MRAM brings native persistence at speed to memory applications

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Ballroom C

Safe Harbor Statement

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This presentation contains "forward-looking statements" that involve risks, uncertainties and assumptions.
If the risks or uncertainties materialize or the assumptions prove incorrect, our results may differ materially from those expressed or implied by such forward-looking statements. All statements other than statements
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We assume no obligation, and do not intend, to update these forward-looking statements, except as required by law.
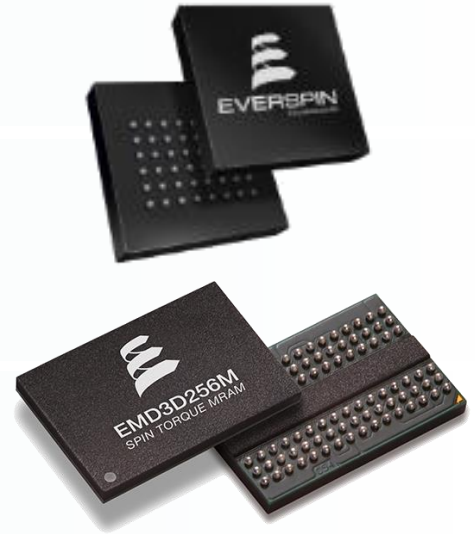
MRAM's Time Has Come!

MRAM is here **today**

MRAM is the **key technology** for tomorrow's need for a universal memory

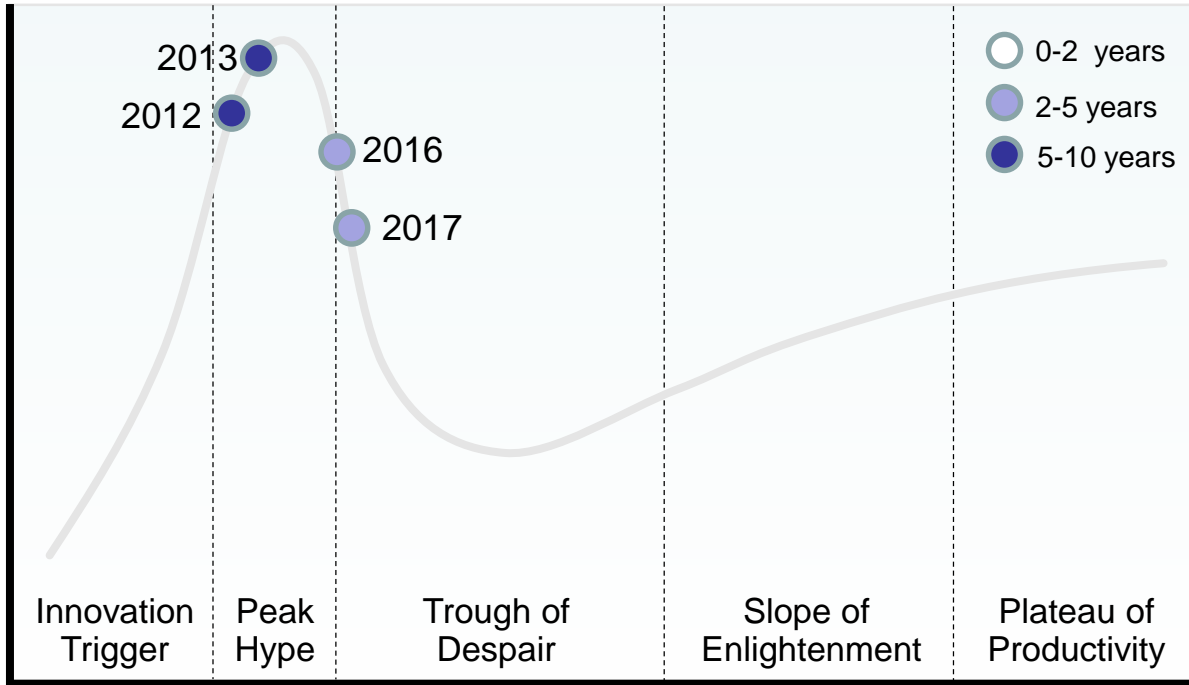Everspin is at the forefront of driving the MRAM **revolution**

