R. Fontana, G. Decad – IBM Systems
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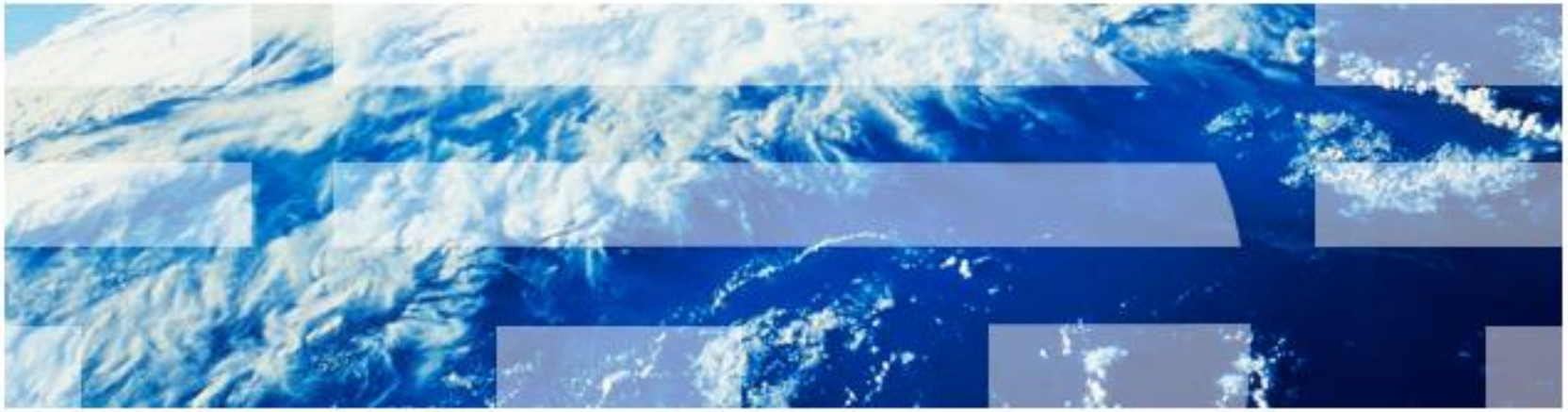
A View on the Future of Tape



