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Tape Technology 2000

The Exciting Future of Magnetic Tape

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West Bethesda MD 20817-5700

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The Exciting Future of Magnetic Tape

Your Business is Safe with Imation

THIC Meeting: October 3-4, 2000
Presenter: James A. Goins
e-mail: jagoins@imation.com

The Exciting Future of Magnetic Tape

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Abstract:

1999 - The STK 9840 and IBM 3590E magnetic tape systems provide new mass storage options to match the requirements of a relentless HDD 60% CAGR.

2000 - LTO (IBM, HP & Seagate) Ultrium Technology and SDLT (Quantum) will add to the network and enterprise storage options.

Performance, reliability and scalability factors of these tape systems must be well understood in order to maximize the benefits of these new options.

Imation Corp.

A
$1.3 Billion
Global Technology Company

Imation Corp.

The name "Imation" reflects the company's core values -- imagination and innovation -- and its core businesses- information and image management

These values provide a strong foundation on which the company is developing new *customer solutions*

Imation Corp. - Statistics

- 4,850 employees globally
- Generated sales of $1.3 billion in 1998
- Imation operates in 60 countries
- Approximately 45% of company sales generated outside the U.S.
- Businesses consist of product and service solutions for Information, Imaging and Color Management
- New York and Chicago Stock Exchange trading symbol “IMN”

Imation Corp. - Structure

Data Storage & Information Management

Color & Image Management

Digital Solutions & Services

We capture and transform data, store it as information, and present it in innovative ways to help customers make better business decisions

Introduction

- The role of tape storage is changing and expanding
  - It’s not just for backup anymore
- New technology has made tape -
  - a very high capacity medium, and
  - a high speed access/retrieval medium
- Automation has brought tape on-line
- New storage architectures enhance tape utilization

Agenda

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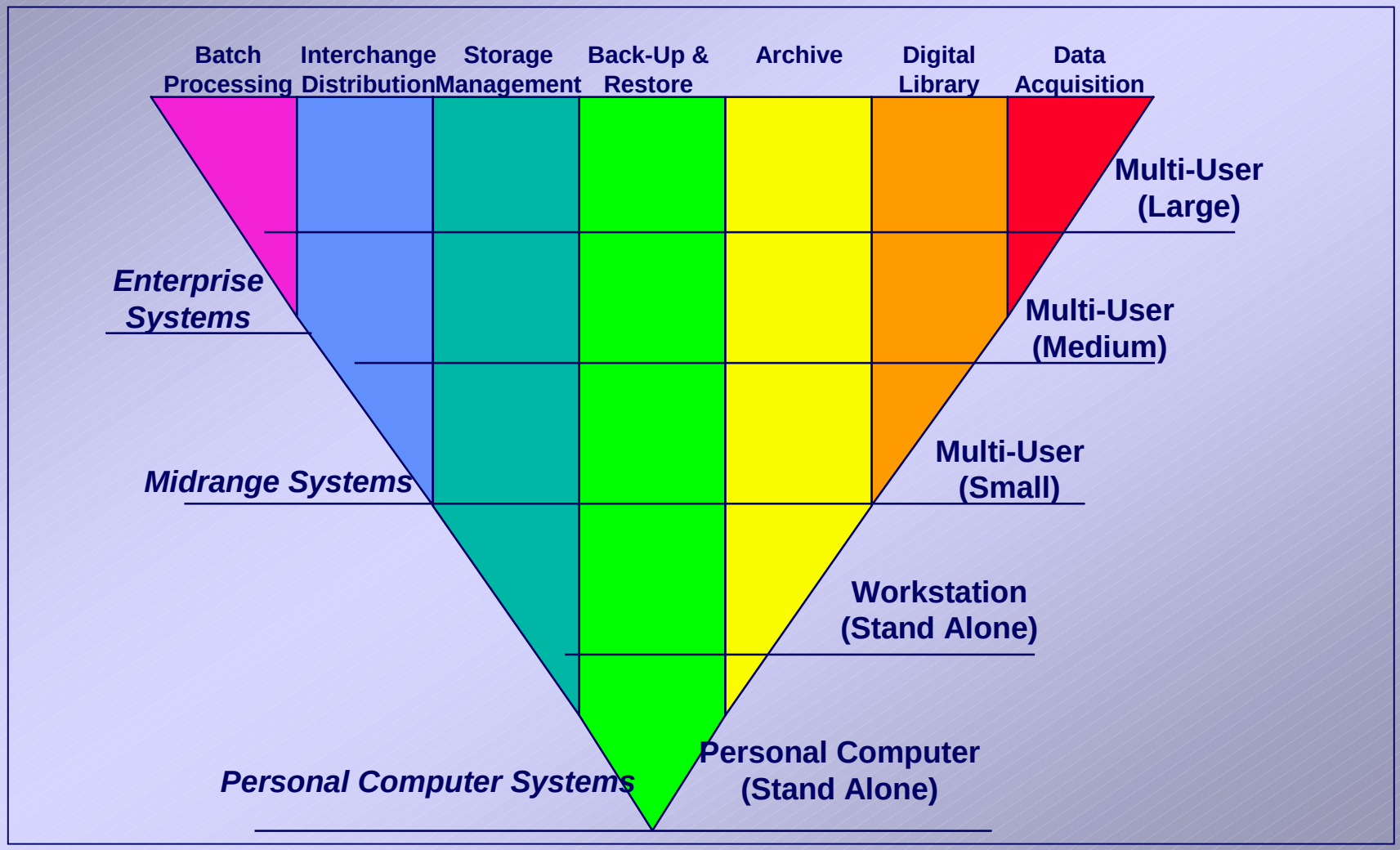
1. Key Applications and Storage Pyramid
   - Review of Systems Migration 74’ - 95’
2. Enabling Technologies
   - System Migration 95 to Present
3. Automation Options
4. Future Tape Technologies
5. Future Storage Network Architectures
6. Challenges

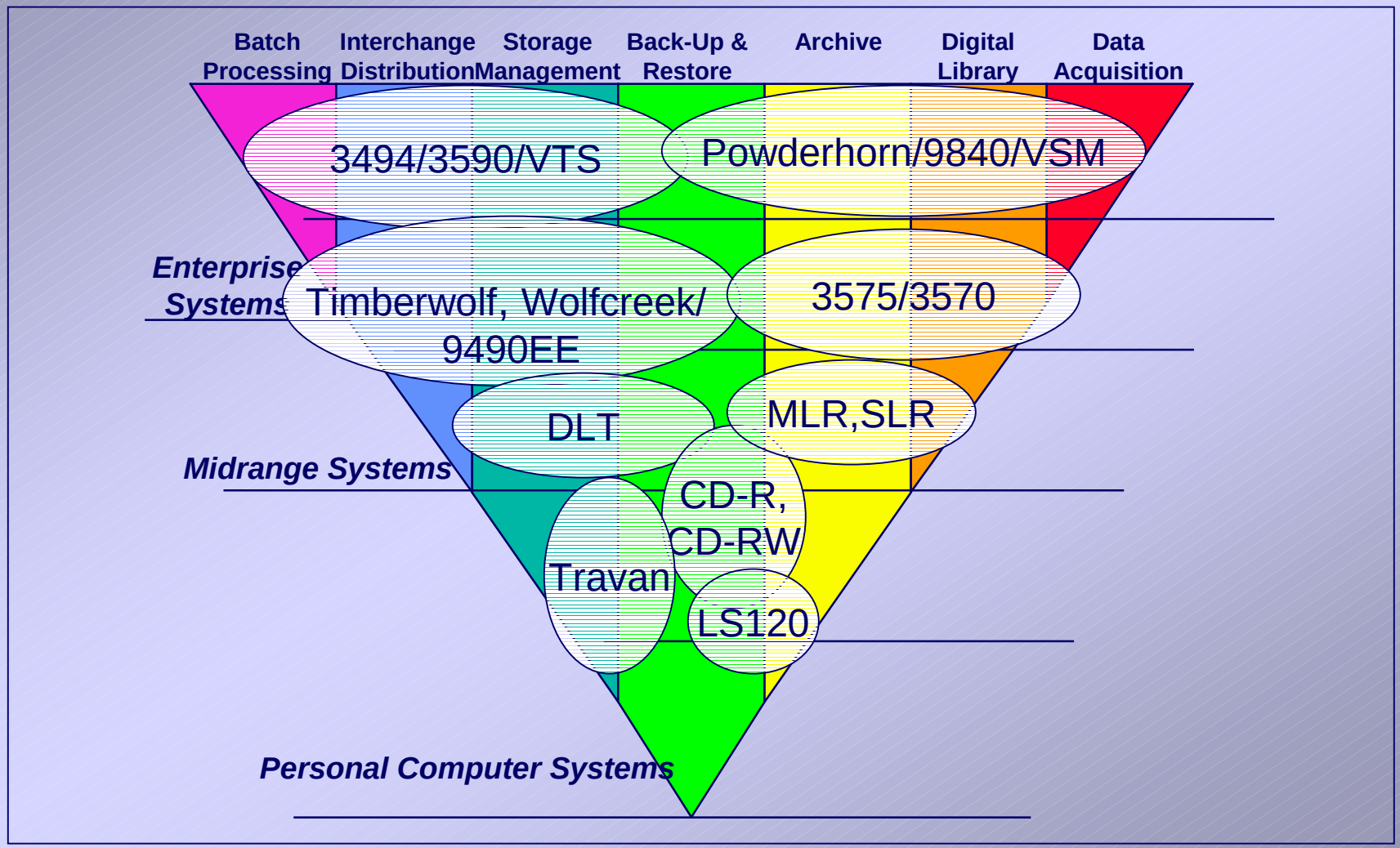
1. Key Applications

- Backup/Restore
  - How much data do you have
  - How much time do you have
- Archive
  - How much data do you have
  - How quickly do you need to retrieve it
- Storage Management
  - How much data do you have
  - How often is it needed

