

The background of the slide is a classical painting. It depicts a man and a woman in a landscape. The man, on the left, is wearing a long, flowing white robe and a turban. He is pointing his right hand towards the horizon. The woman, on the right, is also wearing a long, flowing white robe and a turban. She is looking towards the man. The landscape is a mix of brown and green tones, suggesting a natural setting. The overall style is that of a classical painting, possibly from the 17th or 18th century.

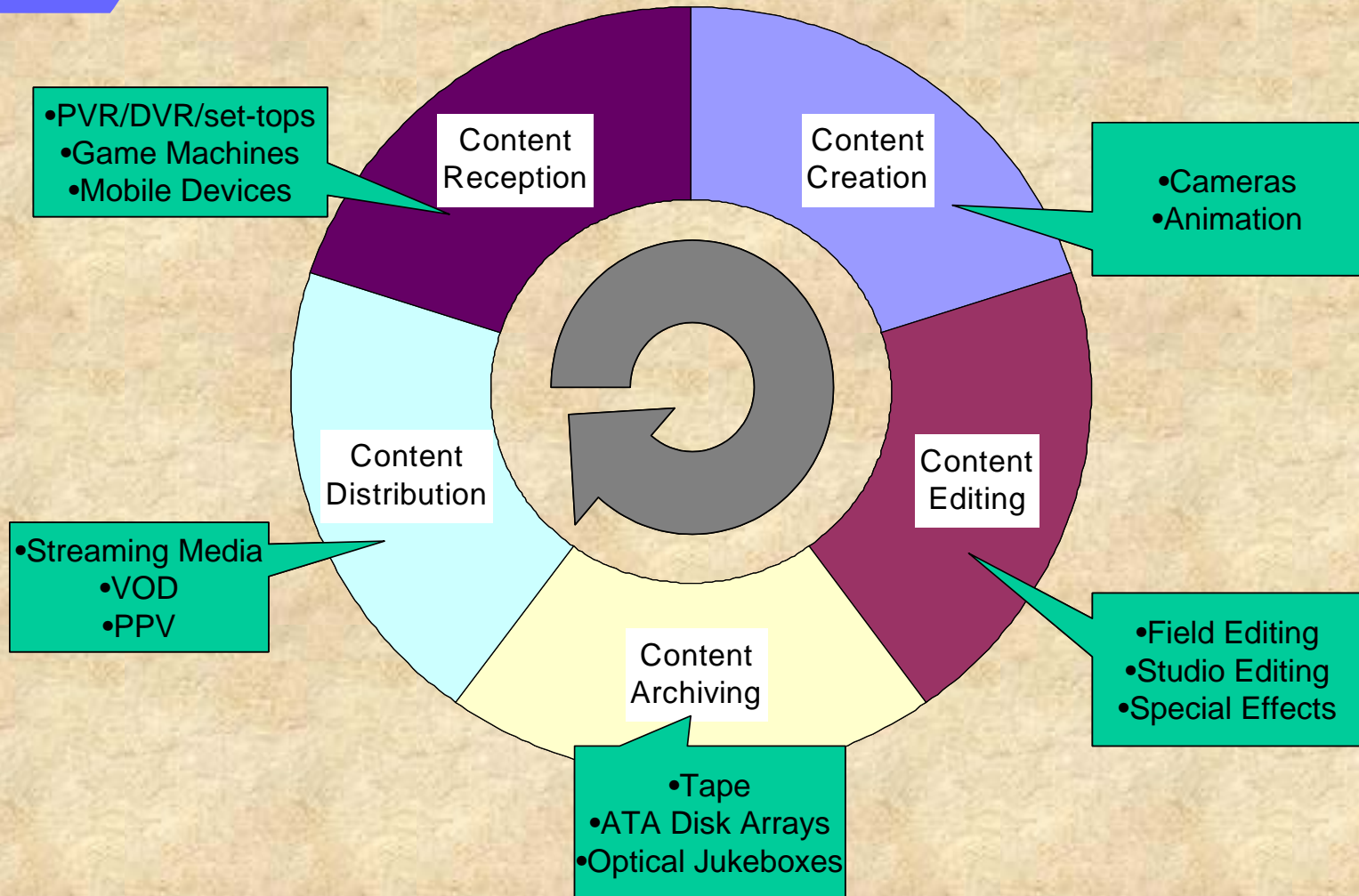
The Content of Storage

Tom Coughlin
Coughlin Associates
www.tomcoughlin.com

Outline

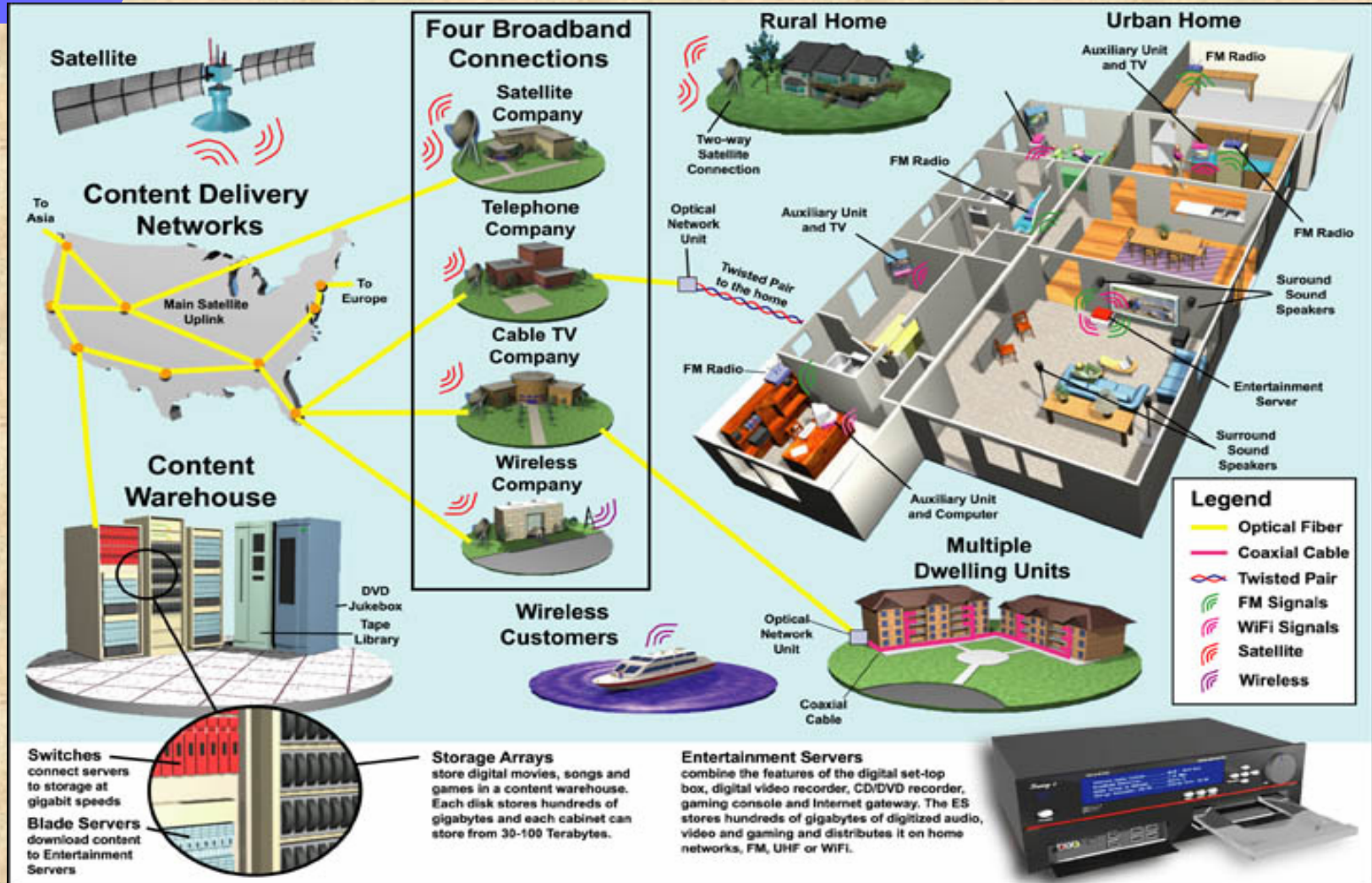
- Content Value Chain and Revenue Streams
- Storage and Entertainment Content Creation
- Applications for Consumer Electronics
- Disk Drive Projections
- Conclusions

Digital Content Value Chain

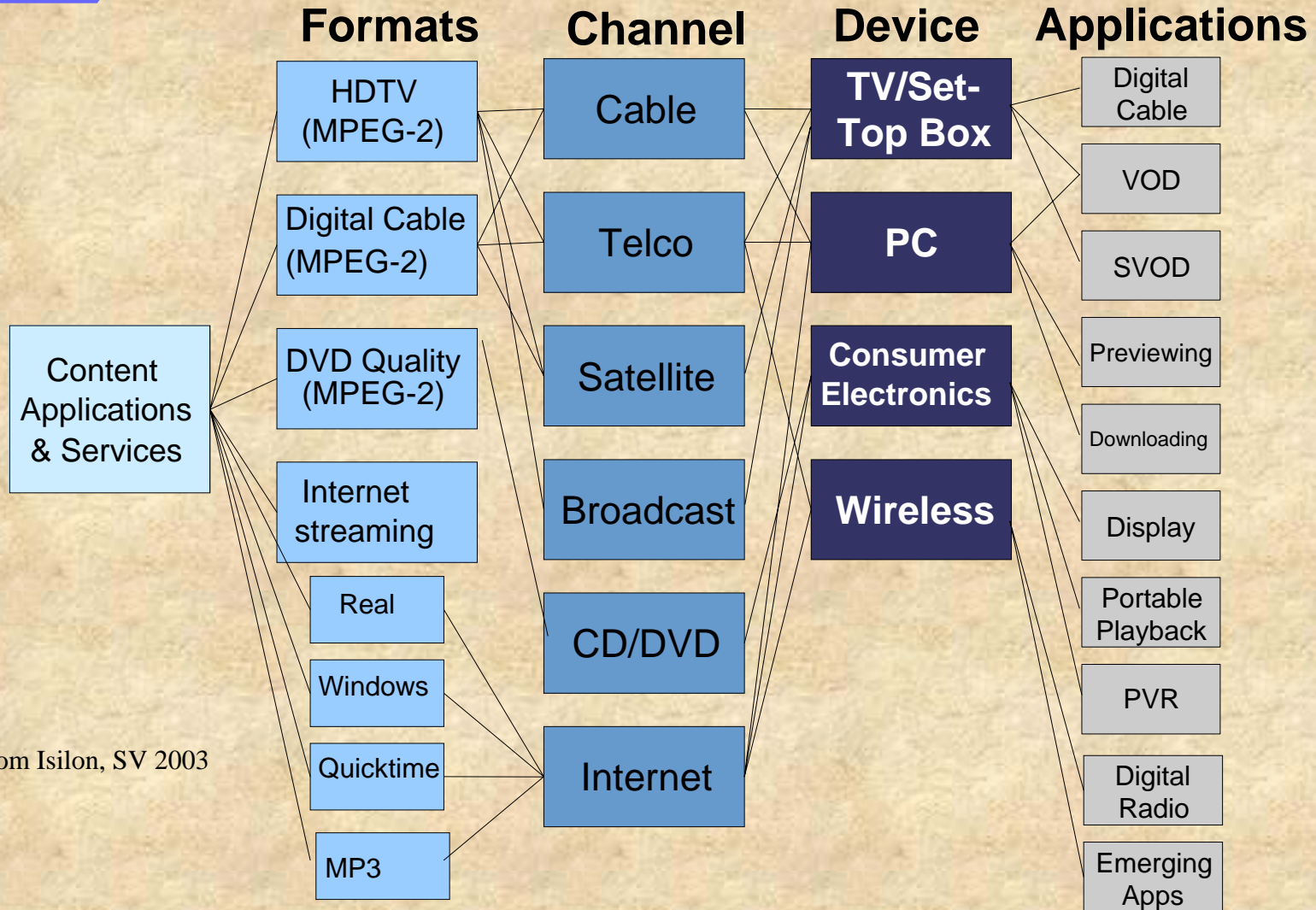


Digital Content Distribution Chain

From Scott Kipp's book "Broadband Entertainment."



