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# Advanced Storage Technology Consortium

Launch Event

January 31 – February 1 2011

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# ASTC

- **Expanding and enhancing the power of R&D funding** and technology development between storage industry participants, suppliers, universities, laboratories, and institutes
- **Mission**: member-directed, scalable R&D organization to address – pro-competitively – fundamental technology challenges
- **Supply chain involvement**
- **HDD technology roadmap**

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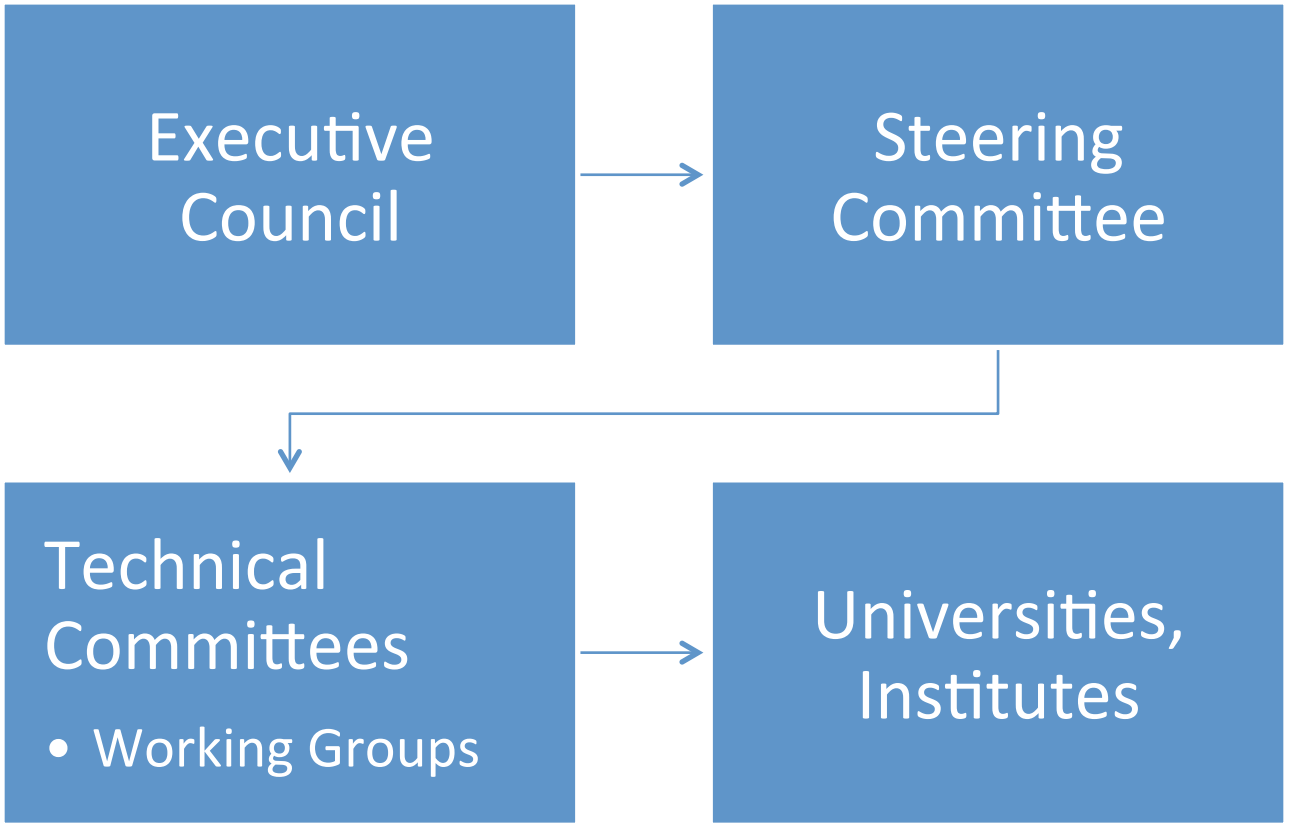
# ASTC Structure

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# Some Facts About Data Storage

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# HDDs and Growing Storage Demand

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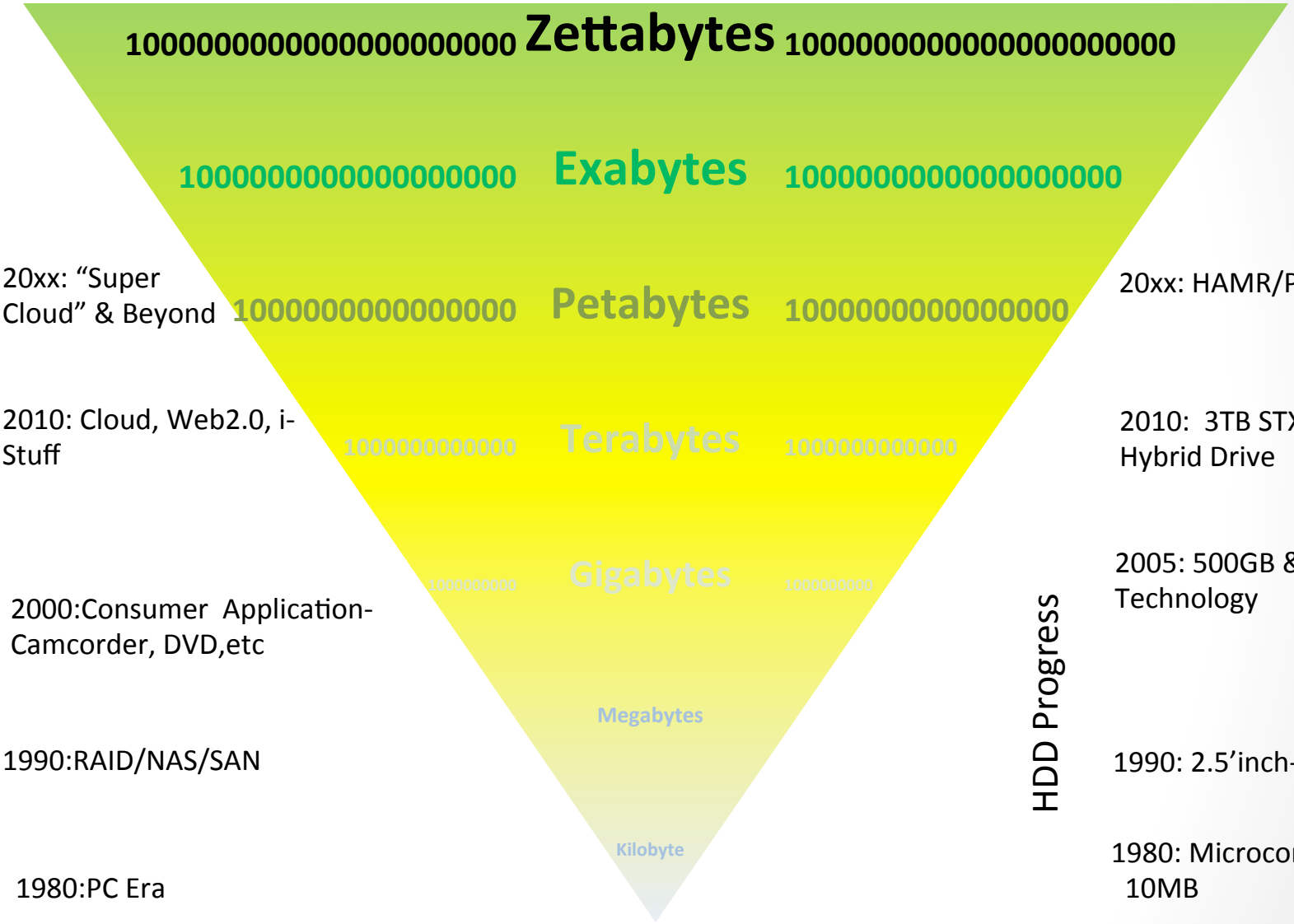


