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# HGST latest technology update: New Enterprise SSD, HDD & JBOD solutions

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# Forward-Looking Statements

## *Safe Harbor / Disclaimers*

This presentation contains forward-looking statements that involve risks and uncertainties, including, but not limited to, statements regarding our product and technology positioning, the anticipated benefits of the integration of HGST and SanDisk into our company, market trends, business strategy and growth opportunities. Forward-looking statements should not be read as a guarantee of future performance or results, and will not necessarily be accurate indications of the times at, or by, which such performance or results will be achieved, if at all. Forward-looking statements are subject to risks and uncertainties that could cause actual performance or results to differ materially from those expressed in or suggested by the forward-looking statements.

Additional key risks and uncertainties include the impact of continued uncertainty and volatility in global economic conditions; actions by competitors; difficulties associated with the integration of SanDisk and HGST into our company; business conditions; growth in our markets; and pricing trends and fluctuations in average selling prices. More information about the other risks and uncertainties that could affect our business are listed in our filings with the Securities and Exchange Commission (the "SEC") and available on the SEC's website at [www.sec.gov](http://www.sec.gov), including our most recently filed periodic report, to which your attention is directed. We do not undertake any obligation to publicly update or revise any forward-looking statement, whether as a result of new information, future developments or otherwise, except as otherwise required by law.

[This presentation contains financial measures defined as non-GAAP. The non-GAAP measures are used by the company's management to forecast, evaluate and review the financial results of the company. Management believes these non-GAAP financial measures are useful because they provide meaningful comparisons to prior periods and exclude certain items that may not be indicative of the underlying performance of the company's business. These non-GAAP financial measures should be used in addition to, and in conjunction with, results presented in accordance with GAAP to better understand the company's financial performance. Non-GAAP measures are not in accordance with, or an alternative for, measures prepared in accordance with GAAP and may be different from non-GAAP measures used by other companies.] <sup>1</sup>

<sup>1</sup> This disclaimer and the corresponding Appendix on pages 34 and 35 of this presentation are required to be included in a presentation that includes any of the following slides: 30 - 33

