



Lifetime Estimation and Health Monitoring

Support for System Qualification Testing

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Introduction

- Impact of FTL and payload on endurance
- Life-time estimation
- Data retention
- Health monitoring



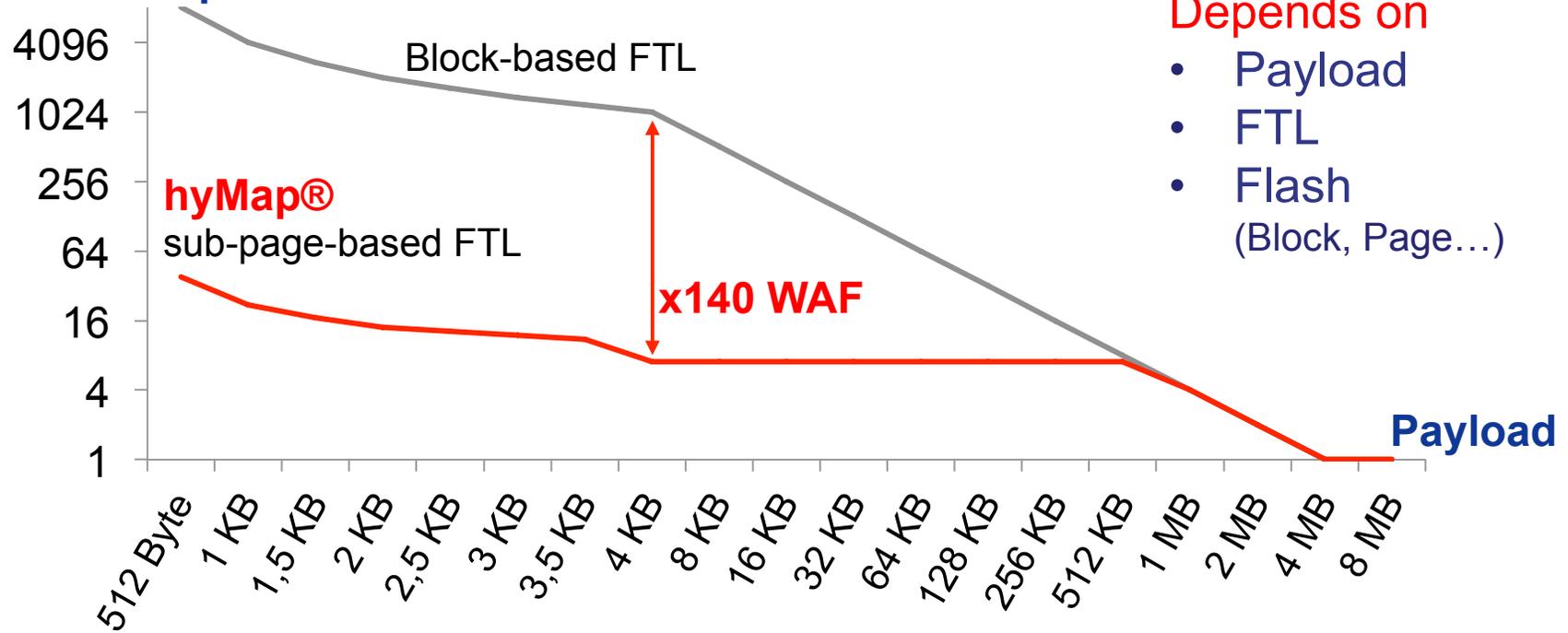
Some Endurance basics...

