

# Lifetime Estimation and Health Monitoring

## Support for System Qualification Testing

Axel Mehnert, VP Marketing

- Impact of FTL and payload on endurance
- Life-time estimation
- Data retention
- Health monitoring
- Performance trade-offs
- Summary

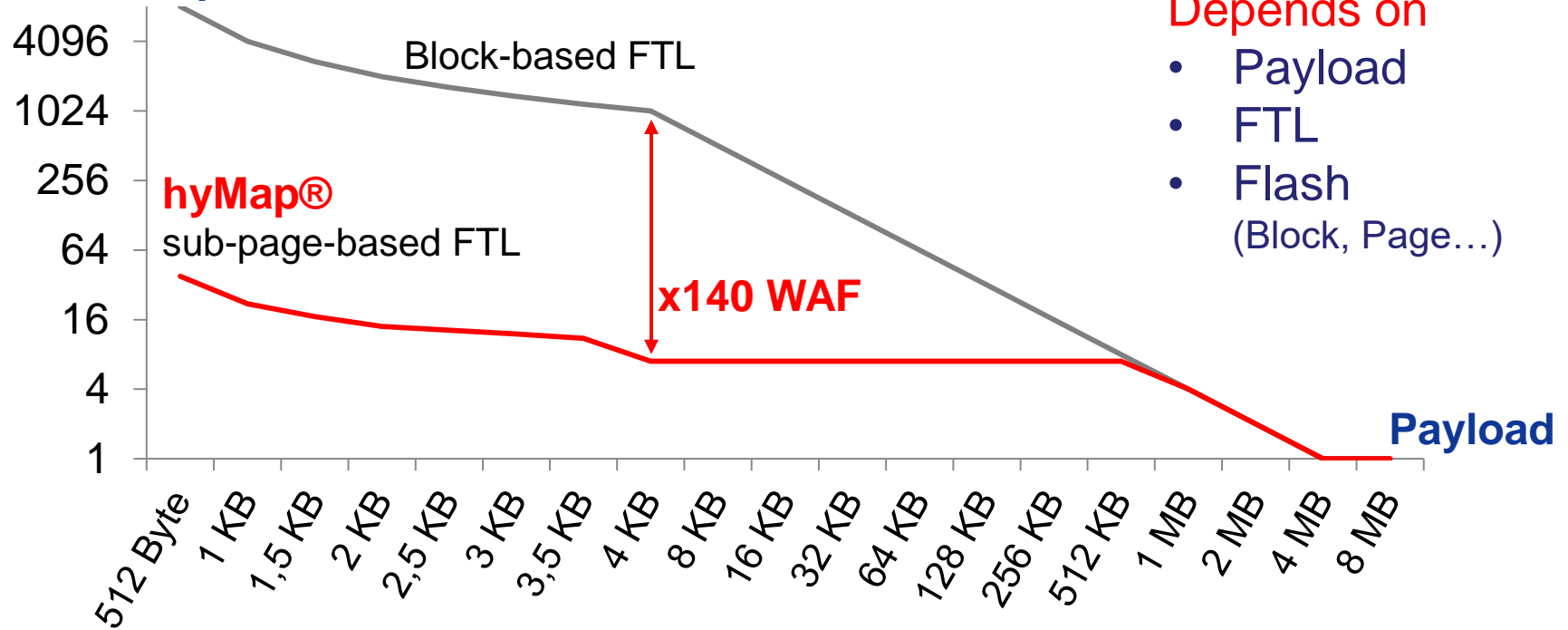
# Some Endurance basics...