Beyond HDD/System

20xx: "Super Cloud" & Beyond

2010: Cloud, Web2.0, i-Stuff

2000:Consumer Application-Camcorder, DVD,etc

1990:RAID/NAS/SAN

1980:PC Era

HDD Progress

20xx: HAMR/PM

2010: 3TB STX Drive, Hybrid Drive

2005: 500GB & PMR Technology

1990: 2.5'inch-100MB

1980: Microcomputer 10MB

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# Fact 1: Consider That

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**40 exabyte($10^{18}$) of Unique new information will be generated worldwide this year**

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# Fact 2: Digital content generated in 2010 is more than has been created in the previous 5,000 years

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Google


*Source: Gartner*

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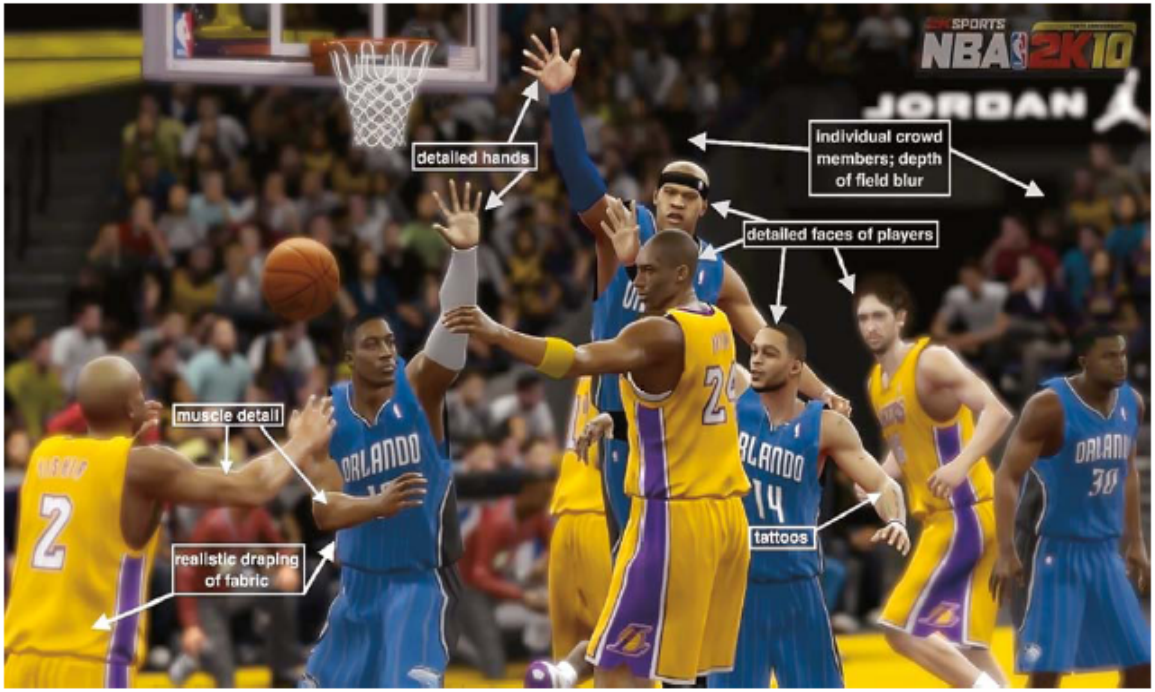
# Fact 3 : The Ever Expanding Growth of Information

**How Much Information?**
**2009**
**Report on American Consumers**

**32GBs passes the human eye every day**

**18 GB of Games**
**12 GB of Video**
**3 GB of Movies**




Sponsors:

Source: *How Much Information? 2009 UCSD*

# Fact 4: The Need for HDDs to Store Information

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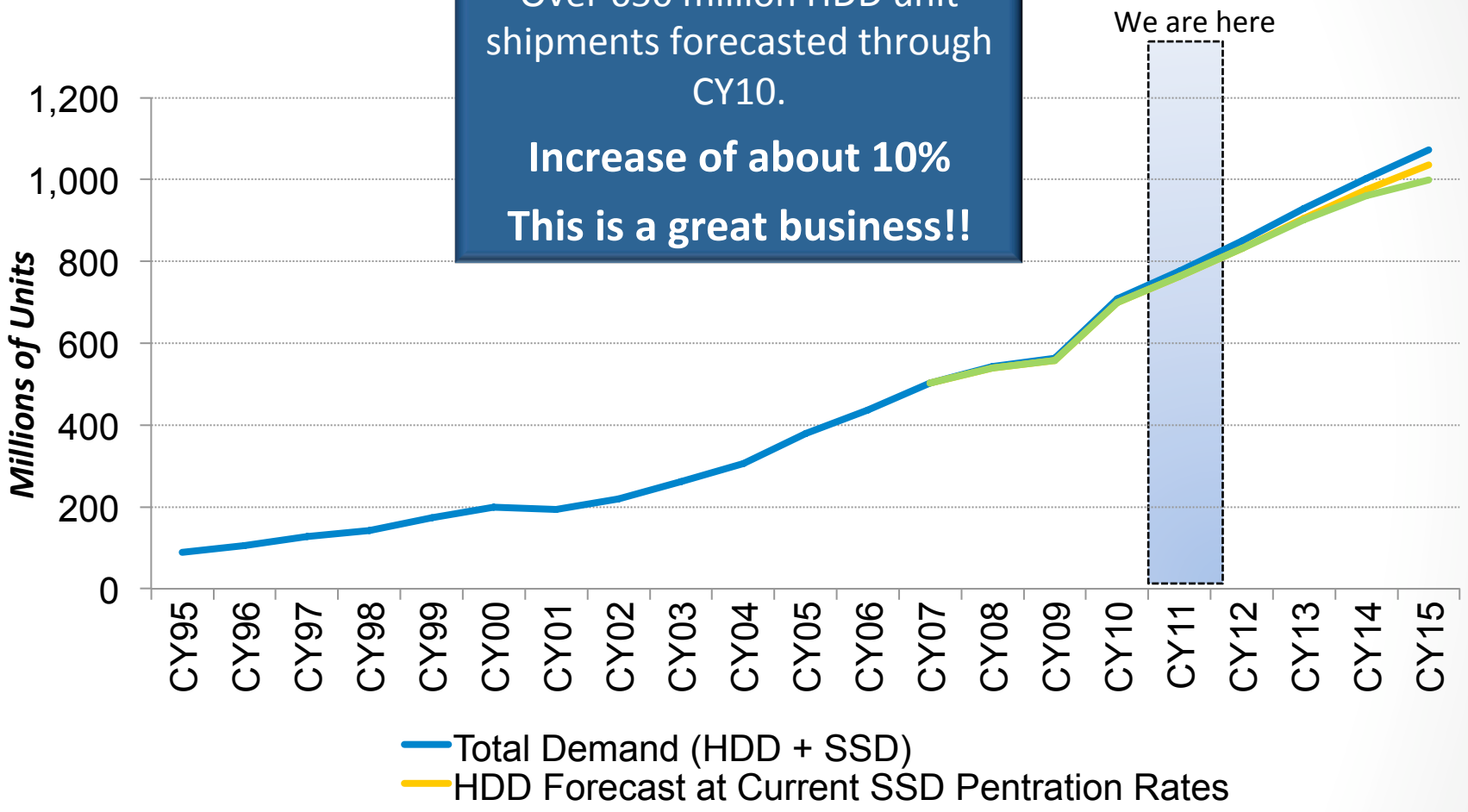
Over 650 million HDD unit shipments forecasted through CY10.

**Increase of about 10%**

**This is a great business!!**




http://www.seagate.com/www/en-us/about/investor_relations/

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# HDD Industry Historical Areal Density Trend

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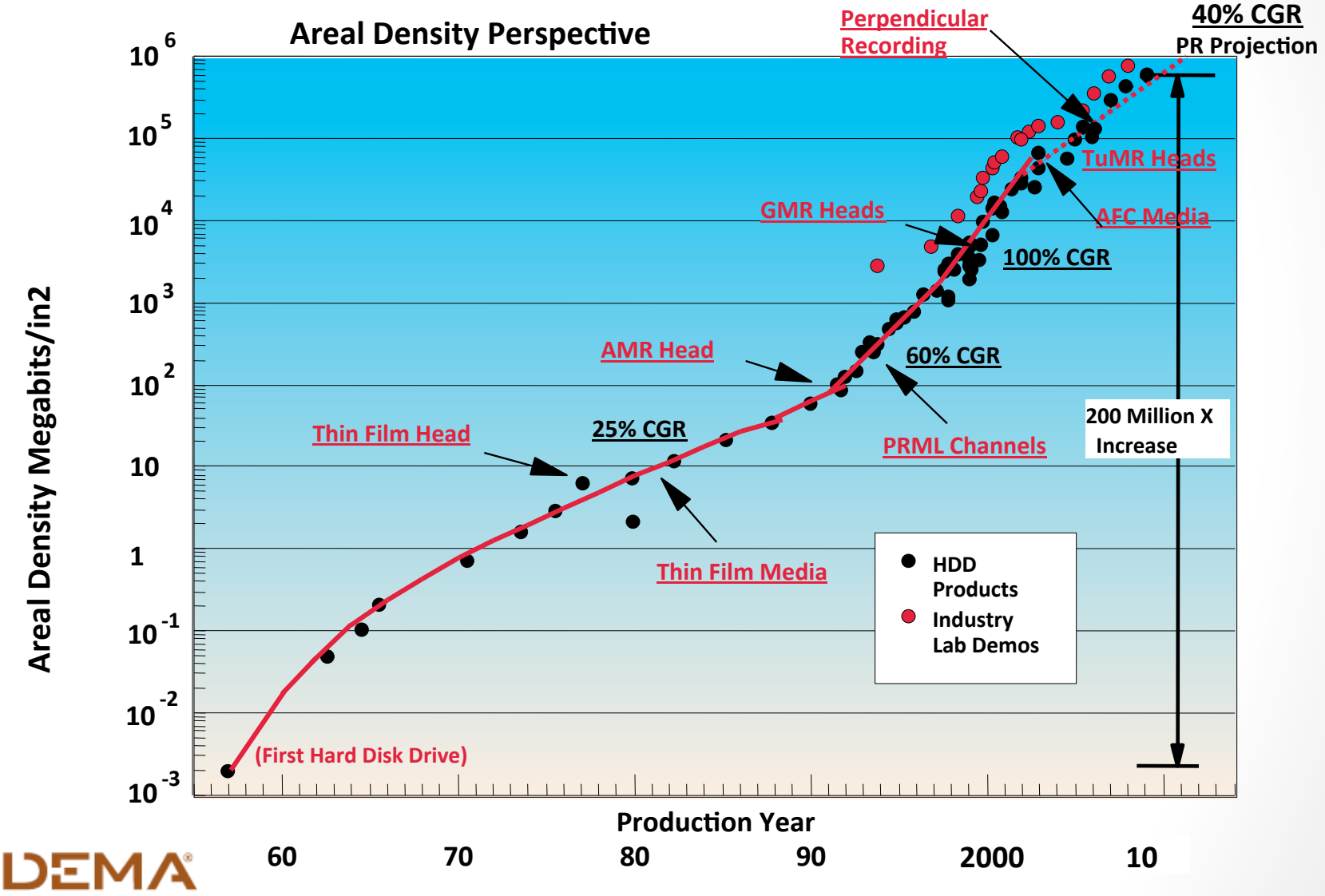