Many Digital Content Revenue Streams



From Isilon, SV 2003

Applications for Consumer Electronics



Storage Devices for Entertainment Reception



- Flash
Memory

- Hard
Disk
Drives

- Optical
Disks

Two Primary CE Market Storage Niches

- Static or Fixed Appliances
 - Such as set top boxes, DVD Recorders/players, DVR/PVRs, etc.

Mobile Devices

Such as MP3 Players, Personal Video Players, Cell Phones, Still and Video Cameras, etc.

What Will CE Devices look like in 2010?

- **2010 Portable Device** (Jim Gray, Microsoft)
 - 100 Gips processor
 - 1 GB RAM
 - 1 TB disk
 - 1 Gbps network
 - Many form factors
- **Example Mobile Communication and Intelligence Device**
 - Stores millions of still photos, thousands of MP3 files, hundreds of MPEG4 movies
 - Ubiquitous mobile and fixed communication capability (all standard interfaces)
 - Carries biometric and other security features and includes all your passwords and contacts
 - With appropriate sensors this can be your life recorder to document your life (you are the entertainment)

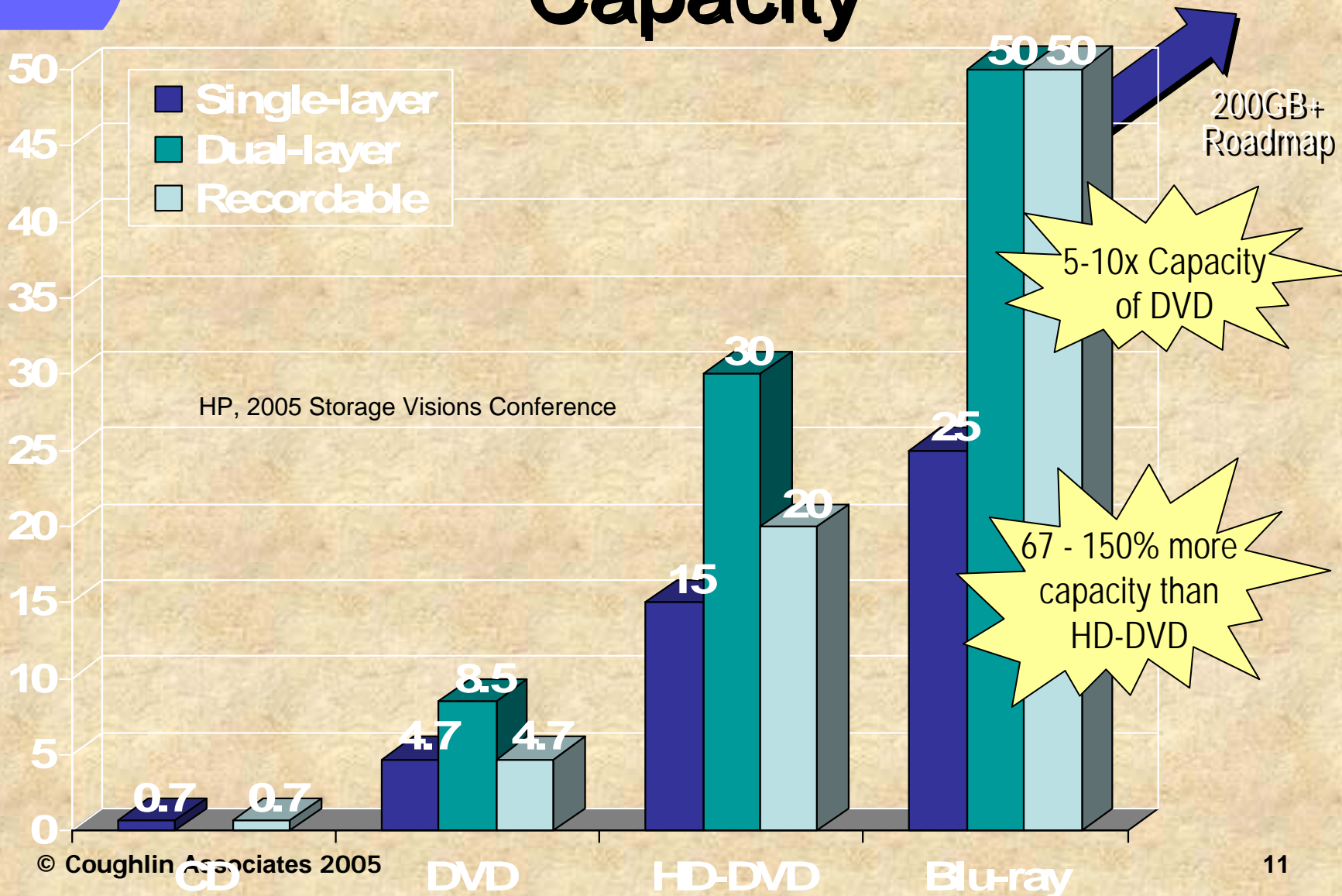


Blue Ray Optical Disks and Drive



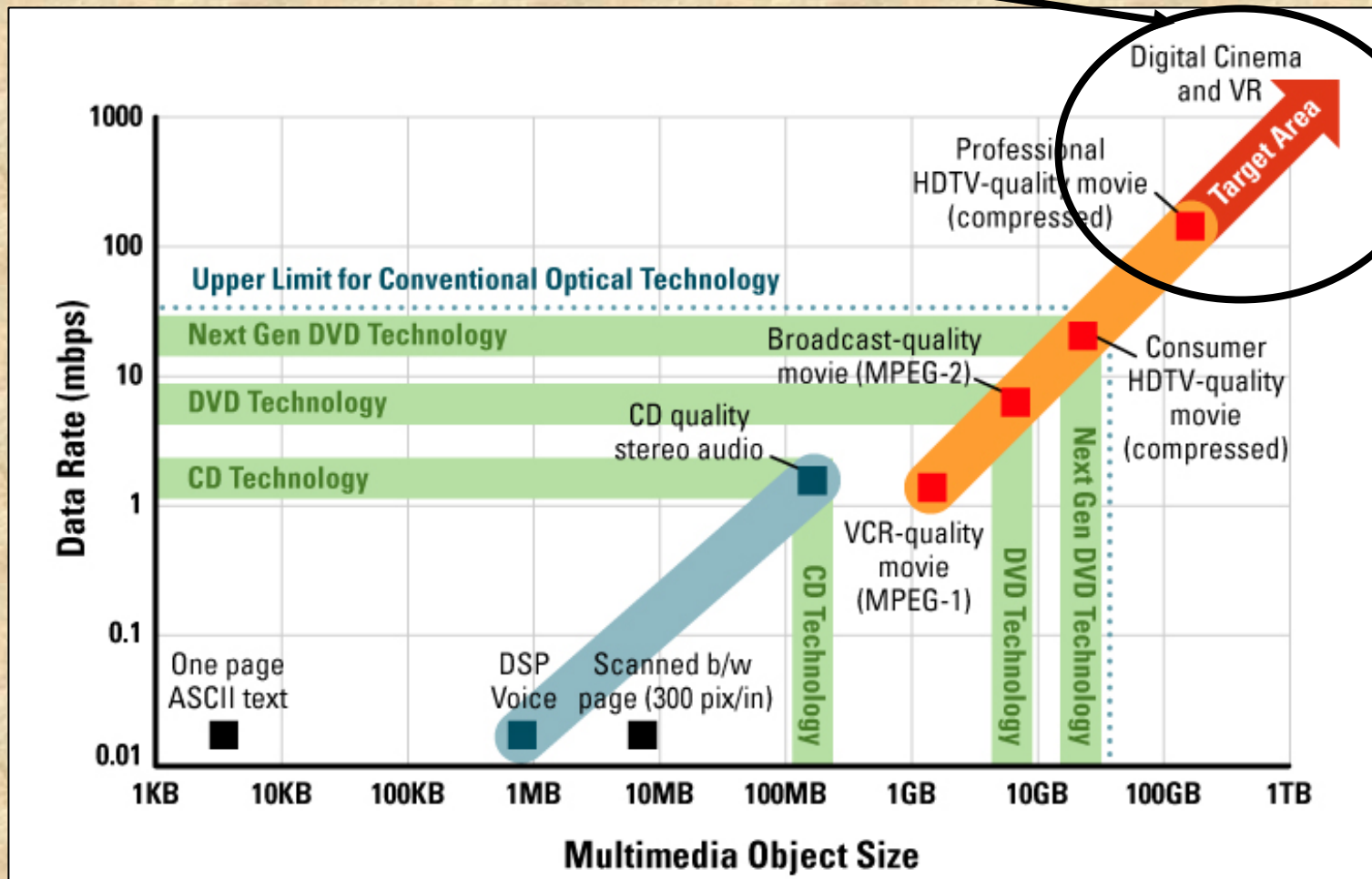
By end of 2005 Blu Ray and HD-DVD Disks will be available with capacities up to 50 GB!

Blu-ray Disc Delivers More Capacity

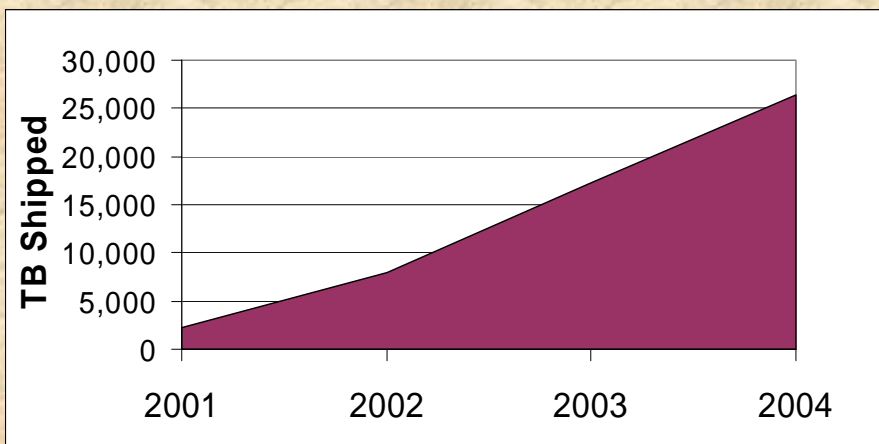


Optical Content Distribution Trends

Holographic Disks



Flash Memory



14 formats and growing...

