



DRIVES WITH INTEGRITY

THE INTEL SSD ADVANTAGE

Q2 2016

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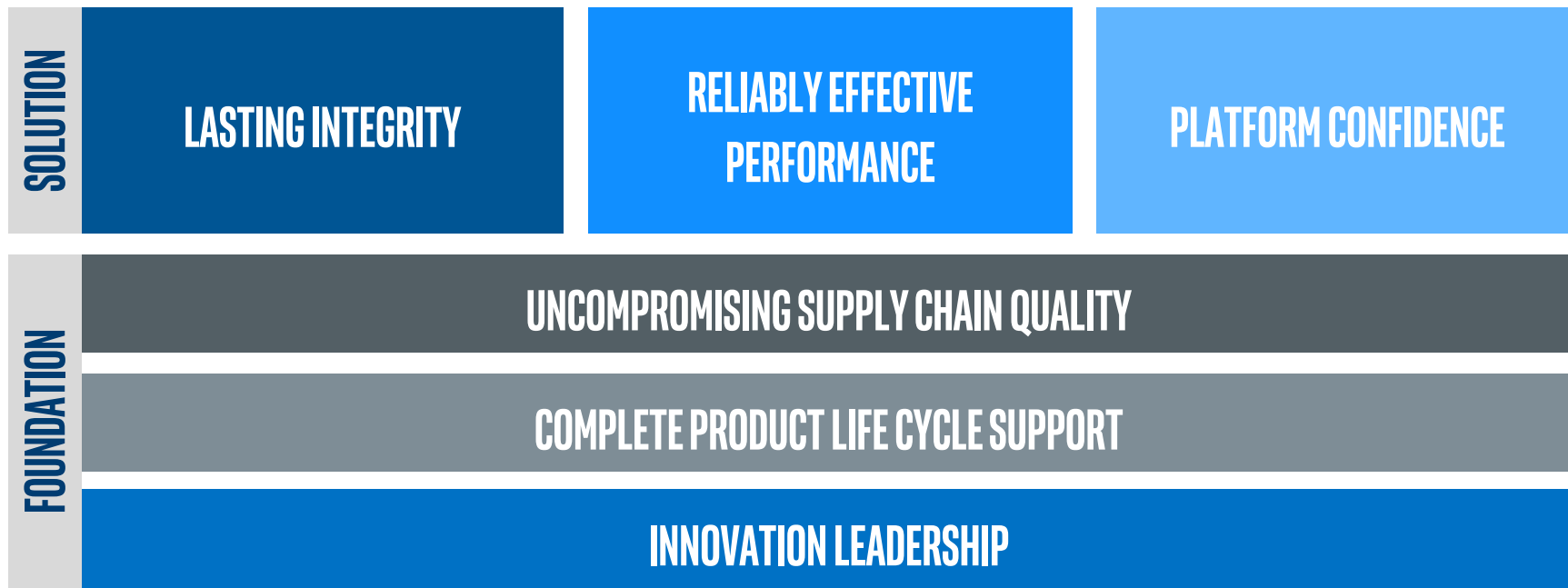
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INTEGRITY.

“Firm adherence to a
code of especially
moral or artistic
values” *Webster.com*

“The quality or state
of being complete or
undivided” *Webster.com*

DRIVES WITH INTEGRITY. THE BUILDING BLOCKS



LASTING INTEGRITY.

ROBUST. RELIABLE. PROVEN.



Proven End-to-End
data protection

Demonstrated 10^{-17}
UBER¹

≥100X more reliable
preventing Silent Data
Corruption (SDC)²

Reliability that
goes beyond



Actual **AFR**³ **consistently**
better than 0.44% goal

Better than JEDEC data
retention and UBER¹⁶



>2M PLI cycles and
self-test delivers
trusted protection
from data loss.

Select competitor drives **do not**
conduct a self-test⁴



RELIABLY EFFECTIVE PERFORMANCE.

TRUSTED. EFFECTIVE. CONSISTENT.



