

DATA IS POTENTIAL

# Seagate Storage Update

*LOC Designing Storage Architecture for Digital Collections*

September 17<sup>th</sup>, 2018

Jon Trantham  
Principal Technologist  
Seagate Research



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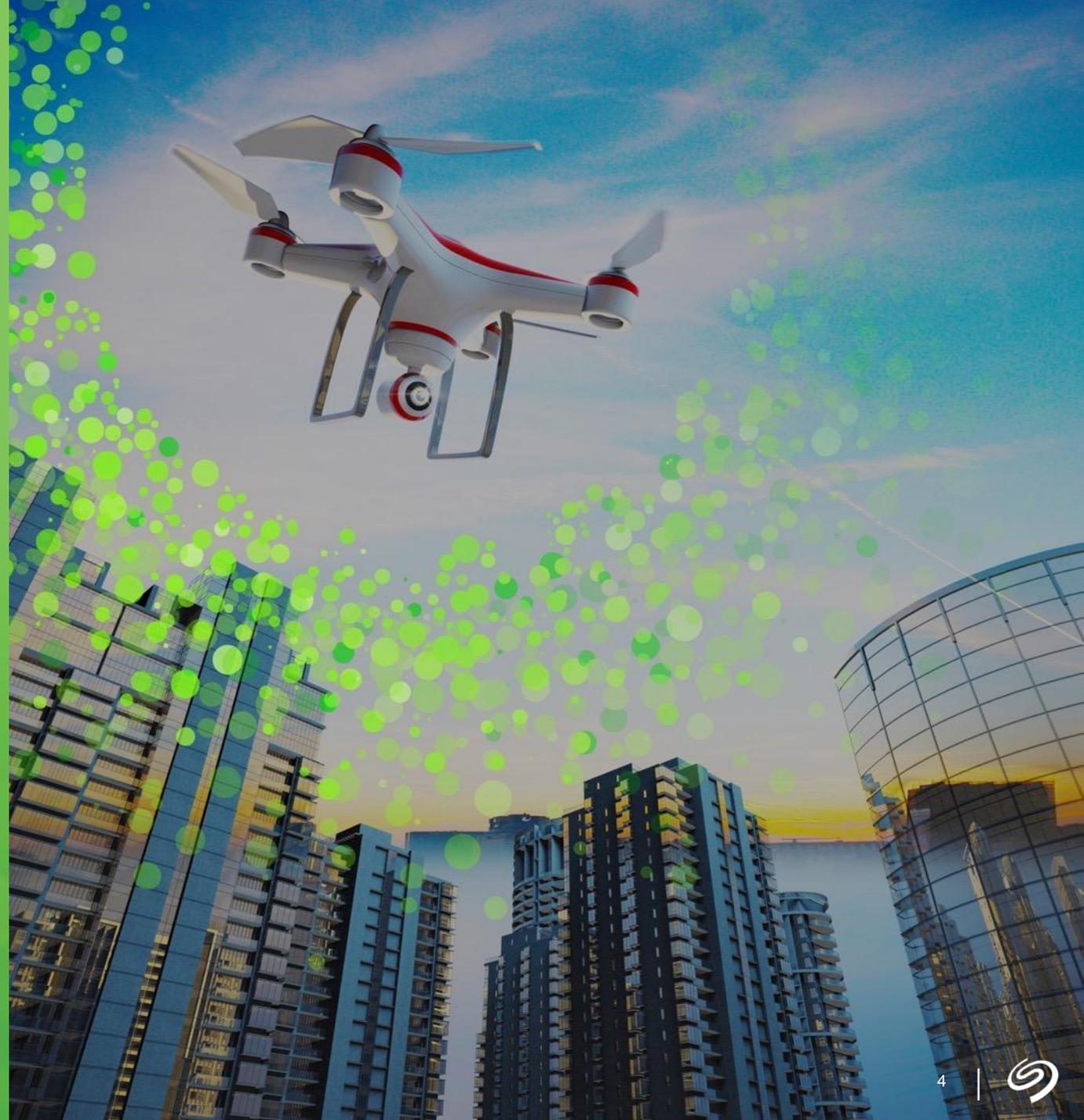
# Contents

- Industry Update
- HAMR Update
- Dual-Actuator Hard Disk Drives
- Future Storage Device Interfaces



