Driving SSD Storage into Today's Embedded Systems Computing Architecture's

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Presentation Agenda

- Standard Form-Factors and Applications
- Market Trends
- Common Figures of Merit
- Embedded SSD
  - Value Set
  - FF Examples & Comparison
  - Design Points
- Case Study
- Summary

When we think mainstream SSD, we think…

Form-factors	Target Applications	Figures of Merit
 2.5” SSD	**Client – Note/Netbook**	**$/GB (MLC)**
	Enterprise - Server	**IOPS/GB, IOPS/Watt, TCO**
 1.8” SSD	**Embedded / Industrial**	**Form-Factor, Reliability, Service Life**

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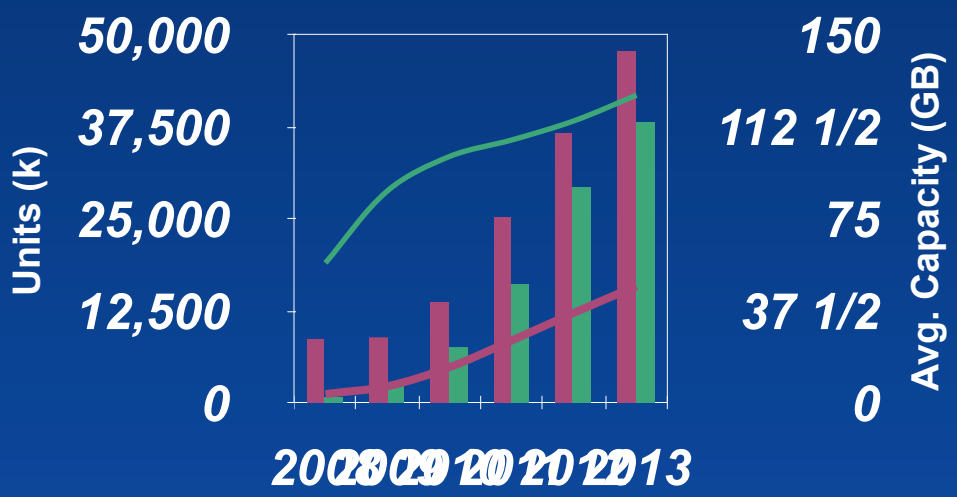
SSD Market Trends

January 2009, "Standard 1.8" & 2.5" SSD's are forecasted experience a CAGR of 84% from 2007 thru 2012. "

More Recently, the forecast for Notebook and Netbook penetration has been pulled back, largely due to MLC Nand Pricing and Supply challenges



Source: IDC, 2009

When we think SSD Figures of Merit, we think…

Figure of Merit	Description	Trend
GB	Drive Capacity	Raw, User, Over Provisioning
Form-Factor	1.8”, 2.5”, 3.5”, or other**	2.5” & Embedded FF’s
Interface	PATA, USB, SATA, SAS, PCIe	Serial IO
MB/s & IOPS	Sustained vs. Random RW	As compared to HDD
IOPS/Watt	Performance per Watt	As compared to HDD
$/GB	Cost per GB	SLC vs MLC
Endurance (aka Drive Life)	Defined by (P/E Cycles, Write Amp, Over provisioning, Usage Model, Write IOPS)	Consumer 3 yrs Embedded 7-10 yrs
Reliability	SSD BER f(Raw NAND BER)	ECC correction x10’s

Embedded Systems Design: SSD Value Set…

While we cant claim the following holds true for all,
Embedded System Applications are more likely to value:

Form-Factor – GB/mm^3 – the smaller the better

Reliability – SLC driven, Data Retention, BER (die shrink)

