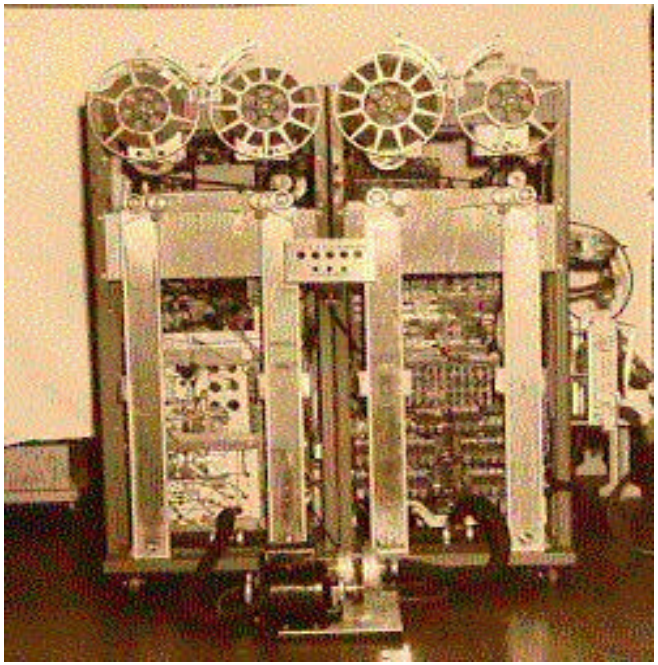
Tape



Emerging Storage Technology Panel
IEEE/NASA Conference MSST2008
September 25, 2008

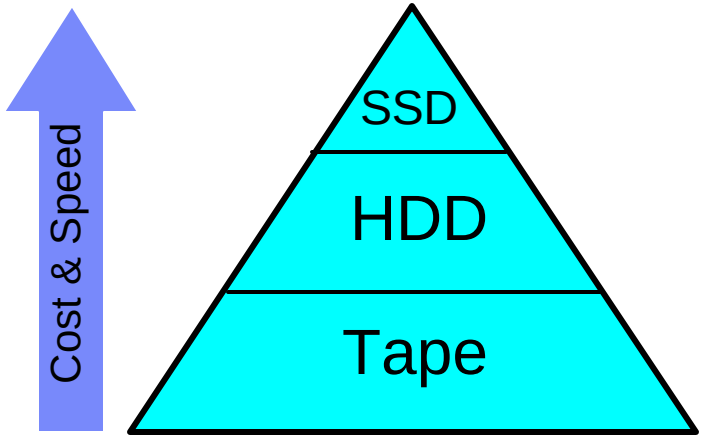
Glen Jaquette
IBM Distinguished Engineer / Architect
Tape Drives, Automation, & Subsystems

The "Storage Hierarchy"