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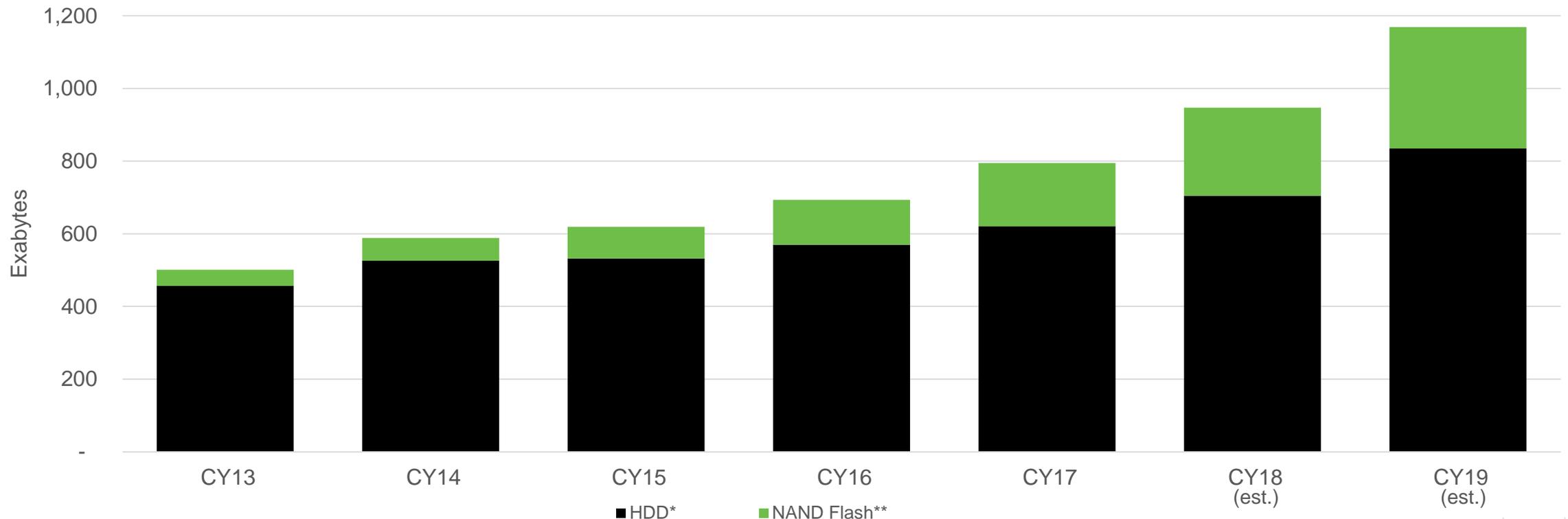
# Storage Industry Update





# Industry Update

- Hard Disk Drives remain the predominate store of data
- Over the past year the industry shipped 621EB of HDDs & 174EB of SSDs
- Demand exceeds component supplies in both HDD and SSDs
- New HDD/SSD technology, in the forms of HAMR/MAMR/QLC should help alleviate shortages

