

Magnetic Tape as the Mass Storage Medium

Ted Schwarz

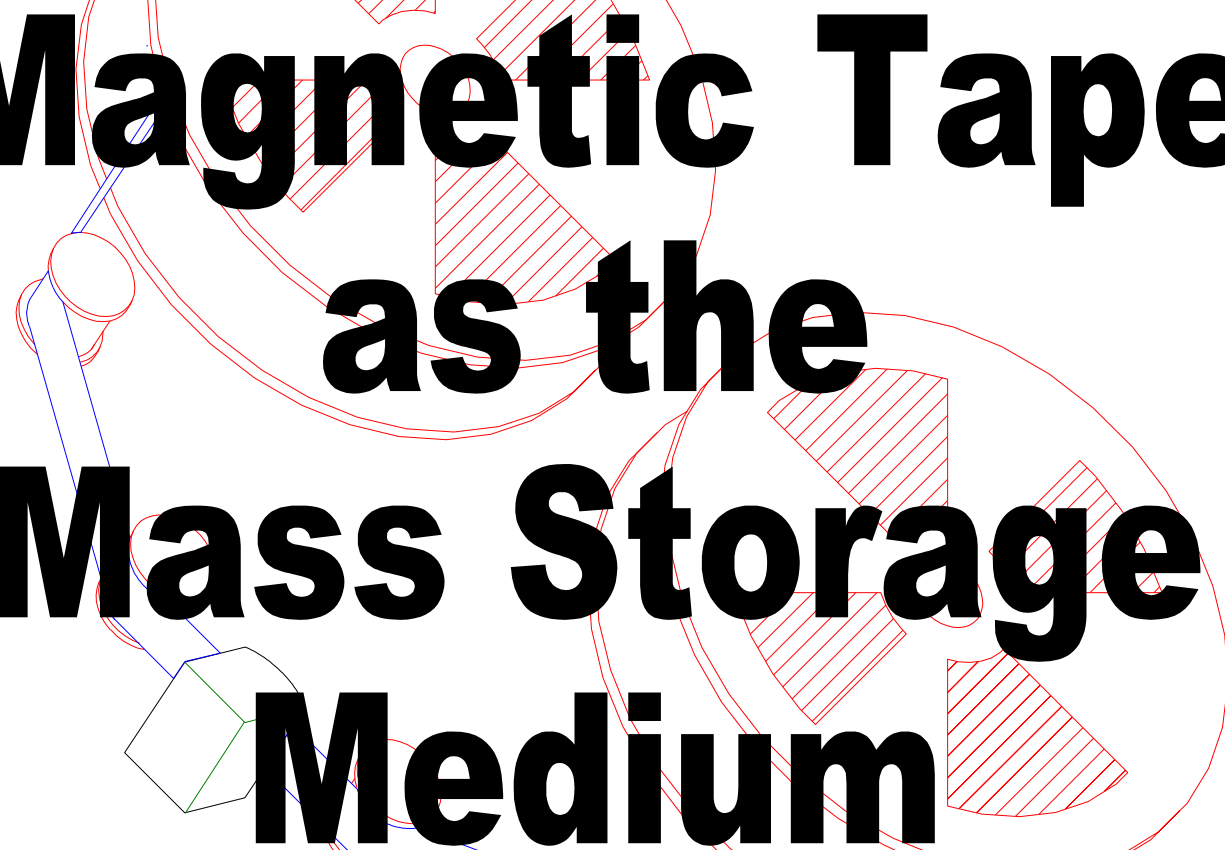
Peregrine Recording Technologies

1462 Tamberwood Trail, St Paul MN 55125-3363

Phone: + 1-651-730-4862; FAX: + 1-612-331-1211

e-mail: TedSchwarz@aol.com

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Englewood CO 80112
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Magnetic Tape as the Mass Storage Medium



Outline

- Density/Capacity
- Cost
- Performance (Data Rate)
- Key Technologies
- Summary



Mass-Store Metrics

1. Magnetic Disk Drive Cost/bit
2. Total Volumetric Density
 - Not Areal Density
 - Archival Storage Density
3. Thru-put



Density Migration

Today

100 kbp*i*

750 t*pi*

3000 l*pi*

75 Mb/in²

28 Gb/in³



Density Migration

Today

ATS

100 kbp*i* → 300 kbp*i*

750 tpi → 20 ktpi

3000 lpi → 3000 lpi

75 Mb/in² → 6.0 Gb/in³

28 Gb/in³ → 3.8 TB/in³
(2 b/um³)



Technology Objectives

track density:	20,000 tpi	787 tpmm
linear density:	300,000 bpi	11,811 bpmm
areal density:	6.00 Gb/in²	9.30 Mb/mm²
layer density:	5,000 lpi	197 lpmm
vol density:	3.80 TB/in³	229 MB/mm³
LTO Cartridge:		
tape width:	0.50 inches	12.70 mm
tape length:	5512 feet	1,680 m
total area:	230 ft ²	21.34 m ²
volume:	4.71 in ³	77,183 mm ³
user efficiency:	70%	70%
CAPACITY:	12.53 TB	12.53 TB
<small>THIC-0627.XLS</small>		