# Business Overview



# The Evolving Role of Data

*Creating the data-driven economy*



## Data as a Record



## Data as Communication



## Data as Efficiency



## Data as Currency



Value

# Diverse and Connected Data Types

*Tight coupling between Big Data and Fast Data*



## Big Data

Discover



Prediction



Prescription



Scale

## Fast Data

Mobility



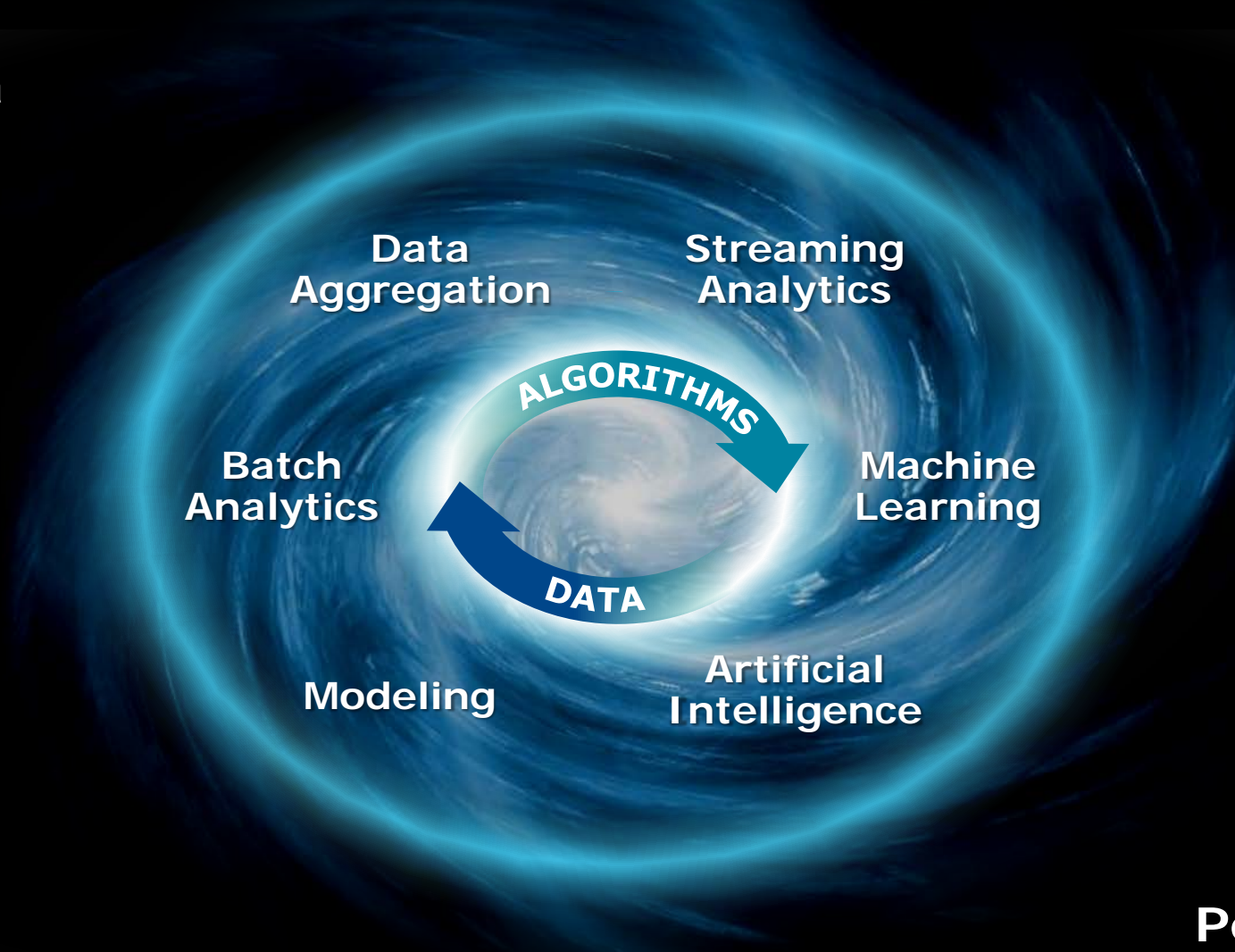
Real-time Results



Smart Machines



Performance

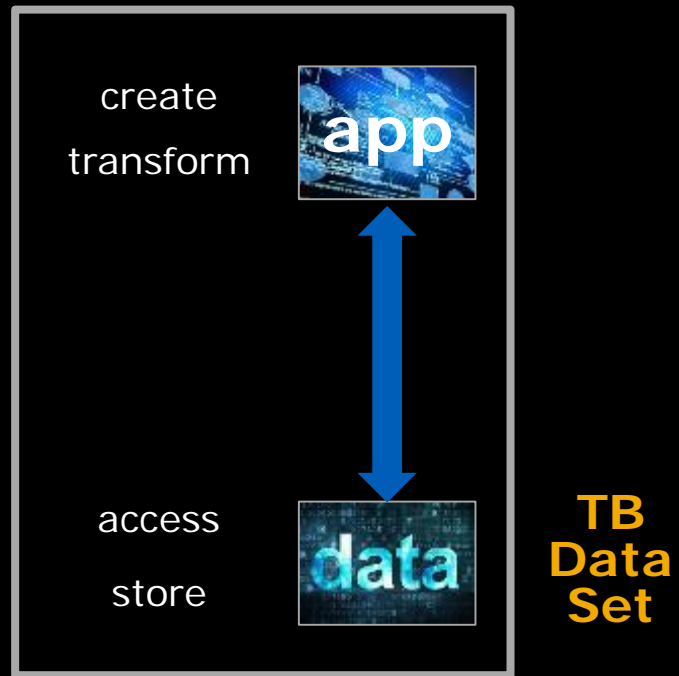


# The Changing Nature of Data Interaction



## Past

Data Held Captive by Single Application



## Current and Future

Data Pooled and Shared by Multiple Applications



# Company Profile



# Industry Leading Combination

- Integrated company supported by the best brands in data storage

A graphic showing the Western Digital logo at the top, with two arrows (one blue, one black) pointing towards the HGST logo. Below the Western Digital logo is the text 'Powerful Platform' and 'Rich Heritage'. At the bottom left is the SanDisk logo, and at the bottom right is the HGST logo. The background is a gradient from blue at the top to grey at the bottom.

**Western Digital**<sup>®</sup>

Powerful Platform

Rich Heritage

**WD**<sup>®</sup>

**SanDisk**

**H G**  
**S T**

We **are** storage.

In 1956, we invented the world's first hard drive.

We didn't stop there.

Today, HGST innovates at every level of the storage stack – from the fastest solid-state drives to the densest storage systems on the planet.

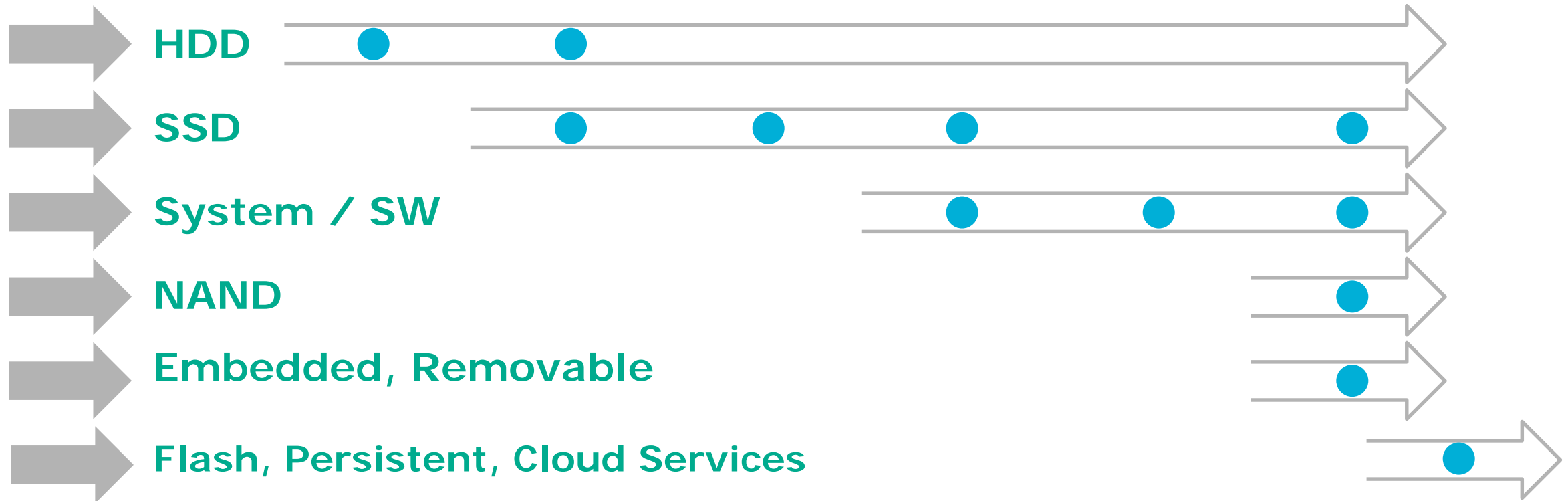


## *A Data Storage Solutions Leader*

- In a strong strategic position to lead global evolution of broad-based and changing storage industry
- Broad storage portfolio, including HDDs, SSDs, embedded and removable flash memory, and storage-related systems
- 13,500+ active patents worldwide
- Vertically integrated business model to maximize operational efficiency
- Consistent profitable performance, strong free cash flow



# Acquisitions for Storage Technology Breadth ...



... and Strategic Investments

**Western Digital®**  
Capital

# Broadest Portfolio of Products & Solutions

## Client Solutions



## Client Devices



## Data Center Devices & Solutions



Western Digital®

SanDisk®

WD®

HGST

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# Delivering the Possibilities of Data



