



# Customization Key to Embedded Storage Applications

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The logo for the Flash Memory Summit features a stylized yellow sunburst with multiple rays. The word "Flash" is in red, "Memory" is in blue, and "SUMMIT" is in white on a blue rectangular background.

# Flash Memory Summit Agenda

- Embedded Storage Market Overview
- Design Considerations
- Needs for Customization
- Case Studies

# Embedded Storage Is Everywhere!

## Automotive

In-Vehicle  
Infotainment



## Industrial & Medical Devices

Various Industrial



Medical



RFID and POS



## Networking Appliances

Infrastructure  
Equipment



Enterprise Video /  
VoIP



Servers





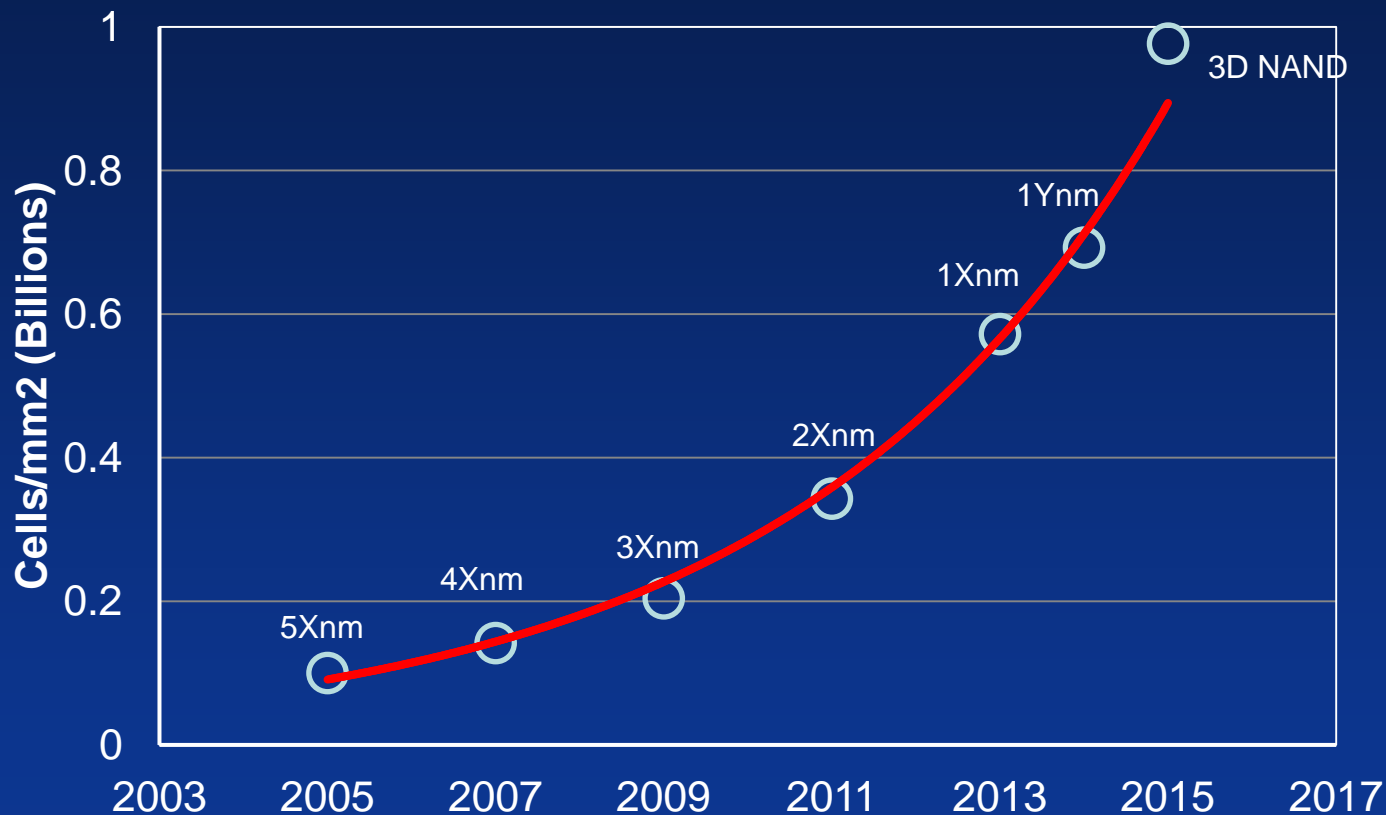
# Embedded Design Considerations

- NAND technology
- Hardware interface and protocol standards
- Software support infrastructure
- Performance requirements and use cases
- Form factor
- Thermal constraints
- Customization for specific needs
- Product life-cycle
- Cost