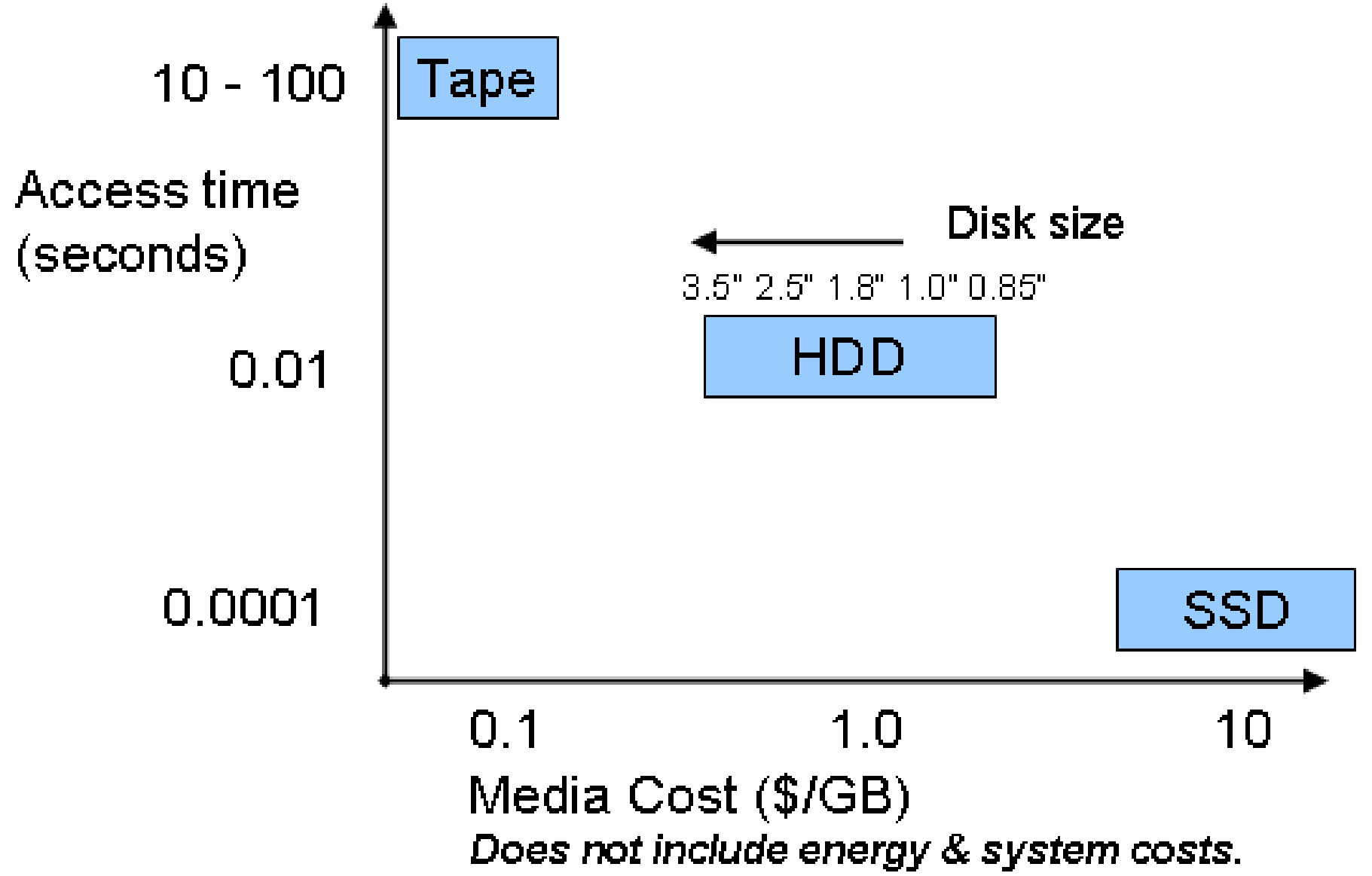
Solid state disk (nonvolatile) ~ $10 to 50 / GB
- Fastest access time
- Being built into bricks and subsystems

Direct access storage devices (HDD) ~ $ 1 / GB
- Slower access time, update in place
- Expandability / archivability limitations

Removable media storage devices (tape) ~ $ 0.1 / GB
- Slowest access time, typically nearline
- Portable, interchangeable, archivable
- "Infinite capacity", volumetric efficiency
- Data Compression build into drives
- WORM cartridges available
- very strong encryption @ line speed