Validated on a
massive scale

1000s of drives

1000s of configurations

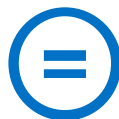
>5000 workloads

>1M power cycles

Tested **beyond JEDEC** standard



≤11% performance degradation
over the product life⁵



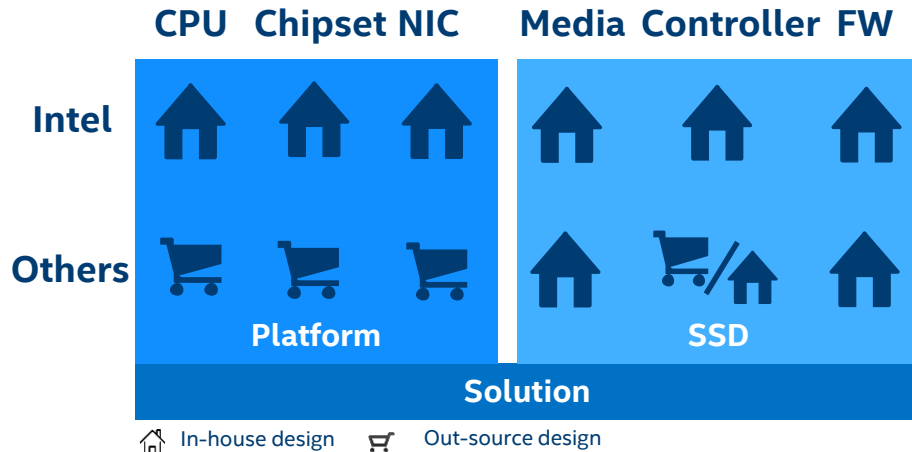
Up to **90% IOPs** consistency on all
product lines⁶

PLATFORM CONFIDENCE.



SOLUTION LEVEL DESIGN, DEVELOPMENT, VALIDATION

Complete in-house design of
data center solutions



Up to **1 more year** in
extended **platform-level
validation**

Better together platform features

**2.3X more database
transactions** with
Intel® Cache
Acceleration
Software⁷

**Improve RAID
performance and
latency** with Intel®
Rapid Storage
Technology enterprise

UNCOMPROMISING SUPPLY CHAIN QUALITY.

CONSISTENCY. QUALITY. CONFIDENCE

**95% delivery
to commit⁸**



Relentless focus
on quality,
delivering
<100 DPM⁹



**Ranked #4
overall, #1
semiconductor**
in Gartner* 2015
Supply Chain
Ranking¹⁰



COMPLETE PRODUCT LIFE CYCLE SUPPORT.

LAUNCH-READY. PLATFORM-EXPERT.

ECOSYSTEM



>2000 engineers engage ISVs and open source communities developing, optimizing preferred solutions¹¹

Preferred **solutions tuned** and ready for scale at launch

DESIGN-IN



>500 resources dedicated to OEM design-in support¹¹

Support scaled through >10,000 Intel channel partners¹¹

POST-SALES



Our customers rate Intel post-sales support as world-class¹²

Worldwide phone, chat, email, online community support in 11 languages

Platform-wide expertise

INNOVATION LEADERSHIP.

BREAKTHROUGH INNOVATIONS. GROWTH OPPORTUNITIES.



~1000
researchers
in Intel labs.

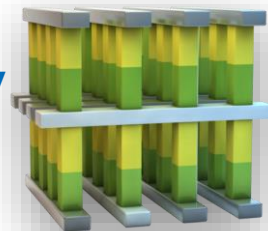
Leader in **memory technology innovation**



Disruptive technologies that drive **growth opportunities**

3D NAND Technology

3D XPoint™ Technology



REASONS TO CARE.

DISRUPTIONS ARE COSTLY



Silent Data Corruption is more costly than perceived



11 drives per 1000 can experience SDC in a year¹⁷

Actual cases demonstrate the impact

NETFLIX *

55 distribution centers down for 3 days

<http://www.pcmag.com/article2/0,2817,2328778,00.asp>

amazon *

S3 cloud service down for 36 hours

<http://cloudsecurity.org/blog/2008/06/25/a-question-of-integrity-to-md5-or-not-to-md5.html>



10-15% photos not available for 48 hours

<http://www.computerworld.com/s/article/9129263/>

Data center downtime cost **\$7.9K/min.** on average¹³



HDDs fail **~50X** more often than Intel SSDs¹⁴

REASONS TO CARE.