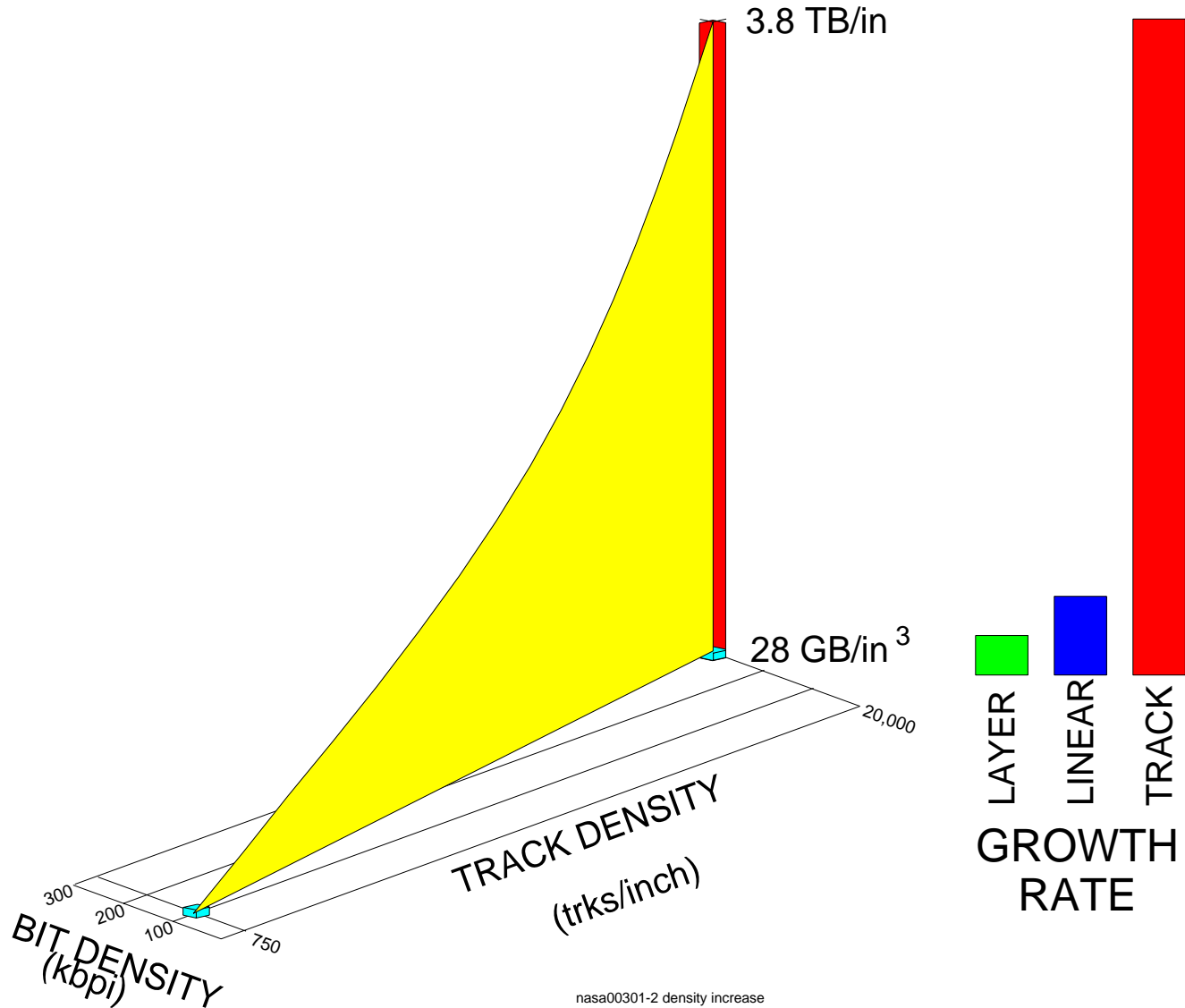


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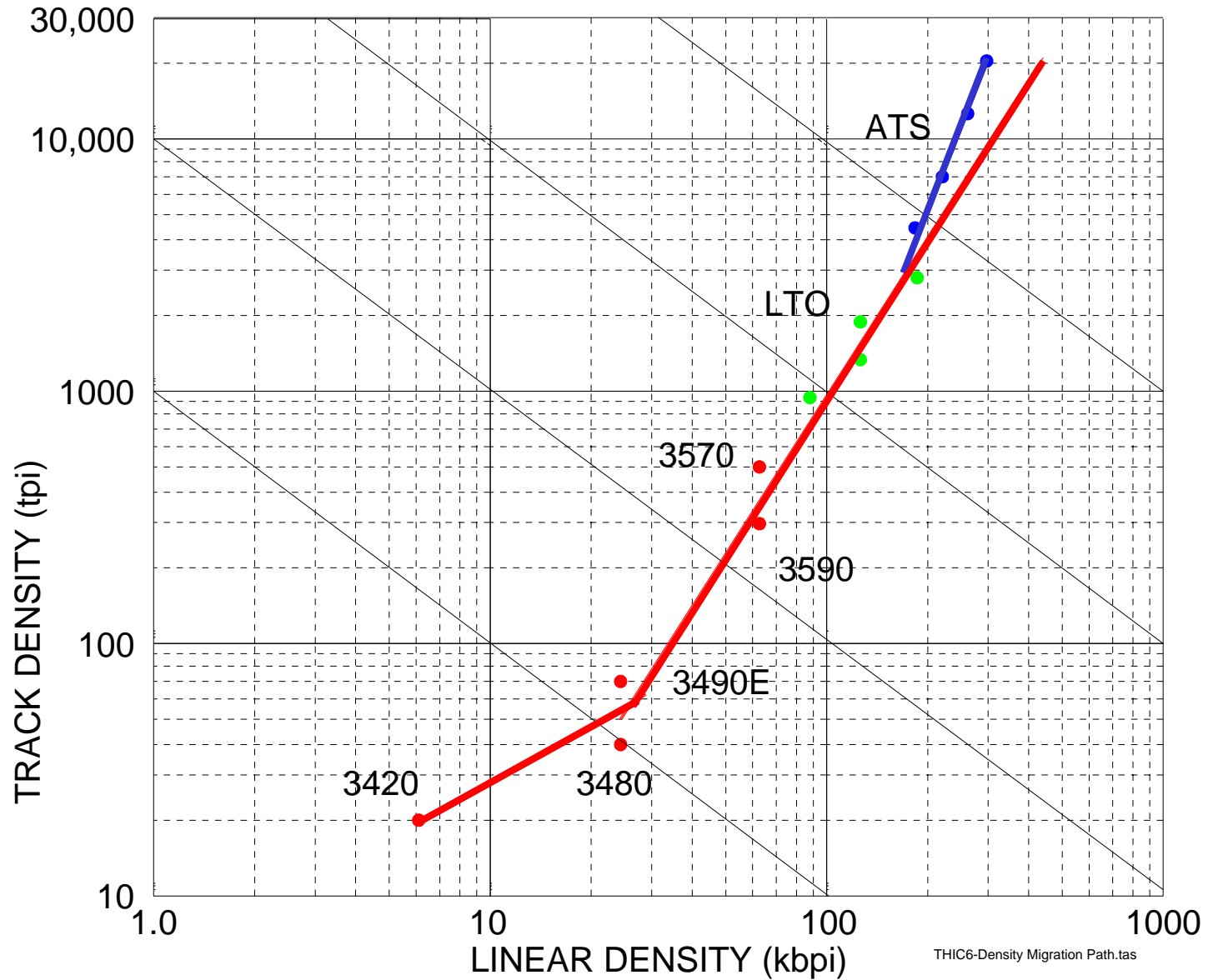
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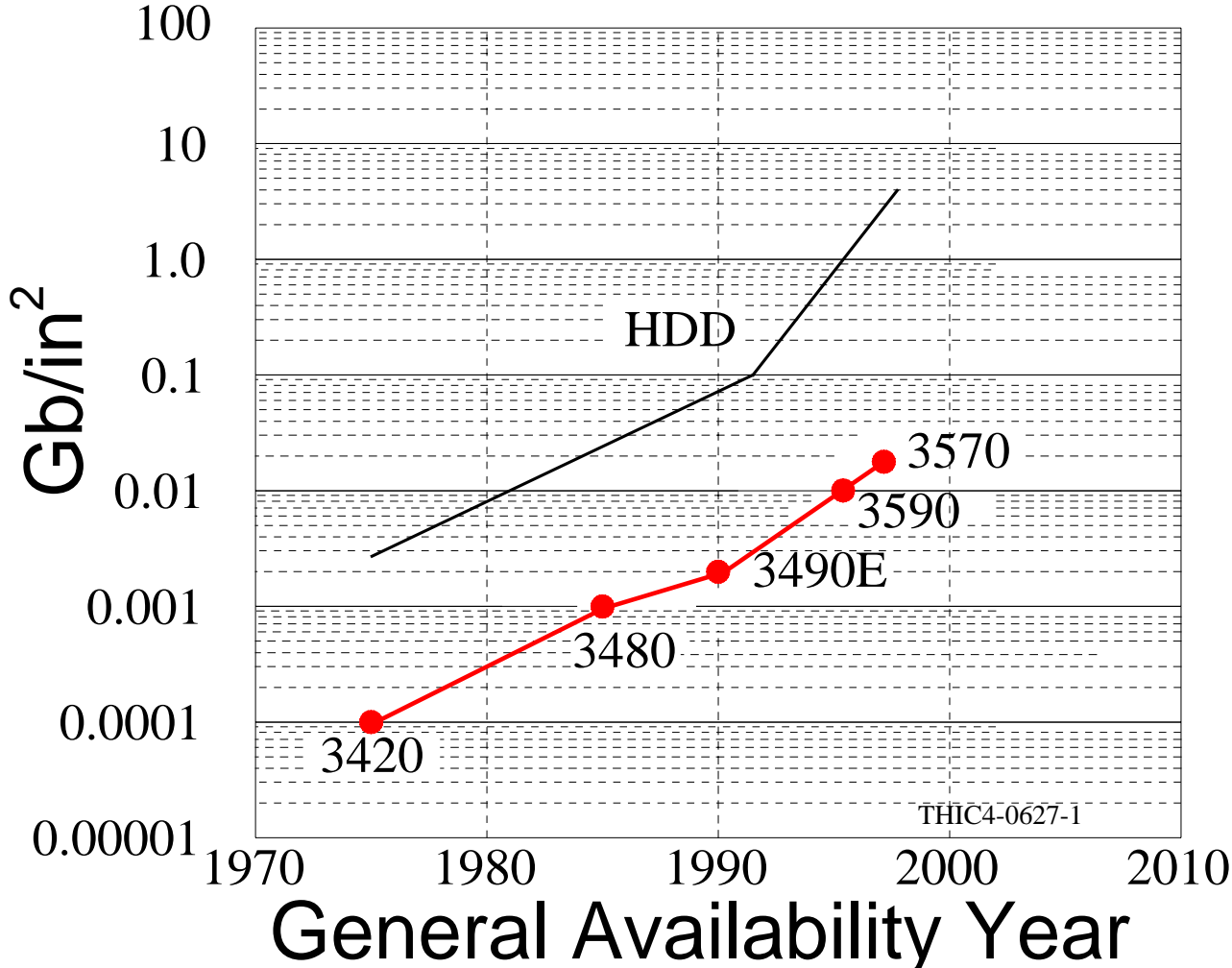
Data Density Growth



