intel experience what's inside™

# INTEL® OPTANE™ MEMORY

CCG MARKETING

# LEGAL DISCLAIMER

Intel technologies' features and benefits depend on system configuration and may require enabled hardware, software or service activation. Performance varies depending on system configuration. No computer system can be absolutely secure. Check with your system manufacturer or retailer or learn more at intel.com.

Results have been estimated or simulated using internal Intel analysis or architecture simulation or modeling, and provided to you for informational purposes. Any differences in your system hardware, software or configuration may affect your actual performance.

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# AGENDA

- Market landscape
- What is Intel® Optane™ memory
- Performance benefits
- User impact
- Launch momentum and timeline

# PERFORMANCE COMPUTING IS GROWING

## Top Purchase Drivers for Desktops[1]

- Performance
- Security of personal information / data
- Storage Capacity

## COMPUTING

7TH GEN INTEL® CORE™ PROCESSOR

## STORAGE

INTEL® OPTANE™ MEMORY

Smart and adaptable system acceleration



1) IMRA February 2016 AIO and Desktop buyer Study – US Report

3) JPR (Jon Peddie Research), Jan 2017

# DESKTOP BUYERS WANT LARGE LOCAL STORAGE

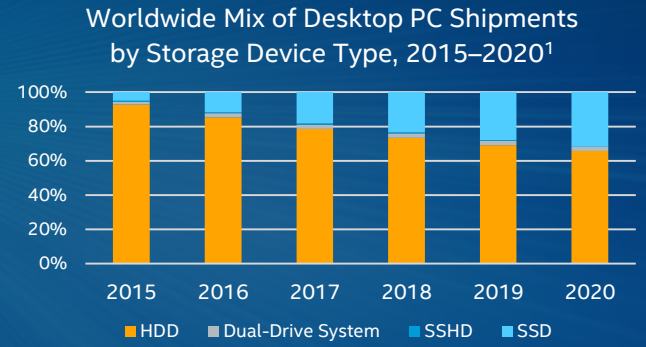
## AS THE AMOUNT OF DATA GENERATED INCREASES…
## SO WILL THE NEED FOR LARGE CAPACITY STORAGE

- GRAND THEFT AUTO* V[4] ~65 GB
- WINDOWS* 10X64 DISK SPACE REQUIREMENT[5] ~20 GB
- 4K RAW VIDEO[3] ~742 GB/HR
- 4K GOPRO* VIDEO[6] ~29 GB/HR

## DESKTOP 2017 STORAGE FORECAST

**HDDs[1,2]**
~ 79% of DT in 2017

**SSDs[1,2]**
~ 18% of DT in 2017




1) IDC Worldwide Solid State Drive Forecast Update, 2016–2020
2) SSHD, Dual-Drive, and embedded NAND not shown

Typically, choosing large local storage = lower overall system performance

3) http://www.4kshooters.net/2014/06/25/how-much-hard-disk-space-do-you-need-shooting-4k/
4) https://support.rockstargames.com/hc/en-us/articles/203428177-Grand-Theft-Auto-V-PC-System-Spec
5) https://www.microsoft.com/en-us/windows/windows-10-specifications
6) http://shop.gopro.com/cameras



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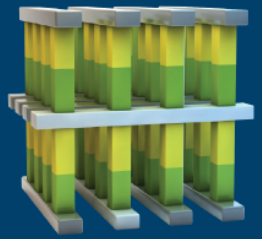
# WHAT IS INTEL® OPTANE™ MEMORY?

## 3D XPOINT™ MEMORY MEDIA



**Scalability**

Cross Point Structure

**High Performance**

Breakthrough Material Advances

\+

## STANDARD M.2 CONNECTOR MODULAR FORM FACTOR

PCIe* Gen 3.0x2
M.2 2280
Single-sided

\+

## INTEL® RAPID STORAGE TECHNOLOGY

The two physical devices are paired into a single volume

Files needed for important tasks are immediately recognized and accelerated

Over time, frequently used files and applications are monitored and accelerated as well

=

## INTEL® OPTANE™ MEMORY

M.2 2280

**16GB 32GB**

FOR 7TH GEN INTEL® CORE™ PLATFORM

Intel® Optane™ memory requires specific hardware and software configuration. Visit www.intel.com/OptaneMemory for configuration requirements.



