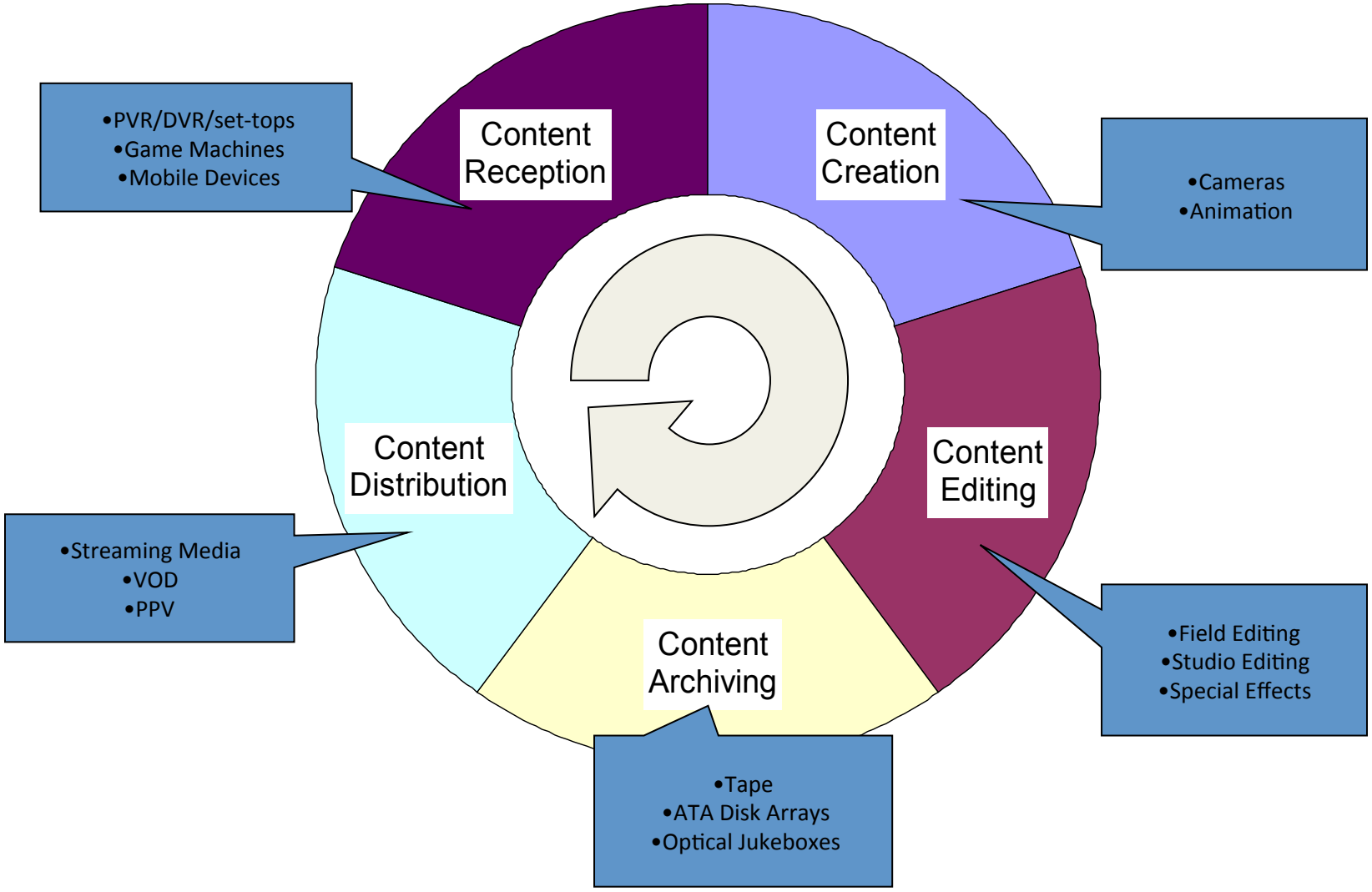
Ultra-HD Digital Storage Innovations and Trends for the Professional Media and Entertainment Industry

Tom Coughlin
Coughlin Associates
www.tomcoughlin.com

Outline

- Richer Content = More Storage (Exabyte Video Projects)
- Different Storage for Different Applications
- Storage and Media Workflows
- Keeping Stuff for the Long Term—Archiving Professional Content

Digital Content Value Chain



Example Resolution, Data Rates and Storage Capacity Requirements for Professional Media Standards

Format	Resolution (width X height)	Frame Rate (fps)	Data Rates (MBps)	Storage Capacity/Hour (GB)
SDTV (NTSC, 4:2:2, 8-bit)	720 X 480	~30	6.25	22
HDTV (1080p, 4:2:2, 8-bit)	1920 X 1080	24	49.8	179
Digital Cinema 2k (4:2:4, 10-bit) YUV	2048 X 1080	24	199	716
Digital Cinema 4K (4:4:4, 12-bit) YUV	4096 X 2160	48	1,910	6,880
Digital Cinema 8K (4:4:4, 16 bit)	7680 X 4320	120	23,890	86,000

8K Ultra-HD may use more than 100X capacity of HD!

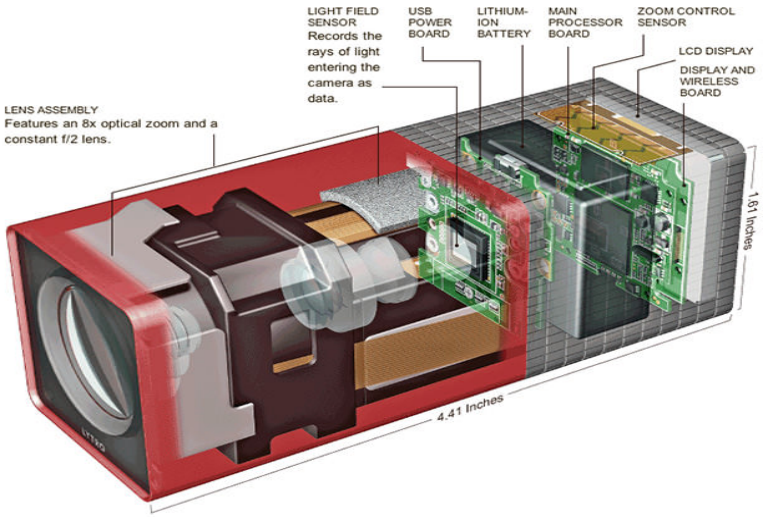
8K X 4K based upon "Super Hi-Vision" Video Parameters for Next Generation Television, SMPTE Motion Imaging Journal, May/June 2012, P. 63-68

