	190.0	290.0	48.0	75.0
PCM (11352 MB)	--	--	--	--	125.0	185.0	295.0	450.0	185.0	280.0
PCM (17028 MB)	--	--	22.0	35.0	45.0	70.0	42.0	65.0	25.0	40.0
IBM (22704 MB)	--	--	--	--	--	--	24.0	30.0	120.0	185.0
PCM (22704 MB)	--	--	--	--	--	--	11.0	15.0	170.0	260.0
TOTAL SPINDLES	439.2	678.5	513.0	795.0	504.0	755.0	598.0	905.0	548.0	840.0
TOTAL FORMATTED CAPACITY (Terabytes)		3,266.5		5,108.4		7,620.0		10,926.3		14,814.4
		+66.9%		+56.4%		+49.2%		+43.4%		+35.6%

NOTES: When PCM drives are designed to emulate specific IBM drive models, quantities of such drives are counted in units equivalent in capacity to IBM individual spindles, even though different disk diameters and physical file organizations may be used. In some cases, an "equivalent" PCM spindle may be composed of two or more physical spindles in order to equal the capacity of a specific IBM spindle. In the case of PCM drives which do not match the capacities of specific IBM models, average capacities per spindle are used. For disk drive arrays such as IBM's RAMAC, capacities shown are net available capacities per spindle for all of the drives used in the array.

TABLE 74

FIXED DISK DRIVES, MORE THAN 20 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	24.2	.1
MAINFRAME SYSTEMS				
General purpose	10.0	100.0	725.0	3.0
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	--	--	1,546.5	6.4
PERSONAL COMPUTERS				
Business and professional, single user	--	--	21,023.5	87.0
WORKSTATIONS				
Engineering and office, single user	--	--	96.7	.4
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	749.1	3.1
OTHER APPLICATIONS	--	--	--	--
Total	10.0	100.0	24,165.0	100.0

TABLE 75

FIXED DISK DRIVES, MORE THAN 20 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1996	1997 (Forecast)	1998 (Forecast)	1999 (Forecast)	2000 (Forecast)
Captive					
5.25"	--	--	--	--	--
3.5"	--	--	--	.09	.06
2.5"	--	--	--	--	.05
Captive Average	--	--	--	.09	.06
PCM/Distributor					
5.25"	.08	.06	.05	.03	.01
3.5"	--	--	--	.04	.02
2.5"	--	--	--	--	.02
PCM/Distributor Average	.08	.06	.05	.04	.02
OEM/Integrator					
5.25"	--	.06	.05	.03	.01
3.5"	--	--	--	.04	.01
2.5"	--	--	--	--	.02
OEM/Integrator Average	--	.06	.05	.04	.01

Notes: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

2.5 inch totals include 3 inch drives.

RIGID DISK DRIVE SPECIFICATIONS

RIGID MAGNETIC DISK DRIVE SPECIFICATIONS

Coverage

This section includes most rigid disk drives intended for computer data storage which are now in new production or announced, arranged alphabetically by manufacturer. Specifications on drive models sold by computer system manufacturers, but purchased on an OEM basis from others, have been included in some cases, for identification purposes. In the case of IBM's disk drives and those produced by some other system manufacturers, captive drives which are similar to OEM/Integrator models made by the same manufacturer are not listed.

Capacities

Formatted capacity defines the appropriate DISK/TREND product group for each disk drive. Prior to 1992, drives were grouped by unformatted capacity, but the industry movement to embedded controllers eventually made that practice obsolete, since most rigid disk drives are now specified in formatted capacities.

In the specifications, capacities are listed as "U" for unformatted or "F" for formatted. In general, unformatted capacities are shown only for OEM/Integrator and PCM/Distributor drives without embedded controllers, and formatted capacities are given for captive drives and noncaptive drives with embedded controllers, such as SCSI and IDE (PC AT), or the newer serial interfaces, SSA and FC AL. Capacities per track are listed, except for drives with zoned recording, in which each band of tracks has a different capacity.

Linear density, recording code, areal density

When specified by the drive manufacturer, both BPI (bits per inch) and FCI (flux changes per inch) are listed. The ratio between BPI and FCI varies, depending upon the recording code used. For example, with 1,7 RLL (run length limited) encoding, the value for BPI is 133% of the value for FCI. With PRML (partial response maximum likelihood), several variations are used and some manufacturers have not specified FCI. Areal density (BPI multiplied by TPI) is useful in comparing the recording density used in various disk drives.

Average access time

DISK/TREND specifications use the term "average access time" to describe the combination of average positioning time and average rotational delay. Some in the industry have fallen into the habit of using the term average access time to describe average positioning time, or "seek" time, but this usage fails to adequately describe the time required for a disk drive to start to respond to a system request. DISK/TREND specifications show separately average positioning time, average rotational delay, and average access time, in order to avoid confusion.

Transfer rate

The transfer rate shown in the specifications is the highest rate at which data is transferred between the drive and the computer to which it is attached, in the case of drives with embedded controllers, or the data rate between the drive and its controller, if the controller is not embedded. If the manufacturer has specified more than one communication mode (such as synchronous and asynchronous for SCSI drives, or PIO and DMA for IDE drives), both data rates are indicated.

Interfaces

Specific interfaces available are indicated for most drives, using references to manufacturers' own unique interfaces or to industry standards, either de facto or formalized. However, this is a rapidly changing area, so please be alert to the need to check for manufacturers' latest information if you need precise data.

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.

1997 DISK/TREND product groups for rigid magnetic disk drives

Removable magnetic media:
1. Disk cartridge drives

Fixed magnetic media:
2. Fixed disk drives, less than 500 megabytes
3. Fixed disk drives, 500 MB - 1 gigabyte
4. Fixed disk drives, 1 - 2 gigabytes
5. Fixed disk drives, 2 - 3 gigabytes
6. Fixed disk drives, 3 - 5 gigabytes
7. Fixed disk drives, 5 - 10 gigabytes
8. Fixed disk drives, 10 - 20 gigabytes
9. Fixed disk drives, more than 20 gigabytes

MANUFACTURER	AVATAR PERIPHERALS	AVATAR PERIPHERALS	AVATAR PERIPHERALS	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY
DRIVE	2250i Shark	250 Shark	3250i Shark	CT-130MC CT-131FD callunacard	CT-170MC CT-171FD callunacard
DISK/TREND GROUP	1	1	1	2	2
MARKET	OEM	PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	48 mm	48 mm
Recording medium	Thin Film*	Thin Film*	Thin Film*	Thin Film*	Thin Film*
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	Parallel Port	IDE	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 249.5	F: 249.5	F: 249.5	F: 130	F: 170
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	2	2	2	4
Tracks per surface	2404	2404	2404	1958	1768
Track density (TPI)	4300	4300	4300	4400	4400
Maximum linear density (BPI)	98500	98500	98500	82391	58082
(FCI)	73875	73875	73875	61793	43561
Areal density (Mb/square inch)	423.6	423.6	423.6	362.5	255.6
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3805	3805	3805	4800	4800
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	16	16
Average rotational delay (msec)	7.9	7.9	7.9	6.25	6.25
Average access time (msec)	19.9	19.9	19.9	22.25	22.25
Data transfer rate (MBytes/sec) Internal, min/max	--/2.5	--/2.5	--/2.5	2.3/4.5	1.8/3.1
External	13.3 DMA Mode 1	1.2	13.3 DMA Mode 1	11.1	11.1
SIZE: (mm) H x W x D	17.5 x 72.6 x 119.6	25.4 x 89 x 140	17.5 x 72.4 x 119.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	9/96	4/97	9/96	5/94	9/94
COMMENTS	Removable data cartridge. *Glass disk.	Removable data cartridge. *Glass disk.	Removable data cartridge. *Glass disk.	PCMCIA Type III *Carbon disk. CT-131FD is 50 pin IDE version	PCMCIA Type III *Carbon disk. CT-171FD is 50 pin IDE version

MANUFACTURER	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	FUJITSU	FUJITSU
DRIVE	CT-260MC CT-260FD callunacard	CT-260RM CT-260FM callunacard	CT-520RM CR-520FM callunacard	M2261H/HA/HB M2261S/SA/SB	M2262H/HA/HB M2262S/SA/SB
DISK/TREND GROUP	2	2	3	2	2
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	48 mm	48 mm	48 mm	130 mm	130 mm
Recording medium	Thin Film*	Thin Film*	Thin Film*	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	MIG	MIG
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	F: 357.1	F: 492
REMOVABLE	F: 260	F: 260	F: 520	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	F: 27,136	F: 27,136
Data surfaces per spindle	4	2	4	8	11
Tracks per surface	1958	2576	2576	1658	1658
Track density (TPI)	4400	6000	6000	1712	1712
Maximum linear density (BPI) (FCI)	82391 61793	118285 88714	118285 88714	28816 21612	28816 21612
Areal density (Mb/square inch)	362.5	709.7	709.7	49.3	49.3
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4800	4800	4800	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	12	12	16	16
Average rotational delay (msec)	6.25	6.25	6.25	8.3	8.3
Average access time (msec)	22.25	18.25	18.25	24.3	24.3
Data transfer rate (MBytes/sec) Internal, min/max External	2.3/4.5 11.1	3.4/6.4 20.0	3.4/6.4 20.0	1.875 4.0 synch. 1.75 asynch.	1.875 4.0 synch. 1.75 asynch.
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	3/95	3Q97	1Q97	2Q88	2Q88
COMMENTS	PCMCIA Type III *Carbon disk. CT-260FD is 50 pin IDE version	PCMCIA Type III *Glass disk. CT-260FM is 50 pin IDE version	PCMCIA Type III *Glass disk. CT-520FM is 50 pin IDE version		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2635S	M2635T	M2681S	M1603SAU Picobird-7'E	M1603TAU Picobird-7'E
DISK/TREND GROUP	2	2	2	3	3
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	65 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MIG	Thin Film	Thin Film
Interface	SCSI-2	IDE	SCSI-2	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 160	F: 160	F: 264	F: 540	F: 540
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	3	3	3
Tracks per surface	1572	1572	2379	3457	3457
Track density (TPI)	2660	2660	2713	3676	3676
Maximum linear density (BPI) (FCI)	57000 42750	57000 42750	58000 43500	72700 54525	72700 54525
Areal density (Mb/square inch)	151.6	151.6	157.4	267.2	267.2
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	14.5	14.5	13.8	10	10
Average rotational delay (msec)	6.7	6.7	6.7	5.6	5.6
Average access time (msec)	21.2	21.2	20.5	15.6	15.6
Data transfer rate (MBytes/sec) Internal, min/max External	 2.1/2.6 10.0 synch. 5.0 asynch.	 2.1/2.6 8.0	 2.8/4.7 10.0 synch. 5.0 asynch.	 4.3/7.8 10.0 synch. 5.0 asynch.	 4.3/7.8 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	17 x 69.9 x 100	17 x 69.9 x 100	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	2Q93	2Q93	1Q94	3/95	2/95
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M1612TAU Picobird-8'	M2684S	M2684T	M2712TAM Hornet-6'	M2713TAM Hornet-6'
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film*	Thin Film*
DRIVE: Heads	MIG	MIG	MIG	MR Thin Film	MR Thin Film
Interface	IDE	SCSI-2	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 545	F: 532	F: 528	F: 544	F: 816
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	6	6	2	3
Tracks per surface	4133	2379	2379	3916	3916
Track density (TPI)	4394	2700	2700	6606	6606
Maximum linear density (BPI) (FCI)	90853	58000 43500	58000 43500	133000	133000
Areal density (Mb/square inch)	399.2	156.6	156.6	878.6	878.6
Recording code	8,9 PRML	1,7 RLL	1,7 RLL	PR4ML	PR4ML
Rotational speed (RPM)	4500	4500	4500	3634	3634
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	13.8	13.8	12	12
Average rotational delay (msec)	6.67	6.7	6.7	8.26	8.26
Average access time (msec)	18.67	20.5	20.5	20.26	20.26
Data transfer rate (MBytes/sec) Internal, min/max External	4.4/8.0 16.6 PIO Mode 4 16.6 DMA Mode 2	2.8/4.7 10.0 synch. 5.0 asynch.	2.8/4.7 11.1 PIO Mode 3	3.4/6.8 16.6 PIO Mode 4 16.6 DMA Mode 2	3.4/6.8 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	12.5 x 70 x 100	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	9/95	1Q94	1Q94	10/95	10/95
COMMENTS				*Glass disk.	*Glass disk.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2722 Hornet-7'	F6429G	F6429H	M1606SAU Picobird-7'E	M1606TAU Picobird-7'E
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	Captive	Captive	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	130 mm	130 mm	95 mm	95 mm
Recording medium	Thin Film*	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	IDE	Fujitsu	Fujitsu	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 816	F: 1,260	F: 1,890	F: 1,080	F: 1,080
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 47,476	F: 47,476	Varies by zone	Varies by zone
Data surfaces per spindle	2	15	15	6	6
Tracks per surface		1770	2655	3457	3457
Track density (TPI)	8537	3310	3310	3676	3676
Maximum linear density (BPI) (FCI)	152300	45423 34067	53084 39813	72700 54525	72700 54525
Areal density (Mb/square inch)	1300	150.4	175.7	267.2	267.2
Recording code	PR4ML	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4000	4340	4340	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	12	10.5	12	10	10
Average rotational delay (msec)	7.5	6.9	6.9	5.6	5.6
Average access time (msec)	19.5	17.4	18.9	15.6	15.6
Data transfer rate (MBytes/sec) Internal, min/max External	4.5/8.4 16.6 PIO Mode 4 16.6 DMA Mode 2	4.5	4.5	4.3/7.8 10.0 synch. 5.0 asynch.	4.3/7.8 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	12.5 x 70 x 100			25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	9/96	6/94	6/94	3/95	2/95
COMMENTS	*Glass disk.	Drive has maximum of 32 spindles.	Drive has maximum of 32 spindles.		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M1614TAU Picobird-8'	M1623TAU Picobird-9	M1636TAU Picobird-9	M2714TAM Hornet-6'	M2723TAM Hornet-7'
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film*	Thin Film*
DRIVE: Heads	MIG	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,090	F: 1,700	F: 1,280	F: 1,088	F: 1,224
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	3	2	4	3
Tracks per surface	4133	6237	6237	3916	5157
Track density (TPI)	4394	6600	6600	6606	8537
Maximum linear density (BPI) (FCI)	90853	120000	136300	133000	150388
Areal density (Mb/square inch)	399.2	792.0	899.6	878.6	1284
Recording code	8,9 PRML	8,9 PRML	PRML	PR4ML	PR4ML
Rotational speed (RPM)	4500	5400	5400	3634	4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	10 RD/12 WR	10 RD/12 WR	12	12
Average rotational delay (msec)	6.67	5.6	5.6	8.26	7.5
Average access time (msec)	18.67	15.6 RD/17.6 WR	15.6 RD/17.6 WR	20.26	19.5
Data transfer rate (MBytes/sec) Internal, min/max External	4.4/8.0 16.6 PIO Mode 4 16.6 DMA Mode 2	7.6/11.8 16.6 PIO Mode 4 16.6 DMA Mode 2	7.6/13.8 16.6 PIO Mode 4 16.6 DMA Mode 2	3.4/6.8 16.6 PIO Mode 4 16.6 DMA Mode 2	4.5/8.4 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	12.5 x 70 x 100	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	9/95	9/96	8/96	10/95	9/96
COMMENTS				*Glass disk.	*Glass disk.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2724TAM Hornet-7'	MPA3017AT	F6429K	M1624TAU Picobird-9	M1638TAU Picobird-9
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	Captive	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	95 mm	130 mm	95 mm	95 mm
Recording medium	Thin Film*	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	Fujitsu	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,632	F: 1,750	F: 2,835	F: 2,160	F: 2,560
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	F: 47,476	Varies by zone	Varies by zone
Data surfaces per spindle	4	2	20	4	4
Tracks per surface	5157	8713	2988	6237	6237
Track density (TPI)	8537	9202	3310	6600	6600
Maximum linear density (BPI) (FCI)	150388	137285	56681 42510	120000	136300
Areal density (Mb/square inch)	1284	1263	187.6	792.0	899.6
Recording code	PR4ML	8,9 PRML	1,7 RLL	8,9 PRML	PRML
Rotational speed (RPM)	4000	5400	4340	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	12	10 RD/12 WR	12	10 RD/12 WR	10 RD/12 WR
Average rotational delay (msec)	7.5	5.56	6.9	5.6	5.6
Average access time (msec)	19.5	15.56/17.56	18.9	15.6 RD/17.6 WR	15.6 RD/17.6 WR
Data transfer rate (MBytes/sec) Internal, min/max External	4.5/8.4 16.6 PIO Mode 4 16.6 DMA Mode 2	8.0/15.0 16.7 PIO4/DMA2 33.3 Ultra DMA	4.5	7.6/11.8 16.6 PIO Mode 4 16.6 DMA Mode 2	7.6/13.8 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	12.5 x 70 x 100	25.4 x 101 x 146		25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	9/96		6/94	9/96	8/96
COMMENTS	*Glass disk.		Drive has maximum of 32 spindles.		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2932S/H/Q/R Allegro-2	M2952S/Q/R/E Allegro-3'	MPA3026AT	M2909 Allegro-1	M2934S/H/Q/R Allegro-2
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	Ultra SCSI	IDE	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,170	F: 2,400	F: 2,620	F: 3,087	F: 4,350
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	9	5	3	19	18
Tracks per surface	3422	5713	8713	3150	3429
Track density (TPI)	3871	6500	9202	3553	3871
Maximum linear density (BPI) (FCI)	100946	118737	137285	75534	100946
Areal density (Mb/square inch)	390.8	771.8	1263	268.4	390.8
Recording code	8,9 RLL	8,9 RLL	8,9 PRML	PRML	8,9 RLL
Rotational speed (RPM)	7200	7200	5400	5400	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10 RD/11.2 WR	8 RD/9 WR	10 RD/12 WR	10.3 RD/11.2 WR	10 RD/11.2 WR
Average rotational delay (msec)	4.17	4.17	5.56	5.6	4.17
Average access time (msec)	14.17/16.17	12.17/13.17	15.56/17.56	15.9 RD/16.8 WR	14.17/16.17
Data transfer rate (MBytes/sec) Internal, min/max External	8.6/11.3 20.0 synch. 12.0 asynch.	9.9/14.9 40.0 synch. 12.0 asynch.	8.0/15.0 16.6 PIO4/DMA2 33.3 Ultra DMA	4.7/6.8 20.0 synch. 6.0 asynch.	8.6/11.3 20.0 synch. 12.0 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101 x 146	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	3/95	10/95		2/94	3/95
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2954S/Q/R/E Allegro-3'	MPA3035AT	MPA3043AT	M2949S/Q/R/E	MPA3052T
DISK/TREND GROUP	6	6	6	7	7
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	IDE	IDE	Ultra SCSI	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,350	F: 3,500	F: 4,370	F: 9,100	F: 5,250
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	9	4	5	18	6
Tracks per surface	5713	8713	8713	5770	8713
Track density (TPI)	6500	9202	9202	6500	9202
Maximum linear density (BPI) (FCI)	118759	137285	137285	118574	137285
Areal density (Mb/square inch)	771.9	1263	1263	770.7	1263
Recording code	8,9 RLL	8,9 PRML	8,9 PRML	PR4ML	8,9 PRML
Rotational speed (RPM)	7200	5400	5400	7200	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.	Embedded
Average positioning time (msec)	8 RD/9 WR	10 RD/12 WR	10 RD/12 WR	10 RD/11.5 WR	10 RD/12 WR
Average rotational delay (msec)	4.17	5.56	5.56	4.17	5.56
Average access time (msec)	12.17/13.17	15.56/17.56	15.56/17.56	14.17/15.67	15.56/17.56
Data transfer rate (MBytes/sec) Internal, min/max External	9.9/14.9 40.0 synch. 12.0 asynch.	8.0/15.0 16.6 PIO4/DMA2 33.3 Ultra DMA	8.0/15.0 16.6 PIO4/DMA2 33.3 Ultra DMA	9.9/14.9 40.0 synch. 12.0 asynch.	8.0/14.9 16.7 PIO Mode 4 16.7 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101 x 146	25.4 x 101 x 146	41.3 x 101.6 x 146	25.4 x 101 x 146
FIRST CUSTOMER SHIPMENT	10/95				
COMMENTS					

MANUFACTURER	GIGASTORAGE INTERNATIONAL	GIGASTORAGE INTERNATIONAL	HITACHI	HITACHI	HITACHI
DRIVE	B5300A	B5512A	DK212A-81	DK222A-54	DK223A-81
DISK/TREND GROUP	6	7	3	3	3
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film			MIG
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,000	F: 5,120	F: 810	F: 540	F: 810
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	6	4	6
Tracks per surface	6957		2602	2602	2605
Track density (TPI)	5309	6200	4500	4500	4400
Maximum linear density (BPI) (FCI)	92000 69000	90000 67500	99000 74250	99000 74250	99000
Areal density (Mb/square inch)	488.4	558.0	445.5	445.5	435.6
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	8,9 GCR
Rotational speed (RPM)	3600	3600	4464	4464	4464
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11	11.5	12	12	12
Average rotational delay (msec)	8.3	8.3	6.7	6.7	6.7
Average access time (msec)	19.3	19.8	18.7	18.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	5.0/11.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.0/11.0 16.6 PIO Mode 4 16.6 DMA Mode 2	3.0/5.1 11.1 PIO Mode 3	3.6/6.1 11.1 PIO Mode 3	3.7/6.1 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 146 x 210	25.4 x 146 x 210	19.05 x 69.9 x 101.9	12.5 x 69.9 x 101.9	12.7 x 70 x 100
FIRST CUSTOMER SHIPMENT	12/96	3Q97	1Q95	1Q95	2Q96
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK212A-10	DK213A-13	DK213A-18	DK223A-11	DK224A-14
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film*	Thin Film*	Thin Film
DRIVE: Heads		MIG	MIG	MIG	MIG
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,350	F: 1,800	F: 1,080	F: 1,440
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	10	10	6	6
Tracks per surface	2602	2605	3116	3116	4032
Track density (TPI)	4500	4400	5200	5200	7100
Maximum linear density (BPI) (FCI)	99000 74250	99000	125000	125000	124000
Areal density (Mb/square inch)	445.5	435.6	650.0	650.0	880.4
Recording code	1,7 RLL	8,9 GCR	8,9 GCR	8,9 GCR	8,9 GCR
Rotational speed (RPM)	4464	4464	4464	4464	4464
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	12	12
Average rotational delay (msec)	6.7	6.7	6.7	6.7	6.7
Average access time (msec)	18.7	18.7	18.7	18.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	3.6/6.1 11.1 PIO Mode 3	3.7/6.1 16.6 PIO Mode 4 16.6 DMA Mode 2	4.5/7.7 16.6 PIO Mode 4 16.6 DMA Mode 2	4.5/7.7 16.6 PIO Mode 4 16.6 DMA Mode 2	4.5/7.0 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	19.05 x 69.9 x 101.9	19 x 70 x 100	19 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100
FIRST CUSTOMER SHIPMENT	1Q95	2Q96	6/96	6/96	9/96
COMMENTS			*Glass disk.	*Glass disk.	