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# Technology Maturity: Slowing PMR Capacity Growth Rate

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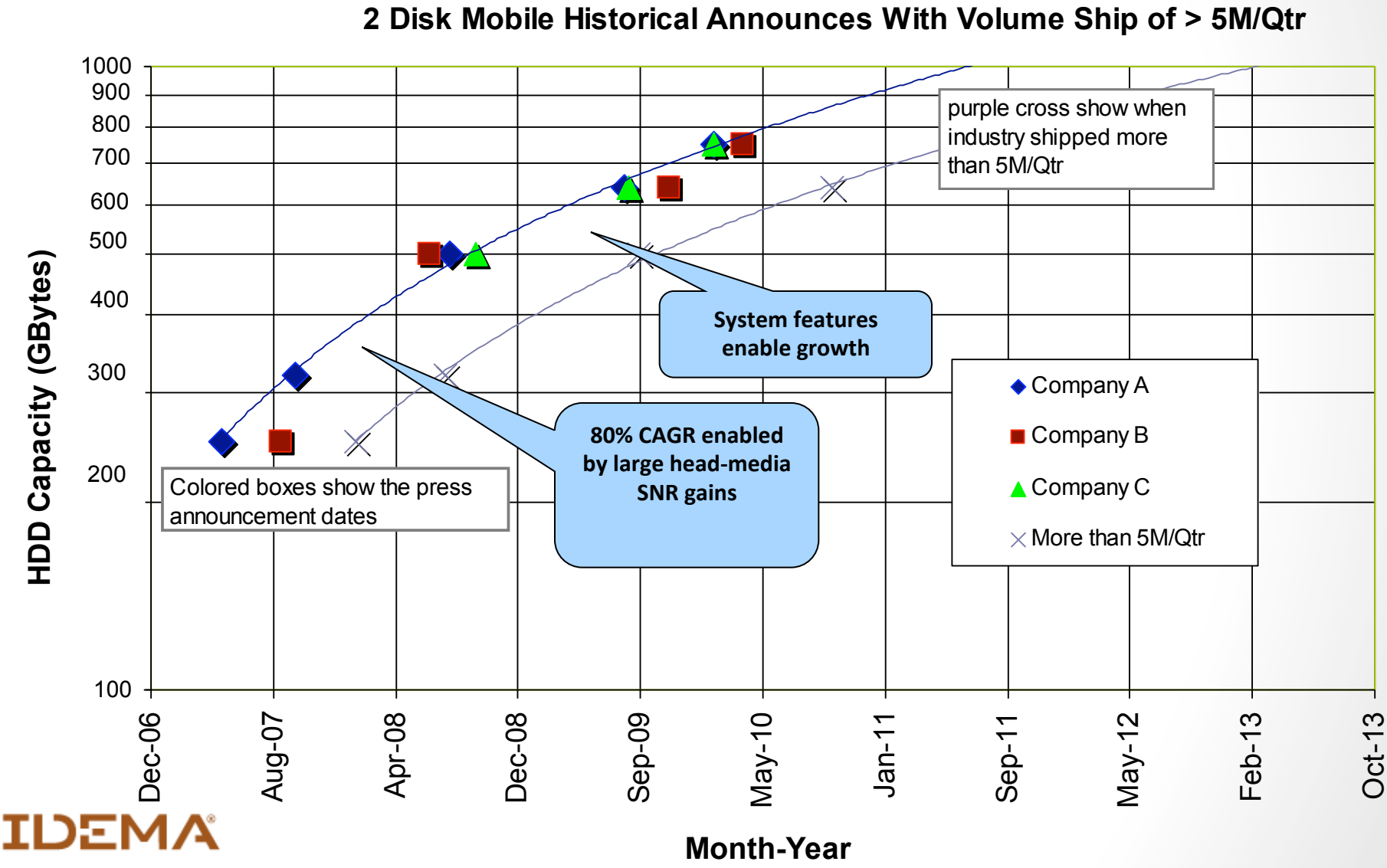


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# Historical Perspective: Jumping "S" Curves in HDD