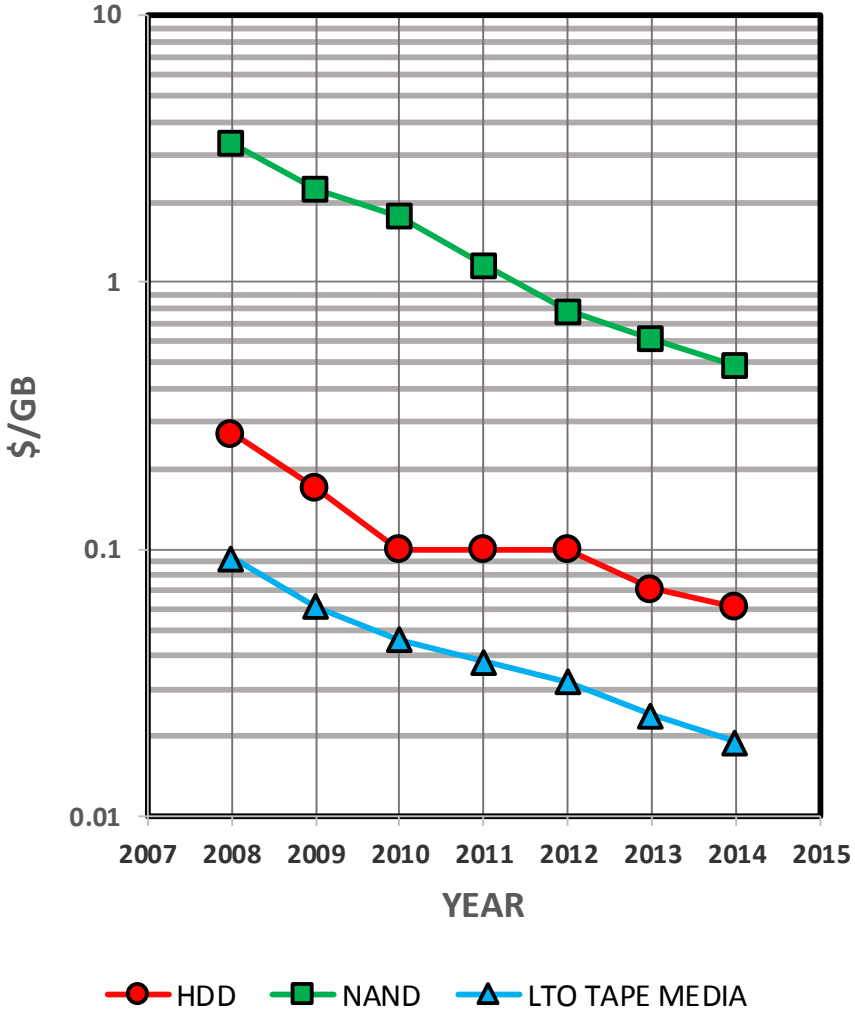
A View on the Future of Tape

- TAPE, HDD, NAND Flash are alive and evolving
- Post Consumer Nature of Storage Components – The Storage Landscape
- The Storage Gap
- The “Data Driven” Tape Market
- Tape Future Technology

Tape, HDD, NAND Flash are all providing value to the Client

- Statements related to replacement of tape technology by competing storage components do a dis-service to the storage client base.
- Today's rates of improving storage technology performance is different from rates of improvement of 10 years ago. Future extrapolations of $/GB, density, PB shipments are likely not reflective of 10 year historical rates.
- HDD areal density growth has slowed
  - Replacement strategy of HDDs on a 4 year cycle is favorable when areal density quadruples (40%/yr growth) and $/GB drops by 75% (30%/yr decrease).
  - Replacement strategy of HDDs on a 4 year cycle is less favorable when areal density increases by 70% (15%/yr growth) and $/GB drops slow
- PB shipment growth for storage components is not elastic
  - Replacing all of HDD PB with NAND Flash would require an additional $240B from clients and an additional $400B investment from NAND manufacturers
- Storage requirements dictate a spectrum of access times from 10^{6} seconds (archive) to 10^{-8} seconds (transactions/computations)
- Awareness of the market landscape is critical

