
TECHNICAL BRIEF

# Continuous Innovation for Highest Capacities and Lower TCO

Prepared by:
Western Digital

Hard Disk Drives (HDDs) remain the foundation of the data center and will continue to be the dominant storage media for the foreseeable future. Cloud-based workloads continue to drive demand for capacity-optimized HDDs that support the growing data needs of cloud and hyperscale storage, massive scale-out high density data centers, content delivery networks, commerce and XaaS. Cloud service provider business models rely on continued HDD capacity increases to efficiently meet data center storage density requirements as data growth increases.

For nearly 50 years, Western Digital has enabled the data revolution by innovating a variety of technologies to grow HDD capacity on a regular cadence, meeting this increasing demand. IDC estimates that the amount of data created by endpoints, the edge and at the core will reach 143 zettabytes by 2024[1].

To meet the requirements of this Zettabyte Age, new HDD technologies will be required to expand the amount of data in the data center while lowering the system-level Total Cost of Ownership (TCO).

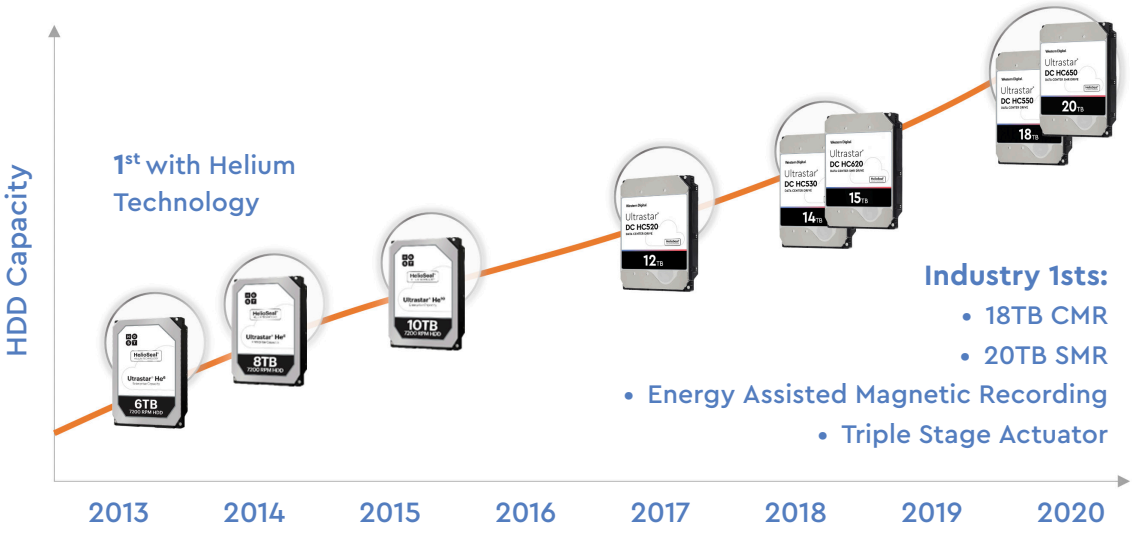


Figure 1: Ultrastar helium-filled HDDs

A data center HDD is a complex piece of hardware and software with nearly 300 components and more than a million lines of software code. It is a technically sophisticated system with multiple interdependent technologies working together to deliver high capacity data storage, performance and reliability.

The Ultrastar® DC HC550 18TB CMR HDD and Ultrastar DC HC650 20TB SMR HDD are the first HDDs to achieve these industry-leading capacities and result from Western Digital's areal density leadership. These drives increase the number of Tracks per Inch (TPI) as well as increase Bits per Inch (BPI) to write even more data per platter over prior generation products.

