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The Status of Tape Storage Technology

Fujifilm Global IT Executive Summit

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Tape Elevator Pitch

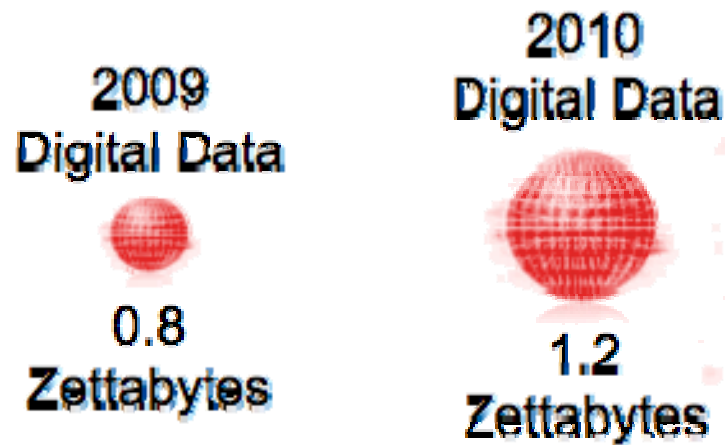
Tape is the most scalable, cost effective storage. In world of explosive data growth, tape is a staple in the enterprise data center for archive and backup.

- Best Scalability
 - More than 30x maximum capacity of disk
- Best TCO
 - Less than 1/15th the cost of disk*
 - Less than 1/200th the power/cooling of disk*

* The Clipper Group, Dec 2010

IT Storage Challenges Have Not Slowed

Increasing Demand for Storage Capacity



2020
Digital Data

35
Zettabytes
(44x growth)

- Regulations on data retention continue to rise sharply
- IT budgets and headcounts can't keep up with this growth

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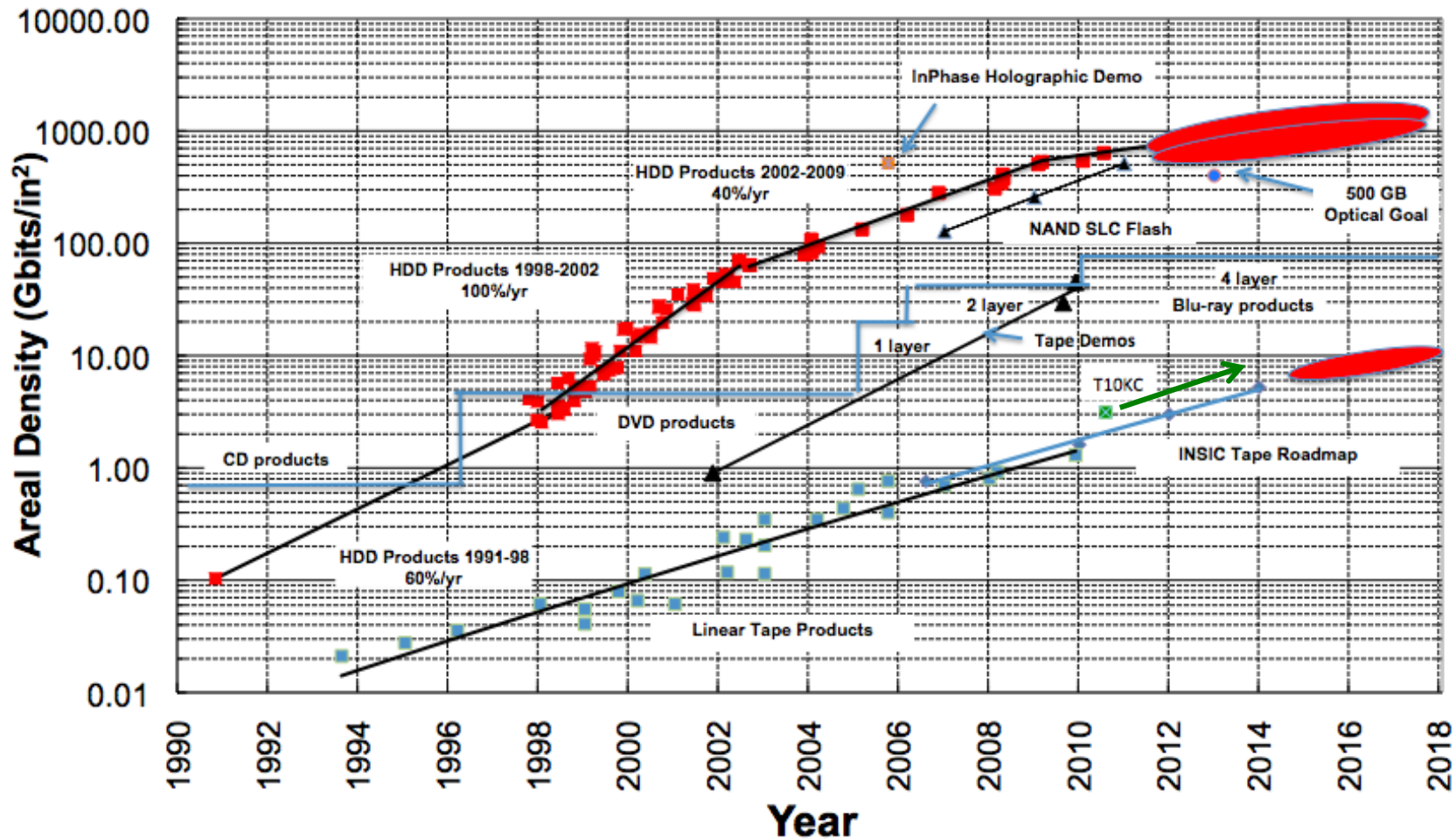
Source: IDC, White Paper Sponsored by EMC, The Digital Universe Decade - Are You Ready? Doc.# IDC_925, May 2010