1. Data Storage Pyramid



1. Data Storage Pyramid



1. Data Center Systems Tape Drive Performance
Past & Present

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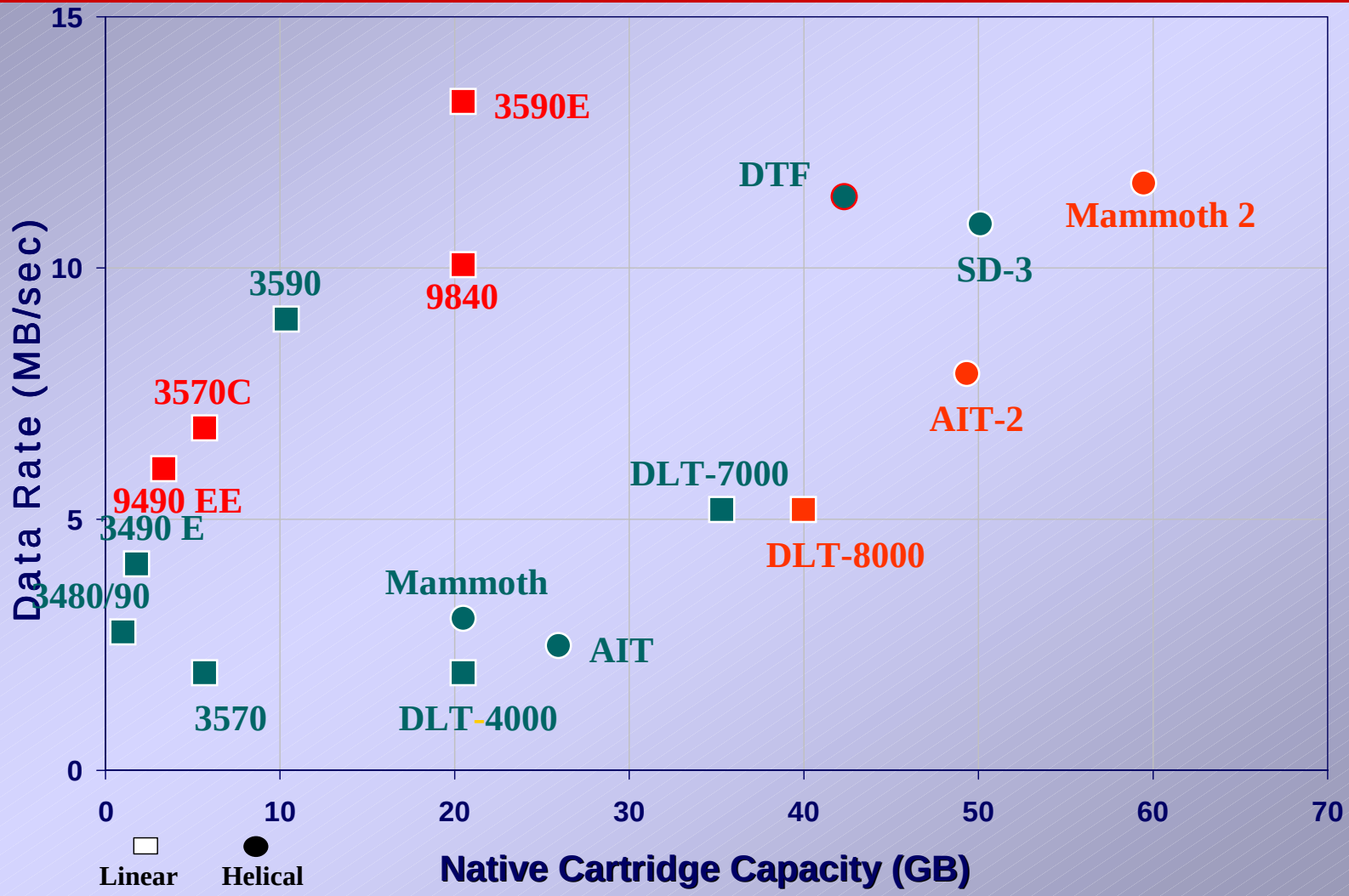

1. Tape Subsystem Migration

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1974-1995								
Drive	**3420**	**3480**	**3490**	**3490E**	**3490E**	**9490**	**3590**	**SD-3**
Media	reel-reel	3480	3480	3480	3490E	3490E	3590	SD-3
Date	1974	1984	1989	1991	1992	1995	1995	1995
Capacity (MB)	150	200	200	400	800	800	10,000	50,000
Transfer Rate	1.25	3	3	3-4.5	3-4.5	6	9	11
Length	2400	550	550	550	1100	1100	1100	1200
Tracks	9	18	18	36	36	36	128	helical
Pigment	Iron	CrO2	CrO2	CrO2	CrO2	CrO2	MP1	MP1
Coercivity	300	520	520	520	520	520	1600	1600

2. Enabling Technologies

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- Advanced tape formulations - Metal Particle (MP1)
- Advanced substrate development
- Advanced Cartridge Development
  - Uni-Reel & Precision Tape Path Development
  - Center-Parked Dual Tape Reels & In-Cartridge Tape Guidance
  - Precision molded cartridge components
- Thin Film Magneto-resistive, Multi-channel Heads
- Track-Following Servos and Servo-Written Tape
- Robotics & Automated Libraries

2. Advanced Metal Particle (MP1) Magnetic Coatings

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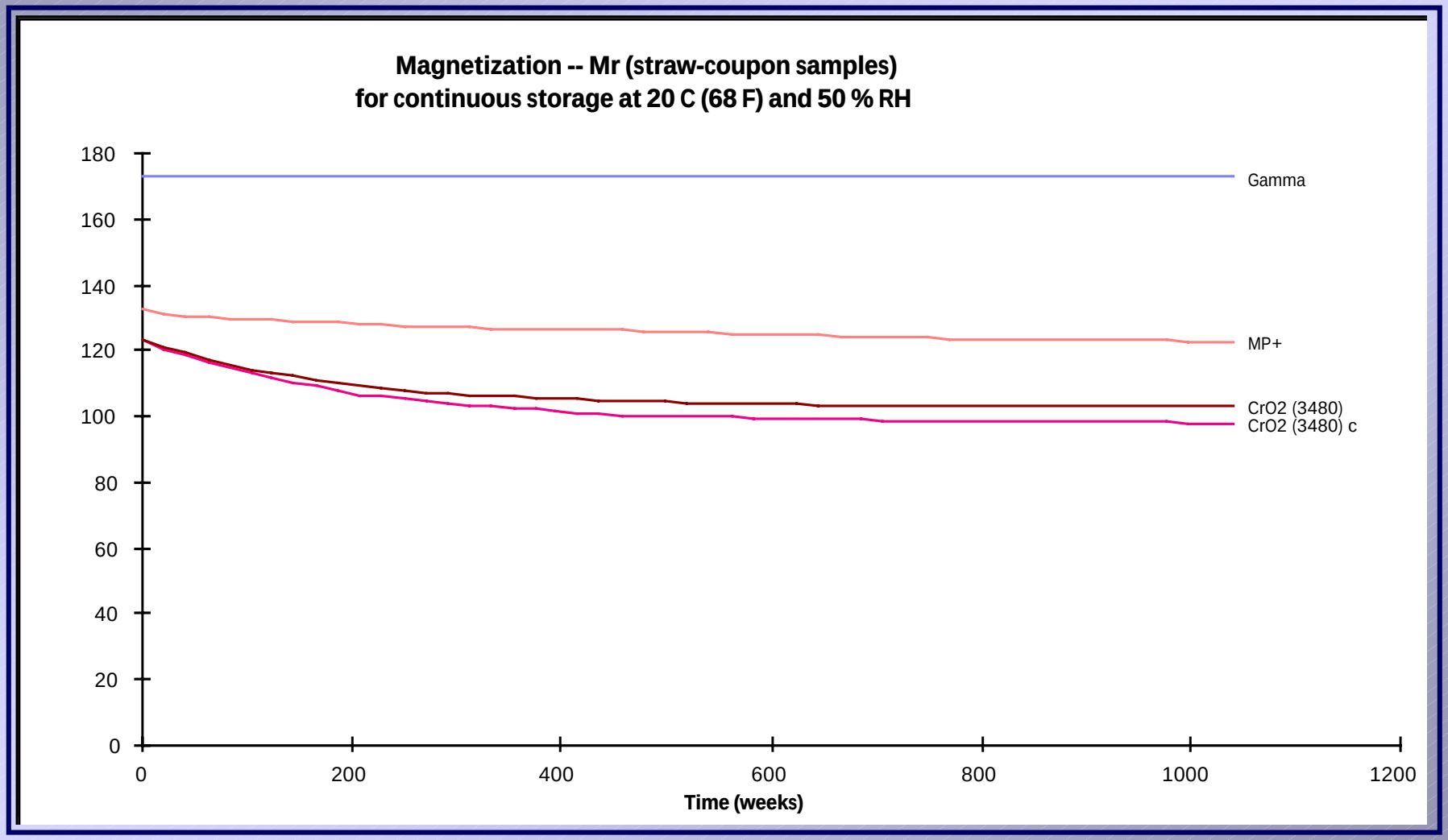
3M, National Media Laboratory (NML), and Carnegie-Mellon University Performed Joint and Independent Studies

