M-Systems
Flash Disk Pioneers

Rugged & Reliable Data Storage
Solid-State Flash Disk overview

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Mechanical Disk

- High capacity
- Low cost
- Moving parts mechanism
- Commercial environmental specification
- Highest failure rate component !

Rugged Mechanical Disk

- Mechanical disk sealed in a rigid cartridge
- Protecting from high humidity and altitude changes
- Advanced cartridges contain loop servo system:
  - Heating & cooling elements
  - External shock absorber

Rugged Mechanical Disk

- Advantages
  - Better environmental specification than mechanical disk
- Disadvantages
  - Additional cost
  - Increasing solution size
  - Increasing solution weight
  - Does not fully comply with military environmental requirements

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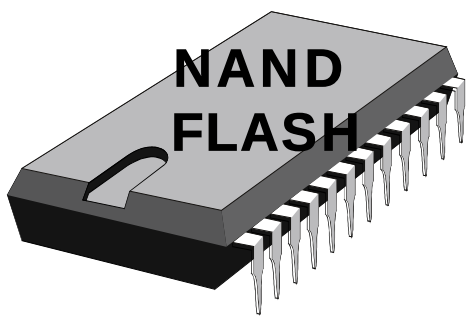
Flash Disk Technology

Flash: Non-volatile memory

- NOR : for XIP (code storage)

- NAND : for data storage



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Disk Emulation & Flash management

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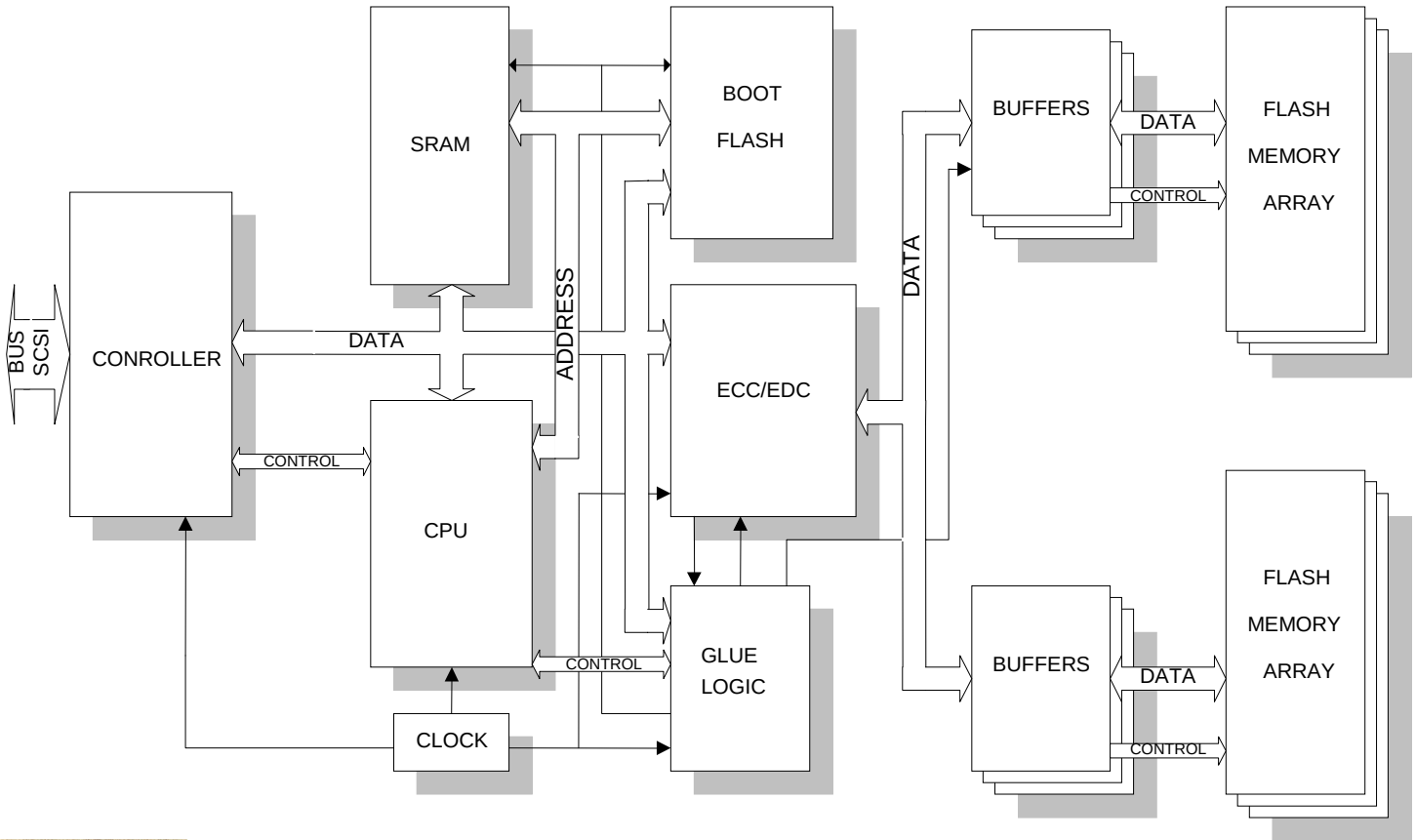
Flash Disk structure