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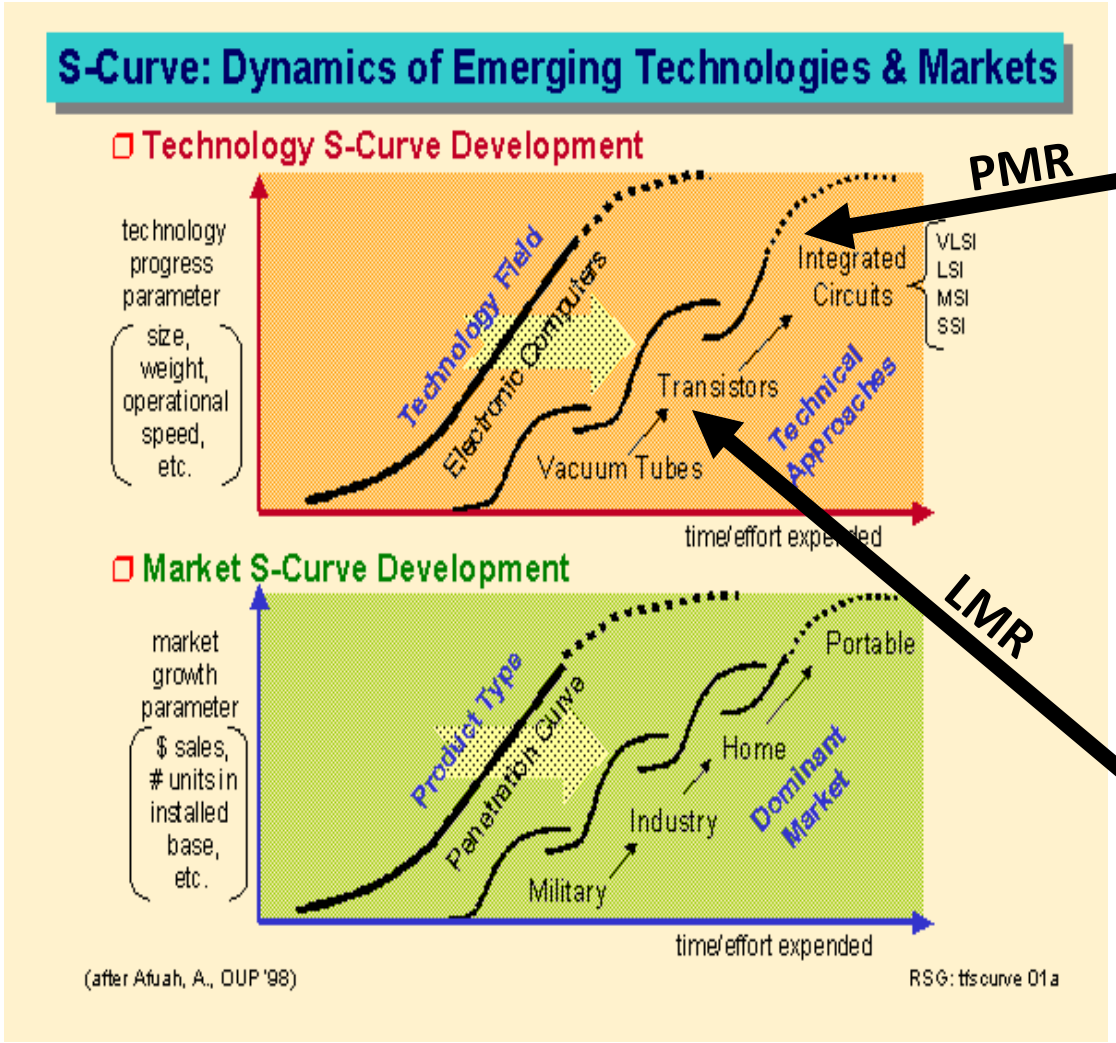
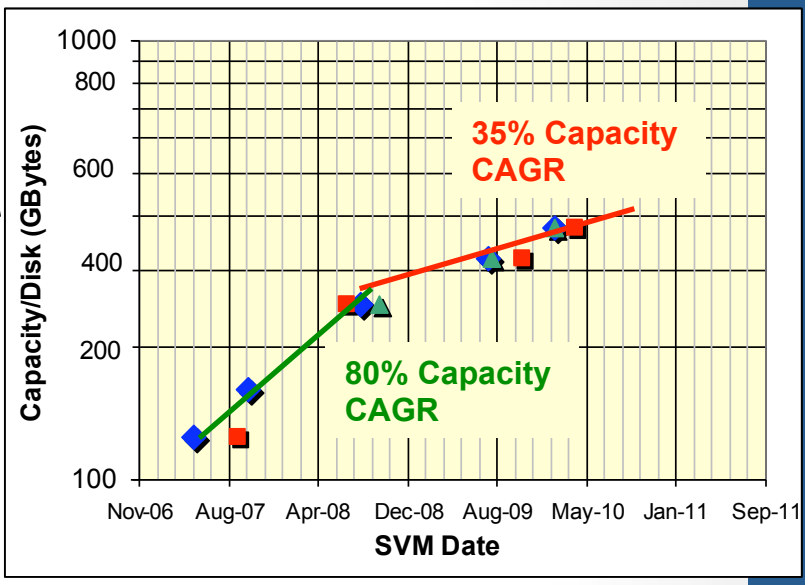
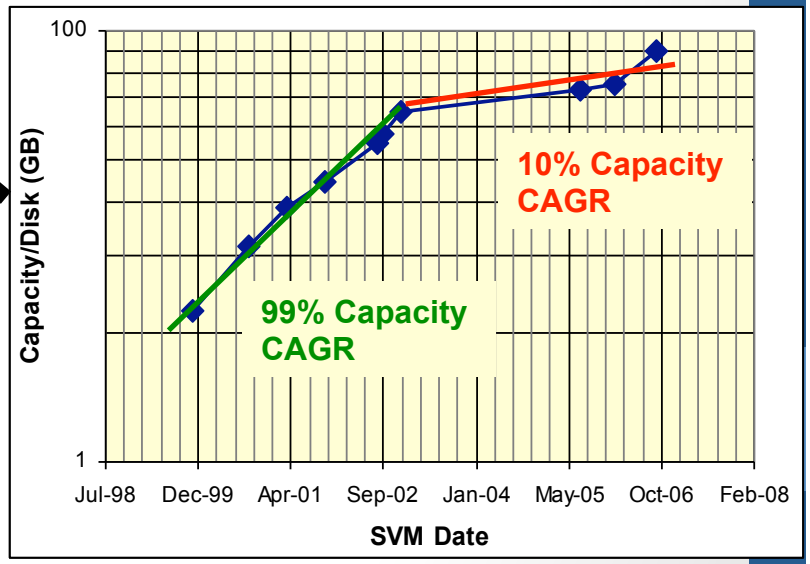



PMR

LMR

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# Areal Density Scaling and the Magnetic "Trilemma"

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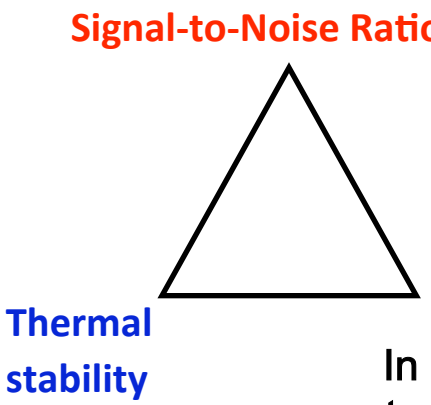
To preserve signal-to-noise ratio:

**SNR~log10(N)**

the # of grains in a bit must be constant.