Flash Format	Size	Capacities
 Compact Flash Type I 	42.8 x 36.4 x 3.3 mm	Standard Capacity (MB) 32 64 128 256 512 1024 2048 Performance Capacity (MB) 256 512 1024 2048 4096
 Smart Media Card	45.9 x 37.0 x .76 mm	Capacity (MB) 32 64 128
 Multimedia Card	32.0 x 24.0 x 1.4 mm	Capacity (MB) 16 32 64 128
 SD (Secure Digital) Card	32.0 x 24.0 x 2.1 mm	Capacity (MB) 16 32 64 128 256
 SD Expansion Card Palm OS Devices	32.0 x 24.0 x 2.1 mm	Capacity (MB) 32 64 128 256 512
 xD Picture Card Olympus & Fuji Digital Cameras	20.0 x 25.0 x 1.7 mm	Capacity (MB) 64 128 256 512
 Memory Stick (Standard & Magic Gate) Sony Devices	50.0 x 21.5 x 2.8 mm	Capacity (MB) 16 32 64 128
 Memory Stick Pro (Standard & Magic Gate) Sony Devices	50.0 x 21.5 x 2.8 mm	
 Memory Duo Stick (Standard & Magic Gate) Sony Devices	50.0 x 21.5 x 2.8 mm	
 Memory Duo Stick Pro (Standard & Magic Gate) Sony Devices	31.0 x 20.0 x 1.6 mm	

(1) Capacities as of September 2003

Consumer Hard Disk Drive Form Factors



3.5-Inch Drives



0.85-Inch Drives

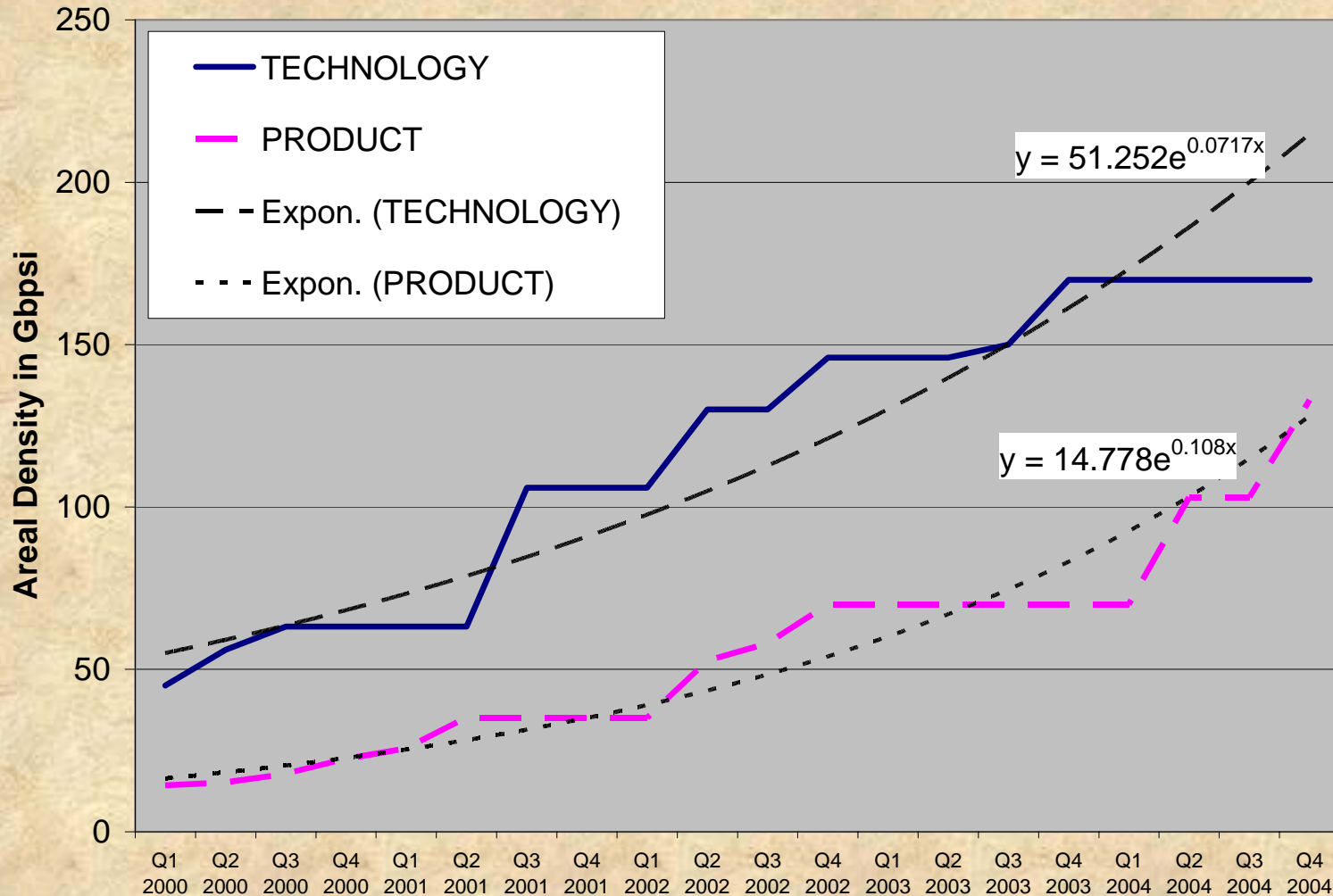


2.5-Inch Drives



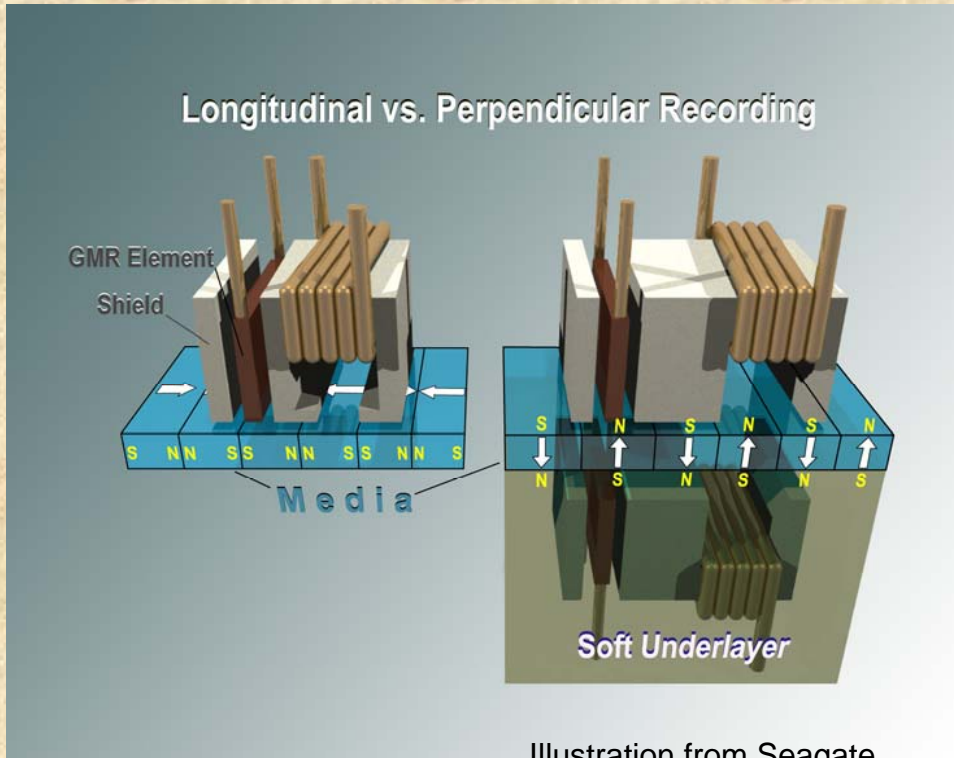
1.0-Inch Drives

HDD Quarter by Quarter Public Technology Demonstrations and Product Announcements



Perpendicular Recording

Toshiba announced a 1.8 inch drive with perpendicular recording technology to be available in the second quarter of 2005.



- Perpendicular Recording improves thermal stability of recording, thus increasing areal density
- Development of perpendicular recording systems could cause an increase in areal density growth similar to that with the introduction of the MR head in the early 1990s
- We could find areal density growth in the next few years again exceeding 60% annually
- Not all companies will convert to perpendicular recording at once, still life left in longitudinal recording

What this means...

By 2006 or 2007 we will have
1 TB 3.5-inch Disk Drives and
20 GB 1 inch drives!

Hitachi New Drives

MIKEY

- Smallest Microdrive
- Available in 2nd half 2005
- Embedded version only
 - PATA, CE-ATA, MMC-like
- 8 – 10GB capacity
- Targeting small handheld products, including multimedia phones

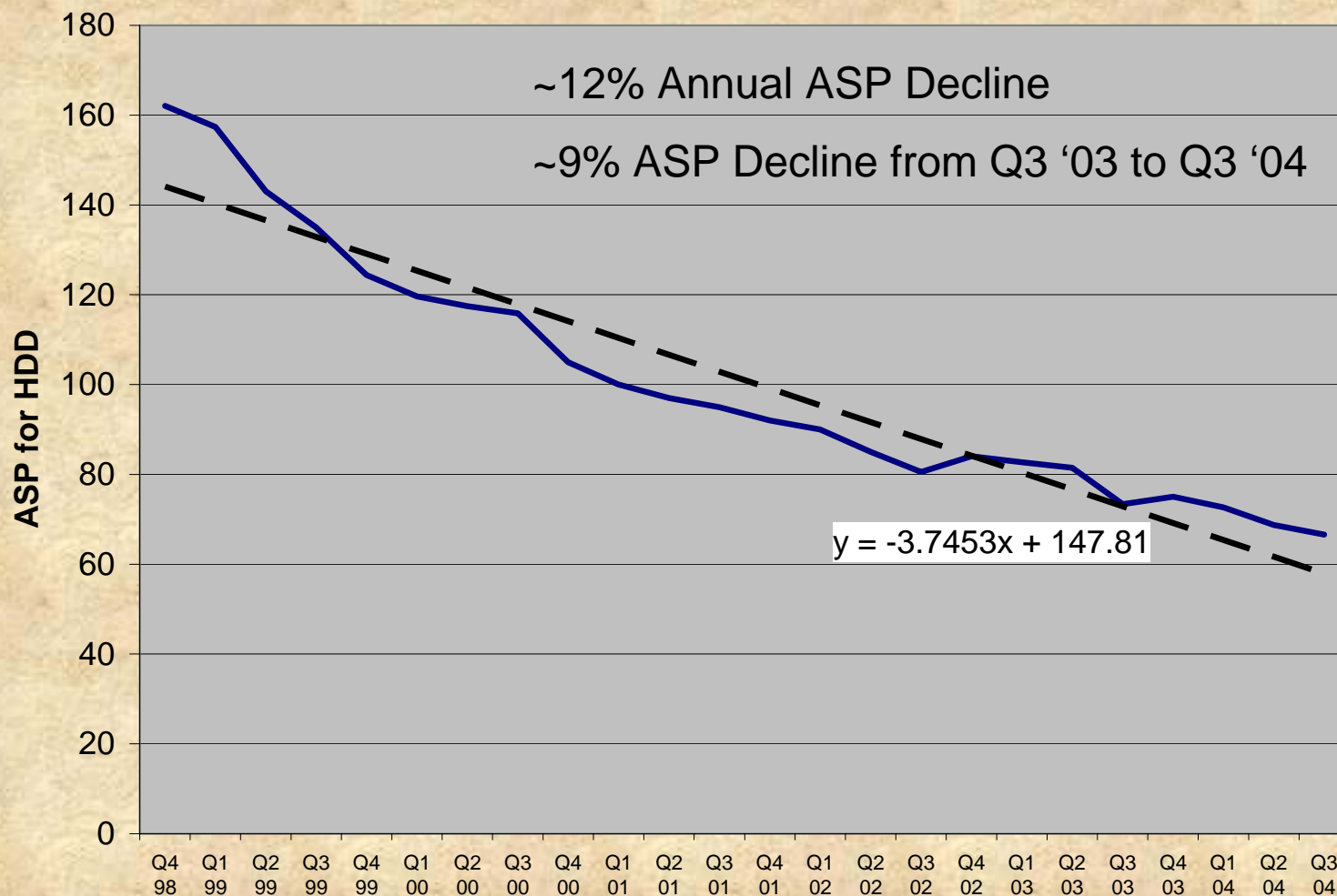
SLIM

- Smallest 1.8" hard drive
- Single disk and 2-disk versions
- 60 – 80GB capacity
- Available in 2nd half 2005
- Embedded version
 - PATA, CE-ATA (future)
- Targeting handheld audio and video products