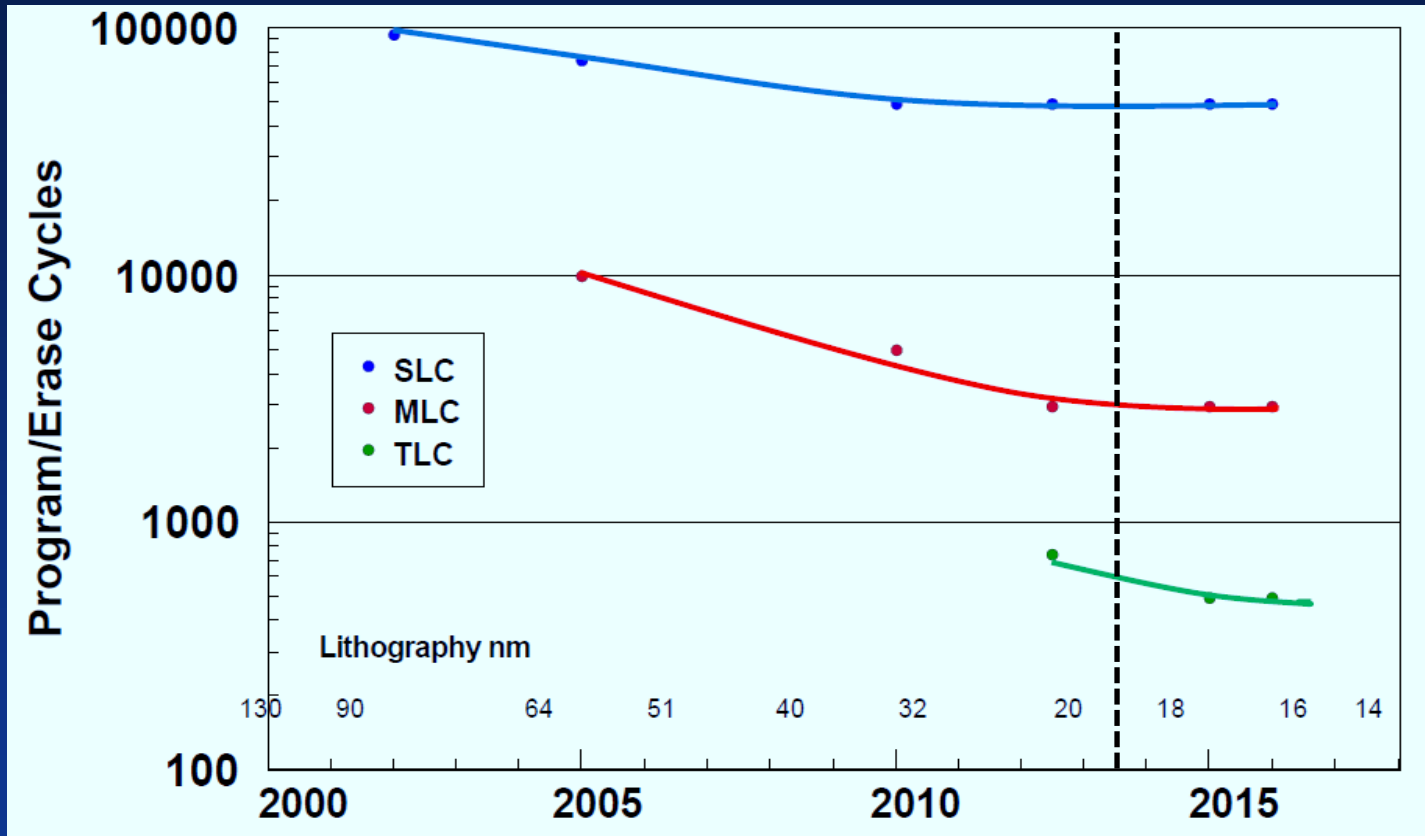
# NAND Process Scaling => Lower

## Cost



Relentless scaling to reduce bit cost while increasing bit production

# NAND Flash Memory Endurance Trending Downward



Source: iSuppli Q4'12

Matching the right NAND technology to applications

- Price / Endurance / Density tradeoffs



# Interface Technology Comparison (for Embedded Applications)

	SATA II/III	PCIe (AHCI)	PCIe (NVMe)	USB 2.0	CF	CFast	SD 2.x/3.0	eMMC 4.5
Command Protocol	ATA	ACHI (ATA)	NVMHCI (NVMe)	SCSI	ATA	ATA	SD	eMMC