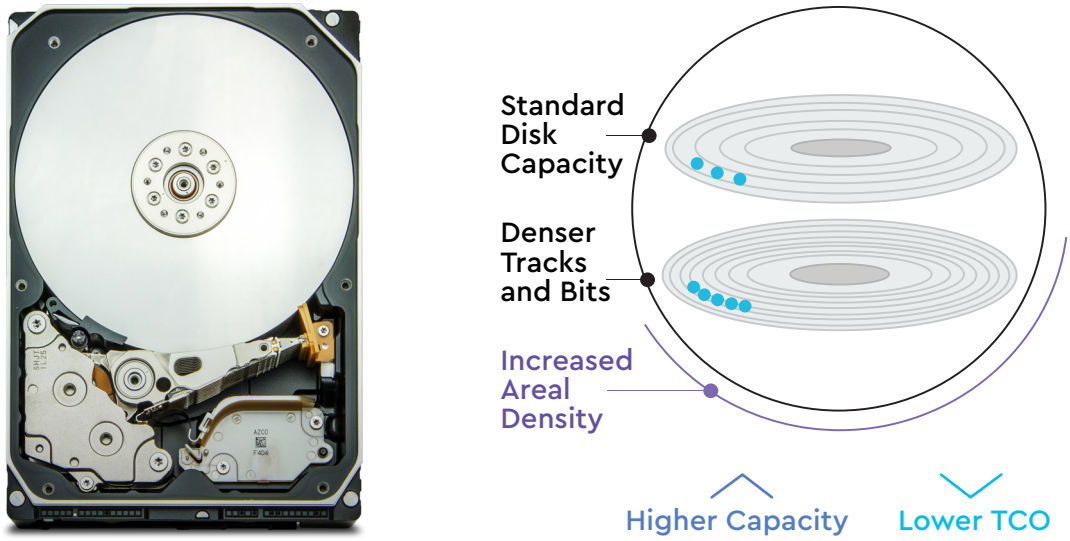


Figure 2: Areal density benefits

The Ultrastar DC HC550 18TB CMR HDD and Ultrastar DC HC650 20TB SMR HDD introduce the industry's first Energy-Assisted Magnetic Recording (EAMR) technology and the industry's first Triple Stage Actuator (TSA). These technologies are integrated with foundational HelioSeal® technology. Western Digital's Shingled Magnetic Recording (SMR) technology achieves the highest capacity point at 20TB. These are, individually, leadership technologies but when combined and integrated they deliver the industry's highest capacity data center HDDs.

## Energy-Assisted Magnetic Recording

Western Digital's 18TB and 20TB HDDs are the industry's first to use EAMR technology to push areal density to 1022 Gbits/in$^2$ for the Ultrastar DC HC550 18TB CMR HDD and 1160 Gbits/in$^2$ for the Ultrastar DC HC650 20TB SMR HDD. Energy-assisted PMR (ePMR) is the first generation of EAMR to scale beyond legacy Perpendicular Magnetic Recording (PMR). ePMR was productized as part of Western Digital's research and characterization of EAMR technologies such as Microwave Assisted Magnetic Recording (MAMR) and Heat Assisted Magnetic Recording (HAMR) technologies.