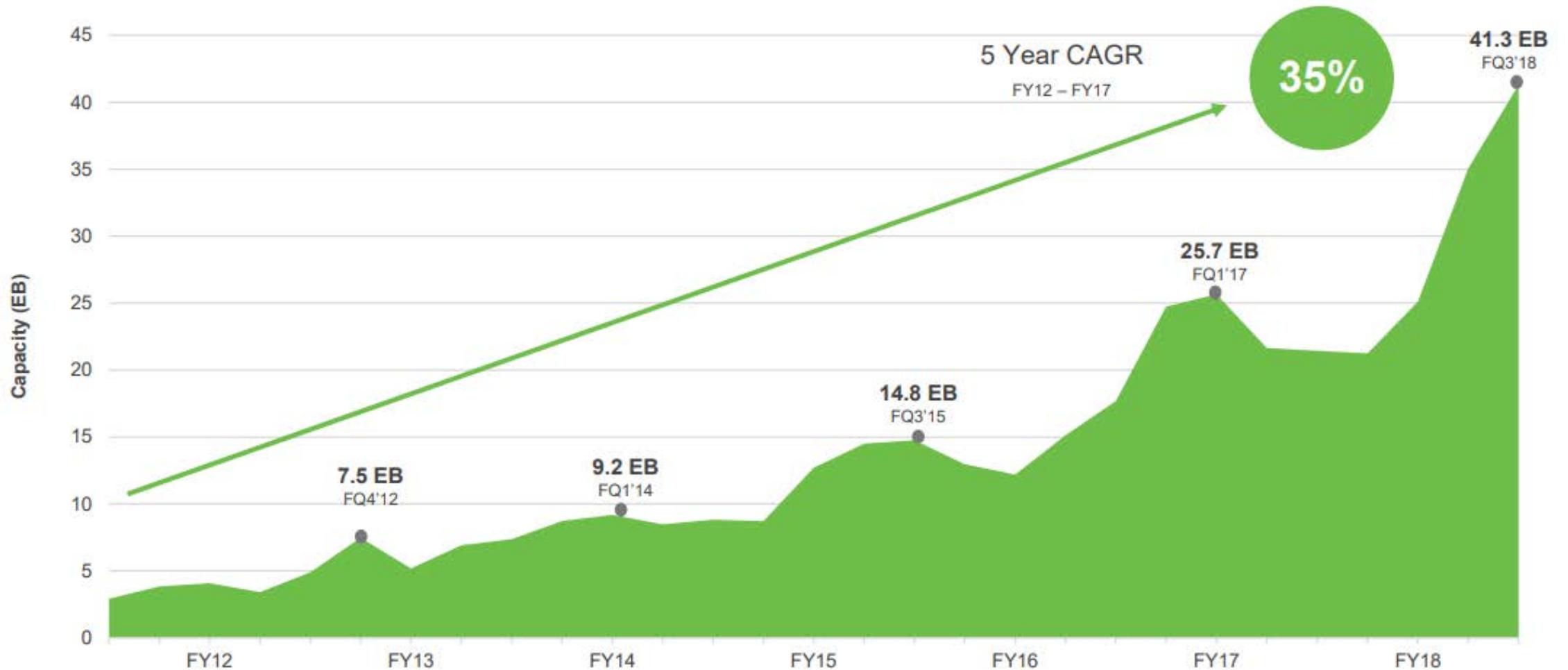


Note: the applications for NAND flash are: Flash Memory Card, USB Flash Drive, MPS/ PMP Player, Mobile Phone, Digital Still Camera, Personal Navigation Device, Digital Video Camcorder, Solid State Drive, Tablet, e-Reader, Smartwatch  
\* Seagate Market Research MTW 62 Q2 CY16 \*\* Forward Insights NAND Insights Q2' CY16



# Nearline Demand Trend

Storage is shifting to the cloud



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# Recording Technology

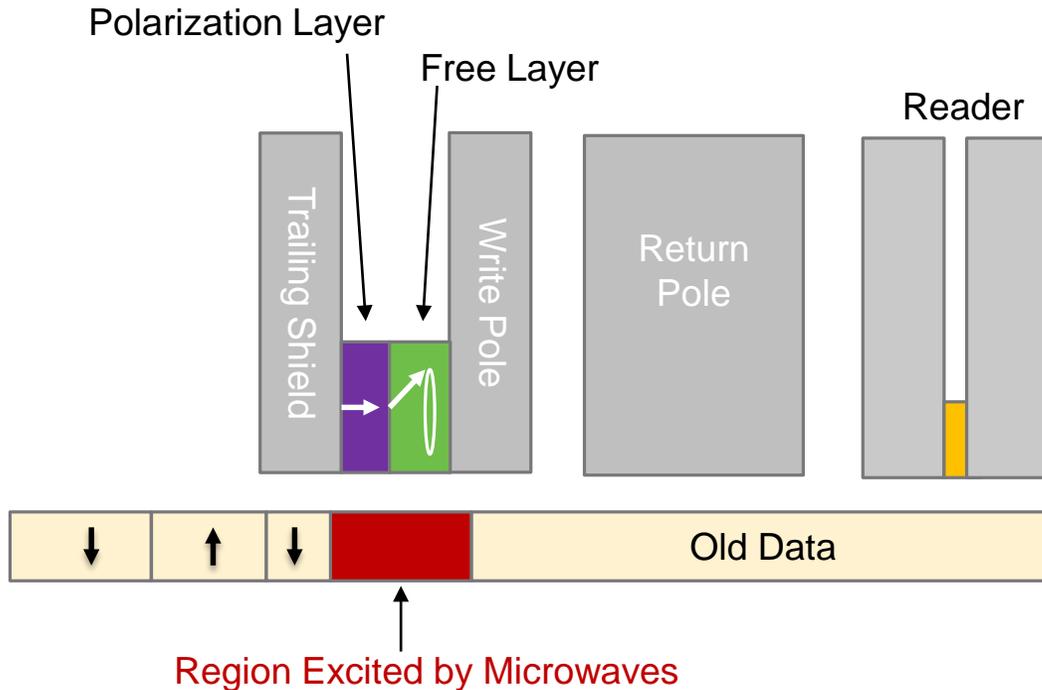


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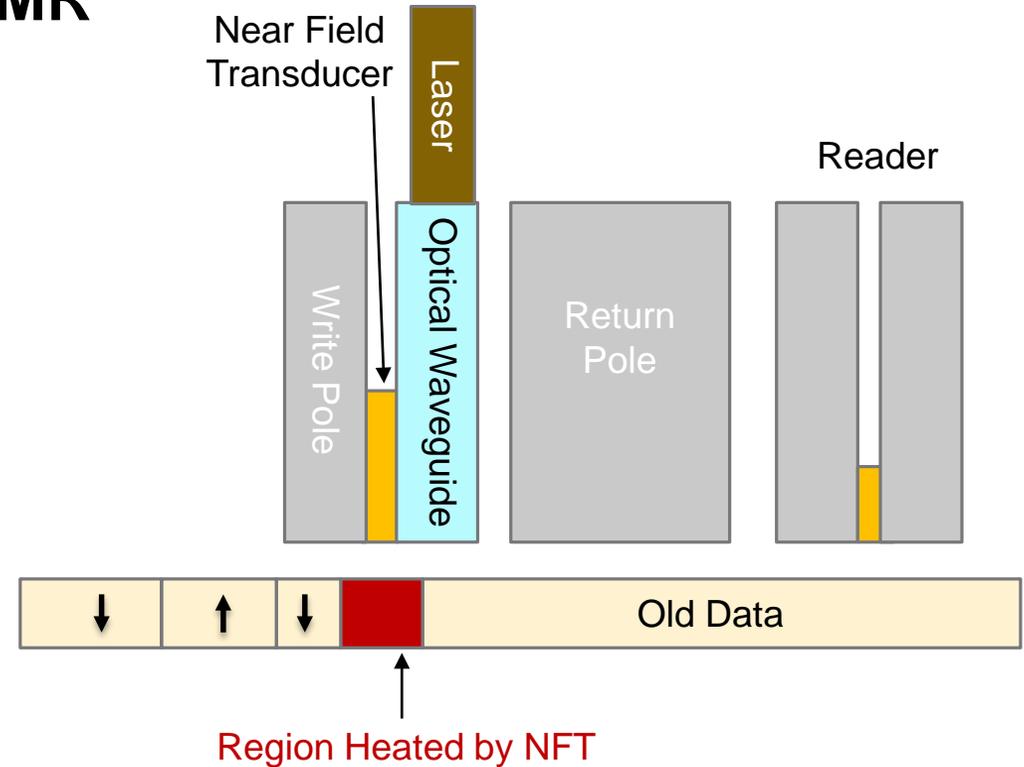
# MAMR / HAMR Overview