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

$= \frac{PE \text{ cycles}}{WAF_{(workload, FTL, Flash)} * \text{Warranty [Years]} * 365}$

# Write Amplification

## Write Amplification Factor

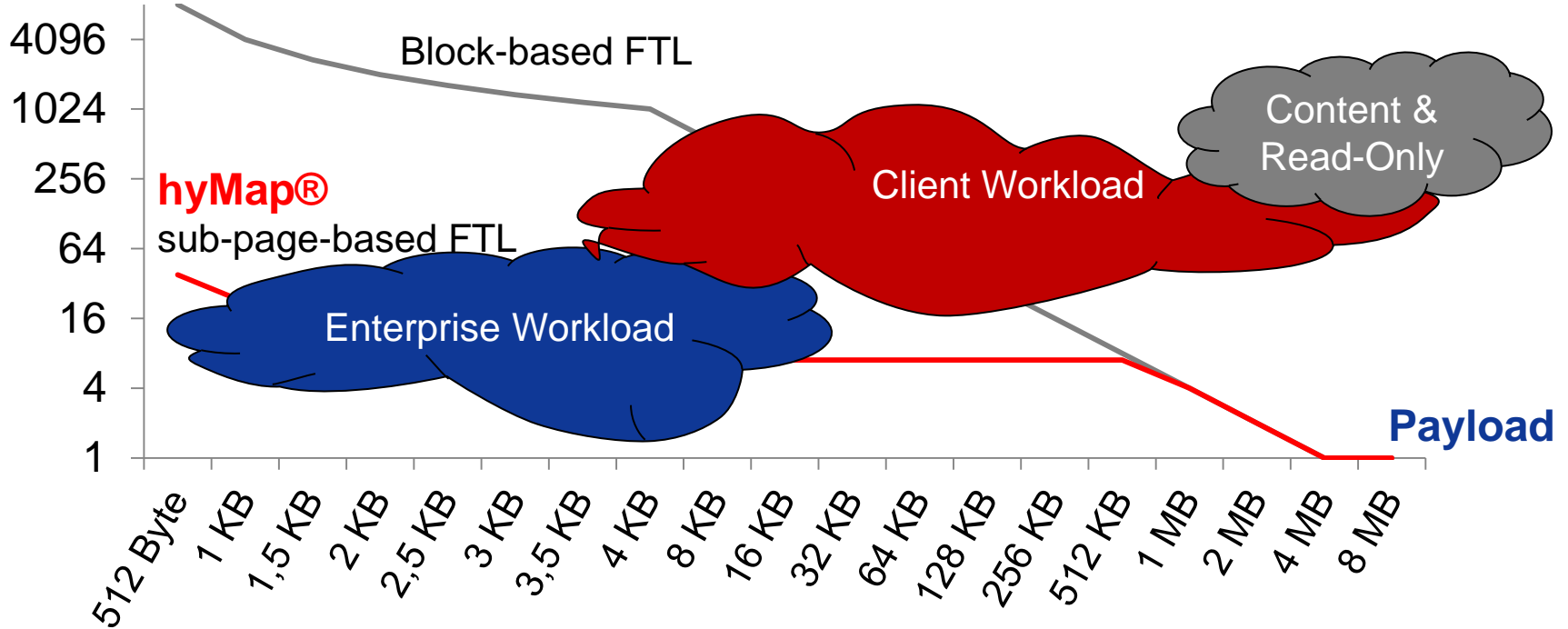


Depends on

- Payload
- FTL
- Flash (Block, Page...)