- $WAF(\text{workload, FTL, Flash}) = \text{Bytes written to NAND} / \text{Bytes written from Host}$
- $TBW = \text{Capacity [GB]} / 1000 * PE \text{ cycles} / WAF = \text{Capacity [GB]} * PE \text{ cycles} / 1000 * WAF$
- $\text{Lifetime [Years]} = TBW * 1000 / \text{Write Budget per Day [GB]} * 365$
- $DWPD = TBW * 1000 / \text{Warranty [Years]} * \text{Capacity [GB]} * 365 = PE \text{ cycles} / WAF(\text{workload, FTL, Flash}) * \text{Warranty [Years]} * 365$

365

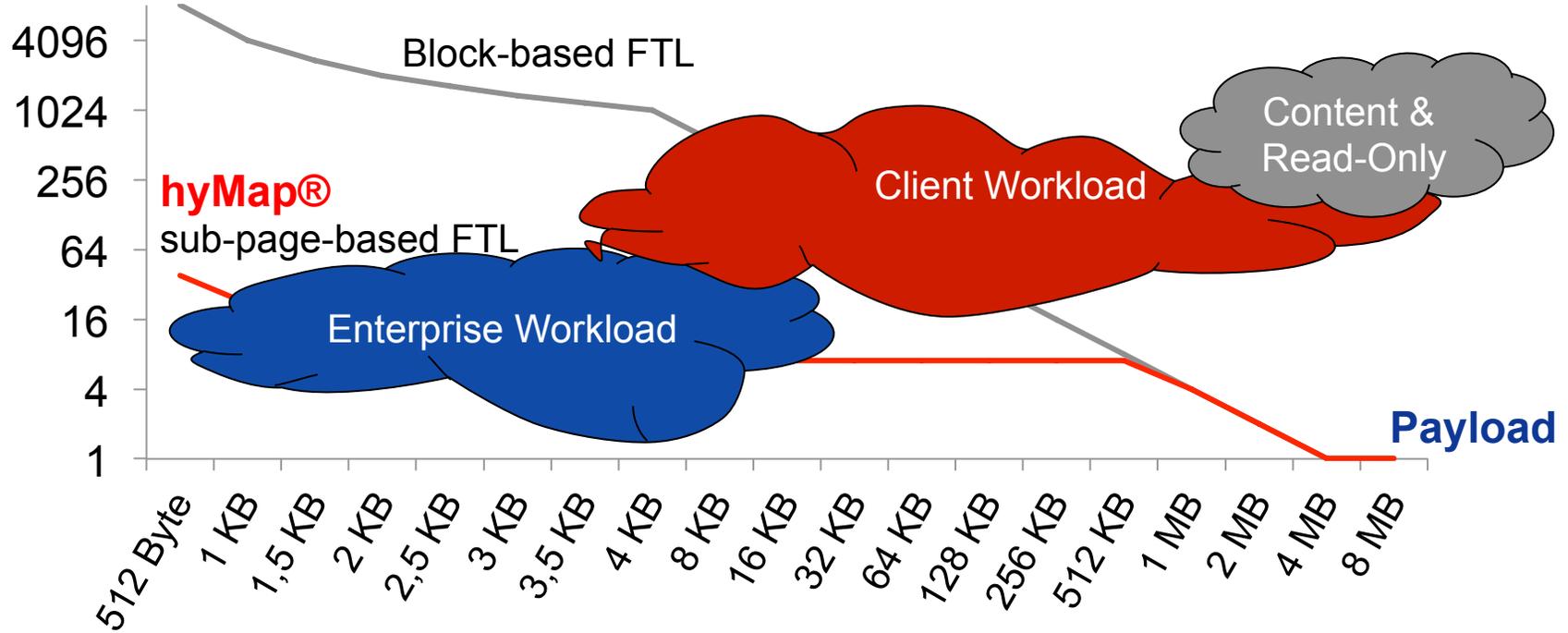
Write Amplification

Write Amplification Factor



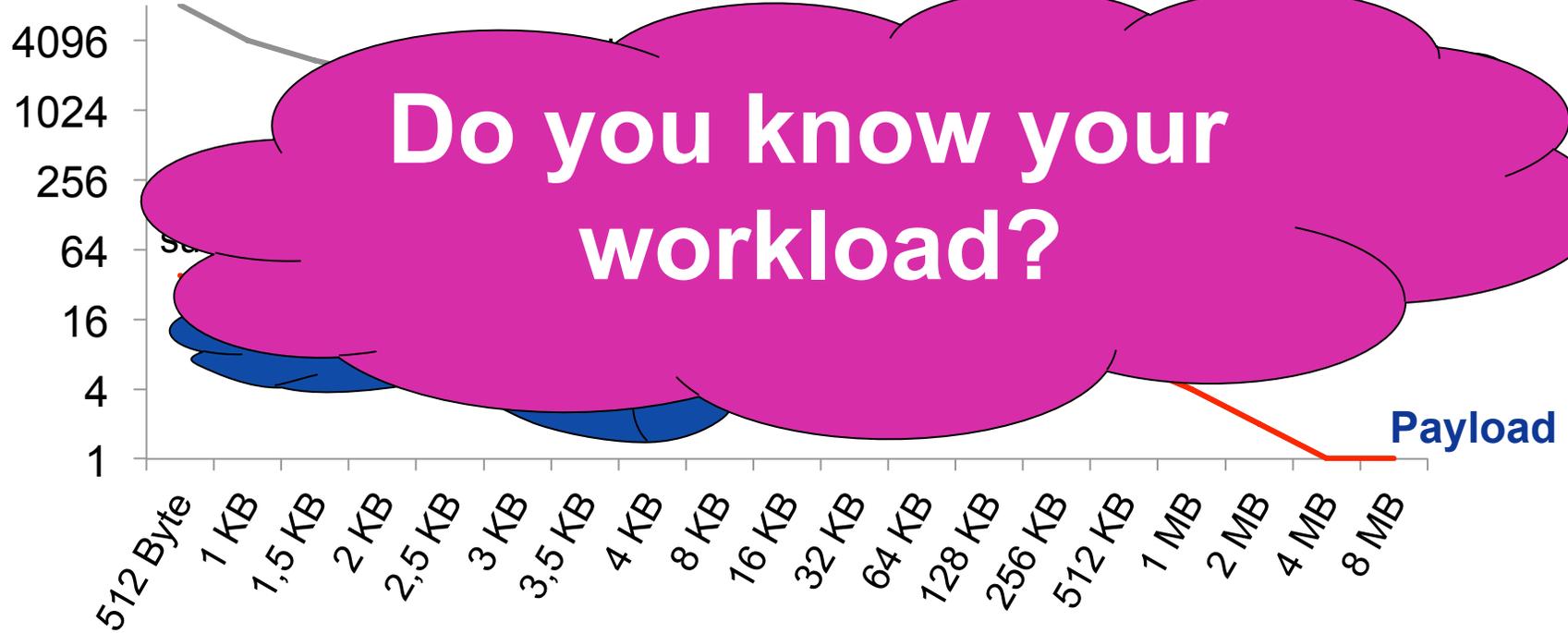
Impact of Workloads

