Cost Effectively Managing the Digital Data Explosion

Fujifilm
8th Annual Global IT
Executive Summit

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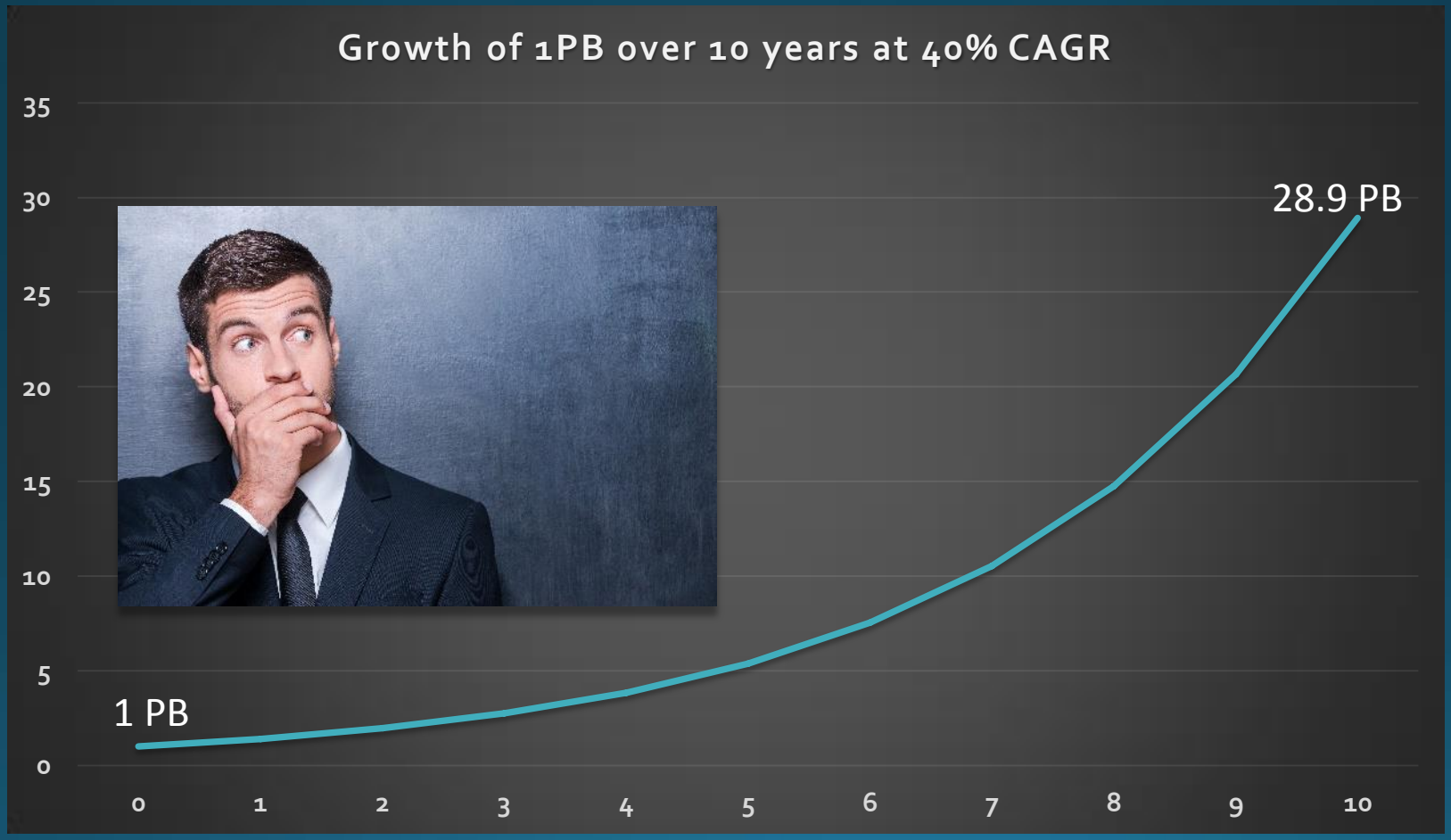
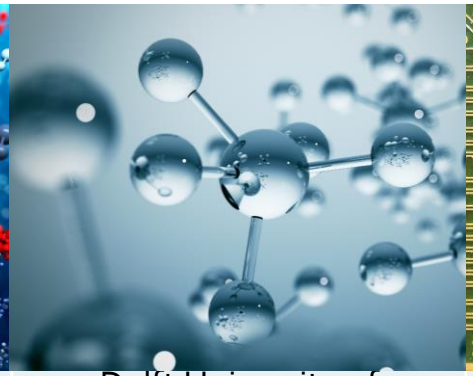
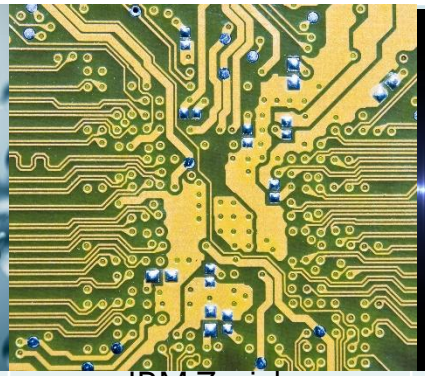
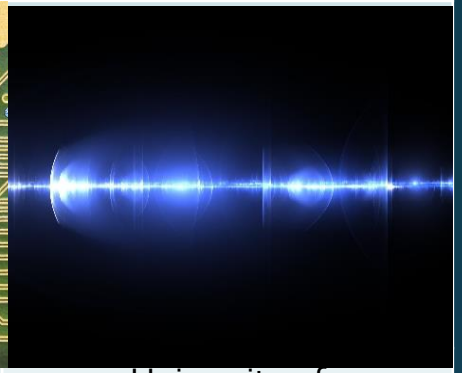
The amount of digital data continues to grow unabated