- Assess chemical, thermal, and archival stability of Advanced Metal Particle (MP1) magnetic coatings
  - Accelerated aging using temperature and humidity cycling to predict archive life
- Studies conducted utilizing predictive models developed by NML

2. Advancements in Metal Particle (MP1) Tape - Stability Studies



2. Advanced Metal Particle (MP1) Tape - Stability Studies (con't)

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All Studies Conclude that Advanced Metal Particle (MP1) Magnetic Coatings Will Achieve a Projected Magnetic Life of **15-30 Years**

Media will lose 5% - 10% of its magnetic moment after 15 years

Media resists chemical degradation even after direct exposure to extreme environments

Range of moment stability varies depending upon particle properties and manufacturing processes

2. Advancements in Cartridge Technology

- Uni-reel
  - 3480/3490/3490E
  - 3590/3590E
  - SD-3 “Redwood” (Helical)
  - DLT IV/7000
- Dual Reel, In-Cartridge Guiding
  - 3570
  - 9840

2. 3590 Magstar Cartridge

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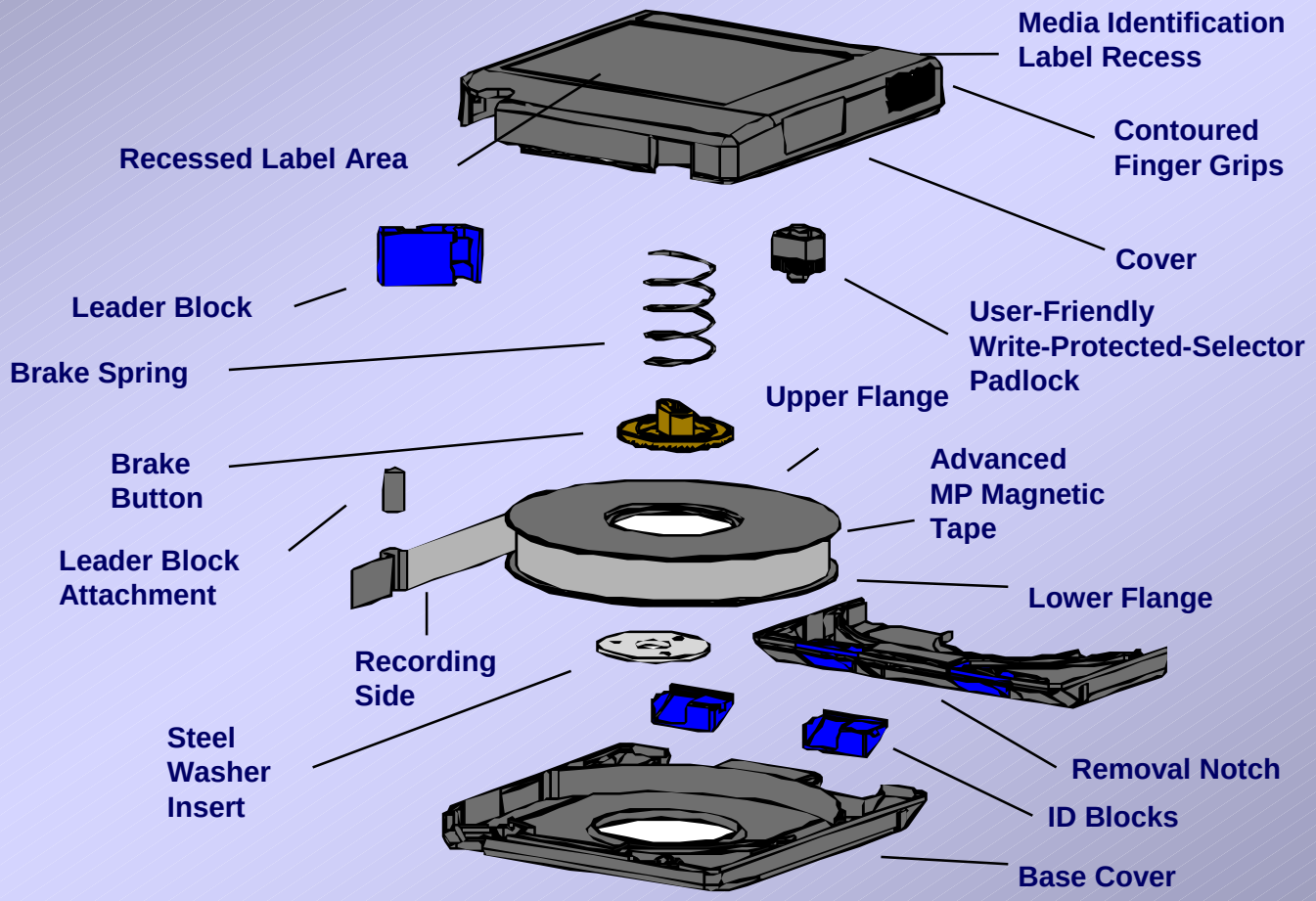

2. Tape Subsystem Migration (cont.)

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Drive	3590	SD-3	3570	9490	9840	3590E
Media	3590	SD-3	3570C	9490EE	9840	3590
Date	1995	1995	1997	1998	1998	1999
Capacity (MB)	10000	50000	5000	1600	20000	20000
Transfer Rate	9	11	7	6	10	14
Length	1100	1200	550	2200	900	1100
Tracks	128	helical	128	36	288	256
Servo	Yes	No	Yes	No	Yes	Yes
Pigment	MP1	MP1	MP1	CrO2	MP1	MP1
Coercivity	1600	1600	1600	520	1600	1600

2. Servo-Writing Technology

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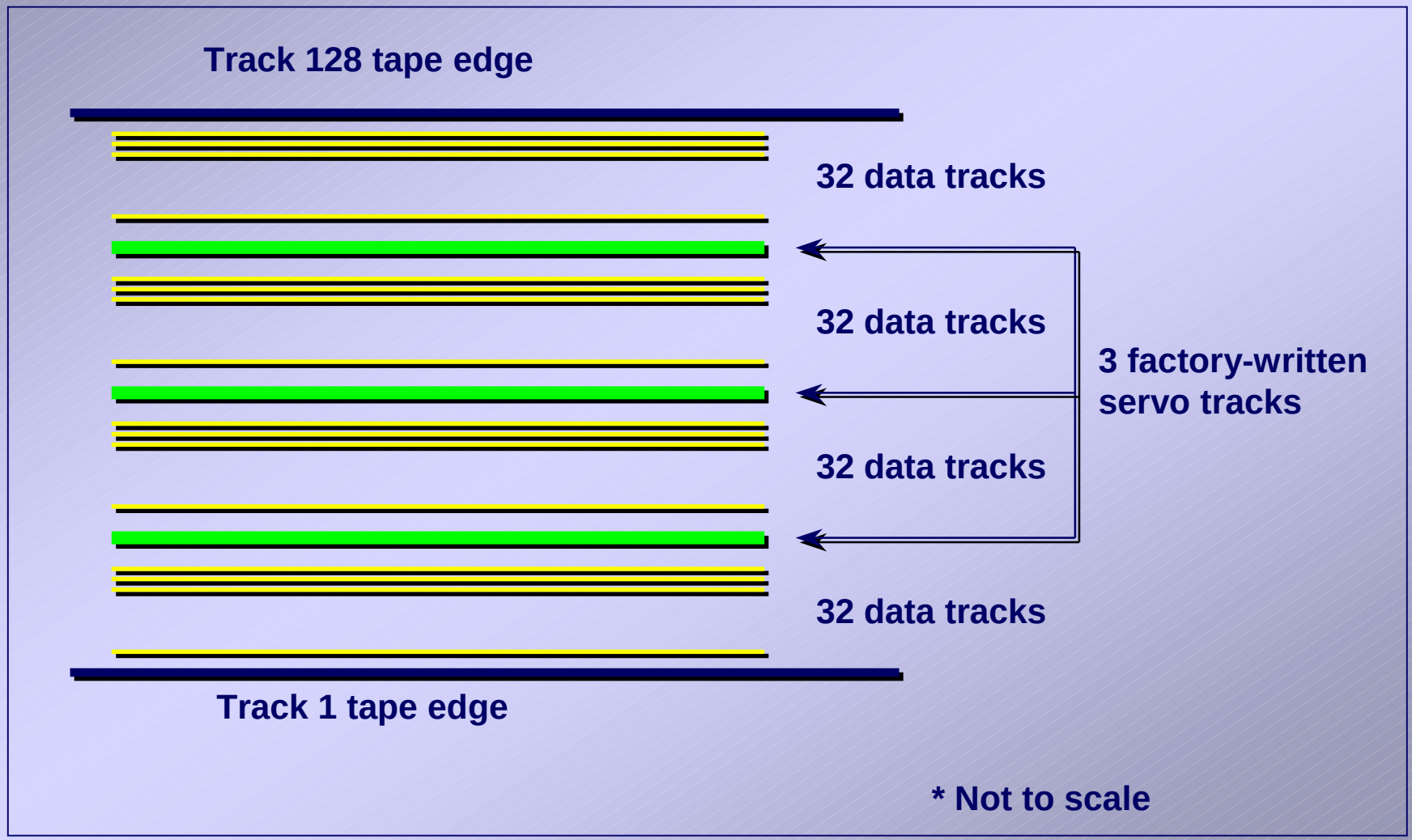
- Allows increased TPI => Closer track spacing
  - Accurate data track alignment
  - Maintain read reliability
- Ensures drive to drive interchangeability