Write Amplification Factor



Impact of Workloads

Write Amplification Factor





Lifetime Estimation

1y-nm MLC - 256Gbit, 16k page, 8192k blk, 3000 P/E

Number of Chips
2

Over Provisioning [%]
10

Early Acknowledge on?
Yes

MLC Mode
Performance

Write Budget [MB/day]
65536

Share of Static Data [%]
30

← Selected configuration

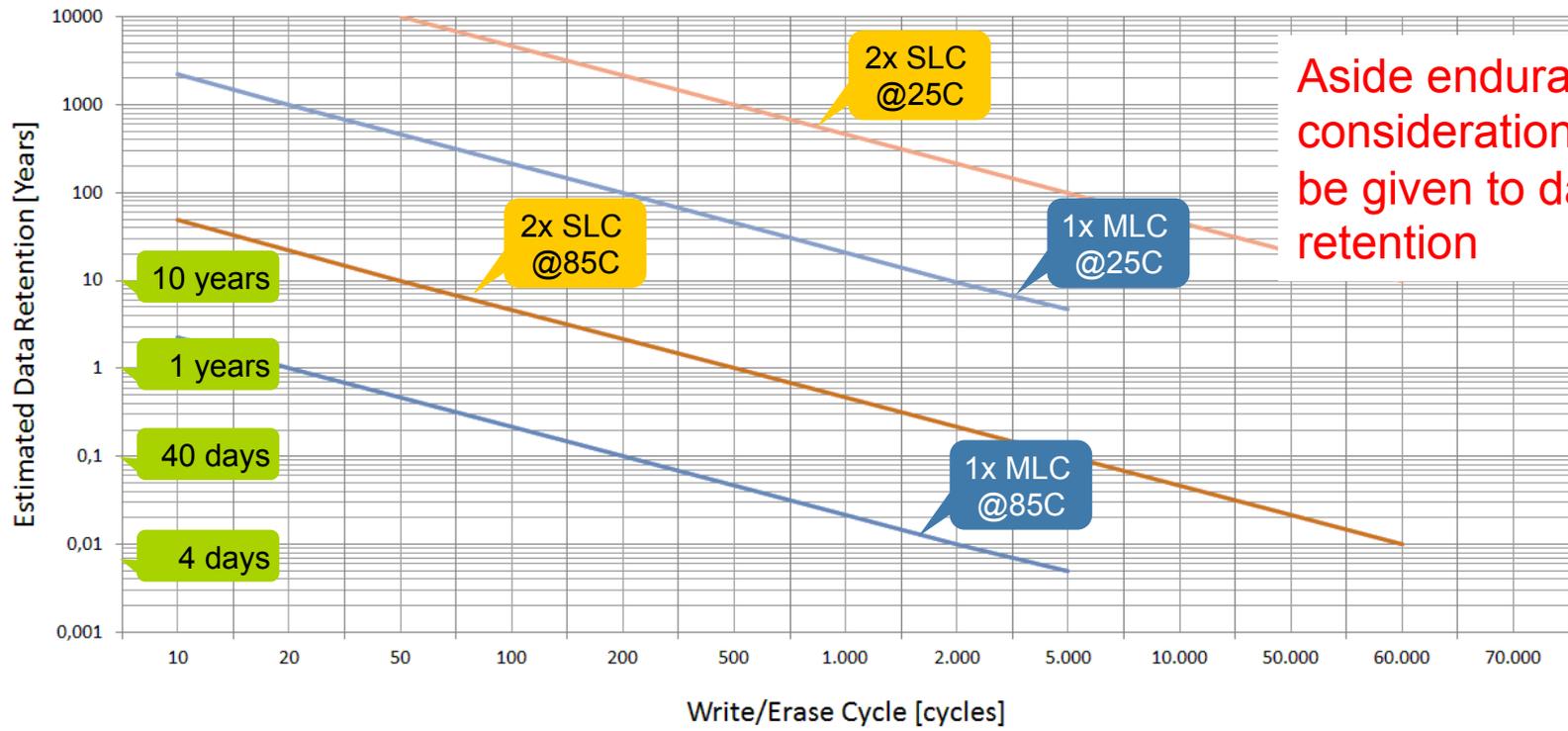
Selected FTL

hyMap®

Life-Time →

Payload (k)	WAF (Avg.)	TBW	Estimated Life (Years)
0.5	36	5.4	0.2
1	20	9.7	0.4
1.5	14	13.4	0.6
2	12	16.4	0.7
2.5	10	19.0	0.8
3	9	21.3	0.9
3.5	8	23.2	1.0
4	5	40.8	1.7
8	5	40.8	1.7
16	5	40.8	1.7
32	5	40.8	1.7
64	5	40.8	1.7
128	5	40.8	1.7
256	5	40.8	1.7
512	5	40.8	1.7
1024	5	40.8	1.7
2048	3	68.6	2.9
4096	2	96.0	4.1
8192	1	192.0	8.2
JEDEC enterprise	6.4	38.0	1.6

Data Retention



Aside endurance, consideration should be given to data retention



Health monitoring

Measuring actual status of your drives' health

- Erase counts
 - Minimum
 - Maximum
 - Average
 - Per stripe and logical channel
- Spare block count
- Read Disturb Management status
- Global Wear Leveling status
- Total correctable ECC errors
- Total number of LBAs read/written
- Power-on count
- Firmware status
- User defined thresholds to generate yellow & red warnings