Status of Disk Storage

- Displacement by flash technology for high IOPS
- Disk technology advances becoming more difficult
 - Future areal density increases will require new technology
 - Heat Assisted Magnetic Recording (HAMR), Bit Patterned Media (BPMR), Shingled Recording (SWR) or others
 - Require significant capital and R&D investment
- More and more industry consolidation
 - Western Digital (50% HDD shipment share)
 - Hitachi, IBM
 - Seagate (40% HDD shipment share)
 - Conner, Maxtor, Quantum, Samsung
 - Toshiba (10% HDD shipment share)
 - Fujitsu

Storage Technologies Areal Density Trends

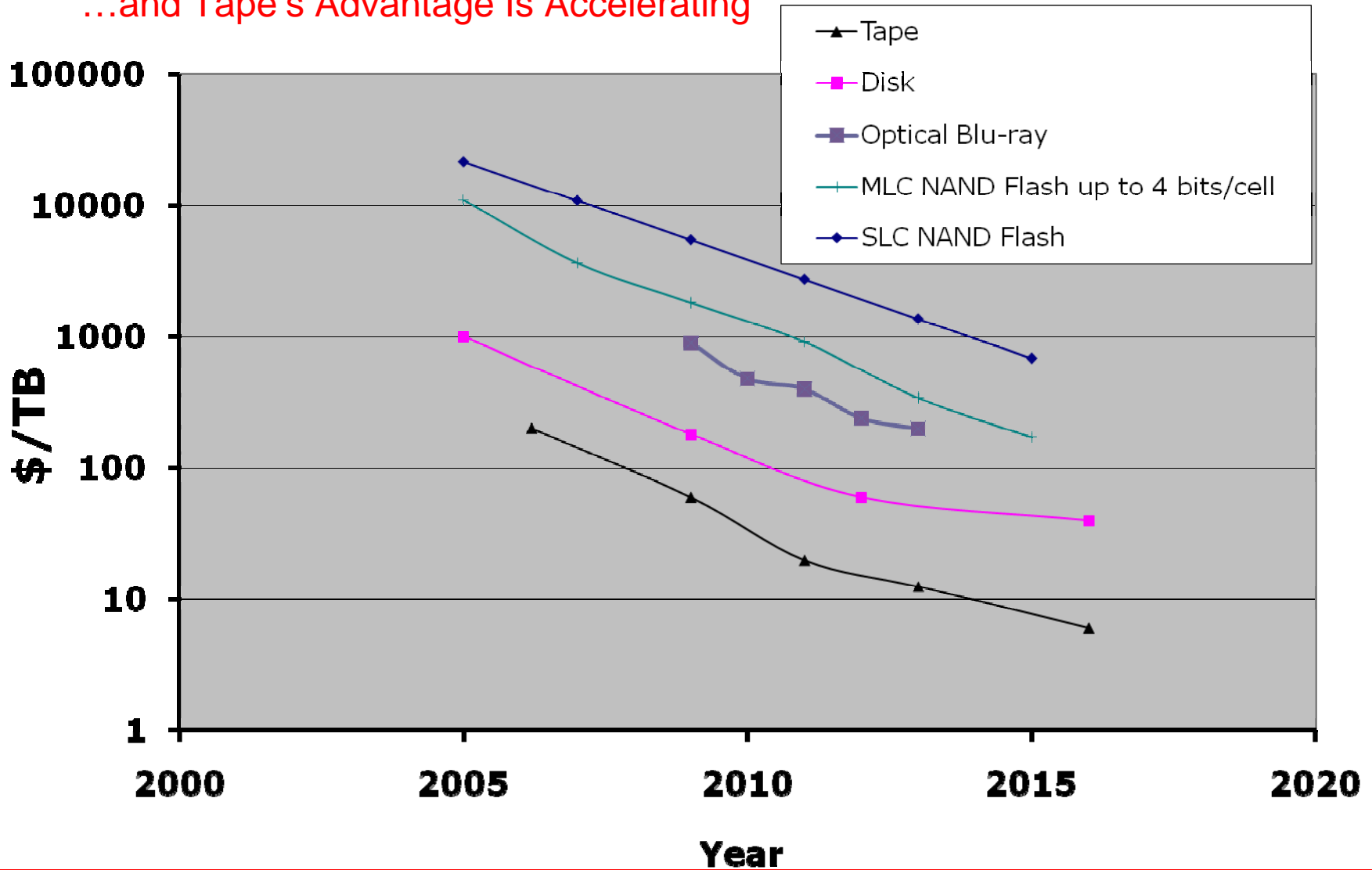


Tape gets its capacity by having 1000X the recording surface area comparing a 1/2 inch cartridge to a 3 1/2 inch disk.



Technology Component Price/GB Projections

...and Tape's Advantage Is Accelerating





Disk Customer - Data Growth Scenarios

Flat to 10% CAGR

- Good times indeed. Opportunity to shift storage to higher performance.