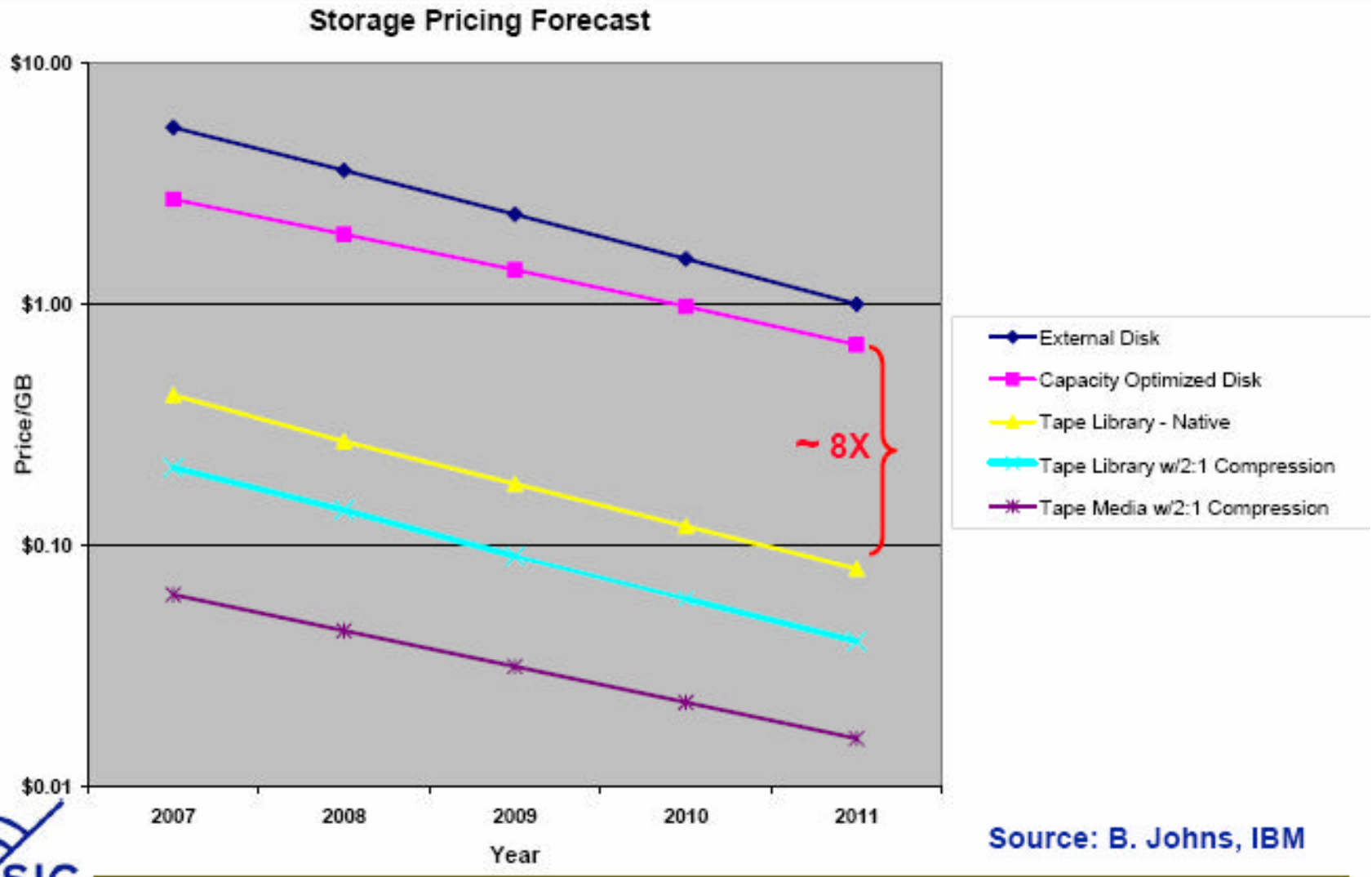
Very approximate view of access / cost tradeoff