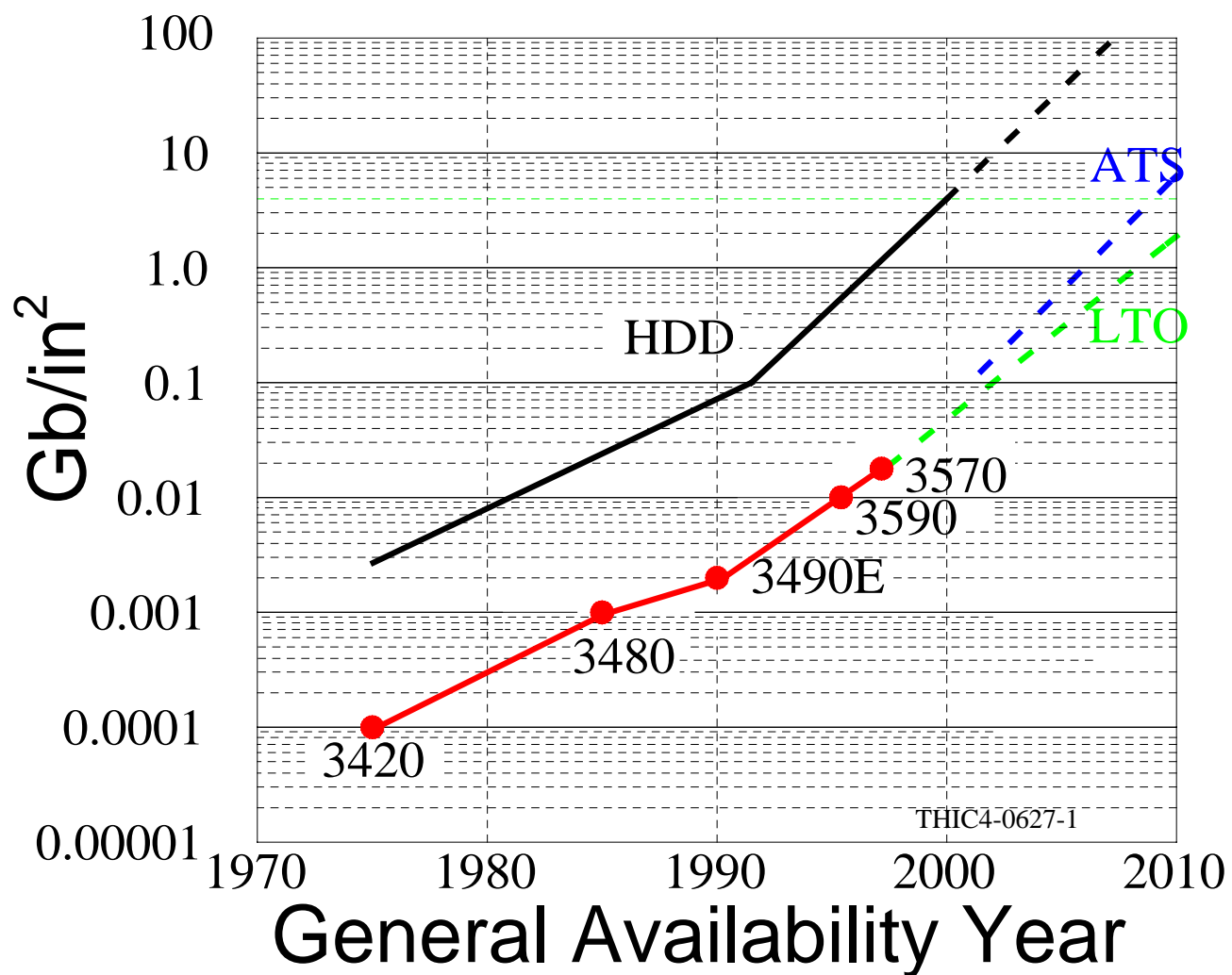
Tape Density Migration



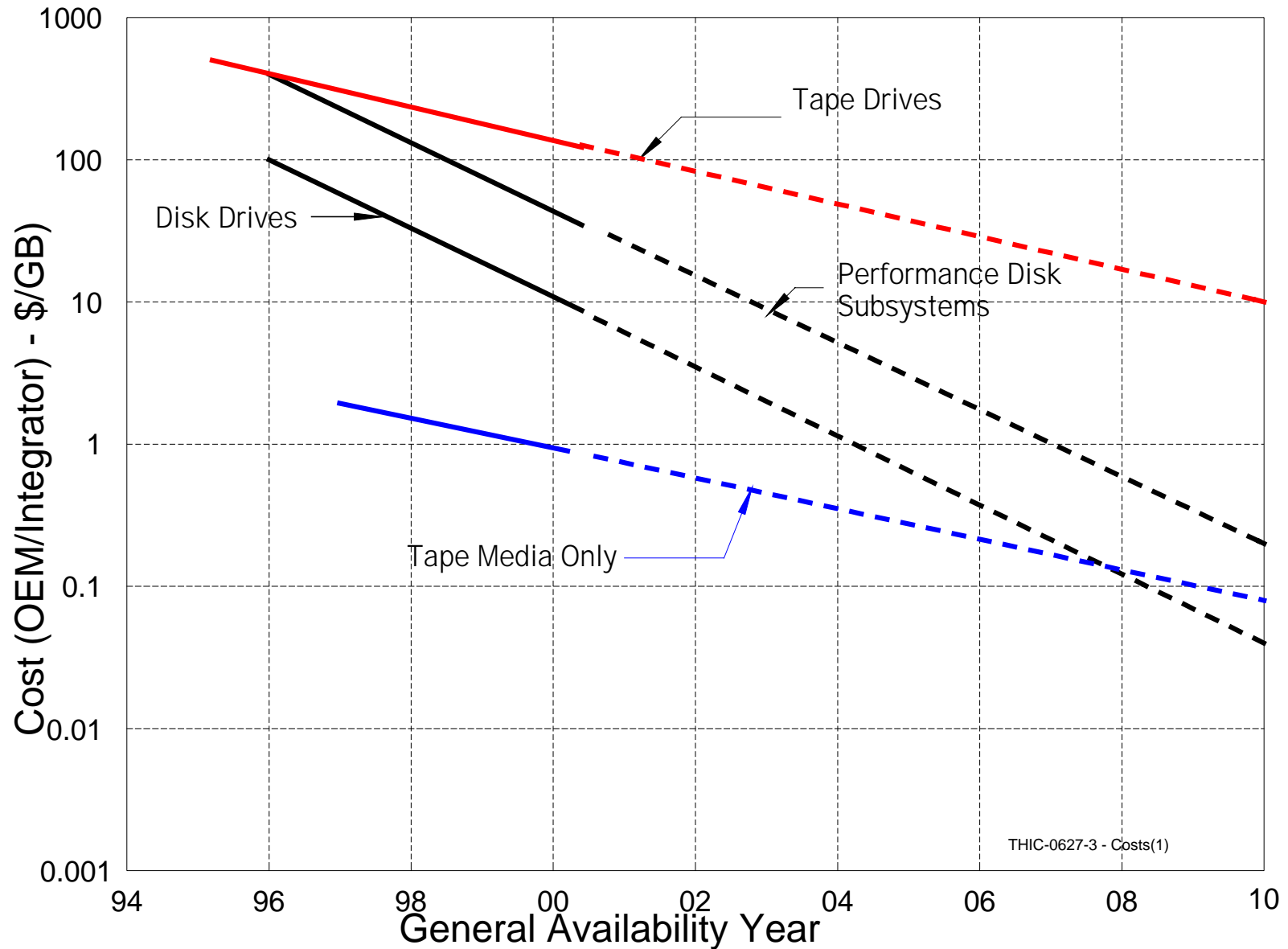
Areal Density Trends



Areal Density Trends



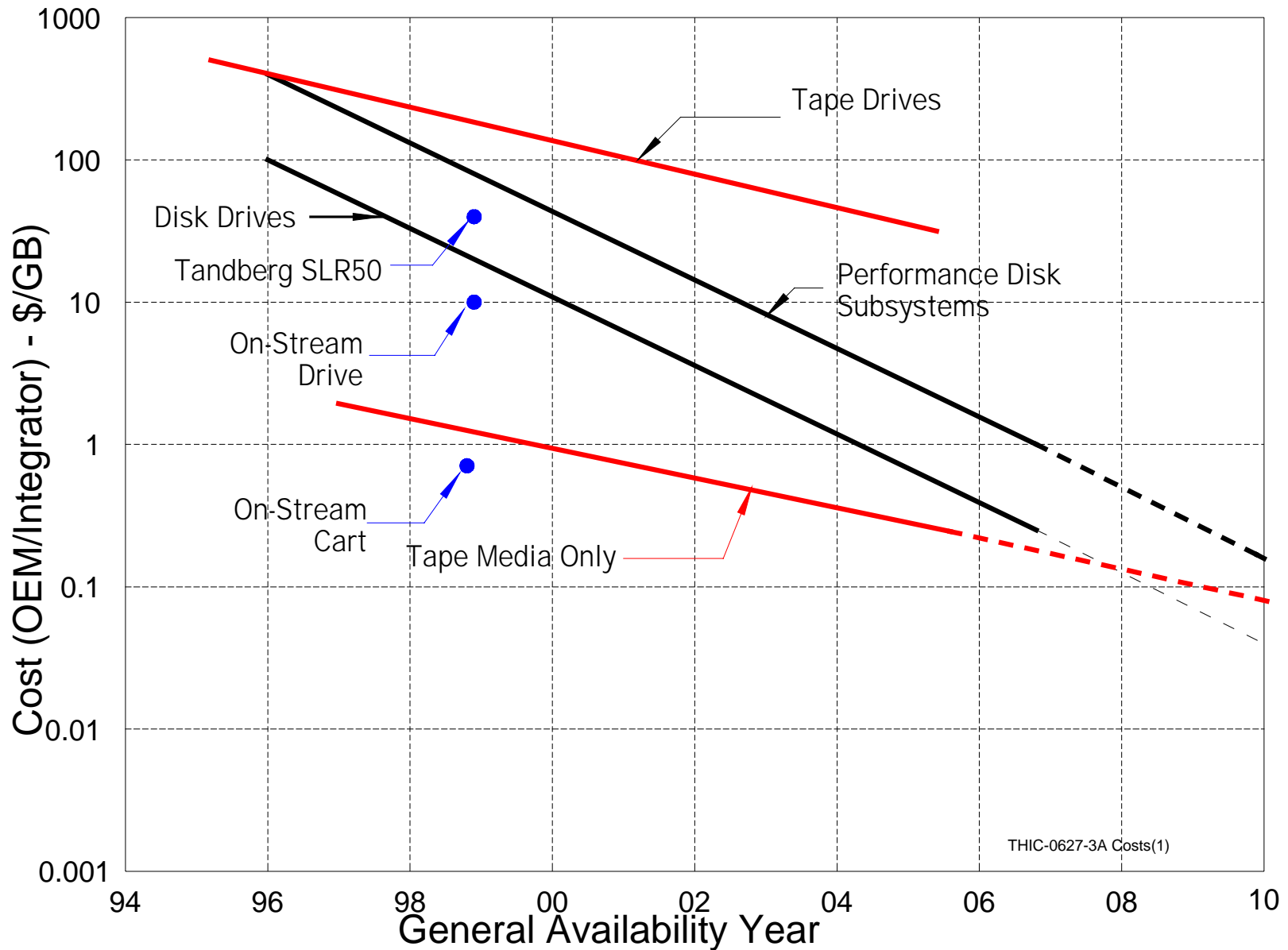
Cost Trends



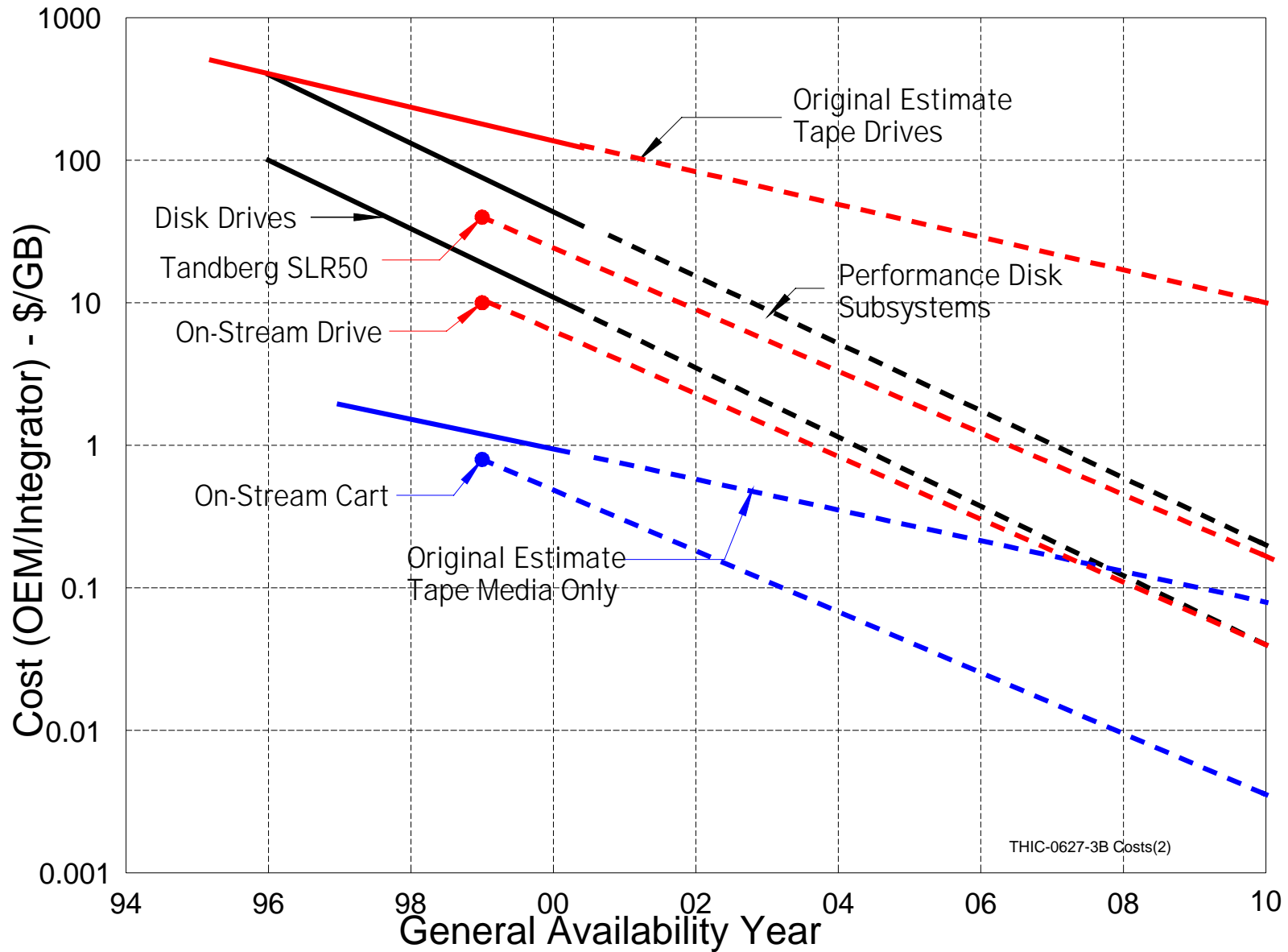
THIC-0627-3 - Costs(1)



Cost Trends

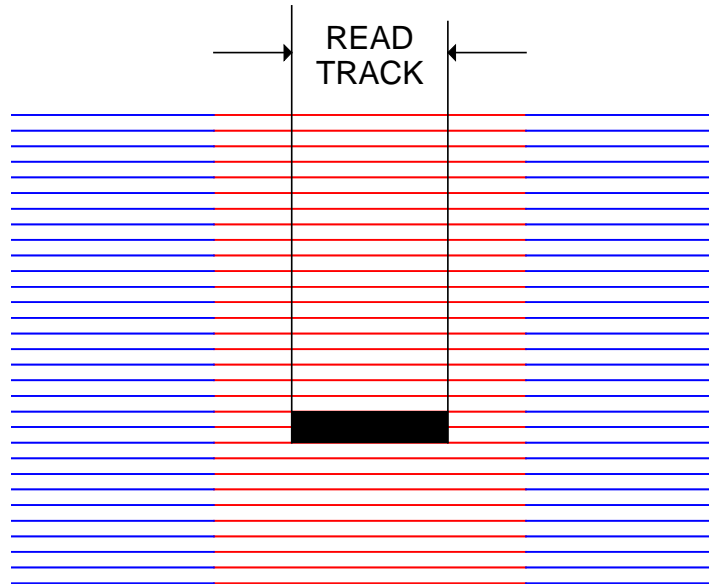


Cost Trends

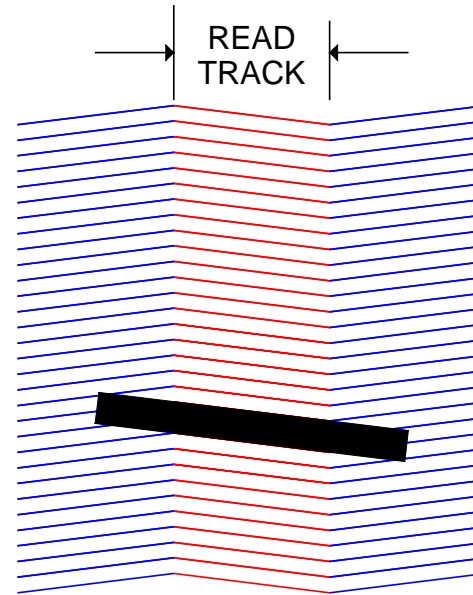


Recording Methods

LINEAR RECORDING



AZIMUTH RECORDING