Richer Images = More Storage

- Frame rates for movie content are increasing from the historical 24 frames per second (fsp) to 48 or 60 fps and may eventually be as high as 300 fps
- Cameras are now available that can support 240 fps (even up to 3,000 fps)
- 4K production is commonplace but 6K and even 8K movie production starting in professional video projects
- Video resolutions of 16K and even higher are contemplated in the future

New Views

Free View Point Video



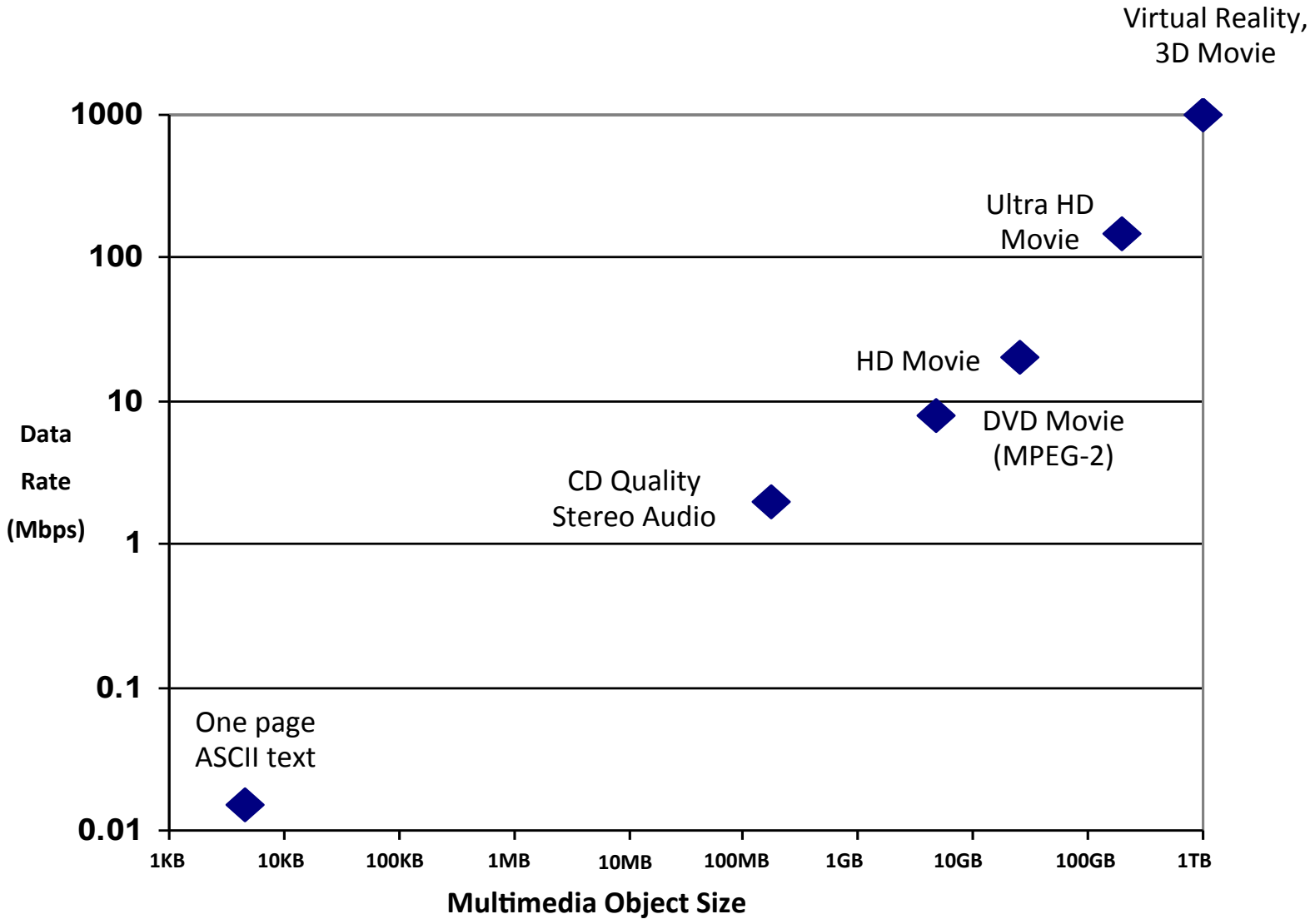
Lytro Light-field Camera

- KDDI and some European players have performed "free viewpoint" demonstrations with content captured using 4-30 4K video cameras simultaneously
- Light-field imaging could allow even more immersive 2D and 3D video (greater image depth possible) and would increase required storage capacity by at least 3X conventional images
- This is in addition to HDR images

How Long Until Exabyte Video?

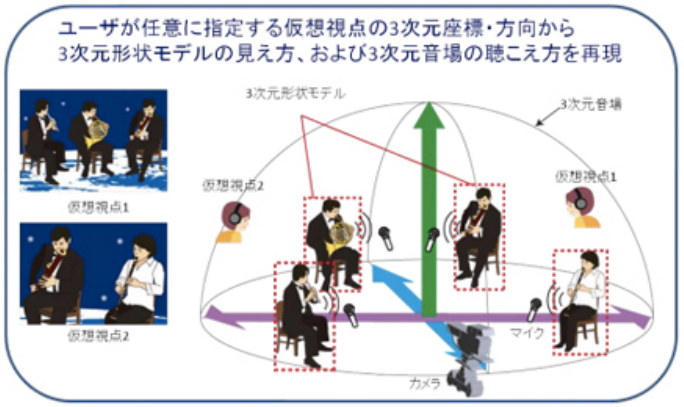
- As video resolution and frame rate increase, camera image complexity increases and stereoscopic projects multiply, the storage capacity and bandwidth performance requirements becomes staggering
- A calculation shows that 16,000 X 8,000 pixel resolution, 24 bits/pixel, 300 fps raw video content could require **115 GB/s data rates and 414 TB/hour**. If this was full stereoscopic capture then these requirements would double. If 4 cameras were used to create data for a "free viewpoint" presentation the raw data would be **1.66 PB for an hour of content**
- Truly the bandwidth and capacity requirements to work with future rich media formats are staggering!
- Even HEVC won't be enough