Source: M. Sharrock, Imation August 13, 2008

INSIC 2008 TAPE Roadmap

Tape Must Remain Cost Competitive with Disk

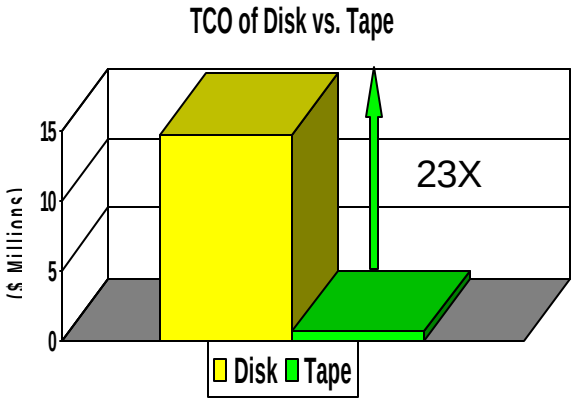


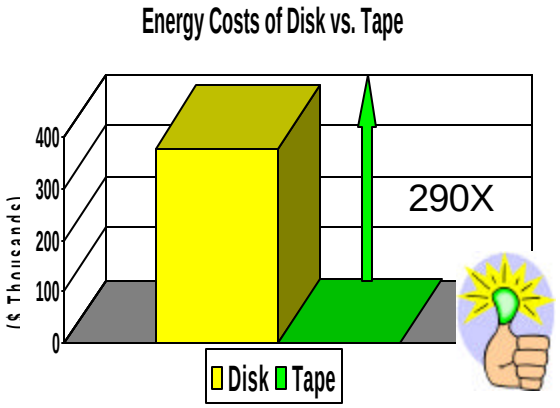
Source: B. Johns, IBM

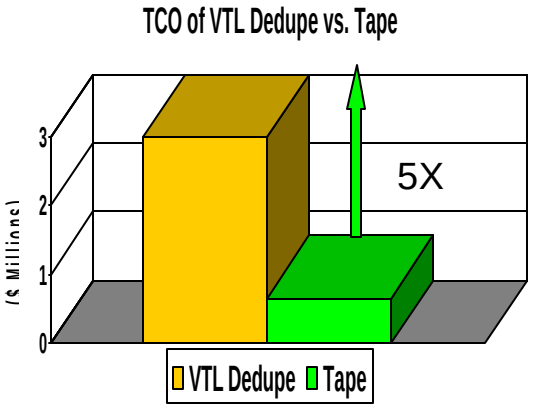
Tape is the Lowest TCO Storage Choice

- **Cost Ratio to store long-term data on SATA Disk versus Tape is 23:1***
  - 5 year TCO to store 2.4 PB of archive data
  - Including hardware, energy, and space costs
  - SATA disk system versus LTO-4 tape library
  - Energy costs of disk system was 290 times more than tape
- **A VTL with 20X data deduplication is still about 5X more costly than tape**

The Cost Ratio for a Terabyte Stored Long-Term on SATA Disk versus LTO-4 Tape is about **23:1**
For energy cost, it is about **290:1**