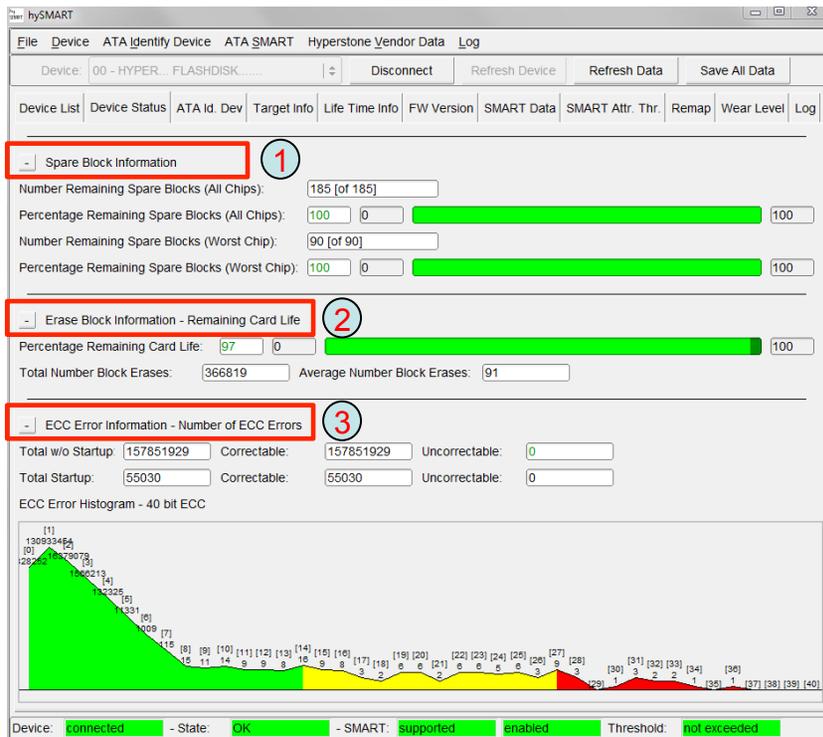
Supports qualification and preventive maintenance



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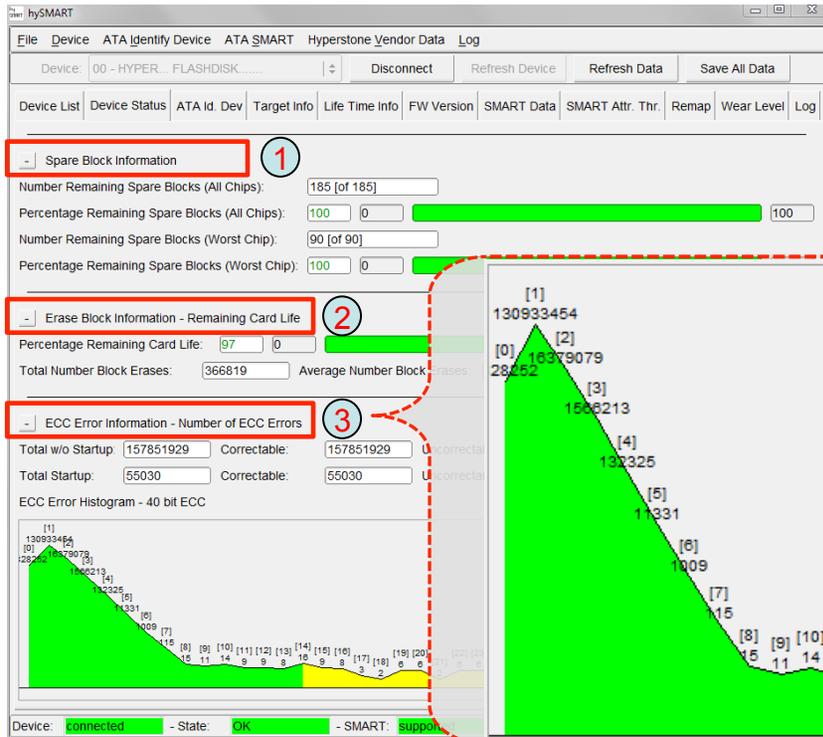
Health Monitoring