Disk Drive ASP Trends

(Weighted Average based on Seagate, Maxtor, and WD)



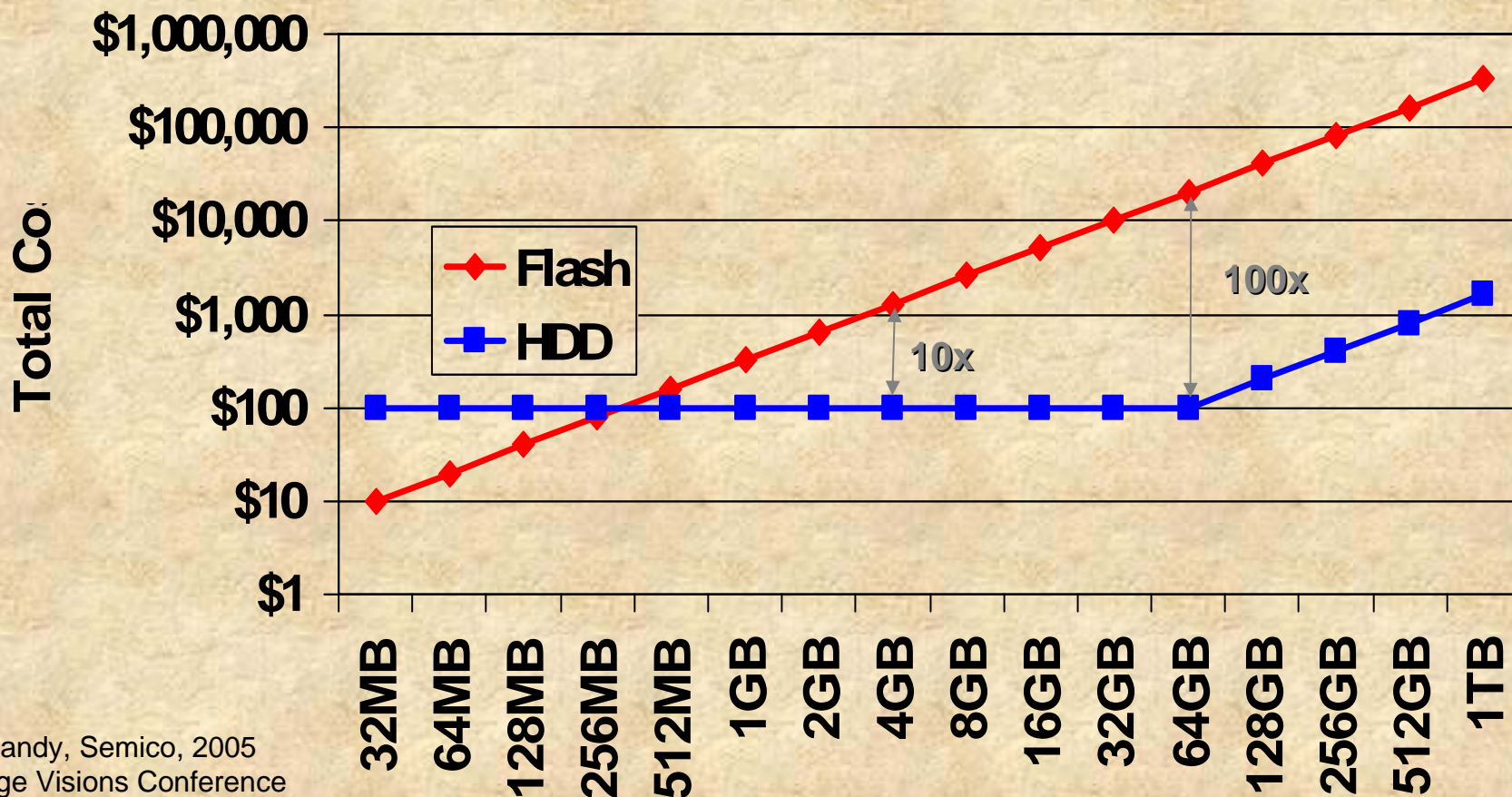
The Battle for Mobile Supremacy



Mobile Storage Factors

- Size
- Capacity
- Price
- Data Rate (BW)
- Power Usage
- Environmental Factors

System Cost vs. MB



Jim Handy, Semico, 2005
Storage Visions Conference

DiskOnChip H1 vs. Mini SD vs. HDD

	HDD (best case)	Mini SD	DiskOnChip H1	DiskOnChip H1
Capacity	1.5 / 2 / 4GB	512MB / 1GB	512MB / 1GB	✓ Scalable
Cost (estimated)	\$50 to \$90	\$27 to \$42	\$25 to \$40	✓ Best cost
NOR-less enable	No	No	Yes – saves cost	
Length	32mm / 42.8mm	21.5mm	18mm	✓ Smallest
Width	24mm / 36.4mm	20mm	12mm	
Height	3.3mm / 5mm	1.4mm	1.4mm	
DRAM read buffer	Yes – adds power	No	No	✓ Best Power cons.
Power consumption	1000mW and up	140mW	20mW	
Temp range	0 to 65°C	-40 to 85°C	-40 to 85°C	✓ Rugged
Drop test	Risky	Good	Excellent	

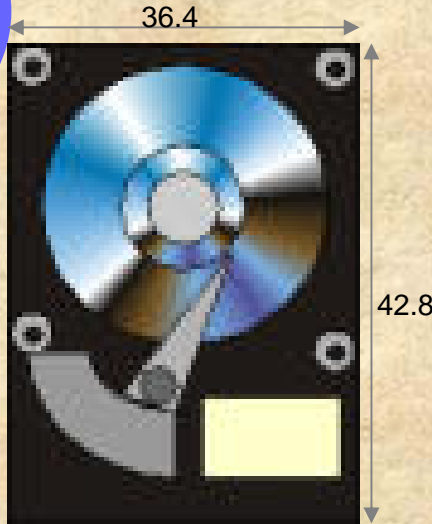
Solid state vs. rotating media cost comparison (estimated):

- 2006 - Flash is lower cost below 4GB
- 2008 - Flash is lower cost below 8GB

M-Systems, 2005 Storage Visions Conference

Small Hard Disk Drives—Not The Answer For Mobile Phones

Based on
Cornice 2GB
dimensions



24.0



32.0

Products available in 2004

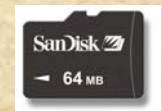
20.0



21.5

Measurements in mm

15.0



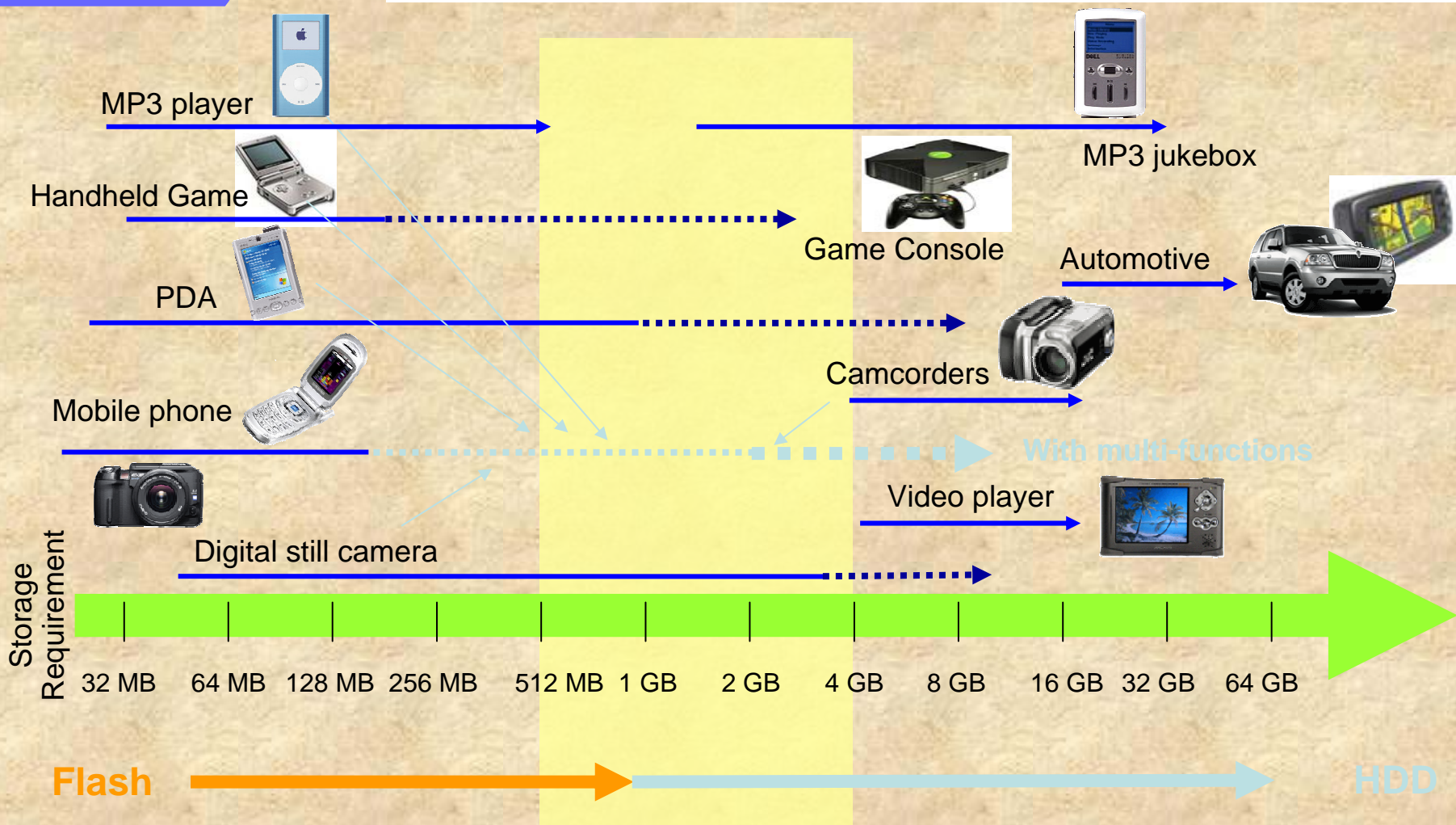
11.0

Thickness (mm)	5.0	2.1	1.4	1.0
Volume (mm ³)	7790	1613	605	165
Capacity* (min)	1 GB* (~\$60)	32 MB(~\$8)	16 MB(~\$6)	16 MB(~\$6)
Capacity ('04 max)	5 GB (~\$70)	2 GB (~\$140)	1 GB(~\$70)	256 MB* (~\$25)
Power	1000 mW *	← 20-50 mW →		
Shock	Risky	← Excellent →		