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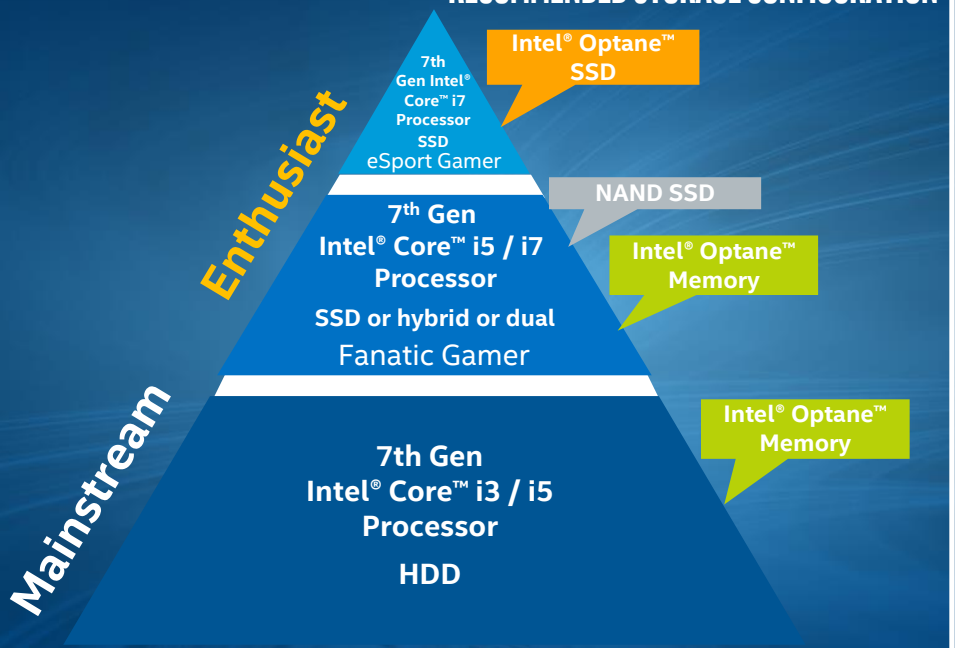
# INTEL® OPTANE™ TECHNOLOGY - END USER TARGET MARKETS

## RECOMMENDED STORAGE CONFIGURATION



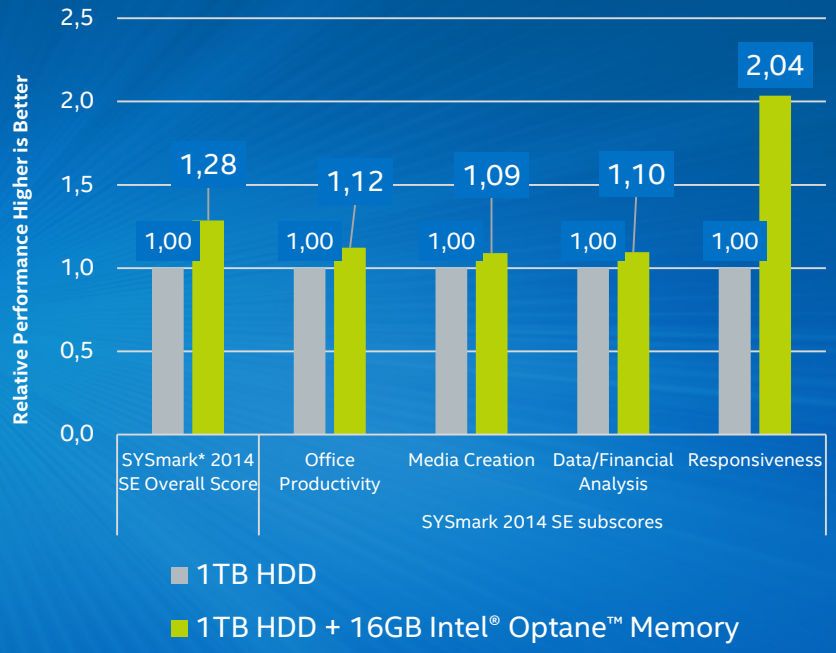

| End-User Configuration | Intel® Optane™ Memory Use Case |
|---|---|
| **Dual-Drive Configuration SSD + HDD** (with supported processors and chipsets) | ✓ Intel® Optane™ memory + HDD<br>Get high performance and large capacity storage without having to manage files |
| **Standalone HDD Configuration** (with supported processors and chipsets) | ✓ Intel® Optane™ memory + HDD<br>Get high performance and large capacity storage |
| **Standalone SATA SSD Configuration** (with supported processors and chipsets) | ✓ Intel® Optane™ memory + SATA SSD<br>Get high performance and eliminate the SATA-interface read bottleneck<br>(Note performance increase is less than Intel® Optane™ memory + HDD) |
| **Standalone SSHD Configuration** (with supported processors and chipsets) | ✓ Intel® Optane™ memory + SSHD<br>Get high performance and eliminate the SATA-interface read bottleneck<br>(Note performance increase is less than Intel® Optane™ memory + HDD) |
| **6th Gen Intel® Core™ Processor, Intel® 100 Series Chipset and Intel® Rapid Storage Technology** | ✗ N/A; 6th Gen Intel® Core™ processors and Intel® 100 series chipsets are not supported |
| **Accelerate a Non-Boot Drive in a Dual-Drive Configuration** | ✗ N/A; Non-boot drive acceleration is not supported |
| **7th Intel® Core™ Processor and Intel® 100 Series Chipset** | ✗ N/A; Intel® 100 series chipsets are not supported |
| **Multiple HDDs / SSDs in RAIDed Configuration** | ✗ N/A; RAID configurations are not supported |