Home

City

Medical

Industrial

Autonomous Vehicles

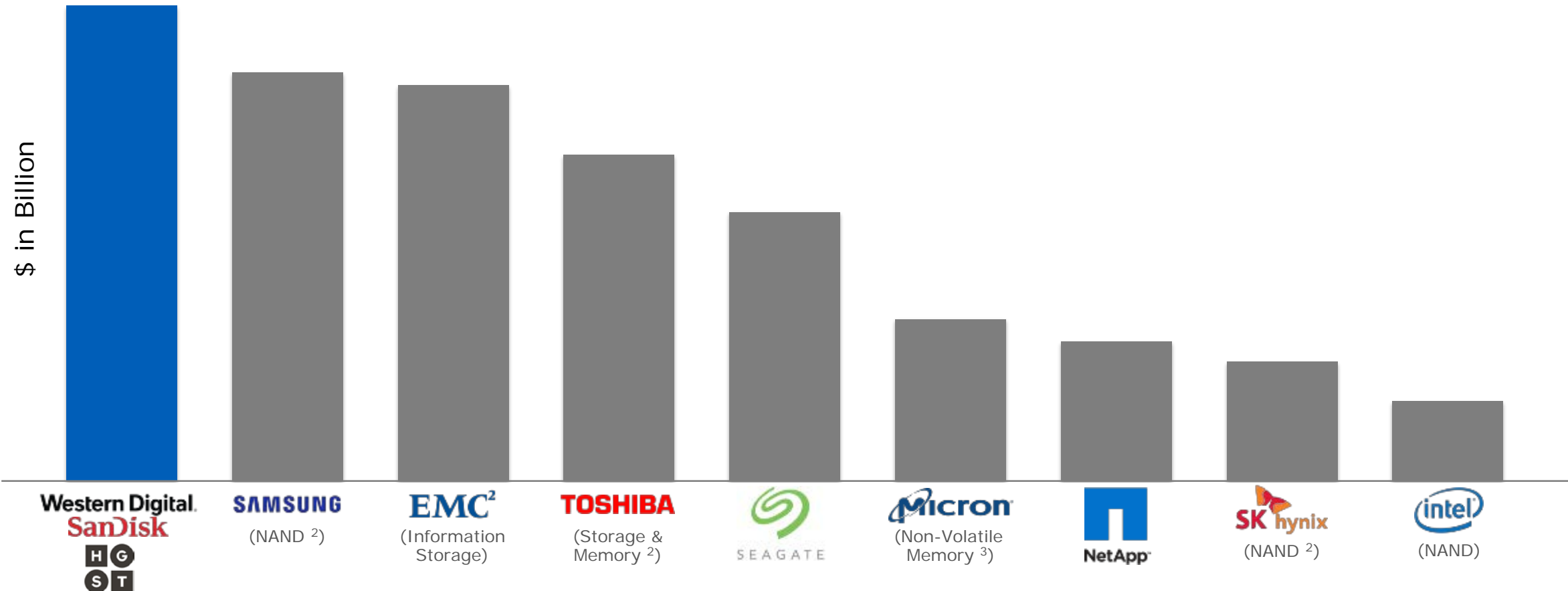
Machine Learning

Mobile

# Global Leader in Storage Technology



## LTM Revenue<sup>1</sup>



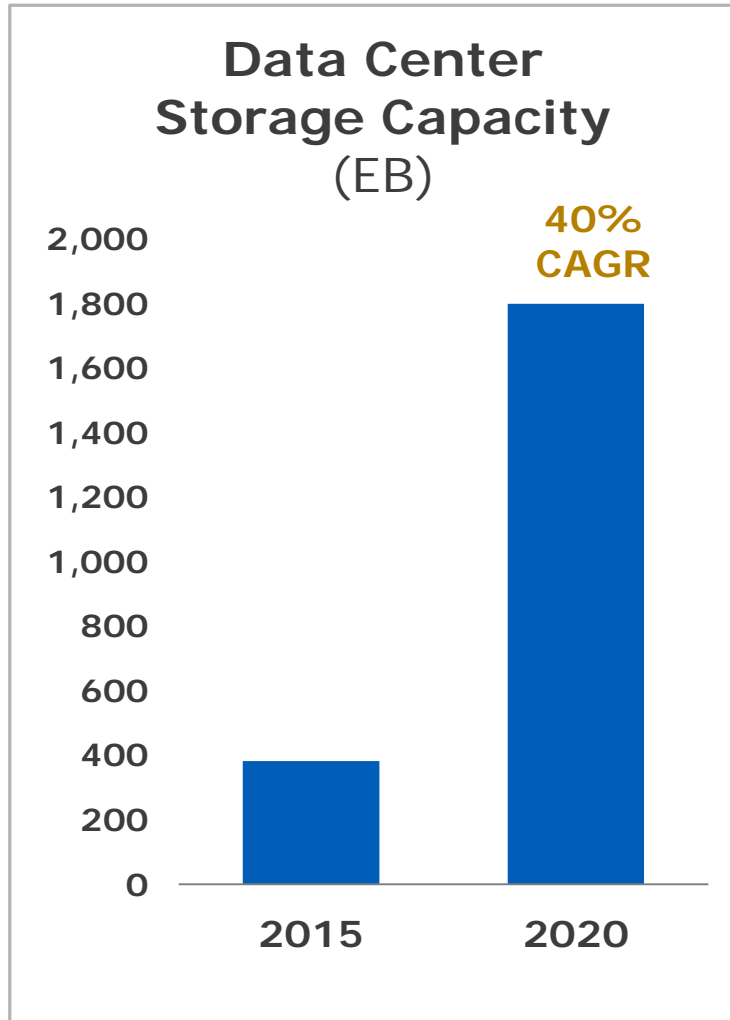
Sources: Company websites; SEC and other public filings; Wall St. analyst reports; S&P Capital IQ

<sup>1</sup> Last 12 months (or LTM) ending June 30, 2017 for WDC, Samsung, Toshiba, Seagate, Micron and SK Hynix; ending Jul 28, 2017 for NetApp; ending Jul 1, 2017 for Intel; and ending Jun 30, 2016 for EMC (Post Dell acquisition, EMC sales numbers not available)

<sup>2</sup> For the LTM, Toshiba revenue converted to USD at an average exchange rate of 109.14 JPY/USD; Samsung and SK Hynix revenue converted to USD at an average exchange rate of 1140.58 KRW/USD (for the period Jul 1 2016 – Jun 30, 2017)

<sup>3</sup> Includes Non-Volatile Memory (Trade and Non-Trade) and Other

# Data Center Market Dynamics



**Big Data Storage Capacity Grows to 240EB**  
(58% CAGR to 2020)



**Streaming Analytics TAM Grows to \$13.7B**  
(35% CAGR to 2020)

Source: WDC estimates; Global Cloud Index: Forecast and Methodology 2015-2020, Cisco, 2016; MarketsandMarkets, 2016

