

Data Storage Trends and Directions

Tom Coughlin

Coughlin Associates & Peripheral Research Corporation

Outline

- The difficulty of predictions
- Drivers for storage growth
- Technology growth
- Pricing trends

- Drive growth areas and drive/component vendors
- Mobile storage growth
- Network storage, tape, optical storage
- Industry Status and Summary

The Aberrant Mirror

- An aberrant mirror gives a distorted view of the world, we draw an analogy to our always inaccurate view of the future.
- Correction of this aberration occurs over time as possibilities become certainties

"Time is nature's way of preventing everything from happening at once." Graffit

US Economy 1998 to 2001 "The real Y2K problem" (1)



...and 2001 is worse!!!

of Labor Statistics

US Economy 1998 to 2001 "The real Y2K problem" (2) In Q2 2001:

- Investment in computers and peripherals dropped 30.1% (further drop in Q3)
- Business Investment declined 14.6%, software and equipment investment fell 15.1% (worse in Q3)
- GDP growth increase was only 0.2% from Q1 2001 (Q3 -0.4%, negative growth)

Drive Projections History (1997-2000 PRC)





History of PRC Head Volume Forecasts

(Source: PRC 1997-2000)



History of PRC Disk Volume Forecasts

(Source: PRC 1997-August 2001)



Drivers for Storage Growth



- Growth in digital information from faster processors and the digitization of human content (from literature, audio, and video to our genes)
- Ever lower cost of digital data storage
- Increasing availability of high data rate access
- New applications inspired by low cost that generate even more digital information



Hans Moravec, "When will computer hardware match the human brain?" Vol. 1, March 1998, Journal of Transhumanism



oemprc2001ab.prz

IBM

Year

Ed Grochowski at Almaden

GROWTH OF MOBILE INTERNET DEVICES TO 2004



Residential Broadband Projections



Source: Pioneer Consulting, "Global Broadband Access Markets: xDSL, Cable Modems and the Threat from Broadband Satellite, Wireless and All-Optical Solutions," Executive Summary, October 1998; Centennial Investments

NON-PC REMOVABLE STORAGE DEVICE OPPORTUNITY FORECAST (UNITS MILLIONS)

APPLICATION	2000	2001	2002	2003	2004
HANDHELD COMP.	9.6	13.3	18.1	24.3	29.8
DIGITAL STILL CAM.	7.9	12.3	17.9	22.8	27.9
CAMCORDERS	15.7	16.1	16.3	16.6	16.8
DIGITAL AUDIO	4.0	7.8	13.3	19.1	24.2
HAND HELD GPS	3.7	6.3	10.9	13.8	16.7
SET-TOP BOX	24.8	33.3	43.3	52.1	58.9
INDUST. NETWORK	3.0	3.1	3.2	3.3	3.4
SUB-TOTAL	68.7	92.2	123.0	152.0	177.7
DIGITAL CELL	326.1	421.1	532.5	585.0	622.0
TOTALS	394.8	513.3	655.5	737.0	799.7

World Wide Storage Capacity of Disk Memory

(In PetaBytes, Source: Disk/Trend plus projection to 2004)



Technology Growth Areas and Concerns

- Data coding, compression, and error correction:
 - How to deal with reducing SNR
 - Variations for niche markets--e.g. video storage
 - Implications of perpendicular recording
- Servo
 - Time for servo writing, self servo writing
 - Higher TPI requirements
- Areal density growth

- Capital investments needed, particularly for head development
- Flight of talent to more lucrative fields may limit creativity available to industry
- Changes from longitudinal to perpendicular recording

Growth Models for Technology

- Is there a finite technology pool or limited resources in technology growth?
- Or could technology growth be ever exponential?
- Limitations could be economic rather than technical.





AREAL DENSITY RACE

(Source: PRC, August 2001)

COMPANY	SIZE	CAPACITY	AREAL	kTPI	kBPI	Time
		(GB)	DENSITY			
PRODUCT			Gb/in ²			
MXTR 96147U8	3.5	61.4	11.3	27.3	412	3/00
IBM 40GV	3.5	40.0	14.3	35.0	415	3/00
IBM	1.0	1.0	15.2	35.0	435	6/00
MXTR DM80	3.5	81.0	14.7	34.0	402	7/00
QTM FBAS	3.5	80.0	14.7	35.4	417	7/00
QTM ATLASIII	3.5	73.4	179	40.0	448	10/00
MXTR 531DX	3.5	15.0	22.5	46.0	489	2/01
TOSHIBA MK1002	2.5	10.0	22.4			3/01
IBM	2.5	30.0	25.7			3/01
MXTR	3.5	40.0	28.3	54.0	524	6/01
TOSHIBA MK4018	2.5	40.0	35.1	56.8	625	6/01
DEMONSTRATION	I					
SEAGATE			45.0	70.0	640	3/00
R-R/KOMAG			50.0	90.0	552	3/00
FUJITSU			56.0	82.7	678	6/00
R-R/KOMAG/HTCH	I/GUZII	<	63.2	105	600	10/00
FUJITSU			106.5	142	750	8/01

AREAL DENSITY PROGRESSION TECHNOLOGY DEMONSTRATIONS / PRODUCTS

(Source: PRC, 2001)



Average Desktop Drive Prices vs. Time (Sources: Disktrend 1999 and

PRC 2001)