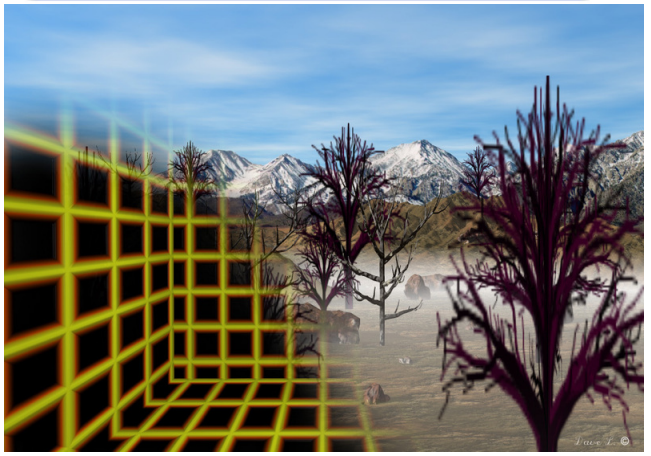
Media Content Size Trends



Virtual Reality: Making A Holodeck

- KDDI has been showing 6-30 camera systems capturing a region of interest that can use an algorithm to interpolate between the captured moving images to create a view point from any perspective within the field of view
- Free floating holographic and other advanced display technologies are in the works—within the next 10 years we could approach something like a display allowing you to move within the action—leading to holodeck-like experiences