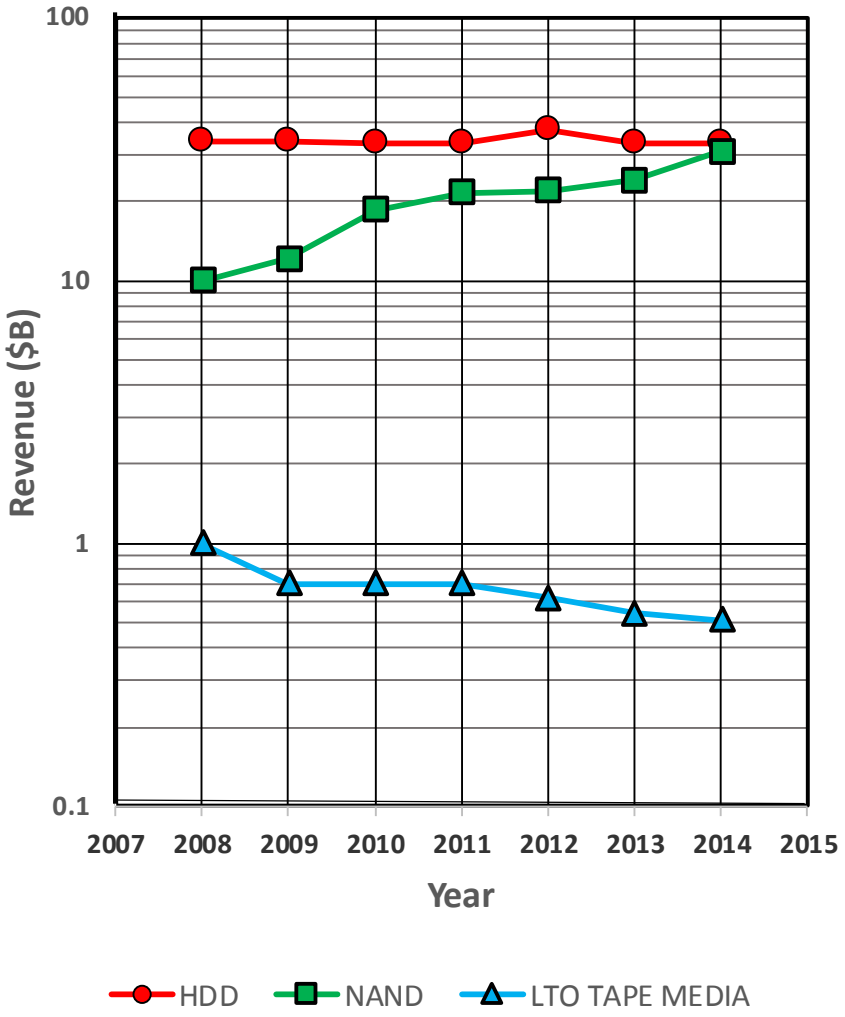
$/GB Reductions are Slowing



$/GB	2013	2014	1 YEAR % Δ	7 YEAR ANNUAL % Δ
LTO TAPE MEDIA	0.024	0.0192	-20.0%	-23.1%
HDD	0.071	0.061	-14.1%	-22.1%
NAND	0.615	0.515	-16.3%	-26.7%

- Observations
  - HDD $/GB reduction slows
  - Historical $/GB reductions range from 22% to 27% (NAND)

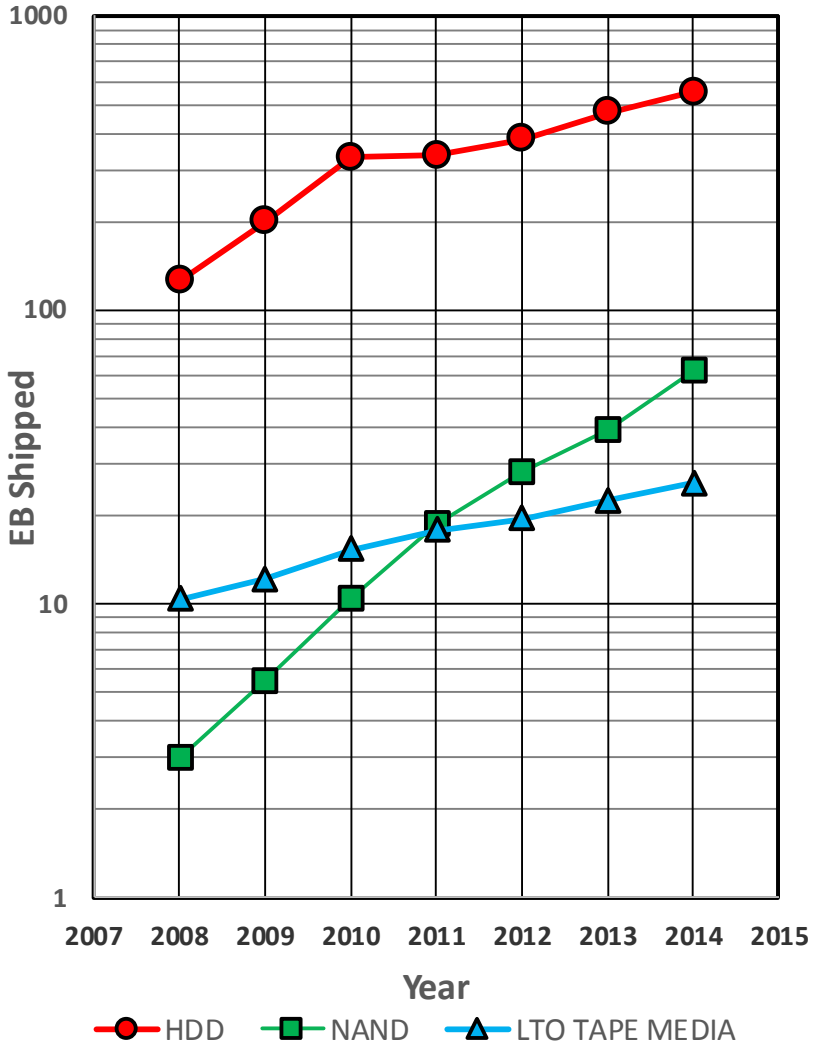
Component Revenue Driven by NAND Consumer Base



