The Content of Storage

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Outline

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

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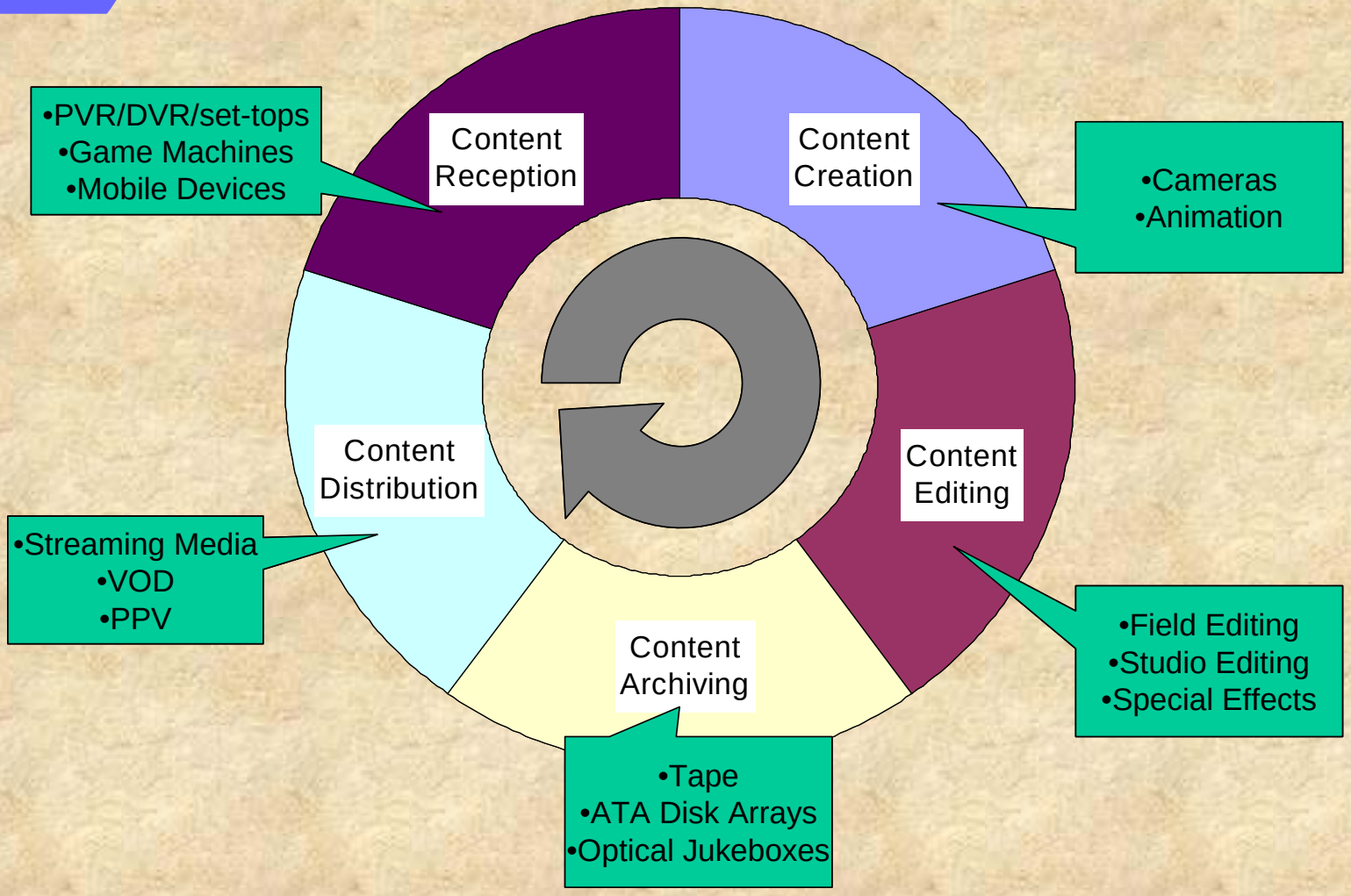
Digital Content Value Chain



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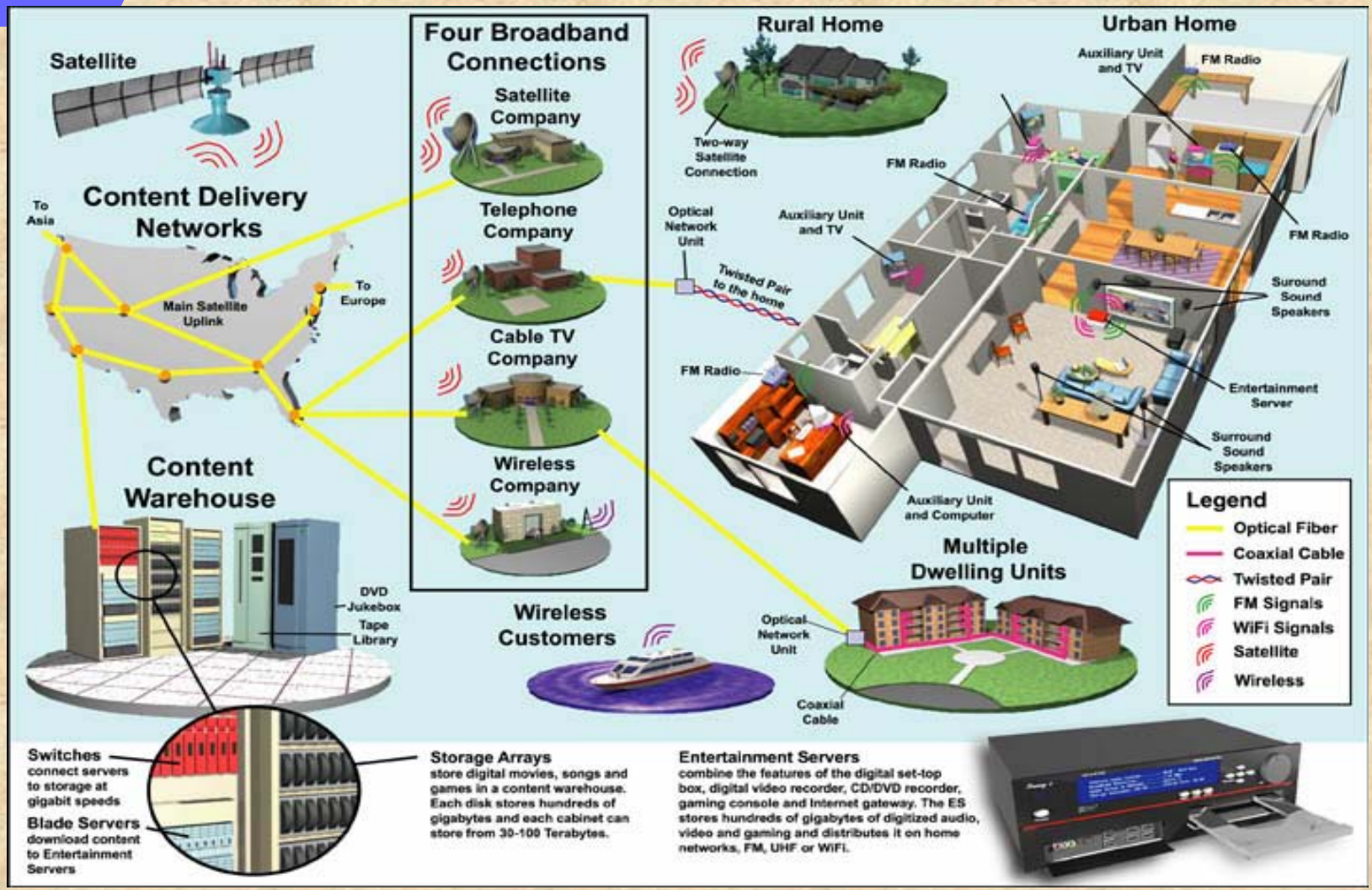
Digital Content Distribution Chain

From Scott Kipp's book "Broadband Entertainment."



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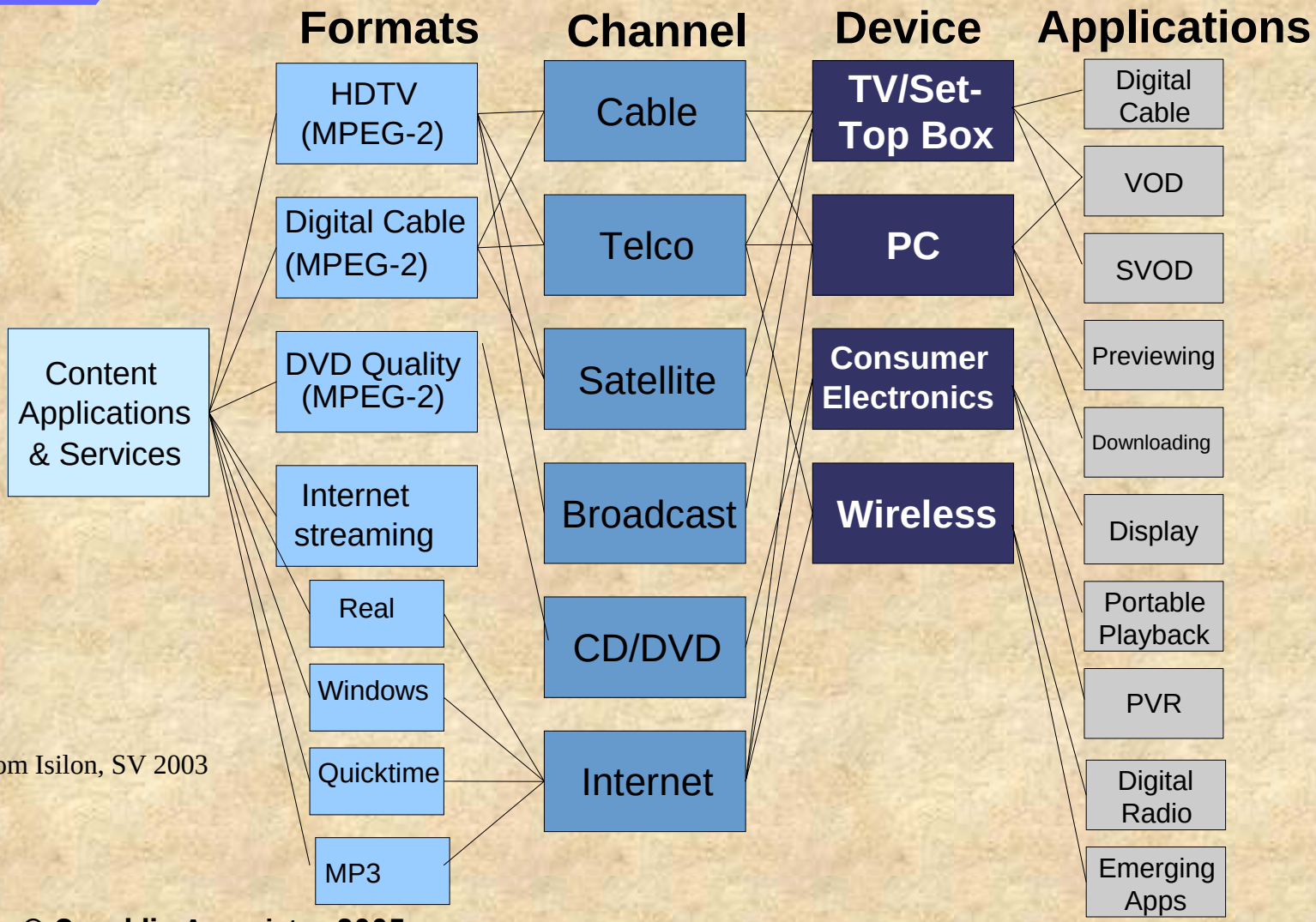
Many Digital Content Revenue Streams



From Isilon, SV 2003

Applications for Consumer Electronics

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Storage Devices for Entertainment Reception

- **Flash Memory**
- **Hard Disk Drives**
- **Optical Disks**

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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)

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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!