10% to 25% CAGR

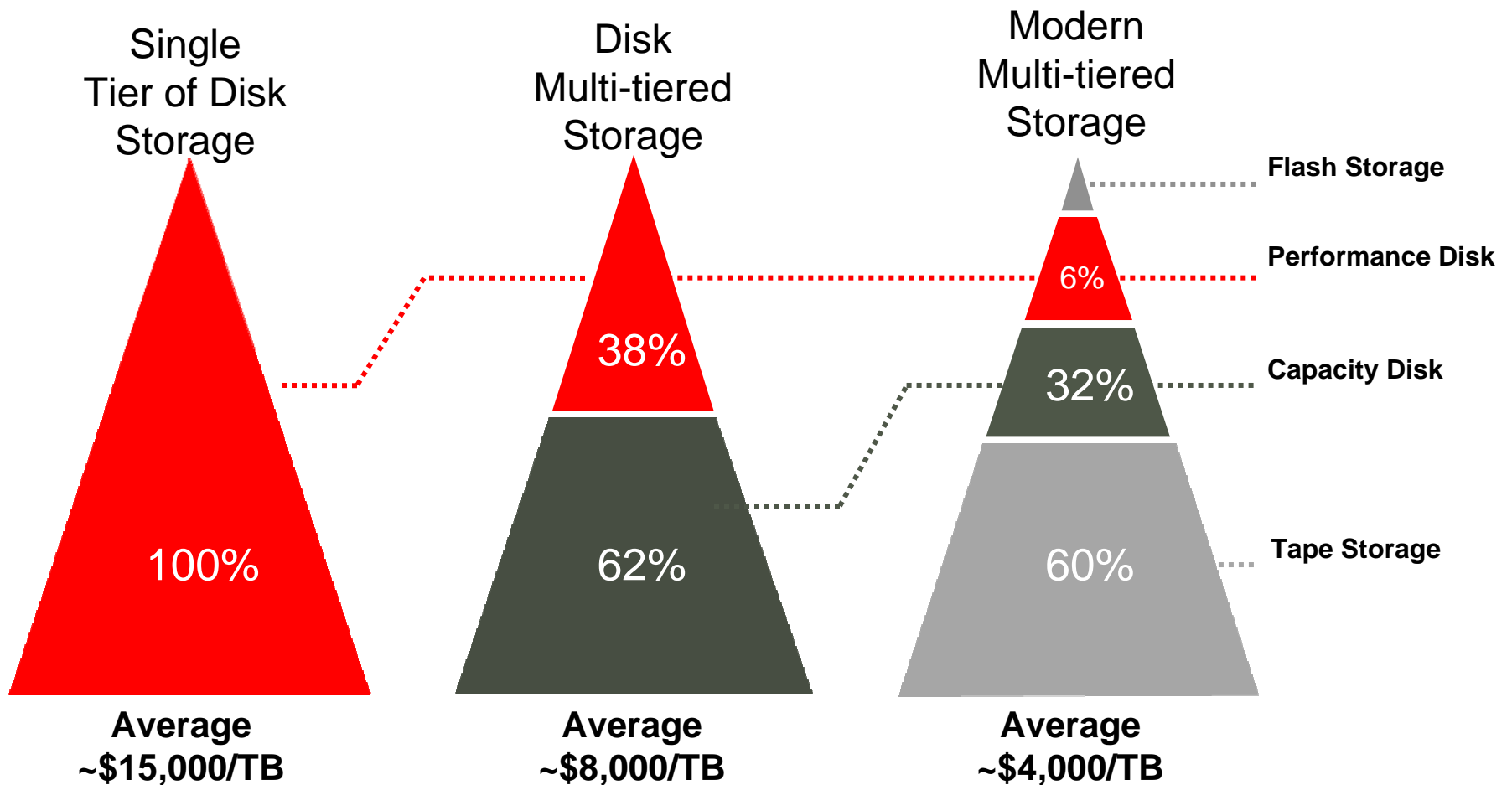
- Status quo. Budget ok.
- Minor tweaks to your storage mix for performance.

25% and higher

- Challenging times ahead
- Queue up for more budget and additional floor space

Data Growth Vastly Outstrips IT Budgets

Data Center Best Practices Require **Tiered Storage Efficiencies**



Source: Horison Information Strategies, Digital Curator Paper, April 2010, updated with T10000C

Tiered Hardware: Automated By Software



Disk Storage

Tape Storage

Primary

Secondary

- Mission Critical Databases
- High-Performance Applications
- Flash Storage
- Hybrid Storage

- Fixed Content
- Backup and Recovery
- Business Continuity
- Snap/Mirror/Replication
- Online Archive

- Video, Medical, Data Archive
- Regulatory Compliance
- Disaster Recovery

Tiered Storage Software	Business Applications (11g partitions)	Unified Storage Hybrid Storage Pool	SAM and VSM
Average Days Since creation	0 Days	30+ Days	90 Days to Forever
Recovery Time Objectives (RTO)	< Second	Seconds	Minutes

It's Not Only About Cost/TB

	Disk	Tape
• Max shelf life (bit rot)	10 years	30 years
• Best practices for data migration to new technology	3-5 years	8-12 years
• Uncorrected Bit Error Rate, Probability (avg 1 error in x TB)	10^{-14} (~10's of TB)	10^{-19} (~1 million TB)
• Power and cooling	290X	X

“The cost of energy alone for the average disk-based (archive) solution exceeds the entire TCO of the average tape-based solution.”

The Clipper Group, “In Search of the Long-term Archiving Solution, December 2010

Oracle StorageTek Tape Portfolio

- Industry-leading reliability and availability
- Best TCO
- Best investment protection



SL24/48



SL500



SL3000



SL8500



LTO



T9840



T10000



VSM

Software

Device Management
Data Management
Tiered Storage
Virtualization
Encryption

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StorageTek T1000C Tape Drive

Available February 1, 2011

- 5 TB native – 10 TB compressed
- Performance: > 240 MB/sec native
- Fujifilm BaFe media
- Investment protection:
 - Media re-use at higher capacity with Generation 4 drive
- 2 GB buffer
- 3rd generation, 32 channel drive
- Native FC & FICON connectivity (without external control unit)



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First **Exabyte** Storage System