Revenue ($B)	2013	2014	1 YEAR % Δ	7 YEAR ANNUAL % Δ
LTO TAPE MEDIA	0.54	0.5	-7.4%	-10.9%
HDD	33.4	33.4	0.0%	-0.3%
NAND	24.0	32.2	34.2%	21.5%
TOTAL REVENUE	57.94	66.1	14.1%	6.3%

- Observations
  - HDD revenue constant
  - LTO Media revenue decreased but better than historical averages
  - Significant NAND revenue growth above historical averages
  - NAND revenue will likely overtake HDD revenue in 2015

Exabyte Shipments – 20% Annual Increases

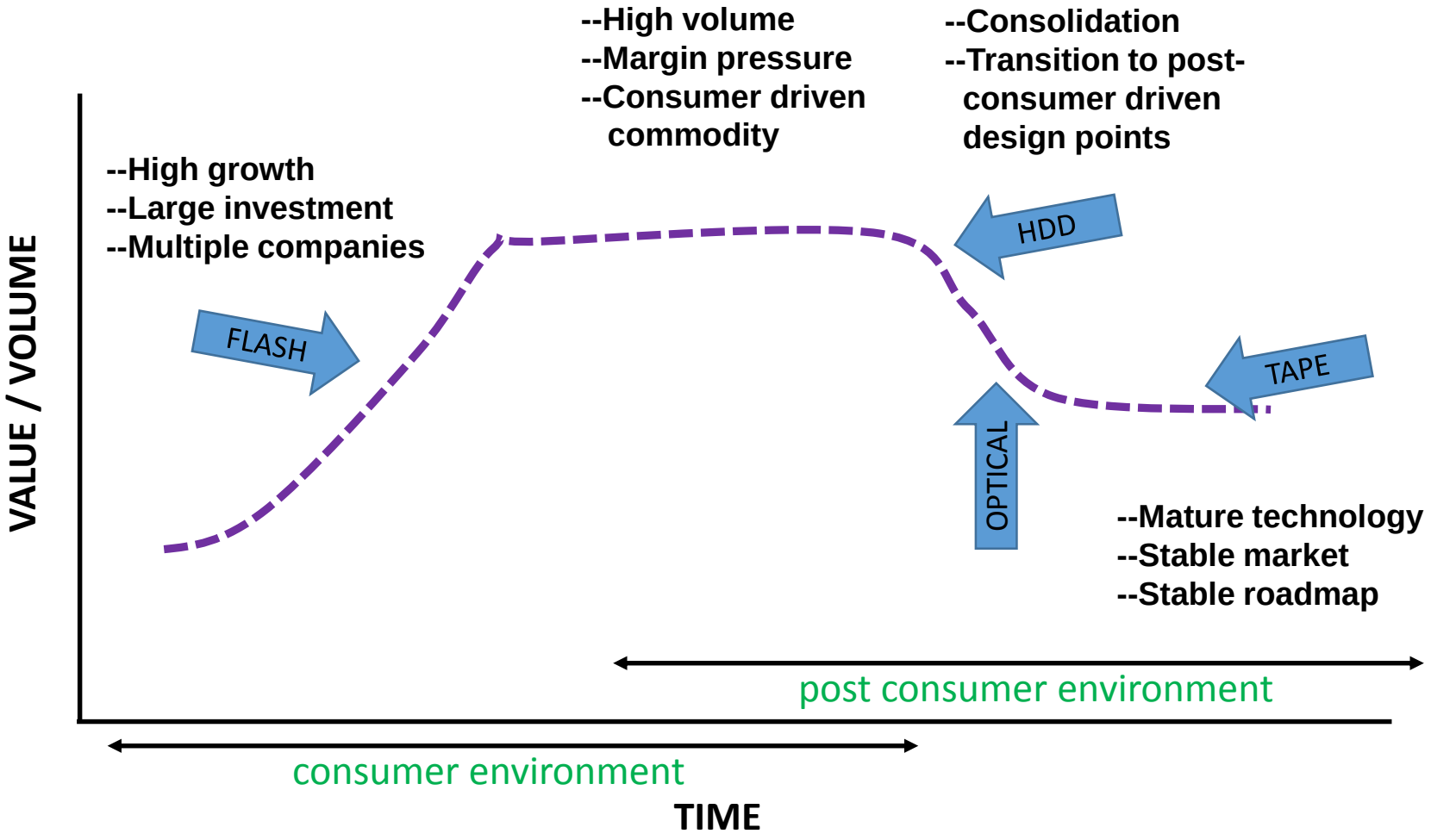