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK225A-14	DK315C-11	DK315C-14	DK326C-10	DK326C-10WD
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,440	F: 1,100	F: 1,400	F: 1,052	F: 1,052
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 30,200	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	15	15	7	7
Tracks per surface	4889	2488	2464	3202	3202
Track density (TPI)	8600	2800	2800	3600	3600
Maximum linear density (BPI) (FCI)	156000	54000 40500	52300 39225	63500 47625	63500 47625
Areal density (Mb/square inch)	1342	151.2	146.4	228.6	228.6
Recording code	8,9 PRML	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4464	4500	4500	6300	6300
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	10.4	11.8	9.8	9.8
Average rotational delay (msec)	6.7	6.7	6.7	4.76	4.76
Average access time (msec)	18.7	17.1	18.5	14.56	14.56
Data transfer rate (MBytes/sec) Internal, min/max External	5.7/9.0 16.6 PIO Mode 4	10.0 synch. 2.5 asynch.	2.7/4.5 10.0 synch. 2.5 asynch.	4.5/7.0 10.0 synch. 2.5 asynch.	4.5/7.0 20.0 synch. 5.0 asynch.
SIZE: (mm) H x W x D	12.7 x 70 x 100	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT		2Q92	3Q92	1/94	3/94
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK516C-16	DK225A-21	DK328C-21 DK328C-21WD DK328C-21WS	DKU-881-310 DKU-F881-304	H-6587-314 H-6587-324
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	OEM	OEM, PCM	Captive
MEDIA: Disk diameter	130 mm	65 mm	95 mm	6.5"	9.5"
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	SCSI	IDE	SCSI-2	Hitachi, IBM	Hitachi, IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,342	F: 2,160	F: 2,100	F: 2,838	F: 2,920
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 41,472	Varies by zone	Varies by zone	F: 56,664	F: 56,664
Data surfaces per spindle	15	6	5	15	15
Tracks per surface	2172	4889	5840	3339	3436
Track density (TPI)	1954	8600	5800	2520	1930
Maximum linear density (BPI) (FCI)	48525 36393	156000	120000 90000	47300 35475	29100 21825
Areal density (Mb/square inch)	94.8	1342	696.0	119.2	56.2
Recording code	1,7 RLL	8,9 PRML	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	4464	5400	4260	4260
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13.5	12	9.8	13.5	12
Average rotational delay (msec)	8.3	6.7	5.6	7.1	7.1
Average access time (msec)	21.8	18.7	15.4	20.6	19.1
Data transfer rate (MBytes/sec) Internal, min/max External	 5.0 synch. 2.0 asynch.	5.7/9.0 16.6 PIO Mode 4 16.6 DMA Mode 2	6.7/11.0 20.0 synch. 10.0 asynch.	4.2	4.2
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	12.7 x 70 x 100	25.4 x 101.6 x 146	--	--
FIRST CUSTOMER SHIPMENT	3Q90	12/96	4Q95	5/93	9/90
COMMENTS				Available with 4 to 32 HDAs.	-314: max. 8 HDAs. -324: max. 12 HDAs. Also compatible mode to H-6586K 2 heads/surface

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	H-6588-314	DK226A-32	DK306-45	DK328C-43 DK328C-43WD DK328C-43WS	DK328H-43
DISK/TREND GROUP	5	6	6	6	6
MARKET	Captive	OEM	Captive	OEM	OEM, PCM
MEDIA: Disk diameter	6.5"	65 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MR Thin Film	Thin Film	MR Thin Film	MR Thin Film
Interface	Hitachi, IBM	IDE	SCSI	SCSI-2	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,920	F: 3,240	F: 4,360	F: 4,300	F: 4,370
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	15	6	29	10	10
Tracks per surface	3436	6255		5840	5890
Track density (TPI)	2520	11000		5800	6200
Maximum linear density (BPI) (FCI)	47300 35475	183000		120000 90000	131000
Areal density (Mb/square inch)	119.2	2013		696.0	812.2
Recording code	1,7 RLL	8,9 EPRML		1,7 RLL	8,9 PRML
Rotational speed (RPM)	4260	4000	6300	5400	7200
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	13.5	12	11.5	9.8	9
Average rotational delay (msec)	7.1	7.5	4.8	5.6	4.17
Average access time (msec)	20.6	19.5	16.3	15.4	13.17
Data transfer rate (MBytes/sec) Internal, min/max External	 4.2	 6.0-9.1 16.6 PIO Mode 4 16.6 DMA Mode 2	 4.7-6.9	 6.7/11.0 20.0 synch. 10.0 asynch.	 9.4/15.6 40.0 synch. 20.0 asynch.
SIZE: (mm) H x W x D	--	12.7 x 70 x 100		25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	6/93	2Q97	3Q95	4Q95	1/97
COMMENTS	Available with 4 to 32 HDAs.		HDD for H-6595 (RAID for mainframe.)		

MANUFACTURER	HITACHI	HITACHI	HITACHI	IBM	IBM
DRIVE	DK308-90	DK318H-91	DKU-881-10 DKU-F881-904 H-6588-9	DDLA-21215 Travelstar VP (Dolce)	DDLA-21620 Travelstar VP (Dolce)
DISK/TREND GROUP	7	7	7	4	4
MARKET	OEM, PCM	OEM, PCM	Captive,OEM,PCM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	6.5"	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI	Ultra SCSI	Hitachi, IBM	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 9,230	F: 9,100	F: 8,514	F: 1,210	F: 1,620
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	F: 113,328	Varies by zone	Varies by zone
Data surfaces per spindle	29	20	19	3	4
Tracks per surface		6124	3955	5120	5120
Track density (TPI)		6450	3500	9000	9000
Maximum linear density (BPI) (FCI)		131000	81964 61473	160900	160900
Areal density (Mb/square inch)		845.0	286.9	1448	1448
Recording code		8,9 PRML	1,7 RLL	PRML	PRML
Rotational speed (RPM)	6300	7200	1980	4000	4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	11.5	9	16.5	13	13
Average rotational delay (msec)	4.8	4.17	15.2	7.5	7.5
Average access time (msec)	16.3	13.17	31.7	20.5	20.5
Data transfer rate (MBytes/sec) Internal, min/max External	7.6-10.7 20.0 synch.	9.4/15.6 40.0 synch. 20.0 asynch.	3.9	5.1/8.3 16.6 PIO Mode 4 16.6 DMA Mode 2	5.1/8.3 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D		41.3 x 101.6 x 146	--	9.5 x 70 x 100	9.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	4Q96	1/97	6/94	1/97	1/97
COMMENTS	HDD for H-6595 (RAID for mainframe).		Available with 4 to 32 HDAs.		

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DMCA-21080 Travelstar 3LP (Marcato)	DMCA-21440 Travelstar 3LP (Marcato)	DTNA-21800 Travelstar 4LP (Tango)	DAQA-32160 Deskstar 3 (Aquarius)	DCAA-32880 Deskstar 4 (Capricorn)
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,440	F: 1,800	F: 2,160	F: 2,880
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	3	4	5	4	4
Tracks per surface	4975	4975	4928	6911	8210
Track density (TPI)	8600	8600	8670	7257	8600
Maximum linear density (BPI) (FCI)	152500	152500	147800	120900 90675	134600
Areal density (Mb/square inch)	1312	1312	1281	877.4	1158
Recording code	PRML	PRML	PRML	1,7 RLL	PRML
Rotational speed (RPM)	4000	4000	4000	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	13	13 RD	9.5 RD	9.5 RD
Average rotational delay (msec)	7.5	7.5	7.5	5.6	5.6
Average access time (msec)	20.5	20.5	20.5 RD	15.1 RD	15.1 RD
Data transfer rate (MBytes/sec) Internal, min/max External	4.9/7.7 16.6 PIO Mode 4 16.6 DMA Mode 2	4.9/7.7 16.6 PIO Mode 4 16.6 DMA Mode 2	4.9/7.7 16.6 PIO Mode 4 16.6 DMA Mode 2	7.0/11.1 16.6 PIO Mode 4 16.6 DMA Mode 2	7.8/12.9 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	12.5 x 70 x 100	12.5 x 70 x 100	12.5 x 70 x 100	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	6/96	6/96	10/96	6/96	11/96
COMMENTS					

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DCAS-32160 Ultrastar 2ES (Orion)	DCRA-22160 Travelstar 2XP (Crescendo)	DLGA-22690 Travelstar 3XP (Legato)	DORS-32160 Ultrastar ES (Orion)	DTNA-22160 Travelstar 4LP (Tango)
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	OEM
MEDIA: Disk diameter	95 mm	65 mm	65 mm	95 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	IDE	IDE	SCSI-3	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,160	F: 2,160	F: 2,690	F: 2,160	F: 2,160
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	3	6	7	5	6
Tracks per surface	8210	4928	5120	6717	4928
Track density (TPI)	8600	8600	8940	7056	8670
Maximum linear density (BPI) (FCI)	134600	153000	151900	103600 77700	147800
Areal density (Mb/square inch)	1158	1316	1358	731.0	1281
Recording code	PRML	PRML	PRML	1,7 RLL	PRML
Rotational speed (RPM)	5400	4900	4900	5400	4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	8.5 RD	12	12 RD	8.5 RD	13 RD
Average rotational delay (msec)	5.6	6.1	6.1	5.6	7.5
Average access time (msec)	14.1 RD	18.1	18.1 RD	14.1 RD	20.5 RD
Data transfer rate (MBytes/sec) Internal, min/max External	7.8/12.9 40.0 synch. 20.0 asynch.	6.1/9.3 16.6 PIO Mode 4 16.6 DMA Mode 2	6.0/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.9/9.0 40.0 synch. 20.0 asynch.	4.9/7.7 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	17 x 70 x 100	17 x 70 x 100	25.4 x 101.6 x 146	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	9/96	6/96	11/96	1/96	10/96
COMMENTS					

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DAQA-33240 Deskstar 3 (Aquarius)	DCAA-33610 Deskstar 4 (Capricorn)	DCAA-34330 Deskstar 4 (Capricorn)	DCAS-34330 Ultrastar 2ES (Orion)	DCHC-34550 Ultrastar 2XP (Scorpion HP)
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	Ultra SCSI	SSA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,240	F: 3,610	F: 4,330	F: 4,330	F: 4,550
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	5	6	6	9
Tracks per surface	6911	8210	8210	8210	6077
Track density (TPI)	7257	8600	8600	8600	6160
Maximum linear density (BPI) (FCI)	120900 90675	134600	134600	134600	134500
Areal density (Mb/square inch)	877.4	1158	1158	1158	828.5
Recording code	1,7 RLL	PRML	PRML	PRML	PRML
Rotational speed (RPM)	5400	5400	5400	5400	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.5 RD	9.5 RD	9.5 RD	8.5 RD	7.5 RD
Average rotational delay (msec)	5.6	5.6	5.6	5.6	4.17
Average access time (msec)	15.1 RD	15.1 RD	15.1 RD	14.1 RD	11.67 RD
Data transfer rate (MBytes/sec) Internal, min/max External	7.0/11.1 16.6 PIO Mode 4 16.6 DMA Mode 2	7.8/12.9 16.6 PIO Mode 4 16.6 DMA Mode 2	7.8/12.9 16.6 PIO Mode 4 16.6 DMA Mode 2	7.8/12.9 40.0 synch. 20.0 asynch.	10.2/15.4 40.0 synch. 20.0 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	6/96	11/96	11/96	9/96	4Q95
COMMENTS					

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DCHS-34550 Ultrastar 2XP (Scorpion HP)	DHEA-34860 Deskstar 5 (Hercules)	DLGA-23080 Travelstar 3XP (Legato)	DPLA-24480 Travelstar 5GS (Prelude)	DTCA-23240 Travelstar 4GT (Toccata)
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film*	Thin Film*
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,550	F: 4,860	F: 3,080	F: 4,480	F: 3,240
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	9	6	8	7	5
Tracks per surface	6077	8209	5120	6976	6976
Track density (TPI)	6160	8600	8940	12500	12500
Maximum linear density (BPI) (FCI)	134500	153400	151900	201000	211000
Areal density (Mb/square inch)	828.5	1319	1358	2513	2638
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	7200	5400	4900	4900	4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	7.5 RD	9.5 RD	12	12	13
Average rotational delay (msec)	4.17	5.6	6.1	6.1	7.5
Average access time (msec)	11.67 RD	15.1 RD	18.1	18.1	20.5
Data transfer rate (MBytes/sec) Internal, min/max External	10.2/15.4 40.0 synch. 20.0 asynch.	8.9/14.9 16.6 PIO4/DMA2 33.3 Ultra DMA	6.0/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2	7.5/12.3 16.6 PIO Mode 4 33.3 Ultra DMA	6.5/10.4 16.6 PIO Mode 4 33.3 Ultra DMA
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	17 x 70 x 100	17 x 70 x 100	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	4Q95	5/97	11/96	9/97	9/97
COMMENTS				*Untextured glass disks. Ramp loaded heads.	*Untextured glass disks. Ramp loaded heads.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DTCA-24090 Travelstar 4GT (Toccata)	DCHC-39100 Ultrastar 2XP (Scorpion HP)	DCHS-39100 Ultrastar 2XP (Scorpion HP)	DHEA-36480 Deskstar 5 (Hercules)	DHEA-38451 Deskstar 8 (Hercules)
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film*	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	SSA	SCSI-3	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,090	F: 9,100	F: 9,100	F: 6,480	F: 8,450
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	18	18	8	8
Tracks per surface	6976	6077	6077	8209	9784
Track density (TPI)	12500	6160	6160	8600	10700
Maximum linear density (BPI) (FCI)	211000	134500	134500	153400	162600
Areal density (Mb/square inch)	2638	828.5	828.5	1319	1740
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	4000	7200	7200	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	8.5 RD	8.5 RD	9.5 RD	9.5 RD
Average rotational delay (msec)	7.5	4.17	4.17	5.6	5.6
Average access time (msec)	20.5	12.67 RD	12.67 RD	15.1 RD	15.1 RD
Data transfer rate (MBytes/sec) Internal, min/max External	6.5/10.4 16.6 PIO Mode 4 33.3 Ultra DMA	10.2/15.4 40.0	10.2/15.4 40.0 synch. 20.0 asynch.	8.9/14.9 16.6 PIO4/DMA2 33.3 Ultra DMA	9.5/15.9 16.6 PIO4/DMA2 33.3 Ultra DMA
SIZE: (mm) H x W x D	12.5 x 70 x 100	41.3 x 101.6 x 146	41.3 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	9/97	4Q95	4Q95	5/97	7/97
COMMENTS	*Untextured glass disks. Ramp loaded heads.				

MANUFACTURER	IBM	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS
DRIVE	DPLA-25120 Travelstar 5GS (Prelude)	8085 Viper 85	8170E Viper 170E	8340PA Viper 340	8510PA Viper 510
DISK/TREND GROUP	7	2	2	2	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	48 mm	48 mm	48 mm	48 mm
Recording medium	Thin Film*	Thin Film*	Thin Film*	Thin Film*	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	Thin Film	MR
Interface	IDE	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 5,120	--	--	--	--
REMOVABLE	--	F: 85.6	F: 170.8	F: 341.1	F: 510
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	1	2	4	4
Tracks per surface	6976	2000	2000	2000	2600
Track density (TPI)	12500	5100	5100	5100	6660
Maximum linear density (BPI) (FCI)	201000	123600 92700	123600 92700	123600 92700	118000 89000
Areal density (Mb/square inch)	2513	630.4	630.4	630.4	785.9
Recording code	PRML	1,7 PRML	1,7 PRML	1,7 PRML	1,7 PRML
Rotational speed (RPM)	4900	4500	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	12	13
Average rotational delay (msec)	6.1	6.7	6.7	6.7	5.77
Average access time (msec)	18.1	18.7	18.7	18.7	18.77
Data transfer rate (MBytes/sec) Internal, min/max External	7.5/12.3 16.6 PIO Mode 4 33.3 Ultra DMA	--/5.7 16.0	--/5.7 16.0	--/5.7 16.0	--/6.5 16.0
SIZE: (mm) H x W x D	17 x 70 x 100	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	9/97	2/97	7/94	7/94	
COMMENTS	*Untextured glass disks. Ramp loaded heads.	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III Ramp loaded heads.

MANUFACTURER	INTEGRAL PERIPHERALS	IOMEGA	JTS	JTS	JTS
DRIVE	32160 Silhouette 2160	Jaz 1GB SCSI	C1300-2AF Champ	C1700-2AF Champion	C1700-3AF Champ
DISK/TREND GROUP	5	1	4	4	4
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	84 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film*	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	MIG	MIG	MIG
Interface	IDE	SCSI-2	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,160	--	F: 1,300	F: 1,700	F: 1,700
REMOVABLE	--	F: 540/1,070	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	4	6
Tracks per surface		4204	5050	3312	5050
Track density (TPI)	6500	4301	5062	5700	5062
Maximum linear density (BPI) (FCI)	130000 98000	89178 66884		117400	
Areal density (Mb/square inch)	845.0	383.6		669.2	
Recording code	1,7 PRML	1,7 RLL	1,7 RLL	PRML	1,7 RLL
Rotational speed (RPM)	4500	5400	4500	5400	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	10 RD/12 WR	14	12	14
Average rotational delay (msec)	6.7	5.6	6.7	5.6	6.7
Average access time (msec)	19.7	15.6 RD/17.6 WR	20.7	17.6	20.7
Data transfer rate (MBytes/sec) Internal, min/max External	--/11.5 16.6 PIO Mode 4 16.6 DMA Mode 2	3.5/6.7 10.0 synch. 5.0 asynch.	13.3 DMA Mode 1	16.6 PIO Mode 4 16.6 DMA Mode 2	13.3 DMA Mode 1
SIZE: (mm) H x W x D	10.5 x 90 x 120	25.4 x 101.6 x 149.9	16.5 x 101.6 x 156.2	25.4 x 101.6 x 156.2	16.5 x 101.6 x 156.2
FIRST CUSTOMER SHIPMENT	5/97	4Q95	3/97	3/97	2/97
COMMENTS	Ramp loaded heads. *Untextured disks.				