To ensure that the recorded bit is thermally stable, the anisotropy needs to increase proportionally to the grain volume reduction

$$\frac{\text{Stored Energy}}{\text{Thermal Energy}} \sim \frac{K_u * V}{k_B * T} > 70$$

In order to write a sharp recorded bit transition, the write field needs to be sufficiently large

$$\text{Write Field} > \alpha \frac{2K_u}{M_s} - N_{eff} * M_s$$

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# Future Technology Options

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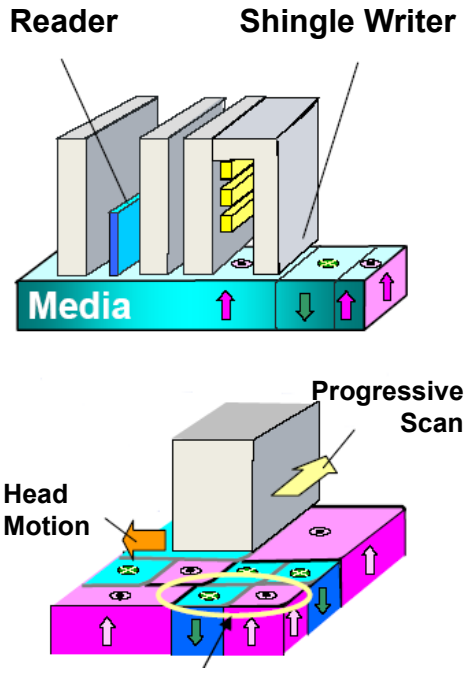


## SMR/TDMR

- Continued scaling requires innovations in systems technologies, materials science and process engineering to advance areal density

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*(Illustrations courtesy of Y. Shiroishi, Intermag 2009)*

# Solid State Technology Memory as a Competitive Storage Technology

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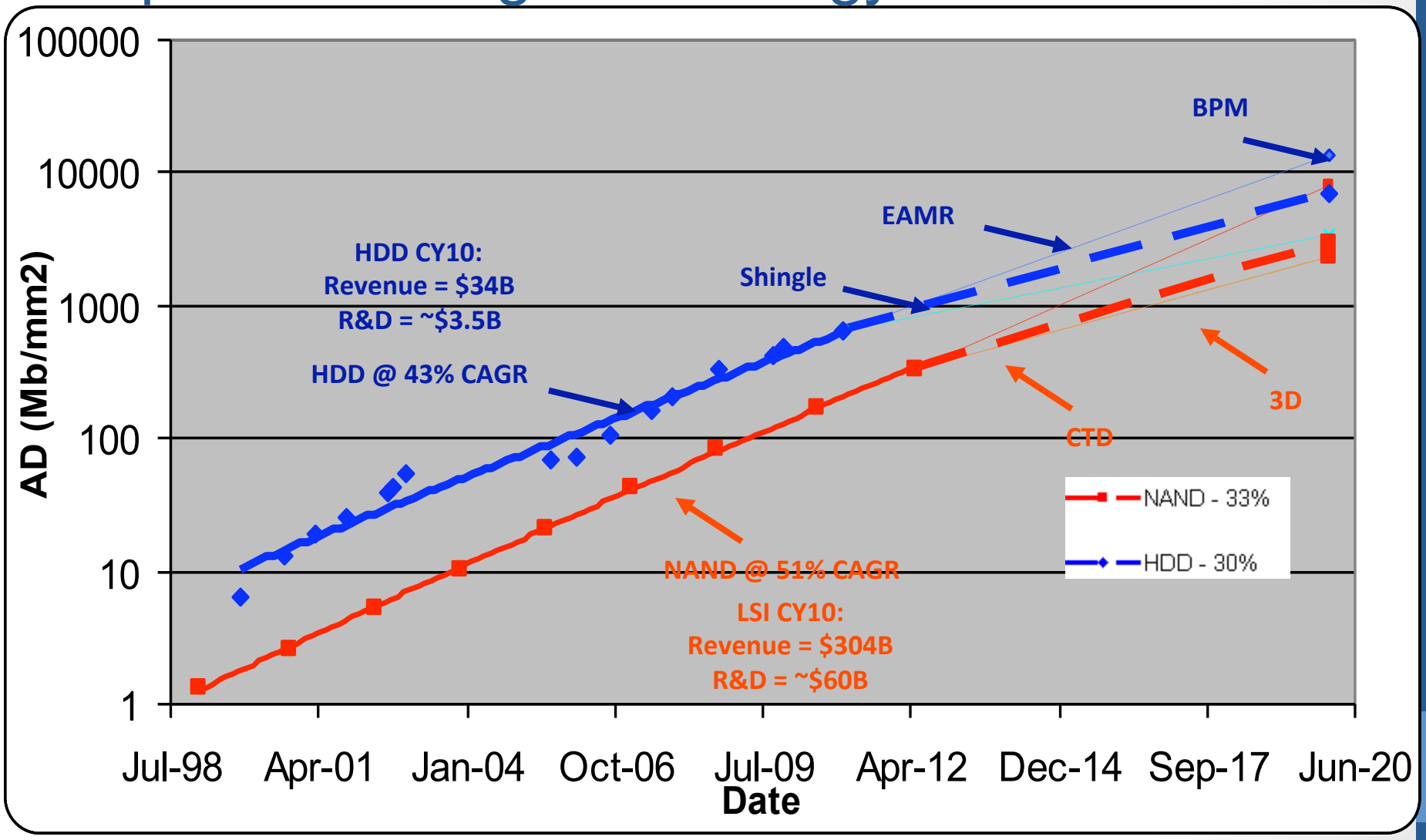