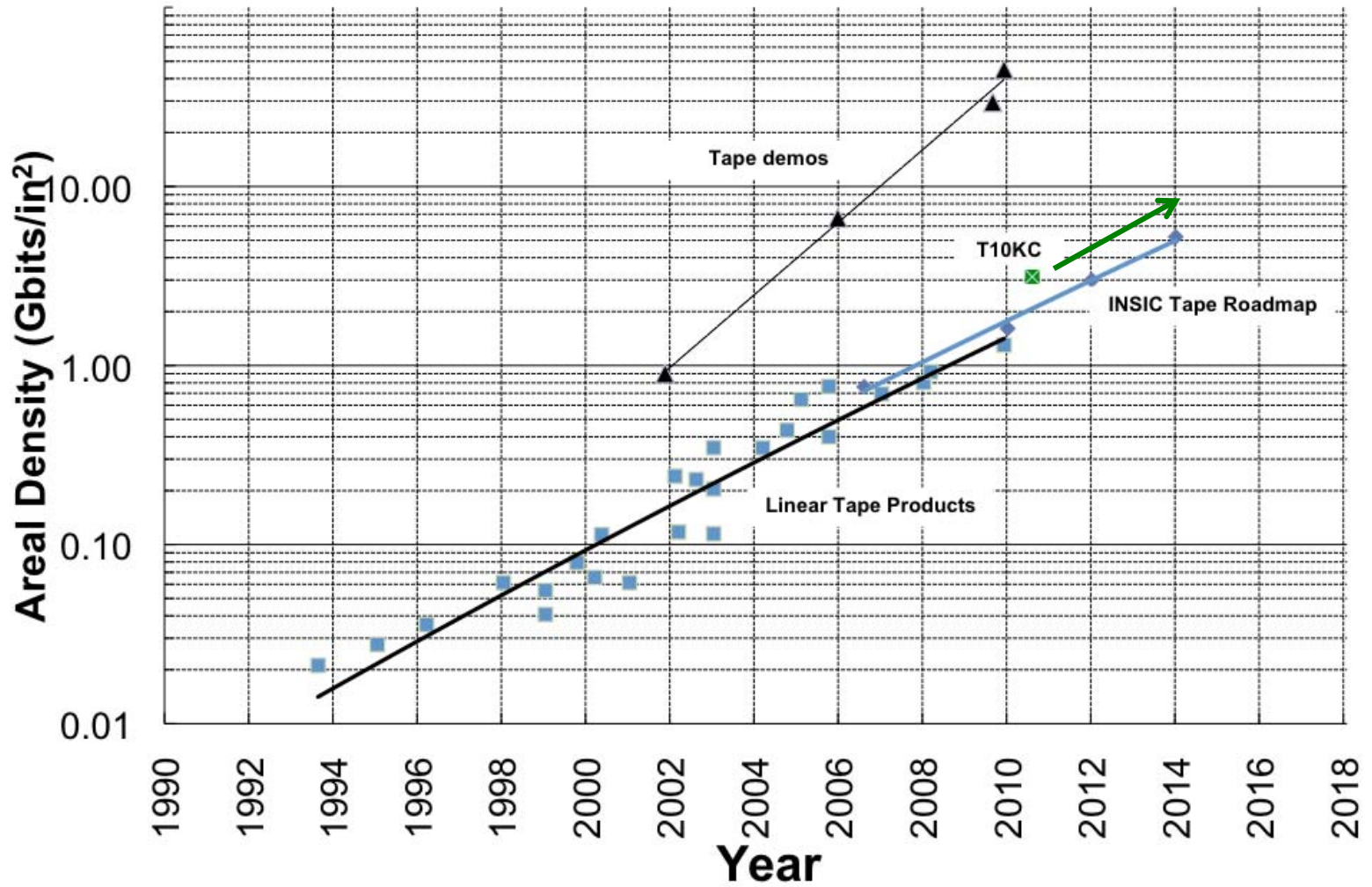
With the T10000C tape drive and SL8500 tape library, Oracle achieved the world's first **Exabyte** capable tape system.



Pictured: Ten string StorageTek SL8500 tape library, capable of holding 100,000 media cartridges

* Assumes 2:1 Compression

Tape Areal Density Trends



Technology Marches Forward – 10 TB Example



1996

- 6000 carts
- TimberLine 9490 – 1.6 GB
- 357 sq ft
- 8200 lbs



2011

- 2 carts
- T10000C – 5.0 TB
- 0.3 sq ft
- 1.2 lbs

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Small Footprint for Tape Storage

10 PB Example

Library	Drives	Libraries	Cartridges	Sq. Ft *
StorageTek SL3000	T10000C	1	2,000	45
StorageTek SL3000	LTO-5	2	6,667	116

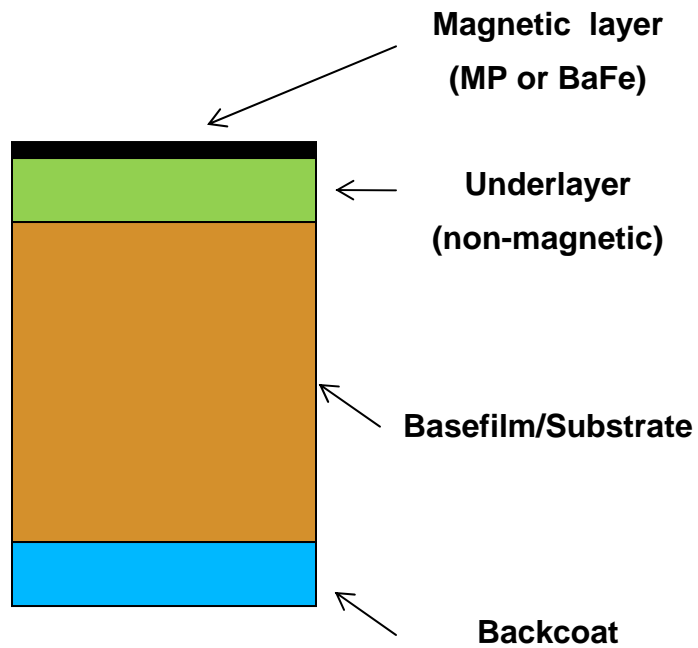
* Floorspace calculations include service area