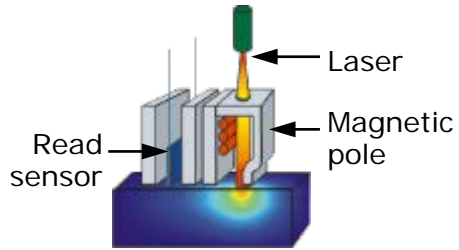
# Innovative Technologies

Advancing NVM & HDD

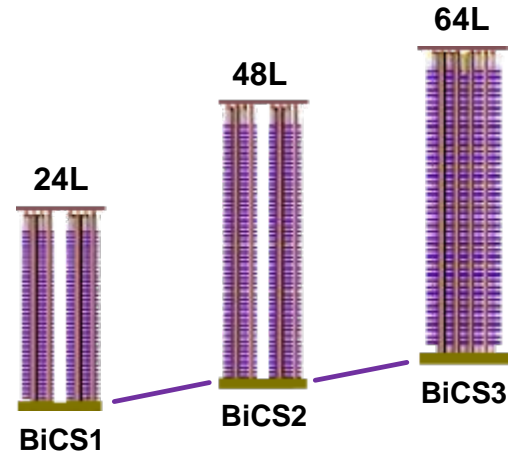


World's first 64-layer 3D NAND architecture

**HAMR**  
Laser + Magnetic Head



4<sup>th</sup> Generation  
Helium technology



**TDMR**  
Two-head small offset configuration

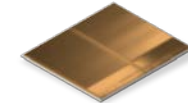


Released first **SMR** product  
Ultrastar® Ha10 in 2015



Write 'over-lapping' data tracks

World's **smallest**  
15nm 2D NAND die



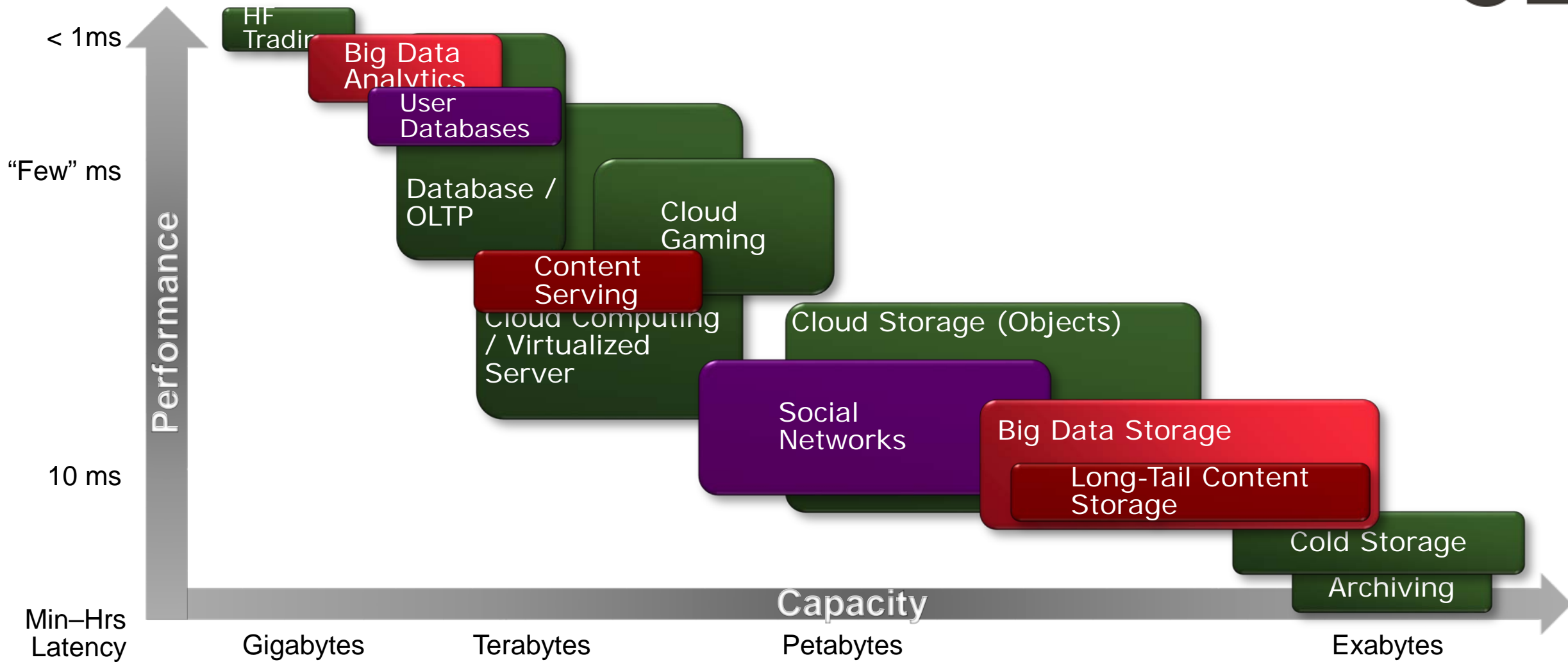


# Products update



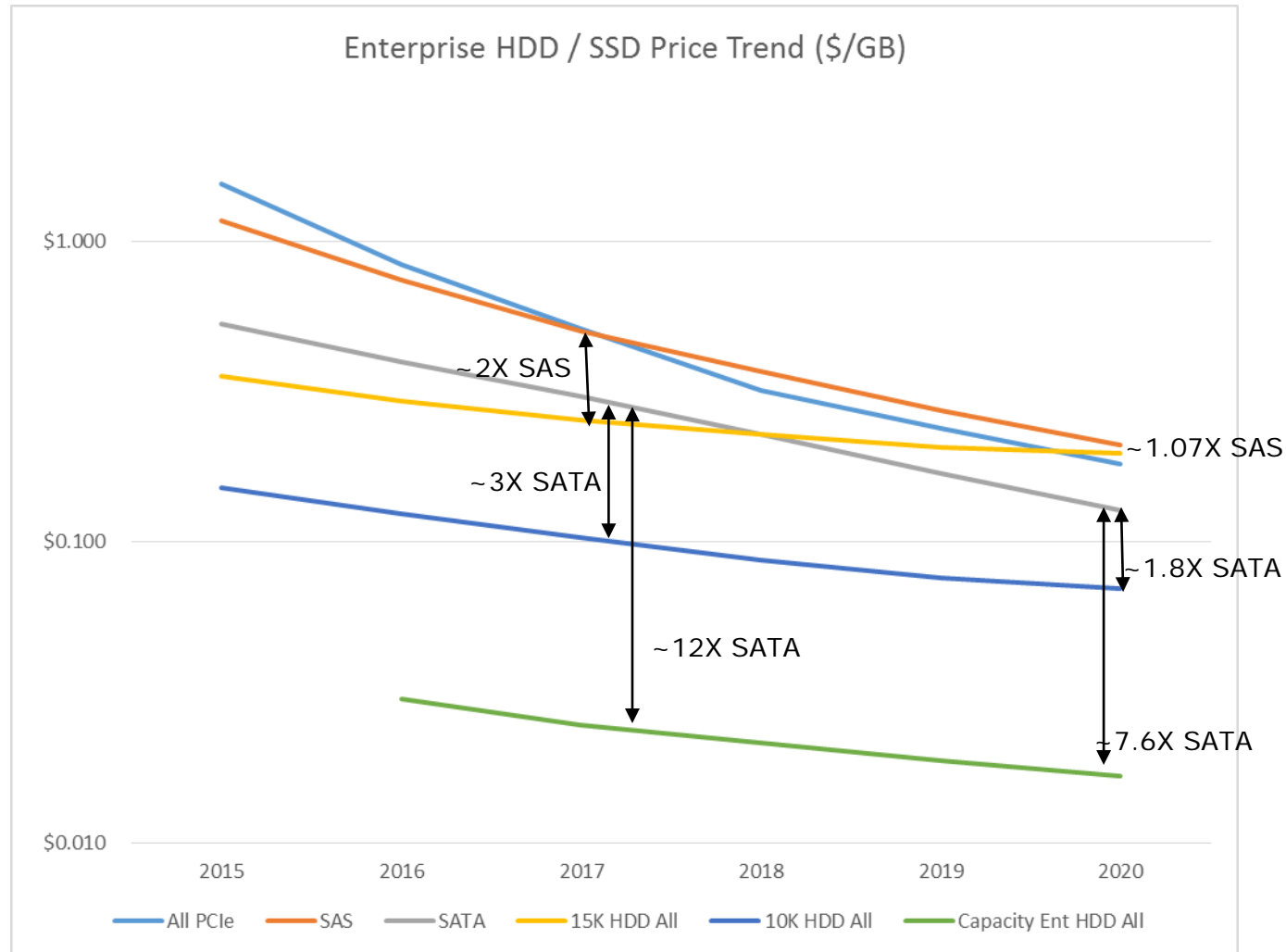


# Many Applications – more expectations



# Performance Enterprise

# Performance HDD & SSD Price Trend (IDC)



Source: IDC eSSD Long Term Forecast May 2016, IDC 4Q Forecast Sep 2016, IDC May 2016 HDD IDC forecast

- Capacity enterprise HDD continues to be a growth segment; no SSD replacements expected in this segment
- Expect pure-play storage customers to transition completely to SSDs by 2018/2019
- Expect OEM server customers to maintain a healthy requirements for Performance HDDs through 2019 and beyond
- PCIe segment shown includes both Perf PCIe and Essential PCIe

# End-to-End Storage

Performance Enterprise Portfolio



## 15K RPM

Ultrastar® C15K600  
600GB



World's fastest hard drive



## 10K RPM

Ultrastar® C10K1800  
1.8TB



Industry's highest 10K capacity

Highest  
Performance

Highest  
Capacity