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Flash Disk provides

- No moving parts
- Retains data when power is off
- Full disk operation
- "Drop-in replacement" for mechanical disks
  - Same mounting holes
  - Same form factor
  - Same interface

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Mechanical vs. Flash Disks

Environmental	Mechanical Disks	Solid-State Flash Disk
Operating Temperature range	5°C to +55°C	-40°C to +85°C
Non-Operating Temperature range	-40°C to +70°C	-55°C to +95°C
Operating Shocks	20G~125G	1500G MIL-STD–810F
Operating Vibrations	0.5G~1G (22-500Hz)	16G (20-2000Hz) MIL-STD–810F
Humidity	5%~90%	5%~95%
Operating Altitude	10,000 ft	80,000 ft
Acoustics, Idle/ready	2.9(Bels)	0

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Mechanical vs. Flash Disks

Reliability	Mechanical Disks	Solid-State Flash Disk
MTBF	300,000~1,200,000	900,000~5,800,000

Power	Mechanical Disks	Solid-State Flash Disk
Power Idle	5.0~0.8 Watts	1.0~0.035 Watts
Power Read/Write	10.0~5.9 Watts	3.0~0.325 Watts

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Securing confidential data

Deleting confidential data in emergency

- Mechanical disk
  - Need >20 times disk format
  - Can still trace erased data

- Solid-State Flash Disk
  - 10-20 seconds (capacity dependant)
  - Irretrievable erased data