QUALITY OF SERVICE. CONFIDENCE.

Deliver consistent QoS

Reliably consistent performance through product life improves **QoS**

Massive validation helps ensure products **perform as expected**



Confidently grow business

Platform-ready and optimized from **day 1**



Proven supply chain quality delivers the **right product at the right time**

Rapid response to **support calls from platform experts**

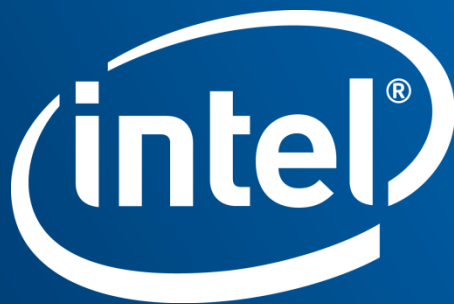


DRIVES WITH INTEGRITY

- ✓ Uncompromised **data integrity** and **drive reliability** designed in
- ✓ Reliable, consistent **performance where it matters**
- ✓ Uncompromising **supply chain quality**
- ✓ **Platform-expert** product life cycle **support**
- ✓ **Technology** and **platform connectivity leadership**



LOOK INTO THE INTEL ADVANTAGE



One page version

DRIVES WITH INTEGRITY. THE INTEL DATA CENTER SSD ADVANTAGE.

Solution

Lasting integrity



≥100X more reliable
preventing Silent Data Corruption²



>2M PLI cycles and self-test
delivers trusted protection from data loss

Reliably effective performance



Validated on a massive scale



≤11% performance degradation
over the product life⁵

Platform confidence



Complete in-house design
of data center solutions



Up to 1 more year
in extended platform-level validation

Foundation

Uncompromising supply chain quality



95% delivery
to commit⁸



<100 DPM
factory quality⁹



**#4 overall,
#1 semiconductor**
Gartner* 2015 Supply Chain
Ranking¹⁰

Complete product life cycle support



>2000 engineers
optimizing top ISV
solutions¹¹



>500 dedicated OEM
design-in resources¹¹



Platform-expert
post-sales support

Innovation leadership



~1000 researchers in Intel labs



Memory technology **innovation leader**

Drives with Integrity.

FOOTNOTES AND DISCLAIMERS

1. **UBER.** Source – JEDEC UBER specifies 10^{-16} . <https://www.jedec.org/standards-documents/focus/flash/solid-state-drives>. Intel data center SSDs deliver 10^{-17} UBER.
2. **Silent Data Corruption.** Source - Intel. Test performed on Intel® SSD S3x00 drives, Samsung PM853T and SM843T, Micron P400e, Seagate 600 Pro and SanDisk Lightening drives. Drives were exposed to increasing amounts of radiation. After a drive “hang”, a power cycle was performed to determine whether the drive would re-boot. If a drive re-booted it was read, and data was compared to the tester's master copy of the up-to-date data that the drive was expected to contain based on writes the drive had acknowledged as completed prior to the “hang” event. If the drive returned data that differed from the expected data, it was recorded as failing for silent errors. The annual rate of silent errors was projected from the rate during accelerated testing divided by the acceleration of the beam (see JEDEC standard JESD89A).
3. **Annual Failure Rate:** Source - Intel. Intel SSD Annualized Fail Rate Report for all of 2015. Intel® SSD DC S3500, S3700, P3700.
4. **PLI:** Source – Intel. Intel® Datacenter Drives provide robust Power Loss Imminent (PLI) circuitry that helps to protect inflight data in the event of power loss. Intel drives monitor the health of the PLI circuitry via a Self Cap Test using SMART attributes. Samsung PM853T and SM843T drives were checked for capabilities and flags. No PLI monitoring capabilities (e.g. SMART Attributes) were listed in the Samsung drive specification sheet. Additionally, the drives were tested by powering off a drive and removing one electrolytic (or any other type) capacitor. The drives were then powered up to recollect SMART attribute data to determine if the cap test detected the removal of the capacitor. The Samsung drives did not detect capacitor removal.
5. **Performance degradation.** Source – Intel. Data collected on Intel SSD for Data Center for PCIe family on a standard endurance offering. Performance data collected on cycled drives using short stroke approach adhering to JESD218 method. Data collected on Intel SSD for Data Center for SATA family on a standard endurance offering. Configuration – Windows 2012 Server, DDR4-32GB, Xeon DP Haswell-EP E5-2699 v3 LGA2011 2.3GHz 45MG 145 W 18 core, G60T0045 firmware. Workload flow Sequence - Prefill seq WR, Seq WR highest QD BS -> lowest, Seq RD highest QD BS ->lowest, RND WR highest QD BS ->70WRhighest QD BS->30WR highest QD BS -> RND RD highest QD BS
6. **IOPS consistency.** Source – Intel. Measured performance of Intel® SSD DCS3710 and DC P3700 on 4K Mixed (70/30) workload. Device measured using Iometer. Quality of Service measured using 4 KB (4,096 bytes) transfer size on a random workload on a full Logical Block Address (LBA) span of the drive once the workload has reached steady state but including all background activities required for normal operation and data reliability. Based on Random 4KB QD=1, 32 workloads, measured as the time taken for 99.9(or 99.9999) percentile of commands to finish the round-trip from host to drive and back to host.
7. **Cache Acceleration Software.** Source – Intel. Baseline HDD test – 6x 15K RPM (300GB Seagate* Savvio* ST930065355) SAS HDDs in RAID 5 using Intel® RAID Controller RS3DC080. CAS test – 6ea 15K RPM (300GB – Seagate Savvio ST930065355) SAS HDDs in RAID 5 using Intel® RAID RS3DC080 Controller. One Intel® SSD DCP3700 Series as caching drive with Intel® CAS v2.8 enabled. Tests measures MySQL transactions completed in 3 hours. To learn more about Intel® CAS and obtain more details on testing go to <http://www.intel.com/content/www/us/en/software/intel-cache-acceleration-software-performance.html>
8. **Delivery to commit.** Source – Intel. Actual measurement of percent shipments for all Intel SSD products that arrive on committed delivery date.