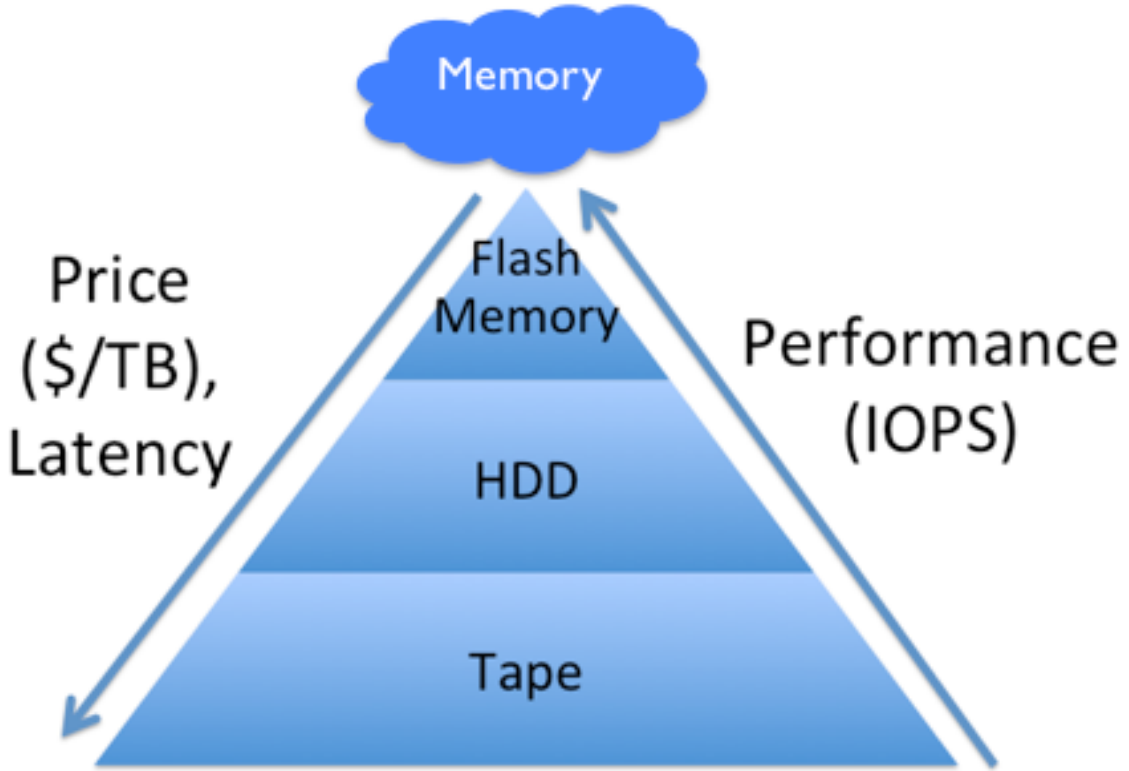




From *Wired Magazine*

Memory/Storage Hierarchy

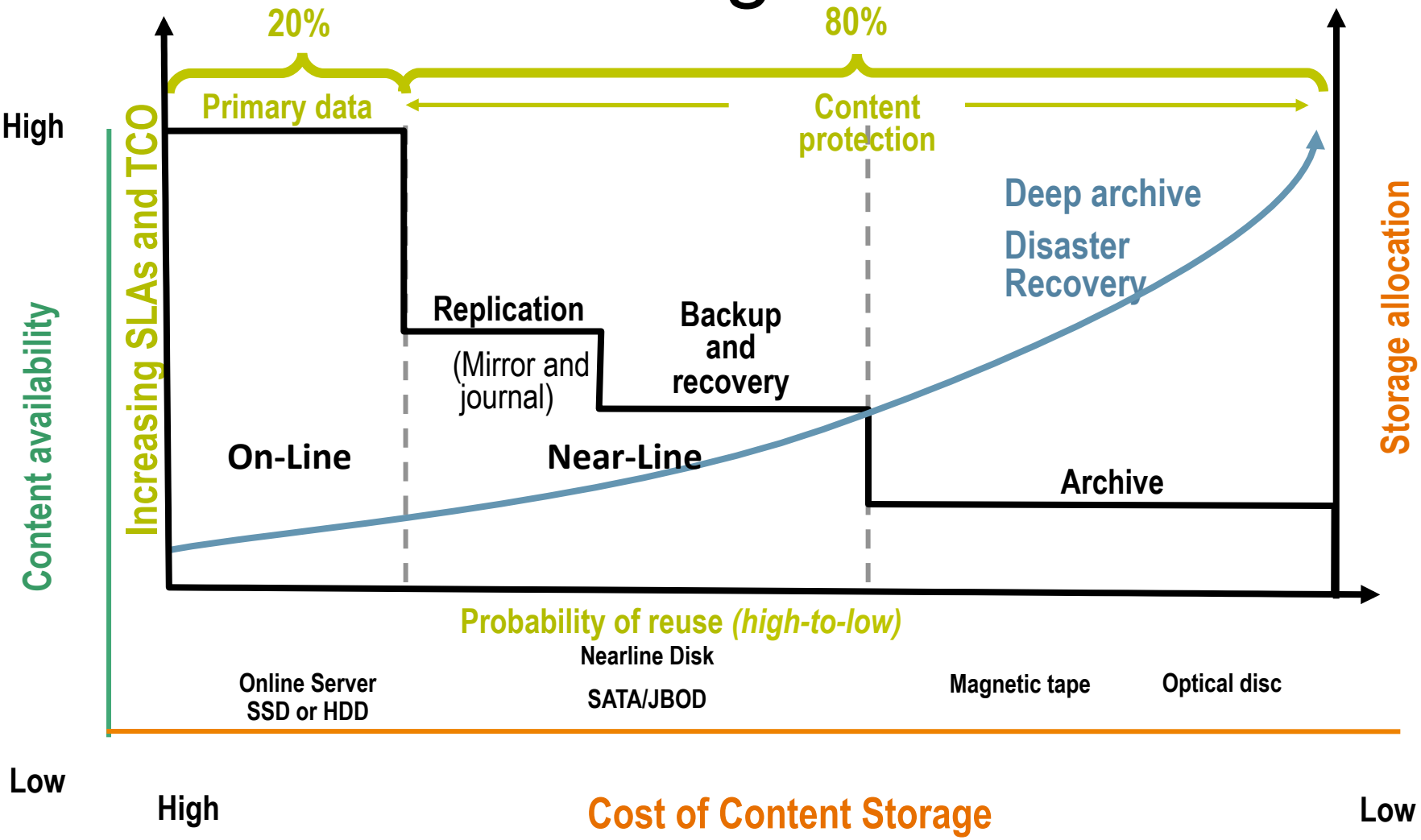
- Qualitative trade offs between volatile (and non-volatile) memory and non-volatile storage technology
  - costs to store data ($/TB)
  - performance of the storage technology (IOPS) or data rates).



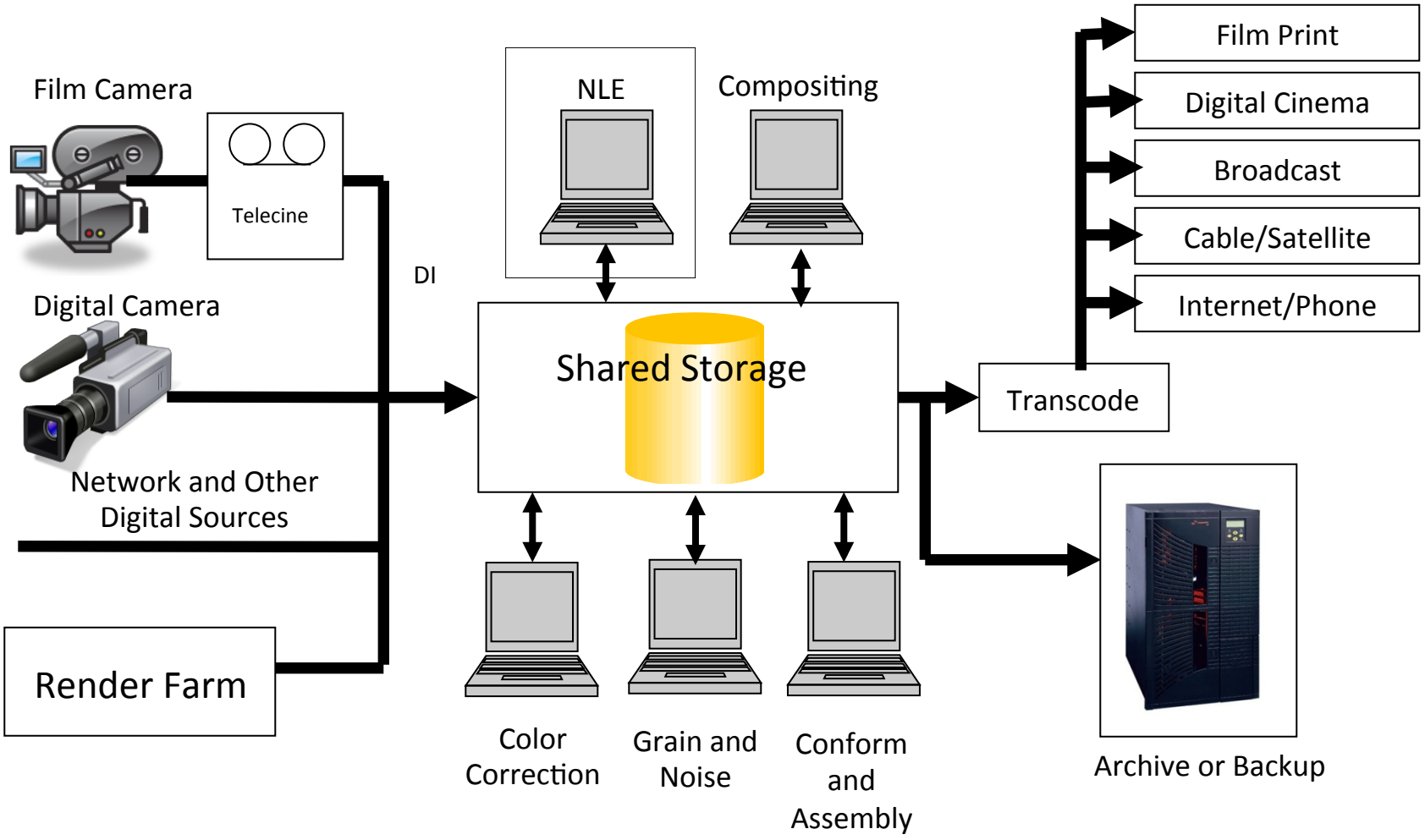
Comparison of Storage Devices

- Hard Disk Drives
  - Low cost storage (now up to 6 TB)
  - Intermediate access latency
  - Infinite re-writability
- Magnetic Tape
  - Inexpensive storage costs (up to 8 TB)
  - High access latency
  - Good long term life
- Optical Discs
  - Inexpensive media (12 disc cartridge 1.5 TB)
  - Lower capacity/media than tapes or HDDs
  - May have long storage life—if get proper product
- Flash Memory
  - Expensive storage (3-10X HDD cost/byte)
  - Fast read and with architecture changes fast write
  - Finite life—especially with re-writes

