

# A new Advanced Storage Research Consortium HDD Technology Roadmap

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We present a new Advanced Storage Research Consortium (ASRC) HDD Technology Roadmap. Technology leaders from member institutions of ASRC met and agreed on the roadmap presented here. The roadmap extends to the year 2035 and outlines the building blocks needed for future generations of hard disk drives.

**Index Terms**— Hard Disks, Magnetic recording, Roadmaps (technology planning),

## I. INTRODUCTION

WE present a new Advanced Storage Research Consortium (ASRC) Hard Disk Drive (HDD) Technology Roadmap. Members from Technology teams of Western Digital, Seagate, Toshiba, Headway and Showa Denko (all members of ASRC) met between February and April of 2022 and we converged on the roadmap in Figure 1.

The vertical axis corresponds to Areal user bit density, and the horizontal axis is the Technology Readiness Date. The roadmap reflects the fact that we are currently transitioning from PMR+ recording including Two-Dimensional Magnetic Recording (TDMR) and with or without Shingled Magnetic Recording (SMR) to Enhanced-PMR, Microwave Assisted Magnetic Recording (MAMR) and Heat Assisted Magnetic Recording (HAMR). We have technology readiness for Enhanced PMR+ with or without energy assist, including MAMR and over the next 5 years transition to HAMR. Different transitional paths have been reported yet they remain aligned towards higher Areal Density. We have also identified several building block technologies to continue Areal Density (AD) growth beyond 10 Tb/sq.in. into the next decade.

HAMR is the technology we have identified that will push our Areal Density growth beyond 5Tb/sq.in. The rate of this growth is estimated to be around 20% Compound Annual Growth Rate (CAGR). The upper boundary of the arrow labeled “HAMR” in Fig. 1 is at 25% CAGR while the lower boundary of the arrow is at 15% CAGR. Beyond HAMR, the next building block for Areal Density growth is “HAMR+” which is HAMR with ordered granular media. And beyond HAMR+ the next building block is Heated-Dot Magnetic Recording (HDMR) and potentially 3-Dimensional recording. Each of these technologies continue the trend of 20% CAGR.

Ordered granular media controls the media grain size and distribution by using templated growth of the media grains. HDMR combines the benefits of HAMR with lithographically patterned magnetic bits for AD near 10 Tb/sq.in. 3-Dimensional recording is the combination of multi-layered recording by separated assisting condition of each layer and multi-level read-out channel technology. This channel study will also be

applicable for multi-track reading SMR system, or multi-level recording media system.

The previous ASRC HDD Technology Roadmap had been released in 2016. In addition to agreeing on this 2022 version of our technology roadmap, we also agreed to meet at least every two years. This way adjustments can be made as we learn more about the future building blocks on our roadmap. And new ideas could be added to the existing building blocks.

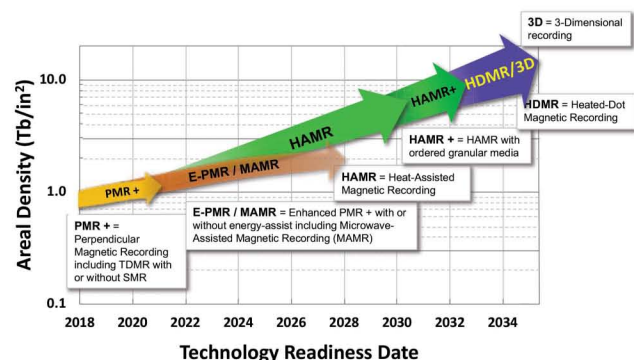


Fig. 1. A new HDD Technology roadmap. The vertical axis corresponds to Areal user bit density, and the horizontal axis is the Technology Readiness Date. The building blocks for future Hard Disk Drives (HDD) include E-PMR, MAMR, HAMR, HDMR, and 3-Dimensional Recording.