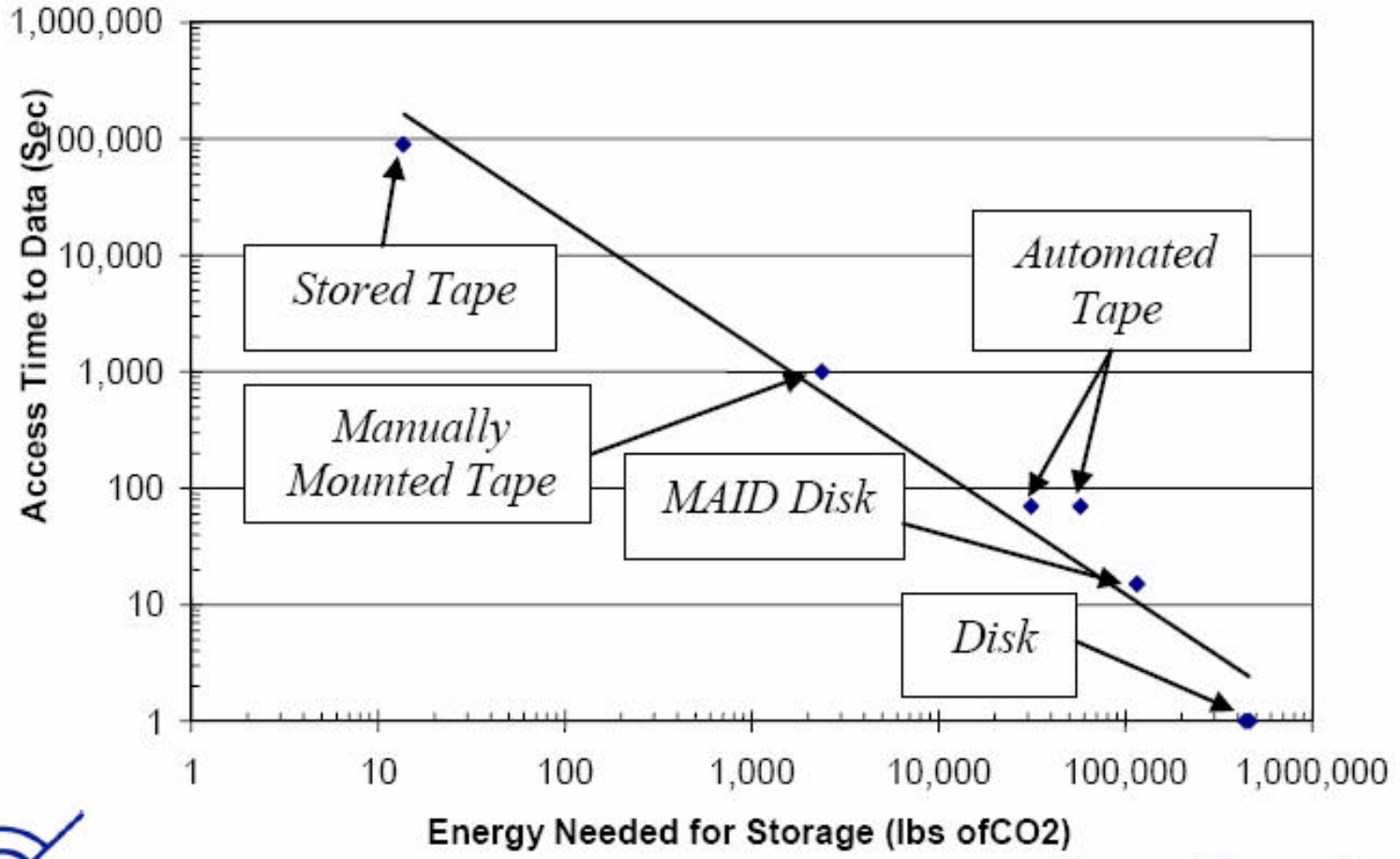


"Tape continues to provide the fiscal responsibility and functional value that enterprises require in the twenty-first century." The Clipper Group

*Source: The Clipper Group, "Disk and Tape Square Off Again" Report #TCG2008009LL, Feb 2008

INSIC 2008 TAPE Roadmap

Energy Consumption Increasingly Important



Source: J. Herron, Sun

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Tape is NOT Dead … NEW Products breaking barriers

It continues to play a vital storage role

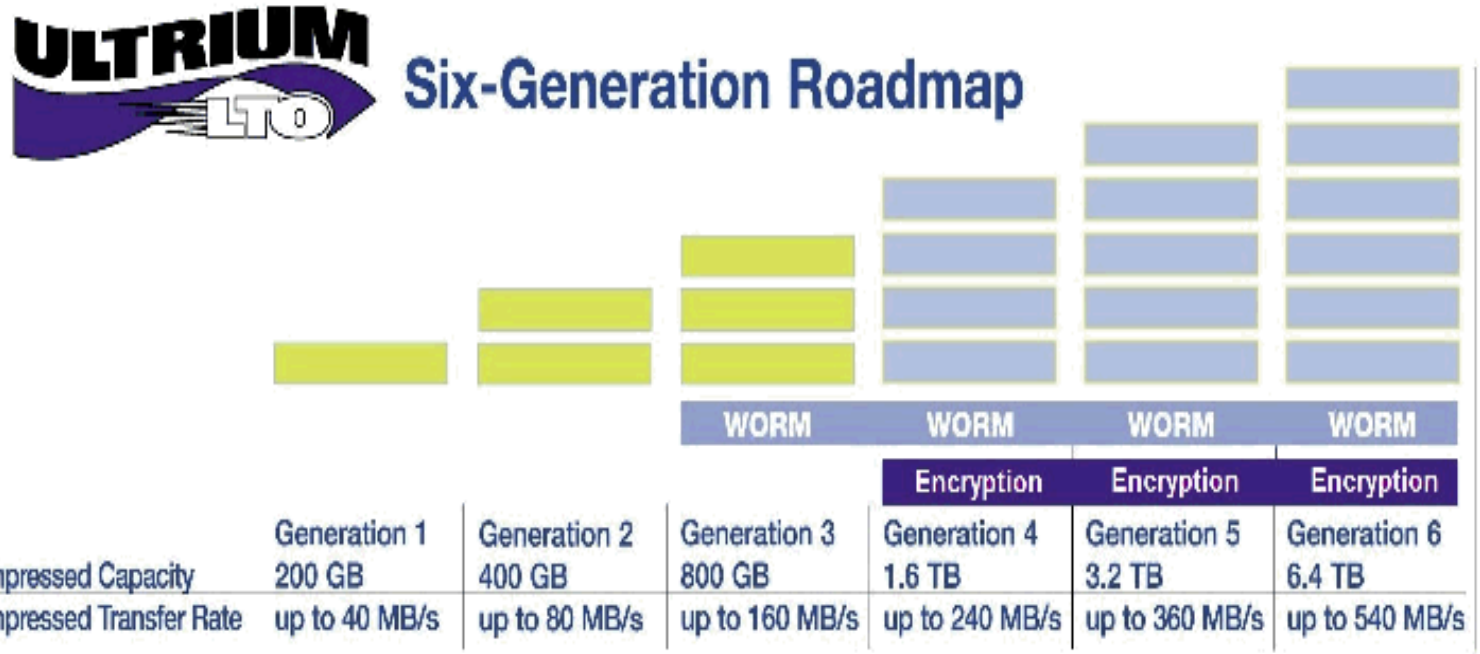
- **Very Cost-effective**
- **Very power efficient**
- **Inherently On Demand**
- **Removable**
- **Transportable & Shareable**