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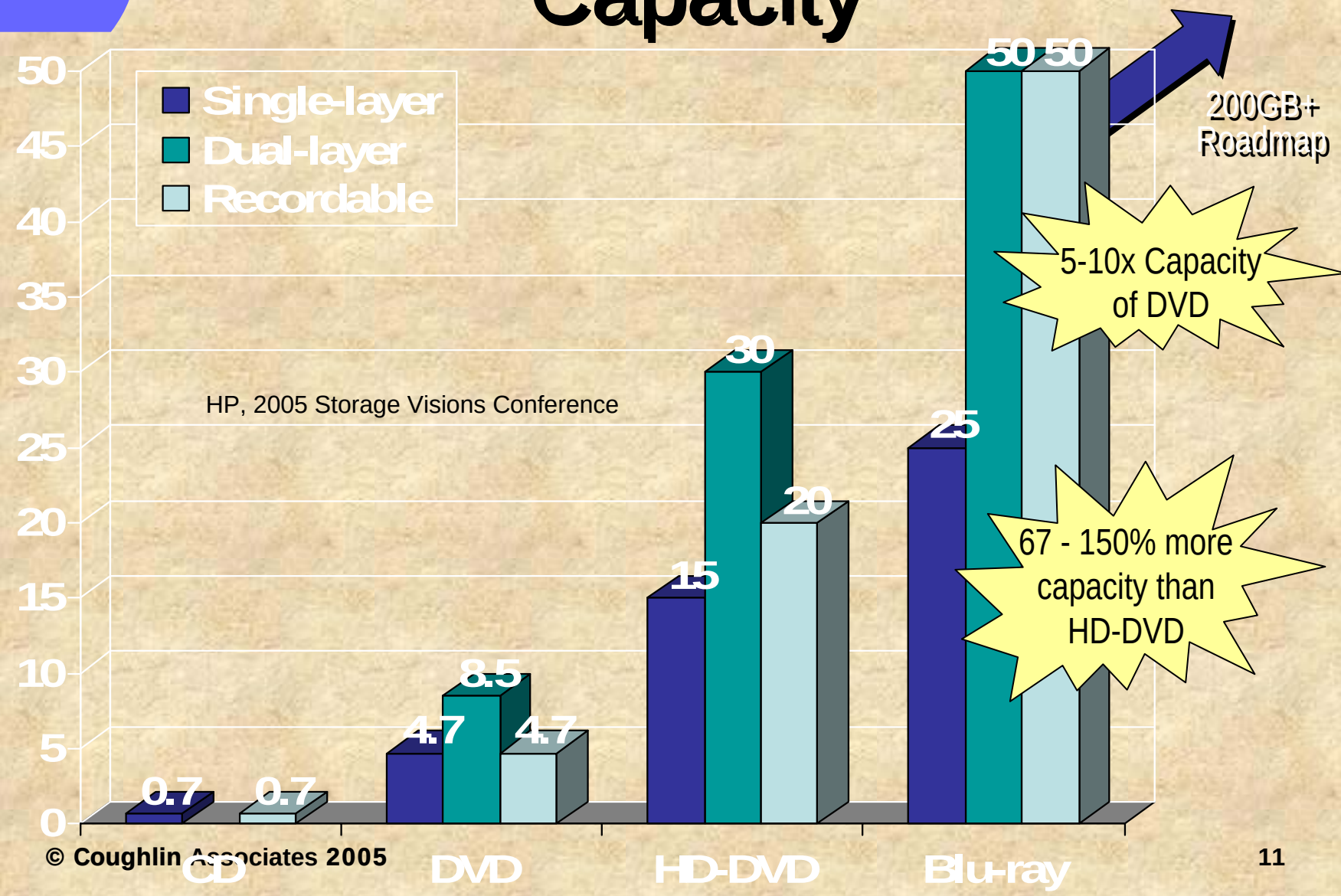
Blu-ray Disc Delivers More Capacity



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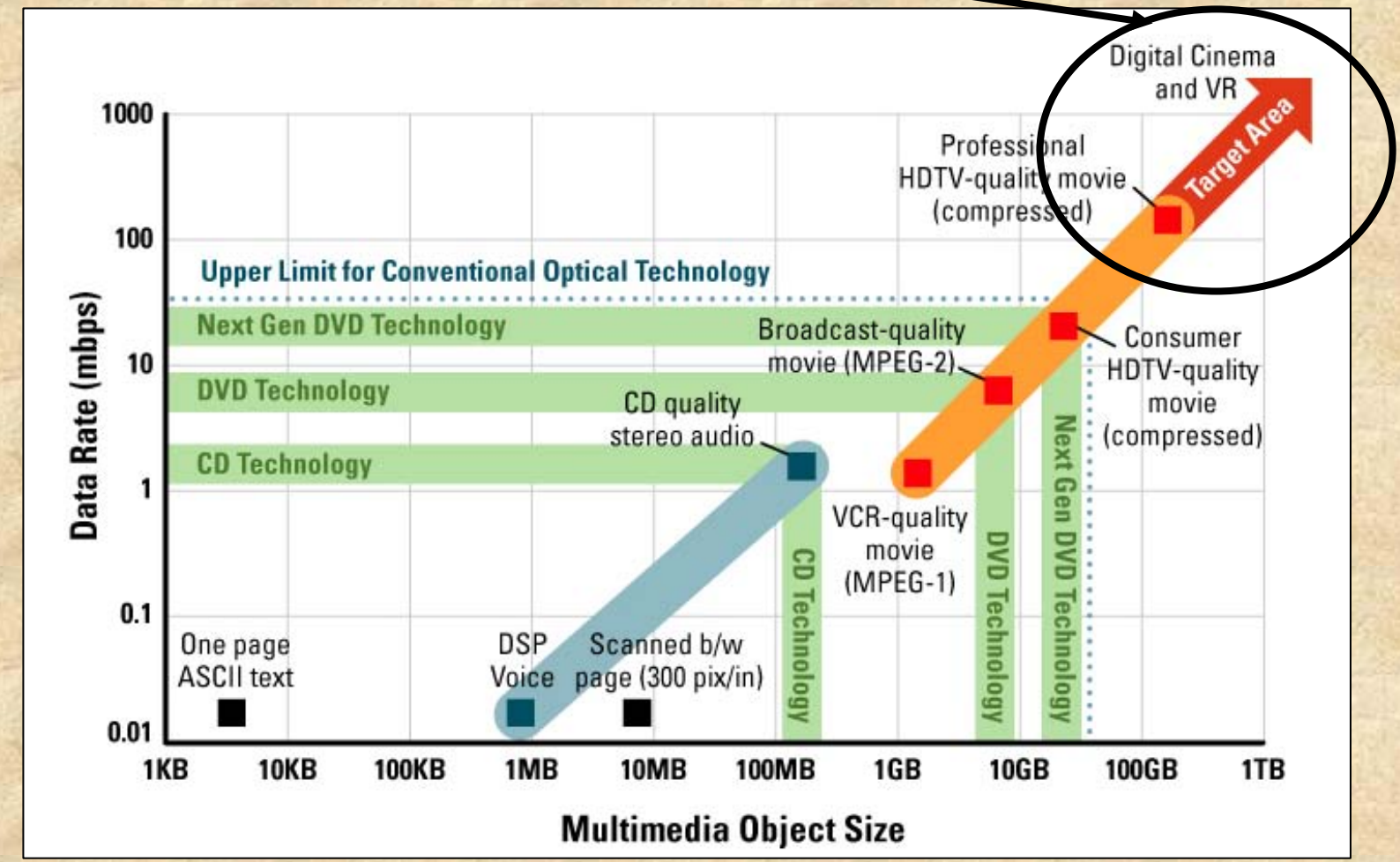
Optical Content Distribution Trends

Holographic Disks



Source: Telcordia 3/03

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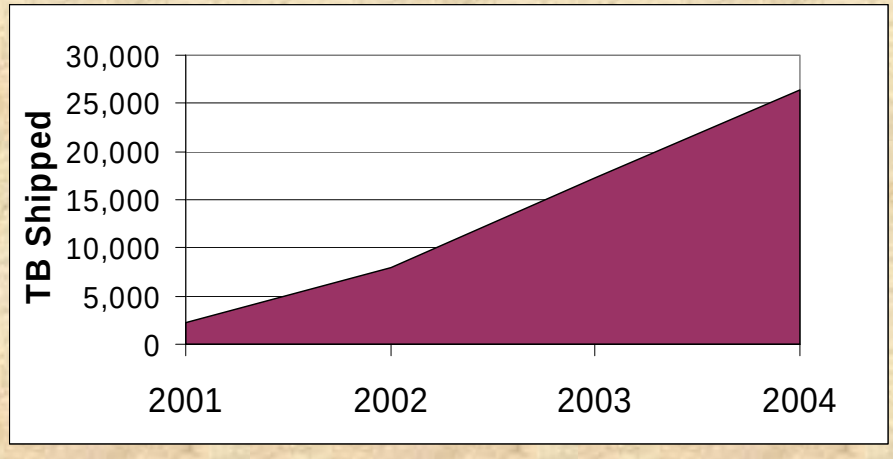
Flash Memory



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 Olypus & 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

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Consumer Hard Disk Drive Form Factors

3.5-Inch Drives

0.85-Inch Drives

2.5-Inch Drives

1.0-Inch Drives

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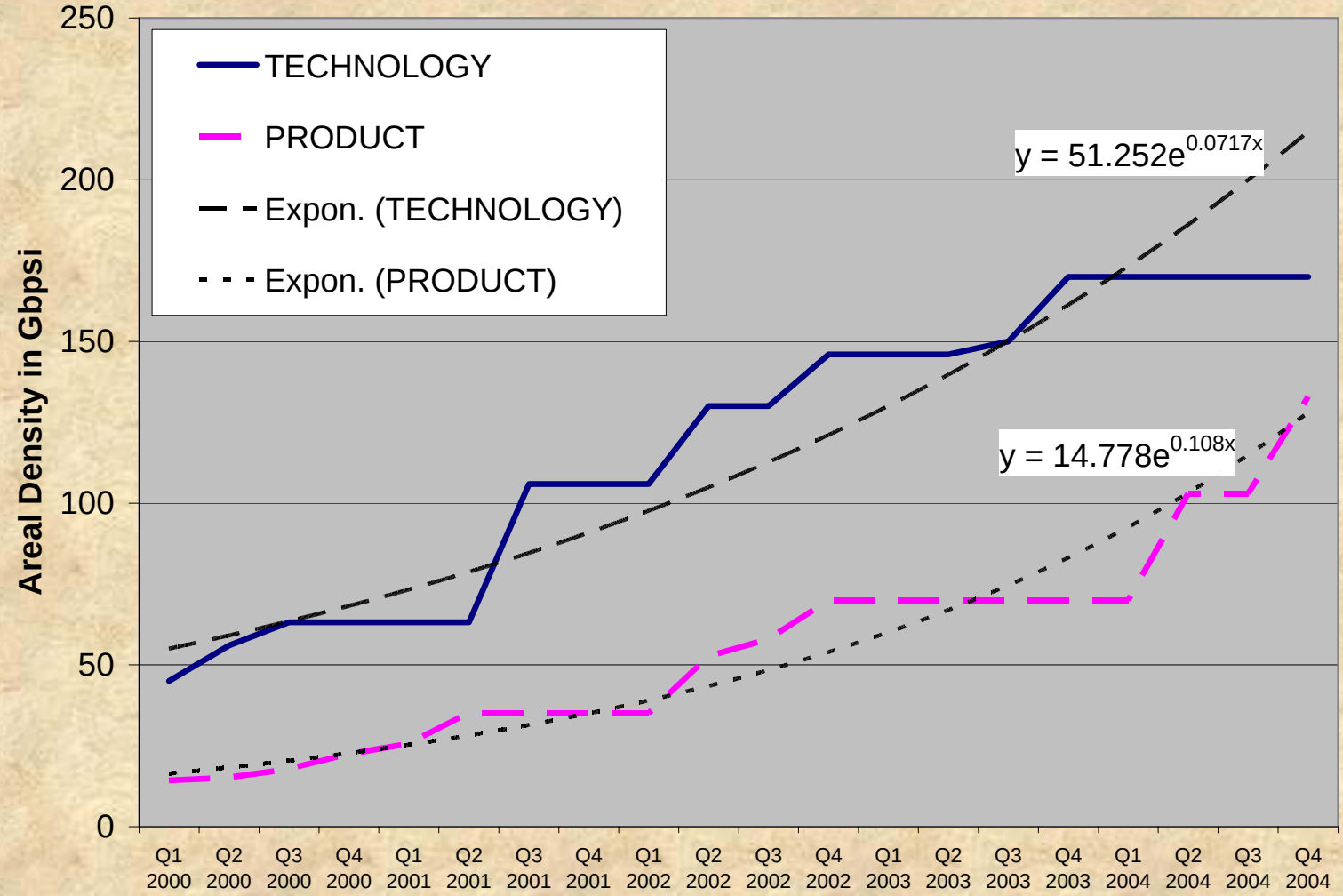
HDD Quarter by Quarter Public Technology Demonstrations and Product Announcements