# PERFORMANCE BENEFITS FROM INTEL® OPTANE™ MEMORY

## 16GB INTEL® OPTANE™ MEMORY + HDD

| | | |
|---|---|---|
| MAINSTREAM | Everyday **Tasks**[1] | Up to **2x More Responsive** |
| | Storage **Performance**[2] | Up to **14x Faster** |
| | Computer **Boot Time**[3] | Up to **2x Faster** |
| | Launch **Web Browser**[4] | Up to **5x Faster** |
| ENTHUSIAST | Launch **Game**[5] | Up to **67% Faster** |
| | Game **Level Load**[5] | Up to **65% Faster** |
| | Open Large **Media Projects**[6] | Up to **4.1x Faster** |
| BUSINESS | Launch **Email**[7] | Up to **5.8x Faster** |
| | Launch **Presentations**[8] | Up to **3.8x Faster** |
| | Windows* **File Search**[9] | Up to **4x Faster** |

## SYSMARK* 2014 SE COMPARISON




[1]SYSmark 2014 SE (Responsiveness Subscore) [2]PCMark* Vantage (HDD Suite) [3]OS Load Time Workload [4]Browser Launch Workload [5]Game Launch & Level Load Workload [6]Media Project Load Workload [7]Email Launch Workload [8]Presentation Launch Workload [9]File Search Workload

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See Appendix I for additional configuration and workload details

- All testing done internally by Intel

Software and workloads used in performance tests may have been optimized for performance only on Intel® microprocessors.

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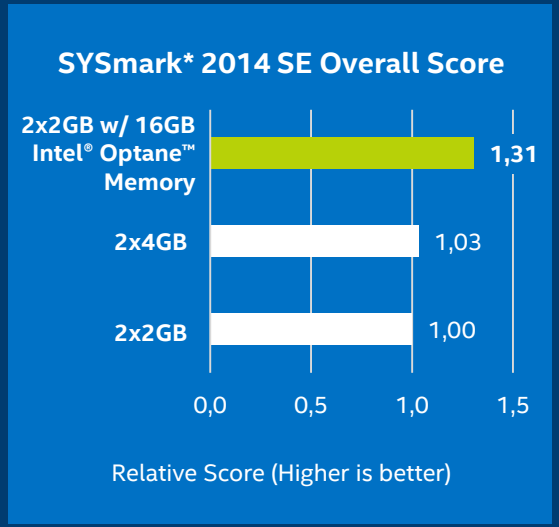
# INTEL® OPTANE™ MEMORY OFFERS BETTER END USER VALUE

16GB Intel® Optane™ memory + 1TB HDD 4GB DDR delivers better responsiveness than 1TB HDD 8GB DDR

## Intel® Optane™ Memory Delivers Visible Benefits

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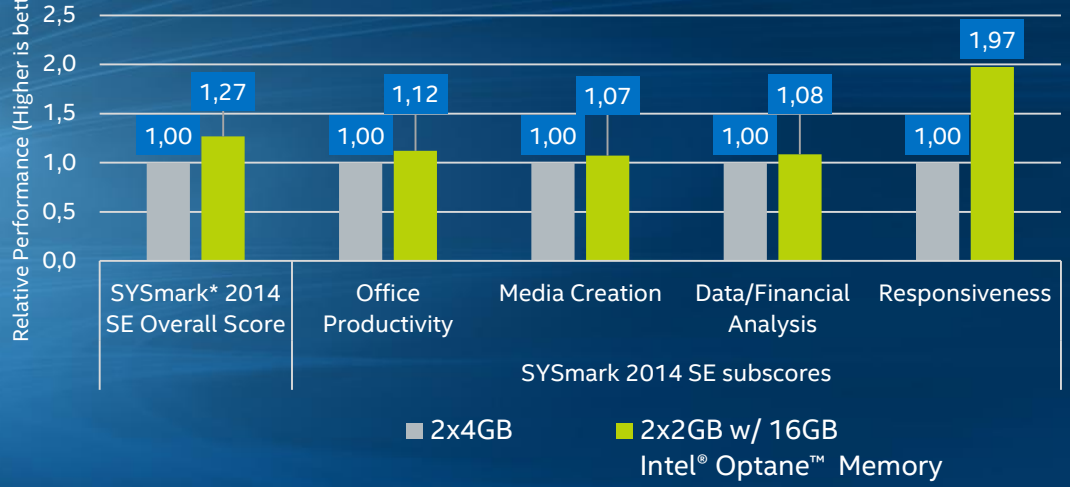


All testing done internally by Intel.
See Appendix I for System Configuration and testing procedures.
Note: Some applications and most games may require 8GB of DRAM memory for loading with or without Intel® Optane™ memory.

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# ENHANCE THE PC EXPERIENCE WITH INTEL® OPTANE™ MEMORY

Each day on average a typical **user** will…

## GO THROUGH

~2[1,2] Consumer | ~2[2,7] IT User POWER CYCLES

## LAUNCH

~11[3,4] Consumer | ~14[8,9] IT User UNIQUE APPLICATIONS

## LAUNCH EACH APP

~7[5,6] Consumer | ~8[10,11] IT User DIFFERENT TIMES

## Consumer

**~80 DISTINCT EVENTS**

## IT User

**~114 DISTINCT EVENTS**

where the user will experience the benefits of Intel® Optane™ memory each day.