## MAMR



- MAMR uses a Spin Torque Oscillator (STO) to energize the media
- The frequency of the STO needs to match that of the media but changes with the field from the writer and the STO current
- STOs require precise thin films in the recording head
- WDC is MAMR's biggest proponent

## HAMR



- HAMR uses a laser diode and an optical antenna to energize media
- The optical antenna is called a near-field-transducer or NFT
- The NFT focuses the laser energy to a spot  $\ll$  wavelength of light
- The media must be carefully designed to utilize the energy
- Seagate is HAMR's biggest proponent



# Seagate's HAMR ASTC Areal Density Measurements

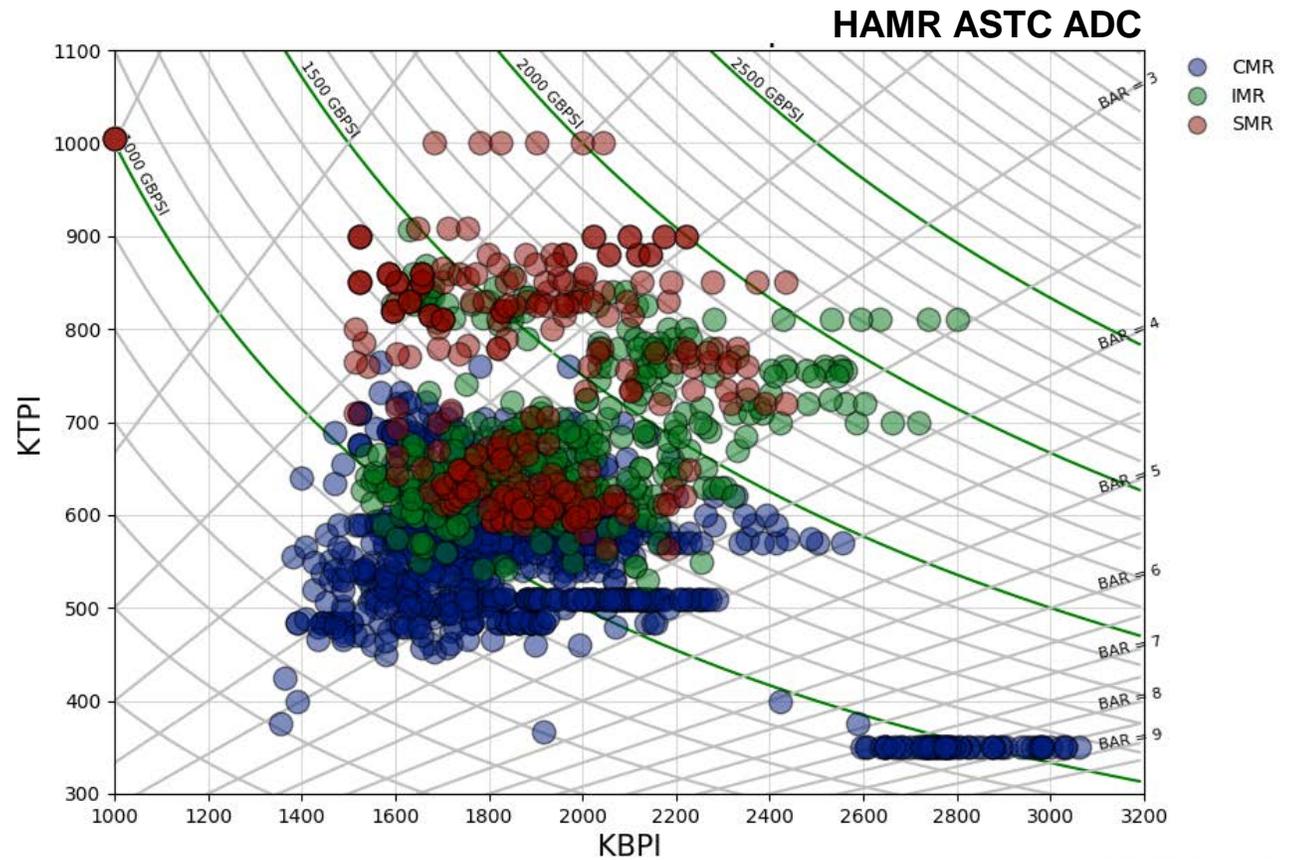
These areal densities are measured under ideal conditions using special test equipment