Portable Consumer Digital Devices

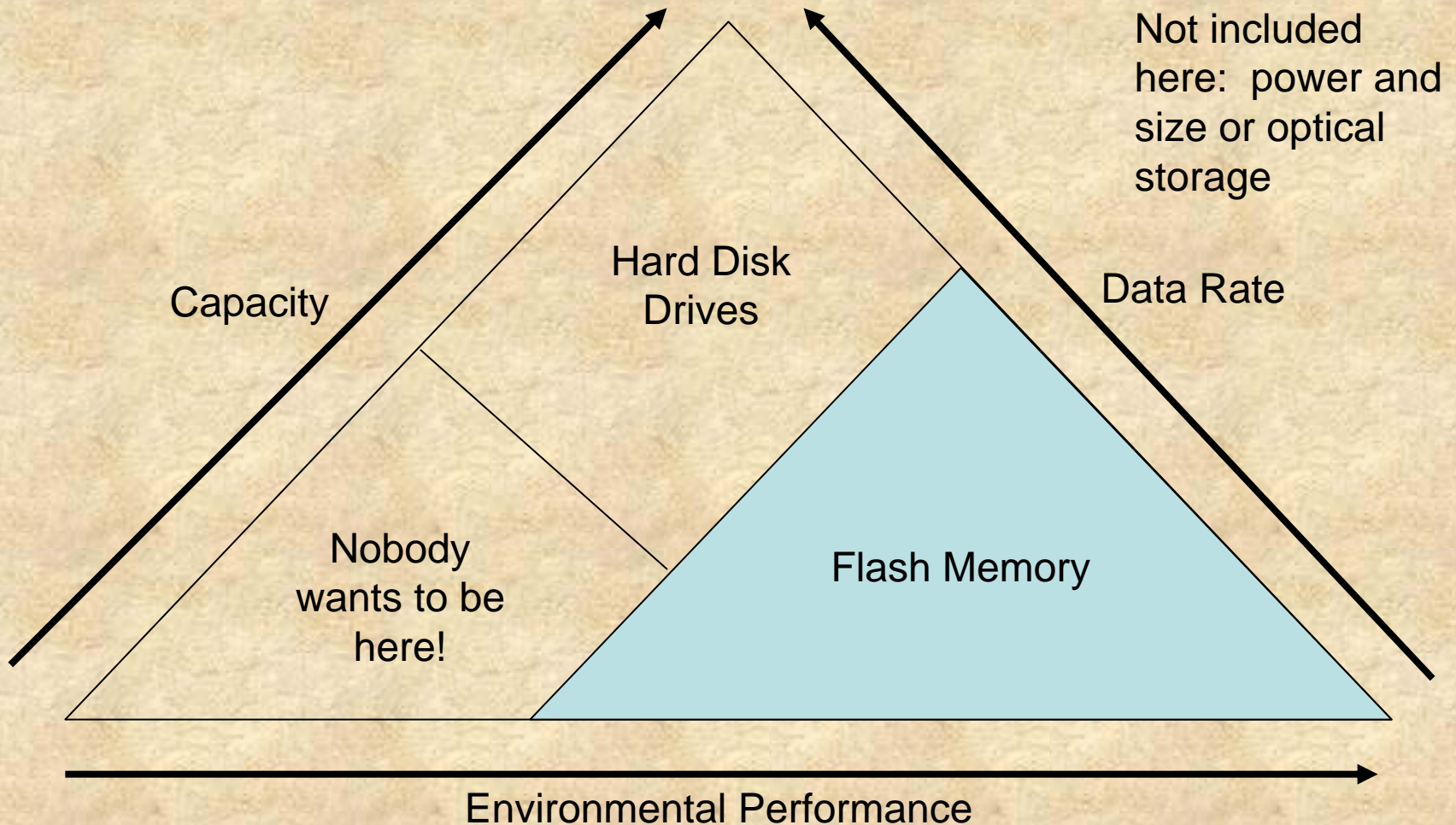
Flash implementation in CE will continue to grow

HDD is an excellent choice for high capacity applications



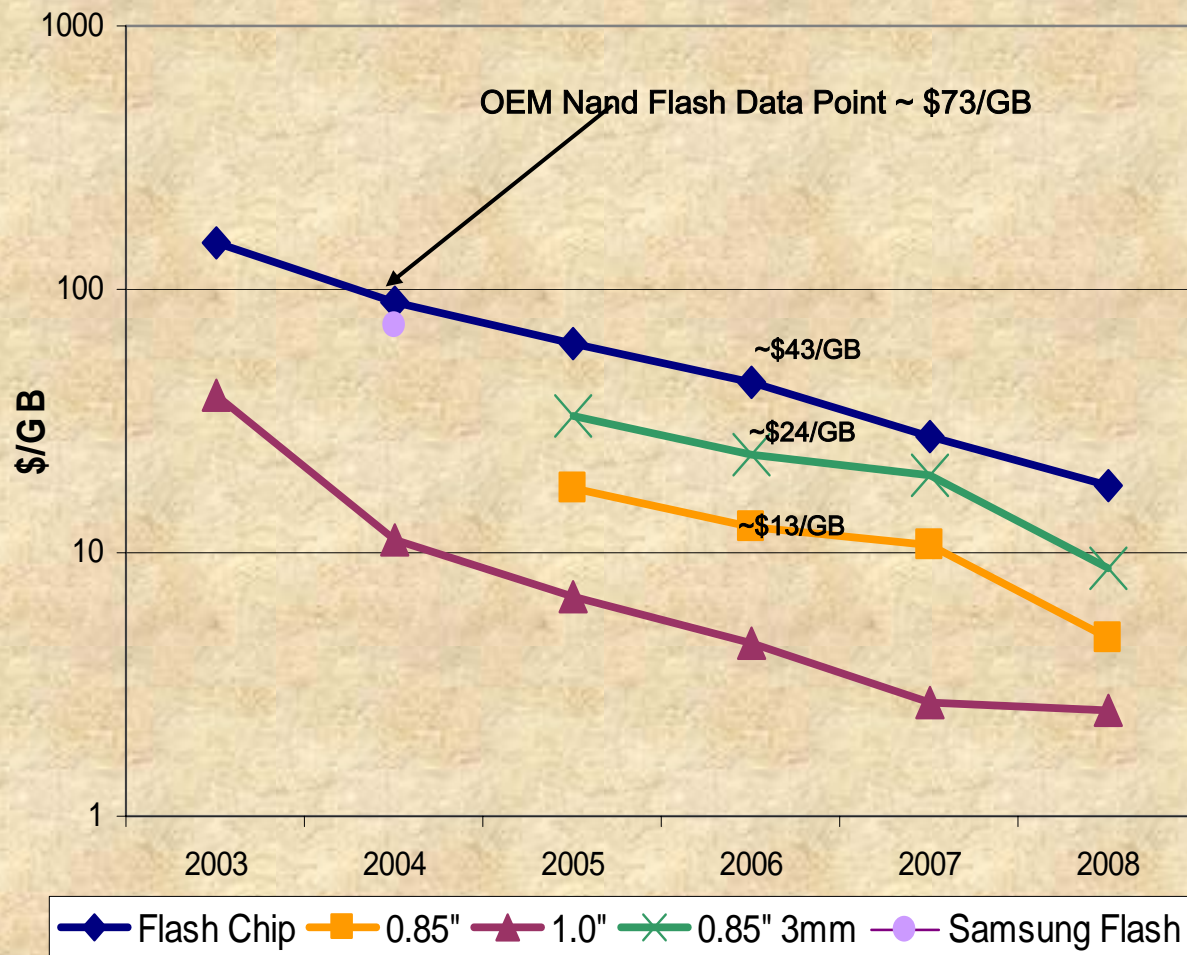
Or is it Mutual Admiration?

A Mobile Storage Hierarchy



\$/GB Advantage of HDDs Less for Smaller Drives

NAND Flash vs. Disc

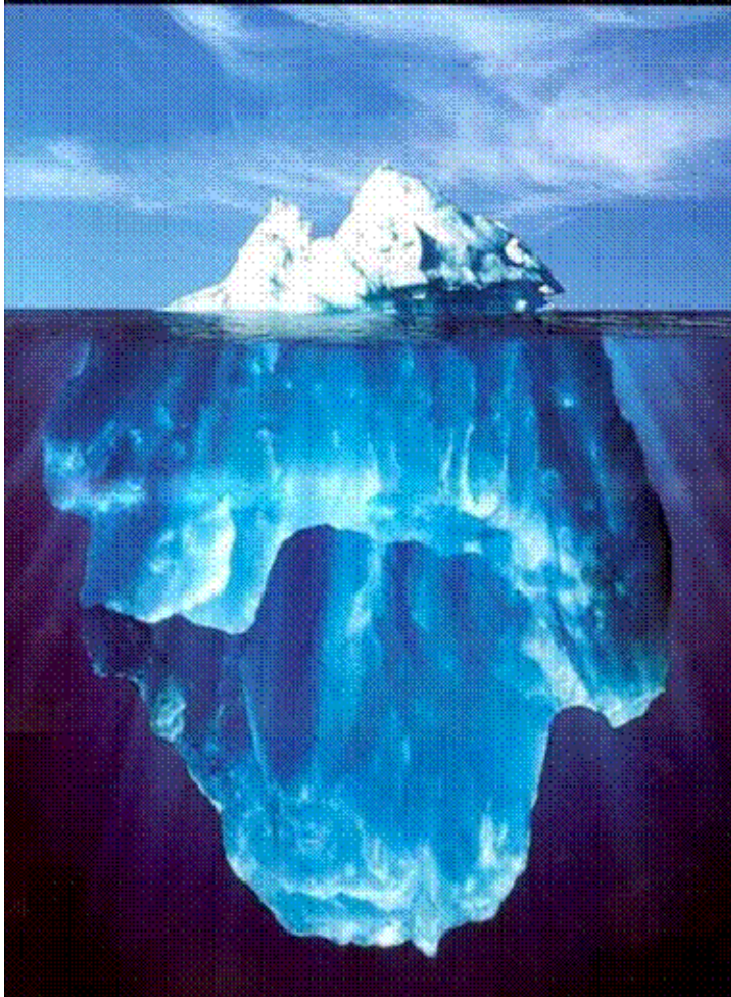


Market Risks

- Nand flash pricing reductions to combat HDD entrance
- 3.3 mm high risk due to \$/GB compared to flash
 - Need cell phone real estate to allow 5mm HDD solutions

Source: Seagate, 2005
Storage Visions Conference

More (or maybe less) to Come...

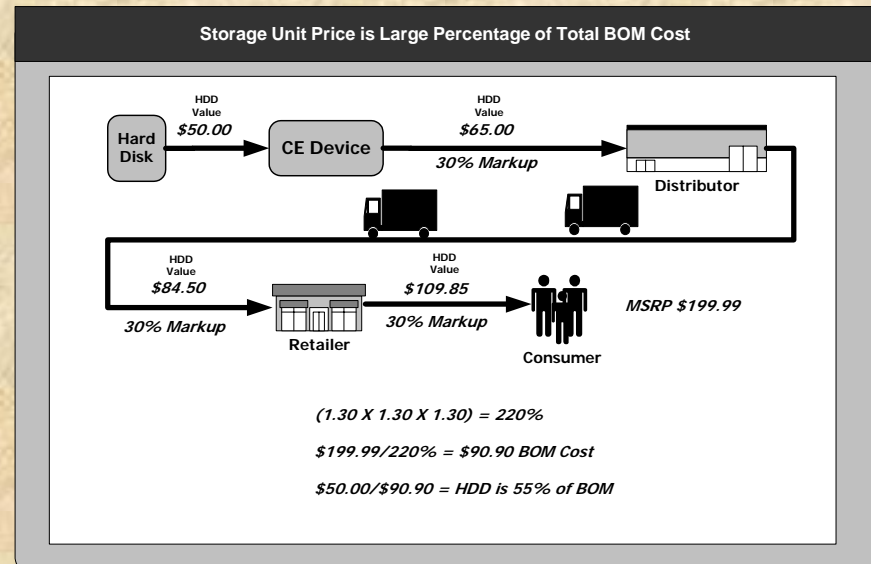


CE Volume is Very Sensitive to Product Price



From Cornice, 2003

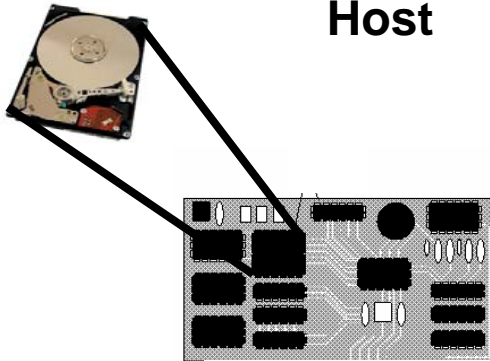
Storage is a significant % of the BOM Costs for CE Devices!