2. Servo-Writing Technology (3590)



2. 3590 Servo Pattern -Amplitude Based Servo

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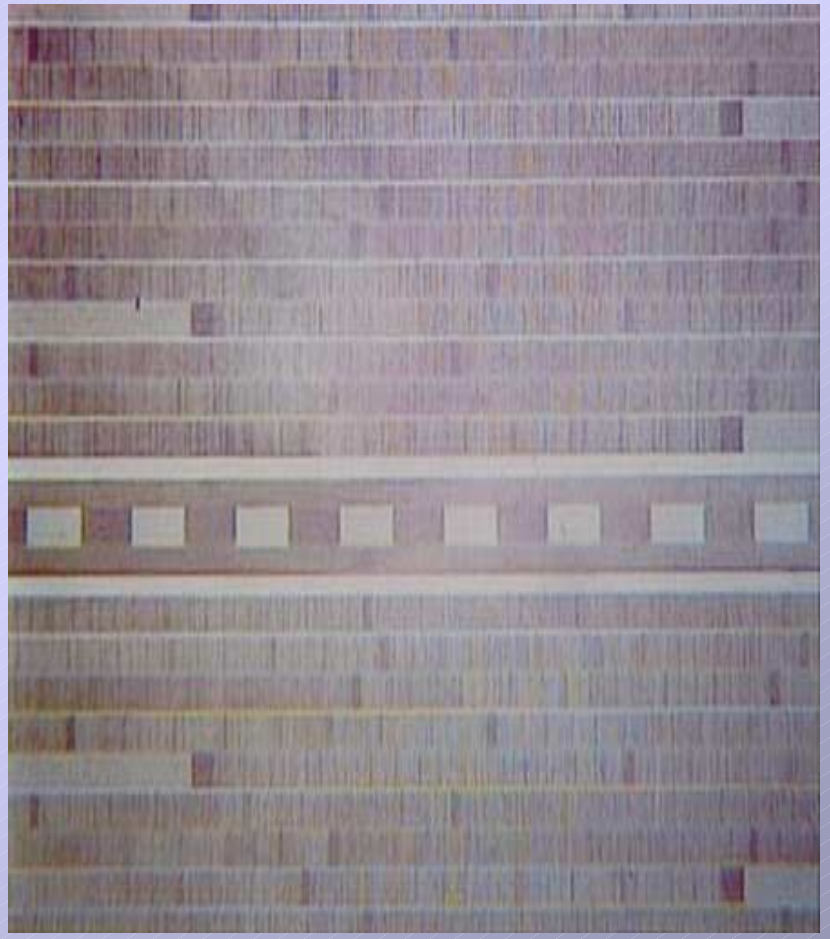
- 3 Servo bands x 2 Tracks
- 128 Data Tracks
- 16 x 2 Write Head Data Channels (79um)
- 16 x 2 Read Head Data Channels (35um)
- 3 Groups of 2 Servo Heads (55um)
- Serpentine Recording



3. 9840 Servo Pattern - Amplitude Based Servo

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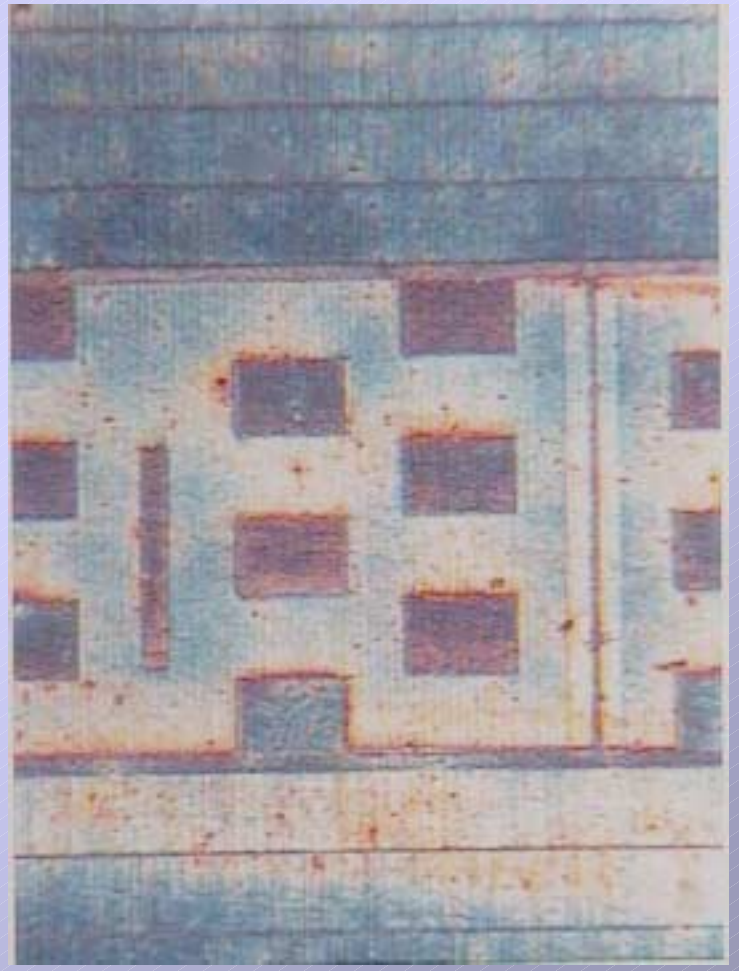
- 5 Servo bands x 5 Servo Tracks
- 288 Data Tracks
- 16 Write Head Data Channels (36um)
- 16 Read Head Data Channels (20um)
- 6 Head Servo Channels (5um)
- Serpentine Recording