They show the capability of the technology

The areal density shown is the user's areal density and includes overhead for error correction codes. The actual raw written areal density is 13% higher than shown

As expected, SMR areal densities are higher than what can be obtained with CMR, both are far higher than conventional technology

We have been able to achieve >2TBPSI with SMR and more than 3000 kBPI with CMR



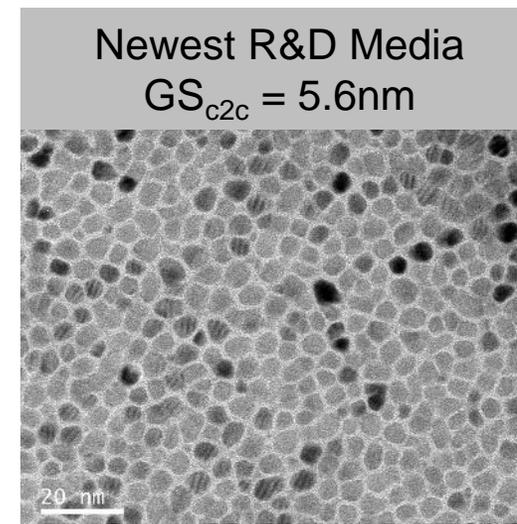
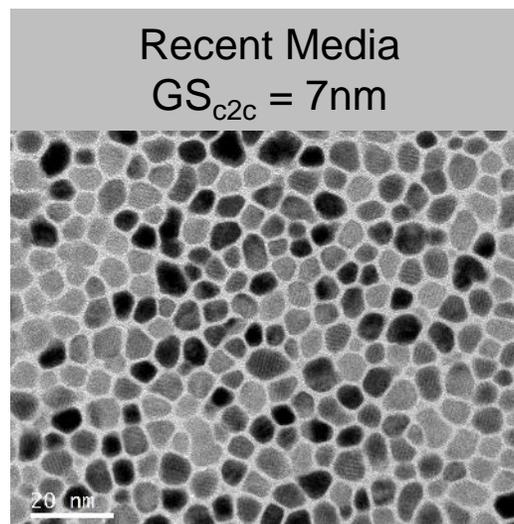
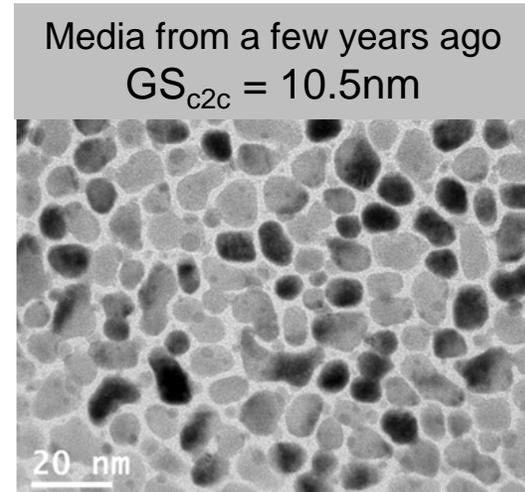
# HAMR Media Grain Size Progress

The newest media is a leap forward in grain size reduction.

Stable 5.6 nm grains.

The newest R&D media will allow more than a 50% ADC gain from the current records on the recent media.

We believe this media is capable of supporting 3TBPSI using the ASTC ADC definition



# HAMR Reliability Progress

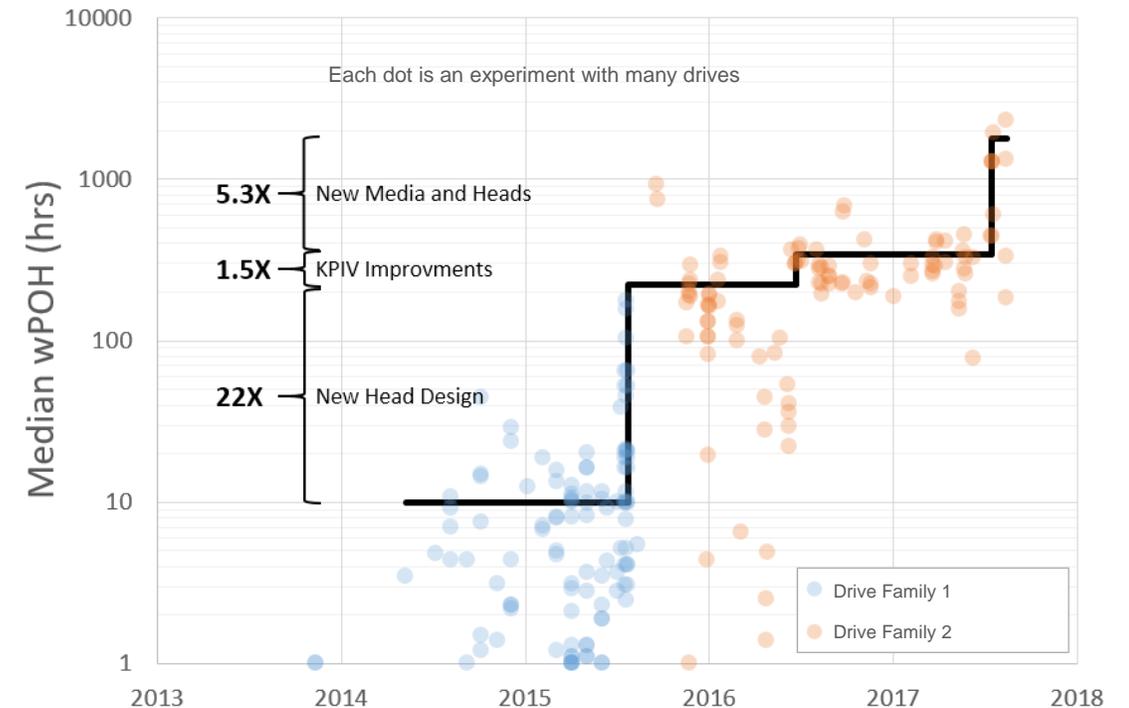
HAMR reliability has made great progress and is now suitable for products