1) Source: Intel® Product Improvement Program Q4'16: 512,070 systems (483,403 desktop, 28,667 AIO) Windows 10*. Intel® Core™ processors
2) Power cycles include on, off, and sleep states
3) Source: Intel® Product Improvement Program Q4'16: 1,081,148 systems. Average 11 apps opened per day. Windows 10*. Intel® Core™ processors
4) Statistic represents an average across distinct applications. Actual number of applications opened per day may be higher. For instance, if Chrome is opened 5 times a day it is counted only once in the this calculation.
5) Source: Intel® Product Improvement Program Q4'16: 1,081,148 systems. Average 11 apps opened per day. Windows 10*. Intel® Core™ processors
6) Statistic represents an average across all applications across all systems. This number can vary depending on the application.
For instance, this number can be higher for an application like Chrome* and much lower for an application like iTunes* or Calculator, etc…
7) Source: Intel® Product Improvement Program Q1'17: 35,187 systems, Desktop/Laptop/2 in 1 Windows 10*. Intel® Core™ processors
8) Source: Intel® Product Improvement Program Q1'17: 12,419 systems, Desktop/Laptop/2 in 1 Windows 10*. Intel® Core™ processors
9) Statistic represents an average across distinct applications. Actual number of applications opened per day may be higher. For instance, if Chrome* is opened 5 times a day it is counted only once in the this calculation.
10) Source: Intel® Product Improvement Program Q1'17: 12,419 systems, Desktop/Laptop/2 in 1 Windows 10*. Intel® Core™ processors
11) Statistic represents an average across all applications across all systems. This number can vary depending on the application. For instance, this number can be higher for an application like Chrome* and much lower for an application like iTunes* or Calculator, etc…


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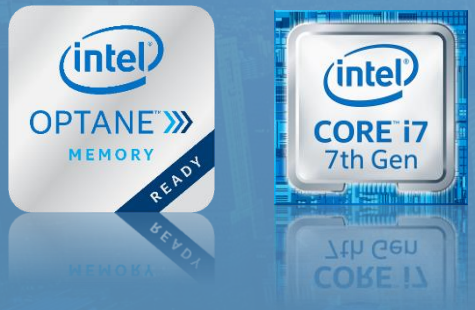
# INTEL® OPTANE™ MEMORY
## LAUNCHED MARCH 27TH 2017

### CES IN JANUARY

Intel® Optane™ Ready Program Launch Alongside 7th Gen Intel® Core™




### AVAILABLE TODAY

130+ Intel® Optane™ Memory Ready Motherboards in Market

ASRock
ASUS
EVGA
GIGABYTE
msi

### Q2 2017 ONWARDS

Intel® Optane™ Memory Enabled System and Motherboards

Lenovo, DELL, hp, ASUS, acer, GIGABYTE, msi, EVGA, ASRock, CYBERPOWERPC, iBUYPOWER, MAINGEAR, DIGITALSTORM, ONDA, POWERSPEC, INFORMATICA, WEIBU, PC LAPTOPS, ZOTAC, iru, next www.nexths.it, NCIX PC, stone, DEPO, RAUSCH NETZWERKTECHNIK www.rnt.de, SOYO, AQUARIUS, JOW 杰微, 七彩虹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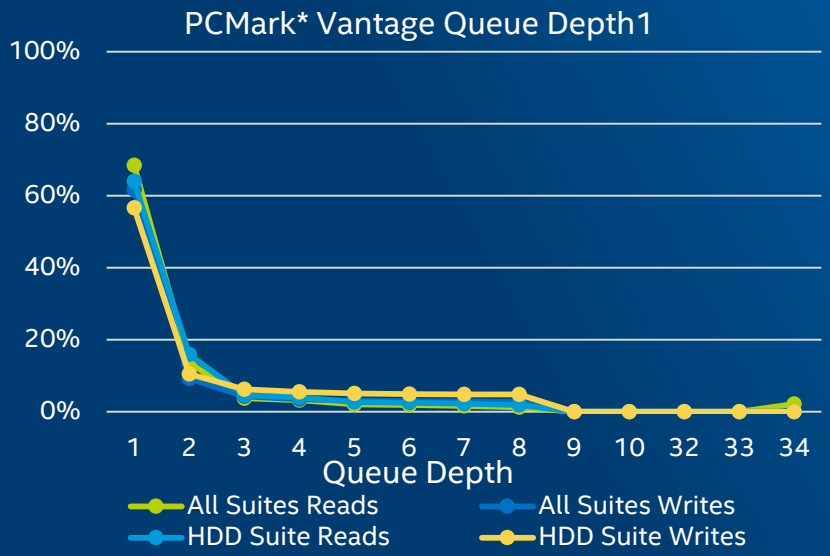
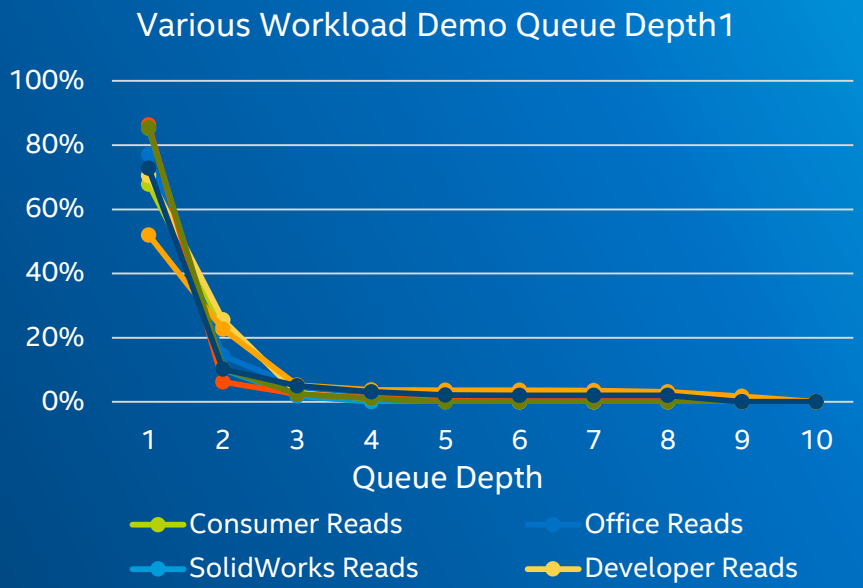
# QUEUE DEPTH