DISK DRIVE UNITS & AVERAGE SALES PRICES 1999-2001

(Source: PRC 2001)

MFG.	Q3 99 UNIT/\$	Q4 99 UNIT/\$	Q1 00 UNIT/\$	Q2 00 UNIT/\$	Q3 00 UNIT/\$	Q4 00 UNIT/\$	Q1 01 UNIT/\$	Q2 01 UNIT/\$	Q3 01 UNIT/\$
MAXTOR	5.8/\$100	6.8/\$102	6.6/\$105	6.5/\$102	6.5/\$95	7.4/\$98	6.7/\$94	12.1/\$85	12.5/\$82
QUANTUM	6.9/\$111	8.7/\$102	8.6/\$105	8.2/\$105	9.0/\$92	6.8/\$104	6.6/NA		
SEAGATE	9.7/\$161	10.3/\$149	10.5/\$140	10.3/\$140	11.6/\$141	10.6/NA	11.2/NA	10.6/NA	11.2/NA
WEST. DIG.	3.4/\$121	5.3/\$106	5.5/\$98	5.2/\$91	5.1/\$86	5.8/\$92	6.0/\$88.9	5.3/NA	5.4/\$82

UNITS IN MILLIONS



Disk vs. Drive Shipment Projections



WW Disk Production Capacity Estimates vs. Disk Shipment Projections



Average Disk and Head Prices



Q2 2001 Disk Drive Company Market Share



DISK DRIVE SHIPMENTS BY SUPPLIER (UNITS MILLIONS)





Q2 2001 Head Company Market Share

(Source: PRC, 2001)



Q2 2001 Media Company Market Share



INDUSTRY STATUS

- NETWORK STORAGE MARKETS TEMPORARILY STAGNANT DUE TO IT RECESSION BUT GROWTH PRESSURE IS INTENSE (OPPORTUNITY FOR LOW COST NETWORK STORAGE)
- SLOWNESS IN P.C. MARKETS
- DRIVE AND COMPONENT
 PRICING PRESSURES HAVE
 LESSENED, ESPECIALLY FOR
 HEADS
- CONSUMER ELECTRONICS
 AND MOBILE MARKETS
 GROWING
- UNIT FORECASTS SHOULD
 INCREASE AFTER 2001



Disk drive growth will be primarily in mobile storage, network storage and new applications. The traditional PC market seems to be near saturation.



Average Mobile Electronic Product Price Projections



Source: Projections based on Intelect Market Tracking for Digital Cameras and PDAs, 2000

Microdrive Price Projections at 20% Gross Margin and 2-Sided Capacity



IBM MICRODRIVE MARKETS

SHIPMENT EST.199920002001(UNITS 000)30.0188.0600.0

APPLICATIONS:

- 40% THINK-PAD, LAPTOP, P.C. APPLICATIONS
- 60% DIGITAL CAMERA

CAMERA MODELS: 19 TOTAL

CANON-4	CASIO-3
KODAK-2	HITACHI- 2
FUJI- 3	SANGYO-2
MINOLTA-3	

* OTHER POTENTIAL "1" INCH DRIVE SUPPLIERS: HALO,

MARQLIN, QUANTUM, TOSHIBA, SEAGATE, OTHERS



Compact flash memory is expected to show strong unit growth and be a significant source of revenue as mobile data storage applications grow.



Disk drive arrays are expected to show strong revenue growth as are storage network systems such as SAN and NAS.

(Source: Peripheral Concepts, Inc. 2001)



Tape drive areal density growth is around 30% annually, much less than disk drive >100% per year areal density growth. This may make tape systems vulnerable to disk drive based storage.



As low cost disk drive storage decreases in price it will offer increasing competition to tape systems for back-up applications.



Optical storage technologies show moderate growth over the next few years driven primarily by content distribution and copying of audio and video content.

(Source: PRC 2001, units Millions)

	2000	2001	2002	2003
CD-ROM	82.9	56.4	30.2	18.6
DVD-ROM	30.1	60.3	92.8	107.3
CD/DVD RW	19.0	25.4	29.8	33.7
R/W < 4 GB	1.9	1.6	1.3	1.0
R/W > 4 GB		.2	.3	.8
TOTALS	133.9	143.9	154.4	161.4

Flash and disk drives show strongest projected sales growth. Tape and floppy units are in decline



■ RIGID DISK DRIVE ■ OPTICAL DRIVES □ TAPE DRIVES □ FLEXIBLE DRIVES ■ FLASH MEMORY

SUMMARY



- 2001 WILL BE A DOWN YEAR FOR STORAGE
- AFTER H1 2002, STORAGE DEMANDS WILL CONTINUE TO INCREASE (ESPECIALLY FOR LOW COST NETWORK STORAGE, MOBILE AND NEW APPLICATIONS)
- SOME ADDITIONAL CONSOLIDATION AND STRATEGIC DIFFERENTIATION (SUCH AS FUJITSU'S DECISION TO GET OUT OF THE DESKTOP DRIVE MARKET)
- AREAL DENSITIES WILL CONTINUE TO INCREASE, MAYBE AT A SLOWER RATE WITHIN 2 YEARS
- MORE COMPONENT INTEGRATION WILL BE REQUIRED, FEW MERCHANT VENDORS WILL REMAIN
- DISK DRIVES WILL ENCROACH FURTHER
 ON TAPE MARKET

Data Storage getting more mature?



"Things are more like they are now than they ever were before."