3. LTO Servo Pattern - Time Based Servo

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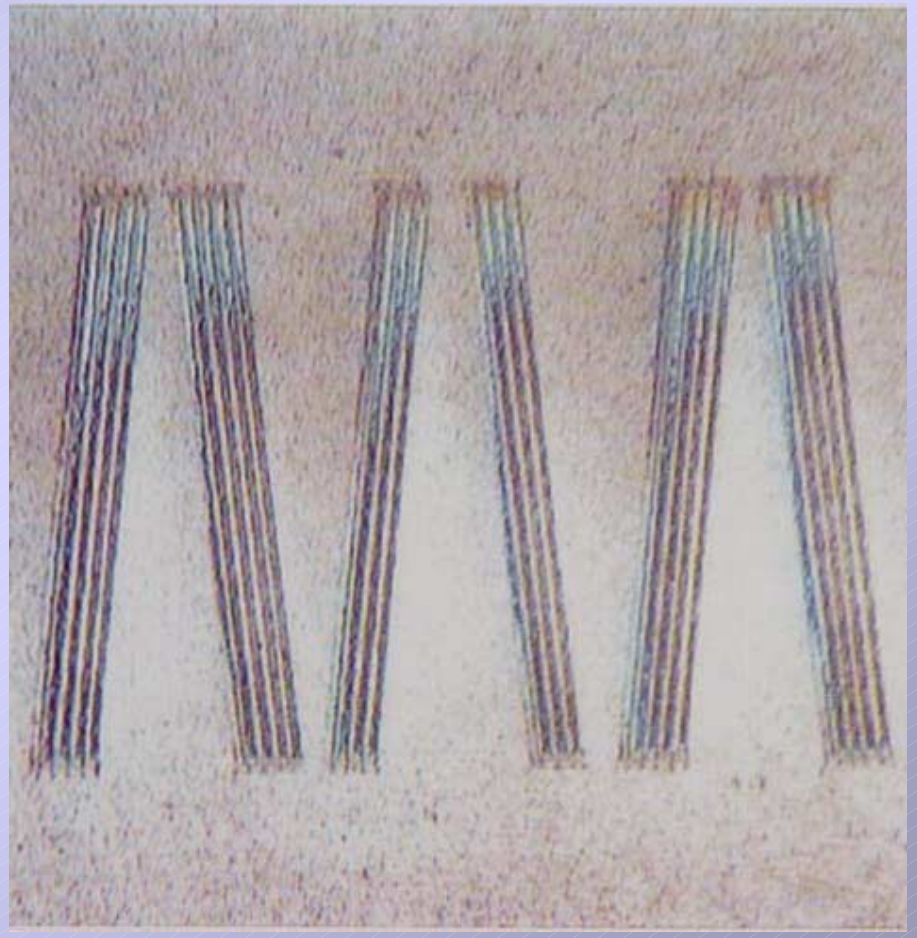
- 5 Servo bands
- 384 Data Tracks
- 8 Write Head Data Channels
- 8 Read Head Data Channels
- 2 Head Servo Channels
- Serpentine Recording



2. In-Cartridge Tape Guidance/ Dual Hub Design

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- In-Cartridge Guiding
  - Thermally stable aluminum base plate
  - Precision aligned tape guides
  - Lower Drive cost
  - Self-contained tape path
  - Tape never leaves the cartridge
- Dual Hub Design
  - A center-parked dual hub design - fast access time
  - Internal cartridge guiding - minimal tape exposure
  - Dual drive motors - tension is servo controlled

2. 9840 Cartridge

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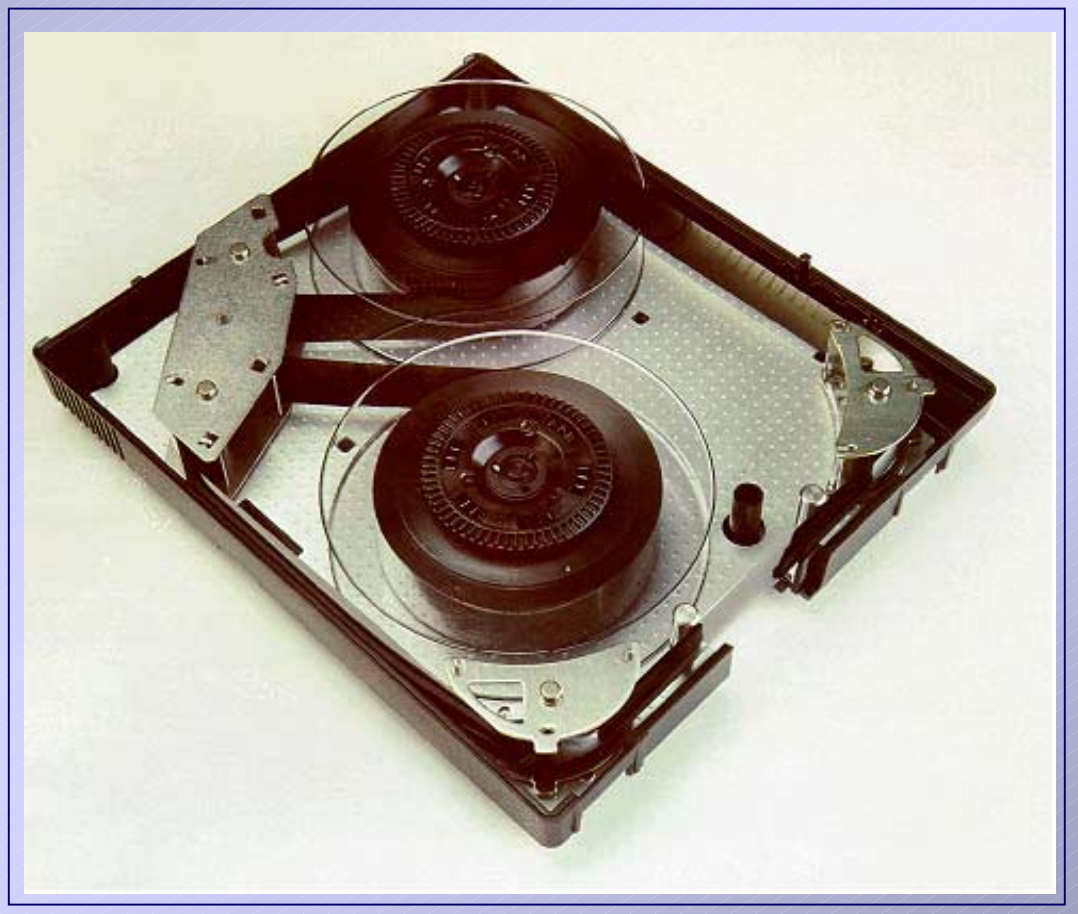

2. Performance Factors - A Comparison

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	Trans Rate Mbytes/Sec	Capacity Native Gbytes	Access Time Including Load Sec
Typ. Hard Disk	6-16 ~	13	< .02
5.25 Opt.Writeable	1.7-3.4	5.2	5.5
3490E	4.5	0.81	**45**
9490EE	6	1.6	**57**
3590	9	10	**53**
SD-3	11	50	**70**
3570C	7	5	***15***
9840	**10**	**20**	***13***
3590E	**14**	**20**	**53**
DLT IV, 7000	5	35	100
Mammoth	3	20	75
AIT	3	25	34

3. Automation - Key Benefits

- Combine large tape capacity with high access speed and library automation
  - An enormous amount of data is readily available to a large number of users in a very short period of time.
- Supporting technologies allow for very efficient tape utilization
  - Volume Stacking
  - Virtual Storage

3. IBM 3494 Library

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3. IBM Library Options

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IBM

Model	Desig	# Drives	Drive Type	# Carts	Cart Type	Capacity (GB)
3575	L06	2	3570C	60	3570C	300
3575	L12	2-4	3570C	120	3570C	600
3575	L18	2-6	3570C	180	3570C	900
3575	L24	2-6	3570C	240	3570C	1200
3575	L32	2-6	3570C	324	3570C	1600

Model	Desig	# Drives	Drive Type	# Carts	Cart Type	Capacity (GB)
3494	L10	2	3490E	240	3490E	192
3494	L12	2	3590	240	3590	2400
3494	L14	2	3590	240	3590	2400
3494	L14	2	3590E	240	3590	4800
3494	L14	2	3590E	240	3590E	9600
3494	D10	2	3490E	300	3490E	240
3494	D12	2-6	3590	335	3590	3350
3494	D14	2-4	3590	345	3590	3450
3494	S10	0	N/A	400	3590	4000
3494	D14	2-4	3590E	240	3590	4800
3494	D14	2-4	3590E	240	3590E	9600

Note: Up to 16 frames with 6240 carts = 248 TB of Native Capacity (3590E Drive & 3590E Cart)

3. STK 9310 Powderhorn

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3. STK Library Options

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STK

Model	Desig	# Drives	Drive Type	# Carts	Cart Type	Capacity (GB)
Timberwolf	9740	2-4	4890	326-494	3490E	395.2
	9740	2-4	9490	326-494	3490E	395.2
	9740	2-4	9490	326-494	9490EE	790.4
	9740	2-4	SD3	326-494	SD3	24700
	9740	2-4	9840	326-494	9840	9880
	9740	2-4	DLT7000	326-494	DLT4	17290
Wolfcreek	9360	2-4	4480	504-949	3480	189.8
	9360	2-4	4490	504-949	3490E	759.2
	9360	2-4	9490	504-949	3490E	759.2
	9360	2-4	9490	504-949	9490EE	1518.4
	9360	2-4	SD3	504-949	SD3	47450
	9360	2-4	9840	504-949	9840	18980
Powderhorn	9310	8-16	4480	2000-6000	3480	1200
	9310	8-16	4490	2000-6000	3490E	4800
	9310	8-16	9490	2000-6000	3490E	4800
	9310	8-16	9490	2000-6000	9490EE	9600
	9310	8-16	SD3	2000-6000	SD3	300000
	9310	8-80	9840	2000-6000	9840	120000
	9310	8-16	3590	2000-6000	3590	60000
	9310	8-16	3590E	2000-6000	3590	120000