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Perpendicular Recording

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

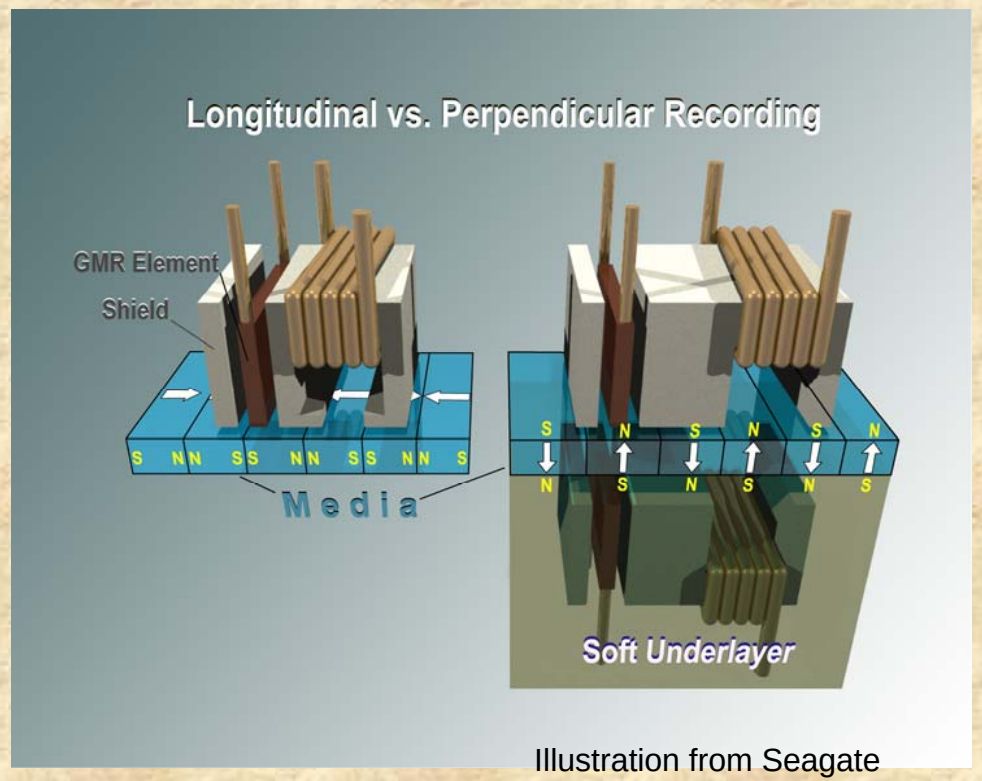

Illustration from Seagate

- 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!

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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

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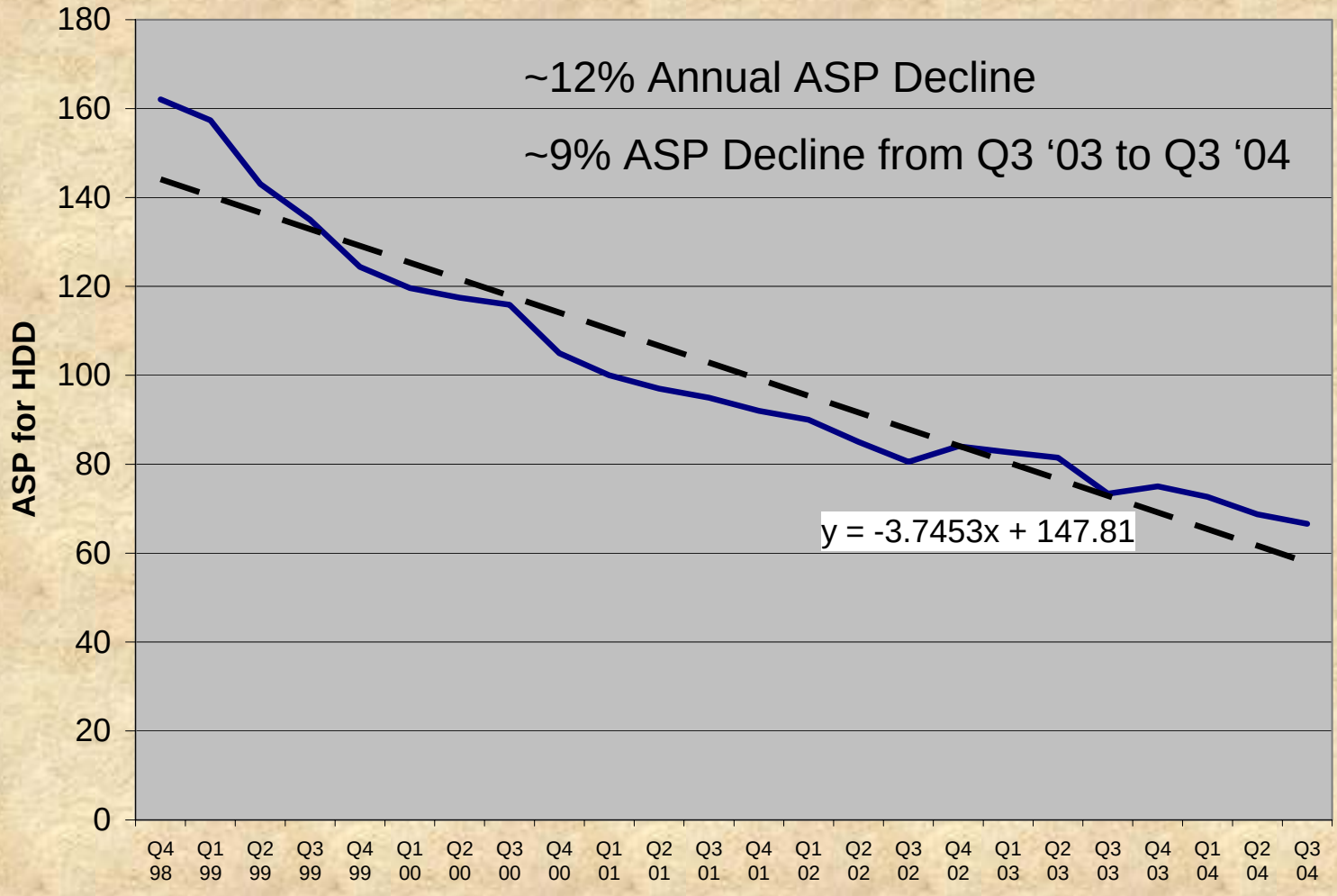
Disk Drive ASP Trends

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



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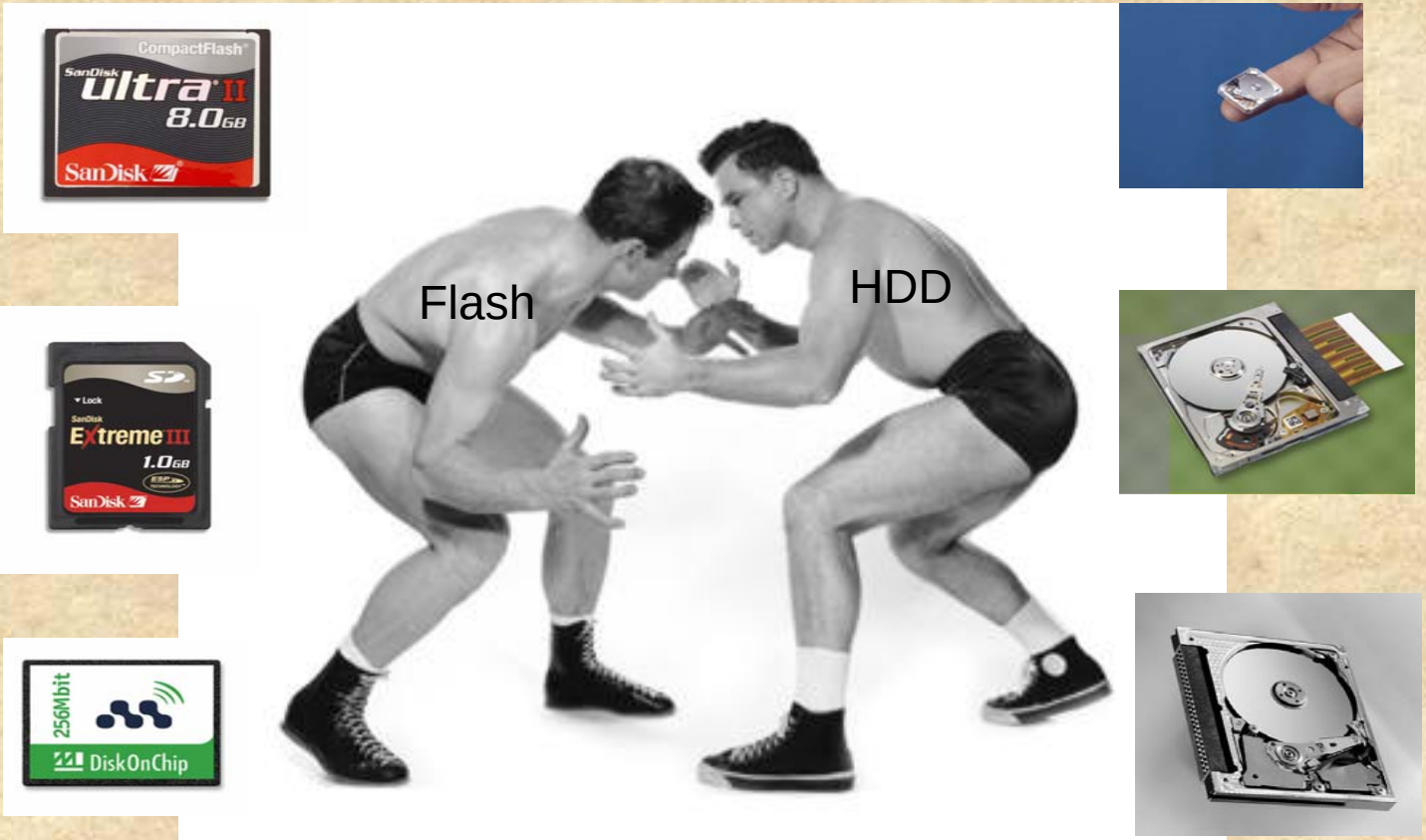
The Battle for Mobile Supremacy