Two Extreme Poles of CE Disk Drive Integration

--Driven by Cost--

**Total
Integration
into the
Host**



Disk Drive Becomes A Chip

**Total
Integration
onto the
Drive**

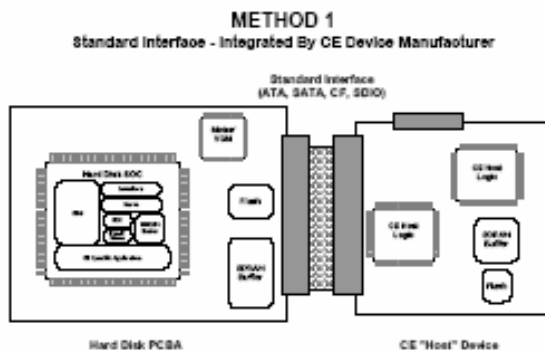


*Disk Drive Companies
Become Contract
Manufacturers for Host
Companies*

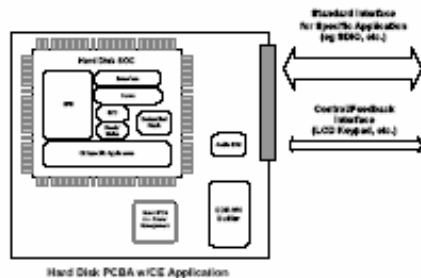
Methods of HDD CE Integration

Tomorrow

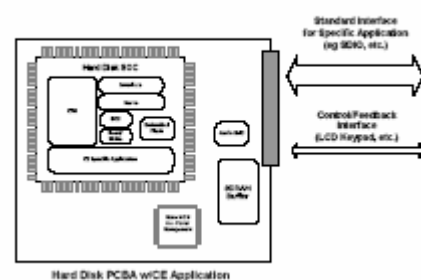
Today



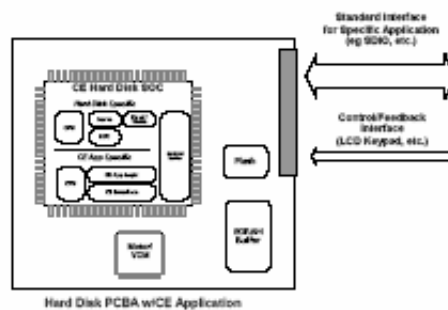
Method 5A
Hard Disk SOC for CE Apps - Single CPU WISE Company Integration



Method 5B
Hard Disk SOC for CE Apps - Single CPU WISE Company Integration

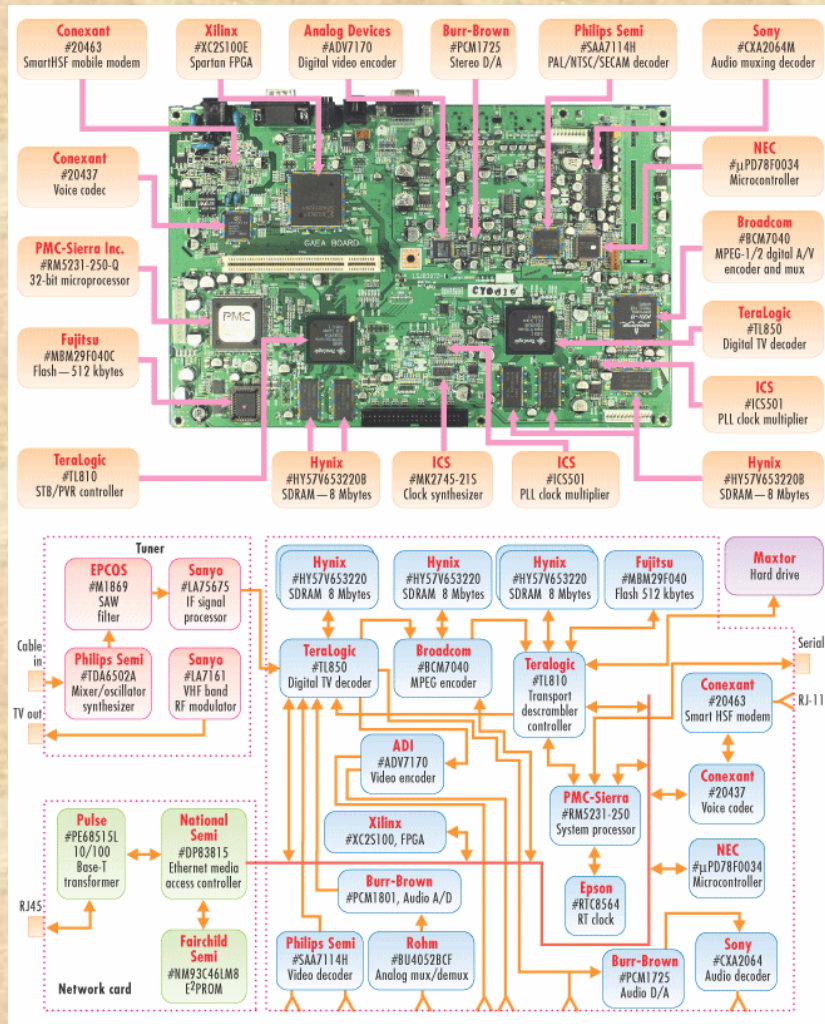


Method 6
Hard Disk SOC for CE Apps - Multi CPU & Custom CE Logic



Replay TV Teardown

--Put it on the Drive Board?--



The four-layer mainboard supports the tuner and more than 38 integrated circuits. The mainboard also provides multiple interface connections, including VGA, digital audio, infrared and S-Video, as well as the PC connection for storing and viewing photos. While virtually all devices found in the Replay TV unit are "catalog items," the architecture is certainly unique to the DVR application. Most key ICs—including TeraLogic video processors and processor/logic components from PMC-Sierra and Xilinx—are connected to a shared PCI bus. Broadcom provides MPEG encoding functions, while a Philips device supplies video decode for external S-Video.

Portelligent Teardown Report from March 24, 2003 EE Times

Integrate What Where?

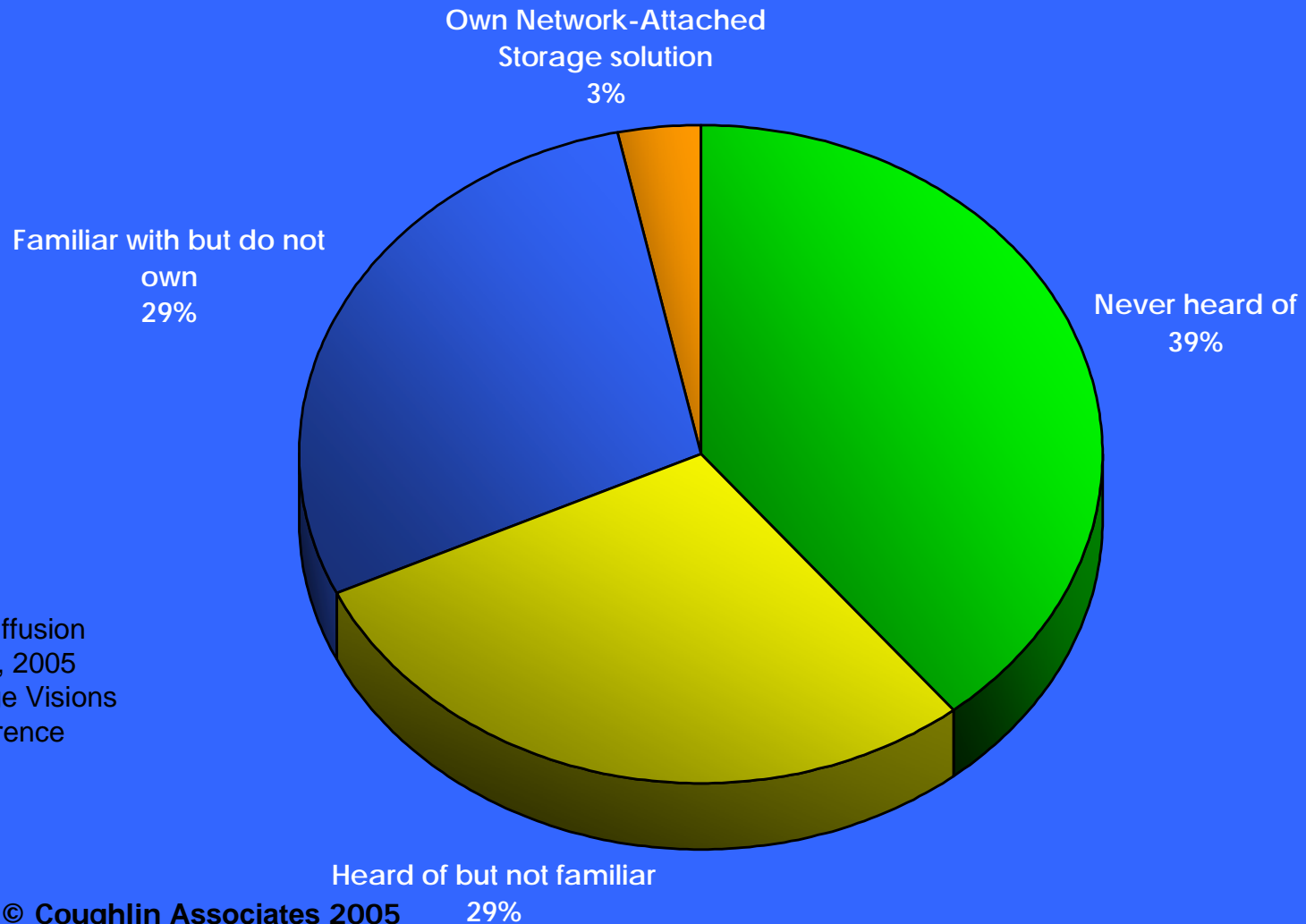
- For single drive enabled applications perhaps integration on the drive board makes the most sense for the ultimate cost reduction
- For a multiple drive application such as network storage perhaps integration of as much electronics off the drive board as possible on the system side offers the greatest cost reduction

Network Storage in the Home

- Driven by the growth of home “reference data” such as photographs, family videos, financial records, etc.
- Need for reliable backup and preservation of this material in the home.
- Also driven by growing home entertainment networking that will require shared storage
- Need Low Cost Options for home networking