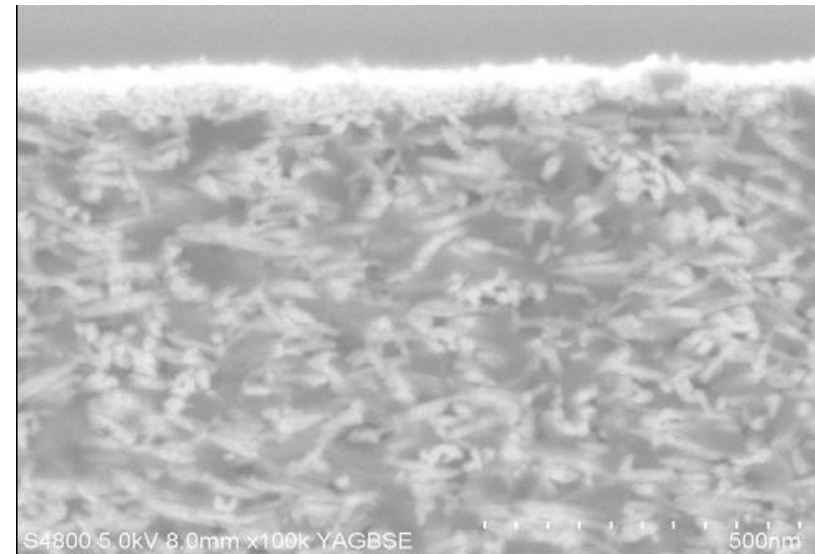
T10000C Enabling Technologies for 5 TB

- Media (new BaFe media)
 - Smaller particles for improved signal-to-noise ratio
 - Reduced dimensional changes, creep, shrink, etc.
 - Lower noise media structures
- Heads (Oracle/STK head facility)
 - 3rd generation, 32 channels
 - MR (magneto resistive) >>>> GMR (giant magneto resistive)
 - Head contour for low tension, smooth media and high tape speed
 - Reduced track spacing
- Tape Path
 - Alternative guiding technologies for improved LTM control
- Recording Channel Improvements

Cross-section of Tape



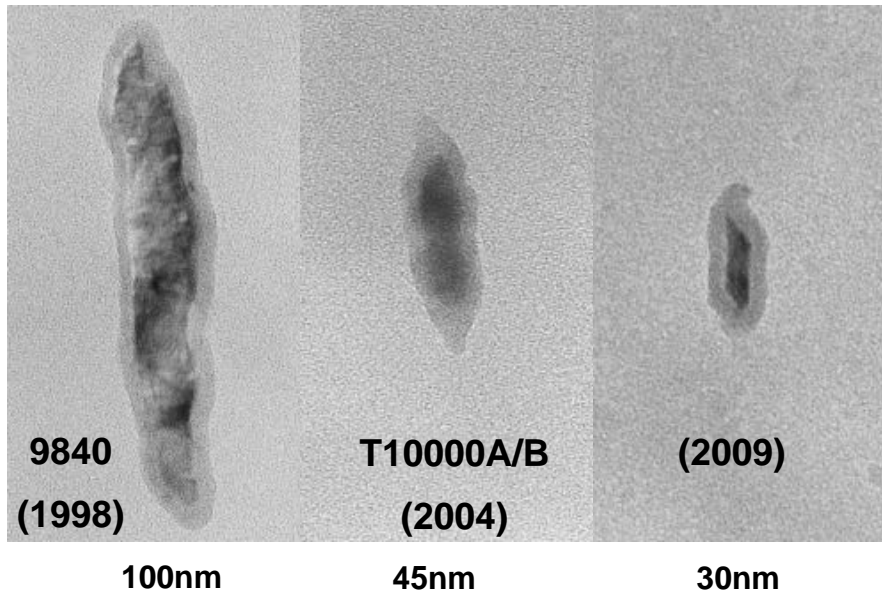
SEM cross section of BaFe



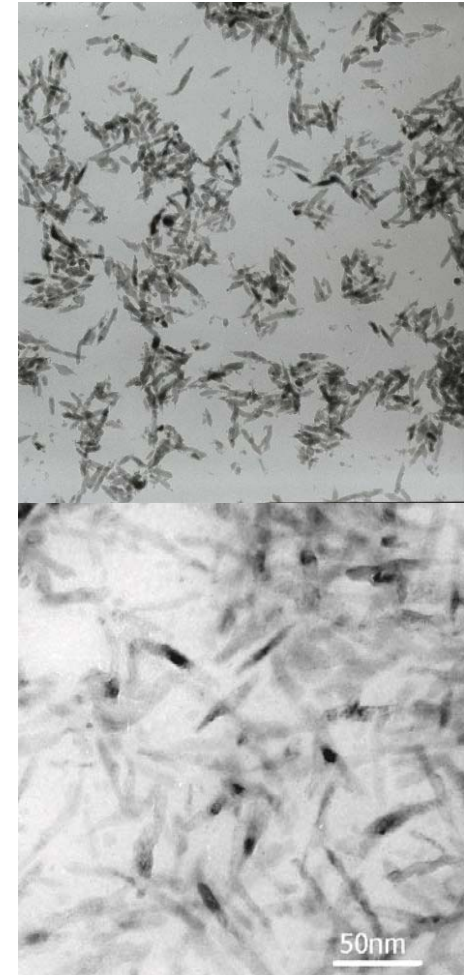
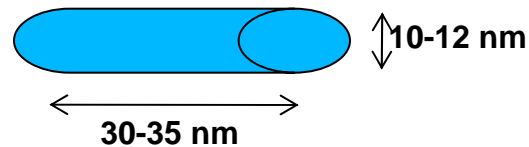
Top layer is BaFe magnetic layer

Media Details – Yesterday & Today

Metal Particle (MP) Evolution



- acicular FeCo alloy with oxidized passivation shell (needle-like)
- 9840, T10000, and LTO media