Performance – 80MB/s < Sustained R/W < 150MB/s

BOM Control – no surprises

Service Life – 5 to 10 years++

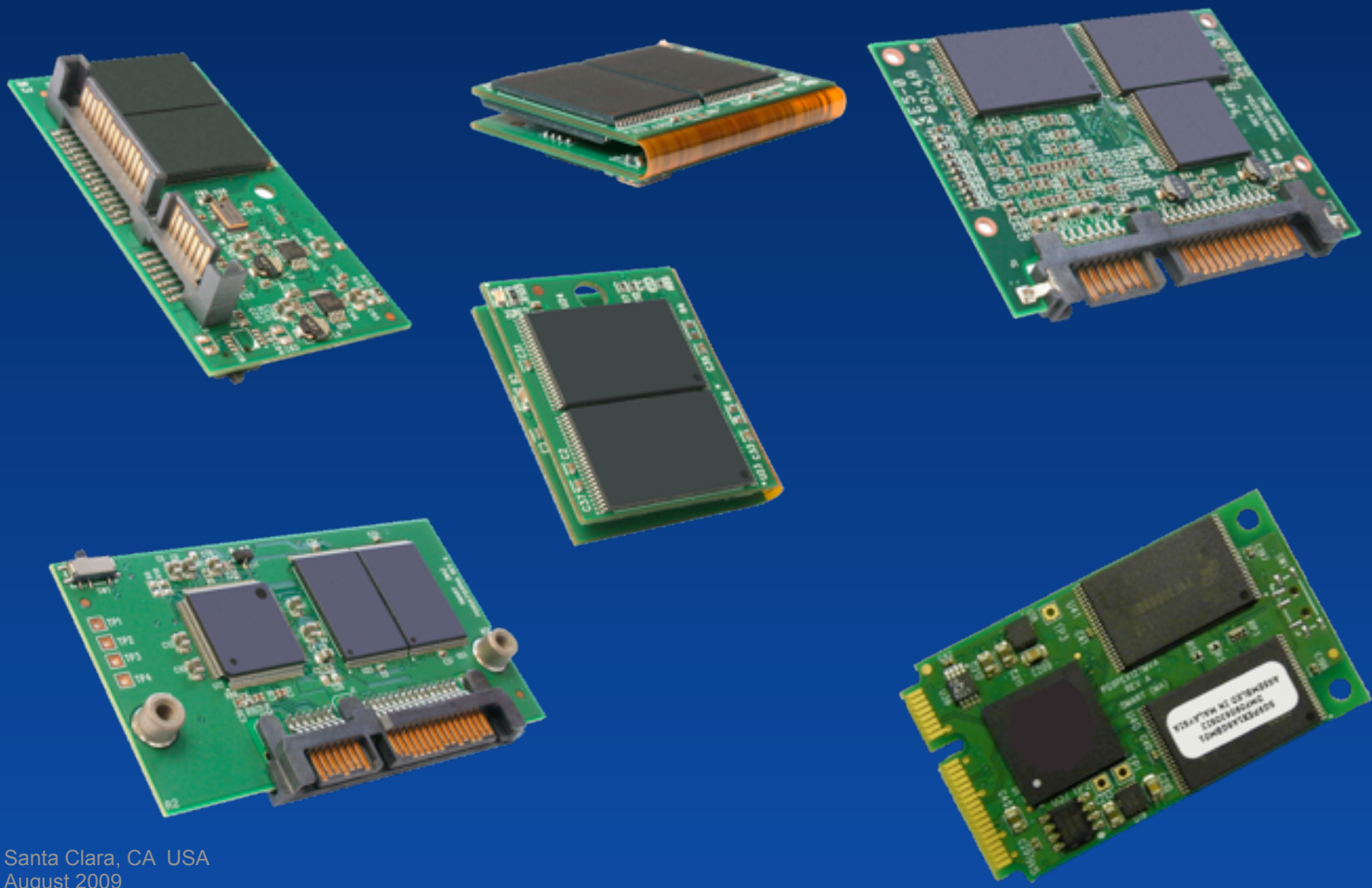
Continuity of Supply – 2nd Source, Standardization

Over

Capacity –8, 16 or 16GB can be sufficient

Cost – always important, but see Reliability above

Embedded SSD Form-Factors



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When size matters…

FF	Dimensions (mm)	Volume (mm^3)	%	Claim to Fame
2.5" SSD	100.2 x 69.85 x 9.5[1]	66490.2	-	Industry Standard – Consumer, Enterprise, etc.
1.8" SSD	78.5 x 54 x 5	21060	68%	Notebook, Mobile, Consumer
iSATA	69.9 x 39.4 x 7.4	20380	69%	Drop in Replacement for 2.5" SSD
Slim[2]	39 x 54 x 4.5	9477	85%	JEDEC MO-297A
mPCIe[3]	51 x 30 x 4.75	7274.6	89%	Target Netbooks, JEDEC Proposal
uSATA	30 x 25 x 7.6	5700	91%	Smallest Removable SATA SSD