- Industry analysts and suppliers project continued digital data growth
  - HP – 36% / year
  - IDC – 40% / year
  - ESG – 56% / year
  - Oracle – 50%/year
- Longer retention periods
  - Legal, Regulatory, Business needs
- Growth drivers vary by industry
  - High definition video
  - Surveillance Video
  - Virtual Reality
  - Electronic medical records
  - Internet of Things
  - Big Data Analytics
  - Seismic processing
  - Test data

These growth rates make for impressive site data growth



New technologies may help in the distant future

DNA	Atomic	Phase Change	Holographic
			
EMBL-European Bioinformatics Institute (EMBL-EBI) , Microsoft, University of Washington	Delft University of Technology, University of Wisconsin	IBM Zurich	University of Southampton
• 100 Million hours of video in a cup of DNA • Lasts 1000's of years • Special equipment to read/write, "snail like" retrieval.	• Stores 500 Tera bits/ inch • Uses Scanning Tunneling Microscope • Must keep temperatures below 321 F or lose data	• 64K PCM device using 3 bit cells • Cost of PCM may be significantly less than DRAM and closer to flash. • 10 M Read/ Write Cycles	• "Superman Crystal" Fused Quartz • Could retain data for millions of years • Theoretical capacity of 360 TB on a platter • Slow write speed

Today's storage technologies have significantly different capabilities

Feature	Flash Disk System	Tape Library	Low Cost Disk Filer	The Cloud	Optical Library
Technology Description	Flash Modules	LTO Gen 7	10 TB 3.5" HDD	Amazon Glacier	Blue Ray Archive
Max Capacity Per System	57 TB Useable	EB's	PB's	Unlimited	181 PB
IOPS (Read)	1.1 M	Low	000's	Batch	Low
Latency (time to first byte)	155 microseconds	Seconds to Minutes	milliseconds	3-5 hours	Seconds to Minutes
Data Rate (MB/Second)	10,000	300 MBs/drive	Hundreds MB/second	Network dependent	780 Mbps Write 1,150 Mbps Read
$/TB Initial Acquisition Cost	$2610*	$63	$260	0	~$240
Energy Consumption	625 W/Unit	110 W – Library 24 W – Drive 0 W - Cartridge	9 W/TB	0	38W/drive

* 5:1 compression

Estimating Total Cost of Ownership (TCO)

- Initial Acquisition Costs (Capex)
  - Hardware Purchase Price
  - Software Initial License Charges
  - Extended Warranties
  - Installation Charges
- Operational Costs (Opex)
  - Maintenance and Support
  - Power and Cooling
  - Floor Space
- *…And Technology Refresh*
  - Replace initial system with new technology
    - Drivers – Reliability, Economic, Technological

Storage Systems Technologies and Projections

Enterprise Flash

System Type	IBM Flashsystem 900
Initial Technology	5.7TB eMLC Flashcard
Refresh	Year 6
Annual % Improvement	36%

Tape Library

System Type	V80 Tape Library
Initial Technology	LTO Gen 7
Refresh	Year 5 – Gen 9
Annual % Improvement	33%