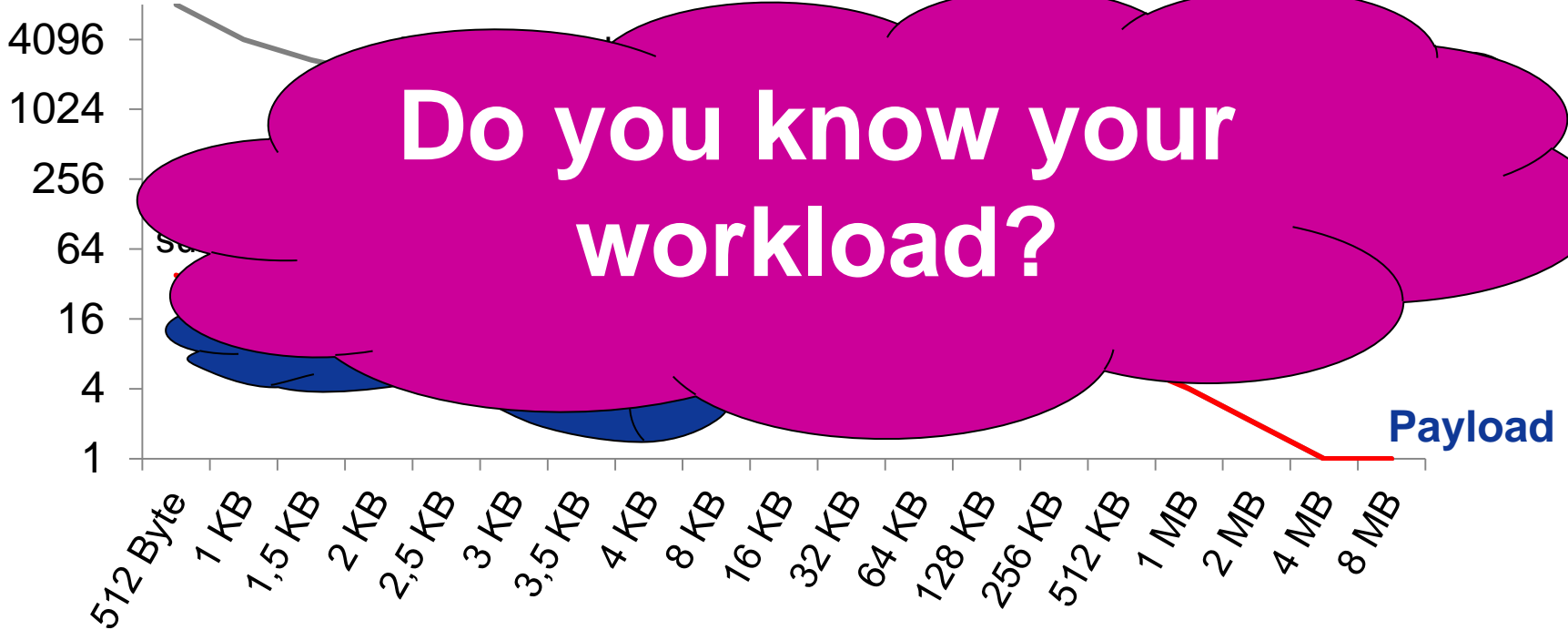
# Impact of Workloads

## Write Amplification Factor



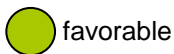
# Impact of Workloads

## Write Amplification Factor



# Impact of Workloads

Use Case	Sub-Page Based FTL	Block Based FTL
Random write	favorable	unfavorable
Sequential write	favorable	favorable



# Lifetime Estimation

Aside of payload and FTL, endurance and reliability are also subject to:

- Efficiency of Garbage Collection
- Wear-leveling
- Randomization
- Read disturb management
- Data Refresh Options
- ECC Strength
- Read Retry options
- Overprovisioning
- Write-Caching
- Firmware protection
- Sudden Power Fail Management
- Reliable MLC/TLC operation

...

... Easy-to-use life-time estimation tool online...