We routinely have heads that write for thousands of hours

Our best recording heads are now writing over 6000 hours (equiv. to 3.2PB of data)

In a product, writes are typically evenly distributed across many heads. A typical head will see less than 40 hours of writing in its life.

Historical HAMR Reliability



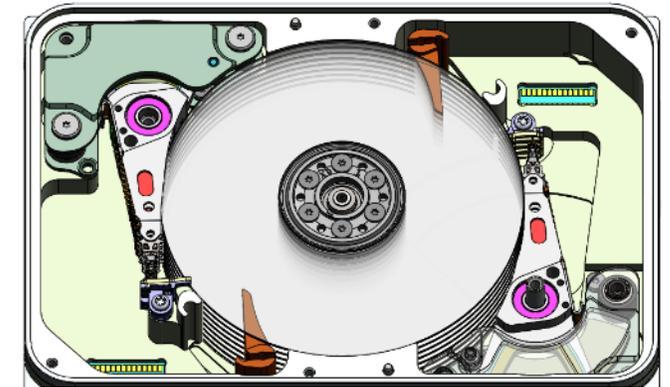
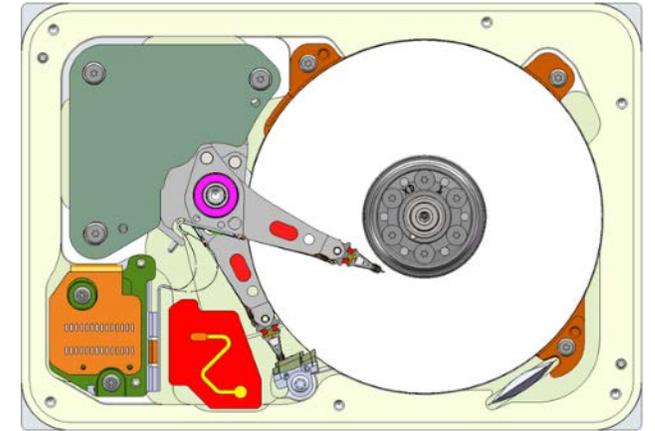
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# Dual Actuator