Seq. R/W Performance (MB/s)	~200/400 ~200/400	>500 >500	>500 >500	~40 ~20	~40 ~20	~100 ~100	~40 ~20	~100 ~40
Random R/W Performance (IOPS)	~30K ~30K	~50K ~50K	~50K ~50K	~1000 ~100	~1000 ~100	~15K ~10K	~1000 ~100	~3K ~1K
Peak Power Consumpt'n	>2W	>2W	>2W	~1W	~1W	>1W	<1W	<1W
Standby Power	Tens of mW	Tens of mW	Tens of mW	Single-digit mW	Single-digit mW	Single-digit mW	<1mW	<1mW
Boot Support	No	No	No	No	No	No	No	Yes
User Configurable Memory	No	No	No	No	No	No	No	Yes
Software Support	●	●	●	●	●	●	●	●
Adoption Trend	↑	↗	?	→	→	↗	→	↑



# Managing Product Life-Cycle

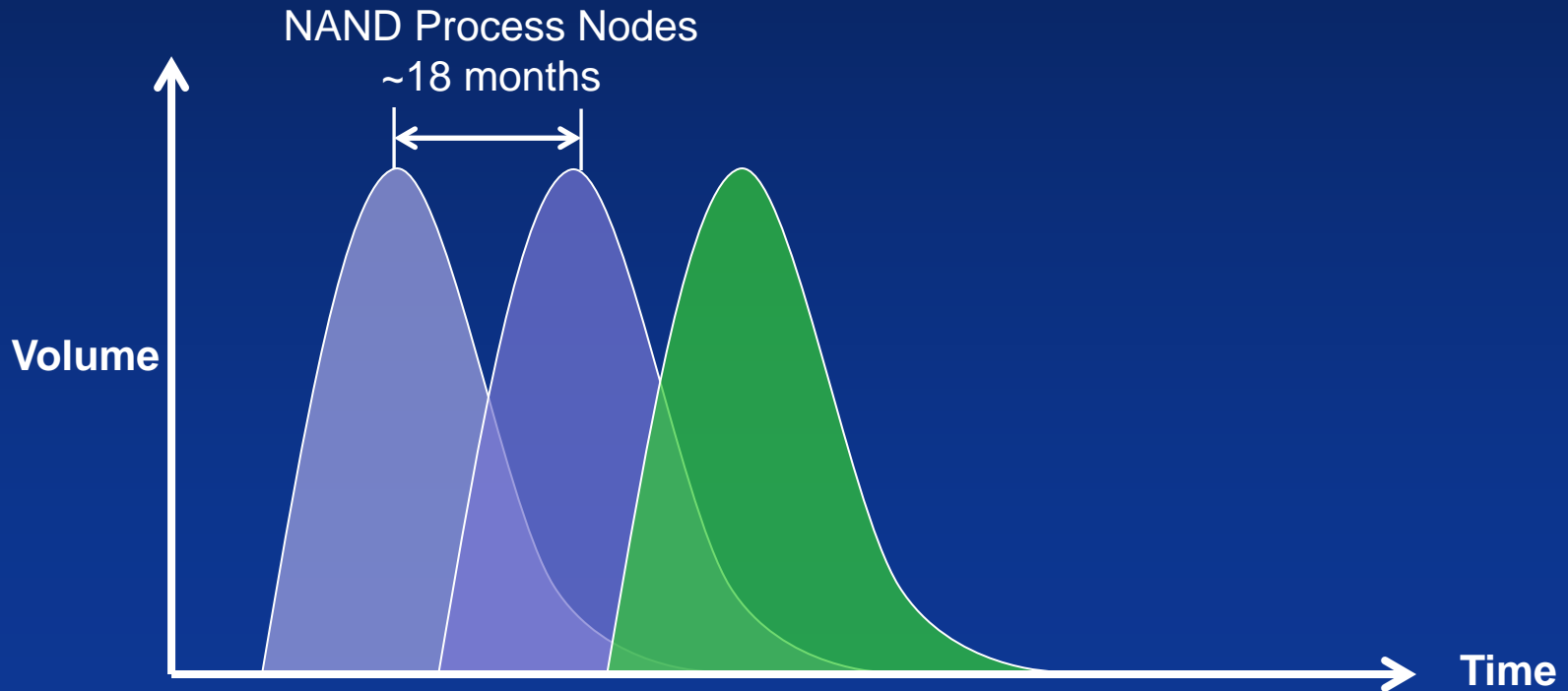
## Considerations:

- Longevity of interface technology and software backward compatibility
- Supplier's product life-cycle management strategy, technology migration path
  - Form, Fit, Function



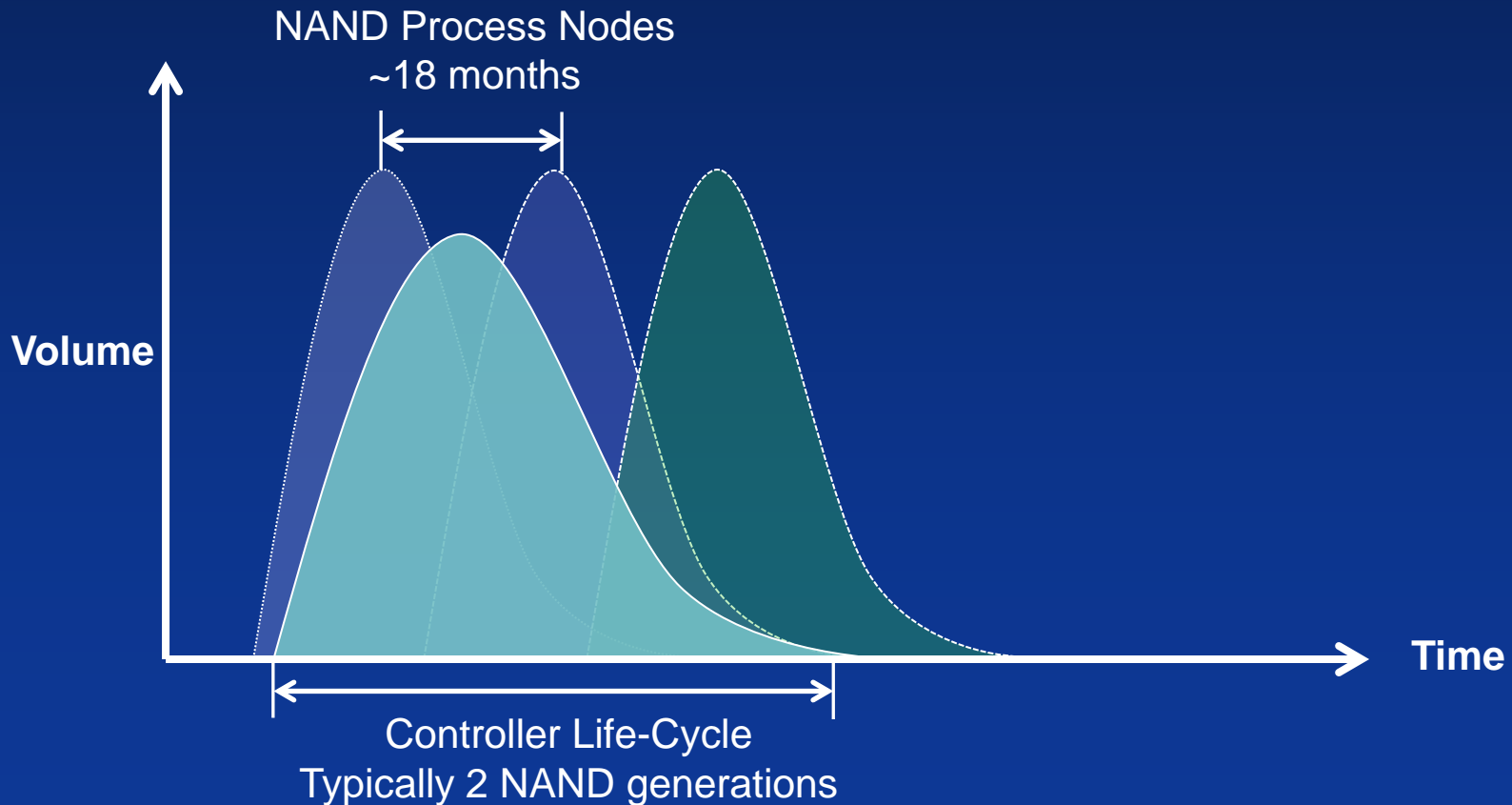