# 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

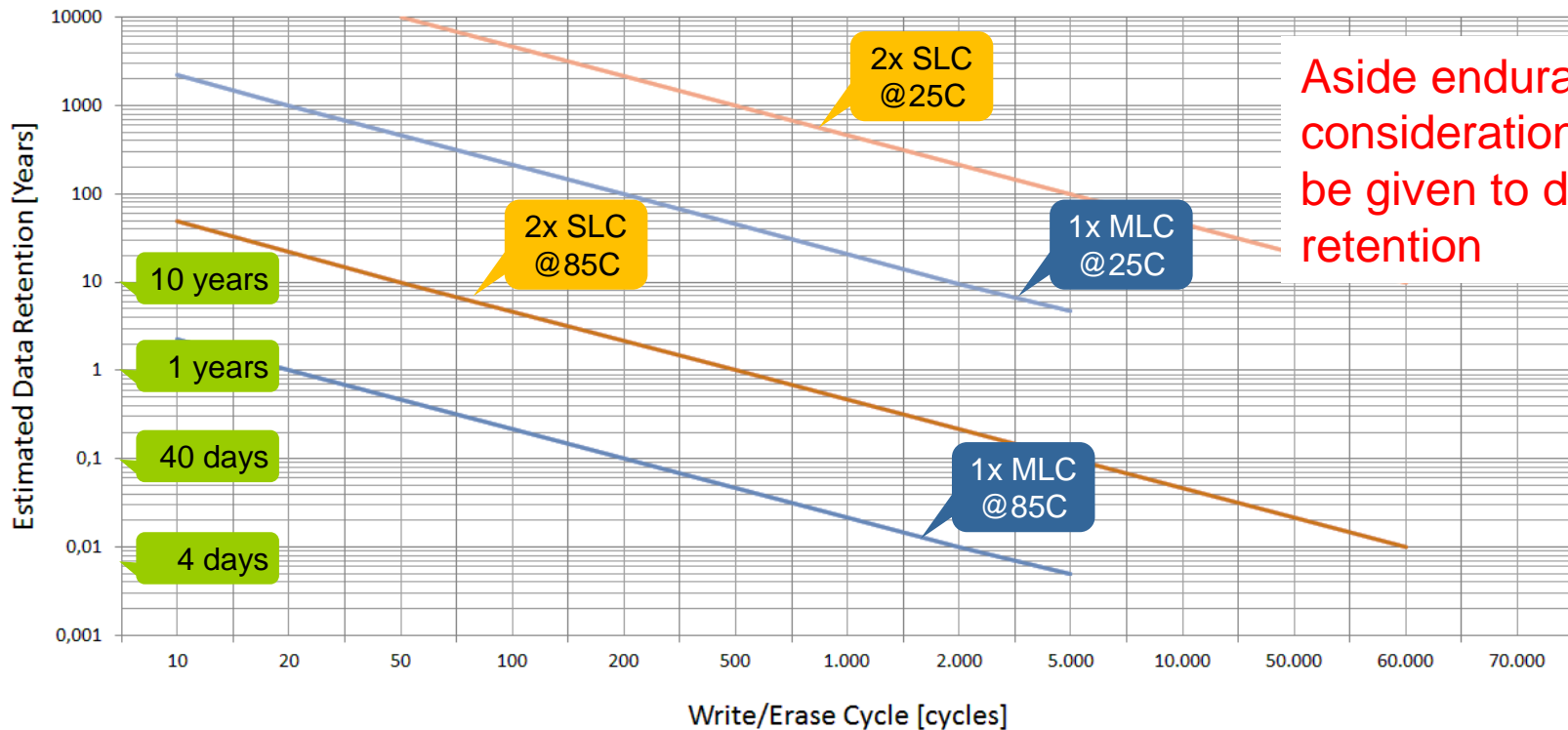
Selected FTL

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
<i>JEDEC enterprise</i>	6.4	38.0	1.6