4. Future Technologies?

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- Thinner film bases - more tape in the same cartridge
- Higher track densities (TPI) - increased areal density
- Advanced Media - higher recording densities
  - MP tapes (MP3 & MP4)
  - ME tapes
- New drives retrofit to current libraries
  - Technology migration and scalability
- New Software features
  - volume stacking => cost reduction
- Fibre Channel Connectivity - faster bus rates
- New System Architectures - SAN vs NAS
- Gigabit Ethernet

4. Data Center Systems Tape Drive Performance
Past, Present & Future

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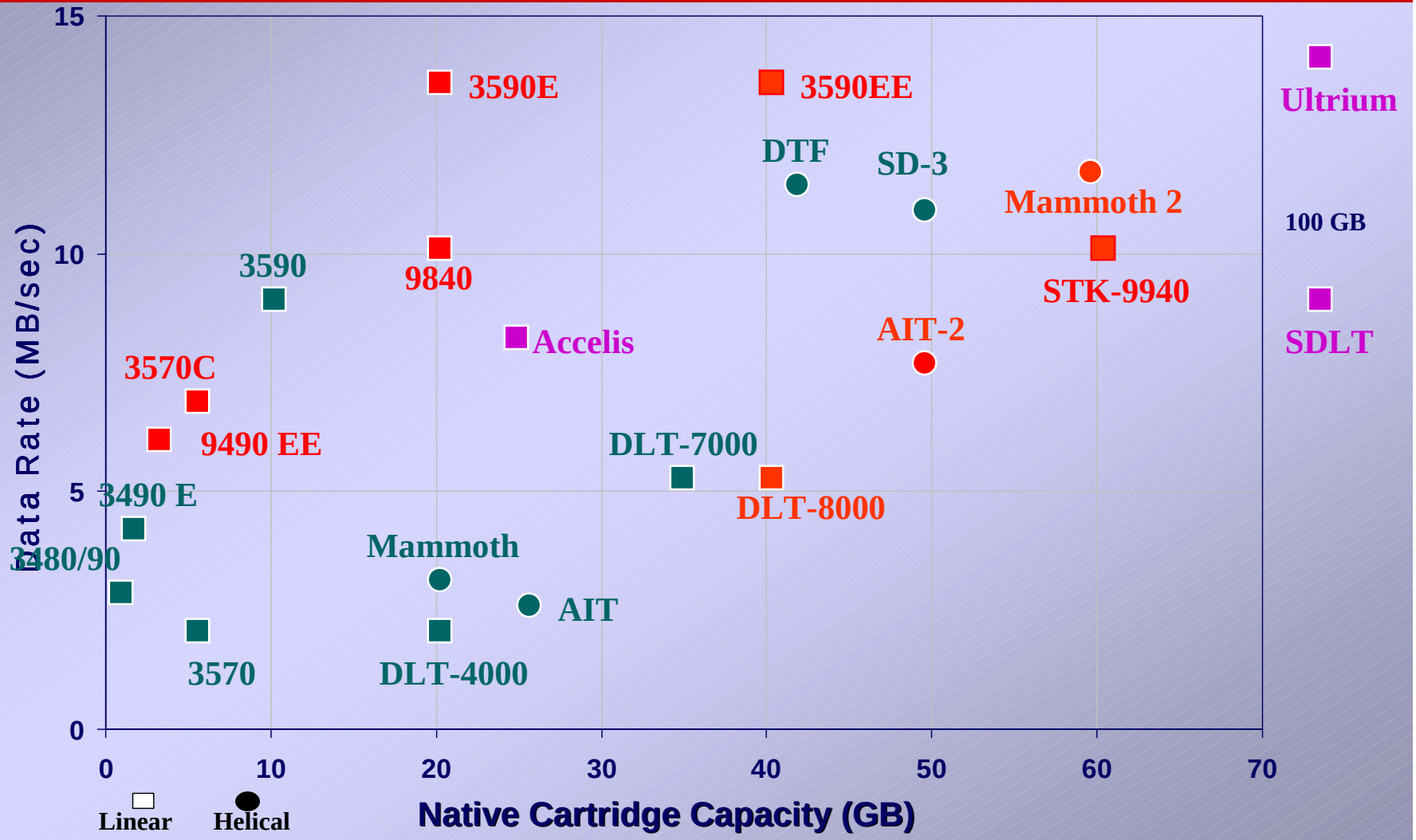

4. LTO Technology

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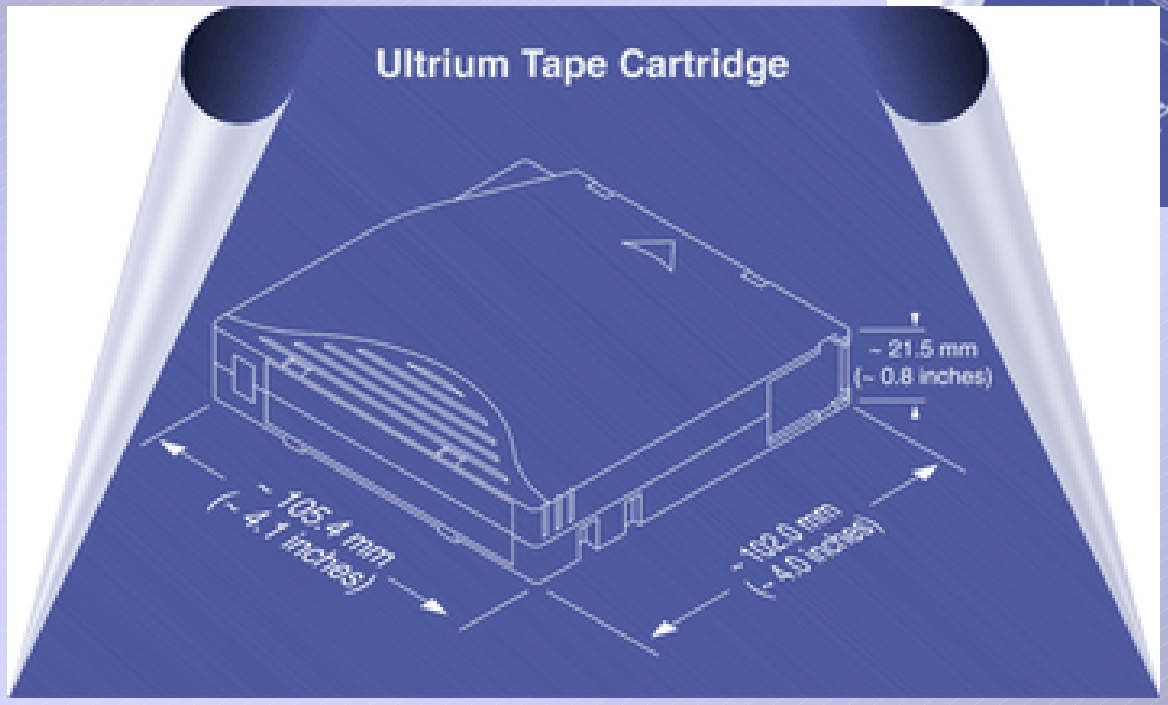