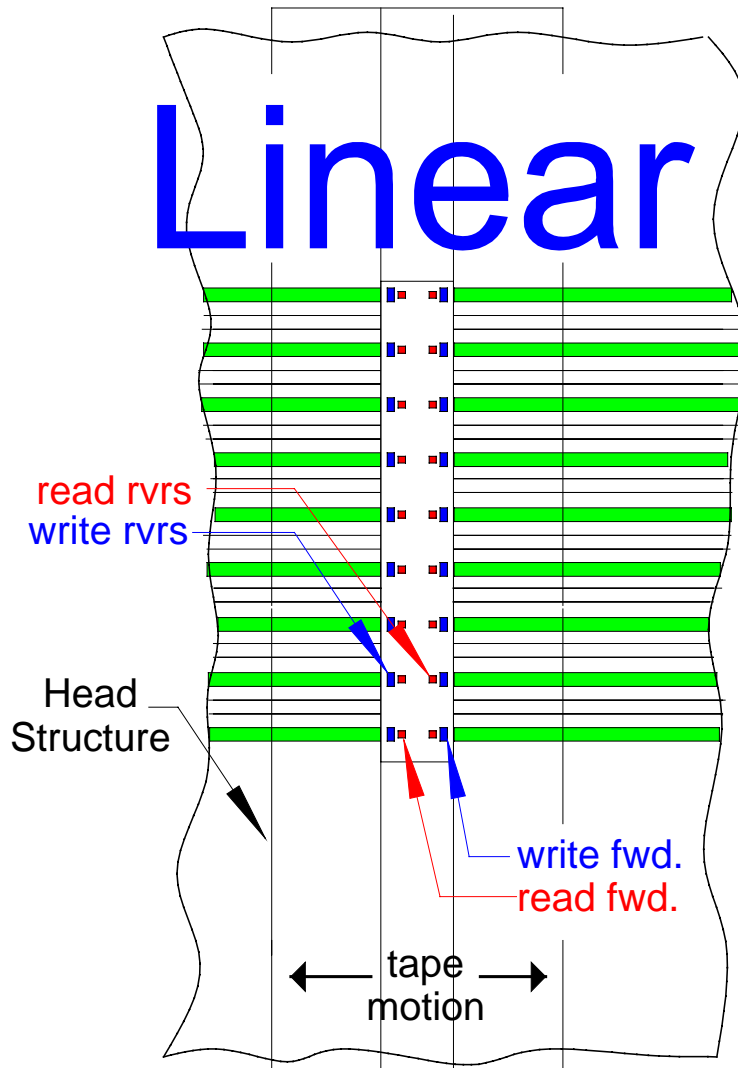
FOR THE SAME READ TRACK WIDTH & PERFORMANCE, AZIMUTH RECORDING CURRENTLY HAS A 2:1 ADVANTAGE IN TRACK DENSITY. AS THE TRACK DENSITY INCREASES FASTER THAN THE LINEAR DENSITY AND THE TAPE SUBSTRATE DIMENSIONAL STABILITY IMPROVES THAT ADVANTAGE WILL SHRINK TOWARDS A 1:1 RATIO.

THIC-0627-4 Recording Method

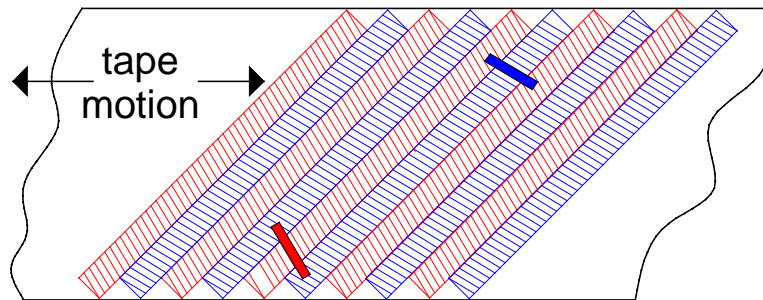
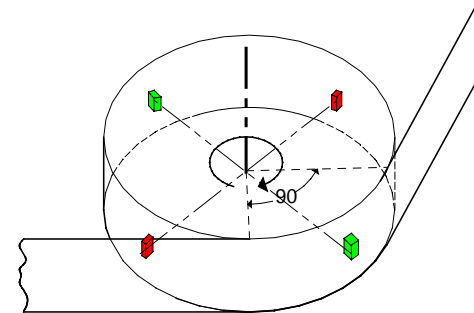