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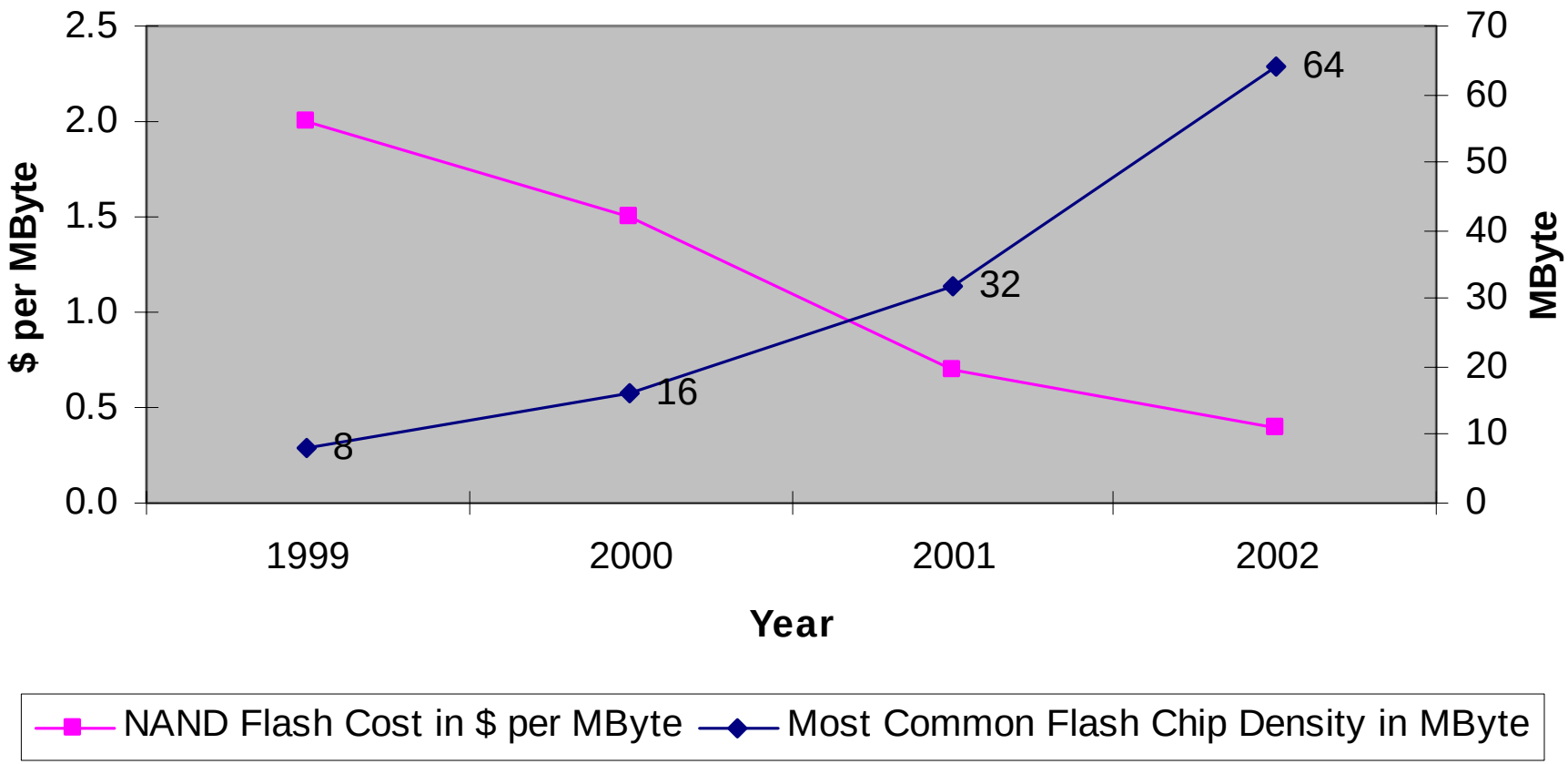
NAND Flash Moore's law