MANUFACTURER	JTS	JTS	JTS	JTS	JTS
DRIVE	N1080-2AR Nordic	N1440-3AR Nordic	N1620-2AS	N1620-3AR Nordic	C2000-2AF Champion
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	84 mm	84 mm	84 mm	84 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MR Thin Film	MIG	MIG
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	F: 1,620	--	F: 2,000
REMOVABLE	F: 1,080	F: 1,440	--	F: 1,620	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	4	6	4
Tracks per surface	4032	3584	5806	4032	3882
Track density (TPI)	5000	5000	7200	5000	5700
Maximum linear density (BPI) (FCI)	93313 69985		140000	93313 69985	117400
Areal density (Mb/square inch)	466.6		1008	466.6	669.2
Recording code	1,7 RLL	1,7 RLL	PRML	1,7 RLL	PRML
Rotational speed (RPM)	4103	4103	4103	4103	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	14	14	12	14	12
Average rotational delay (msec)	7.3	7.31	7.3	7.3	5.6
Average access time (msec)	21.3	21.31	19.3	21.3	17.6
Data transfer rate (MBytes/sec) Internal, min/max External	4.0/7.3 16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	4.0/7.3 16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	10.5 x 90 x 120	12.5 x 90 x 120	10.5 x 90 x 120	12.5 x 90 x 120	25.4 x 101.6 x 156.2
FIRST CUSTOMER SHIPMENT	8/96	10/96	8/97	8/96	3/97
COMMENTS					

MANUFACTURER	JTS	JTS	JTS	JTS	JTS
DRIVE	C2000-3AF Champ	C2500-3AF Champion	N2160-2AS	N2160-3AR Nordic	N2690-3AR
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Disk diameter	84 mm	95 mm	84 mm	84 mm	84 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MR Thin Film	MIG	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,000	F: 2,500	F: 2,160		--
REMOVABLE	--	--	--	F: 2,160	F: 2,690
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	6	4	6	6
Tracks per surface	5500	4970	5806	4435	5806
Track density (TPI)	5062	5700	7200	5500	7200
Maximum linear density (BPI) (FCI)		117400	140000	122000	140000
Areal density (Mb/square inch)		669.2	1008	671.0	1008
Recording code	1,7 RLL	PRML	PRML	PRML	PRML
Rotational speed (RPM)	4500	5400	4103	4103	4103
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	14	12	12	14	12
Average rotational delay (msec)	6.7	5.6	7.3	7.3	7.3
Average access time (msec)	20.7	17.6	19.3	21.3	19.3
Data transfer rate (MBytes/sec) Internal, min/max External	13.3 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	16.5 x 101.6 x 156.2	25.4 x 101.6 x 156.2	10.5 x 90 x 120	12.5 x 90 x 120	12.5 x 90 x 120
FIRST CUSTOMER SHIPMENT	11/96	3/97	8/97	1/97	8/97
COMMENTS					

MANUFACTURER	JTS	JTS	MAXTOR	MAXTOR	MAXTOR
DRIVE	C3000-3AF Champion	N3240-3AR	81280A2 DiamondMax	81312A3 CrystalMax	81620A3 CrystalMax 1080
DISK/TREND GROUP	6	6	4	4	4
MARKET	OEM, PCM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	84 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MR Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,000	--	F: 1,280	F: 1,312	F: 1,620
REMOVABLE	--	F: 3,240	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	6	2	3	3
Tracks per surface	5824	5806	6569	5446	5765
Track density (TPI)	5700	7200	6461	5376.5	5700
Maximum linear density (BPI) (FCI)	117400	140000	137800 155000	115000 86250	117600 132000
Areal density (Mb/square inch)	669.2	1008	890.3	618.2	670.3
Recording code	PRML	PRML	PRML	1,7 RLL	PRML
Rotational speed (RPM)	5400	4103	5400	4480	4480
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	9.7	12	11
Average rotational delay (msec)	5.6	7.3	5.6	6.7	6.7
Average access time (msec)	17.6	19.3	15.3	18.7	17.7
Data transfer rate (MBytes/sec) Internal, min/max			8.0/13.4	5.2/10.0	5.6/11.7
External	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 156.2	12.5 x 90 x 120	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3/97	8/97	4Q96	10/96	3/97
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	81750A2 DiamondMax 1750	81750A4 CrystalMax	82100A4 CrystalMax 1080	82187A5 CrystalMax	82560A3 DiamondMax 1750
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,750	F: 1,750	F: 2,100	F: 2,187	F: 2,560
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	4	4	5	3
Tracks per surface	7825	5446	5765	5446	7825
Track density (TPI)	7797	5376.5	5700	5376.5	7797
Maximum linear density (BPI) (FCI)	153000 172000	115000 86250	117600 132000	115000 86250	153000 172000
Areal density (Mb/square inch)	1193	618.2	670.3	618.2	1193
Recording code	PRML	1,7 RLL	PRML	1,7 RLL	PRML
Rotational speed (RPM)	5200	4480	4480	4480	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10	12	11	12	10
Average rotational delay (msec)	5.8	6.7	6.7	6.7	5.8
Average access time (msec)	15.8	18.7	17.7	18.7	15.8
Data transfer rate (MBytes/sec) Internal, min/max External	--/14.0 16.6 PIO4/DMA2 33.3 Ultra DMA	5.2/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.6/11.7 16.6 PIO Mode 4 16.6 DMA Mode 2	5.2/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2	--/14.0 16.6 PIO4/DMA2 33.3 Ultra DMA
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	6/97	10/96	3/97	10/96	6/97
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	82560A4 DiamondMax	82580A5 CrystalMax 1080	82625A6 CrystalMax	83062A7 CrystalMax	83201A6 CrystalMax 1080
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,560	F: 2,580	F: 2,625	F: 3,062	F: 3,201
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	5	6	7	6
Tracks per surface	6569	5765	5446	5446	5765
Track density (TPI)	6461	5700	5376.5	5376.5	5700
Maximum linear density (BPI) (FCI)	137800 155000	117600 132000	115000 86250	115000 86250	117600 132000
Areal density (Mb/square inch)	890.3	670.3	618.2	618.2	670.3
Recording code	PRML	PRML	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	5400	4480	4480	4480	4480
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.7	11	12	12	11
Average rotational delay (msec)	5.6	6.7	6.7	6.7	6.7
Average access time (msec)	15.3	17.7	18.7	18.7	17.7
Data transfer rate (MBytes/sec) Internal, min/max External	8.0/13.4 16.6 PIO Mode 4 16.6 DMA Mode 2	5.6/11.7 16.6 PIO Mode 4 16.6 DMA Mode 2	5.2/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.2/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.6/11.7 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q96	3/97	10/96	10/96	3/97
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	83240A4 DiamondMax 1750	83500A CrystalMax	83500A4 DiamondMax 1750	83840A6 DiamondMax	84320A5 DiamondMax 1750
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,240	F: 3,500	F: 3,500	F: 3,840	F: 4,320
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	8	4	6	5
Tracks per surface	7825	5446	7825	6569	7825
Track density (TPI)	7797	5376.5	7797	6461	7797
Maximum linear density (BPI) (FCI)	153000 172000	115000 86250	153000 172000	137800 155000	153000 172000
Areal density (Mb/square inch)	1193	618.2	1193	890.3	1193
Recording code	PRML	1,7 RLL	PRML	PRML	PRML
Rotational speed (RPM)	5200	4480	5200	5400	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10	12	10	9.7	10
Average rotational delay (msec)	5.8	6.7	5.8	5.6	5.8
Average access time (msec)	15.8	18.7	15.8	15.3	15.8
Data transfer rate (MBytes/sec) Internal, min/max External	--/14.0 16.6 PIO4/DMA2 33.3 Ultra DMA	5.2/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2	--/14.0 16.6 PIO4/DMA2 33.3 Ultra DMA	8.0/13.4 16.6 PIO Mode 4 16.6 DMA Mode 2	--/14.0 16.6 PIO4/DMA2 33.3 Ultra DMA
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	6/97	10/96	6/97	4Q96	6/97
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	84320A8 CrystalMax 1080	85120A8 DiamondMax	85250A6 DiamondMax 1750	86480A8 DiamondMax 1750	87000A8 DiamondMax 1750
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,320	F: 5,120	F: 5,250	F: 6,480	F: 7,000
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	8	6	8	8
Tracks per surface	5765	6569	7825	7825	7825
Track density (TPI)	5700	6461	7797	7797	7797
Maximum linear density (BPI) (FCI)	117600 132000	137800 155000	153000 172000	153000 172000	153000 172000
Areal density (Mb/square inch)	670.3	890.3	1193	1193	1193
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	4480	5400	5200	5200	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11	9.7	10	10	10
Average rotational delay (msec)	6.7	5.6	5.8	5.8	5.8
Average access time (msec)	17.7	15.3	15.8	15.8	15.8
Data transfer rate (MBytes/sec) Internal, min/max External	5.6/11.7 16.6 PIO Mode 4 16.6 DMA Mode 2	8.0/13.4 16.6 PIO Mode 4 16.6 DMA Mode 2	--/14.0 16.6 PIO4/DMA2 33.3 Ultra DMA	--/14.0 16.6 PIO4/DMA2 33.3 Ultra DMA	--/14.0 16.6 PIO4/DMA2 33.3 Ultra DMA
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3/97	4Q96	6/97	6/97	6/97
COMMENTS					

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	4525A Mustang	4345 Tomahawk 4LP	4345AV 4345WAV Tomahawk 4LPAV	4540A Mustang	4743 Stinger
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	IDE	Ultra SCSI	Ultra SCSI	IDE	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,500	F: 4,550	F: 4,550	F: 4,000	F: 4,300
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	11	11	6	7
Tracks per surface	6565	4821	4821	6565	6575
Track density (TPI)	6525	5100	5100	6525	6525
Maximum linear density (BPI) (FCI)	139000 157000	121000 140000	121000 140000	147000 165000	140000 157000
Areal density (Mb/square inch)	907.0	617.1	617.1	959.2	913.5
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	5200	7200	7200	5200	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10.5	7.9	7.9	10.5	10
Average rotational delay (msec)	5.8	4.17	4.17	5.8	5.6
Average access time (msec)	16.3	12.07	12.07	16.3	15.6
Data transfer rate (MBytes/sec) Internal, min/max External	7.0/13.8 16.6 PIO Mode 4 16.6 DMA Mode 2	9.5/15.6 40.0 synch. 10.0 asynch.	9.5/15.6 40.0 synch. 10.0 asynch.	7.0/13.8 16.6 PIO Mode 4 16.6 DMA Mode 2	7.4/13.1 40.0 synch. 10.0 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4/97		12/96	4/97	5/97
COMMENTS					

