Seagate Storage Update

Designing Storage Architectures for Digital Collections
US Library of Congress
September 9th, 2019

Jon Trantham
Principal Technologist
Seagate Research
Disclaimer

Information presented herein represents the author's personal opinion and understanding of the relevant issues involved. The author and Seagate Technology do not assume any responsibility or liability for damages arising out of any reliance on or use of this information. Some products and technologies are under research and development and may never be manufactured or sold. No warranties expressed or implied. Use at your own risk.
Contents

• Industry Update
• Recording Technology Update
• Dual actuator drives
• Archival Storage Development
Storage Industry Update
Industry Update

• Hard Disk Drives remain the predominate store of data, but SSD is growing
• Hard drive shipments are approaching 1ZB / year and should cross next year
• NAND was in oversupply and is now in-balance. We expect firm pricing this year.
Where are data located?

- Data continues to shift to the cloud
- If trends continue, IDC projects cloud to overtake consumer in 2020, and enterprise in 2022
- However, edge networking constraints will place a limit on this shift, unless solutions are found
Hard Drive Product Deployment Timeline

1st Generation Multi-Actuator Production Drive

PMR

HAMR


5 IOPS/TB

8TB 10TB 12TB 14TB 16TB 20+TB 30+TB 40+TB

10 IOPS/TB

Multi Actuator
Maintain ~8-10 IOPS/TB as capacity scales

Single Actuator
Scale capacity for non performance sensitive applications

Optimal IOPS/TB

Minimum IOPS/TB
Recording Technology
HAMR Technology Update

- HAMR = Heat-Assisted Magnetic Recording
- Seagate is now shipping HAMR drives in limited quantities to lead customers
- HAMR will be required for 20TB drives next year to avoid some radical mechanical changes
- Some of the challenges of ramping HAMR technology follow on the next few slides
Laser on Slider

The laser diode on a submount is actively aligned with the slider.
Precision Manufacturing

The height from the bottom of the slider to the top of the laser module is less than 500 um

The slider will fly over the disk with an air-gap of only 1-2 nm

As HAMR progresses we will continue to shorten this height

Also shown are the TIC bonds which electrically connect the slider to the head.
The Integrated HAMR Head

The writer still delivers flux to the media but there are major changes to the design to accommodate the waveguide and NFT.

The NFT delivers the EM energy to the media before it experiences the peak magnetic field from the write pole. As the media cools, the magnetic orientation is frozen with the applied field direction.

We have made millions of HAMR heads during the life of the program.
Succession of HDD Technology S-curves

- HDD Product Areal Density
- HAMR Demo Areal Density

Areal Density (Gbpsi)

DATE


- 33% CAGR
  - Ferrite Head
  - Oxide Disc
- 30% CAGR
  - Thin Film Inductive Head
  - Hydrodynamic Air Bearing
  - Sector Servo
- Seagate Technology Nov. 1, 1979

- 23% CAGR
  - MR Head
  - Thin Film Disc
  - Zoned Recording
  - PRML Channel

- 56% CAGR
  - GMR Head
  - Glass Disc
  - Ramp Load / Unload

- 52% CAGR
  - PMR
  - TMR Head
  - Femto Slider
  - PRML Channel
  - Fluid Bearings

- 25% CAGR
  - SMR
  - LDPC Channel
  - 4K Sectors
  - μPemto Slider
  - Dual Stage Actuator

- 15-30% CAGR (est)
  - HAMR
  - TDMR
  - HDMR
Latest Areal Density Advancements

With recent head and media advancements we were able to demonstrate 2 TbPSI with Shingled Magnetic Recording (SMR) and Interlaced Magnetic Recording (IMR), and 3000 kBPI (3400 kfc) with Conventional Magnetic Recording (CMR)

This is close to 2X today’s product ADC

With this areal density 3.5” drives could exceed 30 TB

Measurement Criteria Details:
These measurements comply with the ASTC demo criteria that was co-developed by Seagate & Western Digital. The criteria essentially requires no errors in $10^5$ sectors written and read back.

Dual Actuator
2019 Update: Dual-Actuator Hard Drives

- SAS Dual-actuator drives are now shipping in-volume
- These drives are essentially two drives in one package
  - Each actuator is an independent LUN
  - With proper data placement:
    - Doubles random IOPs / TB
    - Doubles sequential MB/s

<table>
<thead>
<tr>
<th>Workload</th>
<th>Compared to Nearline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1X</td>
</tr>
<tr>
<td>4K Rand Reads (Q1)</td>
<td>✓</td>
</tr>
<tr>
<td>4K Rand Writes (Q1)</td>
<td>✓</td>
</tr>
<tr>
<td>1M Rand Writes (Q1)</td>
<td>✓</td>
</tr>
<tr>
<td>4K Rand Writes (Q64)</td>
<td>✓</td>
</tr>
<tr>
<td>Seq Reads</td>
<td>✓</td>
</tr>
<tr>
<td>Seq Writes</td>
<td>✓</td>
</tr>
</tbody>
</table>
Archival Technology Research
Cartridge Storage

Cartridge Storage Research

- Cartridge storage development work continues at Seagate
- Separates the electronics from the drive to reduce total costs

CLASS: Cartridge Library Archival Storage System

- A robotic library for hard disk drive cartridges
- Leverages Seagate’s robotics strengths to move cartridges around
- Can be a compelling tape replacement

<table>
<thead>
<tr>
<th>Cartridge Box</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>~ 24 PB</td>
</tr>
<tr>
<td># of Cartridges</td>
<td>1200</td>
</tr>
<tr>
<td>Cartridge capacity</td>
<td>20 TB</td>
</tr>
<tr>
<td>Areal density</td>
<td>~ 1.4 Tbpsi</td>
</tr>
<tr>
<td>Disk form factor</td>
<td>97 mm</td>
</tr>
</tbody>
</table>
Conclusion
Summary

• Data storage demand is strong and growing

• Dual-actuator drives have emerged and are shipping in volume

• First HAMR drives have shipped in small volumes

• Expect for 2020 to be a transitional year for storage