Highest Reliability



Technology Innovation



Security Encryption



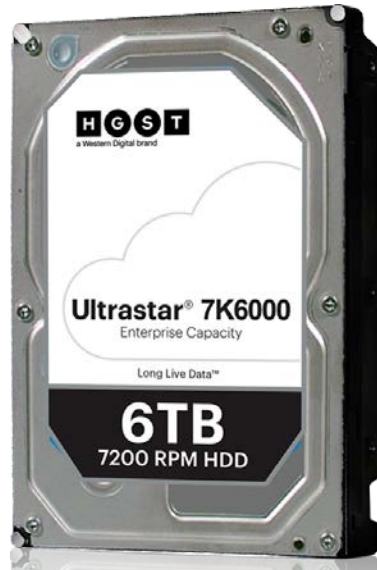
12Gb/s SAS



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# Capacity enterprise / Nearline


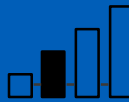
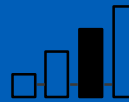
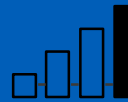






# End-to-End Storage



**2,5M MTBF -  
INDUSTRY THE  
BEST**



**SMR**  
SHINGLED MAGNETIC  
RECORDING

 <b>Entry Level</b>	 <b>Lower Capacities</b>	 <b>High Capacity</b>	 <b>Active Archive</b>
 Legacy Longevity	 Highest IOPS/TB	 Highest Reliability  Best TCO  Lowest Power	 Lowest \$/TB

# World's Highest Capacity HDD

*Helium Advantages Rise Above the Rest*



## Highest Capacity HDD

12TB



## Lower Power\*

Watts/TB



## More Reliable\*

2.5M hours MTBF rating



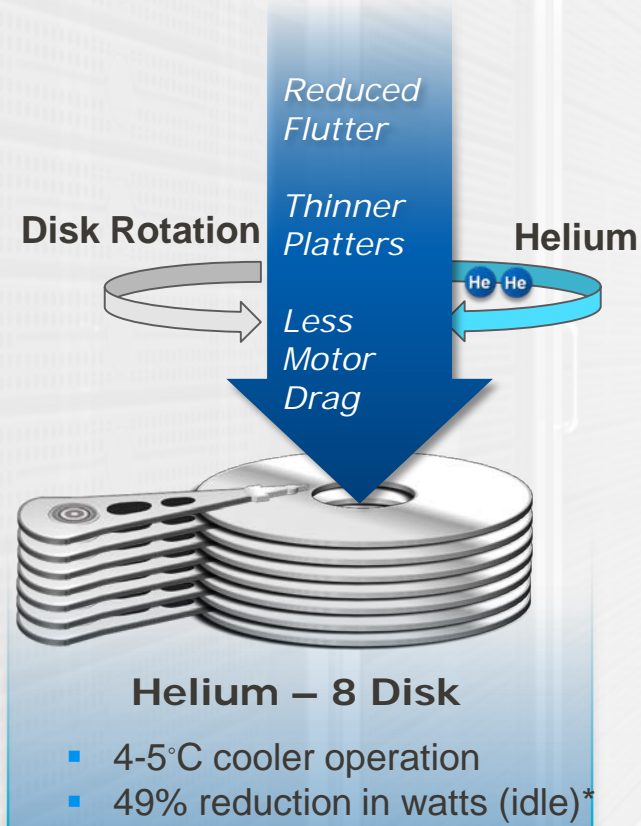
50%  
More capacity\*

54%  
Less power\*

25%  
More reliable\*

\* vs. 8TB air drives as of 12/6

# HelioSeal<sup>®</sup> HDDs: Years Later



- > Few million helium HDDs deployed
  - 1<sup>st</sup> gen He<sup>6</sup> shipping in volume
  - 2<sup>nd</sup> gen He<sup>8</sup> in mass adoption
  - 3<sup>rd</sup> generation shipping
  - 4<sup>th</sup> generation up to 12TB
- Mass market acceptance
  - Deployed in world's largest data centers
  - TCO benefits proven
  - Demonstrated reliability  
NEW! 2.5M hrs MTBF rating\*\*
- Demand continues to scale