EB SHIPPED	2013	2014	1 YEAR % Δ	7 YEAR ANNUAL % Δ
LTO TAPE MEDIA	22.5	26.2	16.4%	16.6%
HDD	470	549	16.8%	28.0%
NAND	39	62.5	60.3%	65.9%
TOTAL EB SHIPPED	531.5	637.7	20.0%	29.0%

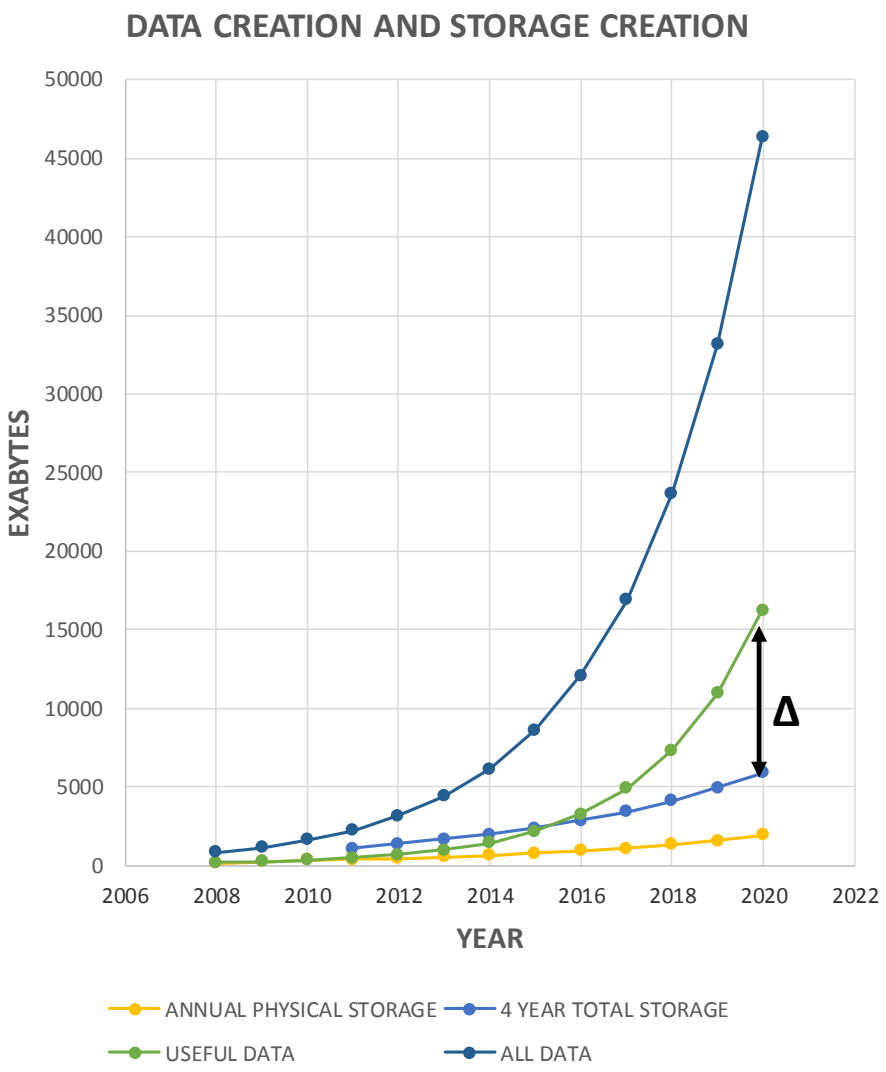
- Observations
  - HDD EB shipment increase less than historical average
  - LTO Media EB shipment increase is stable at ~ 16%
  - Significant NAND EB shipment increase comparable to historical averages of 60% increases
  - NAND EB shipments exceed LTO EB shipments (consumer market, i.e. IPhone6)