Recording Methods

Linear



Helical



nasa00301d-heads

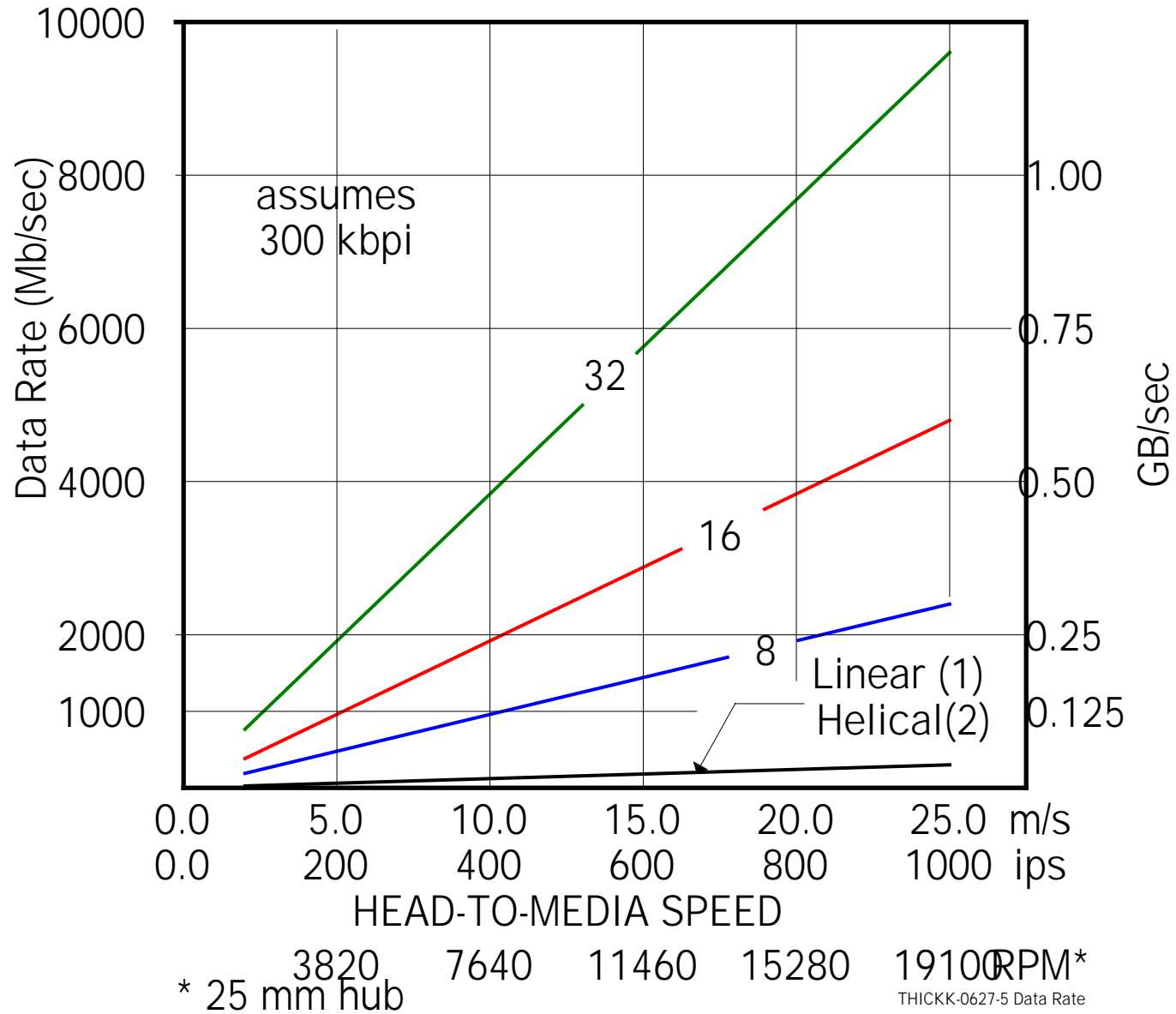


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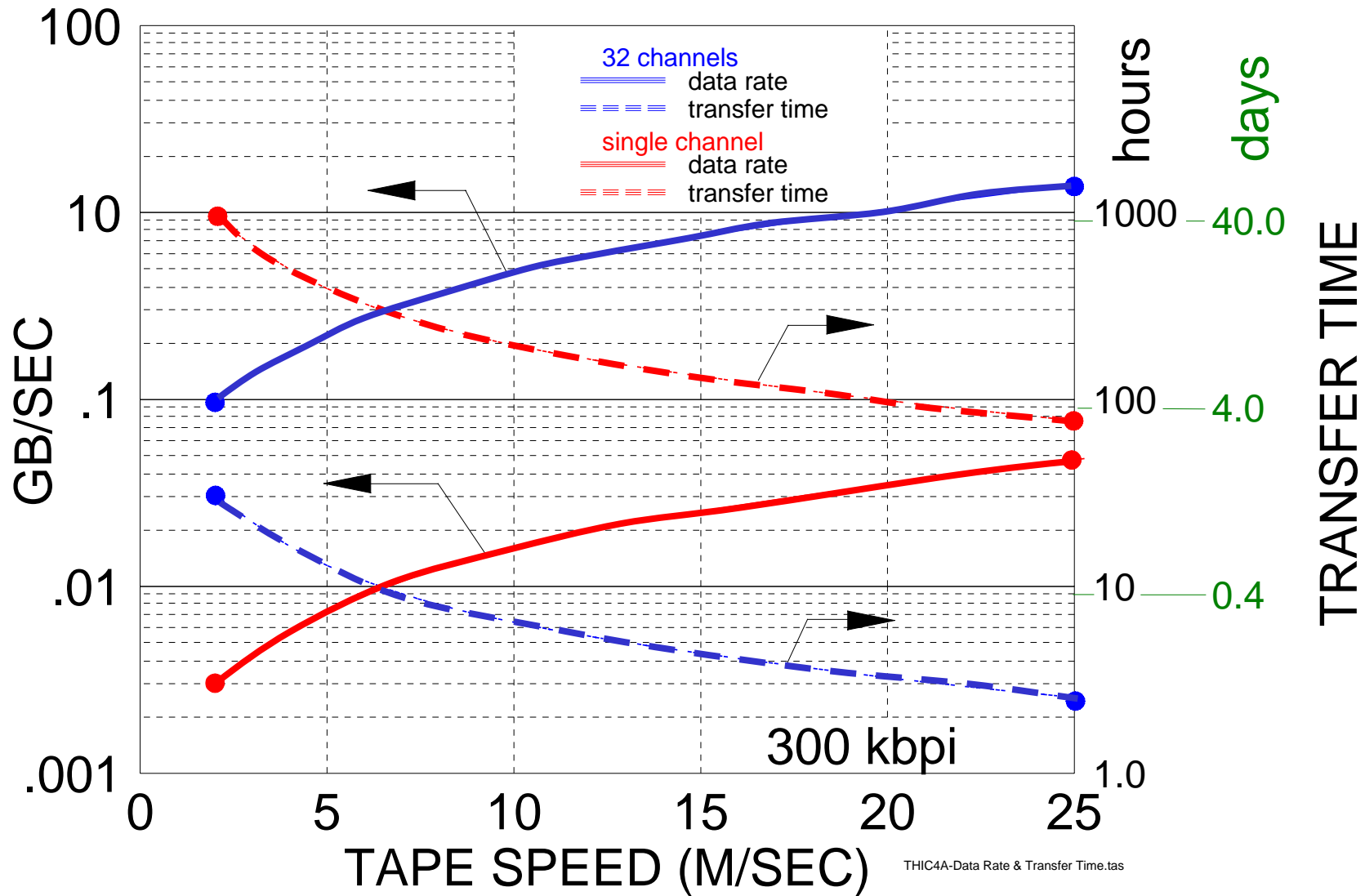
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Data Rate vs. Speed and No. of Elements



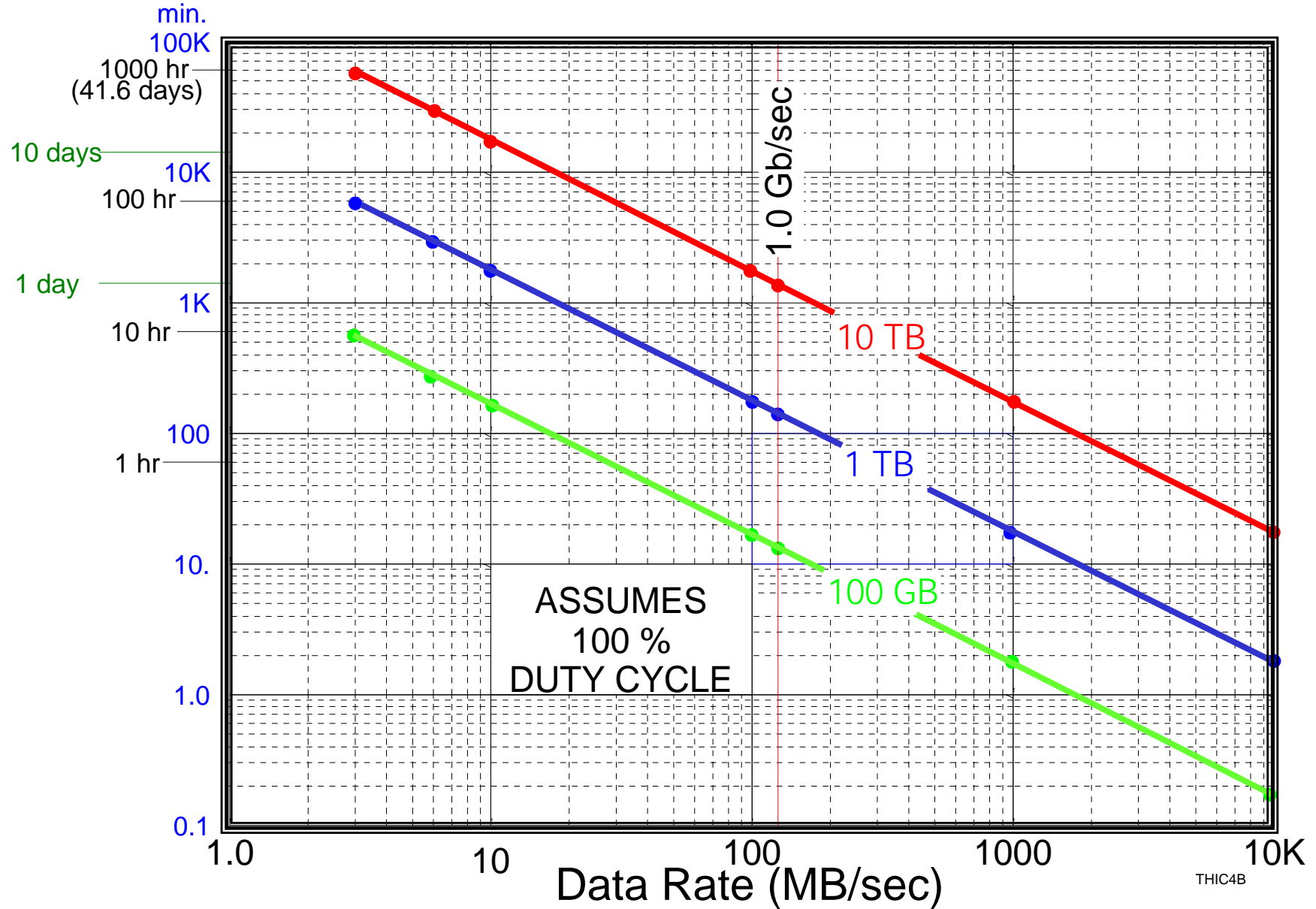
Data Rate & Transfer Time for 10 TB of Data