\* Per TB

\*\* 2.5M hours to be demonstrated through ALORT after LVM





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# Ultrastar SS200 (Odyssey)

# Leading NAND Flash Product Manufacturing Capability



## Yokkaichi, Japan

**JV with Toshiba produces  
40% of industry bit output**

3D NAND product sales begin  
in 2016

2.8M wafers/year

> 500 SanDisk engineers



## Penang, Malaysia

**Industry-first integrated  
SSD manufacturing  
facility**

From wafer to finished drive

Volume production started in  
2015

- SSD manufacturing starts from wafer to finished drive
  - Different NAND quality levels, depending on the location in the wafer
  - Choose higher/lower quality parts of the wafer for higher/lower endurance SSDs
  - Ensure each drive has right mix of grades
  - Direct feedback loop from manufacturing database into R&D and test teams

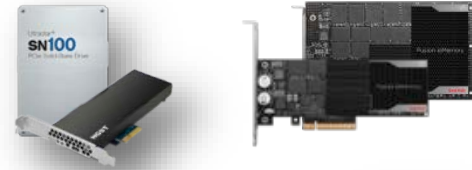
# HGST/SNDK Covers ALL Workloads



Write Intensive

DWPD > 10

Caching  
In-Memory Compute



Mix Use

2 < DWPD < 3

Search  
OLTP  
VDI & Virtualization



Read Intensive

0.5 < DWPD < 1

Exchange Server  
Image Retrieval  
Analytics  
Web Search  
VOD/Media Streaming



Very Read Intensive

DWPD < 0.5

Data Warehouse  
Web Server Logs  
Content Repository



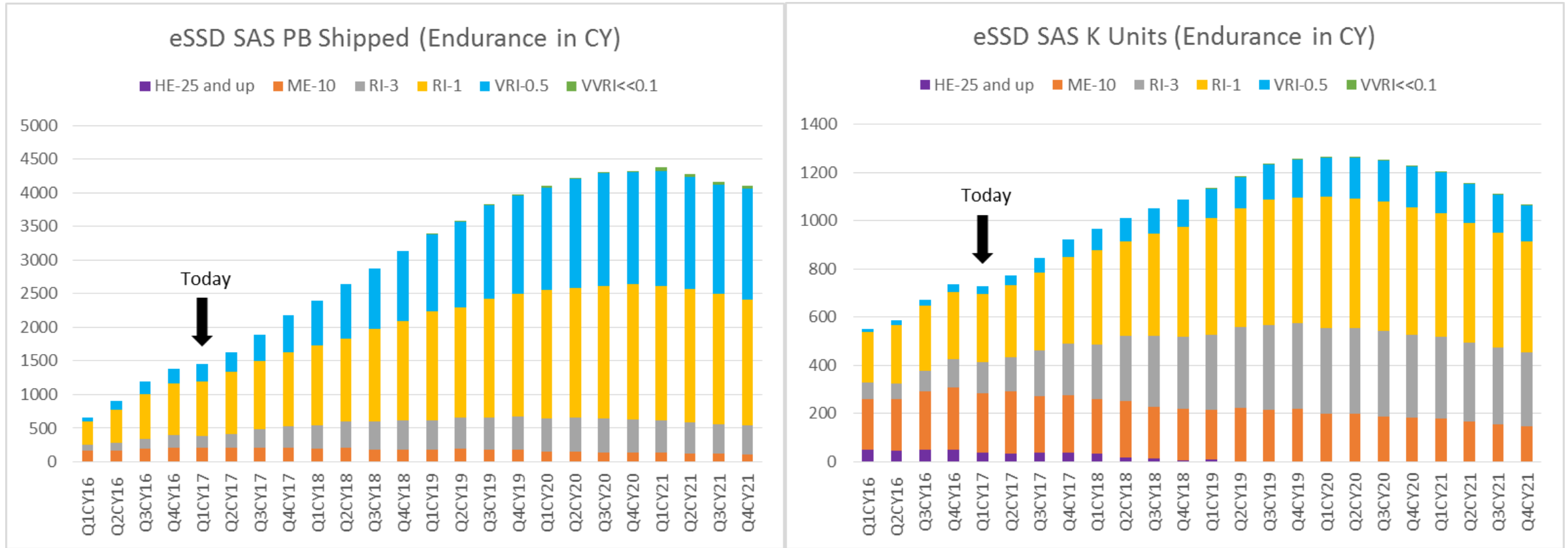
Commercial

Laptops Desktops  
Commercial  
Embedded  
Server Boot



# Enterprise SAS SSD Mix – Endurance

Market Trends towards Lower Endurance SSDs



Source: WDC eSSD Market Model Jan 2017

- VRI: Very Read Intensive (<1 DWPD)
- RI: Read Intensive (1 DWPD)
- RI-3: Read Intensive (3 DWPD)
- ME: Mixed Endurance (10 DWPD)
- HE: High Endurance (25 DWPD)

# HGST Ultrastar® SS200 Series



## SAS Solid State Drives



SAS 12Gbps  
2.5-inch SFF

Raising the bar on performance  
and capacity for HGST SAS SSDs

### Guardian Technology™

Features Guardian Technology implementation delivering enterprise-class reliability to 12G SAS SSDs

## 7.68TB

Expands HGST SAS Portfolio to 7.68 TB @ 1 DWD endurance  
3.2TB @ 3 DWD has been added for offer with HGST 2U24 platform

## 250K

Exceptional **Read Performance** at up to 1800MB/s and 250K 4kiB random Read IOPS

## 1,000MB/s

High **Write Performance** for this endurance class at up to 1,000 MB/s in sequential writes and 37K 4kiB random IOPS



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# SN200 Series Overview

## NVMe PCIe SSD

# HGST Ultrastar™ SN200 Series

## NVMe PCIe SSD



### 2nd Gen

2<sup>nd</sup> Gen NVMe - 2x the capacity and 2x the AIC read performance (6.1GB/s vs 3.0GB/s) vs. SN100