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	NEC	NEC
DRIVE	3391 Tomahawk 9	3391AV 3391WAV Tomahawk 9AV	4550A Mustang	D3745	D3747
DISK/TREND GROUP	7	7	7	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	Thin Film	Thin Film	Thin Film
Interface	Ultra SCSI	Ultra SCSI	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 9,100	F: 9,100	F: 5,000	F: 1,080	F: 1,620
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	22	22	8	4	6
Tracks per surface	4821	4821	6565	3678	3678
Track density (TPI)	5100	5100	6525	4000	4000
Maximum linear density (BPI) (FCI)	121000 140000	121000 140000	139000 157000	100000 112500	100000 112500
Areal density (Mb/square inch)	617.1	617.1	907.0	400.0	400.0
Recording code	PRML	PRML	PRML	8,9 PRML	8,9 PRML
Rotational speed (RPM)	7200	7200	5200	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	7.9	7.9	10.5	11	11
Average rotational delay (msec)	4.17	4.17	5.8	6.67	6.67
Average access time (msec)	12.07	12.07	16.3	17.67	17.67
Data transfer rate (MBytes/sec) Internal, min/max External	 9.5/15.6 40.0 synch. 10.0 asynch.	 9.5/15.6 40.0 synch. 10.0 asynch.	 7.0/13.8 16.6 PIO Mode 4 16.6 DMA Mode 2	 16.6 PIO Mode 4 16.6 DMA Mode 2	 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.2 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	12/96	12/96	4/97	10/95	10/95
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3845	D3847	D5S1050A	D5S1050S	DSE1340A
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,620	F: 1,058	F: 1,058	F: 1,340
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	2	2	4
Tracks per surface	3678	3678			4323
Track density (TPI)	4000	4000			4700
Maximum linear density (BPI) (FCI)	100000 112500	100000 112500			107000 120375
Areal density (Mb/square inch)	400.0	400.0			502.9
Recording code	1,7 RLL	1,7 RLL	8,9 PRML	8,9 PRML	8,9 PRML
Rotational speed (RPM)	4500	4500	5200	5200	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11	11	13	13	11
Average rotational delay (msec)	6.67	6.67	5.77	5.77	6.67
Average access time (msec)	17.67	17.67	18.77	18.77	17.67
Data transfer rate (MBytes/sec) Internal, min/max External	 10.0 synch.	 10.0 synch.	 16.6 PIO Mode 4 16.6 DMA Mode 2	 10.0 synch.	 5.0/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT					9/95
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	DSE1340S	DSE1700A	DSE1700S	D3896	D5S2100A
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM	OEM	OEM	Captive, OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	IDE	SCSI-2	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,340	F: 1,700	F: 1,700	F: 2,160	F: 2,111
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	9	4
Tracks per surface	4323	5045	5045	3928	5045
Track density (TPI)	4700	5350	5350	4070	5350
Maximum linear density (BPI) (FCI)	107000 120375	111000	111000	78000 58500	111000
Areal density (Mb/square inch)	502.9	593.9	593.9	317.5	593.9
Recording code	8,9 PRML	8,9 PRML	8,9 PRML	1,7 RLL	8,9 PRML
Rotational speed (RPM)	4500	5200	5200	7200	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Embedded
Average positioning time (msec)	11	11	11	9	11
Average rotational delay (msec)	6.67	5.77	5.77	4.17	5.77
Average access time (msec)	17.67	16.77	16.77	13.17	16.77
Data transfer rate (MBytes/sec) Internal, min/max External	 5.0/10.0 10.0 synch. 5.0 asynch.	 12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	 12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	 6.23/10.19 20.0 synch.	 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	9/95	6/96	6/96	6/95	
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5S2100S	DSE2010A	DSE2010S	DSE2550A	DSE2550S
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	IDE	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,111	F: 2,010	F: 2,010	F: 2,550	F: 2,550
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	6	6	6
Tracks per surface	5045	4323	4323	5045	5045
Track density (TPI)	5350	4700	4700	5350	5350
Maximum linear density (BPI) (FCI)	111000	107000 120375	107000 120375	111000	111000
Areal density (Mb/square inch)	593.9	502.9	502.9	593.9	593.9
Recording code	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML
Rotational speed (RPM)	5200	4500	4500	5200	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11	11	11	11	11
Average rotational delay (msec)	5.77	6.67	6.67	5.77	5.77
Average access time (msec)	16.77	17.67	17.67	16.77	16.77
Data transfer rate (MBytes/sec) Internal, min/max External	10.0 synch.	5.0/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.0/10.0 10.0 synch. 5.0 asynch.	12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	12.6 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT		9/95	9/95	6/96	6/96
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NOMAI	NOMAI
DRIVE	D5S3100A	D5S3100S	DVF4400S	750.c	MCD-I
DISK/TREND GROUP	6	6	6	1	1
MARKET	OEM	OEM	Captive, OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-2	SCSI, FC	SCSI-2,Par.Port	SCSI-2, IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,166	F: 3,166	F: 4,400	--	--
REMOVABLE	--	--	--	F: 750	F: 540
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	6	10	2	2
Tracks per surface			5707		
Track density (TPI)			6100	5500	4250
Maximum linear density (BPI) (FCI)			117000 131625	100000	100000
Areal density (Mb/square inch)			713.7	550.0	425.0
Recording code	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML
Rotational speed (RPM)	5200	5200	7200	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11	11	8.7/9.0	10	10
Average rotational delay (msec)	5.77	5.77	4.17	6.6	6.6
Average access time (msec)	16.77	16.77	12.87/13.17	16.6	16.6
Data transfer rate (MBytes/sec) Internal, min/max External	 16.6 PIO Mode 4 16.6 DMA Mode 2	 10.0 synch.	 11.64/14.99 10.0 synch.	 4.1/8.8 10.0	 4.1/8.8 10.0
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146.05	33 x 109 x 180	25.4 x 102 x 150
FIRST CUSTOMER SHIPMENT			1Q96	4/97	4Q95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	1.0 AT Fireball TM	1.0 Pioneer SG	1.0 S Fireball TM	1.2 AT Fireball TM	1.2 Bigfoot
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	MR Thin Film	MR Thin Film	Thin Film
Interface	IDE	IDE	Ultra SCSI	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,089	F: 1,082	F: 1,082.7	F: 1,281	F: 1,286
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	2	2	2	2
Tracks per surface			6825	6810	5738
Track density (TPI)	6775	5650	6775	6775	4298
Maximum linear density (BPI) (FCI)	130000 139000	127298 135254	109000 122625	130000 139000	107221 113922
Areal density (Mb/square inch)	880.8	719.2	738.5	880.8	460.8
Recording code	16,17 PRML	16,17 PRML	16,17 PRML	16,17 PRML	16,17 PRML
Rotational speed (RPM)	4500	4500	4500	4500	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	12	15.5
Average rotational delay (msec)	6.7	6.7	6.7	6.7	8.3
Average access time (msec)	18.7	18.7	18.7	18.7	23.8
Data transfer rate (MBytes/sec) Internal, min/max External	5.1/11.9 16.6 PIO Mode 4 16.6 DMA Mode 2	--/12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	5.1/11.3 20.0 synch. 6.0 asynch.	5.1/11.9 16.6 PIO Mode 4 16.6 DMA Mode 2	6.0/11.1 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.05	19.05 x 146.05 x 203.2
FIRST CUSTOMER SHIPMENT	7/96	3/97	6/96	7/96	3/96
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	1.2 S Fireball TM	1.6 AT (FB ST) Fireball ST	2.1 AT Fireball TM	2.1 AT (FB SE) Fireball SE	2.1 AT (FB ST) Fireball ST
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	Ultra ATA	IDE	Ultra ATA	Ultra ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,281	F: 1,614	F: 2,111	F: 2,151	F: 2,151
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	2	4	2	3
Tracks per surface	6810			7644	
Track density (TPI)	6775	7777	6775	8400	7777
Maximum linear density (BPI) (FCI)	130000 139000	154916 164598	130000 139000	195903	154916 164598
Areal density (Mb/square inch)	880.8	1205	880.8	1646	1205
Recording code	16,17 PRML	16,17 EPRML	16,17 PRML	EPRML	16,17 PRML
Rotational speed (RPM)	4500	5400	4500	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	10	10.5	9.5	10
Average rotational delay (msec)	6.7	5.6	6.7	5.6	5.6
Average access time (msec)	18.7	15.6	17.2	15.1	15.6
Data transfer rate (MBytes/sec) Internal, min/max External	5.1/11.9 20.0 synch. 6.0 asynch.	--/16.5 16.6 PIO4/DMA2 33.3 Ultra DMA	5.1/11.9 16.6 PIO Mode 4 16.6 DMA Mode 2	--/19.8 16.6 PIO4/DMA2 33.3 Ultra DMA	--/16.5 16.6 PIO4/DMA2 33.3 Ultra DMA
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	7/96	2/97	7/96	10/97	
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	2.1 Bigfoot CY	2.1 Pioneer SG	2.1 S Fireball TM	2.1 S (FB SE) Fireball SE	2.1 S (FB ST) Fireball ST
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	Ultra SCSI	Ultra SCSI	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,111	F: 2,111	F: 2,111	F: 2,151	F: 2,151
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	4	4	2	3
Tracks per surface				7644	
Track density (TPI)	6775	5650	6775	8400	7777
Maximum linear density (BPI) (FCI)	117167 124490	127298 135254	130000 139000	195903	154916 164598
Areal density (Mb/square inch)	793.8	719.2	880.8	1646	1205
Recording code	16,17 PRML	16,17 PRML	16,17 PRML	EPRML	16,17 EPRML
Rotational speed (RPM)	3600	4500	4500	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	10.5	9.5	10
Average rotational delay (msec)	8.3	6.7	6.7	5.6	5.6
Average access time (msec)	20.3	18.7	17.2	15.1	15.6
Data transfer rate (MBytes/sec) Internal, min/max External	--/11.6 16.6 PIO Mode 4 16.6 DMA Mode 2	--/12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	5.1/11.9 20.0 synch. 6.0 asynch.	--/19.8 20.0 synch.	--/16.5 20.0
SIZE: (mm) H x W x D	19.05 x 146.05 x 203.2	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	12/96	3/97	7/96	10/97	2/97
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	2.1 S Viking	2.2 S Viking	2.5 AT Fireball TM	2.5 Bigfoot	XP32181S Atlas II
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	130 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	Thin Film	MR Thin Film
Interface	Ultra SCSI	Ultra SCSI	IDE	IDE	Ultra SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,180	F: 2,275	F: 2,564	F: 2,577	F: 2,180
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	4	5
Tracks per surface	6720	6176	6810	5738	5964
Track density (TPI)	6750	6432	6775	4298	6000
Maximum linear density (BPI) (FCI)	123000 131000	132000 140000	130000 139000	107221 113922	106000 79500
Areal density (Mb/square inch)	830.3	849.0	880.8	460.8	636.0
Recording code	16,17 PRML	16,17 PRML	16,17 PRML	16,17 PRML	1,7 RLL
Rotational speed (RPM)	7200	7200	4500	3600	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	8.5 RD	8 RD	10.5	15.5	7.9
Average rotational delay (msec)	4.17	4.17	6.7	8.3	4.17
Average access time (msec)	12.67 RD	12.17 RD	17.2	23.8	12.07
Data transfer rate (MBytes/sec) Internal, min/max External	9.3/15.0 40.0 synch.	6.9/11.6 40.0 synch.	5.1/11.9 16.6 PIO Mode 4 16.6 DMA Mode 2	6.0/11.1 16.6 PIO Mode 4 16.6 DMA Mode 2	8.8/13.3 40.0
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.05	19.05 x 146.05 x 203.2	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	1Q97	1Q97	7/96	3/96	4Q96
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	3.2 AT Fireball TM	3.2 AT (FB ST) Fireball ST	3.2 AT (FB SE) Fireball SE	3.2 S Fireball TM	3.2 S (FB SE) Fireball SE
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	Ultra ATA	Ultra ATA	Ultra SCSI	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,216	F: 3,228	F: 3,228	F: 3,216	F: 3,228
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	5	4	3	5	3
Tracks per surface	6810		7644	6810	7644
Track density (TPI)	6775	7777	8400	6775	8400
Maximum linear density (BPI) (FCI)	130000 139000	154916 164598	195903	130000 139000	195903
Areal density (Mb/square inch)	880.8	1205	1646	880.8	1646
Recording code	16,17 PRML	16,17 EPRML	EPRML	16,17 PRML	EPRML
Rotational speed (RPM)	4500	5400	5400	4500	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10.5	10	9.5	10.5	9.5
Average rotational delay (msec)	6.7	5.6	5.6	6.7	5.6
Average access time (msec)	17.2	15.6	15.1	17.2	15.1
Data transfer rate (MBytes/sec) Internal, min/max External	5.1/11.9 16.6 PIO Mode 4 16.6 DMA Mode 2	--/16.5 16.6 PIO4/DMA2 33.3 Ultra DMA	--/19.8 16.6 PIO4/DMA2 33.3 Ultra DMA	5.1/11.9 20.0 synch. 6.0 asynch.	--/19.8 20.0 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	7/96	2/97	10/97	7/96	10/97
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	3.2 S (FB ST) Fireball ST	3.8 AT Fireball TM	4.3 AT (FB ST) Fireball ST	4.3 AT (FB SE) Fireball SE	4.3 Bigfoot CY
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	IDE	Ultra ATA	Ultra ATA	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,228	F: 3,860	F: 4,310	F: 4,310	F: 4,335
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	6	4	4
Tracks per surface		6810		7644	
Track density (TPI)	7777	6775	7777	8400	6775
Maximum linear density (BPI) (FCI)	154916 164598	130000 139000	154916 164598	195903	117167 124490
Areal density (Mb/square inch)	1205	880.8	1205	1646	793.8
Recording code	16,17 EPRML	16,17 PRML	16,17 EPRML	EPRML	16,17 PRML
Rotational speed (RPM)	5400	4500	5400	5400	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10	10.5	10	9.5	14
Average rotational delay (msec)	5.6	6.7	5.6	5.6	8.3
Average access time (msec)	15.6	17.2	15.6	15.1	22.3
Data transfer rate (MBytes/sec) Internal, min/max External	--/16.5 20.0	5.1/11.9 16.6 PIO Mode 4 16.6 DMA Mode 2	--/16.5 16.6 PIO4/DMA2 33.3 Ultra DMA	--/19.8 16.6 PIO4/DMA2 33.3 Ultra DMA	--/11.6 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 146.05 x 203.2
FIRST CUSTOMER SHIPMENT	2/97	7/96	2/97	10/97	12/96
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	4.3 S (FB SE) Fireball SE	4.3 S (FB ST) Fireball ST	4.3 S Viking	4.5 Atlas II	4.5 FC (AIII) Atlas III
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	Ultra SCSI	Ultra SCSI	Ultra SCSI	FC AL
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,310	F: 4,310	F: 4,360	F: 4,550	F: 4,550
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	8	10	5
Tracks per surface	7644		6720		8118
Track density (TPI)	8400	7777	6750	6000	8500
Maximum linear density (BPI) (FCI)	195903	154916 164598	123000 131000		166000
Areal density (Mb/square inch)	1646	1205	830.3		1411
Recording code	EPRML	16,17 EPRML	16,17 PRML		16,17 PRML
Rotational speed (RPM)	5400	5400	7200	7200	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.5	10	8.5 RD	8 RD	7.5 RD
Average rotational delay (msec)	5.6	5.6	4.17	4.17	4.17
Average access time (msec)	15.1	15.6	12.67 RD	12.17 RD	11.67 RD
Data transfer rate (MBytes/sec) Internal, min/max	--/19.8	--/16.5	9.3/15.0		13.8/22.5
External	20.0 synch.	20.0	40.0 synch.	40.0 synch.	200.0
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/97	2/97	1Q97	4Q96	1Q98
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	4.5 S (AIII) Atlas III	4.5 S (VII) Viking II	4.5 S Viking	XP34361S Atlas II	6.4 AT (FB ST) Fireball ST
DISK/TREND GROUP	6	6	6	6	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI Ultra 2	SCSI Ultra 2	Ultra SCSI	Ultra SCSI-3	Ultra ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,550	F: 4,550	F: 4,550	F: 4,360	F: 6,448
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	5	5	8	10	8
Tracks per surface	8118	8338	6176	5964	
Track density (TPI)	8500	8500	6432	6000	7777
Maximum linear density (BPI) (FCI)	166000	158000	132000 140000	106000 79500	154916 164598
Areal density (Mb/square inch)	1411	1343	849.0	636.0	1205
Recording code	16,17 PRML	16,17 PRML	16,17 PRML	1,7 RLL	16,17 EPRML
Rotational speed (RPM)	7200	7200	7200	7200	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	7.5 RD	8	8 RD	7.9	10
Average rotational delay (msec)	4.17	4.17	4.17	4.17	5.6
Average access time (msec)	11.67 RD	12.17	12.17 RD	12.07	15.6
Data transfer rate (MBytes/sec) Internal, min/max External	13.8/22.5 80.0 synch.	12.3/21.3 80.0 synch.	6.9/11.6 40.0 synch.	8.8/13.3 40.0	--/16.5 16.6 PIO4/DMA2 33.3 Ultra DMA
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q98	1Q98	1Q97	4Q96	2/97
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	6.4 AT (FB SE) Fireball SE	6.4 Bigfoot CY	6.4 S (FB SE) Fireball SE	6.4 S (FB ST) Fireball ST	8.4 AT (FB SE) Fireball SE
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	130 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra ATA	IDE	Ultra SCSI	Ultra SCSI	Ultra ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 6,448	F: 6,510	F: 6,448	F: 6,448	F: 8,455
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	6	6	8	8
Tracks per surface	7644		7644		7644
Track density (TPI)	8400	6775	8400	7777	8400
Maximum linear density (BPI) (FCI)	195903	117167 124490	195903	154916 164598	195903
Areal density (Mb/square inch)	1646	793.8	1646	1205	1646
Recording code	EPRML	16,17 PRML	EPRML	16,17 EPRML	EPRML
Rotational speed (RPM)	5400	3600	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.5	14	9.5	10	9.5
Average rotational delay (msec)	5.6	8.3	5.6	5.6	5.6
Average access time (msec)	15.1	22.3	15.1	15.6	15.1
Data transfer rate (MBytes/sec) Internal, min/max External	--/19.8 16.6 PIO4/DMA2 33.3 Ultra DMA	--/11.6 16.6 PIO Mode 4 16.6 DMA Mode 2	--/19.8 20.0 synch.	--/16.5 20.0	--/19.8 16.6 PIO4/DMA2 33.3 Ultra DMA
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 146.05 x 203.2	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/97	12/96	10/97	2/97	10/97
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	8.4 S (FB SE) Fireball SE	9.1 FC (AIII) Atlas III	9.1 S (AIII) Atlas III	9.1 S (VII) Viking II	XP39100S 9.1 Atlas II
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	FC AL	SCSI Ultra 2	SCSI Ultra 2	Ultra SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 8,455	F: 9,100	F: 9,100	F: 9,100	F: 9,100
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	10	10	10	20
Tracks per surface	7644	8118	8118	8338	5964
Track density (TPI)	8400	8500	8500	8500	6000
Maximum linear density (BPI) (FCI)	195903	166000	166000	158000	111000 83250
Areal density (Mb/square inch)	1646	1411	1411	1343	666.0
Recording code	EPRML	16,17 PRML	16,17 PRML	16,17 PRML	1,7 RLL
Rotational speed (RPM)	5400	7200	7200	7200	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.5	7.5 RD	7.5 RD	8	7.9
Average rotational delay (msec)	5.6	4.17	4.17	4.17	4.17
Average access time (msec)	15.1	11.67 RD	11.67 RD	12.17	12.07
Data transfer rate (MBytes/sec) Internal, min/max External	--/19.8 20.0 synch.	13.8/22.5 200.0	13.8/22.5 80.0 synch.	12.3/21.3 80.0 synch.	8.8/13.9 40.0 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	10/97	1Q98	1Q98	1Q98	4Q96
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	RAYMOND ENGINEERING	RAYMOND ENGINEERING	SAGEM
DRIVE	18.2 FC (AIII) Atlas III	18.2 S (AIII) Atlas III	84300	8440	MSA 252-200
DISK/TREND GROUP	8	8	2	2	2
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	Thin Film	Ferrite	Ferrite
Interface	FC AL	SCSI Ultra 2	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 18,200	F: 18,200	--	--	--
REMOVABLE	--	--	F: 306	F: 40.55	F: 200
Capacity per track (Bytes)	Varies by zone	Varies by zone	F: 27,648	F: 11,264	F: 23,040
Data surfaces per spindle	20	20	9	8	16
Tracks per surface	8118	8118	1231	450	720
Track density (TPI)	8500	8500	2075	850	950
Maximum linear density (BPI) (FCI)	166000	166000	46227 30818	17000 17000	19680 14760
Areal density (Mb/square inch)	1411	1411	95.9	14.5	18.7
Recording code	16,17 PRML	16,17 PRML	2,7 RLL	MFM	1,7 RLL
Rotational speed (RPM)	7200	7200	3688	3637	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	7.5 RD	7.5 RD	25	115	17
Average rotational delay (msec)	4.17	4.17	8.1	8.3	8.3
Average access time (msec)	11.67 RD	11.67 RD	33.1	123.3	25.3
Data transfer rate (MBytes/sec) Internal, min/max External	13.8/22.5 200.0	13.8/22.5 80.0 synch.	1.2	0.4	1.5
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	58.4 x 106.7 x 188	58.4 x 106.7 x 188	220 x 440 x 500
FIRST CUSTOMER SHIPMENT	1Q98	1Q98	1991	1987	10/90
COMMENTS			Mil-Spec ruggedized drive and electronics assembly. Removable disk drive cartridge	Mil-Spec ruggedized drive and electronics assembly. Removable disk drive cartridge	Militarized subsystem. Removable Head/Disk module.

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	WN310820A	WN312021A	WN31273A	WN316025A	WNR-31601A
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film		Thin Film		Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,207	F: 1,270	F: 1,620	F: 1,610
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	2	2	3	4
Tracks per surface	6022	6077	6333	5891	5388
Track density (TPI)	6000	6132	6500	5932	5470
Maximum linear density (BPI) (FCI)	111000 125000	130153 146422	136000 153000	123950 139450	95900 108000
Areal density (Mb/square inch)	666.0	798.1	884.0	735.3	524.6
Recording code	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML
Rotational speed (RPM)	4500	4500	5400	4500	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10	10	11	10	11
Average rotational delay (msec)	6.7	6.7	5.6	6.7	5.6
Average access time (msec)	16.7	16.7	16.6	16.7	16.6
Data transfer rate (MBytes/sec) Internal, min/max External	5.8/10.6 16.6 PIO Mode 4 16.6 DMA Mode 2	6.3/12.1 16.6 PIO Mode 4 16.6 DMA Mode 2	8.0/14.4 16.6 PIO Mode 4 16.6 DMA Mode 2	5.8/11.1 16.6 PIO Mode 4 16.6 DMA Mode 2	5.4/10.6 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT					4/96
COMMENTS					

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	WN321010S	WN321620A	WN32162U	WN32543A	WNR-32101S
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film		Thin Film	Thin Film
Interface	SCSI	IDE	Ultra SCSI	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,160	F: 2,160	F: 2,160	F: 2,540	F: 2,013
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	4	4	4	5
Tracks per surface	5588	6022	5909	6331	5589
Track density (TPI)	5700	6000	5932	6500	5700
Maximum linear density (BPI) (FCI)	100000 107850	111000 125000	123646 139102	136000 153000	95900 108000
Areal density (Mb/square inch)	570.0	666.0	733.5	884.0	546.6
Recording code	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML
Rotational speed (RPM)	5400	4500	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11	10	9.5	11	11
Average rotational delay (msec)	5.6	6.7	5.6	5.6	5.6
Average access time (msec)	16.6	16.7	15.1	16.6	16.6
Data transfer rate (MBytes/sec) Internal, min/max External	5.5/10.6 10.0 synch. 5.0 asynch.	5.8/10.6 16.6 PIO Mode 4 16.6 DMA Mode 2	6.9/13.4 40.0 synch. 14.0 asynch.	8.0/14.4 16.6 PIO Mode 4 16.6 DMA Mode 2	5.4/10.6 10.0 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT					1996
COMMENTS					

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	WNR-32102A	VG-332023A	VG-33402A	WN34003A	WN34003U
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,100	F: 3,340	F: 3,400	F: 4,000	F: 4,000
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	4	6	6
Tracks per surface					
Track density (TPI)	6000		8000	6800	6800
Maximum linear density (BPI) (FCI)	116000 131000				
Areal density (Mb/square inch)	696.0				
Recording code	8,9 PRML	8,9 PRML	PRML	8,9 PRML	8,9 PRML
Rotational speed (RPM)	5400	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.9	9	11 RD/12 WR	10	10
Average rotational delay (msec)	5.7	5.6	5.6	5.6	5.6
Average access time (msec)	15.6	14.6	16.6 RD/17.6 WR	15.6	15.6
Data transfer rate (MBytes/sec) Internal, min/max External	 16.6 PIO Mode 4 16.6 DMA Mode 2	 16.6 PIO Mode 4 16.6 DMA Mode 2	 16.6 PIO4/DMA2 33.3 Ultra DMA	 --/12.1 16.6 PIO Mode 4 16.6 DMA Mode 2	 --/12.1 40.0 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/96	3Q97			
COMMENTS					

MANUFACTURER	SAMSUNG ELECTRONICS	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	VG-35102A	ST9420AG Marathon 420sl	ST9810A/AG Marathon 810sl	ST9840A Marathon 840sl	ST31010A Medalist 1010
DISK/TREND GROUP	7	2	3	3	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	65 mm	65 mm	65 mm	95 mm
Recording medium	Thin Film	Thin Film*	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 5,100	F: 420.8	F: 811.3	F: 840	F: 1,082
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	4	4	4	2
Tracks per surface					
Track density (TPI)	8000	3807		5555	5950
Maximum linear density (BPI) (FCI)		94000 70500		120000	115100 86325
Areal density (Mb/square inch)		357.9		666.6	684.8
Recording code	PRML	1,7 RLL	1,7 RLL	PRML	1,7 RLL
Rotational speed (RPM)	5400	4500	3968	4508	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11 RD/12 WR	16	14	12	12
Average rotational delay (msec)	5.6	6.7	7.6	6.7	6.7
Average access time (msec)	16.6 RD/17.6 WR	22.7	21.6	18.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	 16.6 PIO4/DMA2 33.3 Ultra DMA	--/5.5 13.3 DMA Mode 1	--/5.6 16.6 PIO Mode 4 16.6 DMA Mode 2	--/7.6 16.6 PIO Mode 4 16.6 DMA Mode 2	--/11.0 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	12.75 x 70.1 x 101.9	12.7 x 70.1 x 101.9	12.5 x 70 x 100	26.2 x 102.4 x 146.9
FIRST CUSTOMER SHIPMENT		1Q95	7/96	4/96	2Q97
COMMENTS		*Glass disks.			