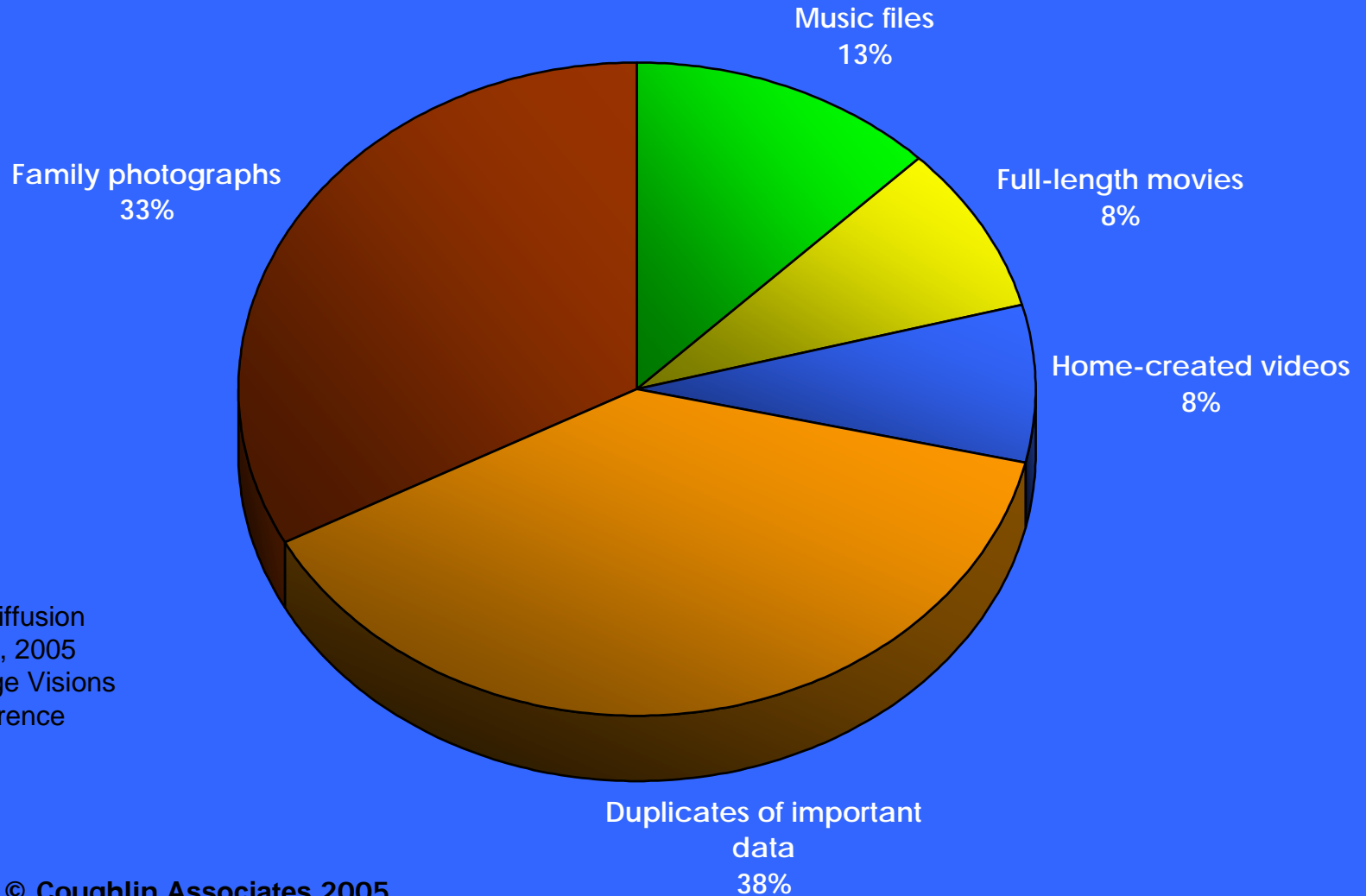
Familiarity with Network-Attached Storage Solutions

(Among Internet Households, Home Network Owners and Intenders, n = 817)



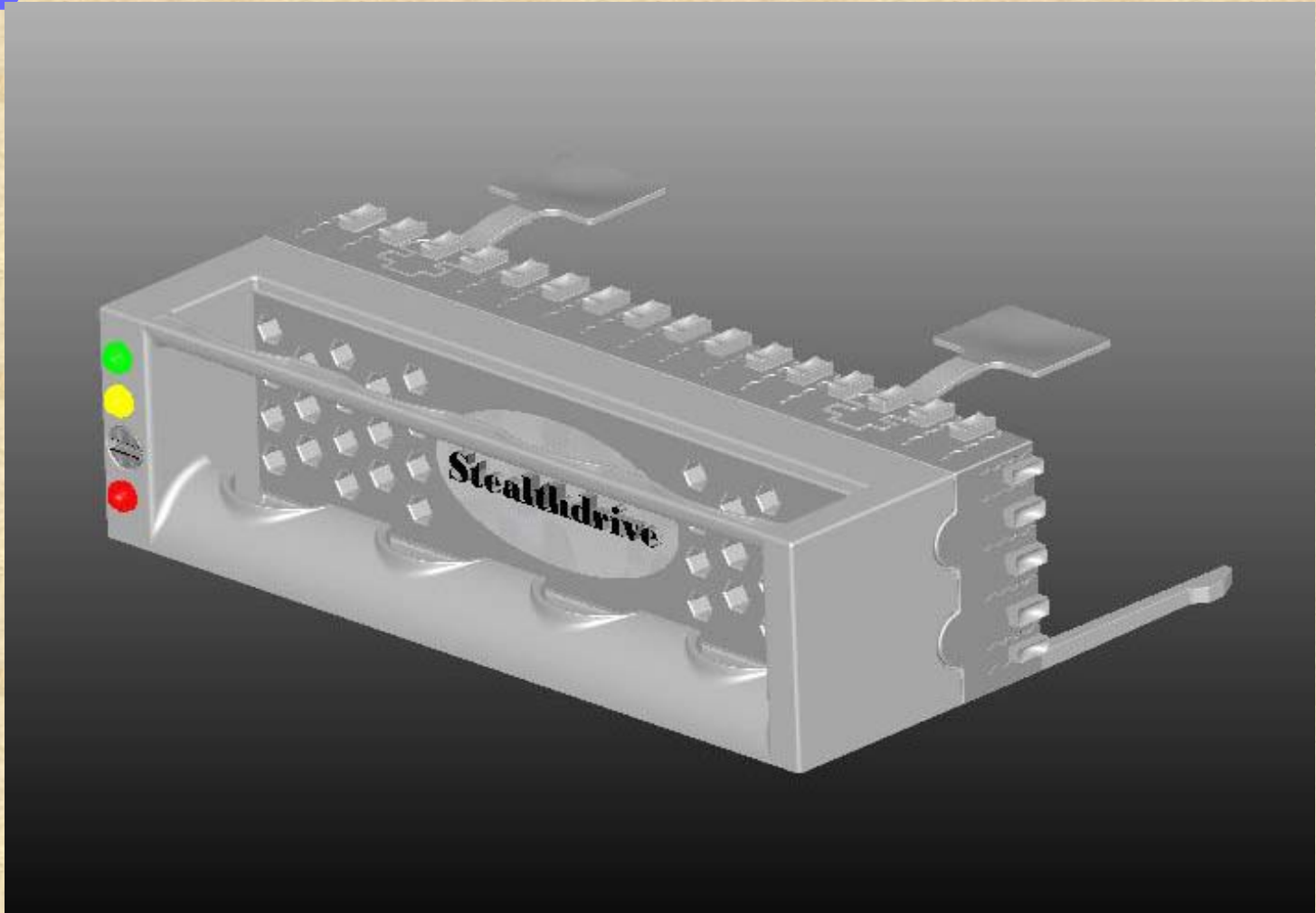
Primary Type of Content to be Stored on NAS

(Among Internet Households, NAS Intenders, n = 280)