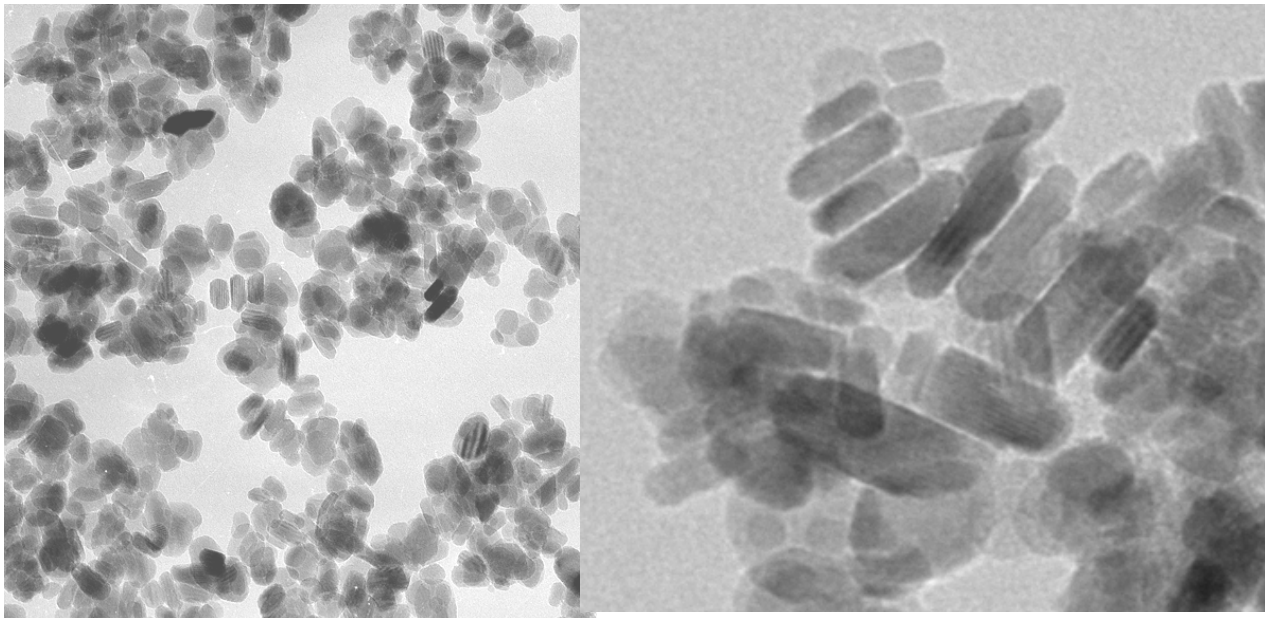
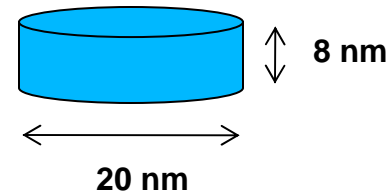


Dispersion of MP
(TEM images)

Media Details – The Latest Technology

StorageTek T10000 T2 Media is Formulated Using Barium Ferrite

- Barium Ferrite ($\text{BaFe}_{12}\text{O}_{19}$)
- Hexagonal, platelet
- Naturally stable oxide
- No corrosion – chemically unreactive



Dispersion of BaFe (TEM images)