Queue depth is the number of pending input/output (I/O) requests for a volume.




1)Based on internal intel queue depth trace analysis; see appendix II ; See Appendix II for System Configuration and testing procedures. All testing done internally by Intel

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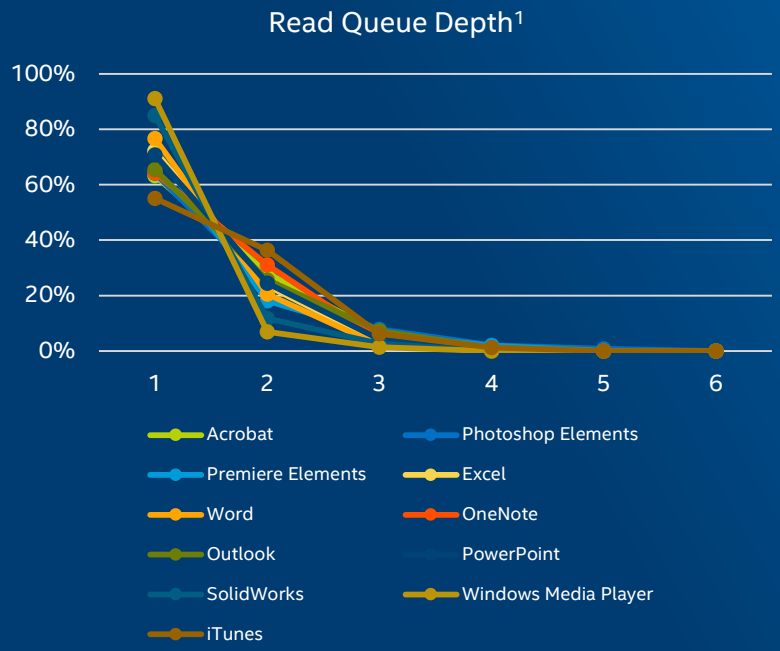
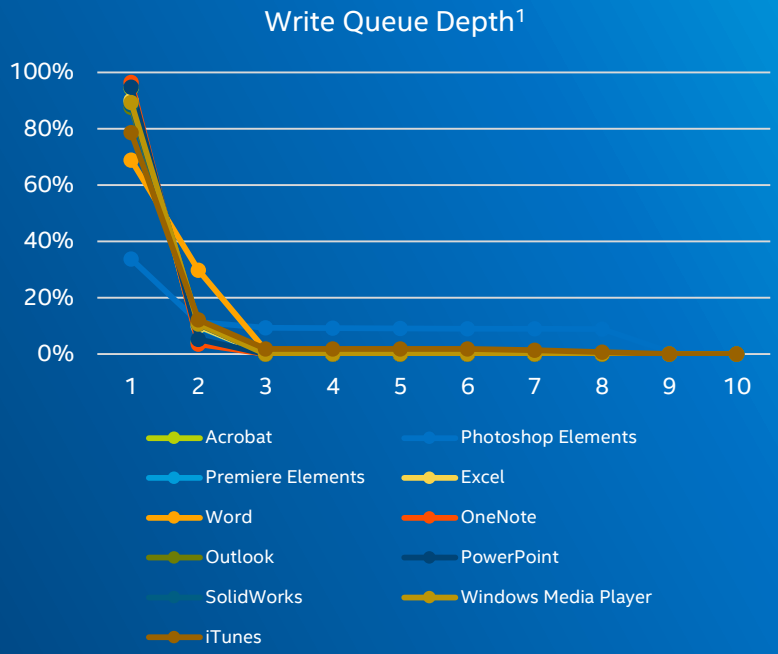
# QUEUE DEPTH DISTRIBUTION FOR COMMON APPLICATION LAUNCHES