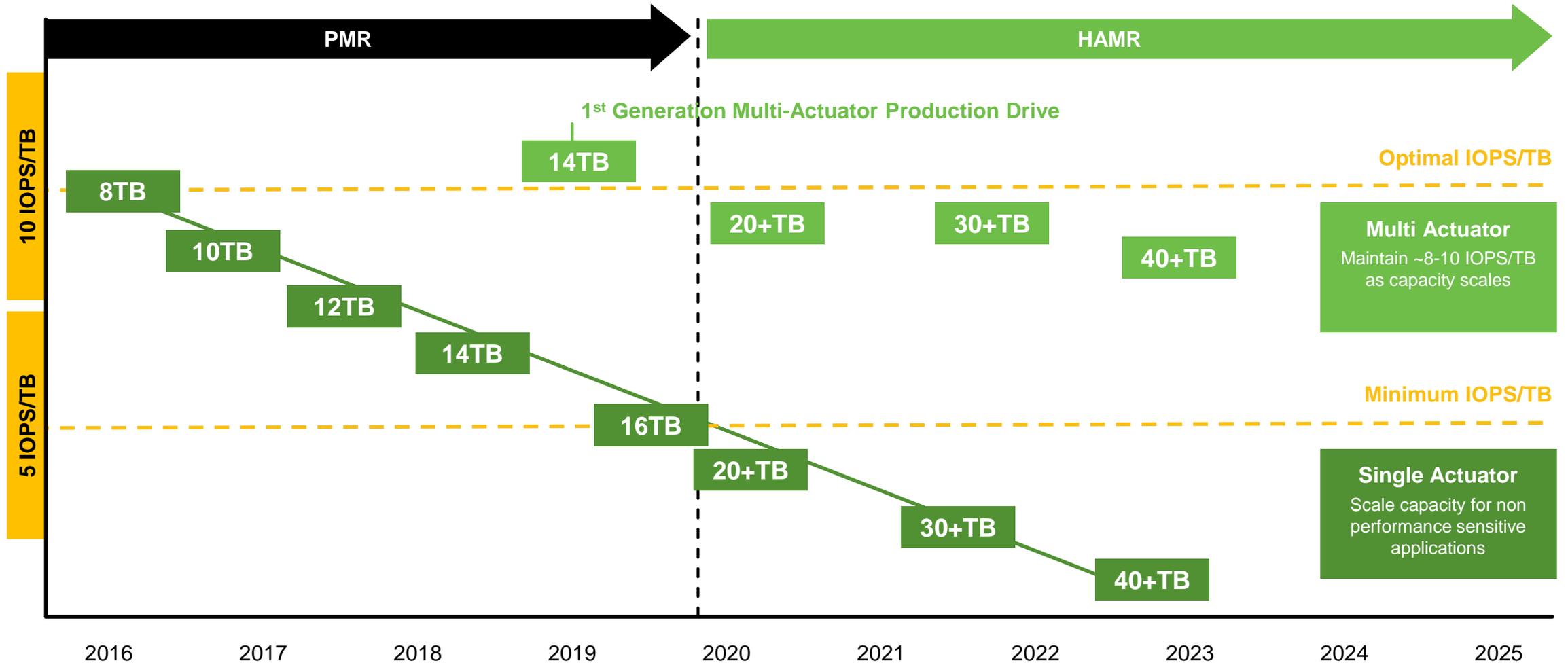


# Dual-Actuator Hard Drives

- Dual-actuator are essentially two drives in one package
  - Each actuator is an independent LUN
  - Doubles random IOPs / TB
  - Doubles sequential MB/s
- Various approaches are possible:
  - Split: co-located actuators on a common pivot
  - Opposed: actuators on different pivots
- Preferred Interface: SAS w/one LUN per actuator
  - SAS's LUN mechanism provides independent control-ability
- Seagate has shipped working prototypes to select customers
  - Volume manufacturing planned in 2019