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# ASTC Can Help Address HDD Technology Challenges

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- HDD Industry is facing challenges to grow areal density at historic rates
- These challenges are distributed throughout component and system level technologies
  - Energy assist technology will not in itself enable AD growth without adequate readers, H/M interface, channel, servo capability, etc.
- Solid State Technology has emerged as a credible alternative to HDD in certain segments, and the semiconductor industry is committed to large scale R&D
- ASTC provides the ideal forum to address these challenges collaboratively as an industry with a holistic but targeted approach

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# Signal Processing Contribution to HDD Density Growth

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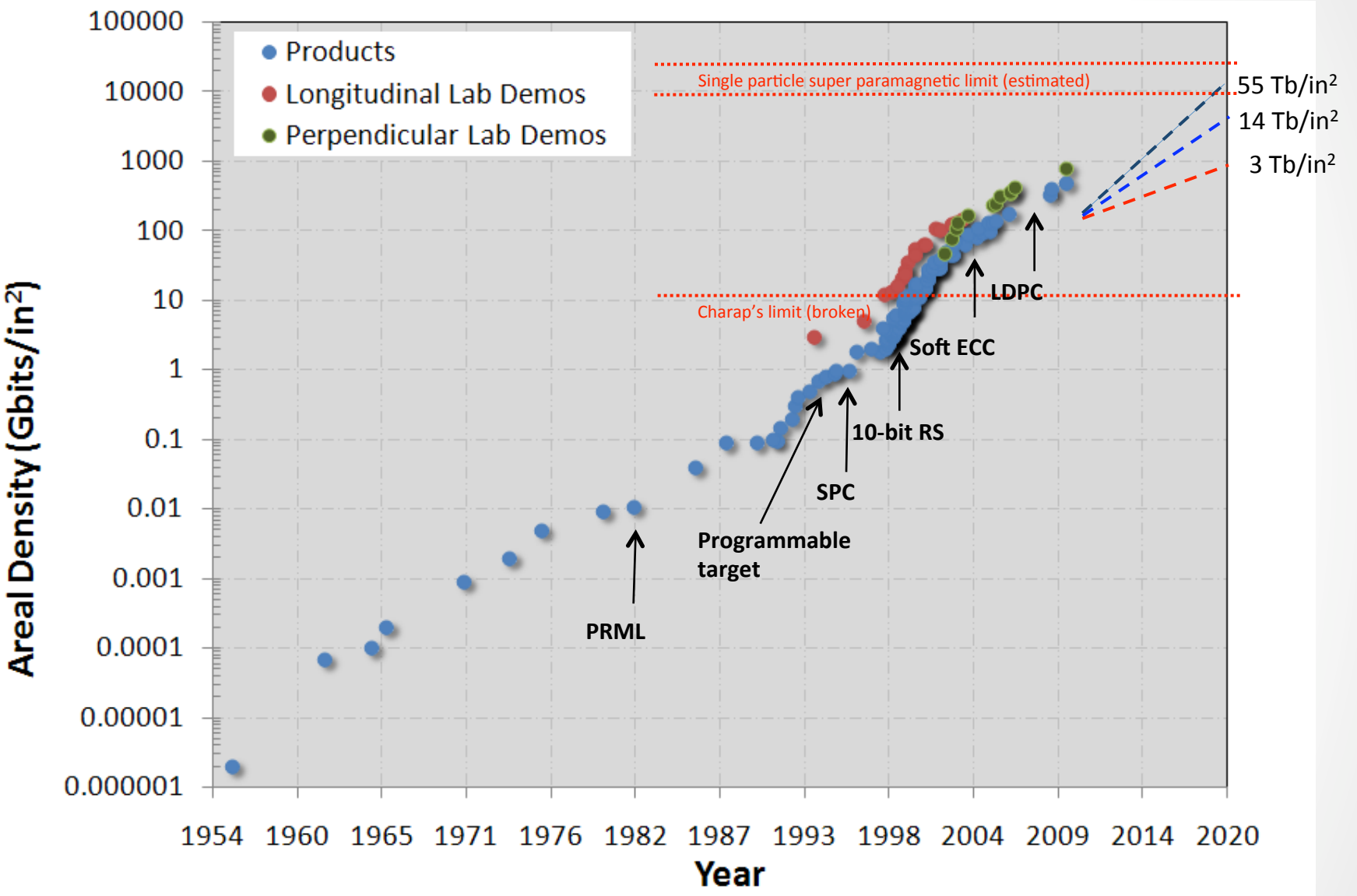


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# Recent Trends in Signal Processing

- SNR improvements coming from the Read Channel (RDC) were driven by advancements in Error Correction Coding (ECC): large codeword size afforded by adaptation of Long Sector Format, and transition to Soft ECC
- Shingled recording, Bit Pattern Recording (BPR), Two-Dimensional Magnetic Recording (TDMR), and Heat Assisted Magnetic Recording (HAMR) provide new challenges to signal processing
- Hard disk controller SOC should no longer be viewed as a standalone component in the drive; it has become an integral part of system solution.

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# Challenges Going Forward

- HDD is facing severe competition from SSD and other storage technologies
- HDD industry needs to collaborate to define a technology roadmap
  - A roadmap gives our industry more negotiation power with customers
- New technologies require more R&D investment and collaboration
  - Peak detectors have long been replaced by PRML with sophisticated detectors designed to take signal characteristics into account
  - Powerful iterative decoders come to replace traditional algebraic ECC's
  - Cutting-edge CMOS technology in electronics design is key to future success.
  - Leveraging some technologies used in solid state drives in support of large block write formats in SMR
  - Adding some level of non-volatile chip memory support for power-loss handling

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# Why is the HDD supply base interested in ASTC?