Higher packing
fraction

+

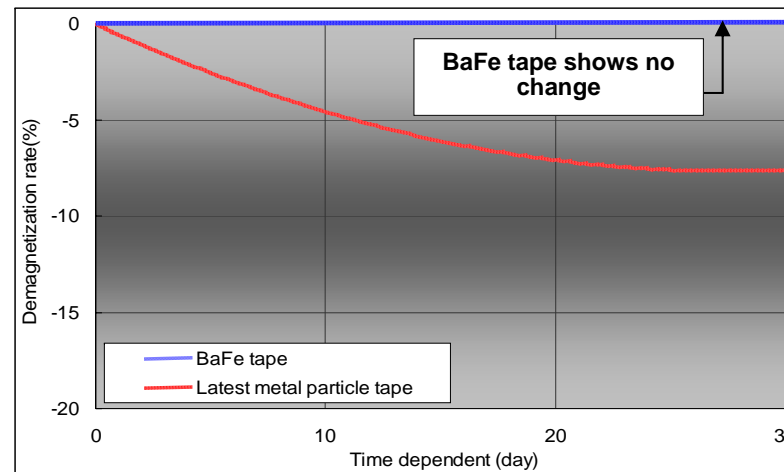
Reduced
Clumping

=

Less media
noise

BaFe - The Ultimate Archive Media

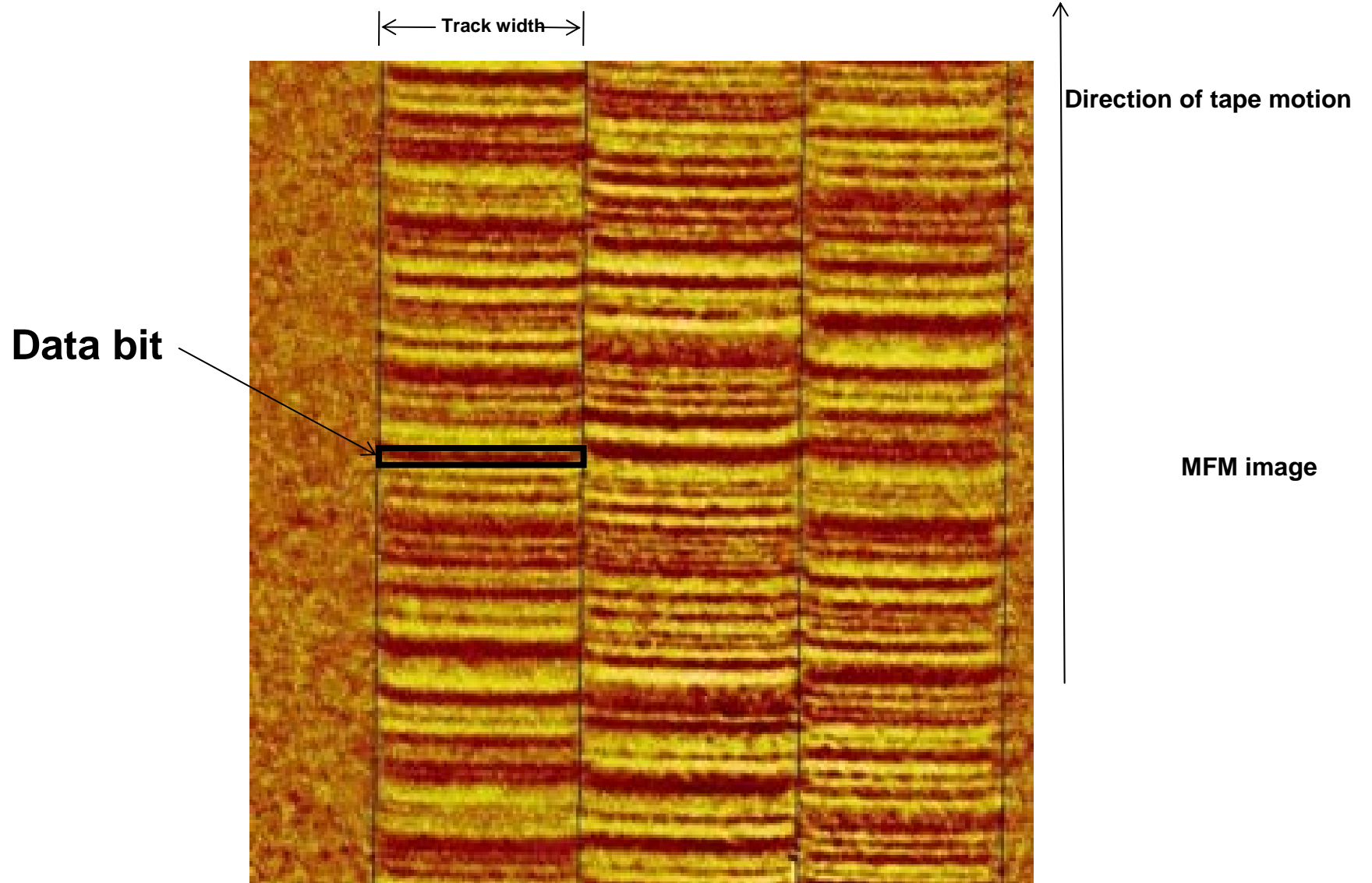
- BaFe has been shown to have superior life for long term archive applications



- 30 year accelerated test shows no change in magnetic data retention compared to current MP media⁽¹⁾
 - ¹ <http://www.fujifilm.com/news/n100910.html>