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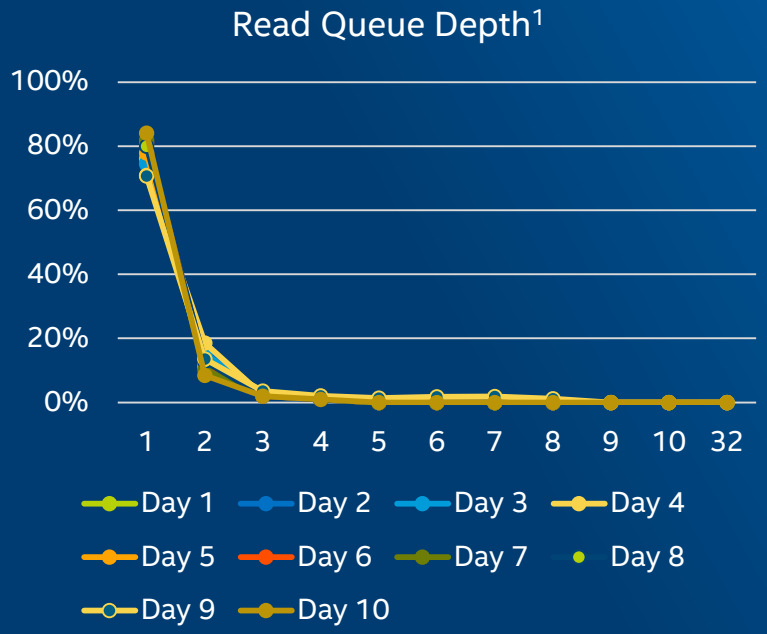
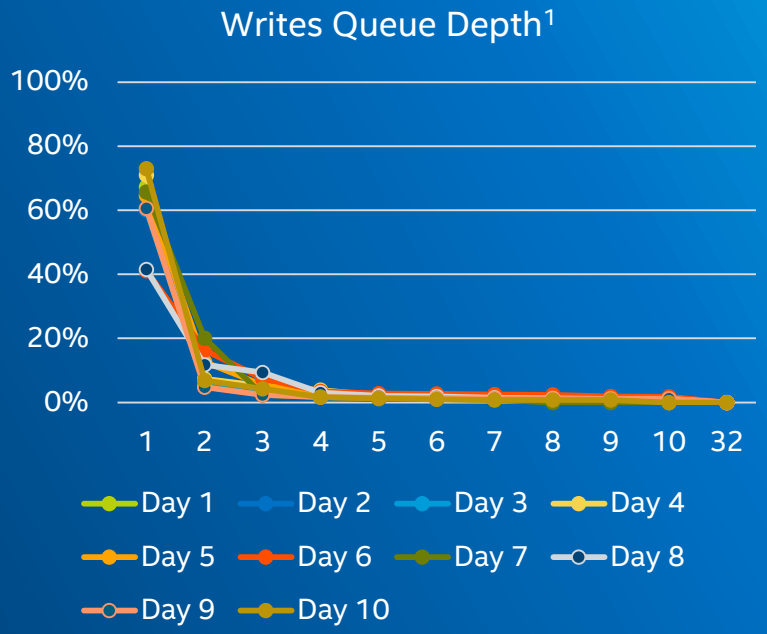
# QUEUE DEPTH DISTRIBUTION FOR TYPICAL WORK DAY

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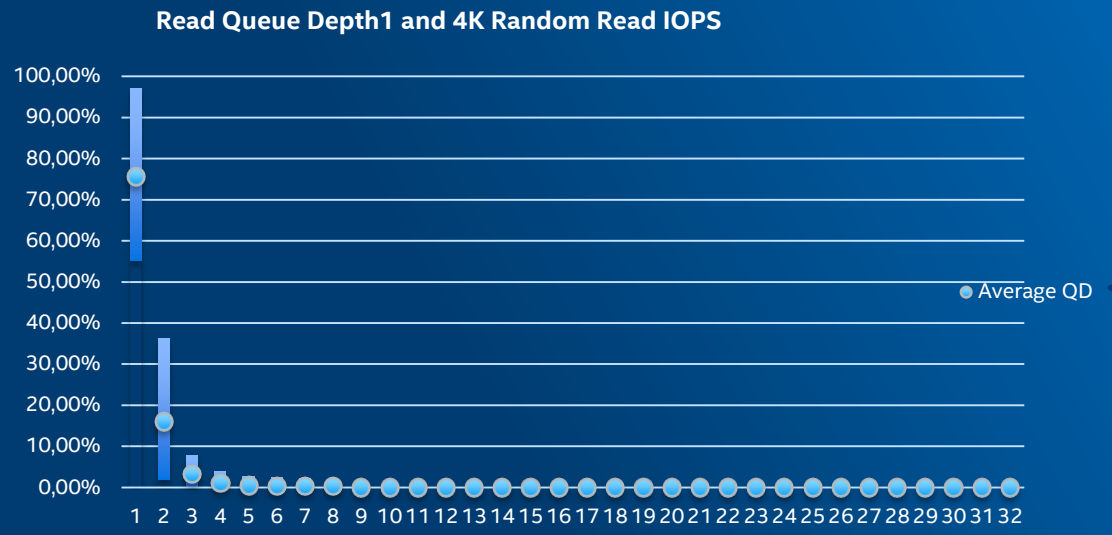
# AVERAGE QD DISTRIBUTION : ALL CLIENT WORKLOADS