Content Lifecycle and Costs of Storage

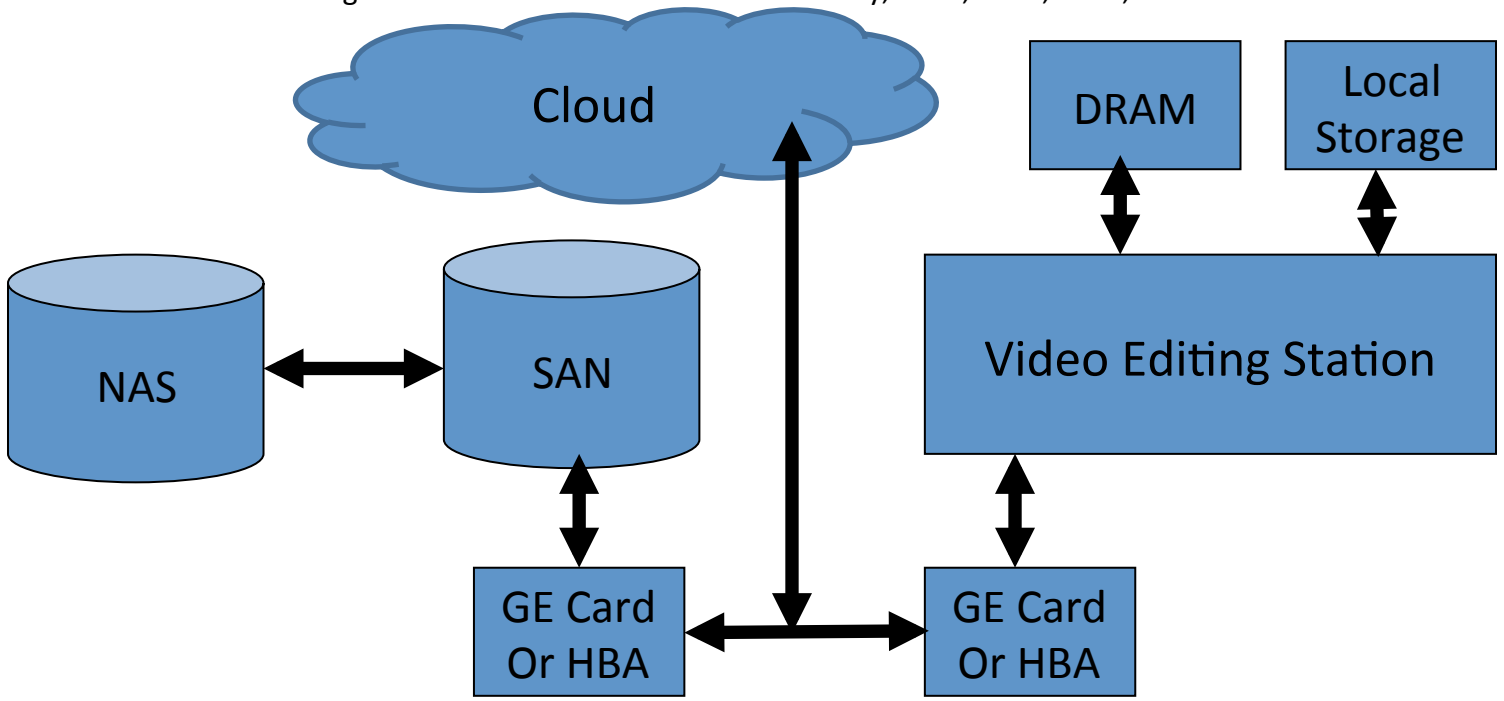


Acquisition, Post-Production and Distribution Workflow



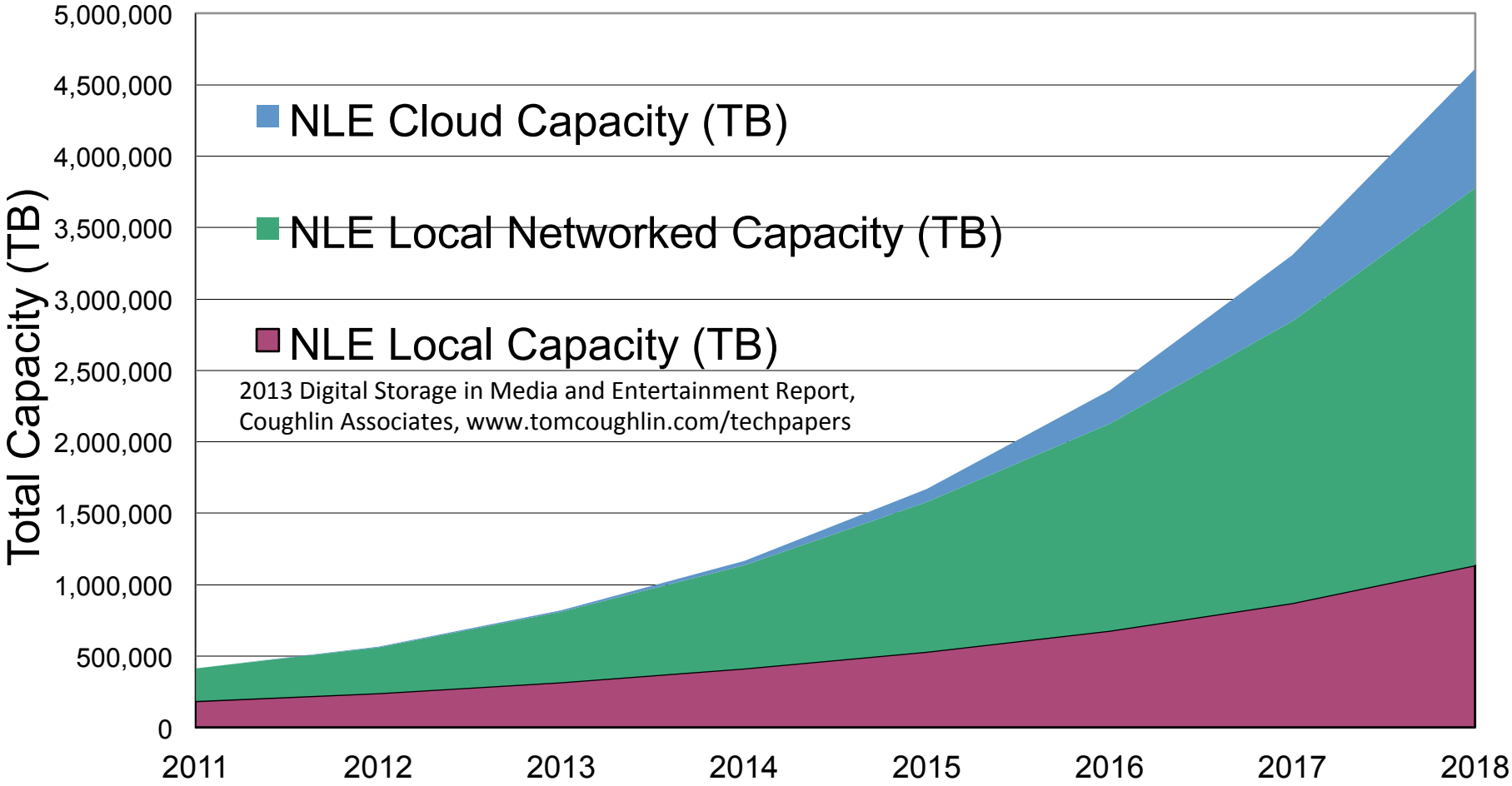
Professional NLE Model system

Coughlin Associates Professional M&E Survey, 2009, 2010, 2012, 2013



- 87.3% had DAS (compared to 92% in 2012, 91% in 2009 and 83.8% in 2010)
  - Over 88% of these had >1 TB of DAS (up from 78% in 2012, 96% in 2010 and 52% in 2009)
  - 18.3% of these had >50 TB of DAS storage and over 7% had >500 TB of DAS storage
- 70.9% had NAS or SAN (compared to 53.8% in 2012, 81% in 2010 and 2009)
  - 57.8% had 50 TB or more of NAS storage
  - About 11% had more than 500 TB of NAS/SAN storage
  - In 2012 about 48% had more than 16 TB of NAS or SAN (compared to 44% in 2009 and 58% in 2010)

Post-production annual demand (TB)



- 24.7% of 2013 Survey participants said that they use cloud-based storage in their post production (15% in 2012) and 23% of these had >1TB of cloud storage (27% in 2012)

The Cloud for M&E Content

- In many regards cloud offerings are an out-sourcing approach
- But there are new M&E capabilities enabled by the rise of remote services
- Growth in cloud storage use by professional video
  - Enables collaborative workflow
  - Internet enabled content distribution with technologies such as those of Aspera or BitSpeed