# Data Retention



Aside endurance, consideration should be given to data retention

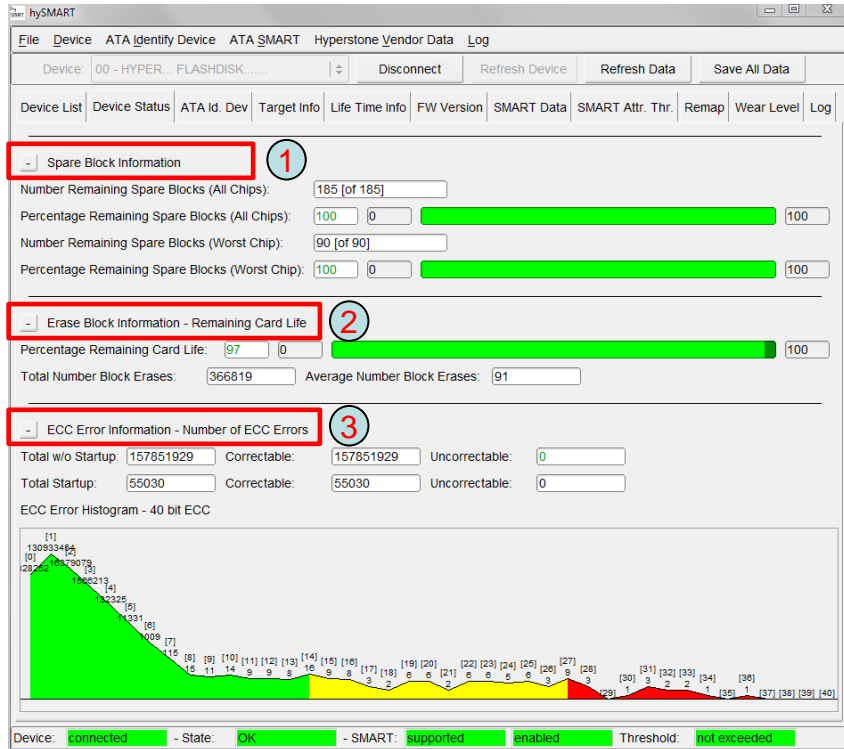
# Health monitoring

## 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

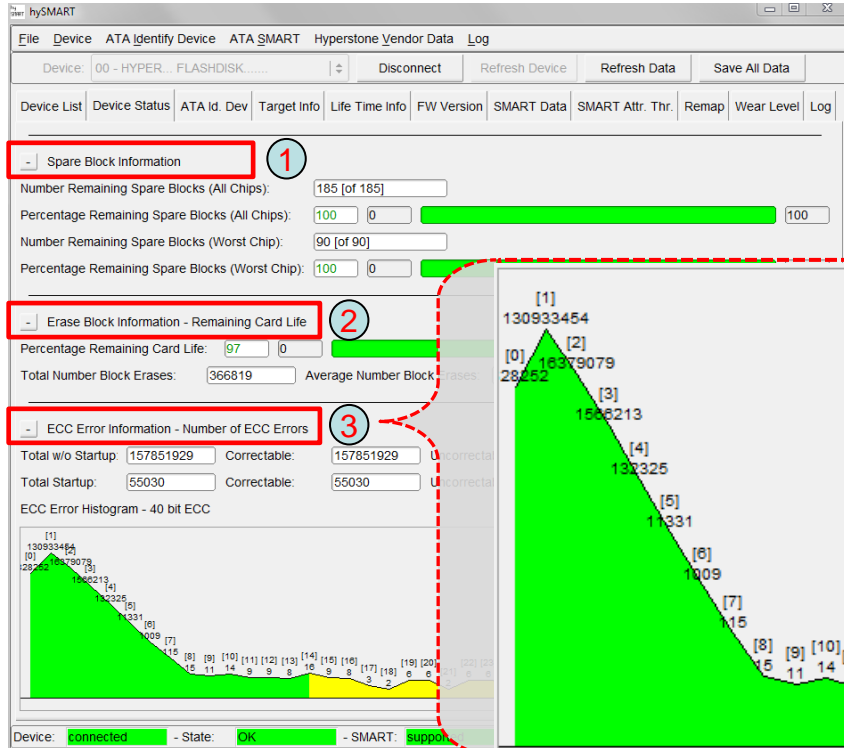
Supports qualification and preventive maintenance