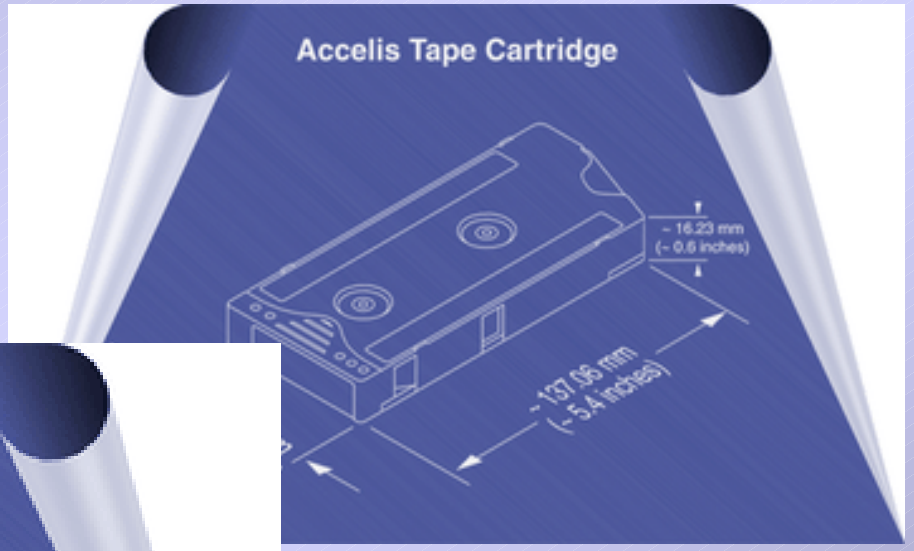

5. Storage Management - Issues/Trends

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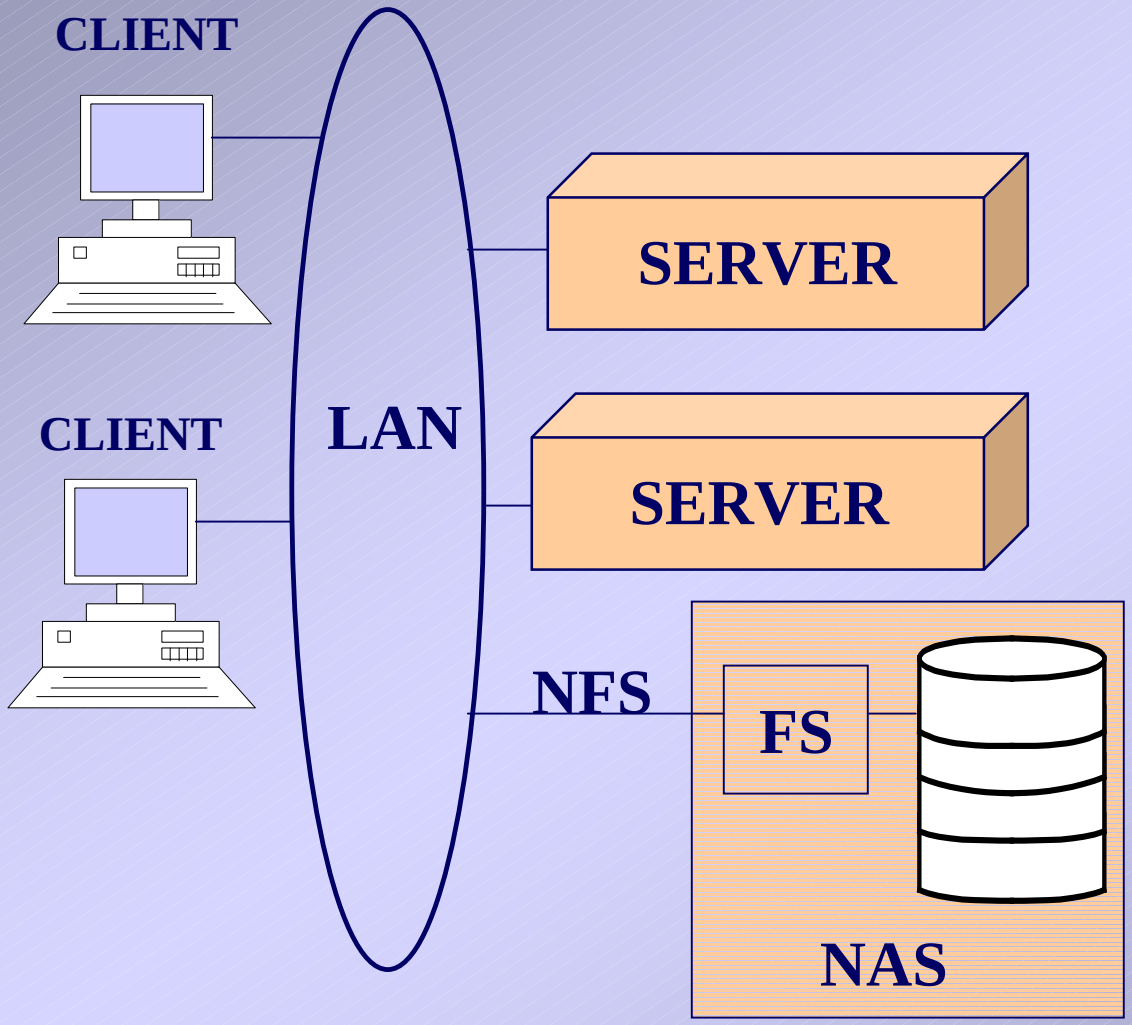
- Backup/Restore time, reliability and performance continue to be issues, even for organizations that have implemented automation.
- Data growth exceeds improvements in network bandwidth and all I/O path elements.
- Broad functionality is increasingly the deciding factor in storage technology acquisitions.
- Physical and operational consolidation of storage devices continues.
- Windows NT and e-commerce growth is driving industry strategies for data storage technology.