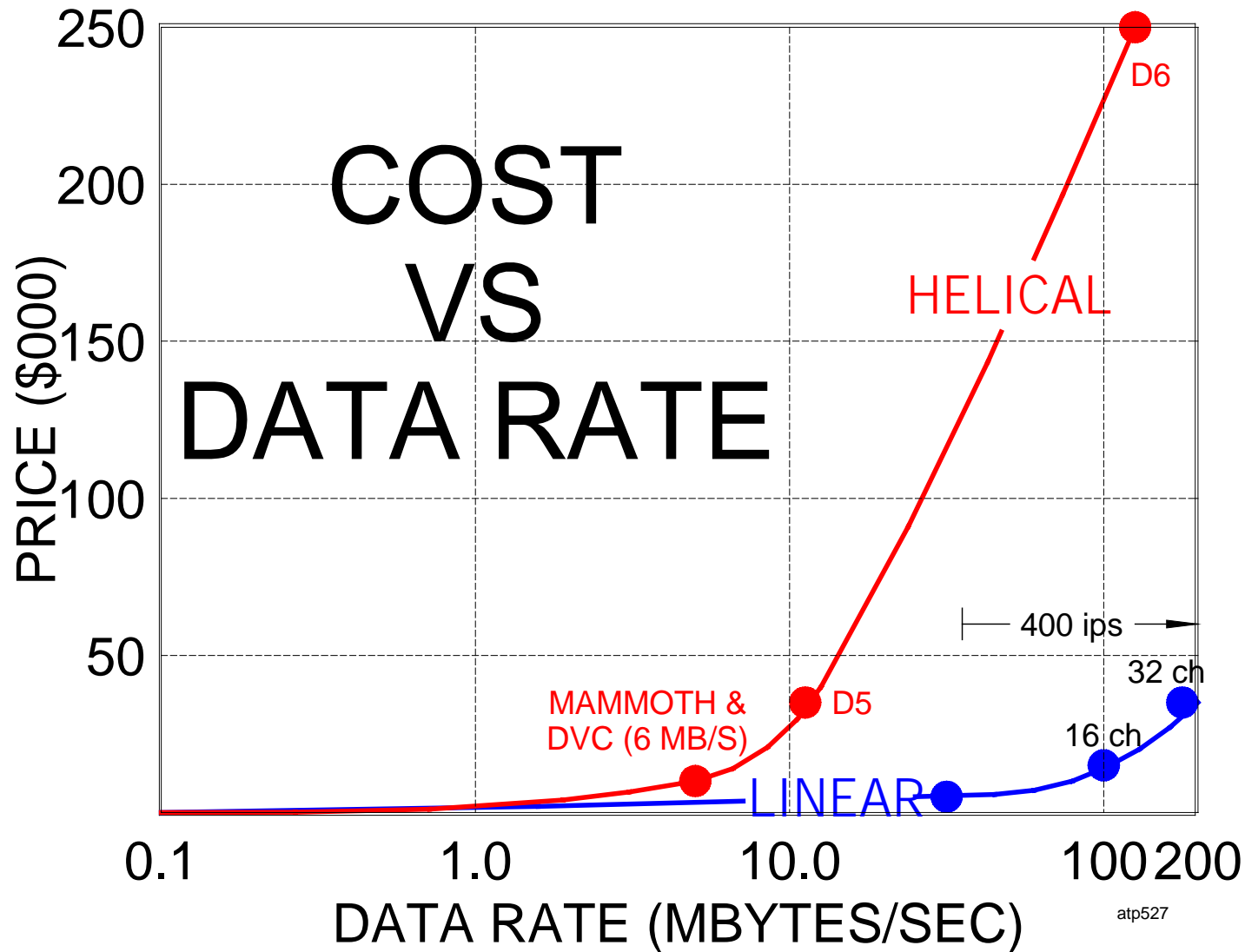
THIC4A-Data Rate & Transfer Time.tas



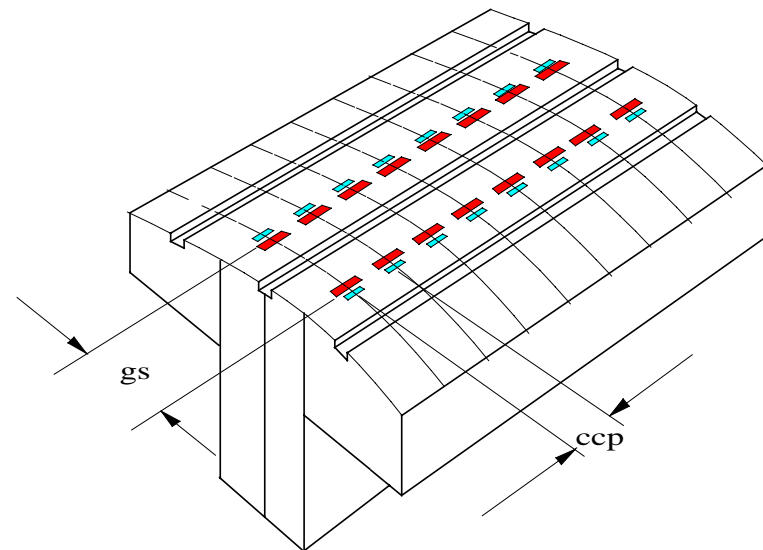
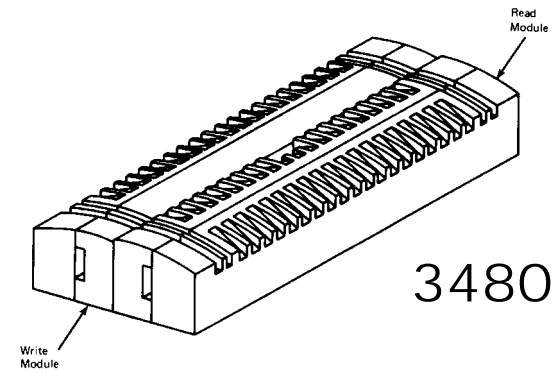
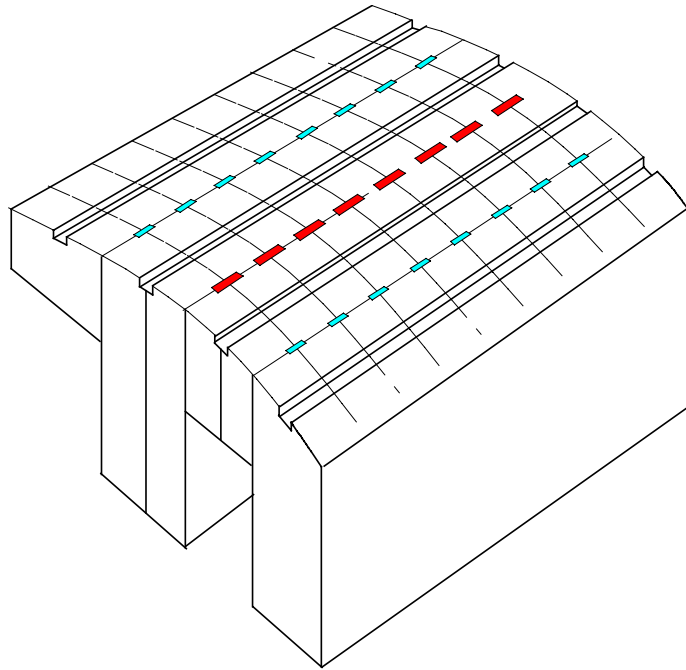
Transfer Time vs. Data Rate