Mobile Storage Factors

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

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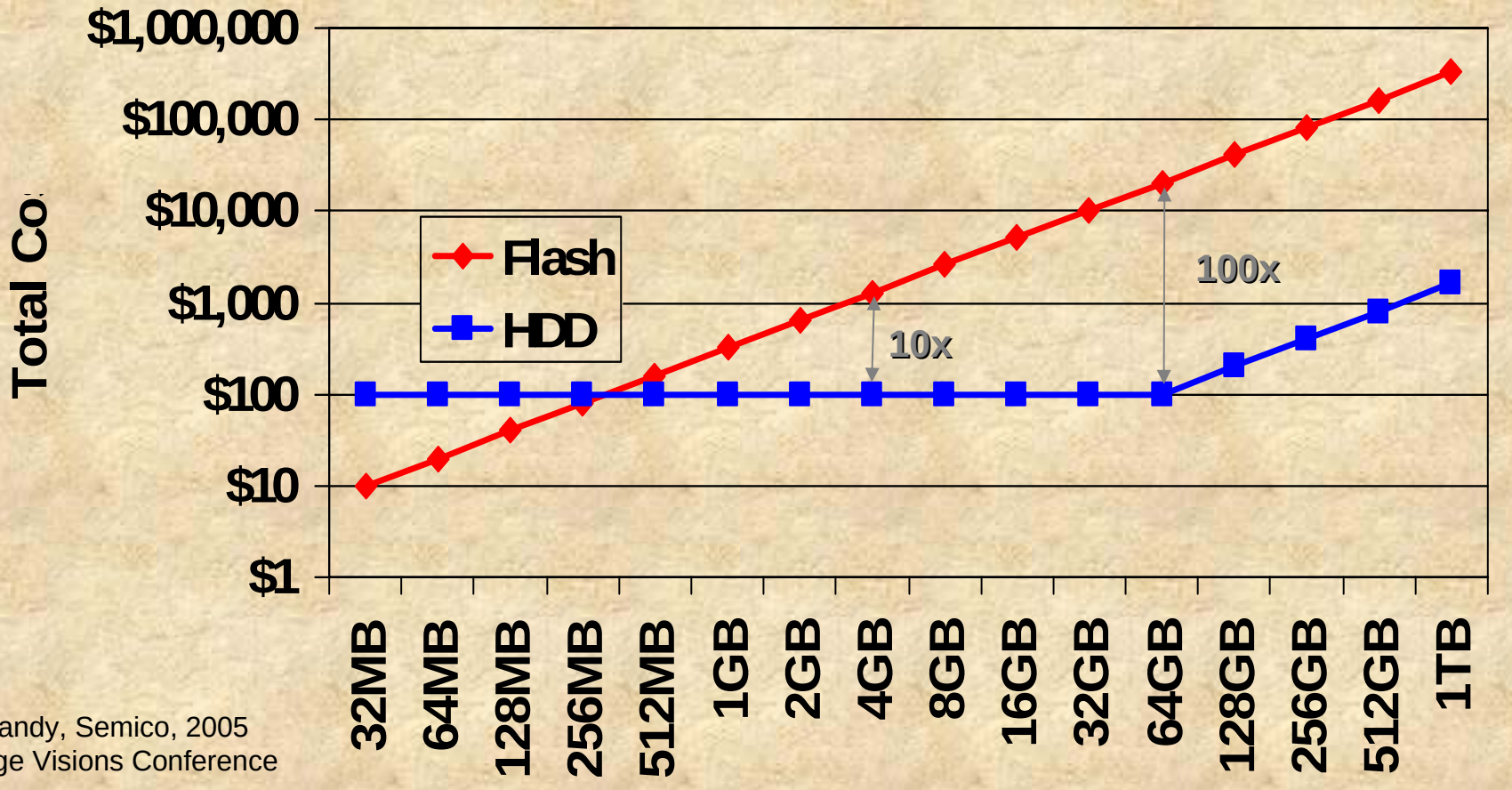
System Cost vs. MB



Jim Handy, Semico, 2005
Storage Visions Conference

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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

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Small Hard Disk Drives—Not The Answer For Mobile Phones

Based on Cornice 2GB dimensions

Products available in 2004

Measurements in mm

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**		

SanDisk, 2005 Storage Visions Conference

*1MB = 1 Million Bytes

Portable Consumer Digital Devices

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current

future

Flash implementation in CE will continue to grow

HDD is an excellent choice for high capacity applications

MP3 player

MP3 jukebox

Handheld Game

Game Console

PDA

Automotive

Camcorders

Mobile phone

With multi-functions

Video player

Digital still camera

Storage Requirement

32 MB 64 MB 128 MB 256 MB 512 MB 1 GB 2 GB 4 GB 8 GB 16 GB 32 GB 64 GB

Flash

HDD

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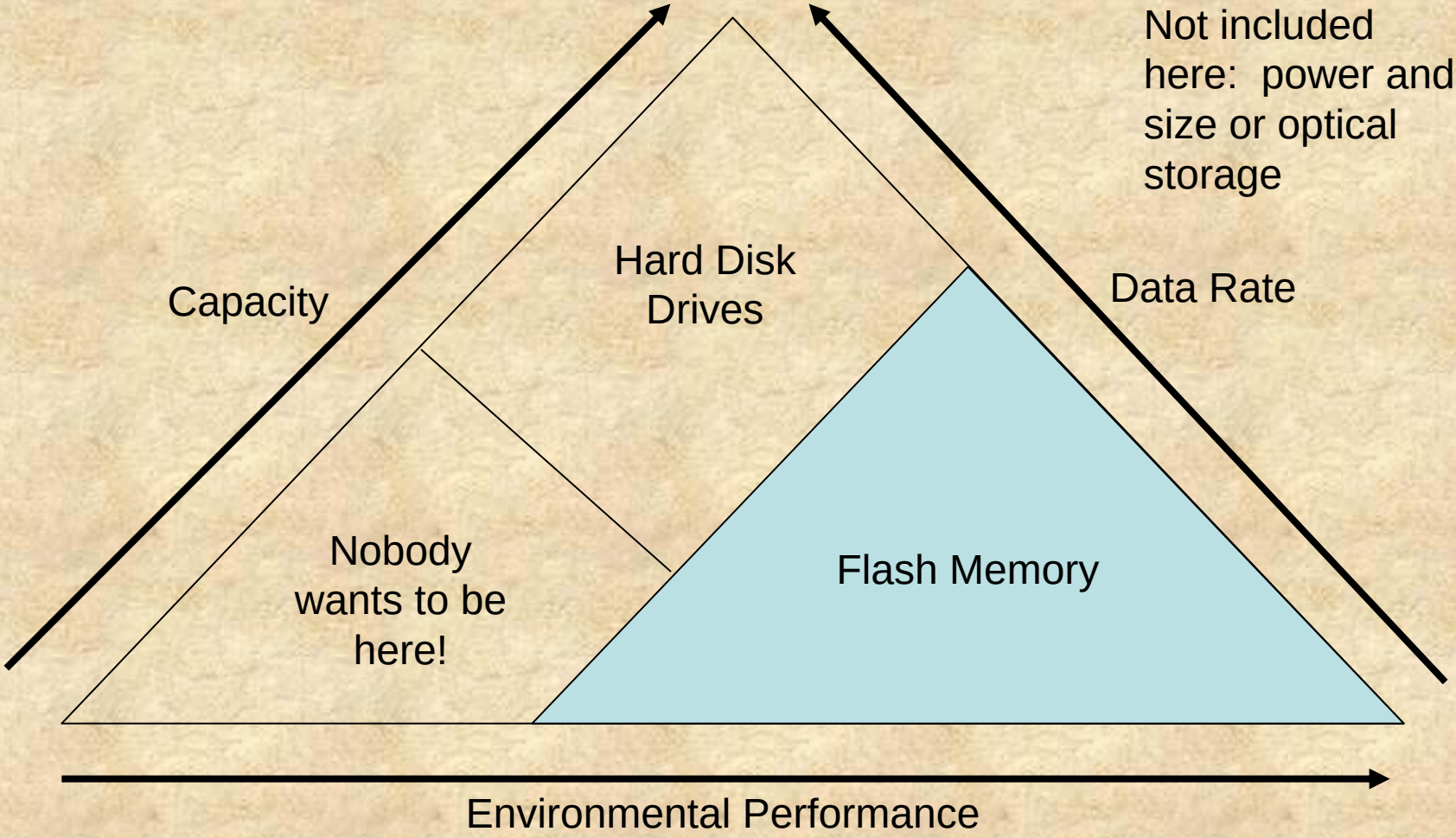
Or is it Mutual Admiration?
A Mobile Storage Hierarchy



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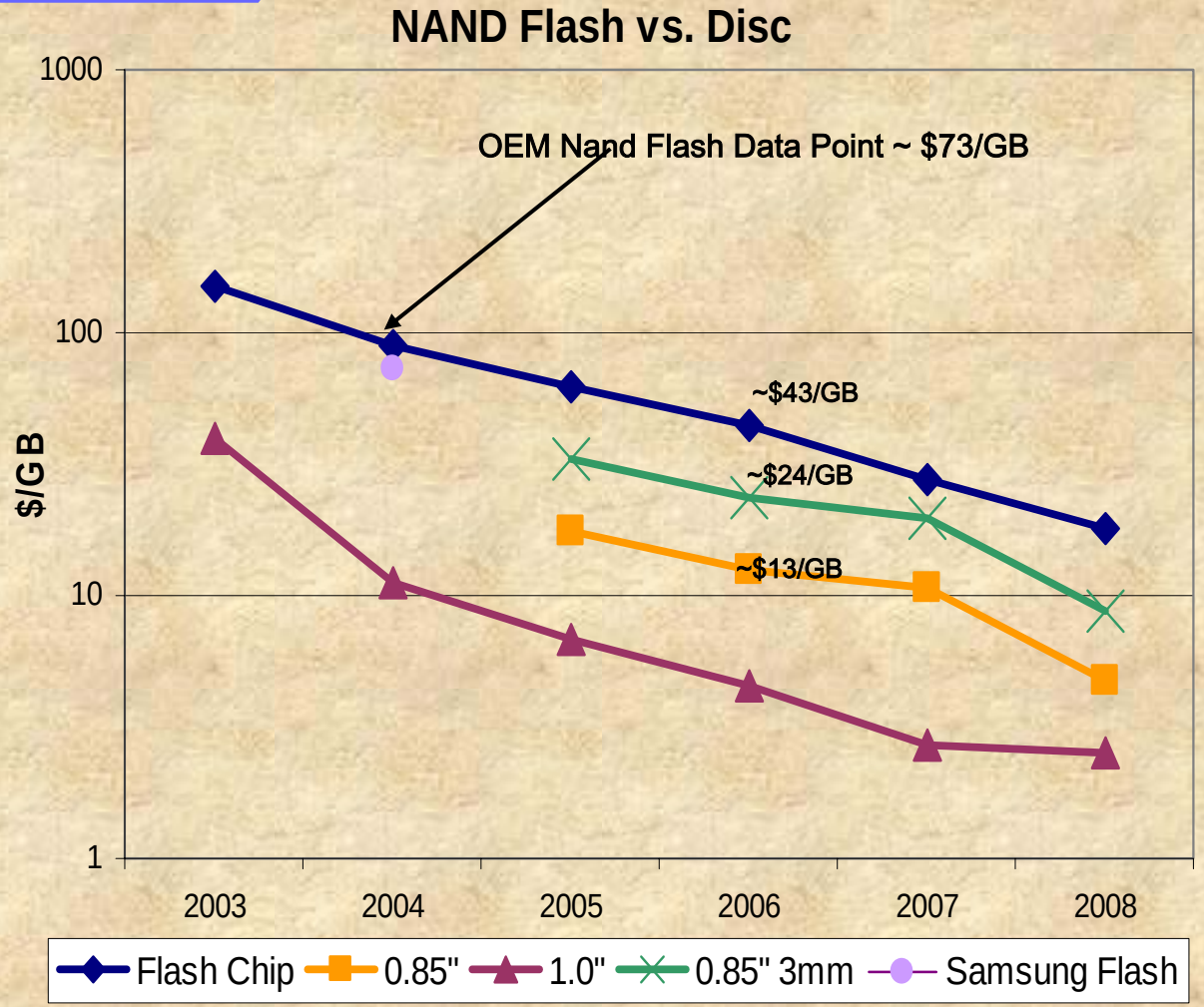
$/GB Advantage of HDDs Less for Smaller Drives