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST31051N ST31055N Hawk 2XL	ST31051W ST31051WC ST31055W ST31055WC Hawk 2XL	ST31230DC ST31230N ST31230NC ST31230ND Hawk 2LP	ST31230W ST31230WC ST31230WD Hawk 2LP	ST31276A Medalist 1276
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR Thin Film	MR Thin Film	Thin Film
Interface	SCSI-2	Ultra SCSI	SCSI-2	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,050	F: 1,080	U: 1,200 F: 1,050	U: 1,200 F: 1,050	F: 1,275
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	5	5	4
Tracks per surface	4117	4117	3892	3892	4893
Track density (TPI)			4200	4200	4973
Maximum linear density (BPI) (FCI)			78000 58500	78000 58500	88400 66300
Areal density (Mb/square inch)			327.6	327.6	439.6
Recording code	PRML (0,4,4)	PRML (0,4,4)	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5411	5411	5411	5411	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	9 RD/10.5 WR	9 RD/10.5 WR	9 RD/10.5 WR	9 RD/10.5 WR	12.5
Average rotational delay (msec)	5.54	5.54	5.54	5.54	6.7
Average access time (msec)	14.54/16.04	14.54/16.04	14.54/16.04	14.54/16.04	19.2
Data transfer rate (MBytes/sec) Internal, min/max External	5.5/8.3 20.0 synch.	5.5/8.3 40.0	4.0/7.3 10.0 synch.	4.0/7.3 20.0 synch.	--/6.4 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	26.2 x 102.4 x 146.9
FIRST CUSTOMER SHIPMENT	8/95		2Q94	2Q94	2Q96
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST31720A Medalist 1720	ST31721A Medalist 1721	ST91350AG Marathon 1350sl	ST91420AG Marathon 1420sl	ST91430AG Marathon 1430sl
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film*	Thin Film
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,705	F: 1,705	F: 1,350	F: 1,441	F: 1,449
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	6	4	6
Tracks per surface			3245		3382
Track density (TPI)		5950	5555	7194	5624
Maximum linear density (BPI) (FCI)		115100 86325	120000	154000	122020
Areal density (Mb/square inch)		684.8	666.6	1108	686.2
Recording code	1,7 RLL	1,7 RLL	PRML	PRML	PRML
Rotational speed (RPM)	4500	4500	4508	4508	4508
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12.5	12	12	12	12
Average rotational delay (msec)	6.7	6.7	6.7	6.7	6.7
Average access time (msec)	19.2	18.7	18.7	18.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max		--/11.0	4.4/7.6	5.7/8.9	4.5/7.5
External	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	26.2 x 102.4 x 146.9	26.2 x 102.4 x 146.9	12.5 x 70 x 100	12.5 x 70 x 100.5	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	3Q96	2Q97	4/96	2Q97	12/96
COMMENTS				*Glass disk.	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST91685AG Marathon 1680	ST32120A Medalist 2120	ST32132A Medalist 2132	ST32151N ST32155N Hawk 2XL	ST32151W ST32151WC ST32155W ST32155WC Hawk 2XL
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	SCSI-2	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,680	F: 2,111	F: 2,113.4	F: 2,148	F: 2,149
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	4	6	8	8
Tracks per surface	3245		5068	4117	4117
Track density (TPI)	5555	5950	5435	4800	4800
Maximum linear density (BPI) (FCI)	120000	115100 86325	89000 97000	84200	84200
Areal density (Mb/square inch)	666.6	684.8	483.7	404.2	404.2
Recording code	PRML	1,7 RLL	PRML (0,12,8)	PRML (0,4,4)	PRML (0,4,4)
Rotational speed (RPM)	4508	4500	4504	5411	5411
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12.5	9 RD/10.5 WR	9 RD/10.5 WR
Average rotational delay (msec)	6.7	6.7	6.7	5.54	5.54
Average access time (msec)	18.7	18.7	19.2	14.54/16.04	14.54/16.04
Data transfer rate (MBytes/sec) Internal, min/max External	4.4/7.6 16.6 PIO Mode 4 16.6 DMA Mode 2	--/11.0 16.6 PIO Mode 4 16.6 DMA Mode 2	4.4/8.5 16.6	5.5/8.3 20.0 synch.	5.5/8.3 40.0
SIZE: (mm) H x W x D	17 x 70 x 100	26.2 x 102.4 x 146.9	25.4 x 102.1 x 146.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4/96	2Q97	10/96	8/95	
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST32171DC ST32171W ST32171WC ST32171WD Barracuda 4LP	ST32171FC Barracuda 4LP	ST32171N ST32171ND Barracuda 4LP	ST32271DC ST32271W ST32271WC ST32271WD Barracuda 4LP	ST32271FC Barracuda 4LP
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	FC AL	Ultra SCSI	Ultra SCSI	FC AL
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,150	F: 2,150	F: 2,150	F: 2,270	F: 2,270
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	5	5	5	5	5
Tracks per surface	5288	5288	5288	5288	5288
Track density (TPI)	5500	5500	5500	5500	5500
Maximum linear density (BPI) (FCI)	120000	120000	120000	129000	123000
Areal density (Mb/square inch)	660.0	660.0	660.0	709.5	676.5
Recording code	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)
Rotational speed (RPM)	7200	7200	7200	7200	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR
Average rotational delay (msec)	4.17	4.17	4.17	4.17	4.17
Average access time (msec)	12.17/13.17	12.17/13.17	12.17/13.17	12.17/13.17	12.17/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	 9.4/15.0 40.0 synch.	 9.4/15.0 100.0 synch.	 9.4/15.0 20.0 synch.	 40.0 synch.	 100.0 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	4Q95	4Q95	4Q95	1Q96	1Q96
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST32271N ST32271ND Barracuda 4LP	ST32272DC ST32272W ST32272WC ST32272WD	ST32272N Barracuda 4XL	ST32430N ST32430ND Hawk 2LP	ST32430W ST32430WC ST32430WD Hawk 2LP
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	Ultra SCSI	Ultra SCSI	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,270	F: 2,260	F: 2,260	U: 2,600 F: 2,147	U: 2,600 F: 2,147
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	5	4	4	9	9
Tracks per surface	5288	6311	6311	3892	3892
Track density (TPI)	5555	6800	6800	4200	4200
Maximum linear density (BPI) (FCI)	123000	139200	139200	78000 58500	78000 58500
Areal density (Mb/square inch)	683.3	946.6	946.6	327.6	327.6
Recording code	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	7200	5411	5411
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8 RD/9 WR	8.8 RD/9.9 WR	8.8 RD/9.9 WR	9 RD/10.5 WR	9 RD/10.5 WR
Average rotational delay (msec)	4.17	4.17	4.17	5.54	5.54
Average access time (msec)	12.17/13.17	12.97/14.07	12.97/14.07	14.54/16.04	14.54/16.04
Data transfer rate (MBytes/sec) Internal, min/max External	 20.0 synch.	 11.5/17.5 40.0 synch.	 11.5/17.5 20.0 synch.	 4.6/7.9 10.0 synch.	 4.6/7.9 20.0 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 145.8	25.4 x 101.6 x 145.8	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q96	4/97	4/97	2Q94	2Q94
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST32531A Medalist 2531	ST32550DC ST32550W ST32550WC ST32550WD Barracuda 2LP	ST32550N ST32550ND Barracuda 2LP	ST52160N MedalistPro 2.1	ST52520A MedalistPro 2.5
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film			MR Thin Film	MR Thin Film
Interface	IDE	SCSI-2	SCSI-2	Ultra SCSI	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,557	U: 2,541 F: 2,147	U: 2,541 F: 2,147	F: 2,170	F: 2,564
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	11	11	4	4
Tracks per surface		3711	3711		
Track density (TPI)	5104	4048	4048	6730	6730
Maximum linear density (BPI) (FCI)	108770 81577	72680 54510	72688 54516	112369	138011
Areal density (Mb/square inch)	555.2	294.2	294.2	756.2	928.8
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	PRML
Rotational speed (RPM)	4500	7200	7200	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	12	8 RD/9 WR	8 RD/9 WR	11	11
Average rotational delay (msec)	6.7	4.17	4.17	5.6	5.6
Average access time (msec)	18.7	12.17/13.17	12.17/13.17	16.6	16.6
Data transfer rate (MBytes/sec) Internal, min/max External	5.3/11.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.8/8.8 20.0 synch.	5.8/8.8 10.0 synch.	7.0/12.4 20.0 asynch.	7.9/14.5 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	26.2 x 102.4 x 146.9	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	19 x 101.6 x 137	19 x 101.6 x 136.6
FIRST CUSTOMER SHIPMENT	2Q97	2Q94	2Q94	3/97	3Q96
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST92130AG Marathon 2130sl	ST92255AG Marathon 2250	ST15150DC ST15150N ST15150ND Barracuda 4	ST15150FC Barracuda 4	ST15150W ST15150WC ST15150WD Barracuda 4
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	65 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film*	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	SCSI-2	Fibre Channel	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,163	F: 2,250	U: 5,062 F: 4,294	U: 5,062 F: 4,294	U: 5,062 F: 4,294
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	10	21	21	21
Tracks per surface		3245	3711	3711	3711
Track density (TPI)	7194	5555	4048	4048	4048
Maximum linear density (BPI) (FCI)	154000	120000	73820 55365	73820 55365	73820 55365
Areal density (Mb/square inch)	1108	666.6	298.8	298.8	298.8
Recording code	PRML	PRML	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4508	4508	7200	7200	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	12	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR
Average rotational delay (msec)	6.7	6.7	4.17	4.17	4.17
Average access time (msec)	18.7	18.7	12.17/13.17	12.17/13.17	12.17/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	5.7/8.9 16.6 PIO Mode 4 16.6 DMA Mode 2	--/7.6 16.6 PIO Mode 4 16.6 DMA Mode 2	6.0/9.0 10.0 synch.	5.9/9.0 100.0	6.0/9.0 20.0 synch.
SIZE: (mm) H x W x D	12.5 x 70 x 100.5	17 x 70 x 100	41.3 x 101.6 x 151.6	41.3 x 101.6 x 151.6	41.3 x 101.6 x 151.6
FIRST CUSTOMER SHIPMENT	2Q97	4/96	2Q94	2Q95	2Q94
COMMENTS	*Glass disk.				

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST15230N ST15230ND Hawk 4	ST15230W ST15230WC ST15230WD Hawk 4	ST33230A Medalist 3230	ST33240A Medalist 3240	ST34340A Medalist 4340
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads			MR Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 5,160 F: 4,294	U: 5,160 F: 4,294	F: 3,227	F: 3,227	F: 4,303
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	19	19	6	8	8
Tracks per surface	3892	3892			
Track density (TPI)	4200	4200	5950	5104	5980
Maximum linear density (BPI) (FCI)	71500 53625	71500 53625	115100 86325	108770 81577	115100 86325
Areal density (Mb/square inch)	300.3	300.3	684.8	555.2	688.3
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5411	5411	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	9 RD/10.5 WR	9 RD/10.5 WR	12	12	12
Average rotational delay (msec)	5.54	5.54	6.7	6.7	6.7
Average access time (msec)	14.54/16.04	14.54/16.04	18.7	18.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	4.3/7.9 10.0 synch.	4.3/7.9 20.0 synch.	--/11.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.3/11.0 16.6 PIO Mode 4 16.6 DMA Mode 2	--/11.0 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	26.2 x 102.4 x 146.9	26.2 x 102.4 x 146.9	26.2 x 102.4 x 146.9
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	2Q97	4Q96	2Q97
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST34371DC ST34371W ST34371WC ST34371WD Barracuda 4LP	ST34371FC Barracuda 4LP	ST34371N ST34371ND Barracuda 4LP	ST34501DC ST34501W ST34501WC ST34501WD Cheetah 4LP	ST34501FC Cheetah 4LP
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	FC AL	Ultra SCSI	Ultra SCSI	FC-AL
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,350	F: 4,350	F: 4,350	F: 4,550	F: 4,550
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	10	10	10	8	8
Tracks per surface	5288	5288	5288	6582	6582
Track density (TPI)	5555	5500	5500	6932	6932
Maximum linear density (BPI) (FCI)	123000	120000	120000	135000	135000
Areal density (Mb/square inch)	683.3	660.0	660.0	935.8	935.8
Recording code	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)
Rotational speed (RPM)	7200	7200	7200	10033	10033
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	7.5 RD/8.5 WR	7.5 RD/8.5 WR
Average rotational delay (msec)	4.17	4.17	4.17	2.99	2.99
Average access time (msec)	12.17/13.17	12.17/13.17	12.17/13.17	10.49/11.49	10.49/11.49
Data transfer rate (MBytes/sec) Internal, min/max External	9.4/15.0 40.0 synch.	9.4/15.0 100.0 synch.	9.4/15.0 20.0 synch.	15.3/22.1 40.0	15.3/22.1 100.0
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q95	4Q95	4Q95	2Q97	2Q97
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST34501N Cheetah 4LP	ST34571DC ST34571W ST34571WC ST 34571WD Barracuda 4LP	ST34571FC Barracuda 4LP	ST34571N ST34571ND Barracuda 4LP	ST34572DC ST34572W ST34572WC ST34572WD Barracuda 4XL
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	Ultra SCSI	FC AL	SCSI-2	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,550	F: 4,550	F: 4,550	F: 4,550	F: 4,550
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	10	10	10	8
Tracks per surface	6582	5288	5288	5288	6311
Track density (TPI)	6932	5500	5500	5500	6800
Maximum linear density (BPI) (FCI)	135000	129000	129000	129000	139200
Areal density (Mb/square inch)	935.8	709.5	709.5	709.5	946.6
Recording code	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)
Rotational speed (RPM)	10033	7200	7200	7200	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	7.5 RD/8.5 WR	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	8.8 RD/9.9 WR
Average rotational delay (msec)	2.99	4.17	4.17	4.17	4.17
Average access time (msec)	10.49/11.49	12.17/13.17	12.17/13.17	12.17/13.17	12.97/14.07
Data transfer rate (MBytes/sec) Internal, min/max	15.3/22.1				11.5/17.5
External	20.0	40.0	100.0	20.0	40.0 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 145.8
FIRST CUSTOMER SHIPMENT	2Q97	1Q96	1Q96	1Q96	4/97
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST34572N Barracuda 4XL	ST19101DC ST10101W ST19101WC ST19101WD Cheetah 9	ST19101FC Cheetah 9	ST19101N Cheetah 9	ST19171DC ST19171W ST19171WC ST19171WD Barracuda 9
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	Ultra SCSI	FC AL	Ultra SCSI	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,550	F: 9,100	F: 9,100	F: 9,100	U: 11,700 F: 9,100
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	16	16	16	20
Tracks per surface	6311	6582	6582	6582	5333
Track density (TPI)	6800	6932	6932	6932	5555
Maximum linear density (BPI) (FCI)	139200	135000	135000	135000	125000
Areal density (Mb/square inch)	946.6	935.8	935.8	935.8	694.4
Recording code	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)
Rotational speed (RPM)	7200	10033	10033	10033	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	8.8 RD/9.9 WR	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	8 RD/9.5 WR
Average rotational delay (msec)	4.17	2.99	2.99	2.99	4.17
Average access time (msec)	12.97/14.07	10.99/11.99	10.99/11.99	10.99/11.99	12.17/13.67
Data transfer rate (MBytes/sec) Internal, min/max External	11.5/17.5 20.0 synch.	15.3/22.1 40.0	15.3/22.1 100.0	15.3/22.1 20.0	9.4/15.0 40.0
SIZE: (mm) H x W x D	25.4 x 101.6 x 145.8	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4/97	2Q97	2Q97	2Q97	1Q96
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST19171FC Barracuda 9	ST19171N Barracuda 9	ST35040A MedalistPro 5.0	ST36450A MedalistPro 6.4	ST410800N ST410800ND Elite 9
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	Thin Film
Interface	FC AL	SCSI-2	IDE	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 11,700 F: 9,100	U: 11,700 F: 9,100	F: 5,040	F: 6,450	U: 10,800 F: 9,090
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	20	20	8	10	27
Tracks per surface	5333	5333	6536	6536	4925
Track density (TPI)	5555	5555	6730	6730	3921
Maximum linear density (BPI) (FCI)	125000	125000	138011	138011	71200 53400
Areal density (Mb/square inch)	694.4	694.4	928.8	928.8	279.2
Recording code	PRML (0,4,4)	PRML (0,4,4)	PRML	PRML	1,7 RLL
Rotational speed (RPM)	7200	7200	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	8 RD/9.5 WR	8 RD/9.5 WR	9.5 RD/10 WR	9.5 RD/10 WR	11 RD/12 WR
Average rotational delay (msec)	4.17	4.17	5.6	5.6	5.6
Average access time (msec)	12.17/13.67	12.17/13.67	15.1 RD/15.6 WR	15.1 RD/15.6 WR	16.6 RD/17.6 WR
Data transfer rate (MBytes/sec) Internal, min/max External	9.4/15.0 100.0	9.4/15.0 20.0	--/14.5 16.6 PIO Mode 4 16.6 DMA Mode 2	--/14.5 16.6 PIO Mode 4 16.6 DMA Mode 2	5.5/8.2 10.0 synch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	26.1 x 101.6 x 147	26.1 x 101.6 x 147	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1Q96	1Q96	4/97	4/97	2Q94
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEIKO EPSON
DRIVE	ST410800W ST410800WD Elite 9	ST423451FC Elite 23	ST423451N Elite 23	ST423451W ST423451WD Elite 23	EHDD170 Hard Disk Card
DISK/TREND GROUP	7	9	9	9	2
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	48 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film*
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	Thin Film
Interface	SCSI-2	FC AL	Ultra SCSI	Ultra SCSI	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 10,800 F: 9,090	F: 23,400	F: 23,400	F: 23,400	--
REMOVABLE	--	--	--	--	F: 170.8
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	27	28	28	28	4
Tracks per surface	4925	6884	6884	6884	1370
Track density (TPI)	3921	5555	5555	5555	3800
Maximum linear density (BPI) (FCI)	71200 53400	125360	124000	124000	84000 63000
Areal density (Mb/square inch)	279.2	696.4	688.8	688.8	319.2
Recording code	1,7 RLL	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	5400	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11 RD/12 WR	13 RD/14 WR	13 RD/14 WR	13 RD/14 WR	12
Average rotational delay (msec)	5.6	5.6	5.6	5.6	6.7
Average access time (msec)	16.6 RD/17.6 WR	18.6 RD/19.6 WR	18.6 RD/19.6 WR	18.6 RD/19.6 WR	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	5.5/8.2 20.0 synch.	9.4/15.0 100.0	9.4/15.0 20.0 synch.	9.4/15.0 40.0 synch.	12.0
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203	82.6 x 146.1 x 203	82.6 x 146.1 x 203	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	2Q94	3Q96	3Q96	3Q96	3/94
COMMENTS					PCMCIA Type III Ramp loaded heads. *Untextured disks. Mfg by Integral Peripherals.

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-1085	XT-1140	XT-2190	XT-4170E	XT-4170S
DISK/TREND GROUP	2	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ST412	ST412	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.32	U: 143.42	U: 191.23	U: 179.45	F: 157.93
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 20,940	F: 18,432
Data surfaces per spindle	8	15	15	7	7
Tracks per surface	1024	918	1224	1224	1224
Track density (TPI)	1070	1070	1070	1070	1070
Maximum linear density (BPI) (FCI)	9934	9280	11155	21064 14043	21064 14043
Areal density (Mb/square inch)	10.6	9.9	11.9	22.5	22.5
Recording code	MFM	MFM	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	27	25.8	28.9	14	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	34.1	37.2	22.3	22.3
Data transfer rate (MBytes/sec) Internal, min/max External	0.625	0.625	0.625	1.25	4.8 synch.
SIZE: (mm) H x W x D	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3
FIRST CUSTOMER SHIPMENT	2Q83	2Q83	3Q84	2Q87	2/86
COMMENTS					

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-4380E	XT-4380S	XT-8380EH	XT-8380SH	XT-8760EH
DISK/TREND GROUP	2	2	2	2	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 384.53	F: 338.41	U: 410.0	F: 360.31	U: 768.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,940	F: 18,432	U: 31,410	F: 27,648	U: 31,410
Data surfaces per spindle	15	15	8	8	15
Tracks per surface	1224	1224	1632	1632	1632
Track density (TPI)	1070	1070	1376	1376	1376
Maximum linear density (BPI) (FCI)	21064 14043	21064 14043	31596 21064	31596 21064	31596 21064
Areal density (Mb/square inch)	22.5	22.5	43.5	43.5	43.5
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	14.5	14.5	16.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	22.8	22.8	24.8
Data transfer rate (MBytes/sec) Internal, min/max External	1.25	4.8 synch.	1.875	4.8 synch.	1.875
SIZE: (mm) H x W x D	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3
FIRST CUSTOMER SHIPMENT	2Q87	4Q87	1Q87	1Q88	1Q87
COMMENTS					

MANUFACTURER	SEQUEL	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	XT-8760SH	SQ5200C	EZFlyer 230A	EZFlyer 230P	EZFlyer 230S
DISK/TREND GROUP	3	1	1	1	1
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI-2	IDE	Parallel Port	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 675.58	--	--	--	--
REMOVABLE	--	F: 200	F: 230	F: 230	F: 230
Capacity per track (Bytes)	F: 27,648	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	15	2	1	1	1
Tracks per surface	1632	2260	4192	4192	4192
Track density (TPI)	1376	1875	4200	4200	4200
Maximum linear density (BPI) (FCI)	31596 21064	49820 37365	77800 58400	77800 58400	77800 58400
Areal density (Mb/square inch)	43.5	93.4	326.8	326.8	326.8
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3220	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16.5	18	13.5	13.5	13.5
Average rotational delay (msec)	8.3	9.32	8.3	8.3	8.3
Average access time (msec)	24.8	27.32	21.8	21.8	21.8
Data transfer rate (MBytes/sec) Internal, min/max External	4.8 synch.	2.6/3.6 5.0 synch. 3.0 asynch.	10.0 synch. 5.0 asynch.	1.25	10.0 synch. 5.0 asynch.
SIZE: (mm) H x W x D	82.6 x 146.1 x 208.3	41.3 x 146.1 x 203.2	25.4 x 101.6 x 146.0	39.4 x 137.9 x 184.2	39.4 x 137.9 x 184.2
FIRST CUSTOMER SHIPMENT	1Q88	2Q94	3/97	6/96	6/96
COMMENTS		Removable data cartridge. Read/write compatible with 44 MB, 88 MB & 200 MB cart.	Removable data cartridge. Internal model.	Removable data cartridge. External model.	Removable data cartridge. Internal model.

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	TOSHIBA
DRIVE	SyJet IAi	SyJet ISE	SyJet ISi	SyJet IPE	MK-0501MAT
DISK/TREND GROUP	1	1	1	1	3
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film*
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	IDE	SCSI-2	SCSI-2	Parallel Port	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	F: 500
REMOVABLE	F: 1,500	F: 1,500	F: 1,500	F: 1,500	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	4	2
Tracks per surface	5241	5241	5241	5241	3830
Track density (TPI)	5400	5400	5400	5400	
Maximum linear density (BPI) (FCI)	108000 121000	108000 121000	108000 121000	108000 121000	
Areal density (Mb/square inch)	583.2	583.2	583.2	583.2	
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	5400	5400	5400	5400	4200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	12	13
Average rotational delay (msec)	5.6	5.6	5.6	5.5	7.14
Average access time (msec)	17.6	17.6	17.6	17.5	20.14
Data transfer rate (MBytes/sec) Internal, min/max External	 5.5/11.5 16.6 PIO Mode 4	 5.5/11.5 10.0 synch. 5.0 asynch.	 5.5/11.5 10.0 synch. 5.0 asynch.	 5.5/11.5	 --/7.0 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 149.3	38.1 x 133 x 200	25.4 x 101.6 x 149.3	38.1 x 133 x 200	8.45 x 69.9 x 100
FIRST CUSTOMER SHIPMENT	4/97	1/97	1/97	1/97	
COMMENTS	Internal model.	Removable data cartridge. External model.	Removable data cartridge. Internal model.	External model.	*Glass disks.

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-0803MAT	MK-1924FBV	MK-1926FBV	MK-1001MAV	MK-1002MAV
DISK/TREND GROUP	3	3	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film*	Thin Film	Thin Film	Thin Film*	Thin Film*
DRIVE: Heads	MR Thin Film		Thin Film		Thin Film
Interface	IDE	SCSI-2	SCSI-2	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 815	F: 543	F: 815	F: 1,085	F: 1,085
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	4	6	5	6
Tracks per surface	5260	2920	2920		3560
Track density (TPI)					
Maximum linear density (BPI) (FCI)					
Areal density (Mb/square inch)					
Recording code	PRML				
Rotational speed (RPM)	4000	4200	4200	4200	4635
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	13	13	13	13
Average rotational delay (msec)	7.5	7.14	7.14	7.14	6.4
Average access time (msec)	20.5	20.14	20.14	20.14	19.4
Data transfer rate (MBytes/sec) Internal, min/max External	--/8.8 16.6 PIO Mode 4 16.6 DMA Mode 2	3.1/5.6 10.0 synch.	3.1/5.6 10.0 synch. 6.0 asynch.	--/6.9 16.6 PIO Mode 4 16.6 DMA Mode 2	--/6.9 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	8.45 x 69.9 x 100	12.7 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100
FIRST CUSTOMER SHIPMENT		3/95		5/96	5/96
COMMENTS	*Glass disks.			*Glass disks.	*Glass disks.