  - New cost effective services through the cloud enable greater sophistication for smaller shops
  - Some vendors offering cloud “archiving” services
- Cloud storage drives growth in tiered storage including flash memory, tape, HDDs

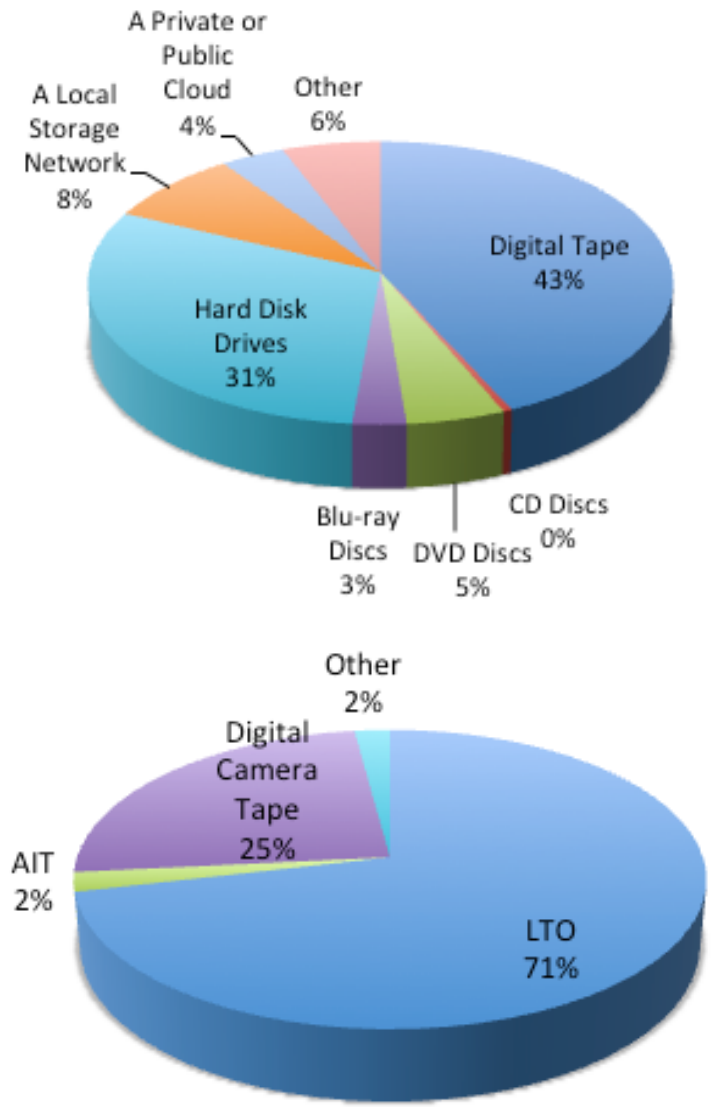
Post Production and the Cloud

- Non-linear editing (NLE) is generally done from uncompressed or at most slightly compressed source cobntent
- However the actual editing may use lower resolution proxies with the editing changes incorporated into the uncompressed content after editing is done
- There is an increasing trend, particularly for movie production, to create collaborative workflows where the post-production activities may be done anywhere in the world
- While the latency of remote access through the Internet may limit the use of cloud storage for direct creative editing, cloud storage can be used effectively for compute intensive operations such as rendering, transcoding, content distribution and archiving

Storage System Trends

- Virtualization
- Deduplication
- Use of flash memory (and PCIe)
- Open Compute Project
- Hadoop Replication
- Erasure Codes
- Software Defined Storage (higher level of abstraction—separating the data plane from the control plane)
- These are elements in hyperscale open storage systems (like much cloud storage)

