TOM COUGHLIN

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Tom's 20+ years of magnetic recording experience included flexible tape and floppy as well as rigid disk recording at such companies as Polaroid, Seagate Technology, Maxtor, Micropolis, Nashua Computer Products, Ampex and SyQuest. Since 1997 Tom has worked with Dennis Waid at Peripheral Research Corporation co-writing several of the annual PRC reports. He has published over 40 articles, reports, technical papers and presentations. Tom has provided marketing, intellectual property and technology assessments and projections for several data storage technologies companies and venture capitalists. In addition he has served as project and general manager for significant technical projects.

A Drive For All Seasons

Thomas M. Coughlin Coughlin Associates

Outline

- Continuous growth in HDD areal density are expected and drive unit growth is increasing.
- The creation, editing, archiving and distribution of digital content is an enormous driver for digital storage growth.
- The consumer value chain creates the means for reception of digital content and itself drives digital storage needs.
- Hard Disk Drives but also other storage technologies in the digital memory hierarchy play an important role in creating new digital content applications.

The Continuum of Recorded Human Experience



2000: Titanic Technology, Sinking Margins

Key Employees

Investors

Component Suppli

SS Areal Density

AREAL DENSITY PROGRESSION / 2000-2003 TECHNOLOGY DEMONSTRATIONS / PRODUCTS (GIGABITS / SQUARE INCH)



Areal Density (Gb/in

SHIPPING PRODUCT DISK CAPACITY PROJECTIONS

 Year
 95mm Mainstream Capacity Per Platter

 2002
 40

 2003
 80

 2004
 120

 2005
 180

 2006
 270

What this Means For HDDs



320 GB 95 mm, 4-disks 2003

320 GB 65 mm, 2-disks 2006-2007

320 GB 48 mm, 2-disks 2008+

Market Niche Projections



Digital Content Value Chain



Drivers for Greater Entertainment Storage Requirements

- Red laser optical disks → Blue laser optical disks
- Current HDD capacities → Higher HDD capacities
- Current Flash capacities → Higher Flash capacities
- Current storage component costs → Lower storage component costs
- Current HDD sizes → Proliferation of smaller drive formats
- PC disk drives in PVR/DVRs → Specialized AV drives in PVR/DVRs
 SCSI/Fibre Channel Storage → Lower cost SATA Storage for Fixed Content storage and SAS and Fibre Channel for higher performance storage
- CD/DVD Purchases → Content downloads and storage
- Struggle between content owners and users → Workable business models for reasonable content prices and usage
- Isolated CE equipment → Networked Homes and Home Media Servers using standardized interfaces and commands
- Mostly isolated computers → Pervasive wired and wireless computer networks
- Today's MP3 players and PDAs → Advanced mobile music and personal video players and integrated PDA/phones
- Decaying analog media in hard to access vaults → Digitized historical content readily available on networks

Drivers for Increased Content Richness

- Analog TV → Digital TV
- Standard Definition TV → High Definition TV
- 2k Film Production → 4k Film Production
- Film Cameras → Digital Cameras
- Film Projection → Digital Projection
- 32-bit Processors → 64-bit Processors
- Dial-up Connections → Broadband Connections



Digital Content Distribution Chain, from Scott Kipp's book "Broadband Entertainment."



From Scott Kipp's upcoming book on Broadband Entertainment Copyright 2004, Coughlin Associates



Uncompressed Video Production Storage Needs (Raw DPX 10 bit log files).

Resolution	Frames/sec	MB/second	Capacity/minute (GB)	
SD	1.7	38.4	2.3	
1K	3.2	76.8	4.6	
HD	8.2	197	11.8	
2K	12.5	300	18.0	
4K	50	1.2	72.0	
	Сорунь			

Digital Content Lifecycle in Production and Distribution.





Comparison of Tape and ATA Disk Storage Economics



Examples of ATA-based Storage Systems



Isilon IQ 3-Node 4.3 TB





Nexsan ATABeast Nexsan's 14 TB for 7 cents a MB

The DX30 separates backup functions from archive functions to optimize the data protection process.

> STK Bladestore product uses 3.5 inch drives on blade acting as one drive to a fibre channel output

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NearStore R100: Costeffective, fast-access storage for online backup and archiving.

R200 now offers up to 96 TB

Professional Digital Camera



Value Chain for Consumer Electronic Devices





Storage Device Segmentation for Consumer Electronic Applications







Sample value chain markup and storage cost as % of BOM

Storage Unit Price is Large Percentage of Total BOM Cost



Total DVR Market



Network PVR/DVR



Toshiba SD-H400

- ~\$500
- 80 GB HDD
- DVD/DVD-R Player
- Built-in Tivo
- Home Media Upgrade allows USB connection to wired/wireless network



ReplayTV RTV4532

- ~\$780
- no longer available
- 320 GB HDD
- Ethernet Connection



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Mobile Storage Hierarchy

Cost/Speed



Disk Drives in Mobile Applications

- Disk drives going into more and more consumer applications
 - 1.8 inch, 1 inch and possibly 0.8 or 0.7 inch drives in mobile devices such as MP3 players, PVP, cameras and mobile phones
 - PVR/DVR market, maybe with DVD-R and networking set to take off

Comparison of Mobile Storage Devices

Storage Type	Capacity	Power (Peak)	Acoustical Charisteristic s	Shock Tolerance (Operating)	Thermal Characteristic s (Operating Temp)	OEM Cost
Flash	64 MB	24 mW	NA	2000 G	-40° to +85° C	\$11
48 mm HDD	10 GB	1.3 W	23 dB	200 G	+5° to +55° C	\$120
27 mm SE	1.5 GB	0.6 W	23 dB	350 G	-10° to +65° C	\$65







Medium Volume and Density



- Memory Card data based on 128MB card.
- Memory Cards are: SD Memory Card, Compact Flash, SmartMedia, Memory Stick
- MicroDrive® data based on 1GB drive.



MicroDrive® is a trademark of IBM.

Chart of Projections of HDD Form Factor Units vs. CE Applications.



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Form Factor Projections



Conclusions

- Rich media markets and CE are big drivers of storage growth
- HDD areal density growth slowed and ASPs stabilized means companies have time and money to develop HDDs tuned to niche application markets
- Drive unit growth is increasing but revenues will not increase at the same rate due to large number of price sensitive applications.
- Tape cartridge capacity grows and point of parity in \$/GB for HDDs vs. tape is put off to the future
- We are likely to see multiple forms of digital storage in all segments of the content value chain driven by trade-offs between price and performance in the storage hierarchy.
- Drives moving to smaller form factors, especially in CE applications, although Dense Datacenter Storage may also drive smaller form factor drives.
- Disk drives for mobile applications are at a critical point since high capacity is needed but it must prove its robustness and overall reliability to the mobile marketplace. Could be a very big market—think cell phones
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Time for the next wave of storage!