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

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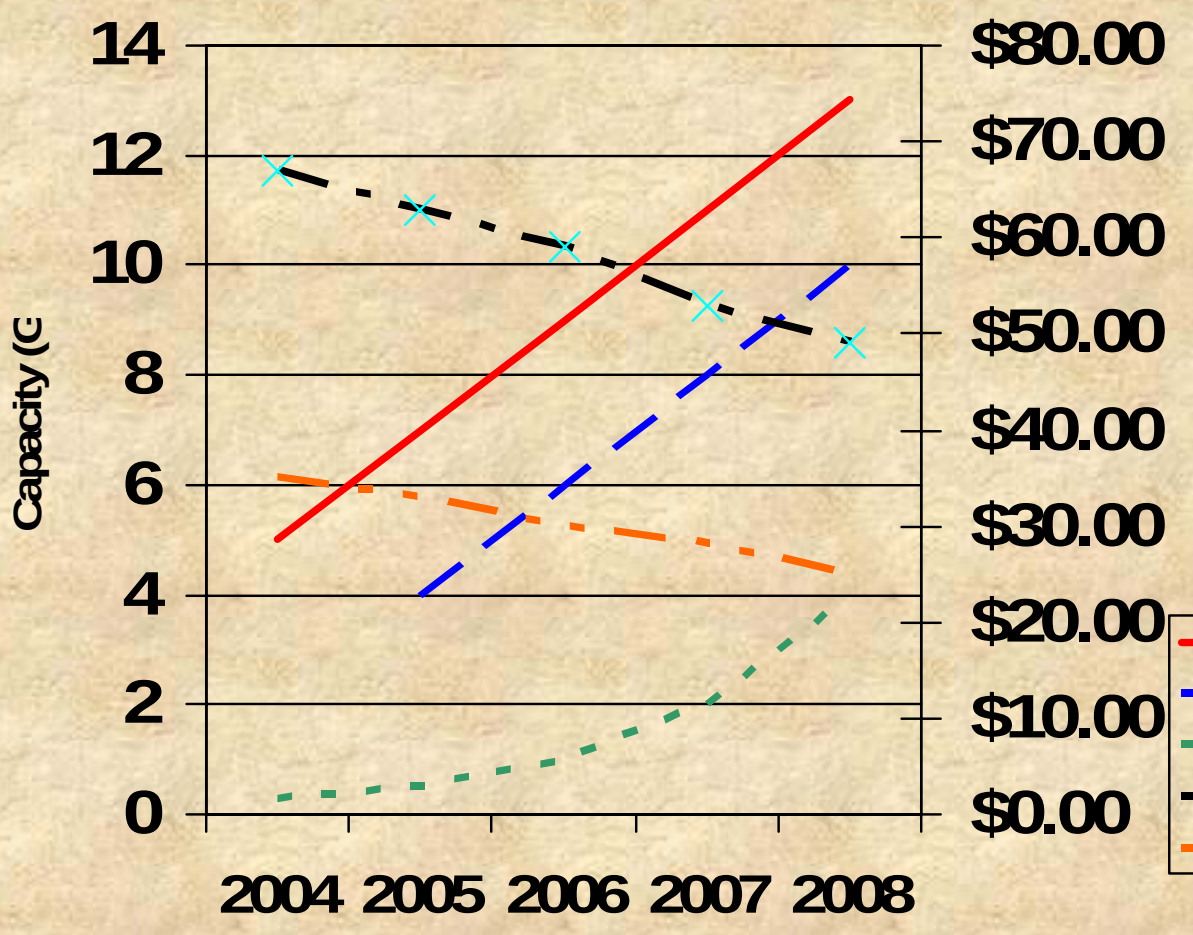
Caparison of Small Form Factor HDD Capacities and Prices vs. Mainstream Flash



- SanDisk announced an 8 GB Type 1 Compact Flash
- Toshiba announced it is possible to get 6-8 GB on a 0.85 inch disk drive

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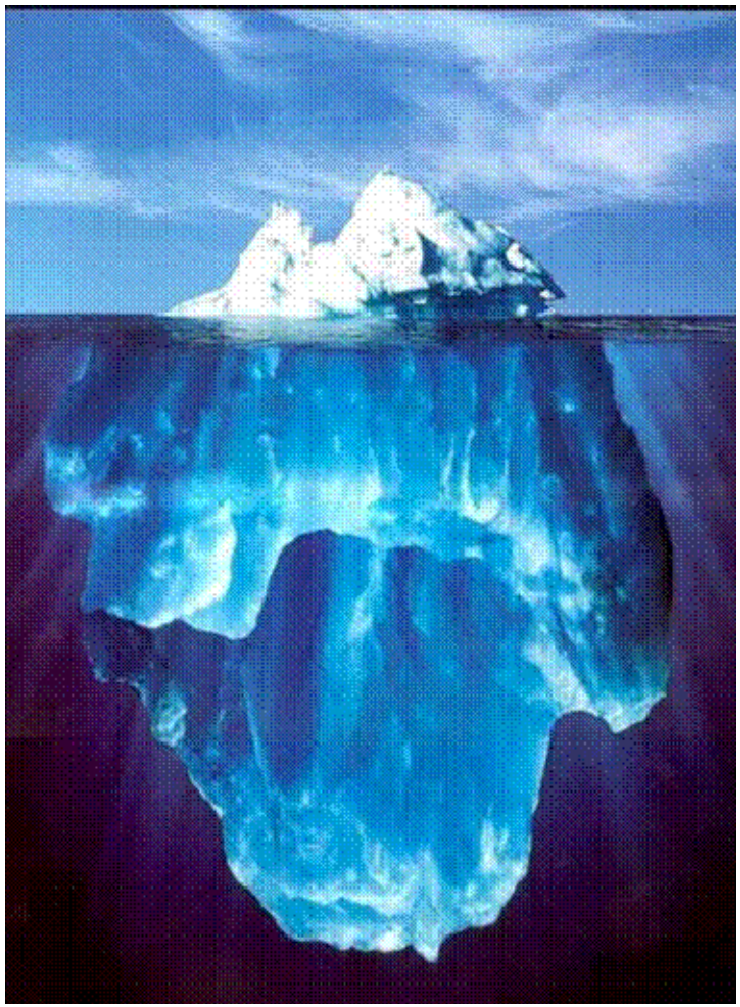
More (or maybe less) to Come…



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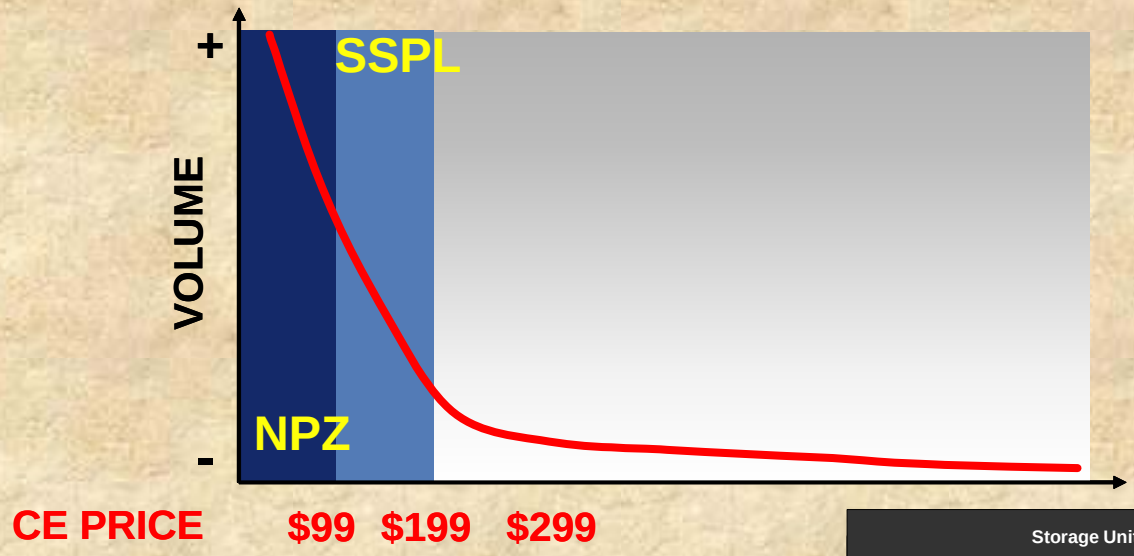
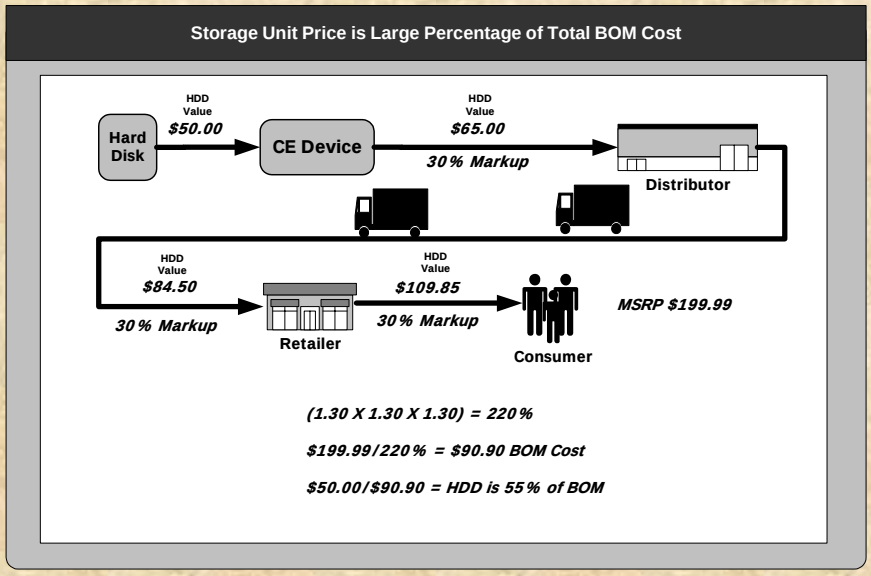
CE Volume is Very Sensitive to Product Price



From Cornice, 2003

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



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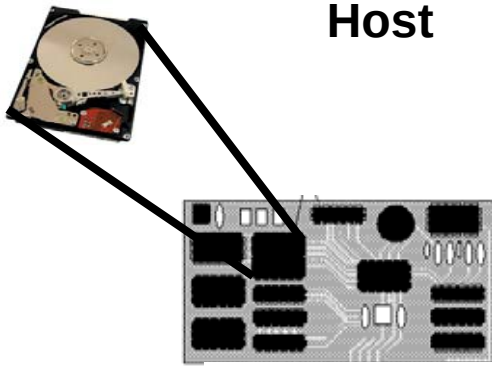
Two Extreme Poles of CE Disk Drive Integration