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-1003MAV	MK-1401MAV	MK-1403MAV	MK-2103MAV	MK-3003MAN
DISK/TREND GROUP	4	4	4	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film*	Thin Film*	Thin Film*	Thin Film*	Thin Film*
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,440	F: 1,440	F: 2,160	F: 3,080
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	3	6	4	6	4
Tracks per surface	5160	3720	5160	3650	5020
Track density (TPI)				8772	
Maximum linear density (BPI) (FCI)				149100	
Areal density (Mb/square inch)				1308	
Recording code	PRML			PRML	
Rotational speed (RPM)	4200	4830	4830	4200	4830
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	13	13	13	13
Average rotational delay (msec)	7.14	6.21	6.21	7.14	6.21
Average access time (msec)	20.14	19.21	19.21	20.14	19.21
Data transfer rate (MBytes/sec) Internal, min/max External	--/8.7 16.6 PIO Mode 4 16.6 DMA Mode 2	--/6.8 16.6 PIO Mode 4 16.6 DMA Mode 2	--/8.7 16.6 PIO Mode 4 16.6 DMA Mode 2	--/6.9 16.6 PIO Mode 4 16.6 DMA Mode 2	--/8.7 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	12.7 x 69.8 x 100	12.7 x 69.8 x 100	12.7 x 69.8 x 100	12.7 x 70 x 100	19 x 70 x 100
FIRST CUSTOMER SHIPMENT				11/96	
COMMENTS	*Glass disks.	*Glass disks.	*Glass disks.	*Glass disks.	*Glass disks.

MANUFACTURER	TOSHIBA	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	MK-3303MAN	PhD1000 Portfolio	PhD1400 Portfolio	WDAC11000 Caviar	WDAC11200 Caviar
DISK/TREND GROUP	6	4	4	4	4
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	84 mm	84 mm	95 mm	95 mm
Recording medium	Thin Film*	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,300	F: 1,083.8	F: 1,440.9	F: 1,055.9	F: 1,281.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	10	4	4	2	2
Tracks per surface	5160				
Track density (TPI)	8518			6100	
Maximum linear density (BPI) (FCI)	146000			119000	
Areal density (Mb/square inch)	1244			725.9	
Recording code	PRML			PRML	PRML
Rotational speed (RPM)	4852	4536	4536	5200	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	14 RD/16 WR	14 RD/16 WR	12 RD/14 WR	11.5 RD/13.5 WR
Average rotational delay (msec)	6.18	6.6	6.6	5.8	5.8
Average access time (msec)	19.18	20.6 RD/22.6 WR	20.6 RD/22.6 WR	17.8 RD/19.8 WR	17.3 RD/19.3 WR
Data transfer rate (MBytes/sec) Internal, min/max External	--/8.7 16.6 PIO Mode 4 16.6 DMA Mode 2	4.0/7.9 16.6 PIO Mode 4	16.6 PIO Mode 4 16.6 PIO Mode 2	--/13.0 16.6 PIO Mode 4 13.3 DMA Mode 2	--/14.3 16.6 PIO Mode 4 13.3 DMA Mode 2
SIZE: (mm) H x W x D	19 x 70 x 100	10.5 x 90 x 120	10.5 x 90 x 120	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1/97	10/96	2Q97	6/96	1/97
COMMENTS	*Glass disks.				

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WDAC21200 Caviar	WDAC21600 Caviar	PhD2160 Portfolio	WDAC22000 Caviar	WDAC22100 Caviar
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	84 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,281.9	F: 1,624.6	F: 2,160	F: 2,000.3	F: 2,111.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	3	5
Tracks per surface					
Track density (TPI)	4850	5600			5600
Maximum linear density (BPI) (FCI)	85300	111500			111500
Areal density (Mb/square inch)	413.7	624.4			624.4
Recording code	PRML	PRML		PRML	PRML
Rotational speed (RPM)	5200	5200	4536	5200	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11 RD/13 WR	12 RD/14 WR	14 RD/16 WR	11.5 RD/13.5 WR	12 RD/14 WR
Average rotational delay (msec)	5.8	5.8	6.6	5.8	5.8
Average access time (msec)	16.8 RD/18.8 WR	17.8 RD/19.8 WR	20.6 RD/22.6 WR	17.3 RD/19.3 WR	17.8 RD/19.8 WR
Data transfer rate (MBytes/sec) Internal, min/max	--/9.6	--/11.9		--/14.3	--/11.9
External	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 PIO Mode 2	16.6 PIO Mode 4 13.3 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	10.5 x 90 x 120	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	12/95	3/96	2Q97	1/97	3/96
COMMENTS					

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WDAC22500 Caviar	WDAC32500 Caviar	WDE2170 Enterprise	WDAC33100 Caviar	WDAC33200 Caviar
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	Ultra SCSI	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,559.8	F: 2,559.8	F: 2,170	F: 3,166.7	F: 3,249.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	4	6	5
Tracks per surface					
Track density (TPI)		5600	6150	6100	
Maximum linear density (BPI) (FCI)		111500	125000	119000	
Areal density (Mb/square inch)		624.4	768.8	725.9	
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	5200	5200	7200	5200	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11.5 RD/13.5 WR	12 RD/14 WR	8 RD	12	11.5 RD/13.5 WR
Average rotational delay (msec)	5.8	5.8	4.17	5.7	5.8
Average access time (msec)	17.3 RD/19.3 WR	17.8 RD/19.8 WR	12.17 RD	17.7	17.3 RD/19.3 WR
Data transfer rate (MBytes/sec) Internal, min/max External	--/14.3 16.6 PIO Mode 4 13.3 DMA Mode 2	--/11.9 16.6 PIO Mode 4 16.6 DMA Mode 2	10.4/17.5 40.0 synch.	--/13.0 16.6 PIO Mode 4 16.6 DMA Mode 2	--/14.3 16.6 PIO Mode 4 13.3 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1/97	3/96	10/96	6/96	1/97
COMMENTS					

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL			
DRIVE	WDAC34000 Caviar	WDE4360 Enterprise			
DISK/TREND GROUP	6	6			
MARKET	OEM, PCM	OEM, PCM			
MEDIA: Disk diameter	95 mm	95 mm			
Recording medium	Thin Film	Thin Film			
DRIVE: Heads	Thin Film	Thin Film			
Interface	IDE	Ultra SCSI			
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,000.7	F: 4,360			
REMOVABLE	--	--			
Capacity per track (Bytes)	Varies by zone	Varies by zone			
Data surfaces per spindle	6	8			
Tracks per surface					
Track density (TPI)		6150			
Maximum linear density (BPI) (FCI)		125000			
Areal density (Mb/square inch)		768.8			
Recording code	PRML	PRML			
Rotational speed (RPM)	5200	7200			
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil			
Servo type	Embedded	Embedded			
Average positioning time (msec)	11.5 RD/13.5 WR	8			
Average rotational delay (msec)	5.8	4.17			
Average access time (msec)	17.3 RD/19.3 WR	12.17			
Data transfer rate (MBytes/sec) Internal, min/max External	--/14.3 16.6 PIO Mode 4 13.3 DMA Mode 2	10.9-17.5 40.0 synch.			
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146			
FIRST CUSTOMER SHIPMENT	1/97	9/96			
COMMENTS					

MANUFACTURER PROFILES

1997 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing moving head rigid magnetic disk drives, or which have indicated specific plans to enter the market, are listed in this section. The heading "1996 disk sales" refers only to the DISK/TREND estimate of moving head rigid disk drive sales for the calendar year -- no sales of other drive types are included, nor are sales of parts or other related products such as controllers. "1996 total net sales" covers the fiscal year ending December 31, 1996, for each firm unless noted otherwise, or for the parent company if the disk drive manufacturer is a subsidiary that does not report financial data separately.

Exchange rates

The exchange rates used in converting the financial data of non-U.S. manufacturers to dollars is given below. The average exchange rates for 1996 are used, as reported by the U.S. Federal Reserve Bulletin, and rounded to three significant figures.

Country	Currency	Currency units per U.S. dollar
France	Franc	5.12
Japan	Yen	108.8
South Korea	Won	805.0
United Kingdom	Pound	0.64

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

U.S. Manufacturers

AREAL TECHNOLOGY, INC.
2075 Zanker Road
San Jose, CA 95131

Areal Technology was founded in February, 1988, by Jack Swartz, an industry veteran and cofounder of Maxtor. The initial target was development of a 3.5" single disk 105 megabyte drive for production start in 1989. A 2.5" 50 megabyte drive was also announced. The drives were to be among the first to use glass substrates, with Nippon Sheet Glass a major investor in Areal. In 1990, management reorganizations resulted in Swartz leaving the company, along with the 3.5" development effort, and Areal subsequently concentrated entirely on 2.5" drives. The firm entered into an agreement with Sanyo Electric to produce Areal's drives in Japan at its Tottori facility, and Sanyo, with other Japanese investors, acquired control of Areal. Production of a 2.5" single disk 62 megabyte drive began at Areal's factory and at Sanyo in 1991, and in recent years the product line extended up to 700 megabyte drives. In mid-1995, the investors closed the U.S. facilities except for service personnel. Several of the Areal drive models continued to be manufactured and sold through 1996 by Tottori Sanyo (see listing in Asian manufacturer section), until the market moved up to higher capacities.

AVATAR SYSTEMS CORPORATION
1455 McCarthy Boulevard
Milpitas, CA 95035

Avatar was founded in 1991 by John Bizjak, a veteran of several pioneering disk drive programs, to develop high capacity disk cartridge drives. The company started production of an 85 megabyte 2.5" disk cartridge drive in mid-1993, using glass disks, and intended for portable and desktop applications. After management changes in 1994, emphasis was placed on 170 megabyte drive models primarily for OEM markets. After more management changes in 1996, emphasis is now being placed on 250 megabyte drive models targeted at distribution markets. Drive development is centered in Milpitas, using a manufacturing facility established in Thailand in 1995.

GIGASTORAGE INTERNATIONAL/BELFORT MEMORY INTERNATIONAL
170 Knowles Drive
Los Gatos, CA 95030

Gigastorage is the latest reincarnation of high-end 5.25" drive designs originally undertaken at Priam, later purchased from the bankruptcy court by Orca, then subsequently purchased from the Orca bankruptcy by a combination of disk drive industry veterans and European investors. The disk drives were assembled in small quantities in Germany during 1993, and a deal was later struck to conduct manufacturing operations in the inactive Bull plant in Belfort, France. Gigastorage designed a 1.08 gigabyte 5.25" drive to be sold at low prices for personal computer applications, and manufacturing started at Belfort in early 1996.

It was a difficult start-up, but not due to conventional product design or manufacturing problems. As the production line started, a variety of French bureaucrats and prosecutors descended on the scene, apparently prompted by a tangled web of French politics. Before the episode was finished, a Gigastorage executive and two local officials were held in jail for weeks, training for plant personnel was disrupted, a protest march was held in Belfort over the potential for lost jobs, and both Gigastorage suppliers and customers were concerned over the strange situation. In late Spring, everyone was released from jail, with various charges of fraud, failure to file paperwork and improper money transfers still pending, although the prosecutor didn't seem to have much of a case. In the middle of this chaos, disk drive production actually commenced at Belfort, although at low levels, and the management has been attempting to obtain additional financing and increase production.

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

1996 disk sales: $76,200,000
1996 total net sales: $38,420,000,000 Net income: $2,586,000,000
(FY ending 10/31/96)

For 20 years, Hewlett-Packard had an extensive manufacturing operation for disk drives at Boise, Idaho, supplemented in mid-1983 with a facility in Bristol, England. H-P made disk cartridge, disk pack, and fixed Winchester disk drives at Boise. In 1987, the company launched an OEM sales program for rigid disk drives in addition to the firm's traditional captive drive program, spearheaded by new 5.25" models. 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. The OEM disk drive program proved to be successful for H-P, and the product line was expanded to include 3.5" drives with capacities up to 8.7 gigabytes.

H-P received widespread attention with its announcement of the pioneering 1.3" "Kittyhawk" drive in 1992. The original 21 megabyte drive was supplemented with a 42 megabyte model, and a contract manufacturing arrangement was established with Citizen Watch. The Kittyhawk's market, which depended upon sales of personal digital assistants, personal communicators, pen based computers and other mobile computing equipment, was slow to take off, and although the program was executed well, and some OEM accounts were obtained, H-P decided in mid-1994 to terminate the Kittyhawk line due to its disappointing sales.

In recent years, H-P concentrated its disk drive program on high-end 3.5" disk drives, but the company attempted to enter the market with a very limited product line, and was slow to establish quantity production. In July, 1996, the Hewlett-Packard management decided to cut its losses and terminate the company's disk drive business, closing down the Disk Memory Division and its facilities in Boise and Penang.

INTEGRAL PERIPHERALS
5775 Flatiron Parkway
Boulder, CO 80301

Integral Peripherals was founded in September, 1990, by engineering and management personnel who previously pioneered in early 2.5" drives at Prairie-Tek. The company was the first to design and manufacture 1.8" disk drives. Its initial product was a 20 megabyte drive, first produced in the second half of 1991, and for which the available market was minimal. Integral had somewhat better luck with a 42 megabyte model, in production since early 1992, and a succession of higher capacity models which followed. The existing 1.8" drives use ramp loaded heads, and are designed to high operating shock and vibration specifications, with low power requirements, in anticipation of wide usage in subnotebook computers and other mobile computer applications.

The company has pioneered in utilizing untextured disks in higher capacity models, a technique made possible by using the ramp loading head method to avoid parking heads on the disk surface. Integral began its high volume manufacturing in Singapore in mid-1992, moved into a new plant in 1995 and has added 1.8" drives with up to 340 megabytes, with a 510 megabyte model announced, all in PC Card Type III format. In 1995, Integral added 2.5" drives as the beginning of a new product family, the result of a design contract with Samsung Electronics to provide designs for 2.5" drives, with both companies entitled to manufacture the drives involved. After finding a cool market reception for latecomers to the 2.5" disk drive business, Integral switched to 3" drives in 1997, with production expected in midyear.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1996 disk sales: $7,024,800,000
1996 total net sales: $75,947,000,000 Net income: $5,429,000,000

IBM shipped the world's first moving head disk drive in 1956, and the company has provided a large share of the industry's advanced technology during the following 40 years. Until the end of the 1970's, most of IBM's product designs were routinely copied by the rest of the industry. However, the advent of personal computers and engineering workstations intensified the development race and inspired the appearance of dozens of new disk drive manufacturers intent upon producing smaller drives, using new interfaces and exploring new marketing approaches.

After a flurry of activity during the first half of the 1980's resulted in various 14", 8", 5.25" and 3.5" drives without much distinction, IBM since 1989 has introduced a series of drives which place it in the first tier of midrange and low-end disk drive manufacturers, as well as maintaining its traditional leadership in high-end disk drives. For PC's and notebook computers, several generations of drives developed at the Fujisawa plant have now matched the industry's current standards for personal computers, with 1" high 3.5" drives offering up to 8.4 gigabytes on 4 platters and 2.5" drives with up to 5.1 gigabytes on 4 platters. After taking 5.25" drives up to 1.5 gigabytes in capacity, IBM stopped 5.25" development, in favor of smaller disk diameter drives.

The 1993 introduction of the 3390-9, offering 17 gigabytes per spindle with comparatively low prices for mainframe disk drives, but at the expense of slow performance, was destined to be a short-lived product. It was impacted by the advent of new generations of disk subsystems and arrays, such as the RAMAC array introduced in 1994, using new families of small diameter disk drives. The RAMAC shipped on schedule in September, 1994, using 2 gigabyte Allicat 3.5" drives, and was upgraded to 4 gigabyte Starfire drives in October, 1995, then to 9 gigabyte Scorpion drives in November, 1996.

IBM disk drives are manufactured at a combination of its own plants and in contract manufacturers' facilities, in the United States, Europe and Asia. The original San Jose facility has been producing older 3.5" high-end drives, with newer models transferred to a new factory in Singapore, already being doubled in size in 1997. San Jose's role will be expanded again, however, benefiting from new expansion plans announced in 1996. Fujisawa (Japan) transferred its manufacturing activities for 3.5" and 2.5" drives for the personal computer market to a contract manufacturing organization in Thailand, and IBM is adding a new plant of its own in Thailand to make 2.5" drives. A new disk drive manufacturing plant has been established in Hungary for personal computer drives. The Havant (U.K.) plant has been spun off in an employee buy out under the Xyratex name (see European manufacturers section), and is now a contract manufacturing source for IBM.

IBM's first significant OEM sales of disk drives were made in 1984, when the firm began selling the 3380 to both Siemens and Honeywell. Some low-end 3.5" drives with Microchannel interfaces were also sold to European system manufacturers who chose to offer personal computer models with the Microchannel bus. For disk drives broadly sold on an OEM basis, it was more difficult for IBM to establish significant sales, due to tough competition. Despite the difficulties, IBM has increased the sales activity for 3.5" drives in the personal computer aftermarket through distribution, and in sales to other system manufacturers of both 2.5" and 3.5" drives offered early in their life cycles.

IBM was confused as to how to label all of this activity. After changing from more than 20 years of "General Products Division" to "Storage Systems Products Division" (which also included the separate "Low End Disk Operations') in 1990, the name became "AdStaR" in early 1992 -- with the general plan to establish the entity as a separate, wholly owned IBM subsidiary. However, with new corporate management and a new spirit of corporate togetherness, the AdStaR name and the separate subsidiary status were quietly abandoned, in favor of the more conventional title of "Storage Systems Division".

IOMEGA CORPORATION
1821 West Iomega Way
Roy, UT 84067

1996 disk sales: $146,900,00
1996 total net sales: $1,212,769,000 Net income: $57,328,000

Iomega, founded in 1980, was successful in establishing production capability for its unique 8" flexible disk drive, which maintained control of head/disk contact with the Bernoulli effect. The product was originally intended as an OEM drive, but Iomega had much better luck with subsystems sold in the personal computer add-on market. The original 8" drives for the IBM PC market provided most of the company's revenue growth until displaced by the 5.25" models in production from 1987 to 1996. But time passes on, and the Bernoulli drive product line is now out of production, as Iomega moves on to new products with much larger markets.

Attempting to broaden its product coverage, Iomega licensed the Insite Peripherals "floptical" drive and media, and selected Chinon as a manufacturing partner for the drive. Iomega's 20 megabyte "floptical" drive was introduced in 1992, but was discontinued in 1994 after only limited sales success. That venture convinced Iomega's management that a comparable drive with higher capacity and the right price could be a success. The result was the 100 megabyte "Zip" 3.5" floppy drive, which began shipments in early 1995, and has found a much broader market, due to its unique combination of 100 megabyte disk capacity and less than $200 drive list price. In mid-1997, the company announced that more than 6 million Zip drives had been shipped.

The one gigabyte "Jaz" drive, which first shipped in late 1995, marked Iomega's entry into the rigid cartridge disk drive market. The Jaz was produced for Iomega under contract by Sequel until the Autumn of 1996, then Iomega moved manufacturing to its own factory in Penang, which was purchased in 1996 from Quantum, when that company discontinued internal manufacturing of high-end rigid disk drives.

JTS CORPORATION
166 Baypoint Parkway
San Jose, CA 95134

1996 disk sales: $119,200,000
1996 total net sales: $119,500,500 (FY ending 2/2/97) Net income: ($152,400,000)

Kalok was founded in 1987 to participate in the market for 20 and 40 megabyte 3.5" drives, designed for very low manufacturing cost. Unable to obtain adequate funding from U.S. venture capital sources, the firm negotiated a manufacturing and inventory financing arrangement with Oriental Precision Company of South Korea. OPC started manufacturing Kalok drives in mid-1988 with substantial shipment levels, but dropped out of the game a few years later after being acquired. In order to broaden its production base, Kalok in 1989 also established a plant in the Philippines, the first hard disk drive producer to do so. In late 1991, Kalok sold its Philippines factory to Xebec Co. Ltd., a Japanese firm, and subsequently sold its entire stepping motor drive product line to Xebec, retaining only the design for a .5" high 3.5" drive family. After a series of management changes and a Chapter 11 filing, Kalok began actively selling a removable version of the .5" high drive.