### 7.68TB

Industry's highest capacity NVMe SSD in 2.5" and HH-HL

### 1.2M

Industry's highest performance in 4K Random Reads up to 1.2 million IOPS

### 560K

Exceptional in mixed workloads (4K 70/30) up to 560K 4KiB IOPS

*Ultrastar™ SN200 Series NVMe PCIe SSD*

"Sampling and GA Q2-2017"



# HGST Ultrastar™ SN260



SN260 Leverages **PCIe 3.0 x8** architecture to deliver industry leading 7.68TB capacity and best in class performance



## Features

- ✓ Faster: 3X Latency improvement in 99.99 4K 70/30 Workload over SN150
- ✓ Lower TCO: **2x Performance & 2x Capacity at the same power of SN150**
- ✓ Ease of Use: Inbox Driver Support for Windows, Linux, & VMware Environments
- ✓ Flexible: Power States 25W, 20W, 14W, Idle 11W
- ✓ Secure: End-to-end data protection, Secure FW Update
- ✓ Reliable: UBER  $1^{18}$ , MTBF 2M
- ✓ NVMe 1.2, NVMe-MI, 128 Namespaces

AIC	3 DWD	1 DWD
Capacity	1.6TB,3.2TB 6.4TB	1.92TB,3.84TB 7.68TB
Random Read 4K	<b>1.2M</b>	<b>1.2M</b>
Random Write 4K	200K	75K
Random Mixed 4K 70/30	560K	270K
Sequential Read	<b>6.1GB/s</b>	<b>6.1GB/s</b>
Sequential Write	2.2GB/s	2.2GB/s

Performance data based on ES FW final results may change



# HGST Ultrastar™ SN200



The SN200 PCIe 3.0 U.2 architecture delivers industry leading 7.68TB capacity and Dual Port capability



U.2	3 DWD	1 DWD
Capacity 1x4, 2x2	800GB, 1.6TB 3.2TB, 6.4TB	960GB, 1.92TB 3.84TB, 7.68TB
Random Read 4K	Up to 830K	Up to 830K
Random Write 4K	Up to 200K	Up to 75K
Random Mixed 4K 70/30	Up to 560K	Up to 240K
Sequential Read	<b>3.2GB/s</b>	<b>3.2GB/s</b>
Sequential Write	2.2GB/s	2.2GB/s

## Features

- ✓ **Dual Port (2x2)**
- ✓ Scatter Gather List (SGL)
- ✓ NVMe 1.2, NVMe-MI Support
- ✓ 128 Namespaces
- ✓ Secure FW Update
- ✓ Power States 25W,20W,14W,11W
- ✓ Inbox Driver Support for Windows, Linux, & VMware Environments

Performance data based on ES FW final results may change





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# HGST Storage Platform

# 4U60 G2 HDD Storage Platform – High Performance IOM

Designed for High-Availability Storage Applications

## JBOD Features

- 4 Rack Units
  - 12Gb/sec SAS3 interconnect
  - 2 x 4 x 4 lanes via **mini SAS** HD connectors
  - 4 ports per IOM, can connect max 4 servers
  - 60 Ultrastar HDD or SSD Modules (**SAS or SATA**)
  - SCSI Enclosure Services (SES-3)
  - High Bandwidth IO-Module Design
  - Remote Management Capability
- Enterprise-class High Availability
    - Hot swappable components: HDDs, IOM, PSU (Fans Integrated)
    - Redundant IOMs for fail-over
  - Low Power Helium and Air Models for Energy Savings
  - Excellent thermal Specification for high Reliability
  - High Vibration Robustness for stable Application Performance



Available in

**720TB**

600TB

480TB

360TB

capacities

Also 24-HDD

**288TB**

240TB

192TB

144TB

capacities

# 2U24 All-Flash Storage Platform

## Overview

*Designed for balanced TB/Host software-defined storage*

Available with  
7.68TB SAS  
3.84TB SAS  
1.92TB SATA  
960GB SATA



### • Platform Features

- 2 rack units
- Up to six 12Gb/s SAS3 connections to host
- Up to 24 Ultrastar® SS200 Series SSD modules (SAS)
- Up to 24 CloudSpeed Eco™ Gen. II SSD modules (SATA)
  - Minimum 12 – upgrade one additional module at a time
- Up to 4.7M IOPS, 23 GB/s; <1ms latency
- Easy maintenance of SSD modules
  - Front accessible & hot-swappable

### • Enterprise-class High Availability

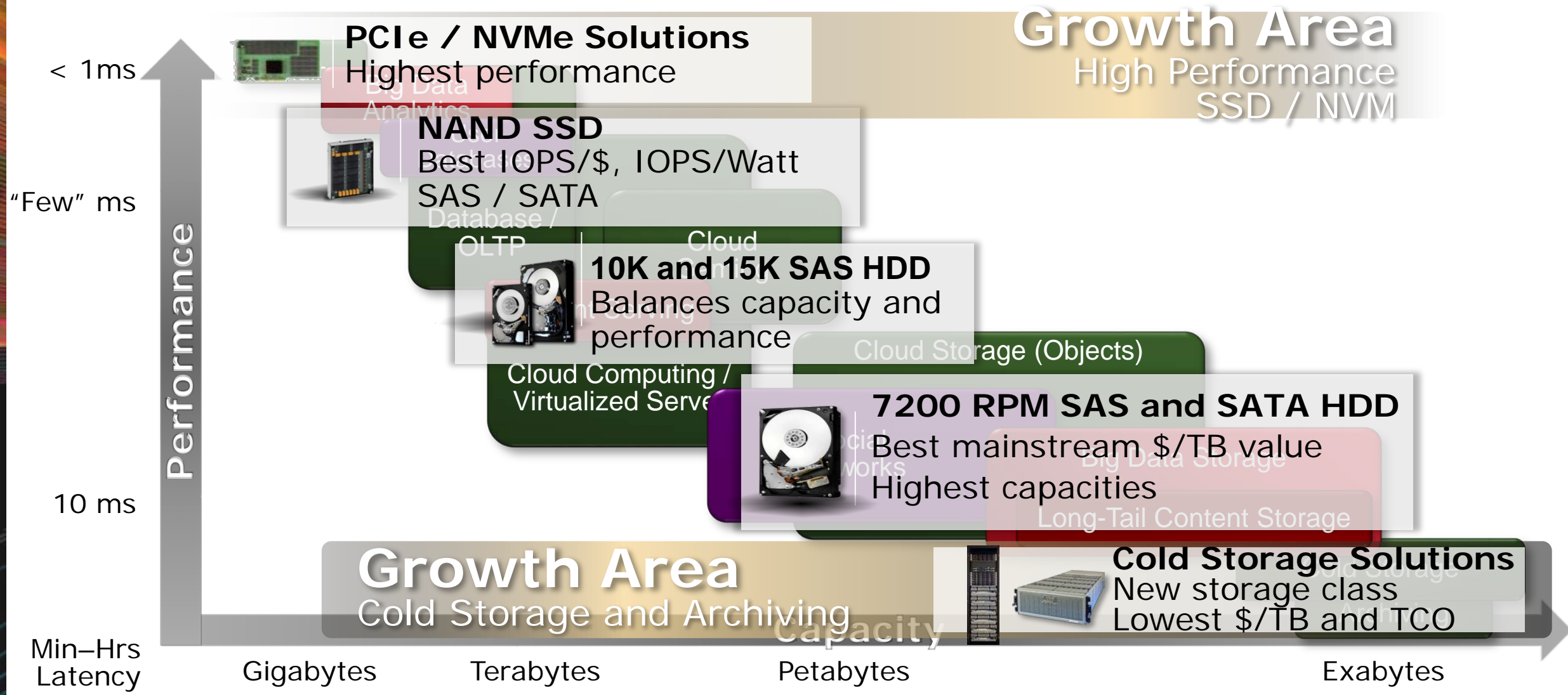
- Hot swappable components: SSDs, IOM, PSU (integrated fans)
- Redundant IOMs for fail-over