# Product Life-Cycle Mismatch

- Mismatch in product life cycles among NAND, controller and end application



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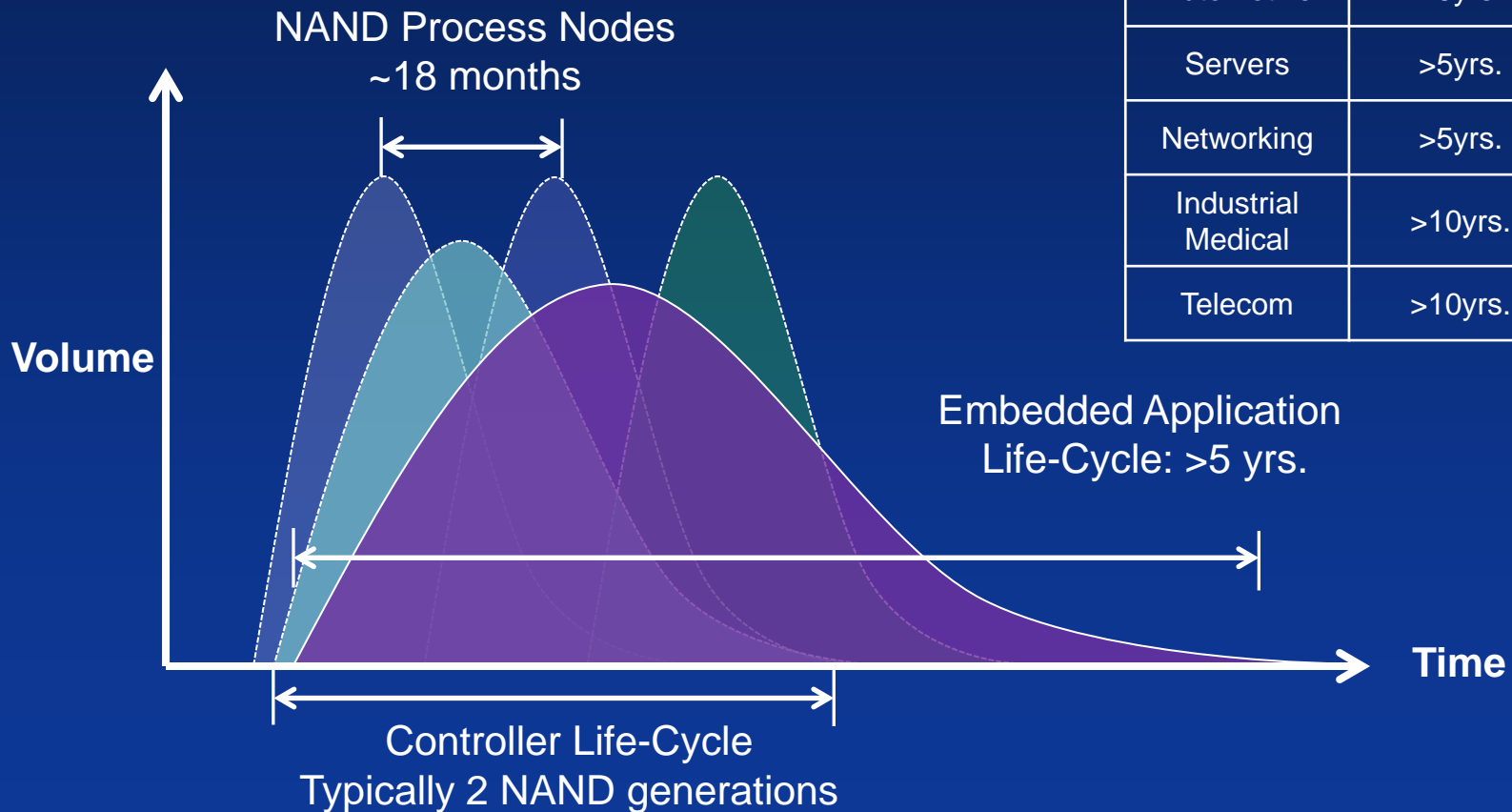