STT-MRAM Hype Cycle

MRAM is the future of memory technology

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TECHNOLOGIES

Technology Life-Cycles & Disruptive Waves

Flash Storage

1993: Flash on Space Shuttle/777

1995: Flash in PDAs and industrial

1997: Flash in Digital Cameras

2008: Flash in Smart Phones

2013: Flash in PCs/Data Center

Innovators

Early Adopters

Early Majority

Late Majority

Laggards

High ← **Propensity to Adopt** — Low — **Propensity to Resist** → High

Technology Life-Cycles & Disruptive Waves

Flash Memory Summit

MRAM

2016: Industrial/ Automotive

2018: SSDs and Storage Accelerators

Innovators

Early Adopters

Early Majority

Late Majority

Laggards

High ← **Propensity to Adopt** — Low — **Propensity to Resist** → High
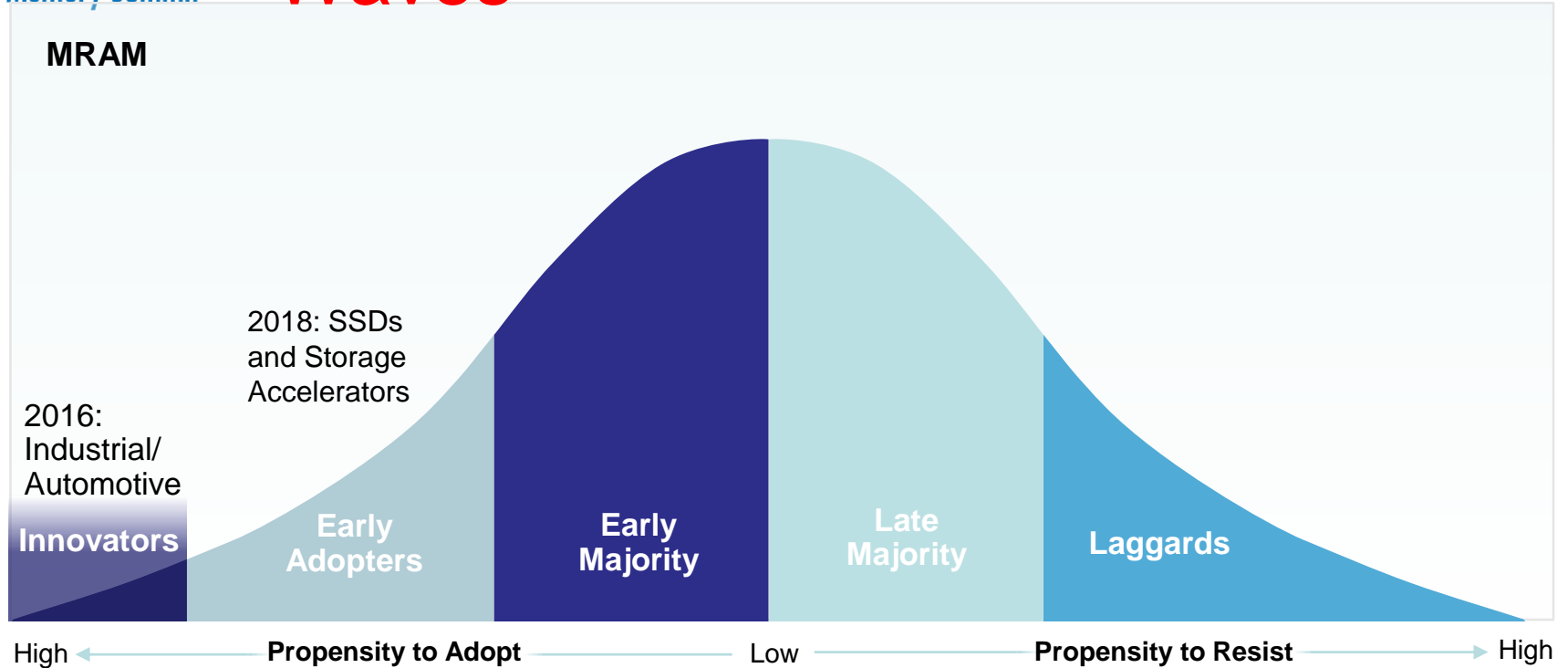
Legacy Discrete Memory Solutions
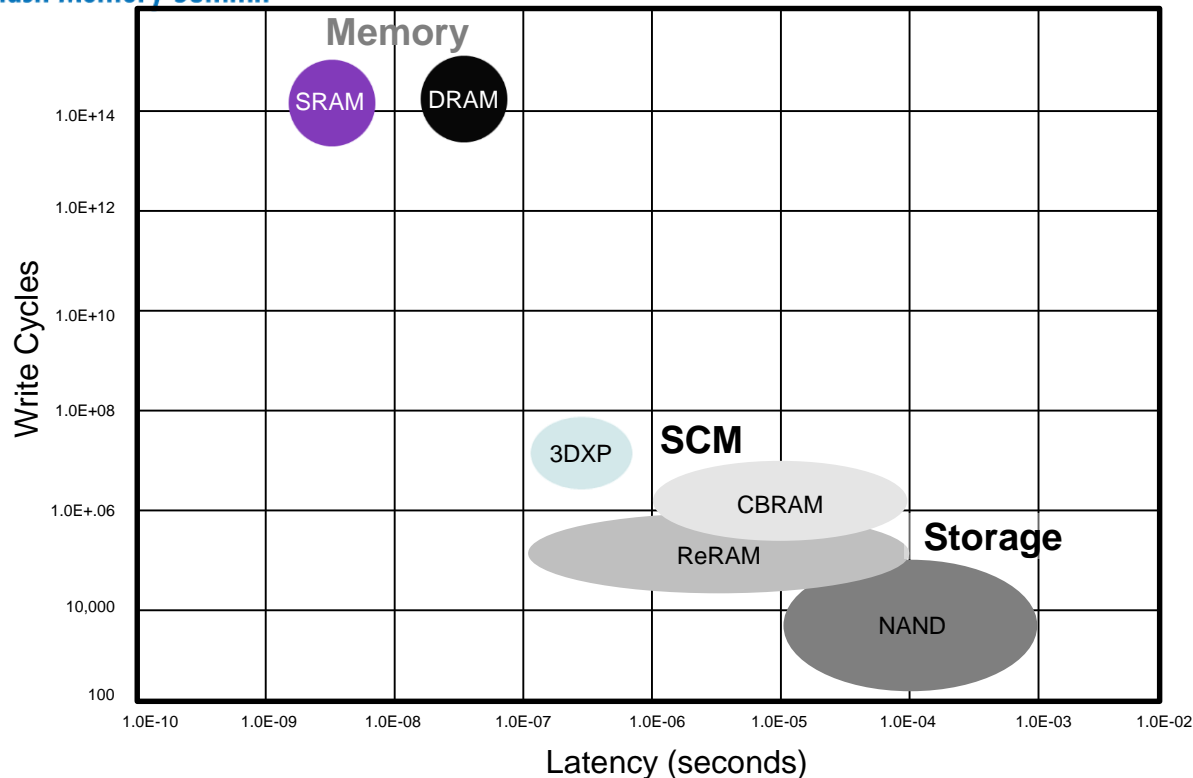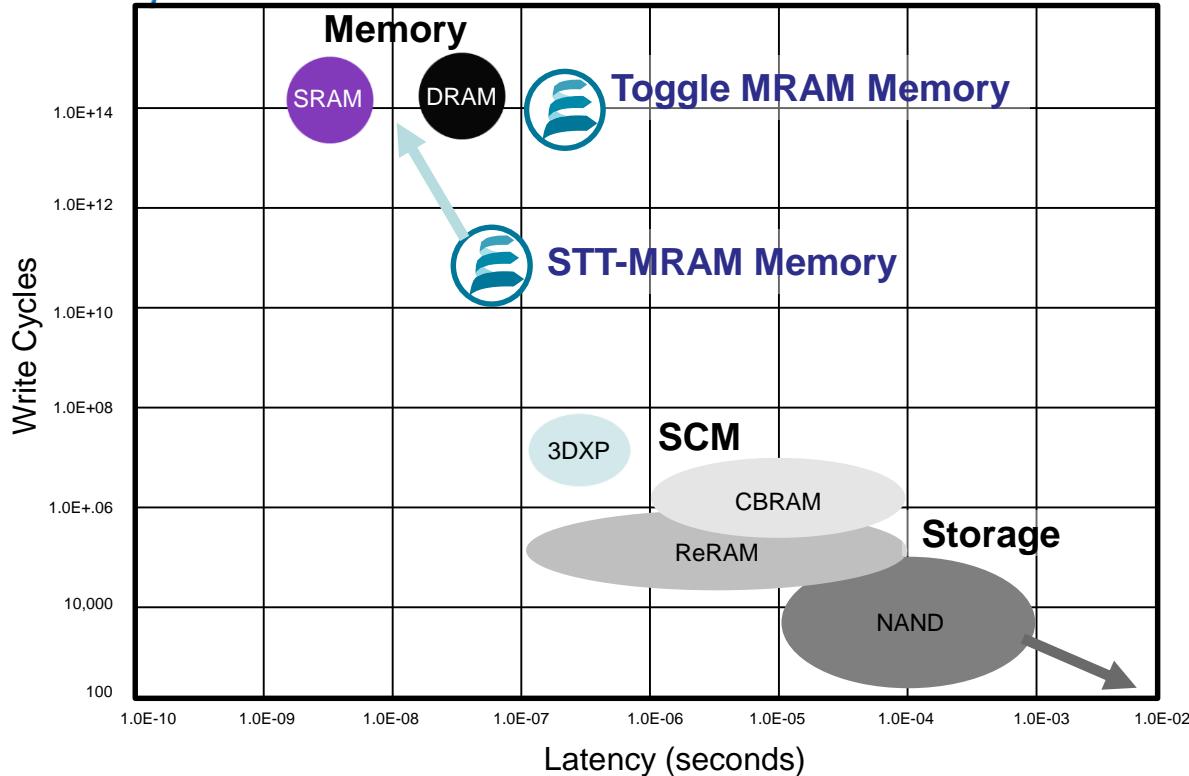