- **IBM's TS1130 announced/available**
  - **1 TB/cartridge, native**
  - **160 MB/s, native**
  - **first GMR head in linear tape drive**

Source: Industry Consultants and IBM

Linear Tape Open™ (LTO™)

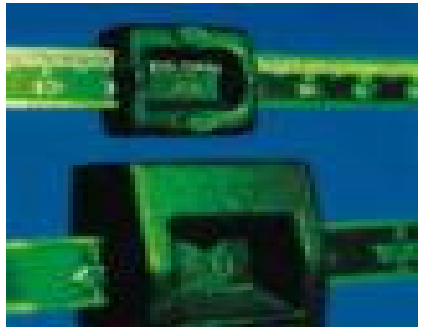
LTO Drives now clear leader in Open 'super' drive category



	Generation 1	Generation 2	Generation 3	Generation 4	Generation 5	Generation 6
Compressed Capacity	200 GB	400 GB	800 GB	1.6 TB	3.2 TB	6.4 TB
Compressed Transfer Rate	up to 40 MB/s	up to 80 MB/s	up to 160 MB/s	up to 240 MB/s	up to 360 MB/s	up to 540 MB/s

Since September 2000 LTO has proliferated:

- By May 2008, IBM had shipped approximately 1M LTO tape drives
- By September 2008, over 100M LTO cartridges had been shipped*