- Benchmarks
- Application Launches
- Various Client Workloads
- Typical Workday Trace

All Trace Data indicates, Performance needed at Low QD's where it matters most for most Client Workloads

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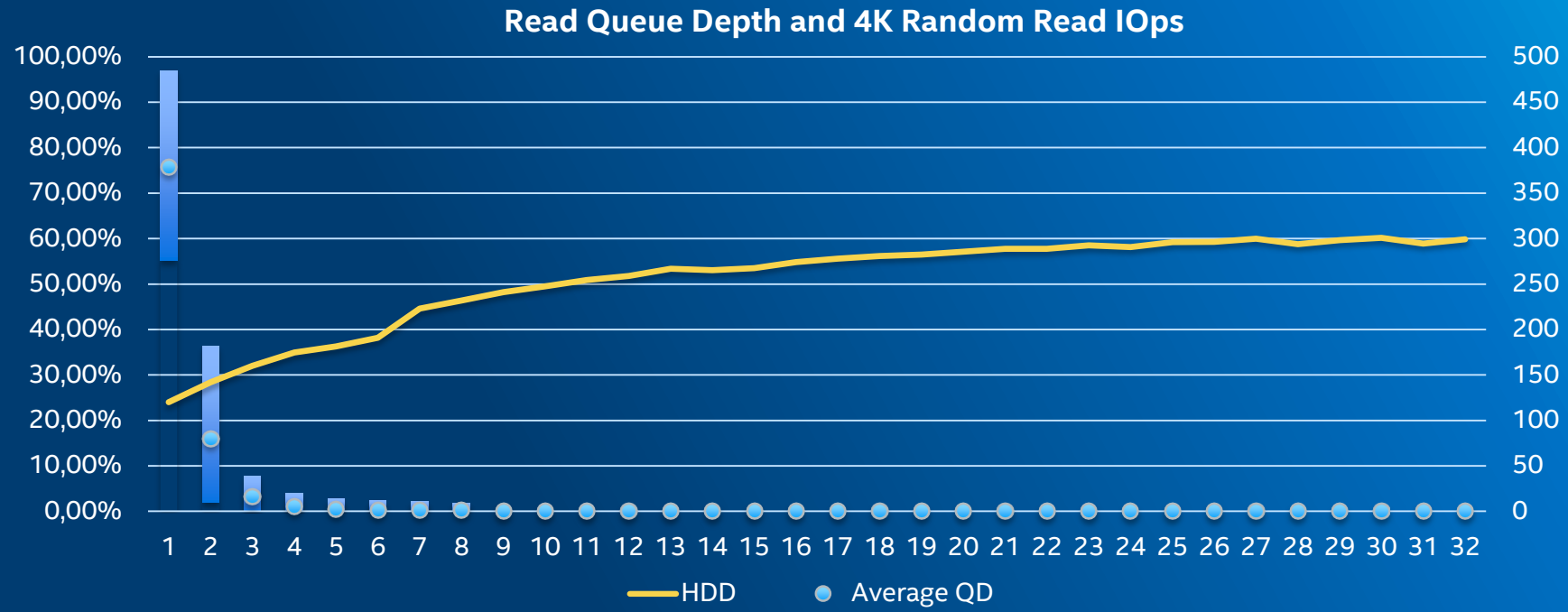
# QD AND 4K RANDOM READ IOPS : DIFFERENT STORAGE DEVICES