5. Networked Storage using LAN



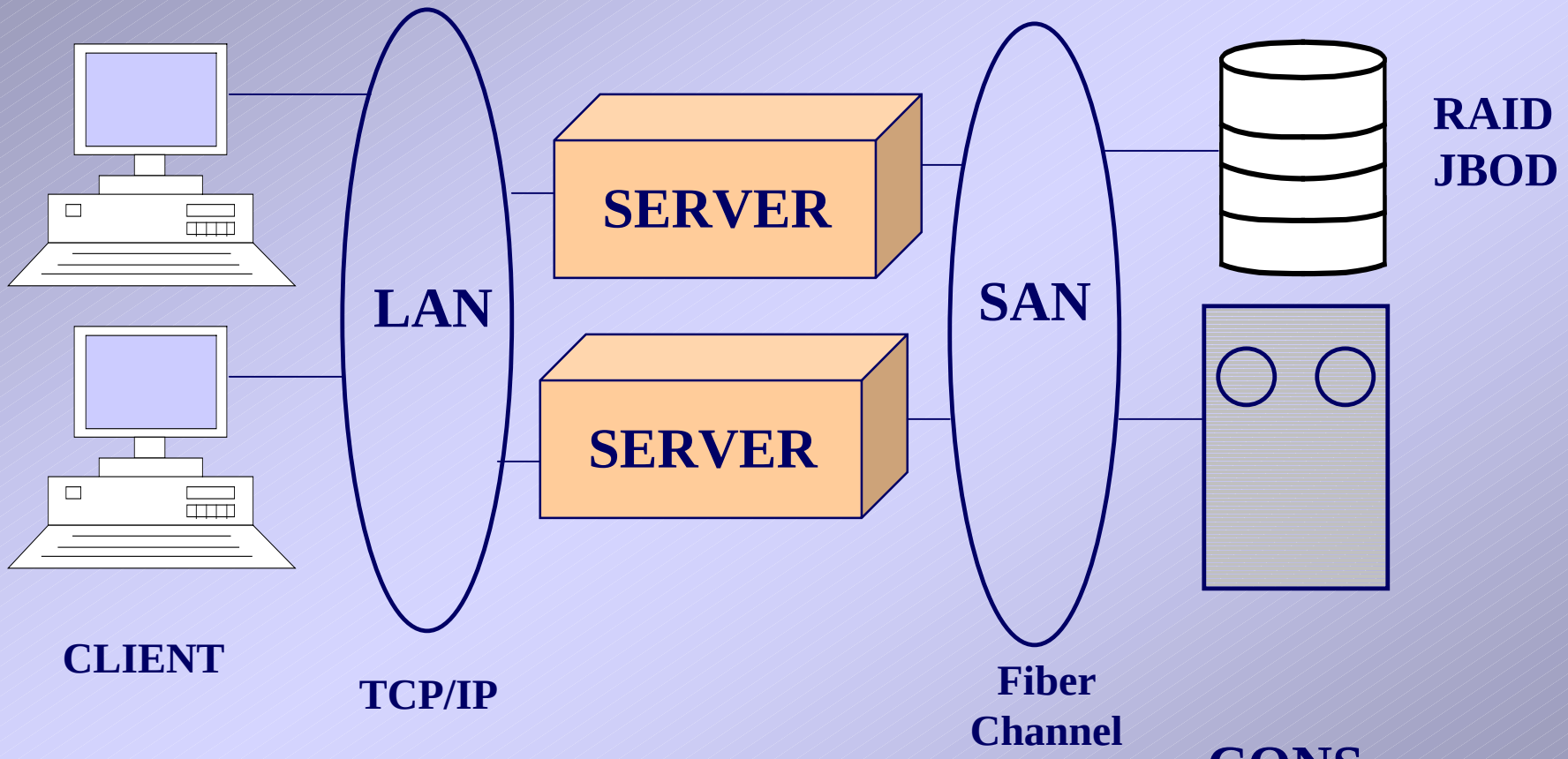
PROS

- Uses Existing Protocols (TCP/IP, NFS, HTTP)
- Only One Network

CONS

- Bandwidth
- No Shared Tape

5. Networked Storage using SAN



PROS

- Performance

CONS

- Cost
- Standards

5. Physical Storage Management Model

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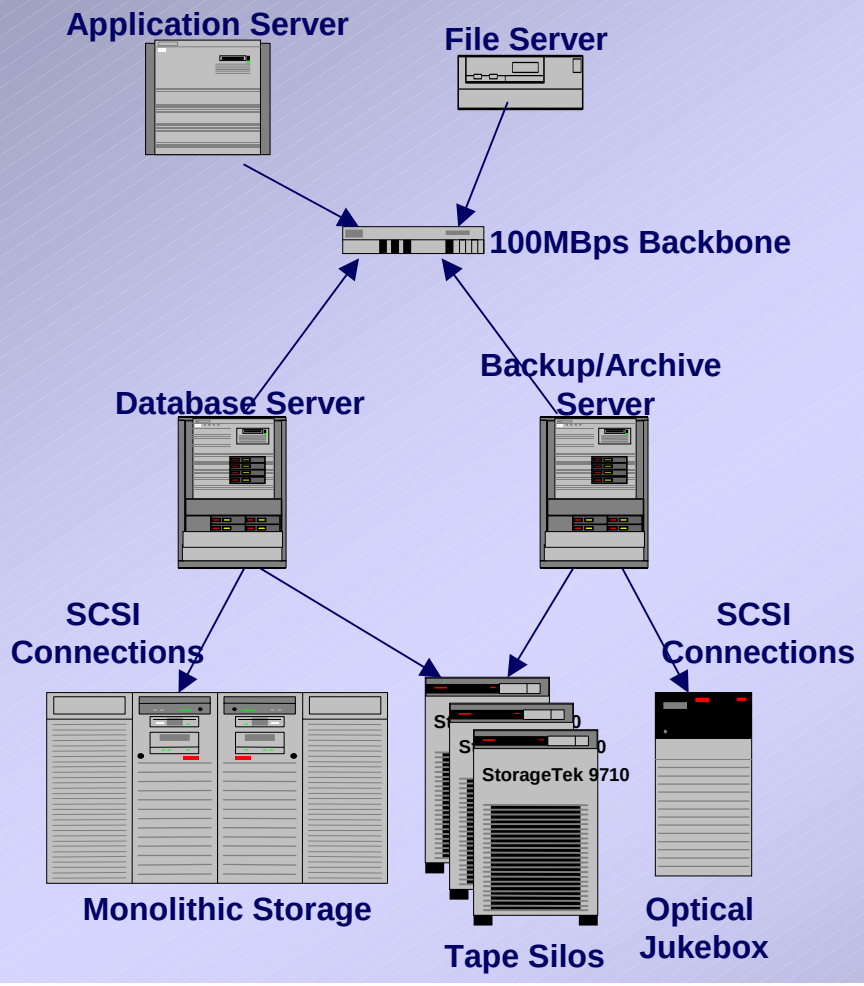
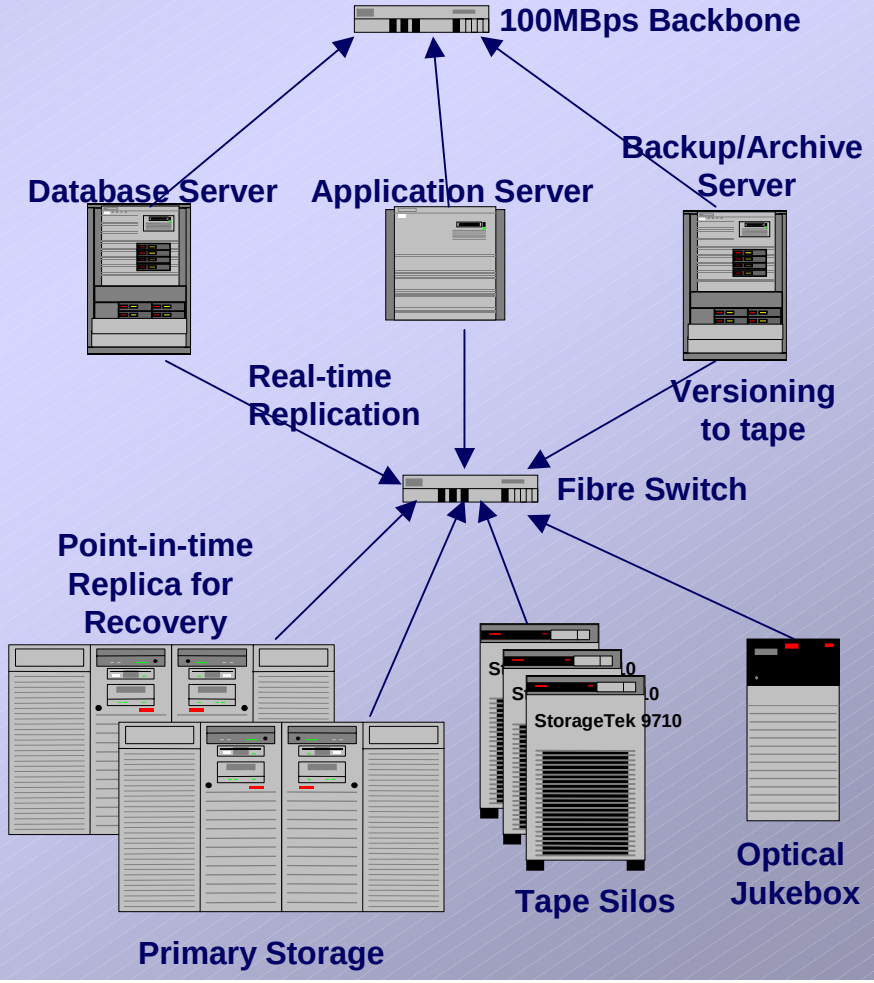
Today's Model



Future Model



5. SAN Benefits

"A SAN represents the next generation in storage architectures, made necessary by newer, information-intensive applications such as data warehousing… The SAN architecture, built on Fibre Channel ... technology, is *complementary* to ATM, Fast Ethernet, and Gigabit Ethernet, and designed to relieve server-storage bottlenecks."

Source: "Maximum Bandwidth - A Serious Guide to High-Speed Networking", by Dan Blacharski. (Italics ours)

5. Fibre Channel Benefits - Network

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- Extended Distances - 10 km vs 25 m
- Extended Addressing - 16 million vs 128
- Easy Connectivity
- Higher Data Throughput/Transfer Rates

Fibre Channel Takes the Best of SCSI
- the Command Set -
and Links it to a High Speed Interface.

5. Fibre Channel Benefits - Mainframe

- Extended Distances
  - - up to 20 Km with repeaters
- Easy Connectivity
  - - Direct Host Attach
- Very High Data Transfer Rates - 100 MB/s

Fibre Channel Transfer Rates are <u>essential</u> to the Implementation of New High Capacity Cartridges in the Mainframe Environment

6. The Challenges for Tape Systems

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- System Migration
  - Capacity: 100GB => 800GB
  - Tracks Per Inch (TPI): 1000 => 2500
  - Linear Density: 90KFCI = 150KFCI
- Advanced tape formulations
  - MP2, MP3 & MP4
    - Thinner coatings: 0.25 µm => 0.1 µm
    - Roughness: < 30 nm peak to peak
    - Slit edge improvements
    - SNR: Hold at >26db
    - Defects: .05/2000ft with an EDD of .6
  - Metal Evaporated - tribology on linear recording heads

6. The Challenges for Tape Systems

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- Advanced substrate development
  - Thinner films: 6.5μm => 4.5μm
  - Dimensional Stability: 600 ppm (7.5μm/12.7mm)

- Thin Film Magneto-resistive, Multi-channel Heads
  - Track widths: 12um (LTO 1) => 5 - 8μm
  - Channels: 8 (LTO 1) => 16
  - Flex Circuits: low stiffness
  - HTI Tribology 30nm spacing

6. The Challenges for Tape Systems

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- Cartridge Components
  - Center-Parked, Dual Tape Reels
    - Low wear, low friction guiding
    - In-Cartridge Tape Guidance
  - Uni-Reel Cartridges
    - Precision plastic molding
    - Low wear, low friction components
- Precision tape paths (Uni-Reel Cartridges)
  - Low edge forces (thinner tape)
  - Stop write limit of => +/- 1.5μm
  - TMR budget will drop from 6.75μm to 3.8μm
- Servowriting
  - 1 Sigma tracking error => .15 μm

Session Summary

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- MP1 tape and servo-writing technology have significantly increased the areal density of magnetic tape recording, and the storage capacities of tape cartridges
- Advanced drive and cartridge designs in combination with robotics can significantly reduce the time to access that data
- A wider range of applications can use tape to reduce overall operating costs while improving performance

Session Summary (con't)

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- Applications can effectively use tape to go beyond the confines of conventional Data Center backup.
- Storage demands continue to grow:
  - Internet/Intranet applications
  - Data Warehousing, Archiving and Mining
  - Online Digital Image Storage
  - Multimedia Content
  - Document Management
  - E-Commerce
  - More…

Session Summary (con't)

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- The storage management landscape is changing in response to the enormous storage growth from NAS (ESCON/SCSI) to SAN (fibre-channel)
- Critical keys remain the same: backup/restore time, reliability and performance, and automation.
- Standards are still being developed for fibre-channel interoperability, but time may be running out as other options (gigabit ethernet) evolve
- True fibre-channel drives are here (9840 in Q2, 3590 in Q3), and are required before larger cartridge capacities can be considered feasible

Where to get more information

- http://www.storage.ibm.com/storage/
- http://www.stortek.com/StorageTek/hardware/
- http://www.sel.sony.com/SEL/rmeg/data/
- http://www.exabyte.com/products/8mm/mammoth/
- http://www.fuji.com/
- http://www.quantum.com/products/dlttape/
- http://www.lto-technology.com/
- http://www.imation.com/products/data/