--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

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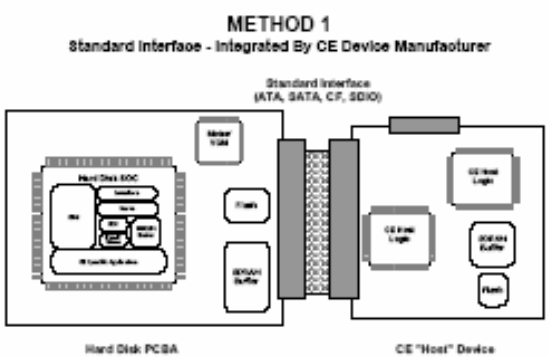
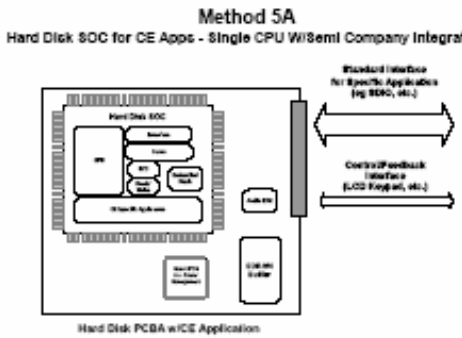
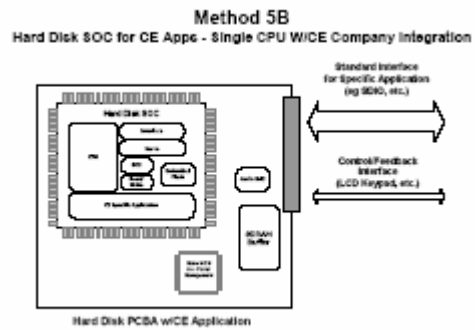
Methods of HDD CE Integration

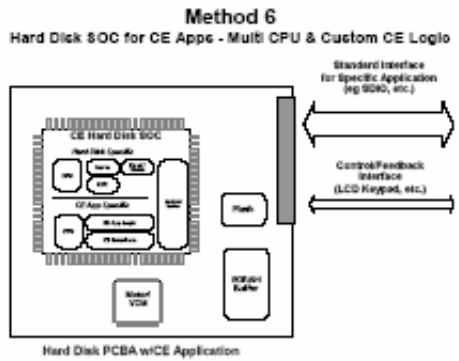
Today



Tomorrow







Source: Pat Hanlon Brief, 2004

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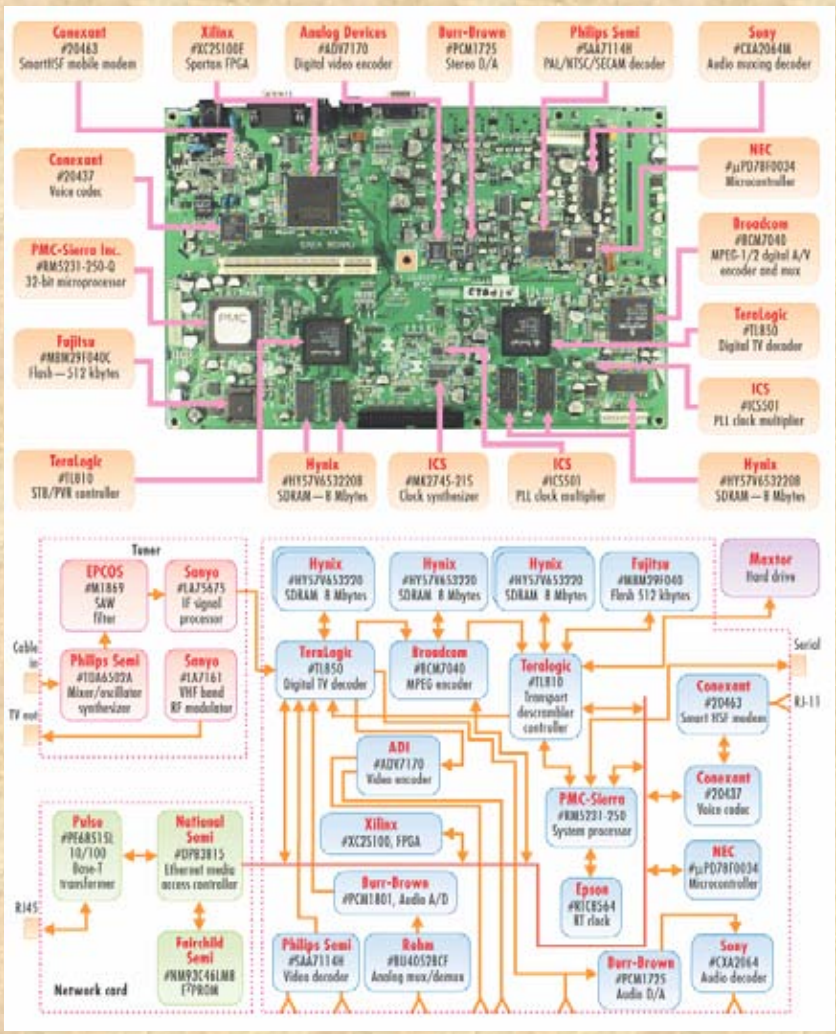
Replay TV Teardown

--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

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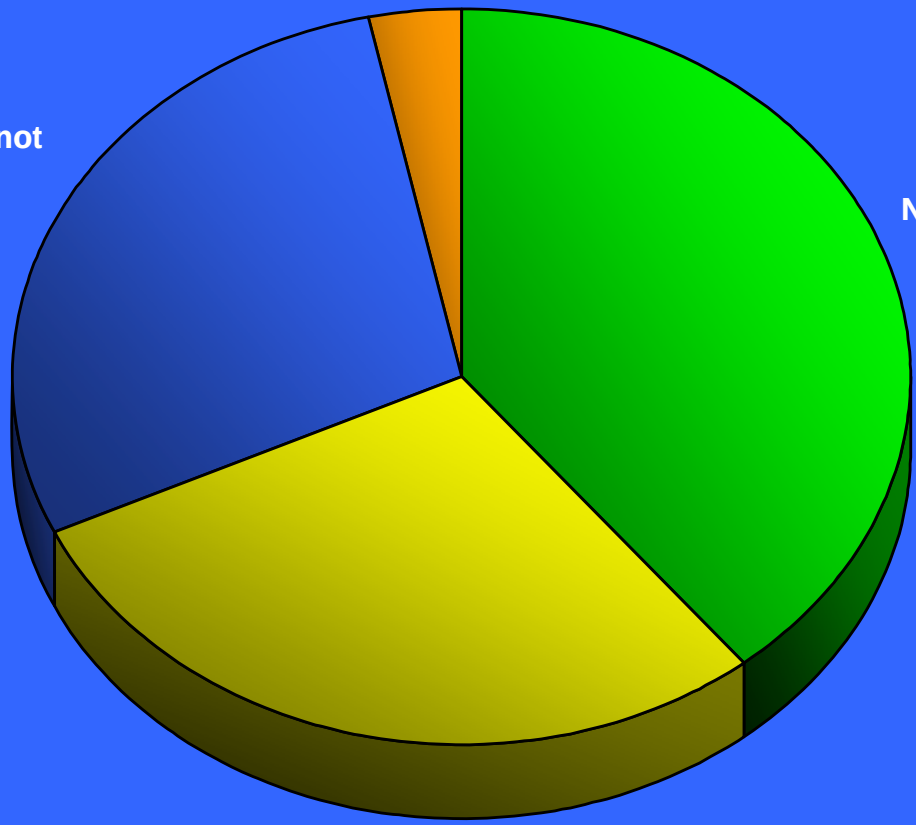
Familiarity with Network-Attached Storage Solutions

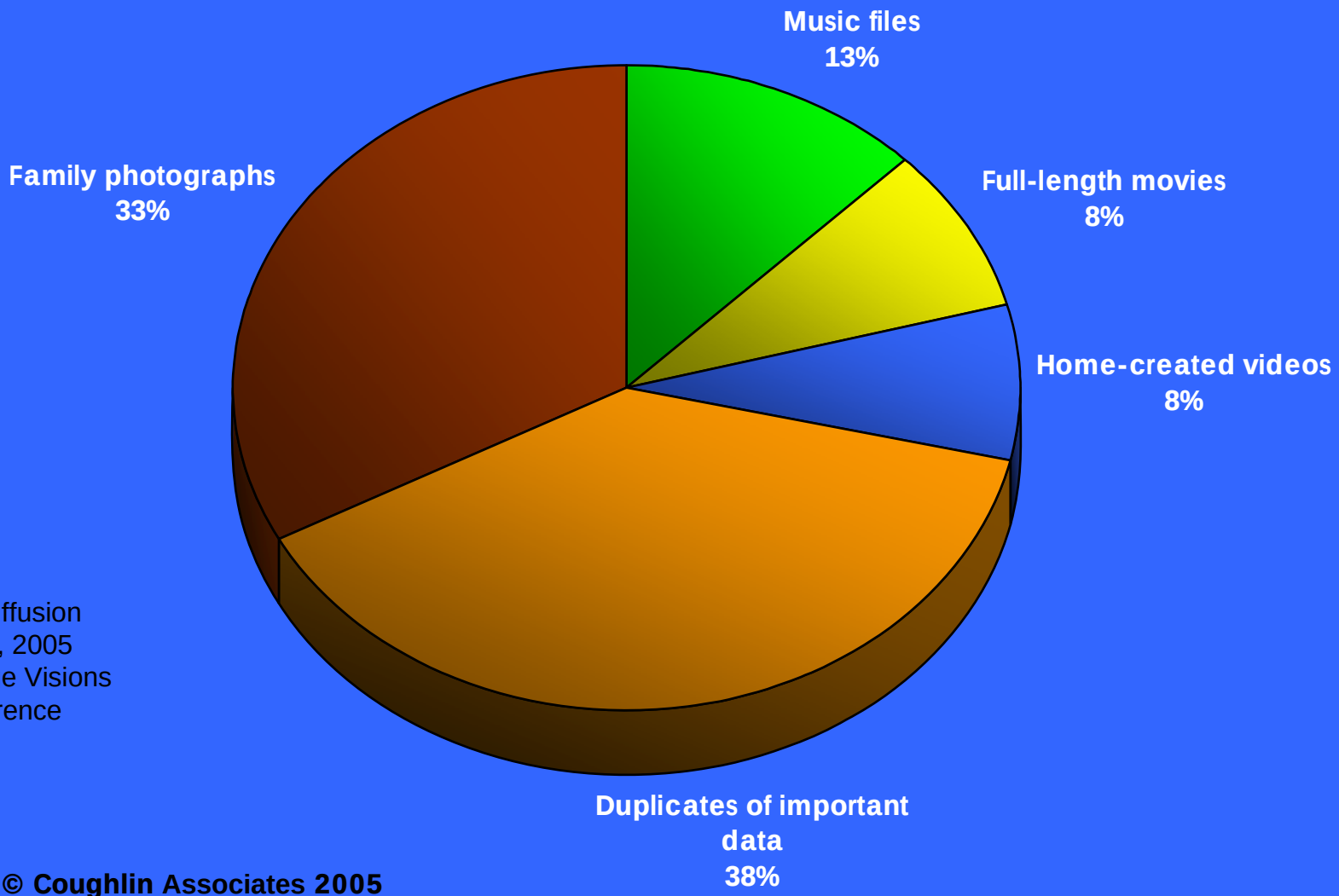
(Among Internet Households, Home Network Owners and Intenders, n = 817)