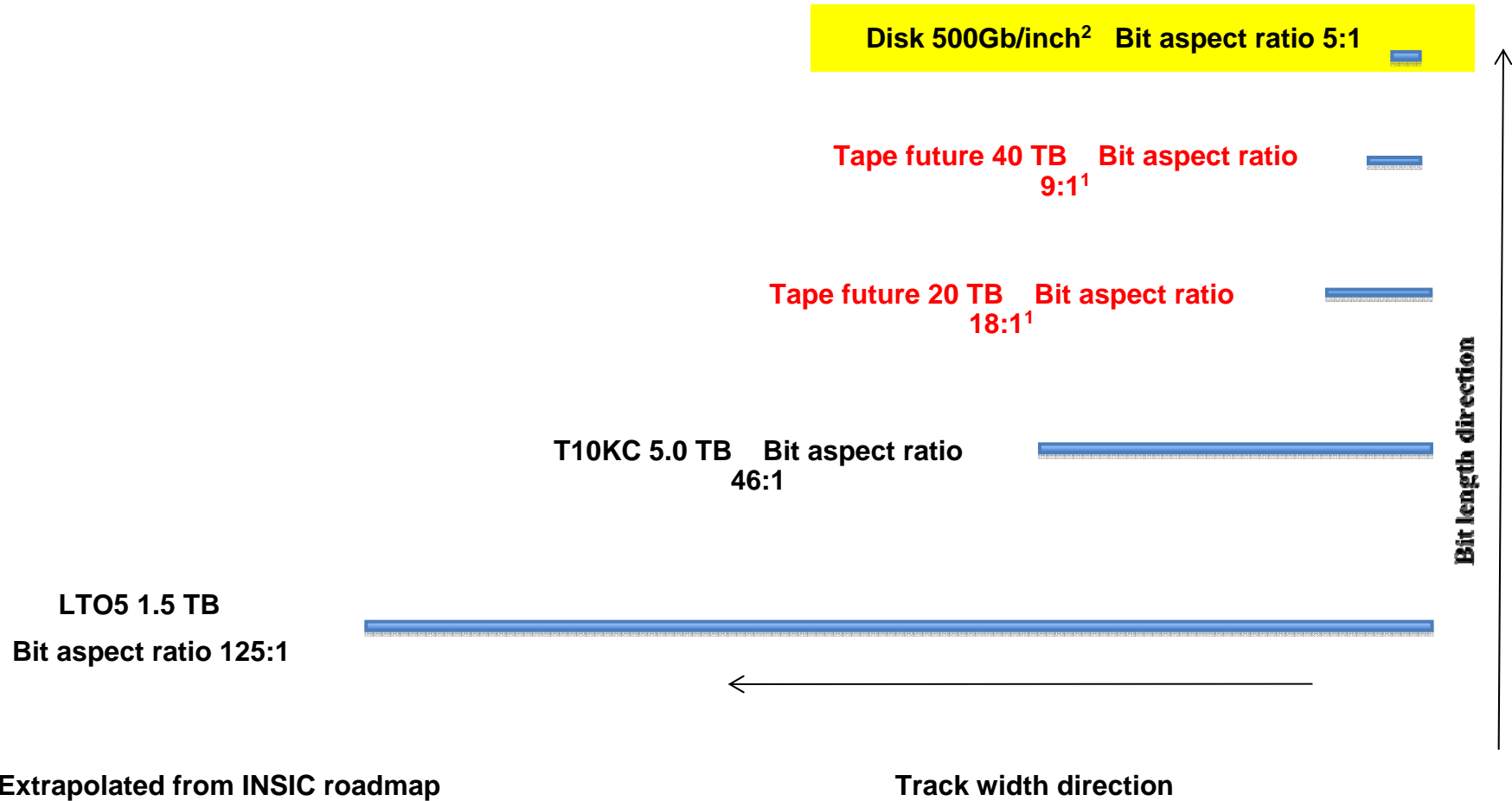


BaFe Written Data Tracks



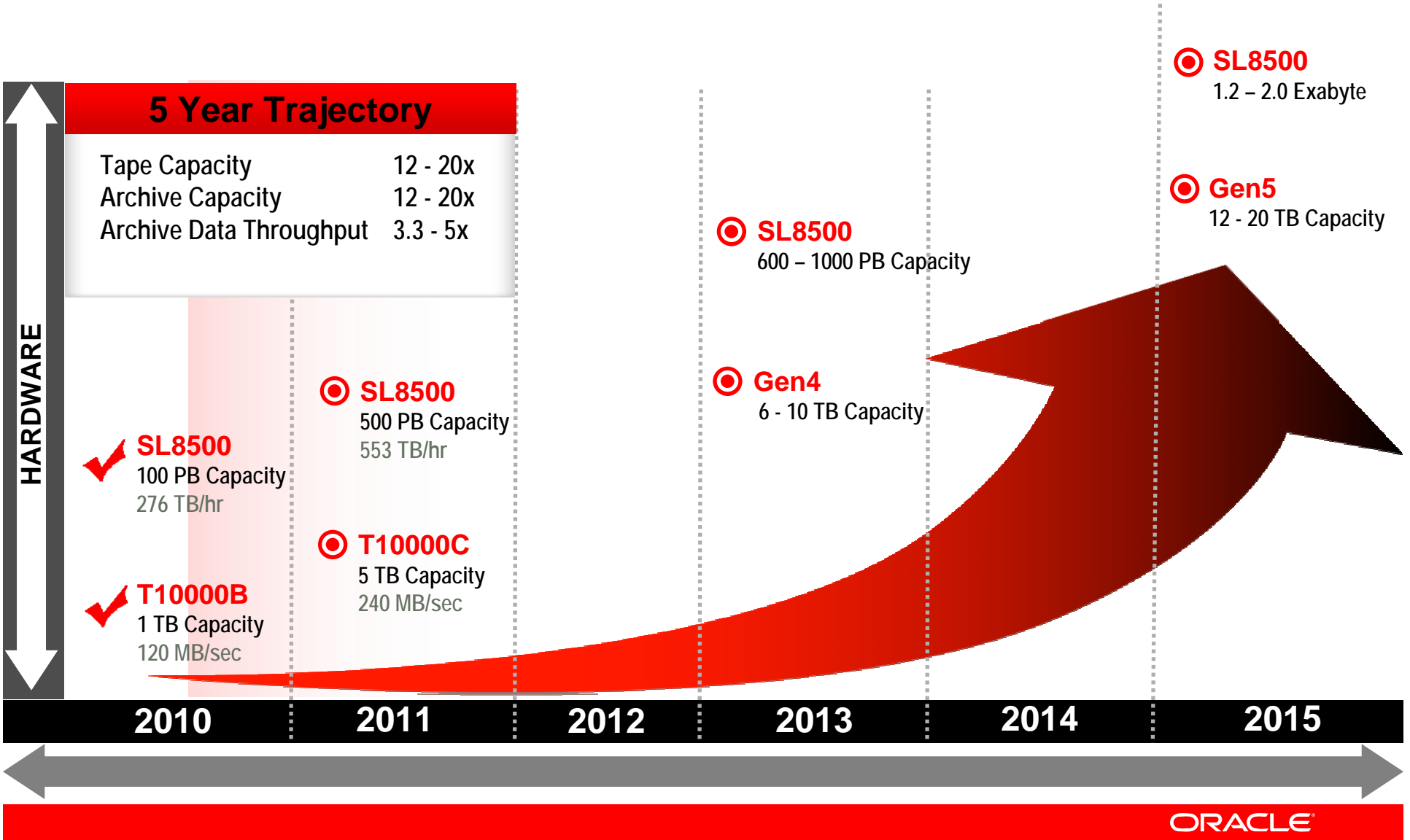


Tape Bit Size Roadmap





Industry Leading Oracle Tape





Tape Software Features

- Native AES-256 bit data encryption
 - First introduced in 2006
- Tape Partitioning
 - 480 partitions in 5 sections
 - Partition size ~9GB
- End-to-End Data Integrity Validation
 - The DIV CRC of each record is written to tape with that record
 - When a record is read from tape the CRC is always checked
 - The SCSI Verify command can be used to check each record without transferring data to the application
- Linear Tape File System
 - Self-describing file system on tape
 - Metadata stored on the tape



Tape Storage Projections

- Tape continues as the archive and large scale backup media of choice
 - Expect cartridge capacities to double at approximately 2 year intervals
 - T10000C breaks this trend with 5x capacity increase
 - \$/GB reduces by roughly ½ every two years
- INSIC tape roadmap shows technology path to 32 TB on a cartridge
- Disk areal density CAGR expected to slow
- Tape will continue as the most cost effective and scalable storage tier

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