- **DRAM** is fast, but volatile and requires refresh cycle

- **SRAM** has lower density than DRAM, but also volatile

  Both require external batteries or capacitors to provide constant power

- **SCM** (Storage Class Memory) is faster than NAND, but lower endurance

- **NAND** Flash is non-volatile, but high latency and low endurance

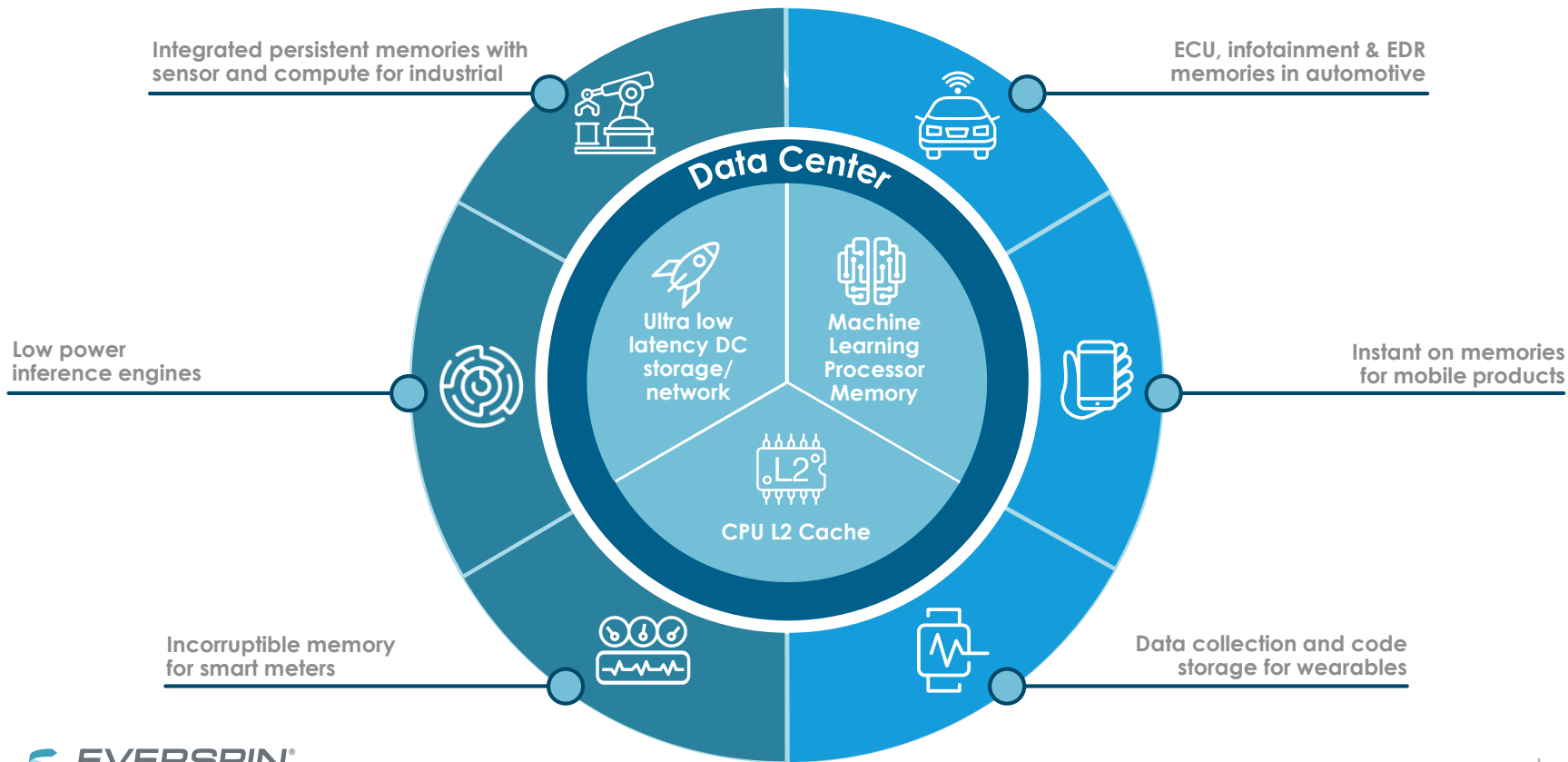# Legacy Discrete Memory Solutions

MRAM combines performance of memory with persistence of storage

- High Performance: DRAM-class write performance
- Non-Volatile: Maintains memory without power
- Fast Read/Write Speeds: Similar to SRAM & DRAM
- Superior Durability: Survives memory workloads
- No Refresh: Data requires no charge

The MRAM Universe

Integrated persistent memories with sensor and compute for industrial

ECU, infotainment & EDR memories in automotive

Low power inference engines

Instant on memories for mobile products

Incorruptible memory for smart meters

Data collection and code storage for wearables

Data Center

Ultra low latency DC storage/ network

Machine Learning Processor Memory

CPU L2 Cache

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The MRAM Universe

Current Focus
Emerging Markets

Edge Applications

Data Center

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Case Study: Server Message Log

- Meets regulatory compliance without the performance penalty of flash
  - 9X Acceleration of message log storage