The Diffusion Group, 2005 Storage Visions Conference

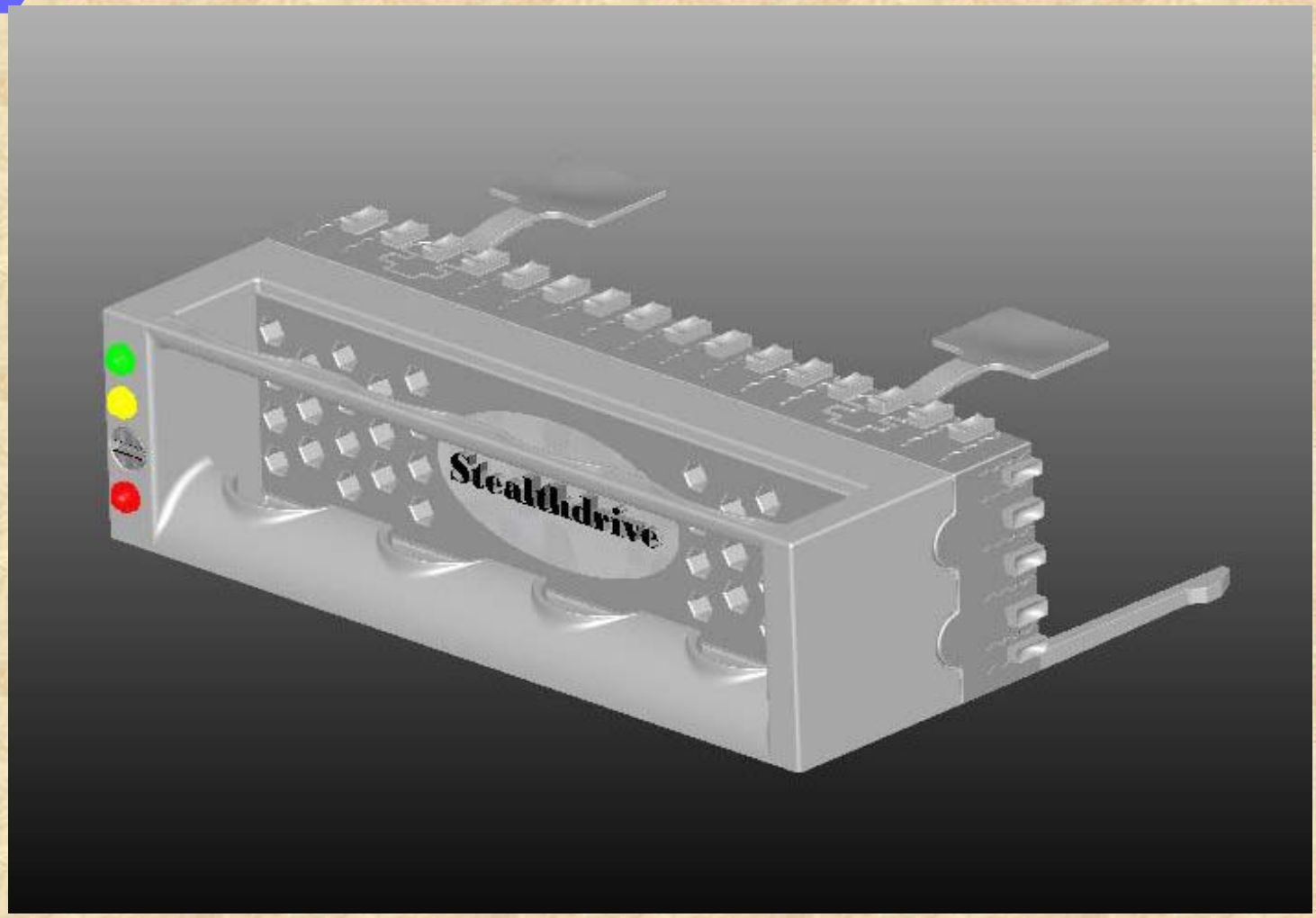
Primary Type of Content to be Stored on NAS

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

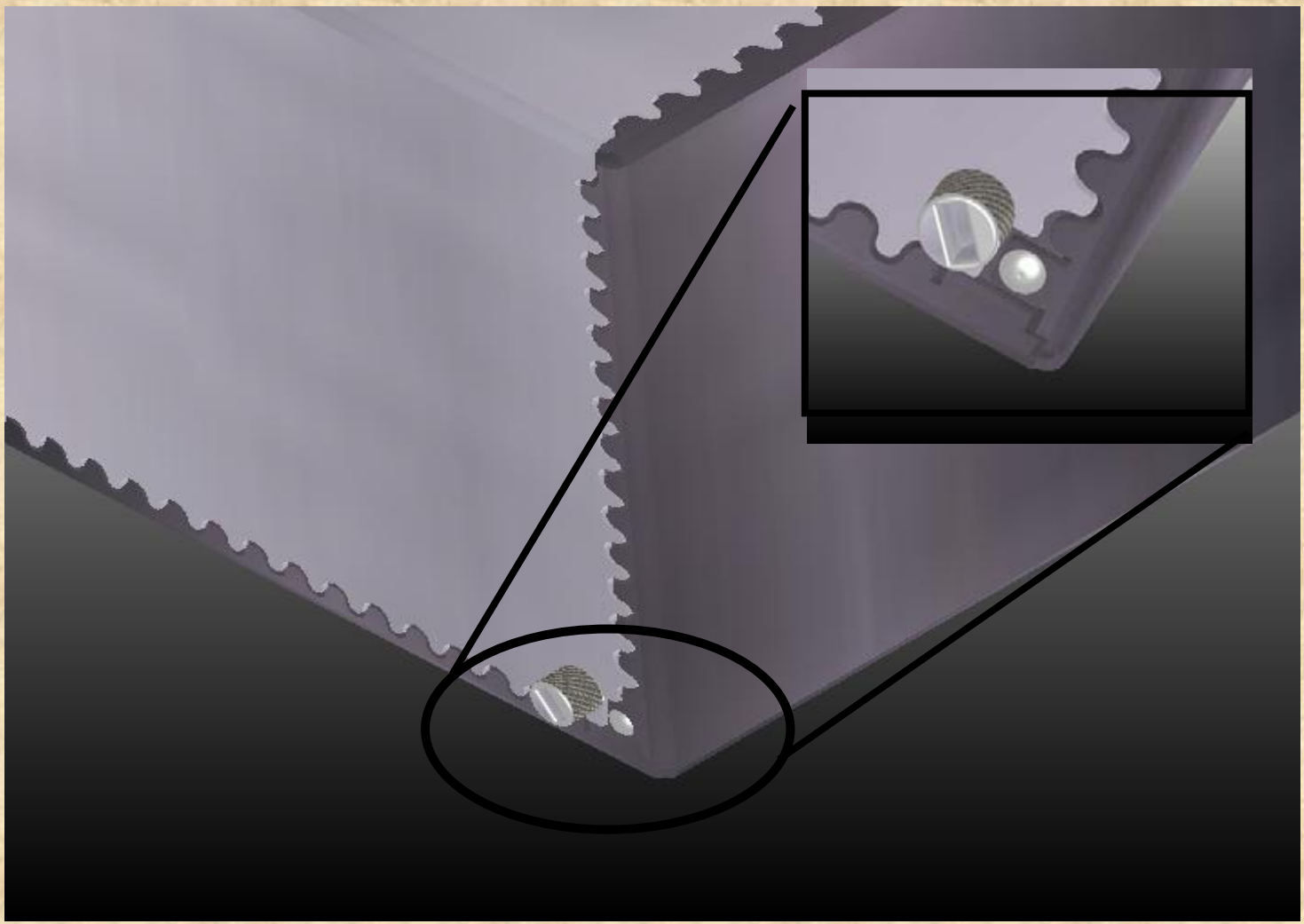


The Diffusion Group, 2005 Storage Visions Conference

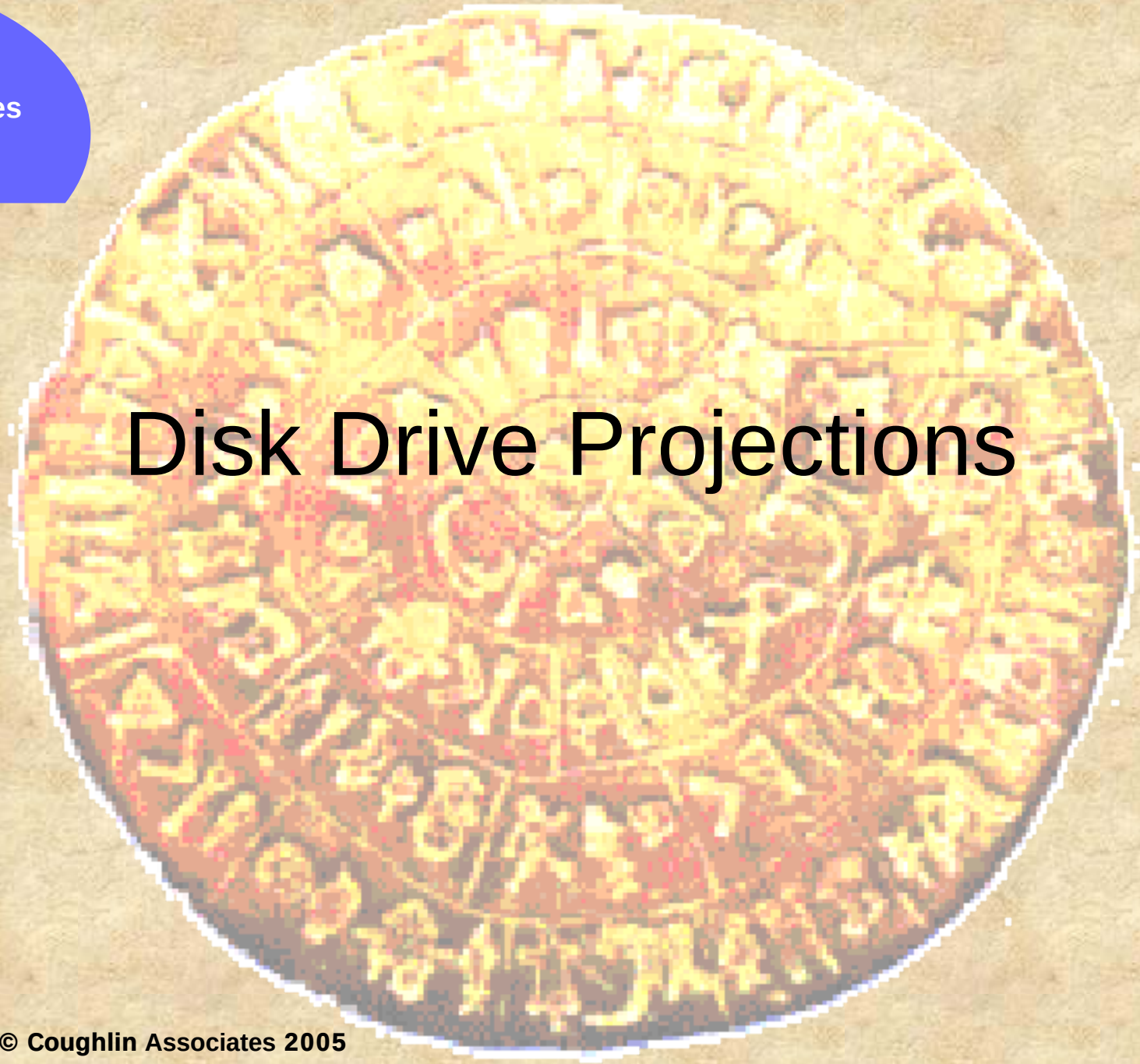
Network Storage Packaging
Stealthdrive Faceplate Assembly