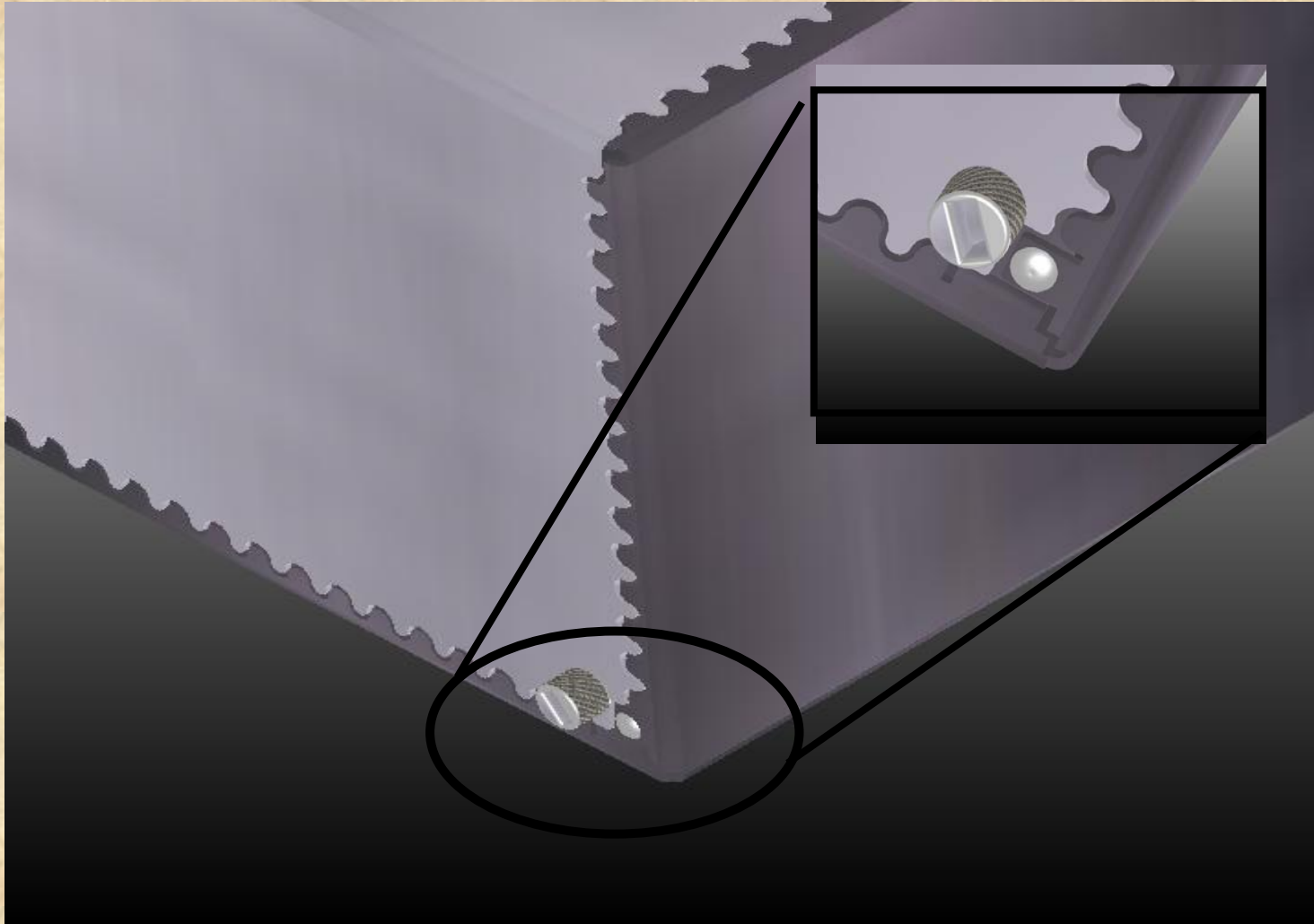


The Diffusion
Group, 2005
Storage Visions
Conference

Network Storage Packaging Stealthdrive Faceplate Assembly

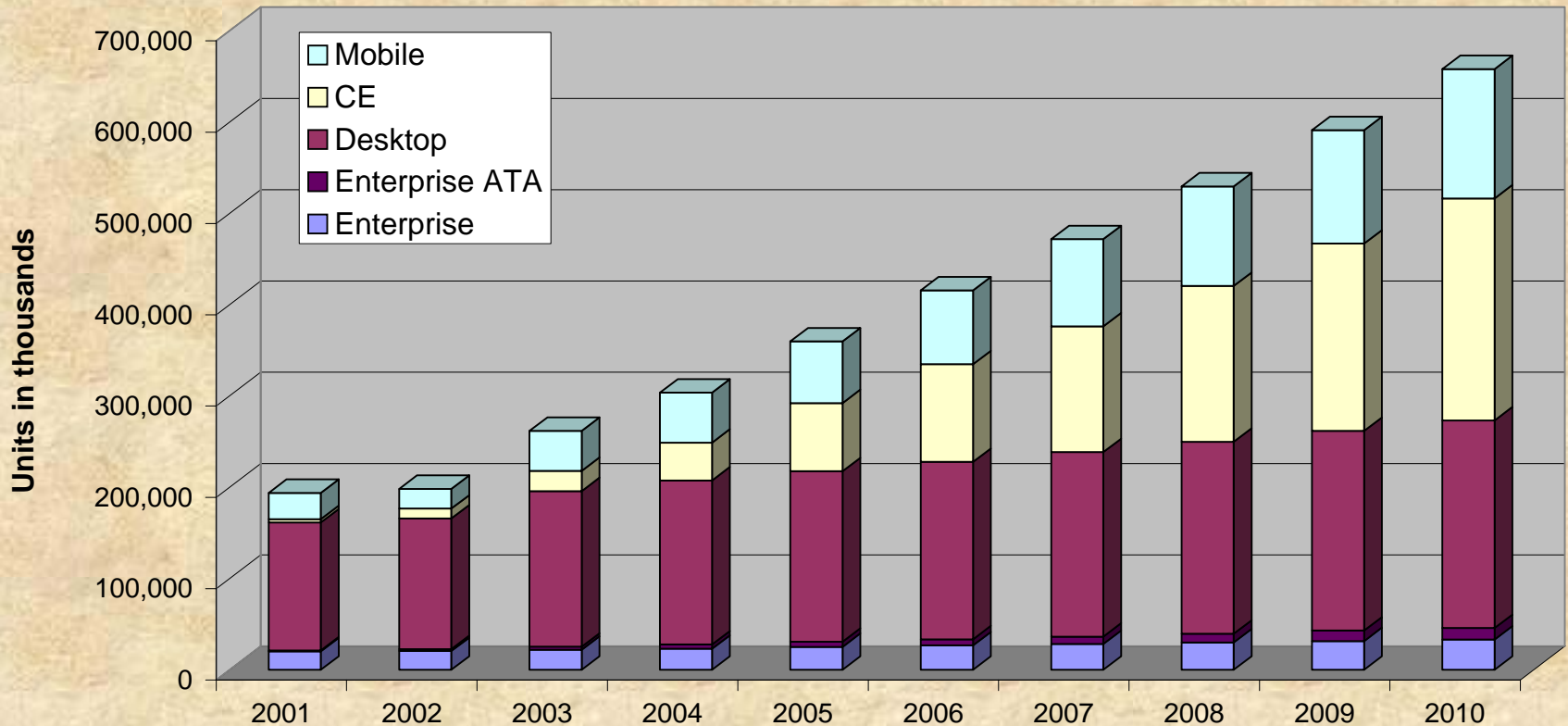


Network Storage Packaging Tortured Path EMC Solutions

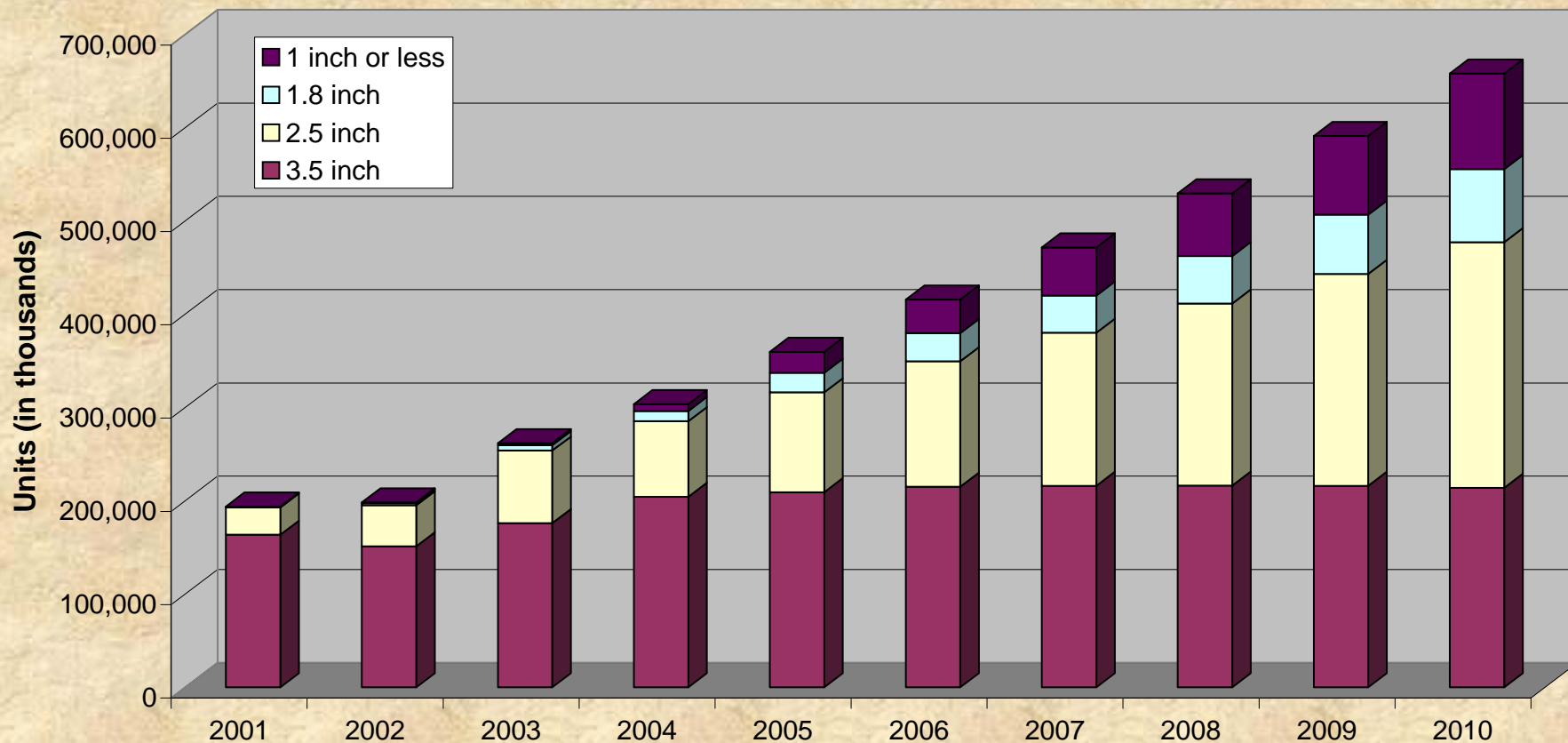


Disk Drive Projections

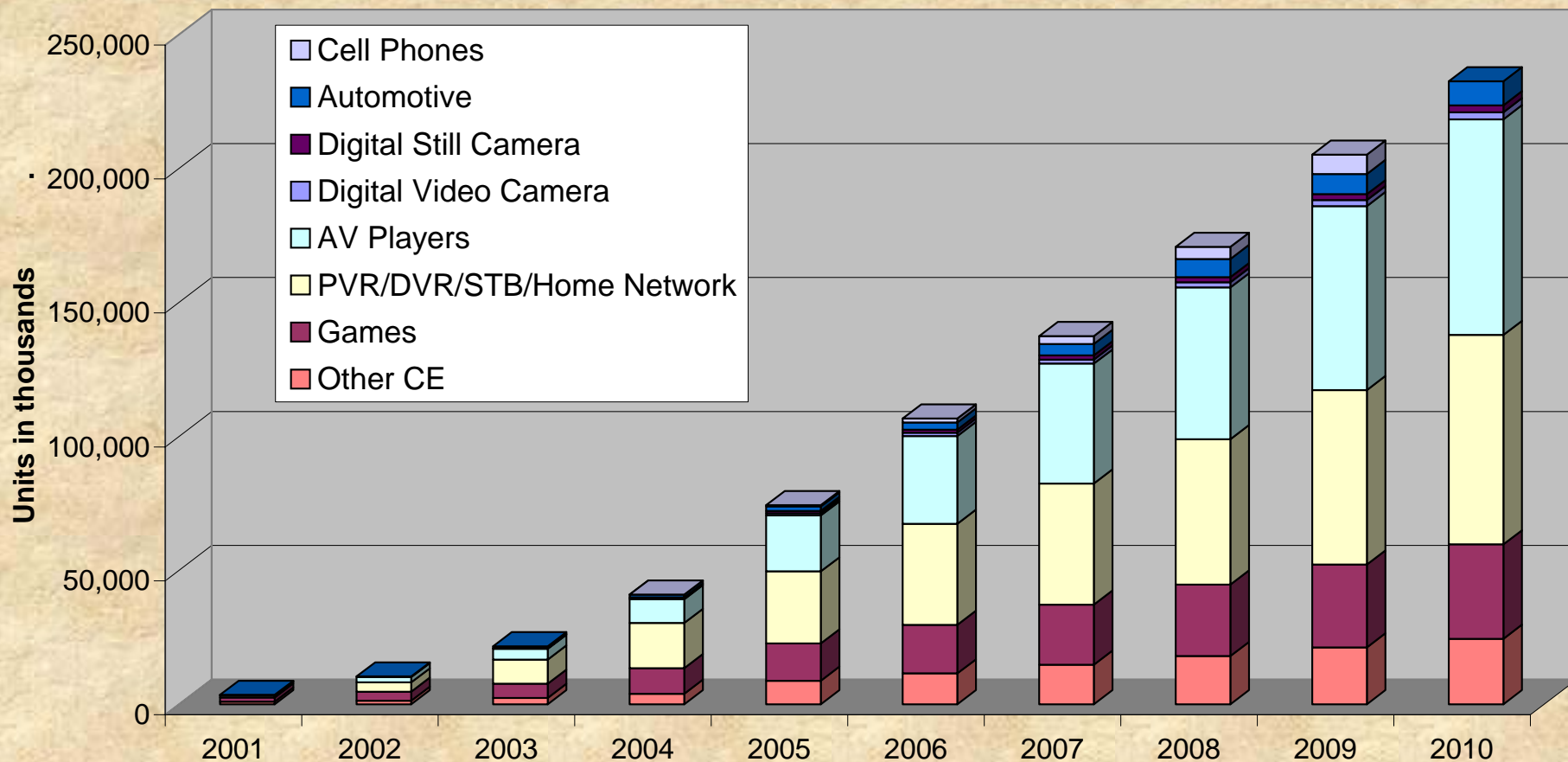
HDD Market Niche Projections



HDD Form Factor Projections



CE Drive Applications



Conclusions

- Digital content creation, distribution, and Consumer Electronics require large volumes of storage
- Storage devices and requirements vary throughout the content value chain
- Choice of storage device based on several factors—storage hierarchy
- Integration of storage into consumer electronics will be a key way to lower prices and increase market penetration of storage applications
- Content Creation and Consumer Electronics represent a fast growing opportunity for storage devices and storage systems companies

Acknowledgement: Much of the material from this presentation was created while researching the forthcoming **2005 Digital Entertainment Series Reports**, For more information see www.tomcoughlin.com.

The journey of a thousand files begins with a single bit...