Drives with Integrity.

FOOTNOTES AND DISCLAIMERS

9. **Factory quality.** Source – Intel. Average Functional Outgoing Quality Monitor measurement across all Intel SSD products.
10. **Best-in-class supply chain:** Source – Gartner. “The Gartner Supply Chain Top 25 for 2015.” Intel #4 ranked overall and top ranked in the technology industry. <http://www.gartner.com/technology/supply-chain/top25.jsp>
11. **ISV enabling, OEM design-in support.** Source – Intel Software and Solutions Group, Intel Non-volatile Memory Solutions Group, Intel Influencer Sales Group, Intel Direct and Channel Sales.
12. **Post sales support.** Source – Intel. Intel 2015 Customer Excellence Program survey **Annual Failure Rate:** Source – Intel. Data from all Intel data center products May 2014 through June 2015.
13. **Cost of Downtime.** Source – Gartner. <http://blogs.gartner.com/andrew-lerner/2014/07/16/the-cost-of-downtime/>
14. **HDD vs. SSD Failure Rate.** Intel SSD source - Intel. Intel SSD Annualized Fail Rate Report for all of 2015. Intel® SSD DC S3500, S3700, P3700. HDD source - Backblaze.com*, <https://www.backblaze.com/blog/hard-drive-reliability-q3-2015/>
15. **Performance degradation for SATA family.** Source – Intel. Data collected on Intel SSD for Data Center for SATA family on a standard endurance offering. Configuration – Windows 2012 Server, DDR4-32GB, Xeon DP Haswell-EP E5-2699 v3 LGA2011 2.3GHz 45MG 145 W 18 core, G60T0045 firmware. Workload flow Sequence - Prefill seq WR, Seq WR highest QD BS -> lowest, Seq RD highest QD BS ->lowest, RND WR highest QD BS ->70WRhighest QD BS->30WR highest QD BS -> RND RD highest QD BS
16. **Better than JEDEC data retention and UBER.** Source – Intel. Intel® SSD DC and Client product specifications. JEDEC – Solid State Drive Requirements and Endurance Test Method (JESD218).
17. **SDC frequency** - Source - NEC, “Silent Data Corruption in Disk Arrays”. <https://www.necam.com/docs/?id=54157ff5-5de8-4966-a99d-341cf2cb27d>