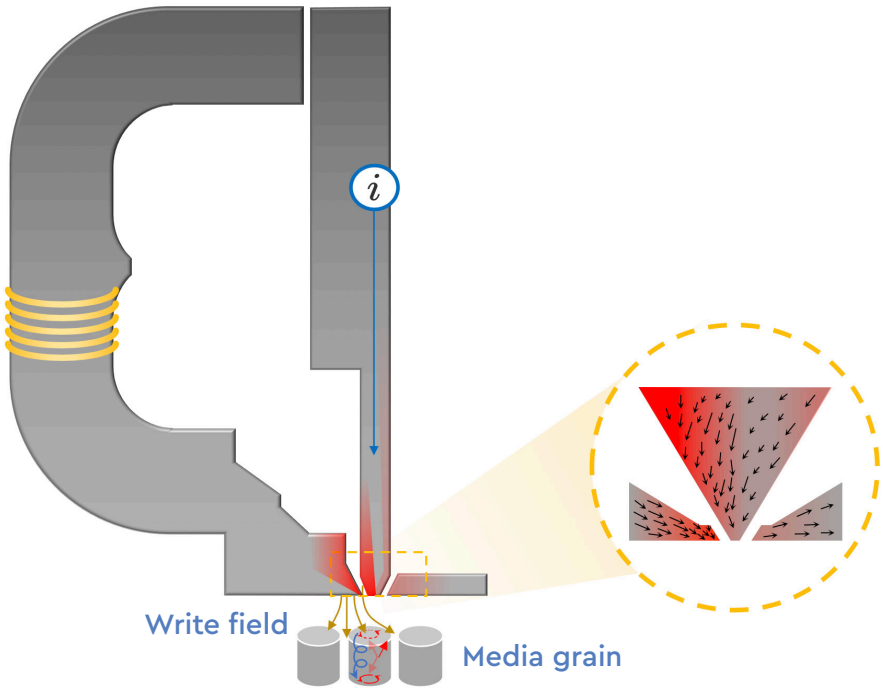


Figure 3: Energy Assisted Magnetic Recording (EAMR) technology

During write operations, recording heads do not reach saturation in a consistent way, and thus provide an inconsistent magnetic field on the media. This produces distortion in write currents, which is characterized as 'jitter'. ePMR applies an electrical current to the main pole of the write head throughout the write operation. This current generates an additional magnetic field which creates a preferred path for the magnetization flip of media bits. This, in turn, produces a more consistent write signal, significantly reducing jitter. When jitter is reduced it is possible to minimize the space between bits written, thus increasing BPI and areal density.

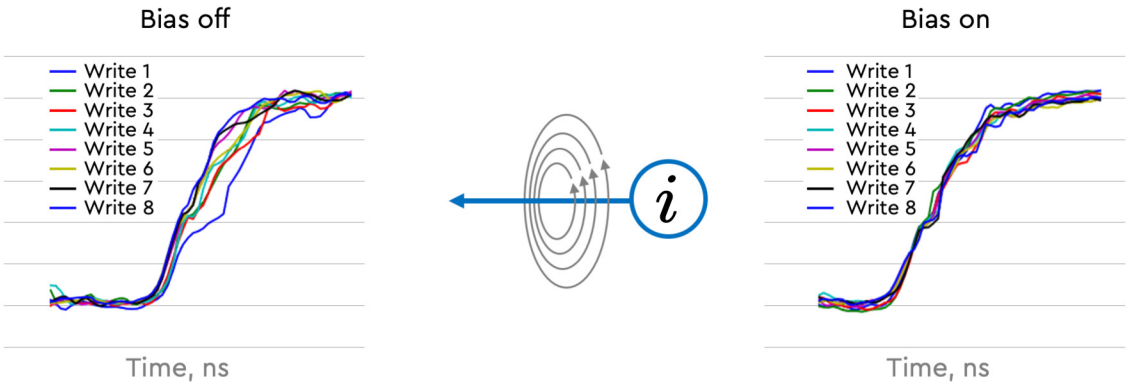


Figure 4: EAMR effect on jitter

## Triple Stage Actuator

Western Digital's 18TB and 20TB HDDs integrate the industry's first TSA onto a 9-disk platform. The TSA makes use of three pivot points: the Voice Coil Motor (VCM) Actuator, the Milliactuator and the Microactuator. Using three pivot points enables a higher bandwidth servo control resulting in a more precise positioning of the head on the track. With greater head position accuracy, tracks can be written closer together for higher TPI and greater areal density, resulting in higher capacity HDDs.