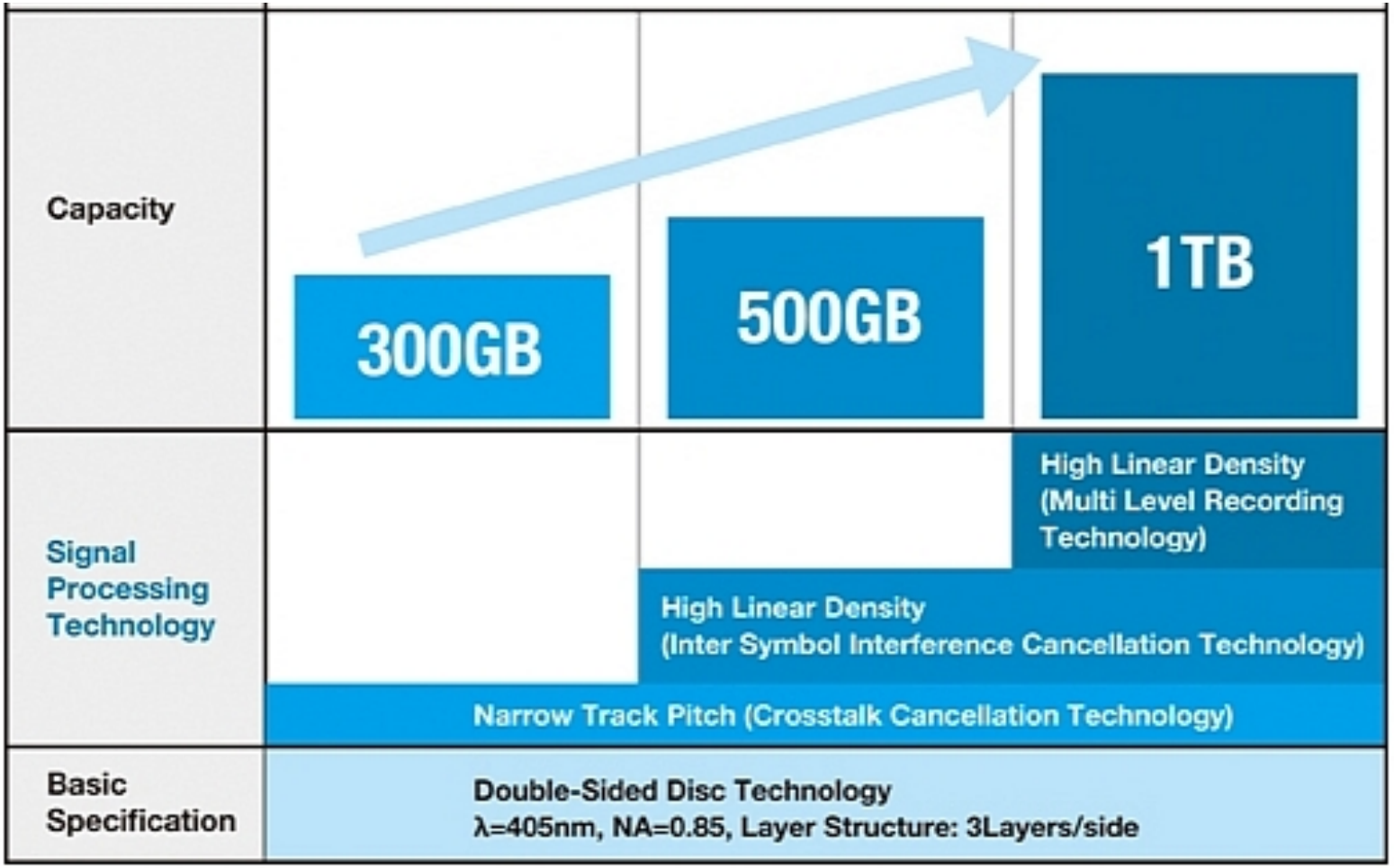
Digital Archive Media



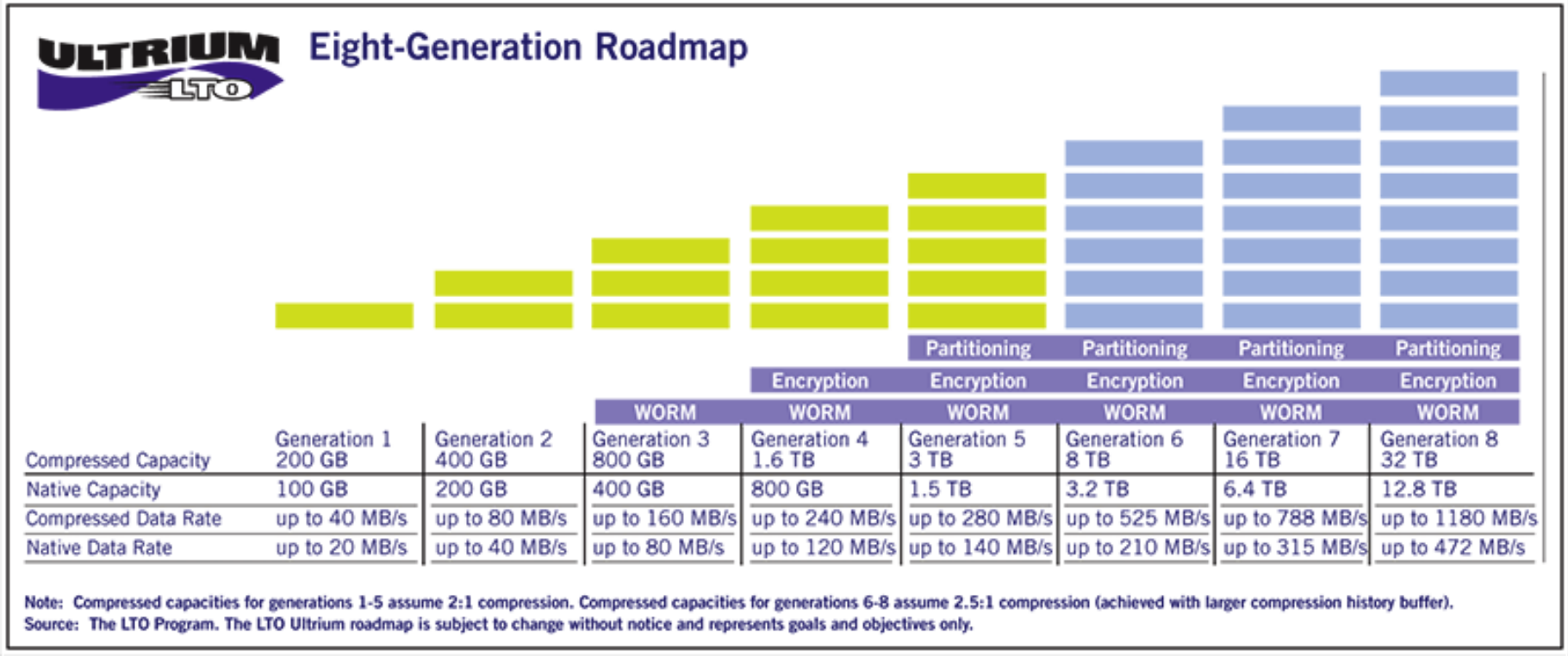
- Tape (LTO & camera tape), and HDDs dominate long term archival media
- Tape and HDDs are projected to show greatest growth in the future
- Some backup to the cloud or local network storage
- New Introductions of Optical Archiving
- About 42% of survey participants never update their digital archives