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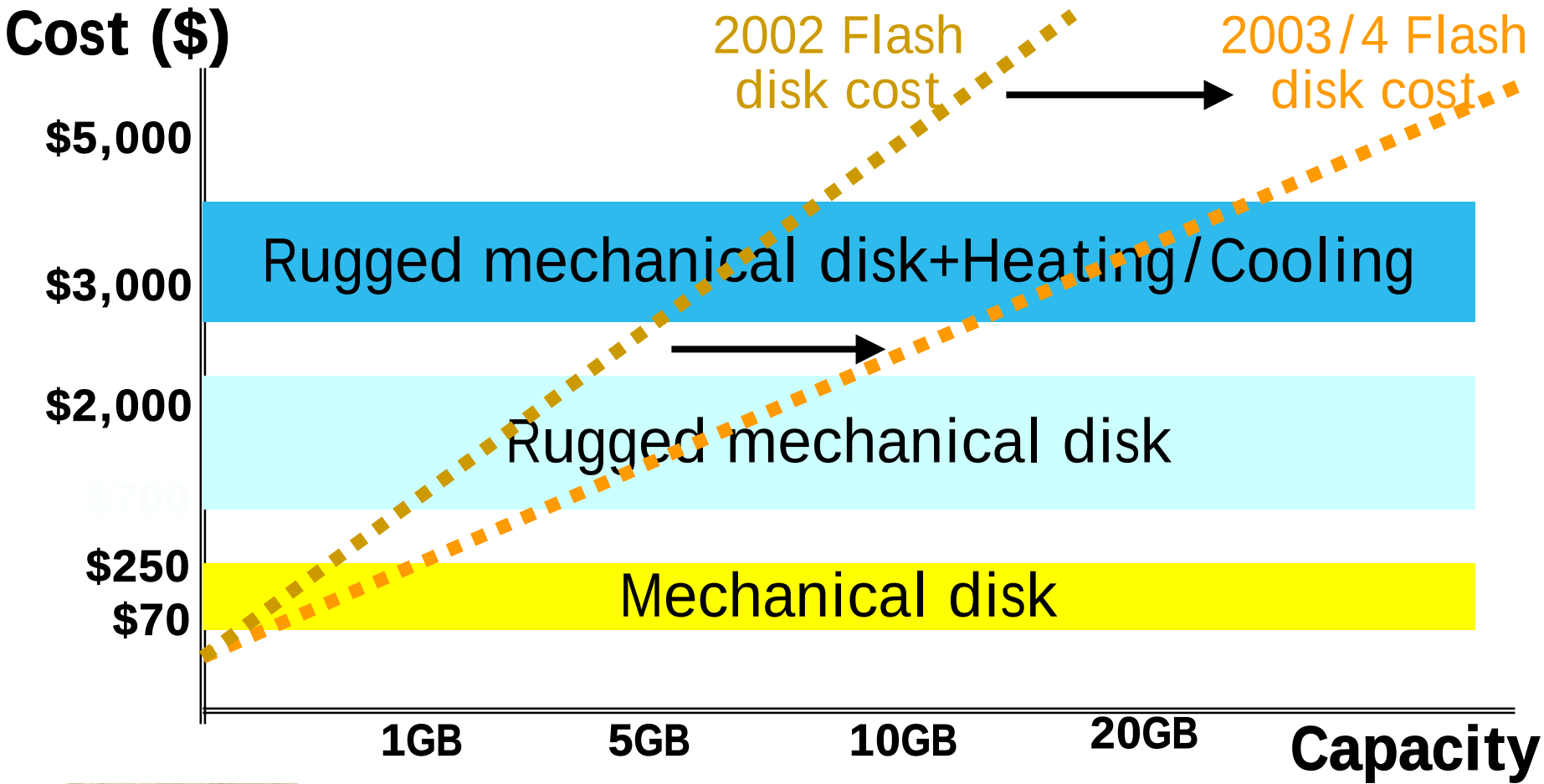
Flash Disk Cost/capacity trends



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Capacity Breakthrough

By end 2002 Solid-State Flash Disk provides

- 35GB in standard 3.5” case 1.6 inch height
- 20GB in standard 3.5” case 1.0 inch height

- 8GB in standard 2.5” case 17mm’ case height
- 2GB in 2.5” case 8mm’ case height