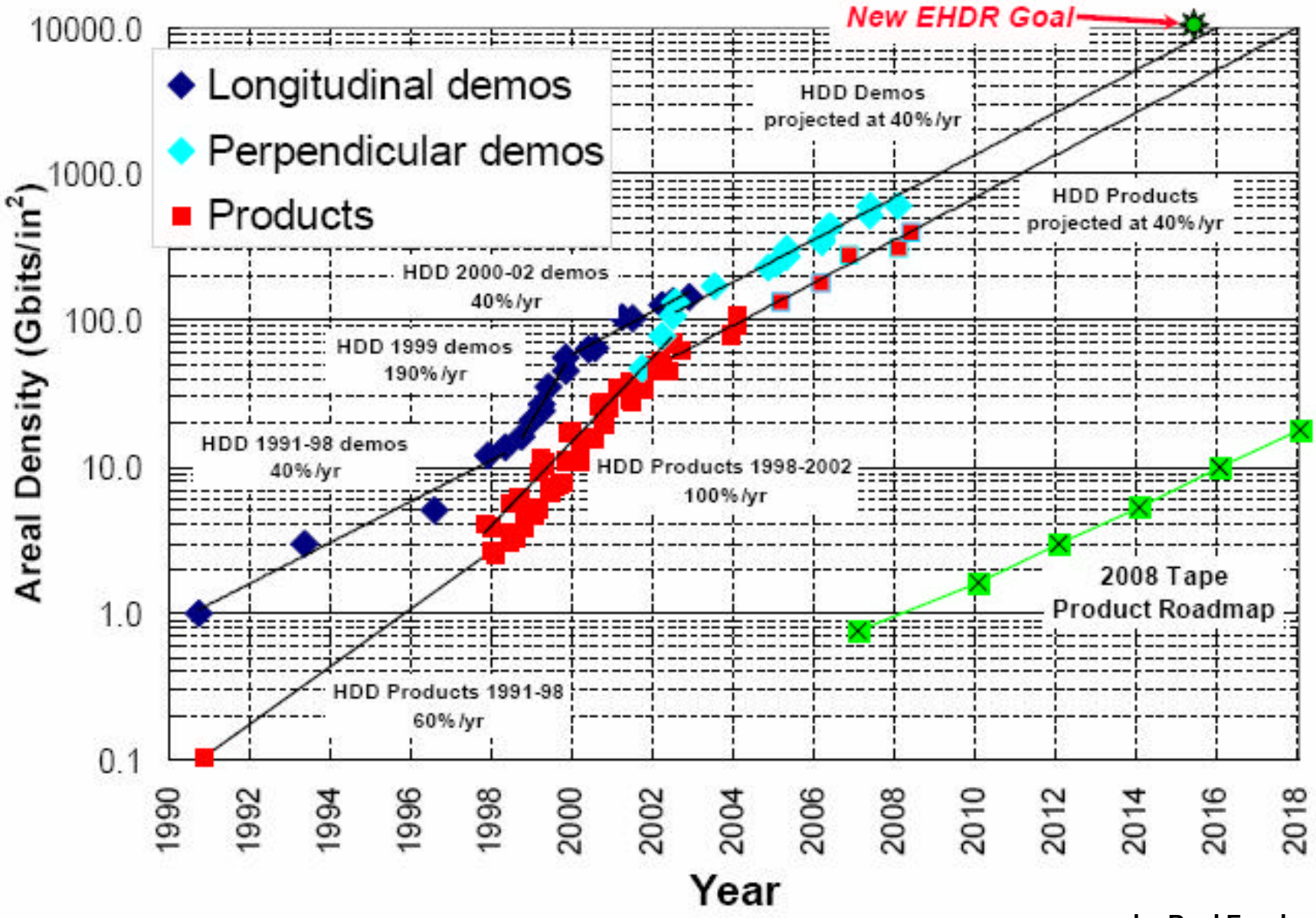


LTO Consortium's Roadmap

- Capacity is planned to approximately double every generation
- Data rate was being oversupplied*, stopped doubling at LTO-4
- WORM added in Gen3; Encryption-capability in LTO-4