Consumer Dynamics and Revenue – Impact on Storage

- Post Consumer Dynamics for TAPE



Manufactured Storage vs Data Creation – The Data Famine



- Observations
  - Total manufactured storage in 2014 increased by ~ 20%
  - IDC (2013) claims for information creation
    - 40% annual increase in information
    - Data created in 2013 -- 4400 EB
    - Data to be created in 2020 -- 44000 EB
    - Useful data in 2013 -- 980 EB (22%)
    - Useful data in 2020 – 16000 EB (33%)
  - Storage Landscape History
    - 20% annual increase in manufactured storage
    - Storage manufactured in 2013 – 530 EB
    - Total storage manufactured from 2010 to 2013 (4 years) – 1700 EB
  - Net result in 2020 – **Data Famine**
    - Total storage manufactured from 2017 to 2020 (4 years) – 6000 EB
    - Useful data in 2020 – 16000 EB
    - **10000 EB shortfall**

Tape and the Data Market (i.e. Cloud and Analytics)

- Cloud
  - Essential to sustain data storage demands
  - Essential for large data sets in analytics requirements
  - Competition in Cloud storage providers driving focus on cost and multi-technology storage management
  - $/TB is essential in cost-sensitive Cloud solutions and to hold massive data for Analytics
  - Backup and replication
- LTO (client comments)
  - The non-proprietary format of LTO tape solutions enables ease of integration and long-term deployment, contributing to tape's case as a scalable, long-term solution
  - Tape is proving more reliable than disk, especially lower cost disk
  - The non-proprietary format of LTO tape solutions enables ease of integration and long-term deployment, contributing to tape's case as a scalable, long-term solution

TAPE Confidence Reflected in the Published 10 Generations LTO Roadmap

Future

	LTO 3	LTO 4	LTO 5	LTO 6	LTO 7	LTO 8	LTO 9	LTO 10
Year	2004	2007	2010	2012	2015			
Native Capacity (TB)	0.4	0.8	1.5	2.5	6.4*	12.8	25.0	48.0
Native Data Rate (MB/s)	80	120	140	160	315*	472	708	1100
Compression Ratio	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5
Compressed Cap (TB)	0.8	1.6	3.0	6.25	16.0	32.0	62.5	120.0
Compressed Data Rate (MB/s)	160	240	280	400	788	1180	1770	2750
*LTO7 TBD								

- Tape density growth is assured by the development of **<u>evolutionary</u>** technology
  - Improved track edge definition (TPI increases)
  - Improved "writeablity" of smaller size grains with high H_k (high moment heads)
  - Sensors to detect smaller bit cell widths
  - Media to support smaller bit cells

Tape Future -- Technology

- Technology to sustain density and capacity goals for LTO were described in the earlier “Technology Overview Session”
- Head technology and media technology exists to support the next generations of LTO, i.e. 6.4 TB, 12.8 TB and 25.0 TB cartridge capacities
- Enterprise capacities are shipping at 10 TB cartridge capacities
- Key technology points
  - No superparamagnetic limitations for near term tape cartridge capacities
  - No nano-technology limitations in processing transducers
  - Future TAPE transducers use existing HDD structures but at 10X 0t 30X larger length scales
- Bit cell size drives the tape technology