### • Fully Upgradeable

- Enclosure includes upgradeable firmware enabling HGST to deliver new innovations and higher capacity drives without impacting your applications

# Warranty and Support

	4U60	2U24 All-Flash Platform
<b>Warranty</b>		
SSD	Earlier of 5 years or $\leq 1\%$ endurance remaining	Earlier of 5 years or $\leq 1\%$ endurance remaining
HDD	5 years	5 years
Enclosure	5 years	5 years
<b>Support</b>		
FRU/CRU RMA Replacement on Receipt	Yes	Yes
M-F Business Hours	Yes	Yes
<b>Fee-based Services</b>		
Advance Replacement Option	Yes	Yes
No Return Option	Yes	Yes



Source: HGST analysis

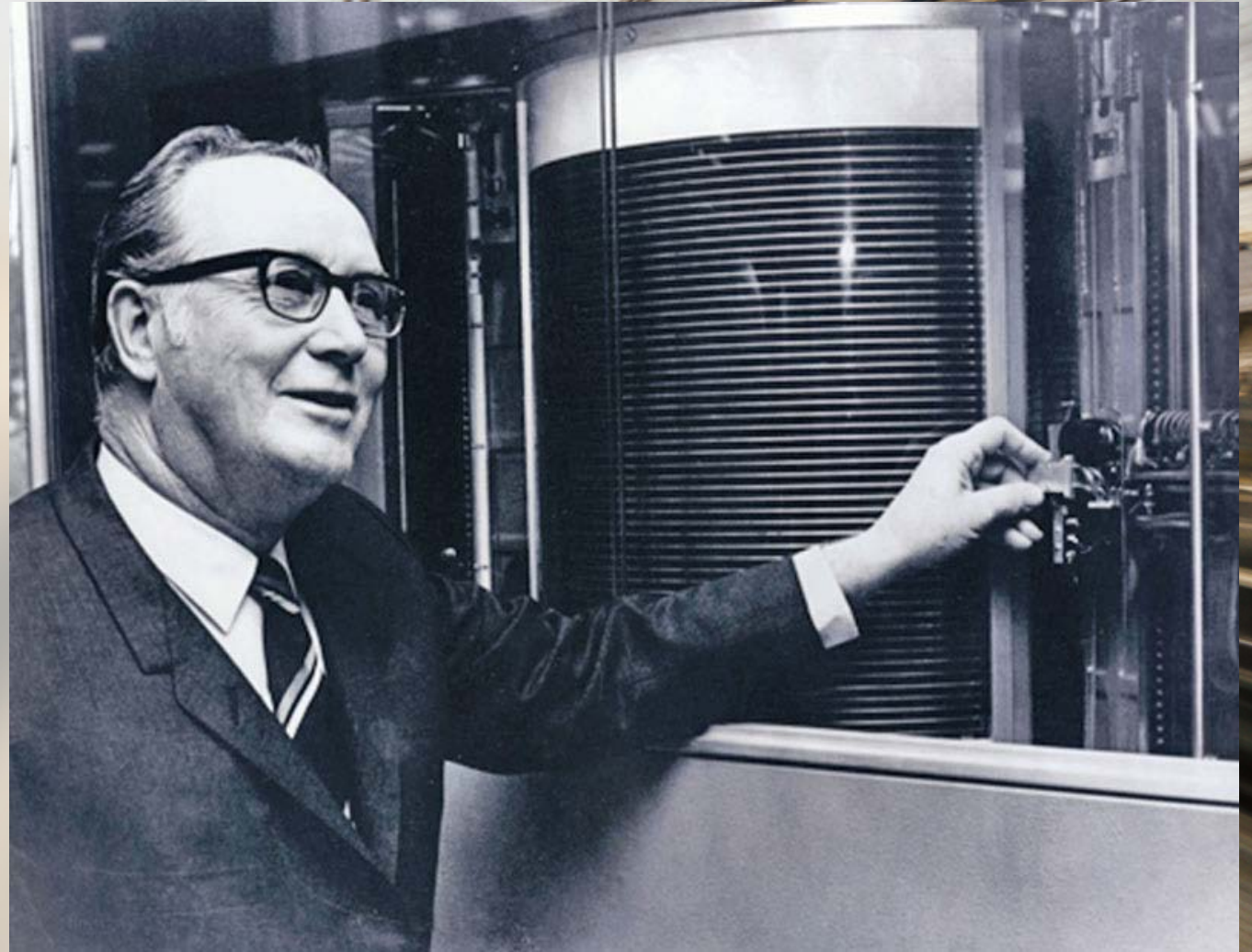
# Why HGST?



HGST has a direct line of expertise going back to the first hard drives

**more than 60  
years of  
enterprise  
HDD  
experience**

IBM's Rey Johnson in front of a RAMAC  
350 Disk File in 1956





# HGST at the heart of CERN



3D view photo of the LHC  
Machine © 2012 CERN

"As one of the largest hard disk manufacturers for enterprise, HGST plays an important role in providing CERN with reliable disk storage media for bulk storage of scientific data."

*Olof Barring*

*Head of facility, planning and procurement*

# HGST - Delivering the possibilities of data