- 1 Remaining spare blocks
- 2 Block erase count
- 3 Corrected errors



Health Monitoring



- ① Remaining spare blocks
- ② Block erase count
- ③ Corrected errors



Health Monitoring

hySMART

File Device ATA Identify Device ATA SMART Hyperstone Vendor Data Log

Device: 00 - HYPER... FLASHDISK..... Disconnect Refresh Device Refresh Data Save All Data

Device List Device Status ATA Id. Dev Target Info Life Time Info FW Version SMART Data SMART Attr. Thr. Remap Wear Level Log

Spare Block Information 1

Number Remaining Spare Blocks (All Chips): 1443 [of 1443]

Percentage Remaining Spare Blocks (All Chips): 100 0 100

Number Remaining Spare Blocks (Worst Chip): 315 [of 315]

Percentage Remaining Spare Blocks (Worst Chip): 100 0

Erase Block Information - Remaining Card Life 2

Percentage Remaining Card Life: 32 0 100

Total Number Block Erases: 69588480 Average Number Block Erases: 2040

ECC Error Information - Number of ECC Errors 3

Total w/o Startup: 3146196 Correctable: 3146196 Uncorrectable: 0

Total Startup: 6 Correctable: 6 Uncorrectable: 0

ECC Error Histogram - 40 bit ECC

Device: connected - State: OK - SMART: supported enabled Threshold: not exceeded

① Remaining spare blocks

② Block erase count

③ Corrected errors



Health Monitoring

Device List	Device Status	ATA Id. Dev	Target Info	Life Time Info	FW Version	SMART Data	SMART Attr. Thr.	Remap	Wear Level	Log
Decoded Hyperstone Life Time Info										
Version Identifier:	0x01									
Read Disturb Management:	0x01 - on									
Global Wear Level:	0x01 - on									
Global Remap:	0x01 - on									
Host Transfer CRC Errors:	0x00000000 - 0									
Total LBAs Read:	0x000000003f64cea -	6647								
Total LBAs Written:	0x00000000420a97b -	6926								
ECC Correction Capability:	0x28 - 40									

Sub Version Identifier:	0x01									
Initial Spare Blocks Worst:	0x0093 - 147									
Initial Spare Blocks Sum:	0x02ea - 746									
Remaining Spare Blocks Worst (%):	0x64 - 100									
Remaining Spare Blocks Sum (%):	0x64 - 100									
Unc. ECC excluding Startup:	0x0000 - 0									
Lowest Wear Level Class:	0x0000 - 0									
Highest Wear Level Class:	0x0000 - 0									
Wear Level Threshold:	0x007f - 127									
Total Number Block Erases:	0x0000000481b -	18459								
Number of Flash Blocks:	0x000042 - 66 (in units of 256 blocks)									
Max. Flash Block Erase Count:	0x00000017 - 23 (in wear level class units)									
Power On Count:	0x00000b80 - 2944									
Firmware Version:	0x16042920									

Total Number Of Reads:	0x000000004a32d18 -	77802776								
Unc. ECC during Startup:	0x00000000 - 0									
Corr. ECC during Startup:	0x0000006e - 110									
Min. Block Erase Count:	0x00000001 - 1									
Max. Block Erase Count:	0x00000002 - 2									
Anchor Block Write Count:	0x00000001 - 1									
Initial Read Disturb Threshold:	0x0000ea60 - 60000									
Current Read Disturb Threshold:	0x0000ea60 - 60000									
RDM Block Refresh Count:	0x00000000 - 0									
Corr. ECC excluding Startup:	0x0000000000c947 -	5152								
Warm Reboot Count:	0x00000012 - 18									
Commit Count:	0x0000495d - 18781									
Flush Count:	0x000044fe - 17662									
Power Up Count:	0x00000000 - 0									
Read Retries excluding Startup:	0x00000000 - 0									