In February, 1994, Kalok was reorganized as JTS with investment from Jugi Tandon, one of the disk drive industry's pioneers in developing high volume disk drive manufacturing for both floppy and rigid disk drives. The current JTS program is centered on the "Nordic" 3" drive, which is intended to offer extremely aggressive price competition to 2.5" drives for notebook computer applications, plus 3.5" drives for the desktop personal computer market. Manufacturing is now at a plant at Madras, India, at a facility originally controlled by the Tandon family. In early 1996, JTS was merged with Atari, with JTS the successor company, and with complete concentration on the disk drive product lines.

MAXTOR CORPORATION (See Asian Manufacturers)

MICROPOLIS PTE. LTD. (See Asian Manufacturers)

QUANTUM CORPORATION
500 McCarthy Boulevard
Milpitas, CA 95035

1996 disk sales: $4,372,000,000
1997 total net sales: $5,319,457,000 (FY ending 3/31/97) Net income: $148,515,000

Quantum's original product strategy was to manufacture an upgrade to the Shugart Associates 8" Winchester drives. The Quantum plan worked well, and

5.25" drives with capacities up to 40 megabytes were added in 1983, becoming the company's major product. As the Quantum full-size 40 megabyte 5.25" drives peaked, the firm announced half high OEM 5.25" drives with up to 80 megabytes, but shipment was late, and Quantum's sales growth flattened out. In 1985, the company established Plus Development as a wholly owned subsidiary, to pioneer development and marketing of the Plus Hardcard, an innovative plug-in card for the IBM personal computer aftermarket, combining a 3.5" Winchester and all controller electronics on a single add-in card. Manufacturing was contracted out to Matsushita-Kotobuki Electronics.

Quantum was able to reestablish growth in OEM drive shipments in 1987, through successful implementation of an emergency plan to quickly develop an OEM 3.5" drive using the Hardcard design and tooling, with manufacturing by Matsushita-Kotobuki Electronics. While Quantum has designed all of its 3.5" and 2.5" drives, manufacturing drives for personal computer and mobile applications is done by MKE, in factories located in Japan, Singapore and Ireland. MKE has rights to distribute drives it manufactures within Japan, under a Quantum license. The Quantum-MKE relationship is successful and contributed to gross margins typically higher than the industry averages, until the price wars of 1993.

In August, 1993, Quantum formed separate operating groups for high capacity storage, to manage the development, production and marketing of the high-end 3.5" drives then manufactured at Milpitas. Quantum hoped to give its high capacity product line a boost in 1994 when the firm purchased Digital's OEM storage products business, adding Digital's lines of high capacity disk drives, tape drives, and thin film heads (including Digital's 80% share of MR head producer Rocky Mountain Magnetics) to its product portfolio. Along with the products came major design and manufacturing facilities in the U.S. and Southeast Asia, plus approximately 5,000 employees, providing Quantum with a major management challenge to digest all of the new resources without losing momentum. After more than a year of trying, Quantum found the Digital acquisition difficult to integrate with its existing high-end disk drive operation, resulting in a 1995 reorganization of executive management, closing out its high-end disk drive manufacturing operations, and turning over production of high-end drives to MKE.

RAYMOND ENGINEERING (Subsidiary of Kaman)
217 Smith Street
Middletown, CT 06457

Raymond Engineering was founded in 1938 as a specialty electromechanical components supplier, and is today a subsidiary of Kaman, a large military electronics contractor. The Memory Systems Division of Raymond Engineering provides ruggedized and mil-spec data storage subsystems, using some disk drives which are internally manufactured, plus repackaged disk and tape drive mechanisms and flash memory based subsystems.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1996 disk sales: $7,726,700,000
1996 total net sales: $8,588,350,000 Net income: $213,261,000
(FY ending 6/28/96)

In 1981, Seagate shipped two thirds of the 5.25" drives produced worldwide, with 35,000 units -- and another de facto standard was created. Seagate took the lead in moving production for its high volume drives offshore to secure lower manufacturing costs. But the world changed for Seagate in mid-1984, with a sharp reduction in sales to its largest customer, IBM -- and an up-and-down buying pattern which continued in 1985. Through tough management, Seagate stayed profitable, rebuilt its revenues, and starting in 1986 became the worldwide leader in OEM disk drive revenues.

After 1985, a major part of Seagate's growth came from the personal computer aftermarket. IBM cut back purchases of Seagate drives in favor of internal captive production, but Seagate launched a successful campaign to take the business away from IBM at the dealer level, with phenomenal success. But the company was vulnerable to IBM's "bundling" hard disk drives with systems at the factory instead of giving dealers an easy opportunity to upgrade with independent disk drives. The effect of this bundling, plus Seagate's late arrival in the 3.5" marketplace, cut into Seagate's shipment rate. The firm overestimated the market in early 1988, causing excess inventory accumulation and disappointing financial results. However, Seagate demonstrated the resiliency likely to be necessary for future survival, and returned to profitability in 1989.

In October, 1989, Seagate completed an agreement with Control Data to acquire Imprimis Technology in a deal valued at $450 million. There was little overlap between the product lines of Seagate and Imprimis, or between Seagate's predominantly aftermarket distribution and Imprimis' predominantly OEM sales. In late 1991, the company made key changes in executive management in an attempt to reassert product leadership and was successful in establishing an aggressive product development program.

The new Seagate has maintained an aggressive pace of product development and market leadership with the high-end 5.25" and 3.5" drives developed at the Oklahoma and Minneapolis operations. High-end 3.5" drives in 5,400, 7,200, and 10,000 RPM models offer capacities up to 9.1 gigabytes. 1" high 3.5" drives at the 1 gigabyte level went into production in the first half of 1993 and were subsequently extended to 4.5 gigabytes. The Elite 5.25" drive series was successfully extended to a successful 9 gigabyte model, then to 23 gigabytes in late 1996.

During the 1993 disk drive price wars, Seagate, alone among the major independent drive producers, maintained consistent profitability as a result of the firm's strength in high end drives and a notable disinclination to price below levels returning a reasonable gross margin. During 1994 Seagate began diversifying into additional markets, acquiring several firms specializing in storage related software, and the company has established a major program to become a major factor in the storage management software market. In September, 1995, Seagate announced an agreement to acquire Conner Peripherals. The acquisition was consummated in early 1996, providing Seagate with major expansions in several areas, including internal disk media manufacturing, low end 3.5" drives for desktop personal computer markets, and a tape drive product line derived from the Conner 1992 acquisition of Archive.

SEQUEL, INC.
2300 Central Expressway
Santa Clara, CA 95054

Sequel was created in November, 1989, as the result of a management buy out of the Unisys rigid disk drive and media production facilities. Sequel supplies new drives to other companies on a contract manufacturing basis, as well as refurbishing older drives. The firm also supplies some media on an OEM basis. Shortly after its establishment, Sequel acquired the rights to manufacture several of Priam's product lines, and has since acquired rights to most of Maxtor's older 5.25" drives, plus some of the Digital Equipment and Seagate Technology older drives. Sequel also carried out a contract manufacturing program for the Iomega Jaz 3.5" disk cartridge drive during that product's first year of production.

SYQUEST TECHNOLOGY
47071 Bayside Parkway
Fremont, CA 94538

1996 disk sales: $75,100,000
1996 total net sales: $200,400,000 (FY ending 9/30/96)   Net income: ($136,700,000)

SyQuest was started in early 1982 to make rigid disk drives using 3.9" (100 mm) plated disks, in both fixed and removable disk cartridge configurations, but after several years of production 3.9" disks were displaced by industry standard sizes. The firm began shipping 5.25" disk cartridge drives with formatted capacity of 44 megabytes and embedded SCSI controllers in 1988, achieving significant success in the Macintosh add-on market, and with its 5.25" disk cartridges, eventually becoming the dominant "prepress" interchange standard for graphics and desktop publishing. In 1989, SyQuest began manufacturing in Singapore.

In the 1990's, SyQuest increased the capacity of its 5.25" cartridge disk drive series to 88 megabytes, then to 200 megabytes. A 3.5" disk cartridge drive program resulted in first shipments of 105 and 270 megabyte models in 1993. SyQuest also manufactures the disk cartridges for the drives, and cartridges account for about half of the firm's revenue. A unique 1.8" drive was announced in 1995, utilizing a disk cartridge designed to be removable from a PC Card Type III disk drive, but the project was stopped in early 1996.

The EZ135, a 135 megabyte drive marketed as a counter to the high capacity floppy Iomega "Zip" drive, began shipping in mid-1995, but the product was a major financial drain and production was stopped in mid-1996. SyQuest has suffered financial difficulties since mid-1995, as the result of costs which were higher than expected for the EZ135, combined with significant penetration of traditional SyQuest markets by both the Iomega Zip drive and the Jaz 1 gigabyte rigid disk cartridge drive. As the result of the company's continuing financial losses, a major management reorganization was undertaken, 60% of the company's employees were laid off, and the company's activities were refocused on new products. The 230 megabyte EZFlyer 3.5" drive replaced the EZ135, and the new 1.5 gigabyte SyJet went into production in early 1997, with the mission to reclaim the high-end disk cartridge market from the Iomega Jaz.

WESTERN DIGITAL CORPORATION
8105 Irvine Center Drive
Irvine, CA 92718

1996 disk sales: $3,533,000,000
1996 total net sales: $2,865,219,000 (FY ending 6/29/96) Net income: $96,894,000

Western Digital, at the time a major supplier of controllers and specialized semiconductor components, entered the rigid disk drive market by purchasing the rigid disk drive operations of Tandon at the end of 1987. Western Digital plans to be a broad-line disk drive producer, and has maintained a disk drive development facility in San Jose for several years to develop drives for the personal computer market. The company has aggressively moved from heavy dependence on aftermarket distribution with the original product line purchased from Tandon to a primary emphasis on OEM sales. WD's early development and shipment of a two platter 340 megabyte 3.5" drive in the first half of 1992 boosted the firm's share of the personal computer disk drive market, and impacted the product development plans of most competitors. Western Digital has continued a program of aggressive development for its Caviar 3.5" drive product line for the desktop personal computer market, with capacities now up to 3.2 gigabytes. WD has also reentered the disk drive market for notebook computers in 1996 with 3" drives, hoping to provide a cost-effective product line to compete with the 2.5" drive market leaders.

Western Digital is currently engaged in a major expansion program to build a major position in the high capacity 3.5" drive market, with a high-end development facility in Rochester, Minnesota, and a new factory in Singapore. The company started production in the second half of 1996 with its initial high-end product line of 2.17 and 4.36 gigabyte 1 " high 3.5" drives, using inductive thin film heads, to facilitate the initial production ramp. WD has indicated that the product line will be enhanced with a 9.1 gigabyte model using MR heads by the end of 1997.

Asian Manufacturers

(All fiscal years end in March, 1997, unless otherwise noted. All companies are in Japan unless otherwise noted.)

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

1996 disk sales: $1,306,100,000
1997 total net sales: $41,399,835,000 Net income: $424,223,000

Fujitsu derives about 68% 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 magnetic disk drives to a product line consisting mainly of fixed disk drives in all capacity ranges and in several disk diameters. Fujitsu is a leading producer of 3.5" optical drives and 3.5" optical libraries. Over 90% of Fujitsu's rigid drive production is currently done outside Japan, in Thailand and the Philippines. Intellistor, located in Longmont, Colorado, is a Fujitsu subsidiary which has developed small diameter disk drives and drive arrays. Fujitsu also has 44% ownership in Amdahl.

Fujitsu has marketed most of its captive drives in OEM versions also, using industry standard interfaces, and is a serious contender in the market for OEM rigid disk drives. Fujitsu is also a participant in the enterprise systems plug compatible disk drive market through products sold by Amdahl. Particularly effective in the OEM market during the 1980's was the series of high performance 8" 48/84/168/337/690/824/1000/2000/2600 megabyte drives. Development of new 5.25" drives was halted in mid-1994 in favor of 3.5" drive development. An extensive 3.5" line now extends to 9.1 gigabytes. A 240 megabyte 2.5" drive was added in 1993, followed by a series of drives with capacities now up to 1.6 gigabytes.

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

1996 disk sales: $409,100,000
1997 total net sales: $78,351,000,000 Net income: $812,006,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major manufacturer of computer systems. 50% of the company's sales are in equipment for information 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 data storage subsystems in the IBM compatible mainframe and midrange market through Hitachi Data Systems (formerly National Advanced Systems, before acquisition by Hitachi), and in 1983 started selling PCM drives for distribution in the European PCM market through BASF, and currently through Comparex. Hitachi was the first independent disk drive supplier to ship a double capacity drive equivalent to the IBM 3380E, and was an early supplier of 3380K equivalent drives. In recent years Hitachi used a 6.5" drive series for IBM plug compatible drive subsystems, including a 3390-9 equivalent subsystem, before transitioning to high capacity 3.5" drives. In 1987, Hitachi began shipping rigid disk drives from a manufacturing facility in Norman, Oklahoma, making high-end rigid disk drives and 5.25" optical disk drives. The company also manufactures an extensive line of OEM 3.5" disk drives that extend up to 9.1 gigabytes.

In September, 1993, MiniStor and Hitachi announced agreements under which MiniStor licensed Hitachi to utilize the firm's 1.8" drive technology. The two companies then jointly developed a family of high capacity 2.5" disk drives, and subsequent development by Hitachi extended the 2.5" series to 3.2 gigabytes, with areal density of 2 gigabits per square inch, the highest in the industry at that time. Plans for 1.8" drives terminated after MiniStor went out of business.

MATSUSHITA-KOTOBUKI ELECTRONICS INDUSTRIES, LTD.
2-2-10, Kotobuki-machi
Takamatsu City 760

1996 total net sales: $5,084,000,000 (FY ending 3/31/96) Net income: $72,000,000

During the 1980's, Matsushita-Kotobuki Electronics concentrated on production of VCRs on an OEM basis for a number of U.S. consumer electronics manufacturers and distributors, as well as for sale under the Matsushita "Panasonic" brand name. In more recent years MKE became the largest producer of CD-ROM drives, which are sold mostly through other Matsushita group companies, and has undertaken a new manufacturing program for 120 megabyte 3.5" "floptical" drives. Matsushita Electric Industrial owns 57.6% of MKE.

In 1985, Plus Development established a contract manufacturing arrangement with MKE for the Hardcard, which evolved into a manufacturing program for the highly successful 3.5" OEM drives offered by Plus' parent company, Quantum Corporation. MKE has the rights to sell the Quantum drives under license in the Japanese domestic OEM market, and activated a marketing program in 1989, but with limited results. MKE produces rigid disk drives in Japan and in a recently expanded Singapore facility, and established a subsidiary in Ireland to manufacture Quantum products for the European market. In early 1996, Quantum turned over the balance of its disk drive production to MKE, including high end drives previously manufactured in California and in plants acquired with the purchase of the Digital Equipment disk drive product line.

MAXTOR CORPORATION
Subsidiary of Hyundai Electronics America
510 Cottonwood Drive
Milpitas, CA 95035

1996 disk sales: $1,072,200
1996 total net sales: $1,113,800 Net income: ($296,000,000)

Maxtor startled its competitors in 1982 by announcing a family of 5.25" drives with up to 140 megabyte capacity. These drives went into production in mid-1983, later joined by 190 megabyte drives in 1984 and the industry's first 380 megabyte drives in 1985. Maxtor became the first company to find space in the standard 5.25" form factor for eight disks, and thus was able to achieve high capacities while maintaining the standard Seagate transfer rate of five megabits per second -- a strategy which proved successful with OEMs wishing to use standard ST412 controllers. In preparation for the ten megabit per second transfer rate required by the 380 megabyte drive, Maxtor became the industry leader in establishing the ESDI interface standard, initially widely used for high performance 5.25" drives.

Maxtor entered the optical disk drive business in 1988 with a magneto-optical 5.25" drive produced by a joint venture with Kubota, maintaining the Maxtor role as a leading edge supplier of OEM disk drives. In 1990, Maxtor acquired the MiniScribe product line and manufacturing facilities, providing the firm with a 1" high 3.5" drive product line and a 2.5" drive that was ready to be announced.

Starting with the departure of several key employees in 1987, a continuing succession of management changes, combined with the numerous internal changes which followed, disrupted Maxtor's ability to continue the pioneering product development activities upon which most of the company's growth was based. Most of Maxtor's current revenues are derived from 3.5" drives sold for personal computer applications. After a strong initiative to secure leadership in 1.8" PCMCIA disk drives found a much smaller available market than anticipated, Maxtor discontinued the 1.8" drives in 1995.

In 1994, Maxtor improved its financial status when Hyundai invested heavily in the company, acquiring approximately 40% of the firm, and in 1995 Maxtor transferred all of its manufacturing facilities to Hyundai. In November, 1995, Maxtor's board of directors agreed to a Hyundai offer to acquire the remainder of the outstanding Maxtor shares. Following shareholder approval early in 1996, Maxtor became a wholly owned subsidiary of Hyundai Electronics America, in turn a subsidiary of Hyundai Electronics Industries Company, Ltd. The Maxtor headquarters has been relocated to Milpitas, but product development remains in Longmont, Colorado, with manufacturing in Singapore.

MICROPOLIS PTE. LTD.
Subsidiary of Singapore Technologies
5, Serangoon North Ave 5
Singapore 554916

1996 disk sales: $195,800,000

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 became a factor in the marketplace, after the usual Winchester early production problems. Micropolis was the 5.25" industry leader at 85 megabytes and 170 megabytes, and a close contender for leadership at 380 megabytes, 760 megabytes, and the 1-2 gigabyte range. Heavy price competition and delays in getting newer products into volume production hurt Micropolis' financial results during the late 1980's, and the firm had to cancel its 3.5" development program in order to concentrate on 5.25" drives. After returning to profitability in 1990, Micropolis reentered the 3.5" drive market in 1991 with the first announced 1 gigabyte 3.5" drive. Although an earlier effort had been aborted, Micropolis succeeded in entering the disk array market in late 1991, creating a separate division to market a modular array in the subsystem market.

Although the firm's disk drive sales growth stagnated in recent years, Micropolis hoped that its high-end 5.25" and 3.5" disk drives would give it a strong position in the nascent video-on-demand server market and that VOD related sales would reignite company growth. It was clear by mid-1995 that the array and video equipment markets would not immediately restart Micropolis' earlier growth, and after production problems created major losses, a change in management occurred.

In January, 1996, the new management reached an agreement to sell the company's disk drive business, consisting of the Micropolis name, the disk drive product line and disk drive manufacturing facilities to Singapore Technologies, a Singapore government controlled manufacturing conglomerate with numerous technology enterprises. Micropolis shareholders voted approval of the deal and it was consummated at the end of March, 1996. The array and subsystem businesses owned by Micropolis Corporation were retained, and the company changed its name to StreamLogic Corporation. The disk drive business owned by Singapore Technologies was named Micropolis Pte. Ltd., with headquarters and manufacturing in Singapore, while product development and marketing remain at the previous company headquarters in Chatsworth, California. The new Micropolis now occupies a new, much larger factory in Singapore and is concentrating its efforts on 3.5" high performance drives, plus a new family of IDE drives for the upper range of the desktop personal computer market.

MOMENTUM PERIPHERALS PTE. LTD.
3 Tech Park Crescent
Singapore 638129

Headquartered in Singapore, Momentum was formed to acquire the factory originally established in Singapore by MiniStor to manufacture 1.8" disk drives. The factory and its equipment were purchased from local bankruptcy proceedings, but without purchasing the MiniStor product designs. Momentum's product line consists of 130 and 170 megabyte 1.8" PC Card drives, with production undertaken on an occasional basis, when orders for the distributor market are received.

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

1996 disk sales: $706,900,000
1997 total net sales: $45,505,000,000 Net income: $1,114,000,000

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 produced in recent years have included 9", 5.25", 3.5", 2.5" and 1.8" disk diameters. All except the 3.5" drives have been phased out. Sales of 3.5" drives have been enhanced by NEC's leadership position in the Japanese personal computer market. 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, and the firm increasingly relies upon its offshore production facilities.

SAMSUNG ELECTRONICS CO., LTD.
7, Soonwha-dong
Chung-ku
Seoul, South Korea

1996 disk sales: $320,200,000
1995 total net sales: $20,948,000,000 Net income: $3,242,000,000

Samsung Electronics, founded in 1969, is Korea's largest electronics company, producing a variety of consumer, industrial and computer products. The firm is the leading supplier of DRAM chips and is becoming increasingly visible in the rigid disk drive market. Samsung made a minority investment in Comport, a 1987 U.S. startup, and manufactured Comport's 3.5" line of disk drives until Comport went out of business. Samsung's production of disk drives is currently entirely in 1" high 3.5" models targeted for the higher capacity range used with personal computers, extending up to 5.1 gigabytes. Samsung arranged for development of 2.5" drives by Integral Peripherals, with production start planned for 1996, but has not entered the 2.5" disk drive market. Samsung maintains an R&D center for disk drive design in San Jose.