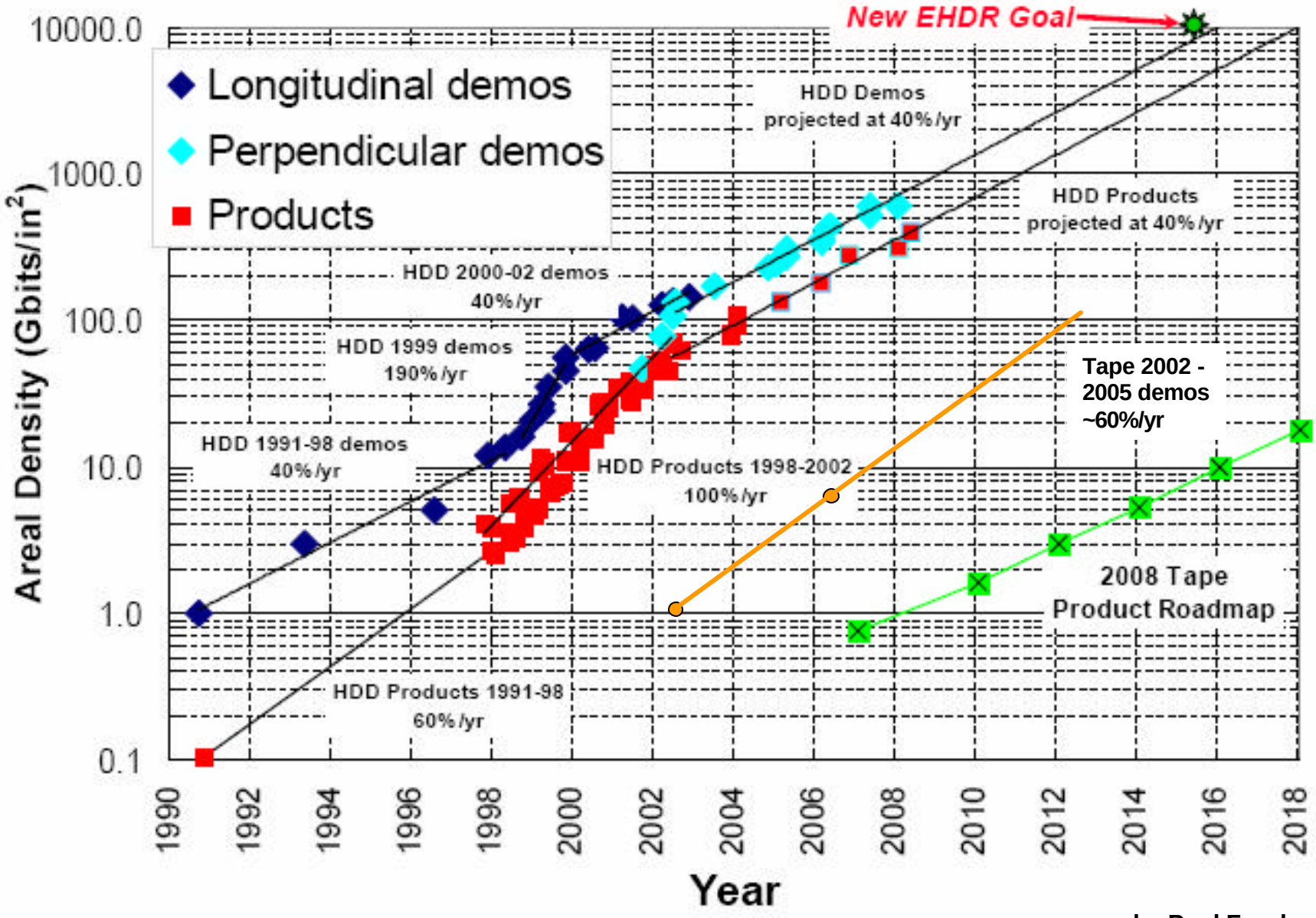
* LTO Consortium press release 9/03/08

HDD Areal Density Trends



by Paul Frank

HDD Areal Density Trends



by Paul Frank

An areal density of 100 Gb/in^2 appears achievable

IBM Journal of Research and Development

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Scaling tape-recording areal densities to 100 Gb/in2

by A. J. Argumedo,
D. Berman,
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C. Narayan,
S. Ölçer,
and P. J. Seger

We examine the issue of scaling magnetic tape-recording to higher areal densities, focusing on the challenges of achieving 100 Gb/in^2 in the linear tape format. The current highest achieved areal density demonstrations of 6.7 Gb/in^2 in the linear tape and 23.0 Gb/in^2 in the helical scan format provide a reference for this assessment. We argue that controlling the head–tape interaction is key to achieving high linear density, whereas track-following and reel-to-reel servomechanisms as well as transverse dimensional stability are key for achieving high track density. We envision that advancements in media, data-detection techniques, reel-to-reel control, and lateral motion control will enable much higher areal densities. An achievable goal is a linear density of 800 Kb/in and a track pitch of 0.2 μm, resulting in an areal density of 100 Gb/in^2.

Redundant Array of Independent* Tape** (RAIT)

- RAID 0 = Striping can be used to increase data rate by N
- RAID 1 = Mirroring for resilience against failures => M x 100% overhead
- RAID 10 = Striping and Mirroring, giving both scaled performance and resilience against any one failure.
- RAID 3, 4, or 5 = Recording calculated parity (byte, block, rotating), giving resilience with reduced redundancy (e.g. 4+P => 25% overhead)

- RAIT would typically be calculated either by:
  - Software (e.g. application, middleware, or filesystem)
  - Hardware (e.g. HBA, appliance, controller)

- Data rate mismatch & synchronization issues can be problematic, but patents have been developed which claim to solve these problems

- RAIT patents by multiple companies, but very little of it was productized

- RAIT does make good sense in scientific & HPC applications

* or Inexpensive ** or Library (RAIL)

Summary of storage density progression

- The data cited projects that Tape can increase volumetric density by up to 40% or more per year for up to 8 years or more
  A tape areal density of 100 Gb/in^2 appears achievable

- HDD's areal density CAGR is now ~40% CAGR, and that will be difficult to maintain as they approach 1 TB/in² in ~2011 (e.g. it declined from 100% to 40% CAGR in 2002)

- HDDs & RAID consume much more power per GB, greatly increasing the true total cost of ownership to more than 20X that of Tape. An automated tape solution can consume as little as 50 mW / TB, vs >5W / TB for a new "green" HDD.

- The data cited projects that Tape can potentially maintain a substantial cost advantage vs HDD in $/GB for up to 8 years or more

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About Linear Tape-Open (LTO) Technology

LTO technology is a powerful, scaleable, adaptable open tape format created by technology providers HP, Quantum, and IBM Corporation to help meet the growing demands of data protection in the midrange to enterprise-class server environments. This ultra-high capacity generation of tape storage products is designed to deliver outstanding performance, capacity and reliability combining the advantages of linear multi-channel, bi-directional formats with enhancements in servo technology, data compression, track layout, and error correction.

The LTO Ultrium format has a well-defined roadmap for growth and scalability. The roadmap represents intentions and goals only. There is no guarantee that these goals will be achieved. Independent compliance verification is vital to meet the free-interchange objectives that are at the core of the LTO Program. Ultrium tape mechanism and tape cartridge interchange specifications are available on a licensee basis. For additional information on LTO technology, visit the LTO Program Web site at www.ultrium.com.