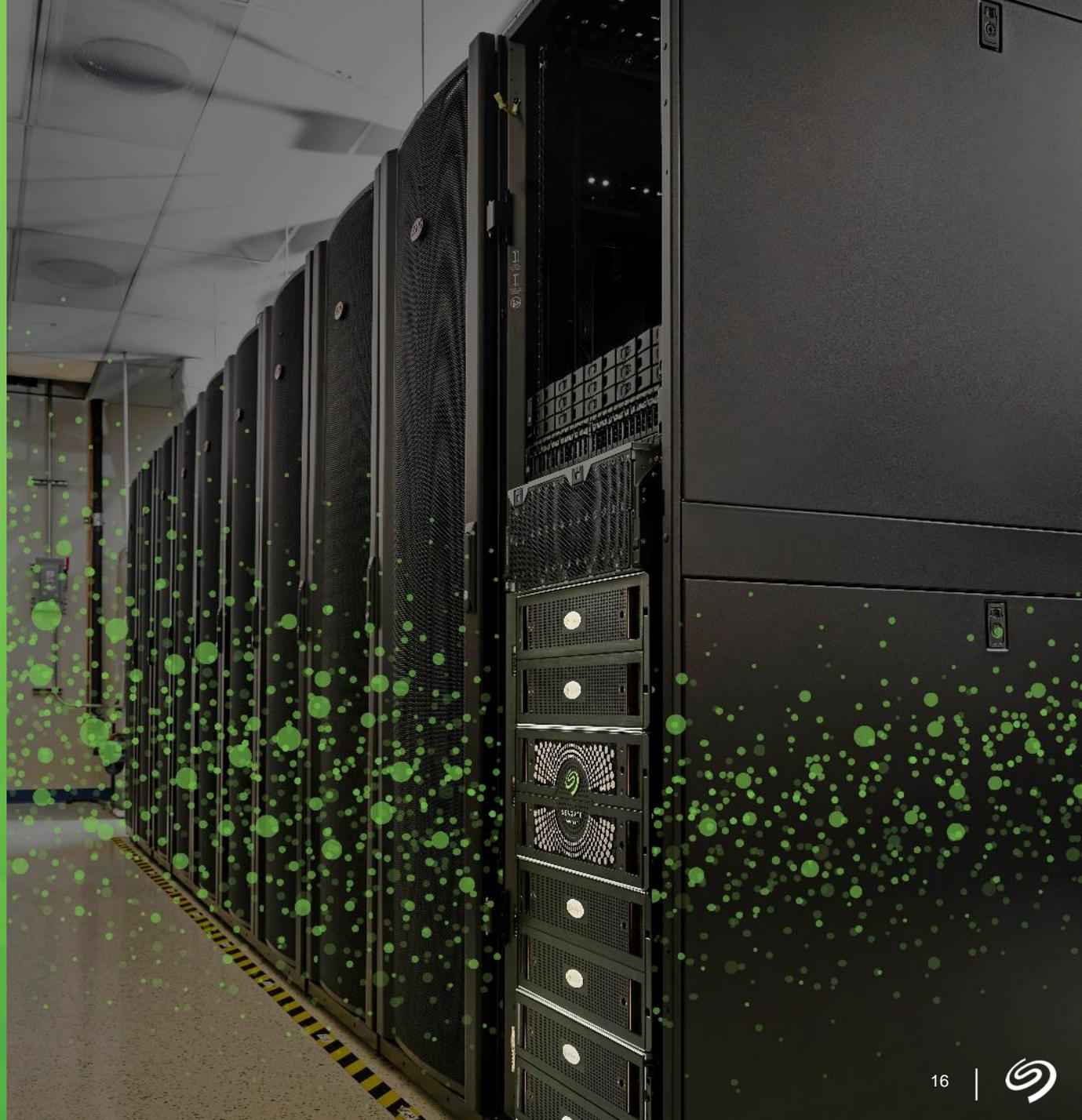


# Product Deployment Strategy



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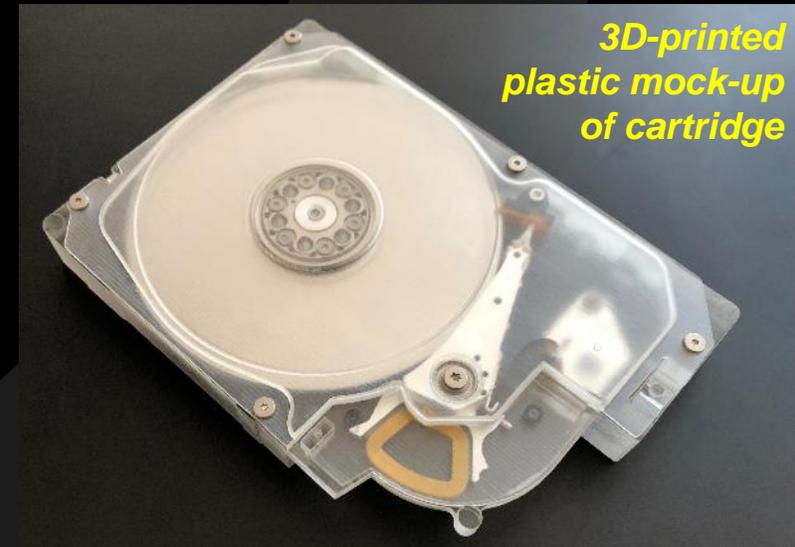
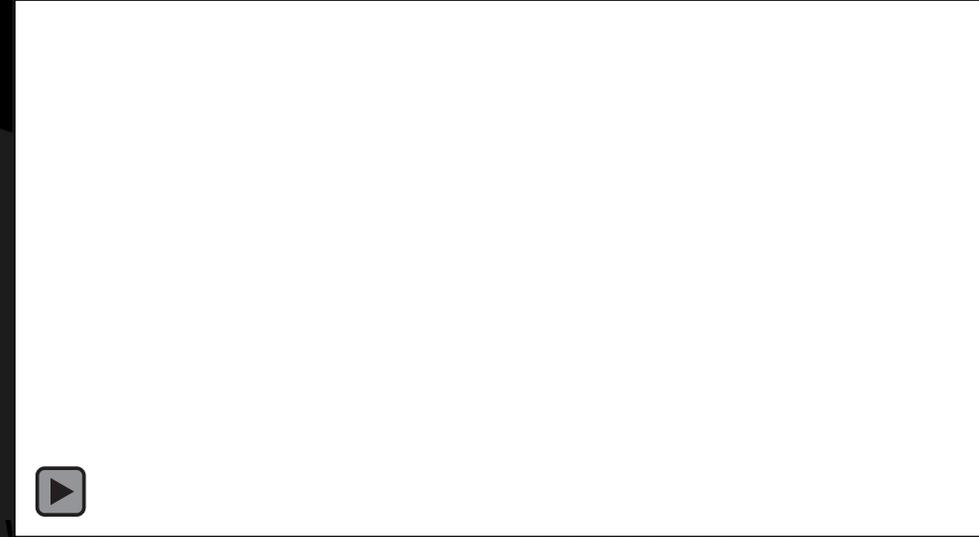
# Future Technology



# HDD Cartridge Storage

## Cartridge Storage Concept:

- Seagate is researching cartridge-based HDDs
- Design Goals:
  - lower the cost of HDD-based archives
    - Include only essential components
  - long shelf life
- Cartridges will have similar capacity to HDDs, but lower performance
- We are looking for partners to sponsor this development



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# Conclusion



## Summary

- Data storage demand remains strong and exceeds current supply
- New HDD storage technologies should emerge during the next year
- Dual-actuator drives are emerging to help utilize these new technologies
- Seagate is actively researching ways to reduce cold data storage costs