Argument for Linear Systems



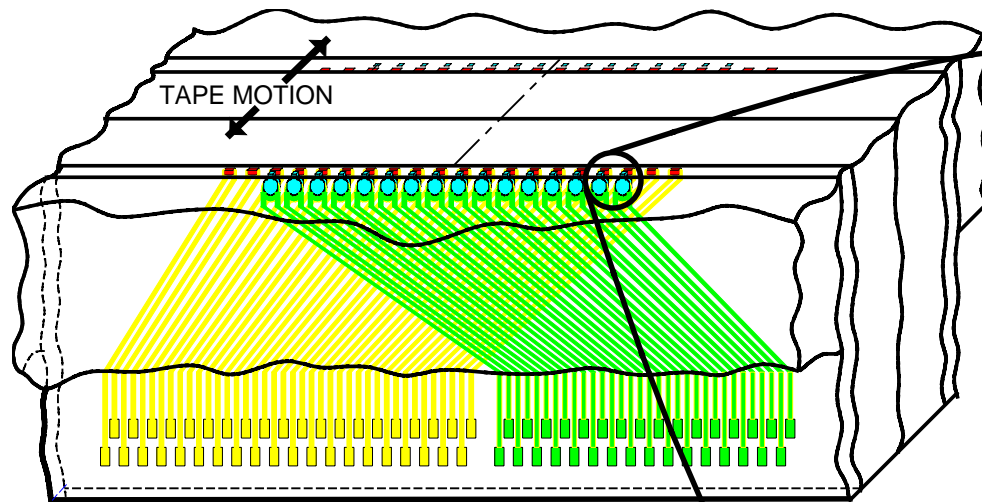
Tape Head Contours



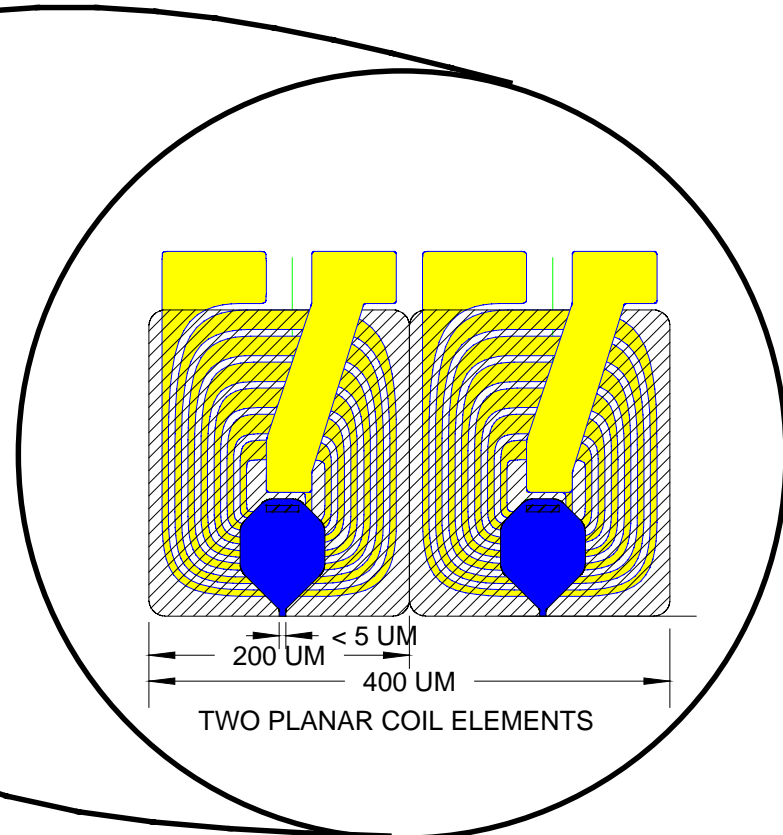
THIC7-head contours



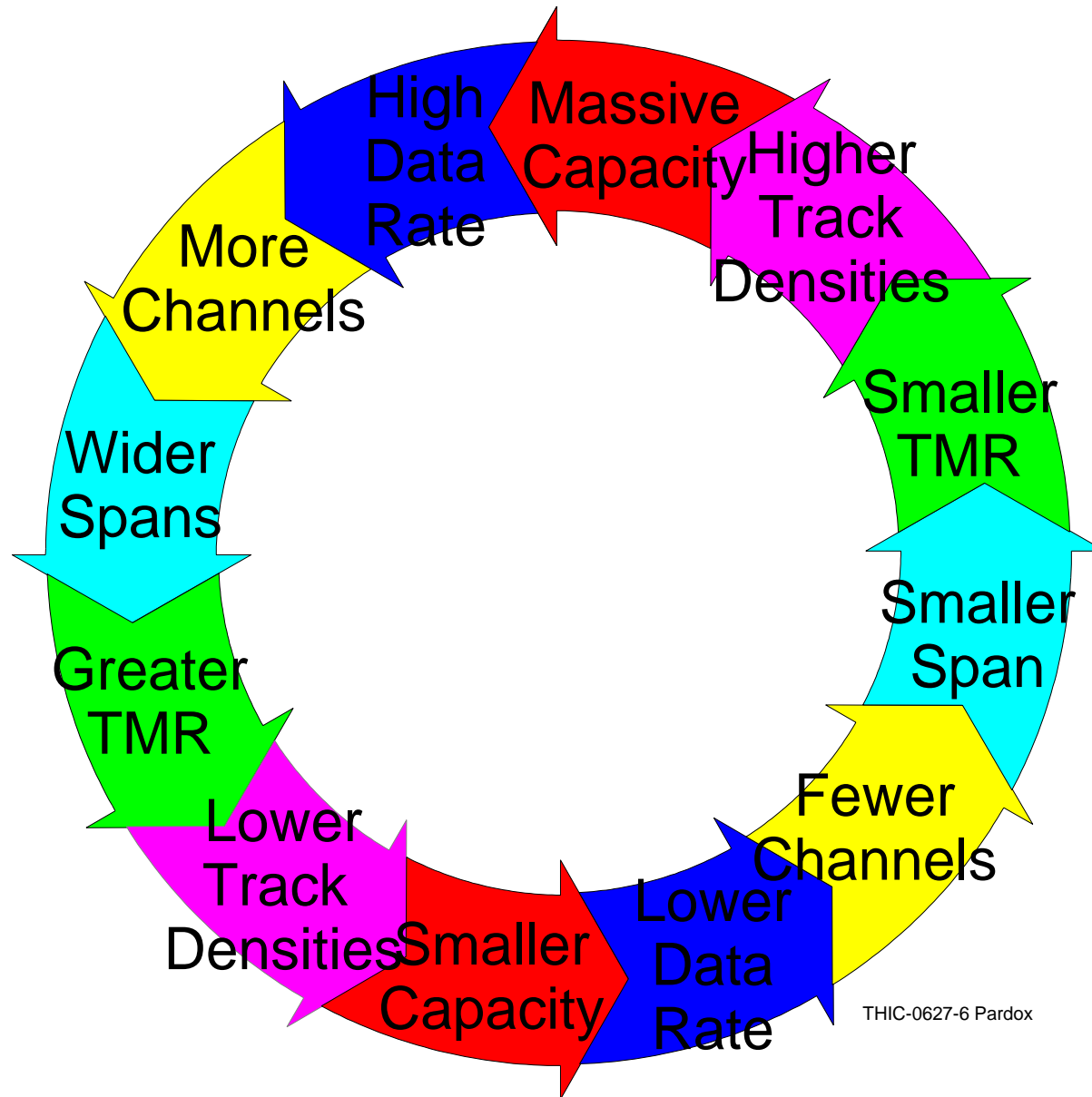
Head Plan View



THIC-0627-8 Head Layouts



Data Rate/Capacity Paradox



THIC-0627-6 Paradox



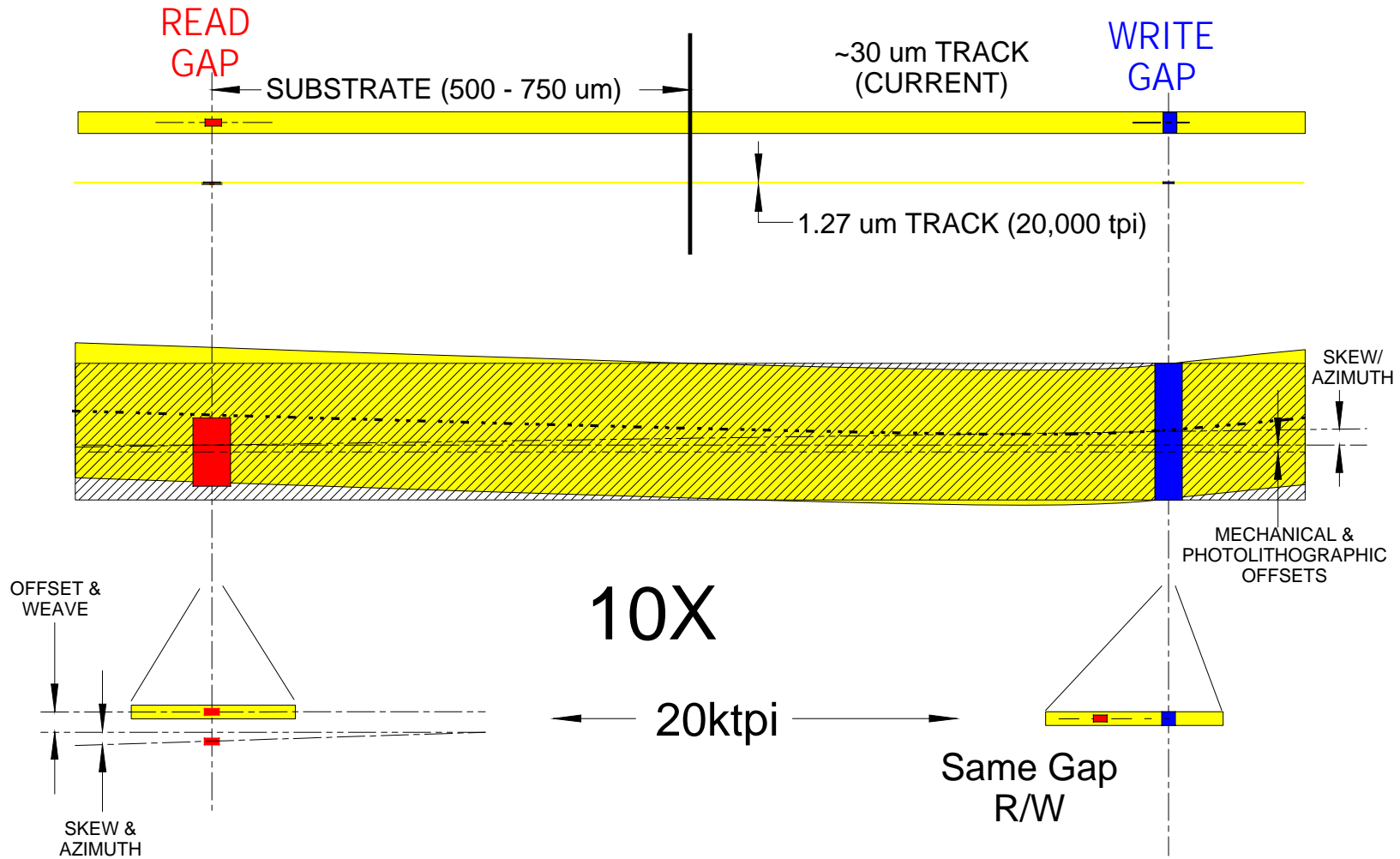
Density Key for Tape

Track Density

- Dimensionally Stable Substrate
- Closely Spaced Channels
- Low “noise” media
 - Maintain intrinsic SNR
 - Reduced surface roughness
- Mech. Alignment & Tolerance Compensation