Network Storage Packaging
Tortured Path EMC Solutions



Paul Cochrane, 2005 Storage Visions



Disk Drive Projections

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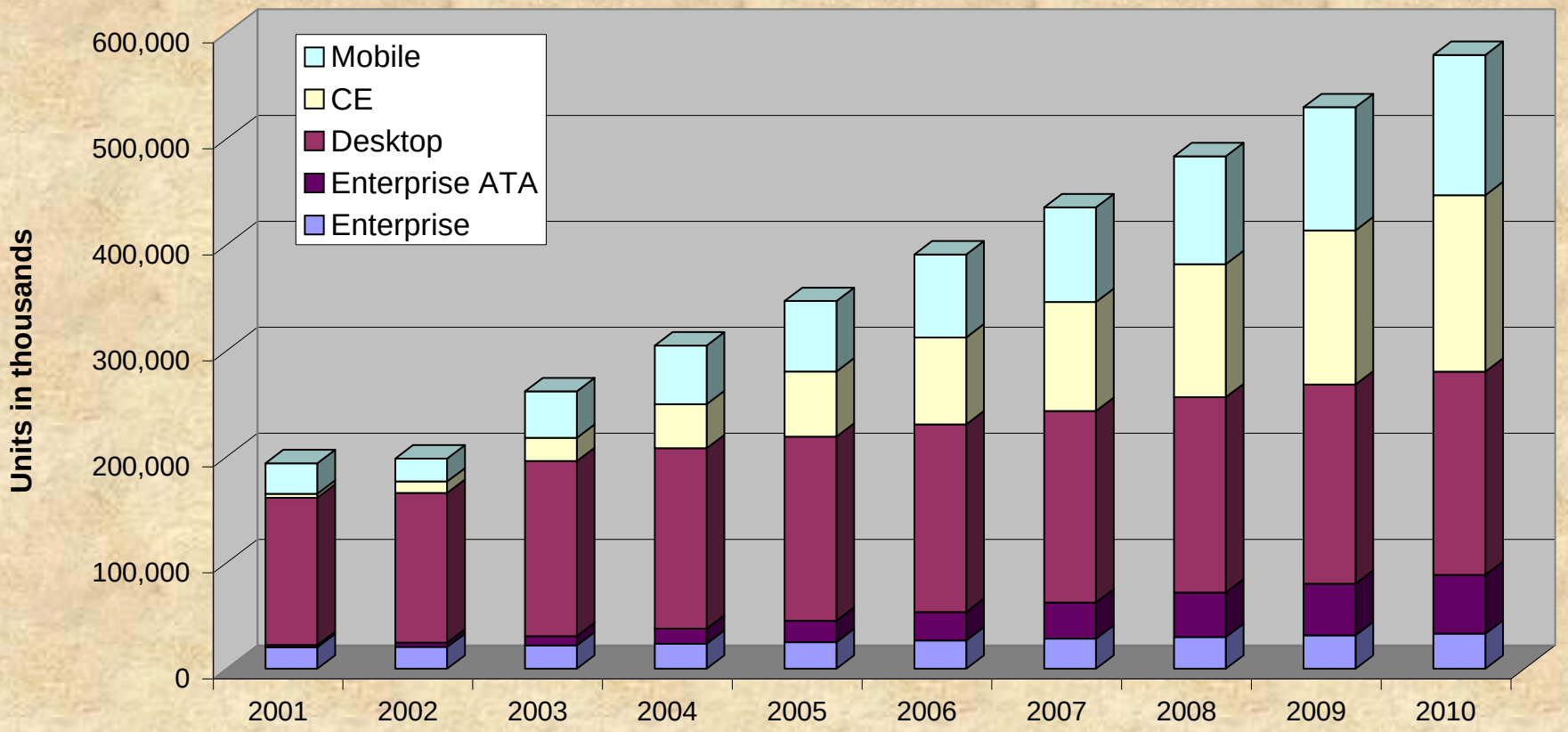
HDD Market Niche Projections



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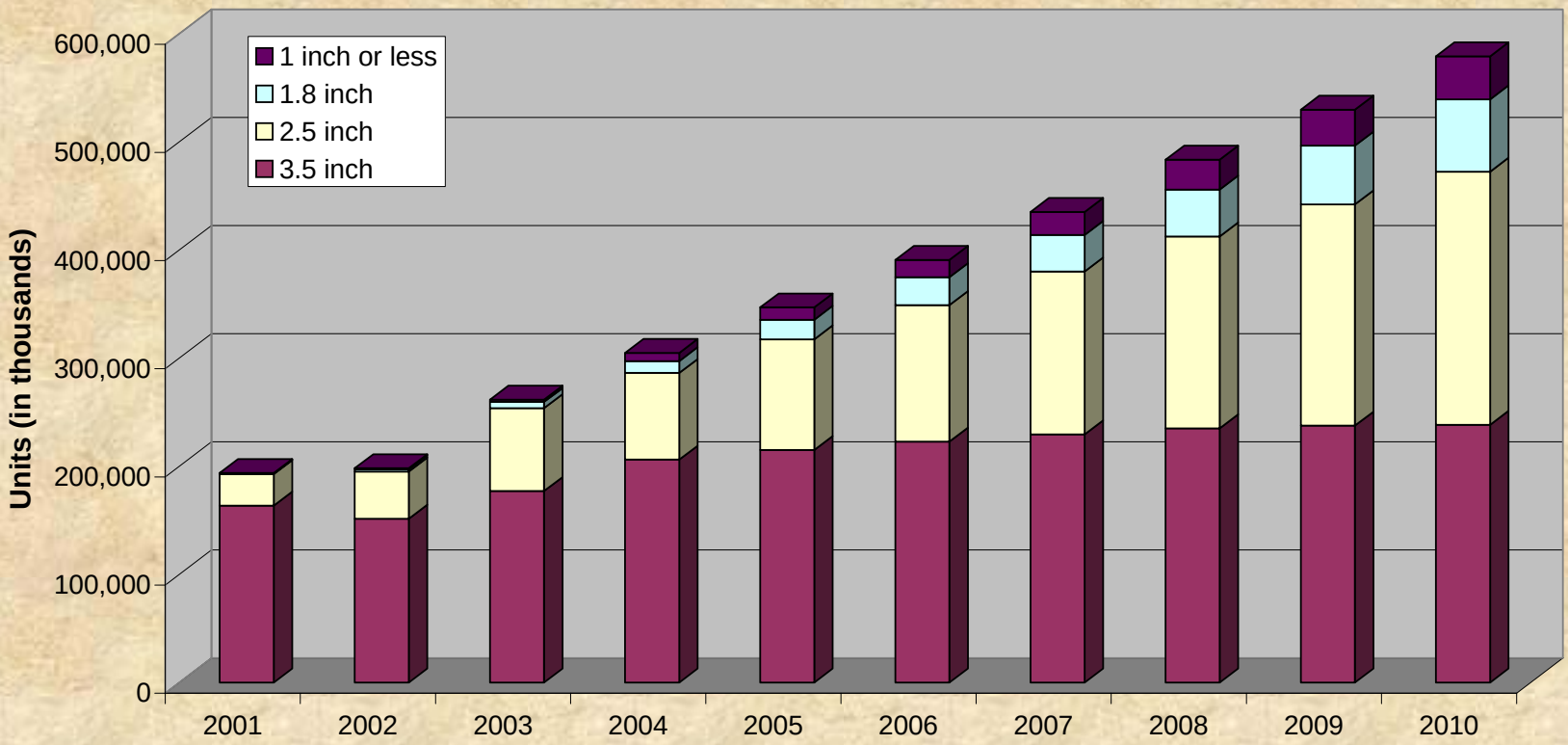
HDD Form Factor Projections



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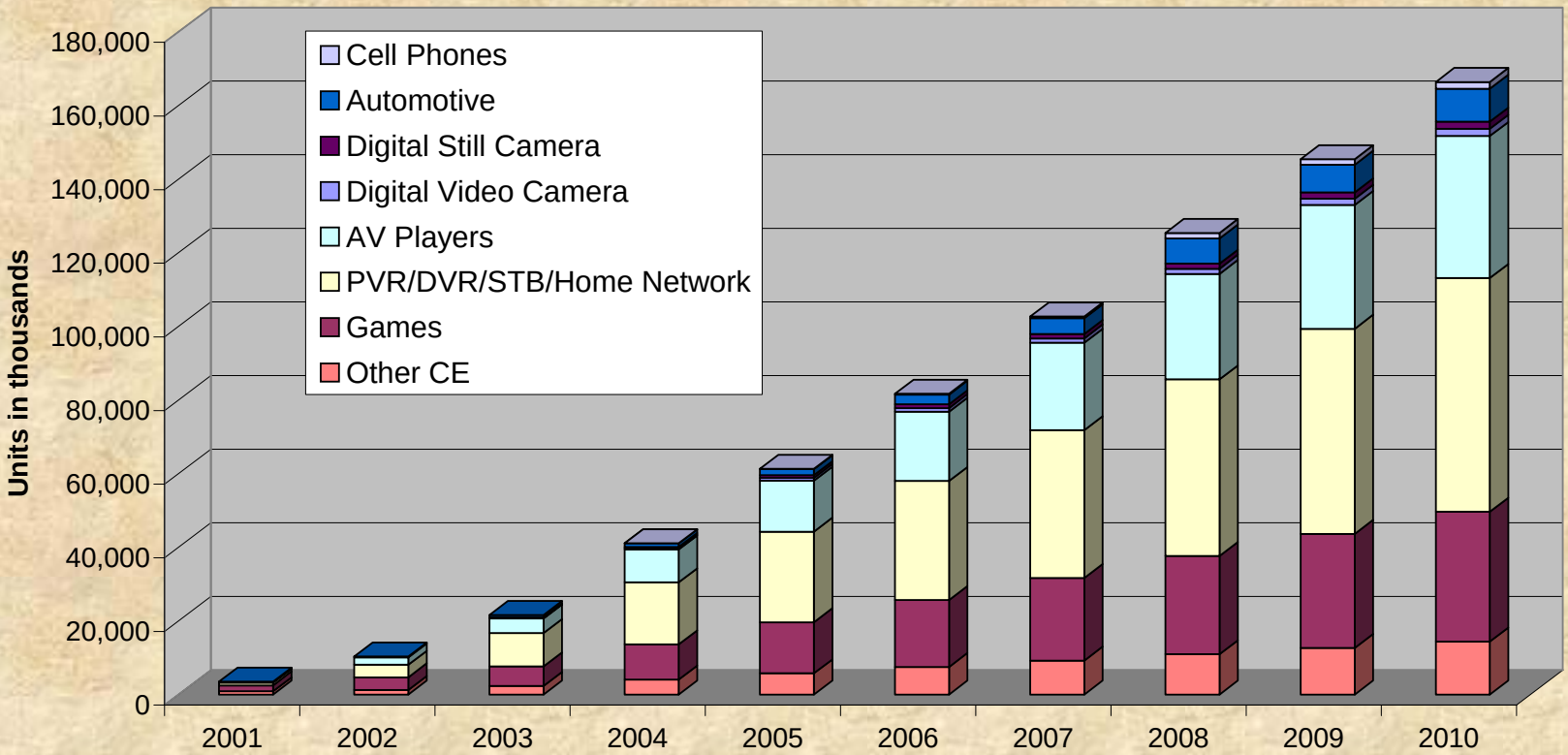
CE Drive Applications



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.

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