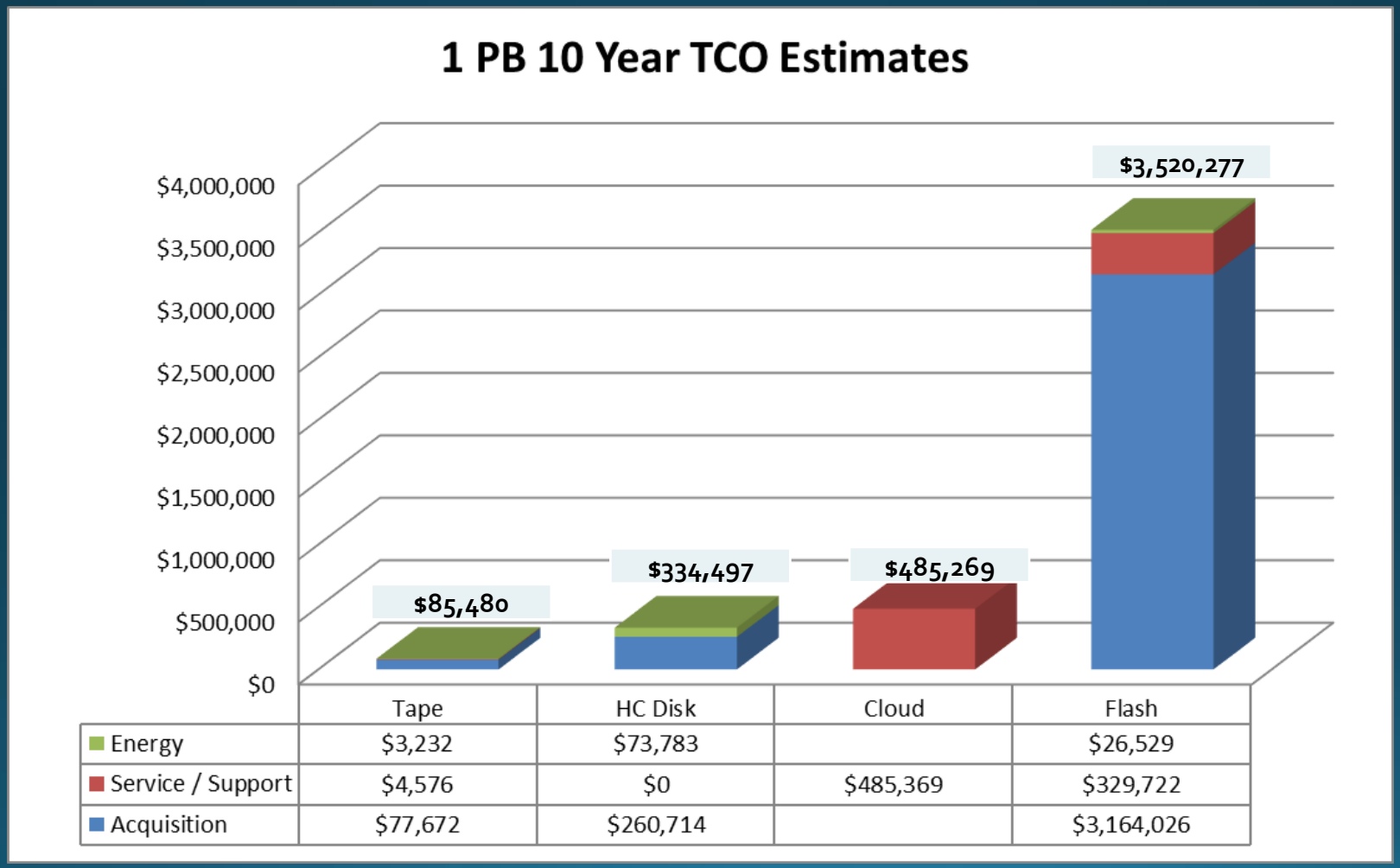
Cloud

System Type	Amazon
Initial Technology	Glacier
Refresh	Annually
Annual % Rate Improvement	20%