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# Suppliers meet HDD Factories

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- HDD producers operates at the outer boundaries of technology & scientific knowledge
- "There's plenty of room at the bottom"§
  - *One nanometer is the characteristic dimension*
    - substrate processes, sputtering, chemistry, metrology
  - *Two million hours is the characteristic MTBF*
    - automation, disk processing systems, cleaning, RV
  - *Three gigahertz is the characteristic frequency*
    - SOC, control, interface
- Suppliers must meet producers needs at the outer boundaries of technology & scientific knowledge



§ **Richard P. Feynman, 29 December 1959**

# Suppliers to HDD Producers

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- Far-flung supply chain provides materials, components, manufacturing, processing, and test equipment:

- *substrates*
- *specialty metals*
- *sputtering systems*
- *automation*
- *cleaning systems*
- *processing equipment*
- *processing supplies*
- *certification*
- *dimensional metrology*

- *magnetic metrology*
- *optical metrology*
- *chemicals*
- *suspensions*
- *pre-amps*
- *channels*
- *SOC's*
- *servo track writers*
- ***Supply Chain Goes On ...***

# Benefits for Infrastructure Companies

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- "Early warning" to technology transitions
- Lead time to meet process and test requirements
- Roadmap alignment within the industry
  - drive, heads, media, electronics, mechanical components
- Roadmap alignment leads to efficient equipment development
  - Agreed-upon equipment platforms serving the industry
  - Efficient use of R&D resources developing equipment and process
  - Meet time-to-market need for advanced technology products and at lower cost

# Partnership HDD/Supply Chain

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- Improving areal density beyond ~1.5 Tb/in$^2$ likely will require a transition to new technology
- HDD producers & supply chain collaboration is essential:
  - To manage technology choices
  - To generate detailed technology roadmap
  - To provide guidelines for each of process areas and infrastructure development: “built for manufacturability & testability”
- The success of ASTC will:
  - Steer suppliers efforts and investments to HDD producers’ needs
  - Yield shared solutions in component technologies
  - Reduce technology risk and improve time-to-market


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# So What is ASTC ?

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# Why Do We Need Something Different ?

- Pace of technology transitions and scope of change required means business as usual approach won't work
- Need to collimate and focus entire industry R&D to be successful
- Need coordinated transition in supply base -- components, equipment, and materials

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# Vision for New ASTC

- Global organization
- Learn and borrow from the successes of INSIC – EHDR and SRC programs
  - Collaborative research programs with universities
- More open collaboration among companies to share directions and manage projects
- Act with a sense of urgency consistent with the needs of the industry
- Engage broader base of companies

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# Expected Outputs from ASTC

- Forum to share and coordinate directions to increase speed and reduce waste
- Focused, collaborative research projects that will enable better understanding of key scientific challenges
- Shared, realistic roadmap for the Industry
- Solutions – **science** to **engineering** to **manufacturing** options – that will shorten time from invention to productization

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# What is Expected from Members ?

- Participation – commitment of time
- Openness – speed and reduce waste
- Higher funding levels
- More collaboration and direction setting in research projects

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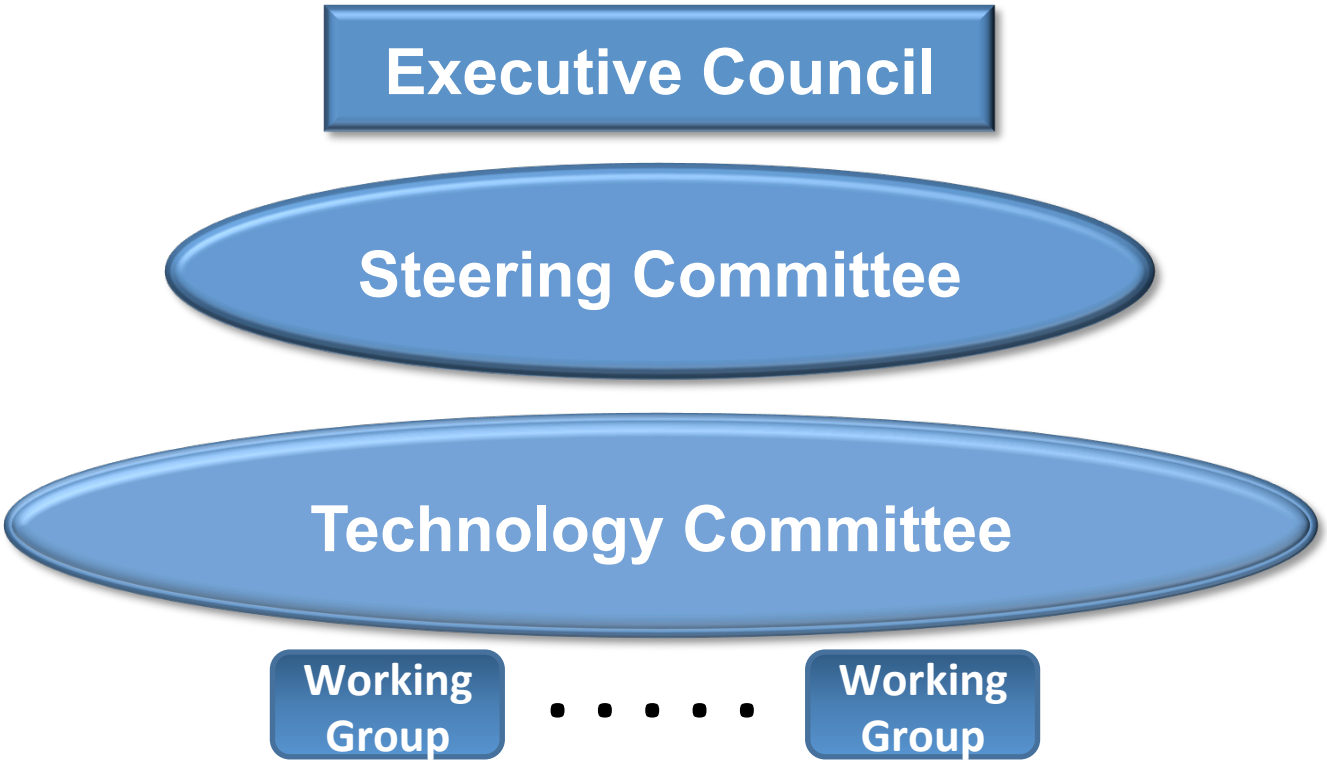
# ASTC High Level Organization

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