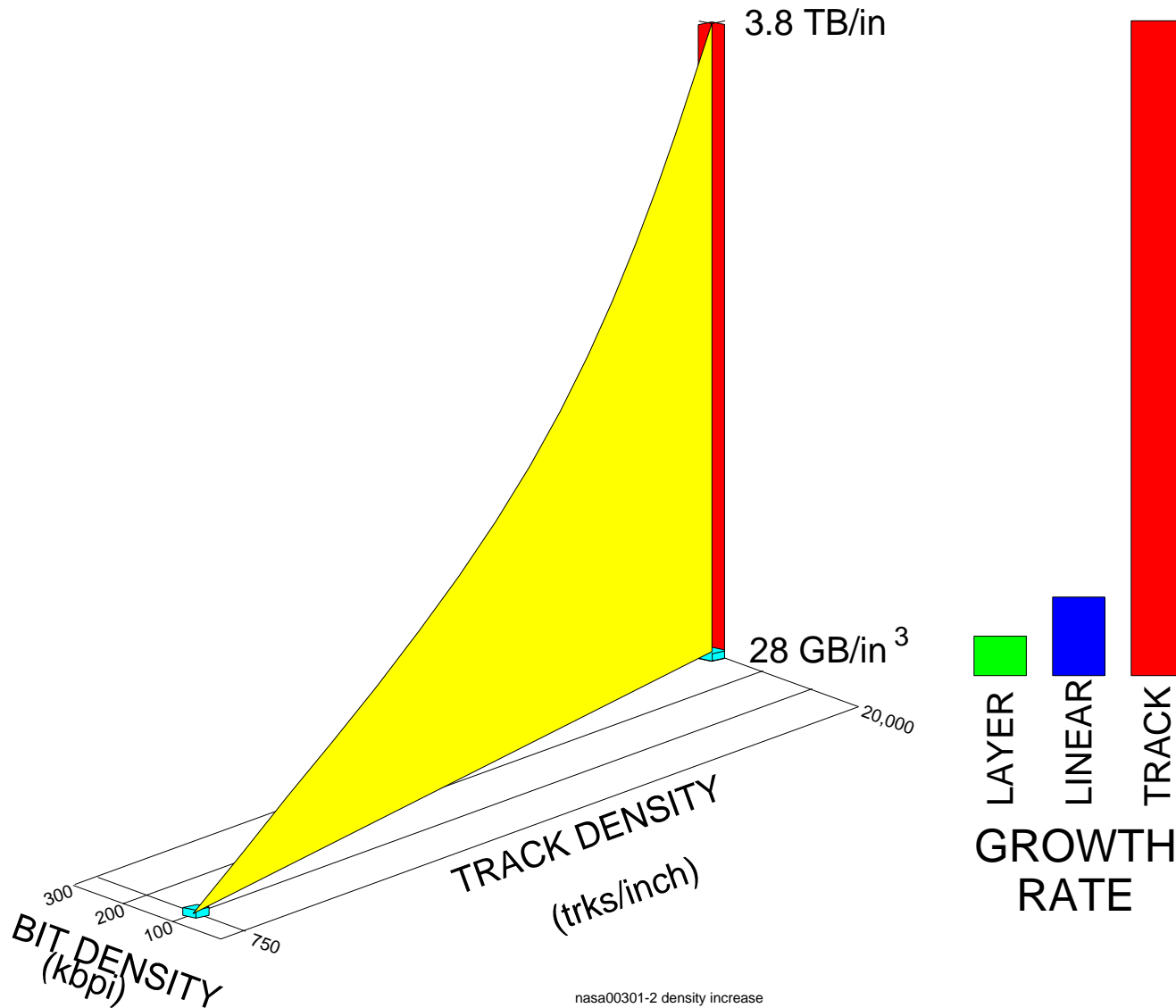
Read/Write Separation



THIC-0627-9 R-W Separation



Data Density Growth



Media

- Higher Coercivity (> 2500 Oe)
- Improved SNR/unit width
 - Reduced Defects
 - Smaller Particles
 - Smoother Surfaces
- Thinner Magnetic Layer ($<.05$ um)
 - Multi-layers
- Metal Film
 - Perpendicular?

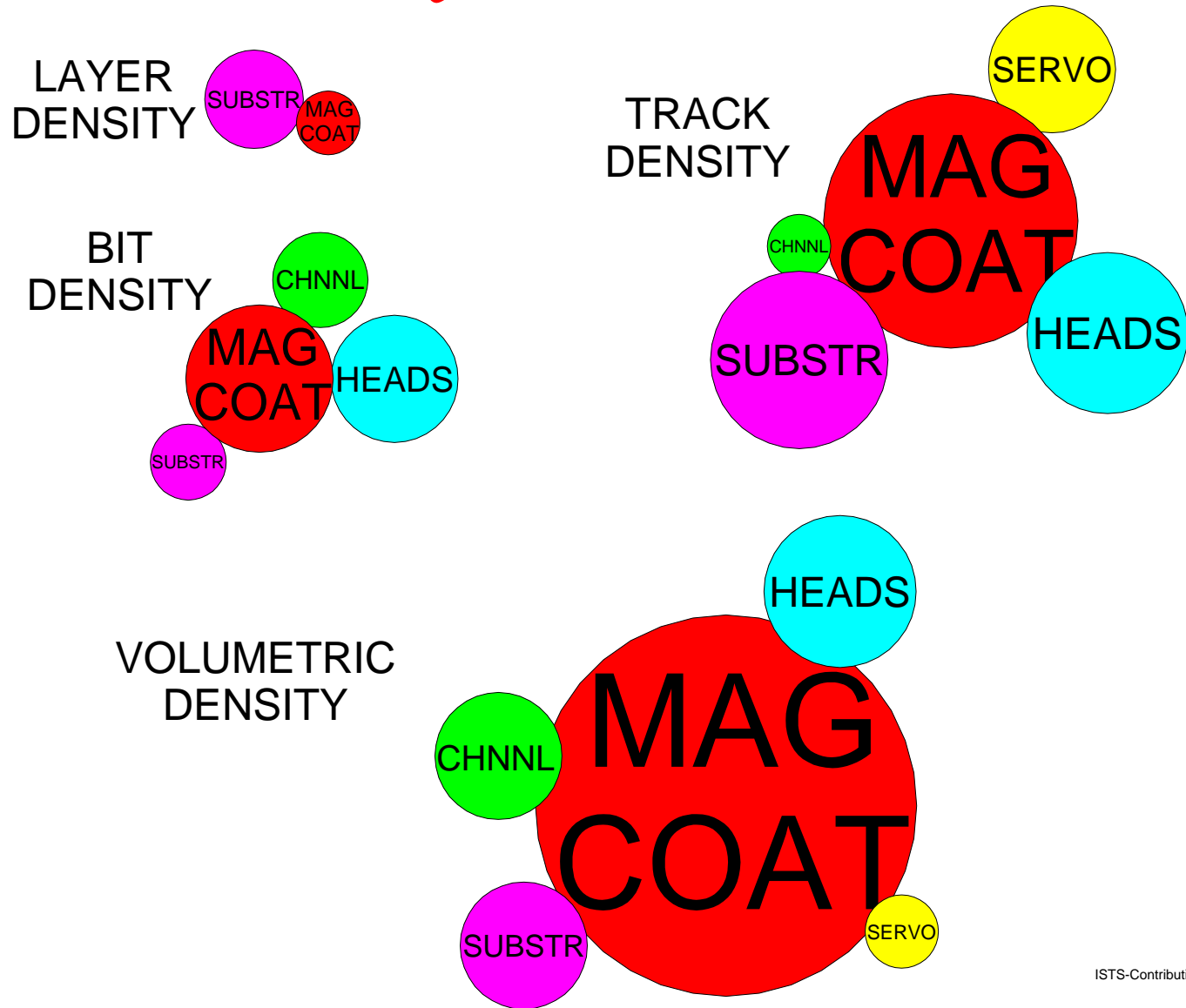


Substrate

- Reduced Dimensional Instability
 - 1000 PPM \longrightarrow 100-200 PPM
 - Humidity
 - Temperature
 - Tension
 - Creep/Compliance
- High T_G (For Metal Film)
- Thinner (4 μm \longrightarrow 2 μm ?)
- Smoother
- Stronger



Density Contributions



ISTS-Contributions



Summary - Goals

6 Gb/in² ---- 3.8 TB/in³

– 3X Bit Density

– ~25X Track Density

>10 TB/Large Cart

>200 MB/sec Data Rate

< 1 cent/GB per Cart (<\$100/Cart)

< \$0.5/GB per Drive (< \$5000/Drive)



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Summary - Challenges

- Data Rate
- Substrate Dimensional Stability
- Head Complexity/Span
- Mechanical Tracking
- Tape Speed
 - Head Wear
 - Handling
 - Tape Durability



Summary

“Tape Will Never Die!

-Jim Hughes – StorageTek

NASA Mass Storage Conference – April 2000