SEIKO EPSON CORPORATION
80 Hirooka
Shiojiri-Shi
Nagano 339-07

Epson is a member of the privately held Suwa Seikosha/Epson group owned by members of the Hattori family, which also controls Japan's Seiko companies, known for watches and electronics. Epson is best known for its printers, but also has manufactured and marketed portable computers, displays, and floppy, optical and rigid disk drives. The company remarkets a Type III PC Card rigid disk drive made by Integral Peripherals.

TAE IL MEDIA CO., LTD.
456-1 Moknae-dong, Ansan
Kyunggi-do
South Korea

Tae Il was established in 1983 and has become a diversified manufacturer of heads and disks for the disk drive industry, plus heads for tape drives, and other electronic components, including printer components, monitors, batteries and a variety of specialized parts. In 1995, the company initiated an expansion program into completed disk drives, starting with flexible disk drives and CD-ROM drives. The program initially included a 1.2 gigabyte 3.5" rigid disk drive for personal computer applications, but the company's rigid disk drive program is now inactive. Manufacturing for the disk drive programs will be centered at a Tae Il facility at Harbin, China, with initial sales programs concentrating on the emerging China market.

TOSHIBA CORPORATION
1-1-1 Shibaura
Minato-ku, Tokyo 105

1996 disk sales: $1,632,300,000
1997 total net sales: $50,101,000,000 Net income: $1,153,705,000

Toshiba is a major factor in consumer electric and electronic products, plus a wide range of industrial electronic products and heavy electric power equipment. The company also has a leading position in the Japanese office computer market. About 61% of revenues are derived from computing and communications products.

Rigid disk drive production at Toshiba has a history of more than two decades including 14", 8", 5.25", 3.5" and 2.5" disk diameters. Toshiba's presence in the U.S. OEM rigid disk drive market was enhanced when it acquired the OEM disk drive operations of Memorex from Burroughs, and Toshiba continued to expand its U.S. operations, establishing a design center in Southern California. Toshiba then dropped most of its 5.25" drives in order to concentrate on 3.5" and smaller form factors. In 1992, the company established a San Jose factory to manufacture high-end 3.5" drives originally developed at its design center in Southern California, but after it became clear that the firm's product designs would be eclipsed by the industry leaders, it phased out the 3.5" San Jose program.

Toshiba has established a very successful 2.5" disk drive series, as a result of an aggressive development program which provided a significant share of the industry's product leadership in 2.5" drives in the early 1990's. In 1993, the company was the first to produce a single platter 126 megabyte 2.5" drive, plus the first to offer a 340 megabyte 2.5" model. Toshiba's 2.5" line now extends to 3.3 gigabytes. Like many other Japanese companies, Toshiba is shifting its rigid drive production offshore, with a factory in the Philippines.

TOTTORI SANYO ELECTRIC CO., LTD.
7-101, Tachikawa-cho
Tottori City, 680

Following a Sanyo Electric investment in Areal Technology, a California disk drive company founded in the late 1980's by U.S. industry veterans, Tottori Sanyo started production of 2.5" drives in 1991, with all sales initially under the Areal name. Despite successful development of follow-on products by Areal and establishment of an active sales program in the U.S. OEM market, the U.S. operations were closed except for service personnel in 1995. Several of the Areal 2.5" drives remained in production at Tottori Sanyo, sold primarily in Asian markets by Sanyo and a sales company, but were phased out as the market moved to higher capacities.

European Manufacturers

CALLUNA TECHNOLOGY LTD.
Blackwood Road, Eastfield
Glenrothes, Fife KY7 4NP
Scotland

Calluna Technology was founded to design and manufacture 1.8" drives in Glenrothes. The founders were all veterans of Rodime, the pioneer manufacturer of 3.5" drives, and many were previously with the Burroughs disk drive manufacturing facility in Glenrothes. Calluna occupied a new industrial building early in 1992 and started production of disk drives in the PCMCIA Type III PC Card format in mid-1993. The PC Card drive product line has since been expanded, and currently includes drives with capacities up to 520 megabytes. Production of the 520 megabyte drive was initiated in 1997, utilizing a contract manufacturing arrangement with Xyratex, the firm which resulted from a management buyout of IBM's facilities at Havant, U.K.

COMPAREX INFORMATIONSSYSTEME GMBH
Subsidiary of BASF
Gottlieb-Daimler-Strasse 10
D-6800 Mannheim
West Germany

Comparex became operational at the beginning of January, 1987, as a joint venture operation comprising the former BASF and Siemens PCM businesses, marketing systems and peripherals made by Fujitsu and Hitachi, with a concentration in recent years on Hitachi products. In late 1991, the owners announced BASF's assumption of complete ownership. Current disk drive activities involve drives produced by Hitachi for plug compatible mainframe and midrange systems, plus optical drive, semiconductor and tape drive storage systems made by third parties. In 1992, Comparex and Hitachi Data Systems announced an agreement under which Comparex controls distribution of Hitachi mainframes and peripherals in Germany and Eastern Europe, and HDS handles distribution in most of the rest of Europe and in the Middle East.

EUROSTOR S.A./D.D.O. S.A.
Velazquez, 17-3D
28001 Madrid
Spain

After establishing a factory at Cadiz and starting to manufacture 240 megabyte 3.5" drives in 1995, Eurostor/D.D.O. later halted the program when it became clear that the market for drives in that capacity range had collapsed. The organization regrouped with an expanded management organization, new designs by a California firm for 3.5" drives targeted at the personal computer market, additional financing by European public agencies, an additional manufacturing plant at La Caruna, and entry into the European market was planned for the second half of 1996. However, the 1996 Spanish national election resulted in a change in government, and a different economic philosophy. Public funding for the new enterprise has dried up and its future is uncertain.

NOMAI
188, rue de la Liberte -- B.P. 141
50301 AVRANCHES cedex
France

Nomai entered the data storage market in 1992 as a manufacturer and marketer of rigid disk drive cartridges compatible with SyQuest 5.25" drives. After a flurry of legal actions by SyQuest were settled, Nomai was successful in setting up extensive distribution for the disk cartridge product line, including the temporary enlistment of Iomega as a reseller.

In 1995, the company announced the development of high capacity 3.5" rigid disk cartridge drives, with initial shipments starting at the end of 1995. The basic 540 megabyte drive design was done in Scotland by Myrica (U.K.) Limited, a design firm staffed with Rodime graduates, with technology assistance from universities in the U.K. and France. The drive is being manufactured at Havant in the U.K. by Xyratex, the IBM spin-off, and is sold by both Nomai and Xyratex. In the Spring of 1997, Nomai added a 750 megabyte disk cartridge drive to its product line, also manufactured by Xyratex.

RODIME LTD.
Nasmyth Road
Southfield Industrial Estates
Glenrothes, Fife KY6 2SD
Scotland

After being formed in late 1980 by key personnel from the Burroughs facility in Glenrothes, Rodime met its schedule for shipments in 1981, and until 1986 continued to achieve a healthy growth rate. With the decline of its older 5.25" models, Rodime's sales increasingly relied on shipments of 3.5" drives, which it was the first to ship in 1983. The company had difficulty in keeping up with the industry's short product life cycles, and in early 1989 top management was completely overhauled as Rodime came perilously near bankruptcy. New financing was obtained, but Rodime never returned to profitability. In mid-1991 Rodime announced that it would file for bankruptcy and cease manufacturing of drives.

Rodime surprised the industry by obtaining patent coverage on the form factor of a 3.5" drive -- claiming no new technology, only a reduction in size. The firm then sued MiniScribe and Conner Peripherals for patent infringement. When IBM announced the PS/2 family, which used 3.5" drives, it sued Rodime to invalidate the patent, and Rodime bravely met the challenge by countersuing IBM for patent infringement. MiniScribe opted out of the legal proceedings by taking a license.

In the meantime, after extensive patent office preliminaries, the affair began a long tour of the U.S. federal court system which ended when IBM and Conner took licenses. Although several other companies have signed up for Rodime licenses, legal proceedings have lingered on. Appeals court rulings in 1995 and 1996 appear to have weakened the Rodime negotiating position, but Rodime continues to argue that other patent claims are still valid.

SAGEM
(Societe d'Applications Generales d'Electricite et de Mecanique)
La Ponant, 27, rue Leblanc
75512 Paris CEDEX 15
France

SAGEM is active in the fields of military electronics, telecommunications, office systems, industrial and military equipment and computer peripherals. The firm's earliest disk drives were head-per-track designs. In 1986, SAGEM introduced a unique 5.25" Winchester drive with multiple heads per slider, sold as a military subsystem. The firm's more recent products have focused upon a line of militarized removable disk drives with 200 megabytes capacity.

XYRATEX (Havant International Ltd.)
P.O. Box 6, Langstone Road
Havant, Hampshire PO9 1SA
United Kingdom

Xyratex was created in December, 1994, as the result of a management buy out of IBM's Havant facilities. Xyratex, the firm's brand name at the time of the buy out, became the company's new name. Products include disk drives, flexible circuits, storage subsystems (including disk drive arrays), test systems and networking equipment, which have been produced under contract for a number of clients, including IBM, Calluna, JTS and Nomai. Xyratex also develops and sells specialized software products.

Although "new", the company is of significant size, occupying about 600,000 square feet of space and employing about 2,000 people. The Havant facility has operated at manufacturing levels of more than two million small disk drives per year.

DISK/TREND ON DISK

1997 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 used on the label of each 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.

IMPORTANT NOTE: Since July, 1994, White Crane is shipping version 3.13 or higher of AutoImport. Instructions in this section are written to work with these later versions. If you have version 2.xx of AutoImport, refer to instructions in previous DISK/TREND reports. You must have AutoImport 3.xx to use DISK/TREND ON DISK with these instructions.

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 information on the following page.

DISK/TREND ON DISK

Information License

DISK/TREND supplies diskettes containing selected information from the 1997 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1997 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 the terms and conditions provided by White Crane Systems, Inc., 8255 Overview Court, Suite 100, Roswell, GA 30076.

Trademarks

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 for the Rigid Disk Drive Report is normally shipped on 3.5" 1.44 megabyte diskettes. 5.25" 1.2 megabyte diskettes are available if requested. There will be two diskettes in a set, one containing statistical tables and one containing specification tables.

STATISTICAL TABLES

Loading and Installation

1. Place the floppy disk marked 'Tables' in a floppy disk drive able to read 3.5" 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 commands are:

   COPY A:*.PRN (if you intend to use Lotus 1-2-3 data parsing)
   COPY A:MASK?2.MSK (if you intend to use AutoImport Version 2.xx)
   COPY A:MASK?3.MSK (if you intend to use AutoImport Version 3.xx)

   The utility files named FORMLIN?.PRN are specifically for use with Lotus 1-2-3 data parsing if you prefer not to use AutoImport for file translation.

   Installing AutoImport V3.xx: 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: COPY A:*.* 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 drive A if required by the security provisions of your spreadsheet program. Start your spreadsheet as usual. When the blank spreadsheet appears on the screen, use the 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
   R (Rigid disk drive data)
   O (Optical disk drive data)
   A (Disk drive array data)
   V (Removable data storage data)

   YY= Table number, as shown in the appropriate report volume

   Examples:
   File RT11.WK1 is Rigid Disk Drive Report Table 11
   File OT1.WK1 is Optical Disk Drive Report Table 1
   File AT3.WK1 is Disk Drive Array Report Table 3
   File VT4.WK1 is Removable Data Storage Report Table 4

   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 commands 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 Table 1 and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.
- o FORMLINB.PRN Used with Table 2.
- o FORMLINF.PRN Used with Tables 3 and 4.
- o FORMLIND.PRN Used with Application tables.
- o FORMLINE.PRN Used with Drive Height and Drive Capacity tables.

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 once familiar with data parsing, 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 as files with .MSK file name suffixes) 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 table below which relates table types to specific masks.

MASK TABLE

Mask File Name	Rigid Report	Removable 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 to 6, 11,12,24,25	Tables 5 to 12	Tables 3 to 7
MASKD	<-- All Product Group Application Tables ---->			N/A
MASKE	N/A	Drive height, Drive capacity	Write-Once/ Erasable Analysis	N/A
MASKH	Tables 7,8	Table 31	N/A	N/A
MASKI	<----- Product Group -----> Price/Megabyte		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	1997 Rigid Report	1996 Removable Report	1996 Optical Report	1996 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	MASKC
6	MASKC	MASKC	MASKC	MASKC
7	MASKH	--	MASKC	MASKC
8	MASKH	--	MASKC	--
9	MASKC	MASKA	MASKC	--
10	MASKC	MASKA	MASKC	MASKA
11	MASKC	MASKC	MASKC	MASKA
12	--	MASKC	MASKC	--
13	--	--	--	--
14	MASKA	MASKI	--	--
15	MASKA	--	--	--
16	--	MASKI	--	MASKA
17	--	--	MASKA	MASKA
18	MASKD	MASKI	MASKA	--
19	MASKI	--	--	--
20	--	MASKI	--	--
21	MASKA	--	MASKD	MASKD
22	MASKA	MASKA	--	--
23	--	MASKA	MASKA	MASKA
24	--	MASKC	MASKA	MASKA
25	MASKD	MASKC	--	--
26	MASKI	MASKA	--	--
27	--	MASKA	MASKA	--
28	MASKA	MASKA	MASKA	--
29	MASKA	MASKA	--	MASKA
30	--	MASKH	--	MASKA
31	--	MASKD	MASKD	--
32	MASKD	--	--	--
33	MASKI	MASKA	MASKD	--
34	--	MASKA	--	--
35	MASKA	--	MASKA	
36	MASKA	--	MASKA	
37	--	MASKI	--	
38	--	MASKD	--	
39	MASKD	--	MASKE	
40	MASKI	MASKA	MASKD	
41	--	MASKA	--	
42	MASKA	--	MASKA	
43	MASKA	--	MASKA	
44	--	MASKD	--	
45	--	--	--	
46	MASKD	MASKA	MASKA	
47	MASKI	MASKA	MASKA	

Cross-reference (continued)

Table Number	1997 Rigid Report	1996 Removable Report	1996 Optical Report	1996 Array Report
48	--	--	--	
49	MASKA	--	--	
50	MASKA	MASKD	MASKE	
51	--	--	MASKA	
52	--	MASKA	MASKA	
53	MASKD	MASKA	--	
54	MASKI	--	--	
55	--	--	MASKE	
56	MASKA	MASKE	MASKA	
57	MASKA	MASKE	MASKA	
58	--	MASKD	--	
59	--	--	--	
60	MASKD		MASKE	
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:MASK?2.MSK *.MSK (if using AutoImport version 2.xx)
   COPY A:MASK?3.MSK *.MSK (if using AutoImport version 3.xx)

   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 "File" menu bar item using the mouse keys or just type /F. (The AutoImport menu system works like the menus in Lotus 1-2-3.)

3. When the next screen appears (File Selection Menu), use the arrow keys or the mouse to select the Mask Name option, then press (or click on) the down arrow to get a list of mask names. 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' (or double click on the selected name). Now position the cursor on the "RETRIEVE MASK" button and select it to load the mask.

4. Select the Input File Name option on the File Selection Menu.

   Enter the name of the file, <u>including the extension</u>, which will be of the form yy? where yy is the year of the report and ? is the report type as above.

   Examples: RT4.97R OT14.97O AT19.97A VT6.97V

5. Select the Output File Name option on the File Selection Menu. (Should always be done after mask retrieval.)

   Enter the name of the file. The file name form recommended is ?Tnn, where ? is the type of report (A, R, V, 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 OT14 AT19 VT6

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 selecting Format from the File Selection Menu and then selecting your preference from the menu of choices displayed.

7. You are ready to translate. Please recheck all the file names displayed to be CERTAIN they are correct. Select the "CONVERT" button using the mouse or arrow keys and ENTER. If you are asked "Do you want to load input file named in mask?", answer "NO". You will see the file being translated scroll by as the translation proceeds. If it does not scroll during translation, you may have a damaged mask file. See the next section for details on mask file creation.

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 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 "File" using the arrow keys or type /F.

2. Select the Input file name option on the File Selection Menu and name the input 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, O, A or V), nn is the table number and yy is the report year.

   Example: RT50.97R

   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 top left of the report table. Now select "Lines" from the menu bar, then select "Headings" from the pop-up window that opens. Using the down arrow key, expand the highlighted area until it extends to just above the first row of numerical data. Press ENTER. The area that will be treated as header will be displayed in bright red.

   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, selecting "Lines" and "Headings" again and 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. Select "Column" from the menu bar, the "Auto Define". 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. Select "Column", then "Width & Move". Select the column you wish to adjust with the mouse (or arrows & ENTER), and then use the arrow keys to move the right column margin clear of the column of values. If you need to move an entire column without changing width, use the arrow keys while depressing the CONTROL key.

5. Save the mask in a mask file. Select "File", then "Mask", then the SAVE MASK button. Fill in the name of the mask file when asked.

   Example: RT50MSK

6. Name the output file, as described in the previous section.

   Example: RT50. You don't need to enter the file extender.

   To create the output file, use the "CONVERT" button as before.

7. To make more masks, repeat from step 2. To quit AutoImport and return to DOS, type /QY (quit).

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

The rigid disk drive specifications may be supplied on two diskettes if 5.25" diskettes were supplied to you or one diskette if otherwise. If you are using two diskettes, specification diskette 1 contains the specifications for DISK/TREND product groups one through five. The other diskette contains specifications for groups six through nine. If your computer has enough memory (it may require expanded memory in some cases) you can load the two data bases sequentially into one large data base for ease of data manipulation. See the comments in the Operating Tips section.

Loading

1. If you have a two floppy disk system: Place the floppy disk marked "Specifications" in a floppy disk drive. 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.

   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*.*

2. 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

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 needed for copy protection. 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= O (Optical disk drive data)
R (Rigid disk drive data)
A (Disk drive array data)
V (Removable Data Storage 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: RS197 Rigid disk specification table, Groups 1 to 5
RS297 Rigid disk specification table, Groups 6 to 9
RS397 Complete specification table: supplied on 1.44 megabyte 3.5" diskette.

Note that the specification tables load directly as a data base. You can use the various 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:

- o There are other 'pop-up' programs resident in the memory of your computer. These should be removed.
- o 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.
- o 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 may have to remove other resident programs and reload Lotus 1-2-3 and the data base. If your computer doesn't have at least 640K of RAM memory, you will probably get this message.

Combining specification data bases: Lotus 1-2-3 makes it possible to combine worksheets into a larger worksheet. If you think your computer has enough memory, you can combine the specification data bases by doing the following:

1. Load the worksheet RS197 from the specification diskette (specification diskette 1 if you have 1.2 megabyte diskettes) into a new worksheet. Now move the worksheet cursor to column A and the row just under the last manufacturer's name.

2. Load the worksheet from RS297 from the specification diskette (or specification diskette 2) using the Lotus command /FCC.

3. Edit the worksheet to remove the header and criteria range areas that were loaded with the second worksheet.

4. Using the data query (/DQ) command, select the new input range so that it covers the entire worksheet area in which there is data. Remember, the column header row must be included in the input range. Quit the DQ menu.

5. Copy the column header row using the /C command to a row 5 to 10 lines below the input range. Using the /DQ command, select the output range. It should include the header row you just established plus as many rows as you would like, and should extend to the last column of data.

6. Quit the DQ menu. You are ready to use the new worksheet. It would be a good idea to save it to a new file name first so that you can easily reload if you make an unrecoverable alteration.

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 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 a subset of product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and use the second file for analysis. The smaller file will take less time to process.

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.

All specification files have been prepared as Lotus 1-2-3 spreadsheets set up for data extraction. Criterion, Input, and Output ranges are predefined.

If you received more than one specification disk, file RS197.WK1 contains DISK/TREND Product Groups 1 through 5. File RS297.WK1 contains Product Groups 6 through 9. File RS397.WK1 contains the entire specification data base, but the amount of memory required is large and may not allow enough room for large data extractions. If file RS397.WK1 is present, you are using a 1.2 or 1.44 megabyte diskette, and should have a computer equipped with expanded memory capability.

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. The 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.

Drive specifications: The affected fields are:

Group	Numeric conversion: You can extract a range of groups.
Surfaces per spindle	Numeric conversion: You can extract a range of values.

Heads per surface	Will be a single numeric value: 1 or 2.
TPI	Will be a single numeric value, 0 if data not available. If a drive model has several configurations, the highest TPI is used.
RPM	Numeric conversion: You can extract a range of values.
Tracks per surface	Will be a single numeric value, 0 if data not available. If a drive model has several configurations, the largest value of tracks per surface is used.
Average positioning time	Will be a single numeric value, 0 if data not available. If a drive model is specified as having more than one positioning time, the shortest will be used. Settling time is always included.
Average rotational delay	Numeric conversion: You can extract a range of values.
Average access time	Same as for average positioning time.

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 ??94 in the criterion field for the First Ship Date column will cause all drives first shipped in 1994 to be extracted.

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**
Fax us at: **415-969-2560**

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.

<u>Apple Macintosh compatibility</u>: 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.