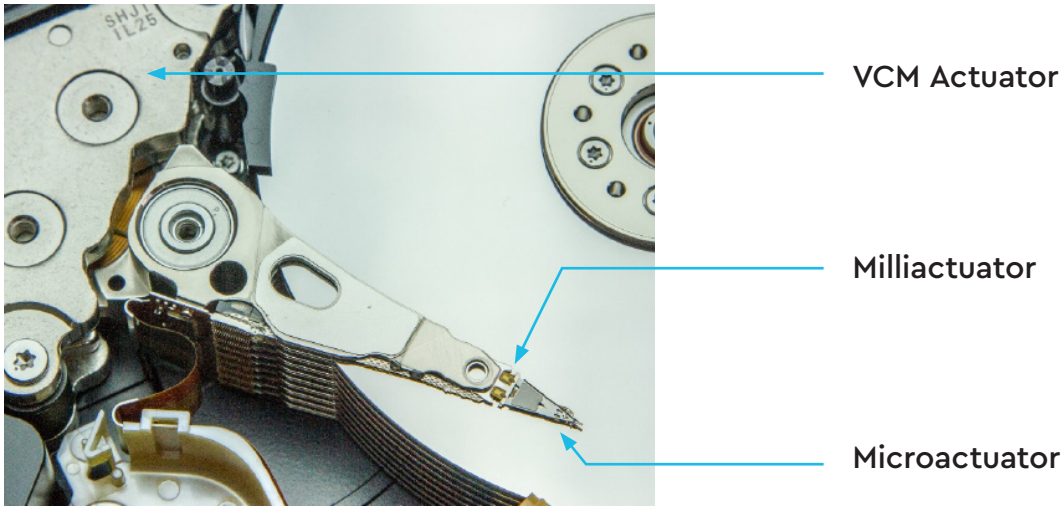


Figure 5: Triple Stage Actuator (TSA)

## HelioSeal Technology

HelioSeal technology is the foundation for Ultrastar high capacity HDDs. Western Digital is the industry leader in helium, having shipped >65 million helium HDDs to-date. The Ultrastar DC HC550 and DC HC650 are Western Digital's 6th generation of product with HelioSeal. HelioSeal provides a less dense atmosphere in the HDD case, virtually eliminating turbulence. This allows read/write mechanisms to track more precisely and reliably over storage media, enabling higher performance, lower power and higher capacity with an increased number of thinner media disks in the enclosure.

## Shingled Magnetic Recording

Shingled Magnetic Recording (SMR) technology enables the highest capacity HDDs. Physically, this is done by writing data sequentially, then overlapping (or "shingling") data with an adjacent track of data. By repeating this process, more data tracks can be placed on each magnetic surface. Once one track has been written, the recording head is advanced by only part of its width, so the next track will partially overwrite the previous one, leaving only a narrow band for reading.

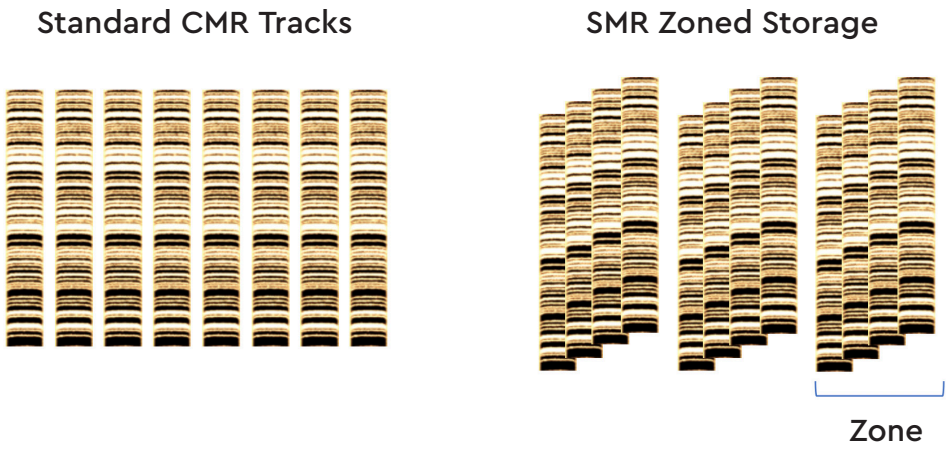


Figure 6: Shingled Magnetic Recording

Overlapping tracks are grouped into bands, called zones, of fixed capacity for more effective data organization and partial update capability. The Ultrastar DC HC650 utilizes Host-Managed SMR, which relies on the host to manage and coalesce write streams within each zone for the capacity advantage compared to conventional data center HDDs. Host-Managed SMR does require application changes to call Linux® libraries to enable data sequentialization of writes to the target zone.

## Summary

The Ultrastar DC HC550 18TB CMR HDD and Ultrastar DC HC650 20TB SMR HDD are delivering industry leading capacity for the data center through a combination of new and proven technologies.

Western Digital is the first to deliver EAMR technology and a TSA. These new technologies combined with further mechanical innovations and HelioSeal technology provide the industry's highest capacities to enable data at scale with optimized TCO for data center architectures, while maintaining workload reliability and performance.

[1] Source: Worldwide Global DataSphere Forecast, 2020–2024: The COVID-19 Data Bump and the Future of Data Growth, April 2020, DOC #US44797920
[2] One terabyte (TB) is equal to one trillion bytes. Actual user capacity may be less due to operating environment.

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