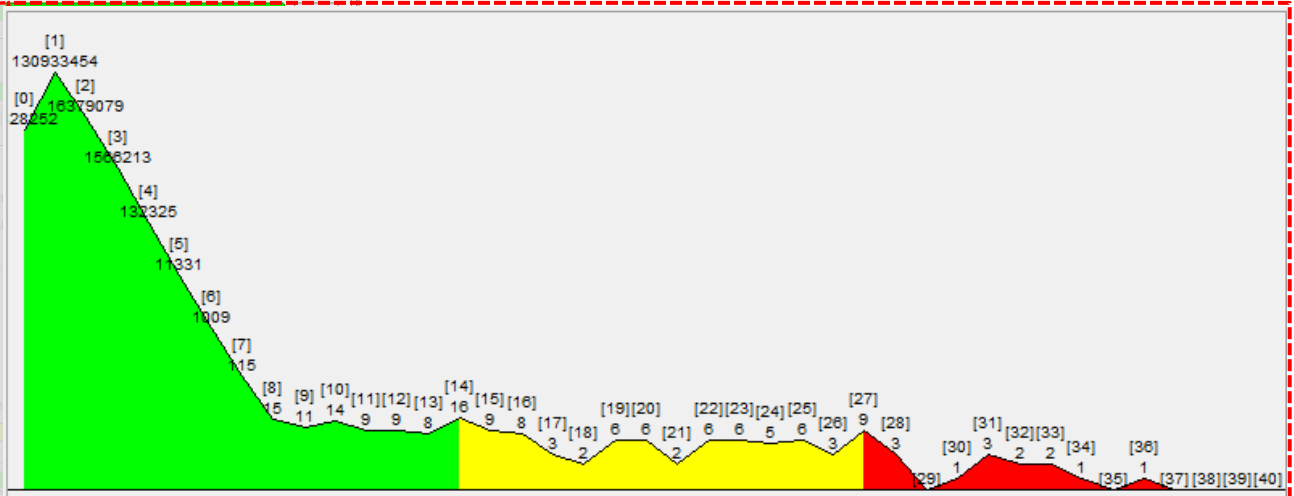


- 1 Remaining spare blocks
- 2 Block erase count
- 3 Corrected errors

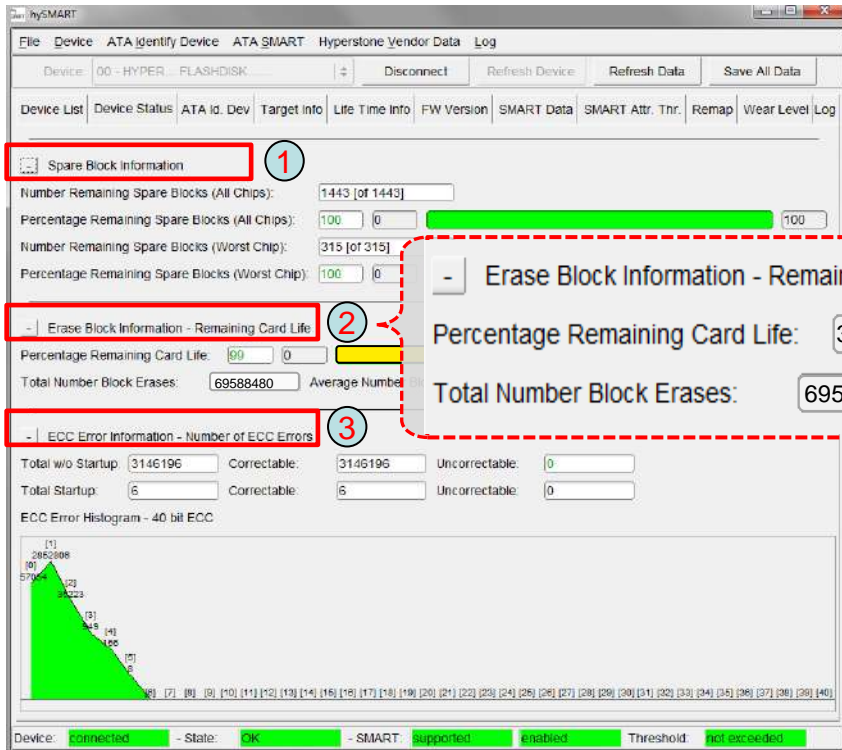
# Health Monitoring



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



# Health Monitoring



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						RAW Hyperstone Life Time Info					
<pre> Version Identifier: 0x01 Read Disturb Management: 0x01 - on Global Wear Level: 0x01 - on Global Remap: 0x01 - on Heat Transfer CBC Errors: 0x00000000 - 0 Total LBAs Read: 0x0000000003f64cea - 6647 Total LBAs Written: 0x000000000420d97b - 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: 0x00000000481b - 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: 0x0000000f - 15 Firmware Version: 0x16042920 ----- Total Number Of Reads: 0x0000000004a32d18 - 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 RDM Read Disturb Threshold: 0x00000000 - 0 RDM Block Refresh Count: 0x00000000 - 0 Corr. ECC excluding Startup: 0x00000000000c947 - 3152 Warm Reboot Count: 0x00000012 - 18 Commit Count: 0x0000495d - 18781 Flush Count: 0x000044fe - 17662 Read Retries excluding Startup: 0x00000000 - 0 </pre>											
<pre> 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 42 040 : 00 00 00 00 04 a3 050 : 00 00 00 01 00 00 060 : 00 00 ea 60 00 00 070 : 00 00 00 12 00 00 080 : 00 00 00 00 00 00 090 : 00 00 00 00 00 00 0A0 : 00 00 00 