Doubling again the capacities in mid 2003

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Performance Breakthrough

Until 2000 Solid-State Flash Disk provided

- 8-bit interface
- Narrow SCSI
- Up to 3.0MB/s sustained read/write rate

Since mid 2001

- 16-bit interface
- Sustained read/write rate: >20.0 Mbytes/sec

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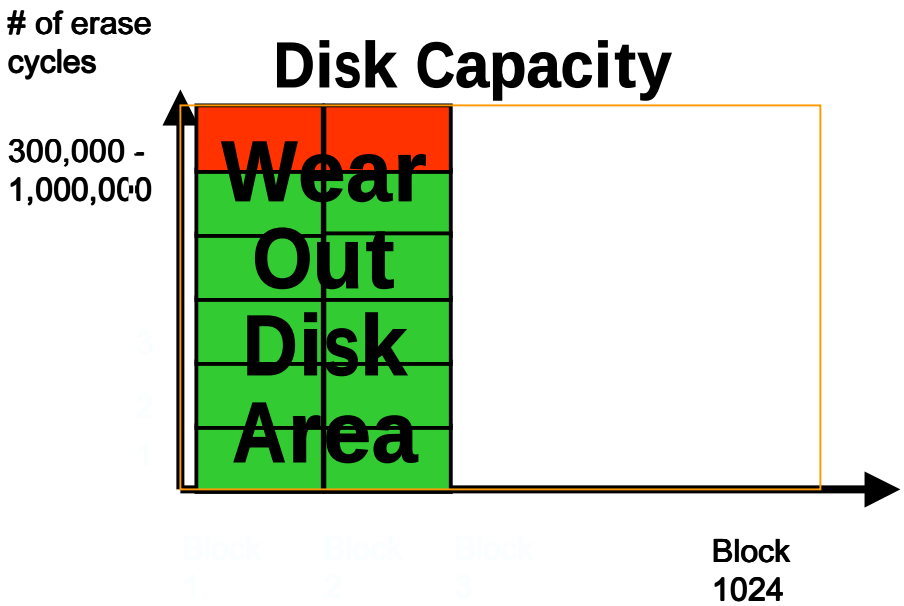
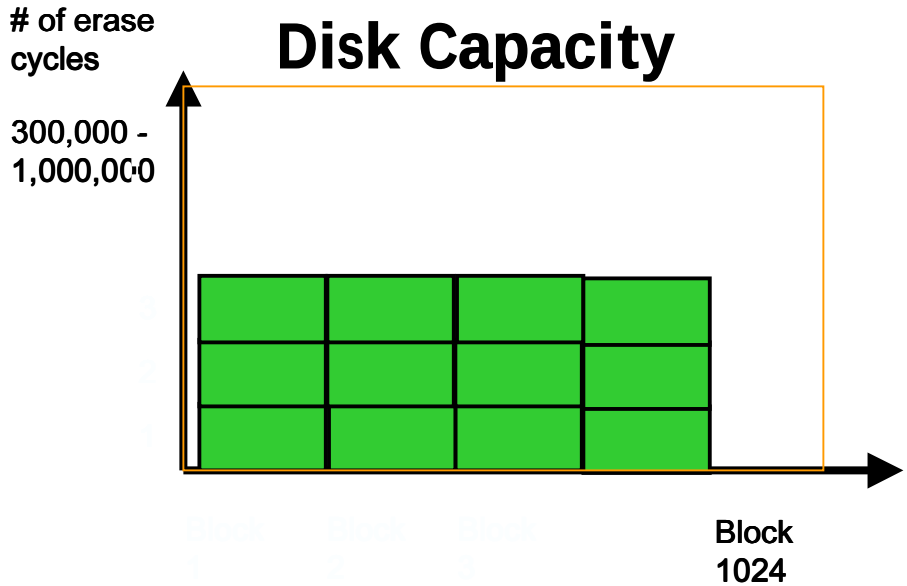
Flash Endurance: Dynamic Wear leveling

Without Wear leveling



M-Systems TrueFFS®
(True Flash File System)
Dynamic Wear leveling



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Improves Flash Limitations

- Limited no' of erase cycles of 300,000 to 1,000,000
  ->Dynamic Wear Leveling
- Accumulates bad blocks over time
  ->Bad blocks Management+pools of spares
- NAND Flash needs two bit error correction capabilities
  -> On the fly H/W + S/W EDC/ECC
- Must be erased before write in full blocks
  -> Flash Management "Garbage collection"