- Standard NVMe integration with no special drivers required

- Capacity up to 1GB
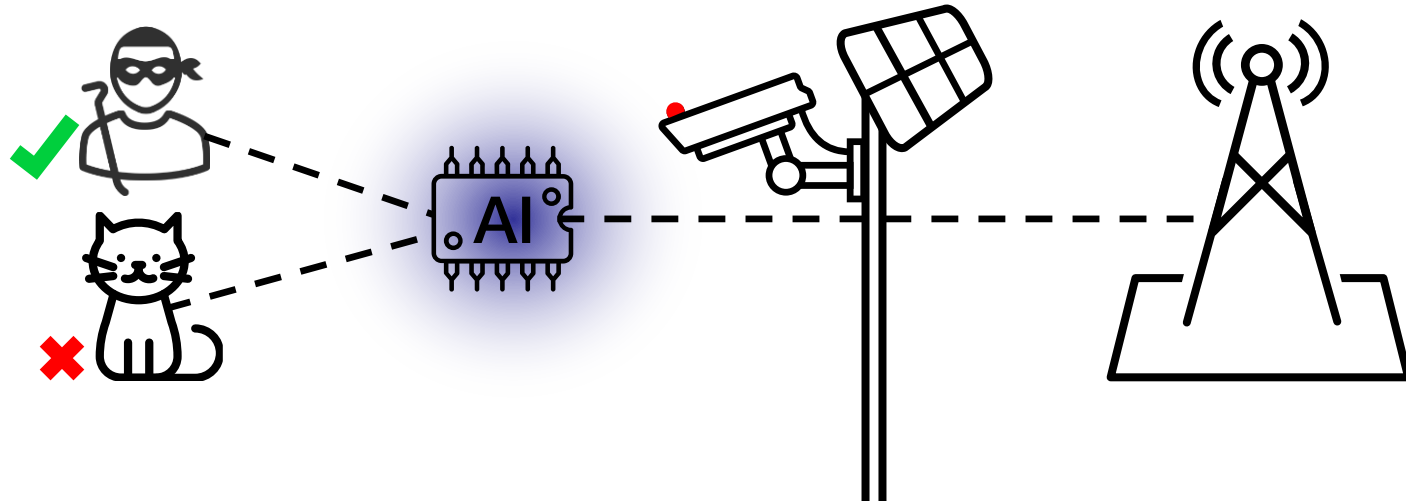 - Sufficient for most NoSQL flash optimized databases

Case Study: Intelligent Security Video Cam

- Remote dispersed deployment, battery powered, solar charge

- Low power motion detecting inference engine front end
  - ANN weights and executable stored in MRAM
  - Fast wake upon motion, analyze image, return to standby

- Doesn't enter record until front end detects interesting event

Case Study: Health Monitor Wearable

- Integrated sensor, compute, wireless, MRAM

- Extended temperature operation

- Low power system implementation
  - No need for boot during recovery from sleep

- Longer term integration of inference engines for advanced diagnostics
  - Real-time health monitor
  - Automatic Health Risk Event detection

AI diagnostic coupled
with Bit data analytics

Case Study: Instant-on Mobile

- No more extended wait for system boot at power on
  - Execution memory stored in MRAM
  - Truly Instant-on

- No DRAM held in refresh during system standby
  - Extends by days need for device to be turned off

24/7

What Is Next for MRAM?

- Broader adoption in legacy markets
  - Toggle MRAM with its unique characteristics will be very long lived

- Growth of today's STT products in data center applications
  - Storage and Network focus
  - "Data persistence at speed"

- MRAM TAM Expansion through further improvements in density, cost, endurance and power

Strong Top-Tier Customer Base in Growing Markets

Flash Memory Summit

Industrial

- Automation
- PLC
- Motor Control
- Lighting
- Network
- Smart Meter
- Casino Gaming

SIEMENS
Schneider Electric
NXP
JAG
Koyo

Automotive & Transportation

- Infotainment
- Transmission Control
- Tachograph/ Odometer
- Electric Brakes
- Engine Management
- Event Recorder
- ADAS

AIRBUS
e2V
Honeywell
COBHAM

Enterprise

- Enterprise SSD
- RAID
- Storage Appliance
- Enterprise HDD
- Server

DELLEMC
BROADCOM
Microsemi

Toggle MRAM Shipments

Initial STT-MRAM Focus

MRAM is the future of memory technology

Thank you.