Low Cost Disk Systems

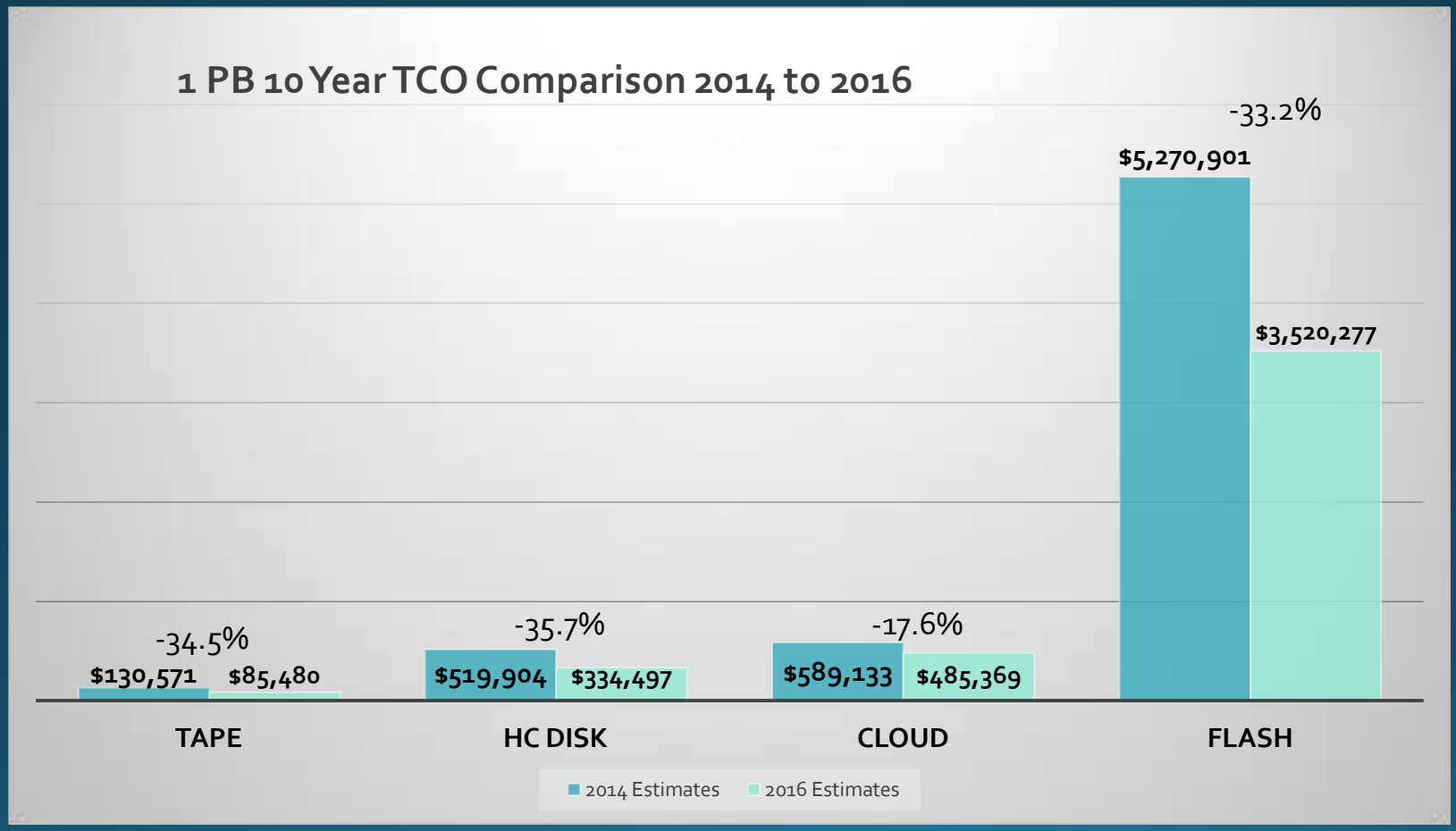
System Type	Composite
Initial Technology	6-10 TB SATA HDD's
Refresh	Year 6
Annual % Rate Improvement	18%

1 PB 10 Year Projected TCO



	Tape	HC Disk	Cloud	Flash
Energy	$3,232	$73,783		$26,529
Service / Support	$4,576	$0	$485,369	$329,722
Acquisition	$77,672	$260,714		$3,164,026

TCO Comparison – 2014 to 2016



Conclusions

- FlashStorage provides very high IOP performance , but is still the most expensive
- Optical storage being marketed for archive, but TCO benefits are not clear, pricing not yet generally available
- High capacity disk TCO has declined significantly, but has not narrowed the gap with tape
- Cloud Storage TCO has not fallen nearly as rapidly as in the past

Tape storage continues to provide the lowest TCO today and likely will for the foreseeable future