# Product Life-Cycle Mismatch

- Mismatch in product life cycles among NAND, controller and end application

## Typical Life-Cycles

Automotive	>5yrs.
Servers	>5yrs.
Networking	>5yrs.
Industrial Medical	>10yrs.
Telecom	>10yrs.





# Designed for Demanding Conditions

- Long product lifetime in the field
  - Extended endurance and reliability requirements
- Data retention at high storage temperature
- Power loss protection
  - Also for crash dump application, separate from main storage application
- High shock tolerance
  - Transportation, defense, military
- Thermal constraints
  - Industrial temp (-40°C to 85°C) for MLC needed
- *Use Case:*
  - *For telecom, NEBS compliance is a costly, major undertaking*
  - *Once the equipment is certified and deployed it is in the*



Endurance



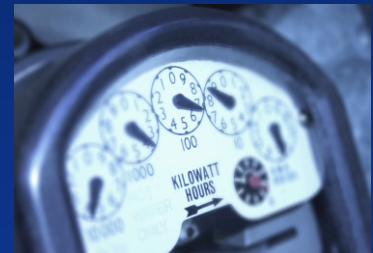
Industrial Temperature

# Matching Application Needs

- Workload
  - Mostly read or write
  - Sequential or random access more important
- Startup time and specific latency requirements
- Power and thermal constraints



Speed

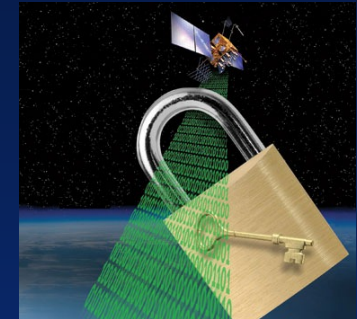


Power  
Consumption

→ *Driving the need for FW optimization and customization*

# Custom Requirements

- Data Security
  - Data encryption – AES crypto engine
  - Secure Erase
  - e.g. gaming application, military/defense
- Custom Burn-In
  - MLC Flash endurance screening
- Device Health Reporting
  - P/E cycle count
  - Reserved block count



AES Encryption  
DATA Security



Device Health



# Case Study #1

- Customer X redesigns its high-performance, high-availability system to replace the dedicated embedded Flash device for boot and system codes, and the SATA drive for user data in the existing design with a single SATA SSD
- Boot/system codes and user data have very different characteristics, usage model and reliability requirements
- *Solution: Customized firmware to enable boot/system codes and user data to be put in separate partitions that are managed separately*



## Case Study #2

- Customer Y has a usage model that requires high number of drive writes per day and sustained write performance
- *Solution: After analyzing the data workload, firmware was tweaked to improve the write performance for the specific workload*





# Take-Aways

- Flash technology is evolving at a rapid rate and is becoming more and more complex for embedded applications.
- Design considerations and product customization specific to embedded applications
- Customization is the key to meet application's specific needs



***QUESTIONS?***



Thank You