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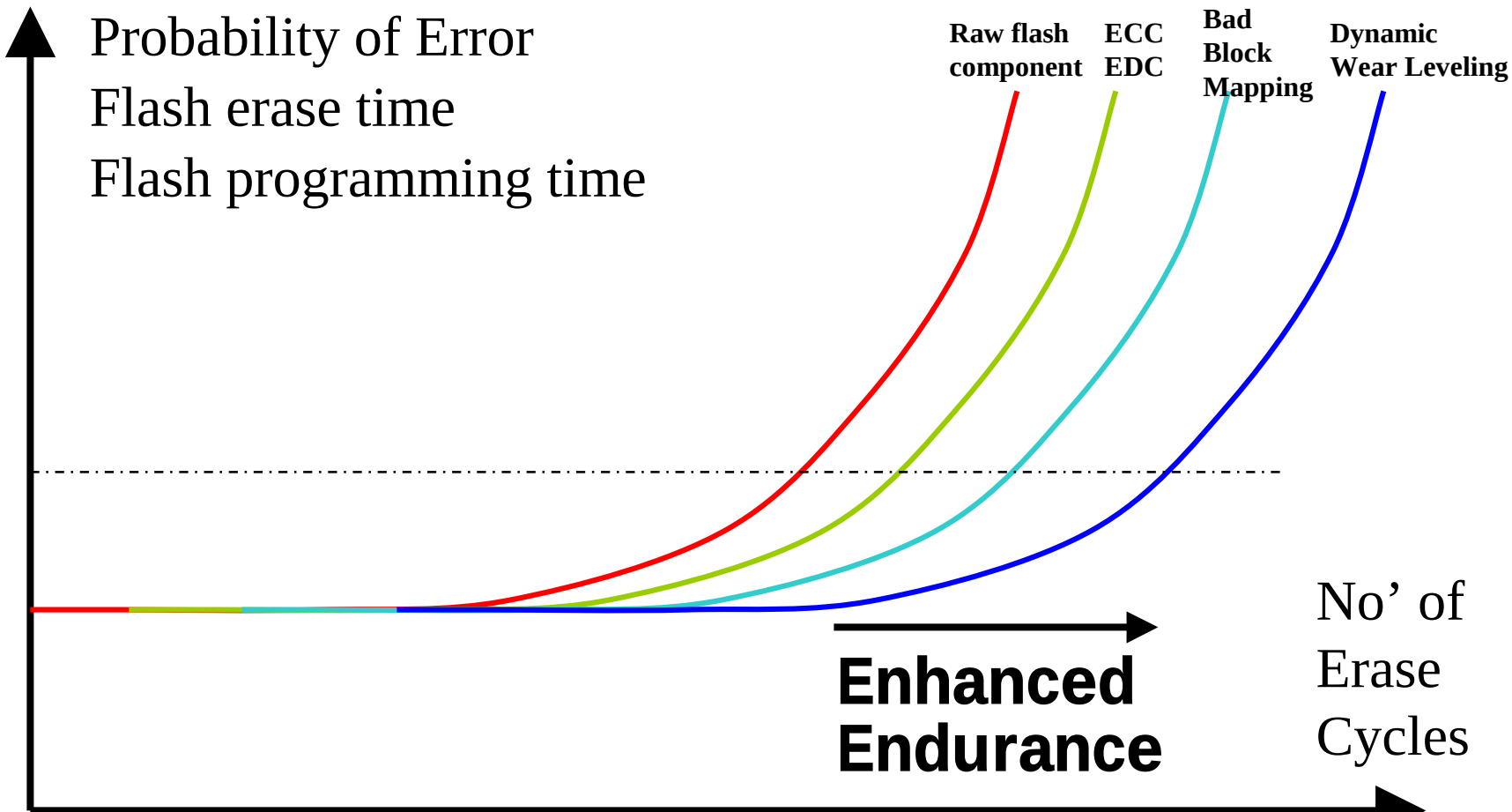
Enhancing Flash Endurance



Alternatives comparison

	Mechanical Disk	Rugged Mechanical Disk	Solid-State Flash Disk
Advantages	-Low cost -High capacity	Enhanced environmental specs than mechanical disk	- Top reliability and Endurance - Military specification - Fast Security erase
Disadvantages	- Moving parts mechanism - Commercial specification - Does not meet military needs	- Increased size and weight - Still contains moving parts - Expensive for low capacities	- Expensive at high capacities (with cost trend decreases)

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Summary

- When **Reliability** counts
- When need to operate in **harsh conditions**
- When **your data** is **valuable**
- When **your data** is **sensitive**
- Where **service/maintenance** is difficult
- When you want to **'Install and Forget'**

Solid-State Flash disk
is now a cost effective COTS solution

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Q&A

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Thank You !