RAW Hyperstone Life Time Info										
000 :	01 01 01 01 01 00 00									
010 :	00 00 00 00 00 04 20									
020 :	64 64 00 00 00 00 00									
030 :	00 00 48 1b 00 04 42									
040 :	00 00 00 00 04 a3									
050 :	00 00 00 01 00 00 00									
060 :	00 00 ea 60 00 00 00									
070 :	00 00 00 12 00 00 00									
080 :	00 00 00 00 00 00 00									
090 :	00 00 00 00 00 00 00									
0a0 :	00 00 00 00 00 05									
0b0 :	00 00 00 00 00 00 00									
0c0 :	00 00 00 00 00 00 00									
0d0 :	00 00 00 00 00 00 00									
0e0 :	00 00 00 00 00 00 00									
0f0 :	00 00 00 00 00 00 00									
100 :	00 00 00 00 00 00 00									
110 :	00 00 00 00 00 00 00									
120 :	00 00 00 00 00 00 00									
130 :	00 00 00 00 00 00 00									
140 :	00 00 00 00 00 00 00									
150 :	00 00 00 00 00 00 00									
160 :	00 00 00 00 00 00 00									
170 :	00 00 00 00 00 00 00									
180 :	00 00 00 00 00 00 00									
190 :	00 00 00 00 00 00 00									
1a0 :	00 00 00 00 00 00 00									
1b0 :	00 00 00 00 00 00 00									
1c0 :	00 00 00 00 00 00 00									
1d0 :	00 00 00 00 00 00 00									
1e0 :	00 00 00 00 00 00 00									
1f0 :	00 00 00 00 00 00 00									

Device:	connected	- State:	OK	- SMART:	supported	enabled	Threshold:	not exceeded		

- ① Total LBAs read/written
- ② Wear-level spread
- ③ Read disturb refresh
- ④ Read retry count

Enabling remote monitoring of field data health



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Summary

- Use cases with random writes benefit from sub-page based FTL
- Web based Lifetime Estimation helps to reduce cost
- Health Monitoring to verify payload assumptions and schedule preventive maintenance and replacement
- Visit our booth to see a life demo of our tools

Questions ?

INDUSTRIAL/EMBEDDED

Quality Health FIT Reliability Data Retention
 Monitoring Long-Term Cost Extended
 Performance Supply SMART Temperature
 Low alpha 8D Power Fail CF/PATA
 SSD Life-Cycle Support MTBF eUSB eMMC SD TCO

ENTERPRISE

Low Latency Speed IOPS SCM
 NVMe RAID High Storage
 Performance Capacity tiers
 Climate controlled PCIe SAS SATA Cost

MOBILE & CONSUMER

SD Short life-cycle 3D Capacity
 SSD Cost TLC
 Performance eMMC
 SATA USB



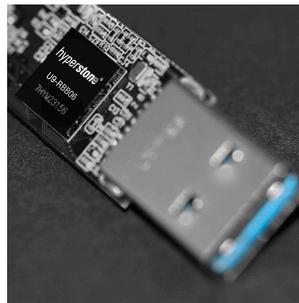
Lifetime Estimation and Health Monitoring

Thank You!

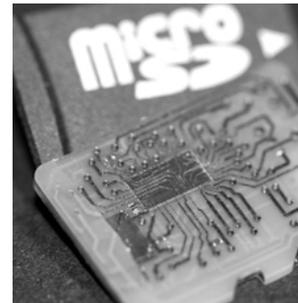
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Hyperstone Products

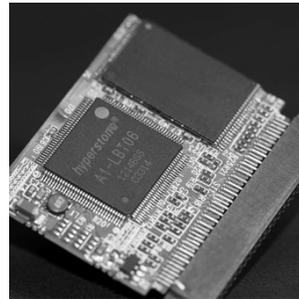
USB



SD/eMMC



CF/PATA



SATA