2013 Digital Storage in Media and Entertainment Report, Coughlin Associates, www.tomcoughlin.com/techpapers

Sony/Panasonic Optical Archive Roadmap



LTO Magnetic Tape Road Map

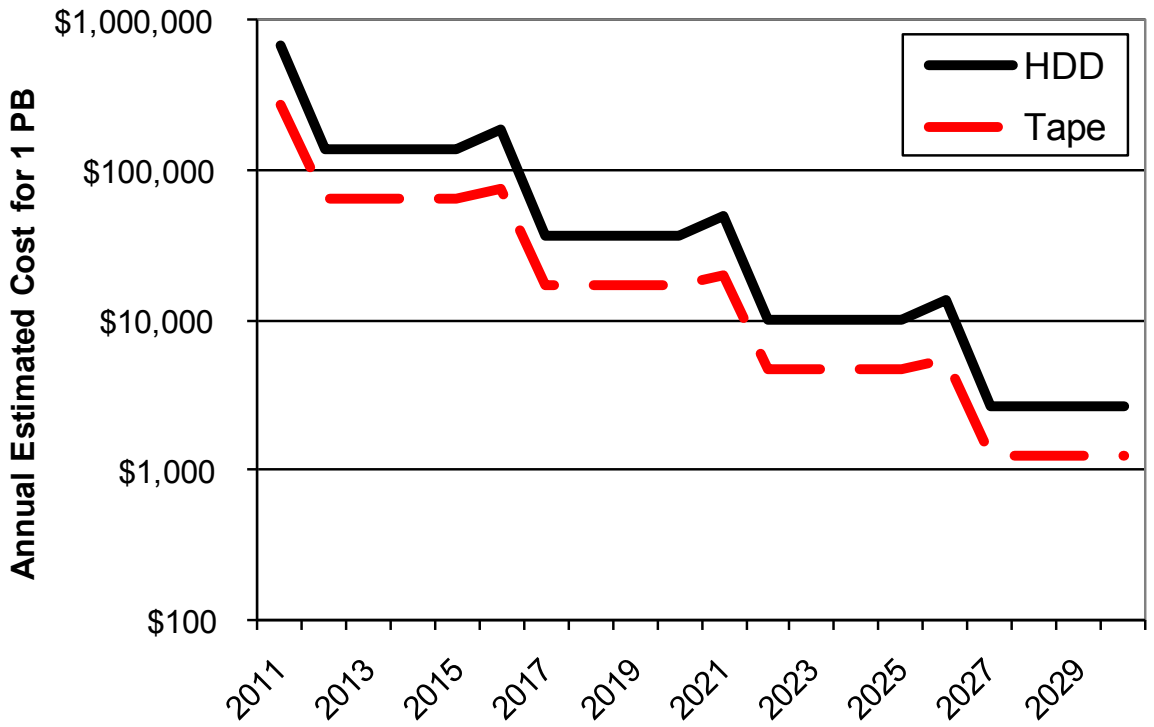


Compressed Capacity	Generation 1 200 GB	Generation 2 400 GB	Generation 3 800 GB	Generation 4 1.6 TB	Generation 5 3 TB	Generation 6 8 TB	Generation 7 16 TB	Generation 8 32 TB
Native Capacity	100 GB	200 GB	400 GB	800 GB	1.5 TB	3.2 TB	6.4 TB	12.8 TB
Compressed Data Rate	up to 40 MB/s	up to 80 MB/s	up to 160 MB/s	up to 240 MB/s	up to 280 MB/s	up to 525 MB/s	up to 788 MB/s	up to 1180 MB/s
Native Data Rate	up to 20 MB/s	up to 40 MB/s	up to 80 MB/s	up to 120 MB/s	up to 140 MB/s	up to 210 MB/s	up to 315 MB/s	up to 472 MB/s

Note: Compressed capacities for generations 1-5 assume 2:1 compression. Compressed capacities for generations 6-8 assume 2.5:1 compression (achieved with larger compression history buffer).
Source: The LTO Program. The LTO Ultrium roadmap is subject to change without notice and represents goals and objectives only.

- LTO allow read compatibility back two generations allowing some time to migrate content
- LTFS file system in LTO 5 & 6 generations
- LTO 6 capacity actually 2.5 TB native

Cost for Storing 1 PB for 20 Years



- 1 PB of storage using 1 TB HDDs with proper environment, racks, HVAC, etc. cost about $1.68 M for 20 years
- The cost of archiving on HDD is about 2.3X greater than tape
- **Over 40% of the total cost of preserving the 1 PB of content is in the first year**

2012 Digital Storage for Media and Entertainment Report, Coughlin Associates

Summary and Conclusions

- Demand for higher resolution and higher frame rate content for media and entertainment applications is driving multiple-PB storage needs—these needs will only increase in the future
- This also increases bandwidth demand for real time and download use of content
- Cloud-based services are playing an increasing role by enabling collaborative workflows
- Archiving and conversion technologies promise to retain more M&E content at lower costs for indefinite periods