00 00 05 0B0 : 00 00 00 00 00 00 0C0 : 00 00 00 00 00 00 0D0 : 00 00 00 00 00 00 0E0 : 00 00 00 00 00 00 0F0 : 00 00 00 00 00 00 100 : 00 00 00 00 00 00 110 : 00 00 00 00 00 00 120 : 00 00 00 00 00 00 130 : 00 00 00 00 00 00 140 : 00 00 00 00 00 00 150 : 00 00 00 00 00 00 160 : 00 00 00 00 00 00 170 : 00 00 00 00 00 00 180 : 00 00 00 00 00 00 190 : 00 00 00 00 00 00 1A0 : 00 00 00 00 00 00 1B0 : 00 00 00 00 00 00 1C0 : 00 00 00 00 00 00 1D0 : 00 00 00 00 00 00 1E0 : 00 00 00 00 00 00 1F0 : 00 00 00 00 00 00 </pre>											
<p>Device: <b>connected</b> - State: <b>OK</b> - SMART: <b>supported</b> <b>enabled</b> Threshold: <b>not exceeded</b></p>											

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

Enabling remote monitoring of field data health



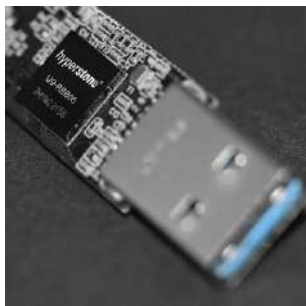
# Summary

- 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



# Hyperstone Products

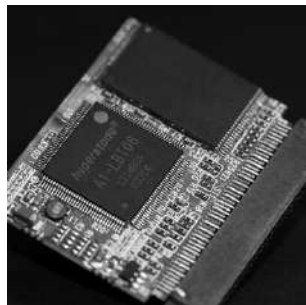
**USB**



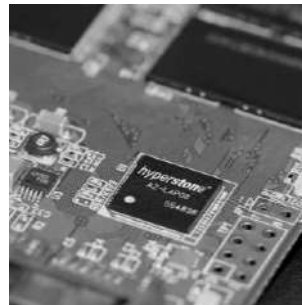
**SD/eMMC**



**CF/PATA**



**SATA**



# Hyperstone Focus

## INDUSTRIAL/EMBEDDED

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

## ENTERPRISE

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

← Mass →  
markets' focus

## MOBILE & CONSUMER

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

# Lifetime Estimation and Health Monitoring

Thank You!

Axel Mehnert, VP Marketing