NOTE: 1. Z-height can be up to 21.5mm
2. SFF-8156 & JEDEC MO-297A
3. Full length mPCIe

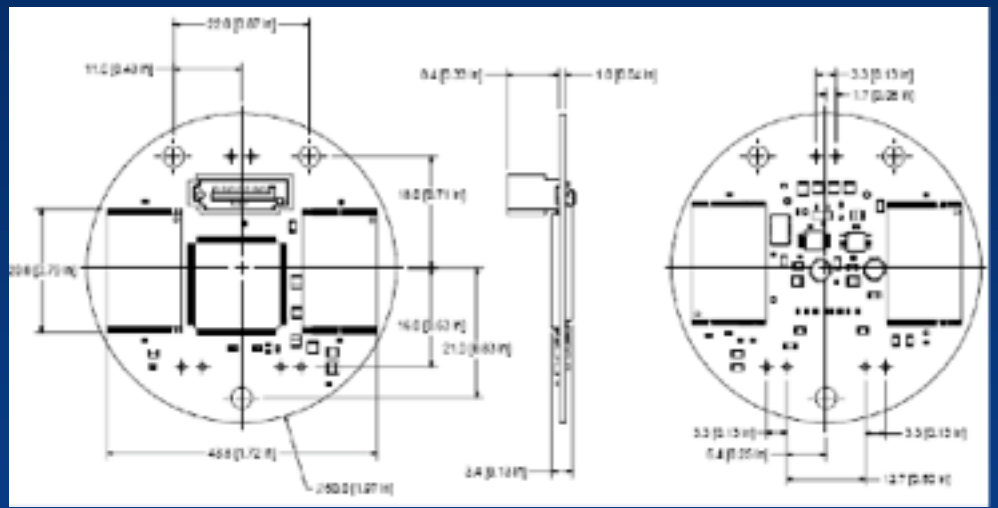
Embedded SSD Design Points

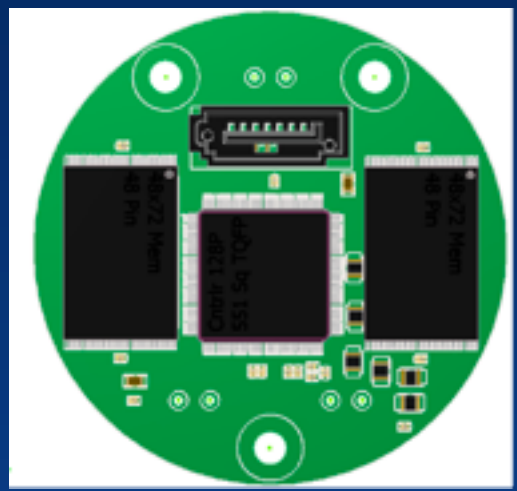
- NAND Technology (SLC vs. MLC) – selection driven by the controller and cost target
- Module x, y & z Footprint – smaller the better, but…
- Connector Interface – 3Gb/s going to 6Gb/s
- Deterministic Performance - worst case write latency?
- Design for Reliability and Endurance – in most cases

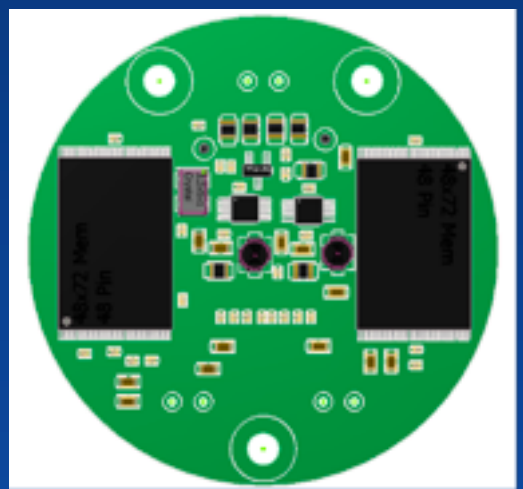
Embedded SSD Reliability

- Embedded Applications typically place a premium on in-system Reliability and installed Service/Drive Life
- The more on-board cache, the more data risk given unexpected power loss – Supercaps are not really an option
- Data Retention as a function of P/E cycles becomes a real problem – corrupted OS image platform does not boot

Case Study :Embedded SSD App







Application Requirements:

Drive Capacity: 8GB or 16GB, with path to 32GB

Interface: SATA 1.0 (1.5Gbps)

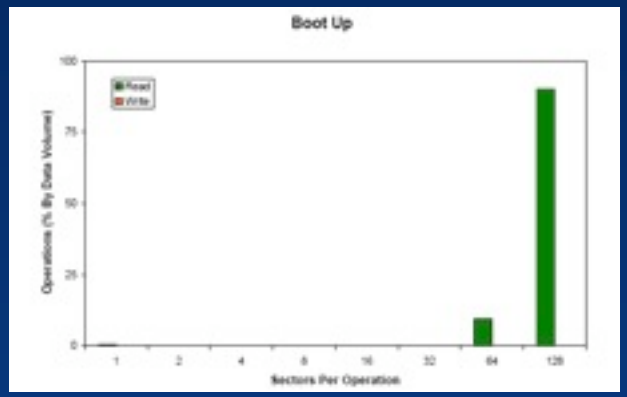
Memory Technology: SLC NAND

Drive Voltage: 3.3V +/- 10%

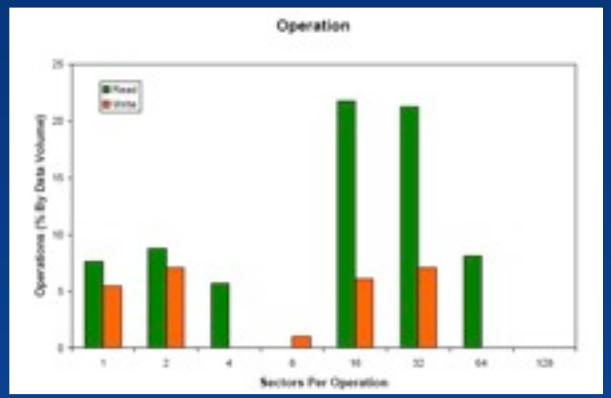
Operating Temp: -45 to +85C, Storage to +125C

Case Study: High Level Usage Model

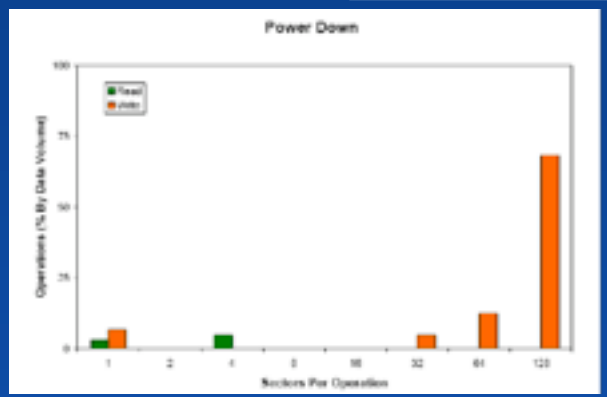
During System Boot – Drive operations are Read-only



During Normal Operations, Read and Write operations are distributed, and can be assumed to be repeatable



In the event of Power Down or Loss, Write operations become more dominant & critical



Case Study: Usage Model

Partition	Size	Write Frequency	Note
OS/Configuration	2GB	10 times per yr	Sequential
Index	512B	once every 10 seconds	Random
User Data	1GB	four times an hour	Sequential
Logging	1MB	once every 10 seconds	Random

Case Study: Drive Life Estimation

Drive Life = $\frac{(\#\text{ of Super Blocks} * \text{P/E Cycle})}{\#\text{ of Super Blocks erased}}$

Note: Write Amplification is accounted for when calculating the # of SB's erased (random vs sequential)

Module Configuration	P/E Cycles Assumed	Drive Life (Yrs)
8GB (SLC)	100K	9.7
8GB (MLC)	5K	.49
16GB (SLC)	100K	19.41
16GB (MLC)	5K	.97

Embedded SSD Summary

- Embedded Apps tend to favor Form-Factor, Endurance & Reliability above all else
- Consumer & Enterprise SSD Application requirements (e.g., High Capacity, Standard 1.8” or 2.5” FF, MLC NAND, Caching, etc.) do not necessarily overlay with Embedded SSD Application requirements.
- Support and Advancement of embedded SSD form-factors (i.e., JEDEC MO-297A Slim) are critical to driving greater acceptance and growth of SSD’s in Embedded applications.

Questions ??

Thank You