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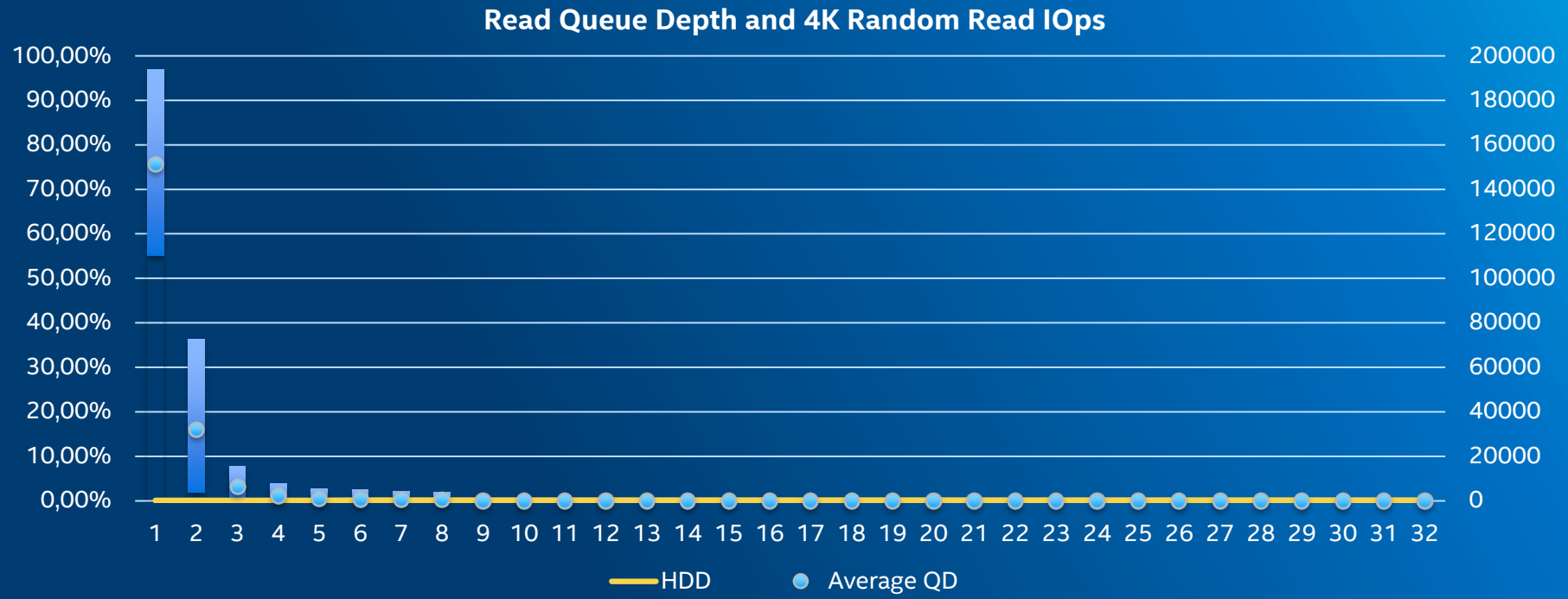


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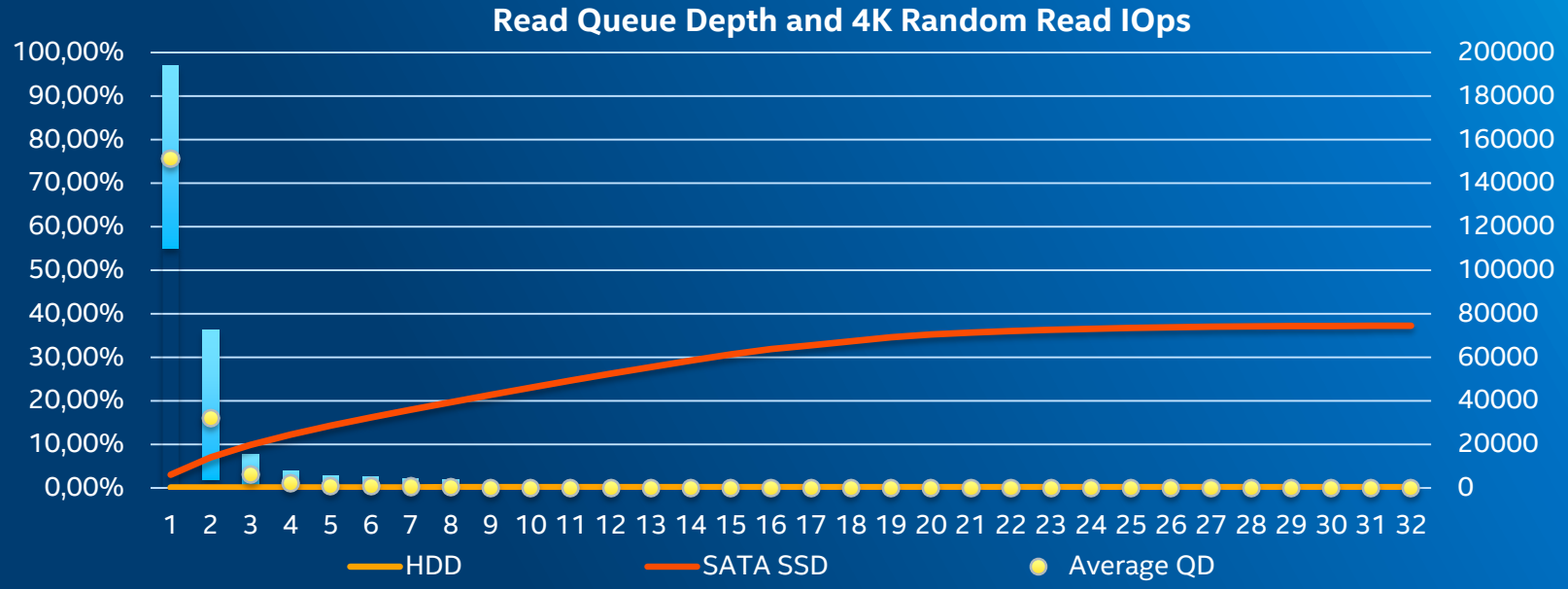


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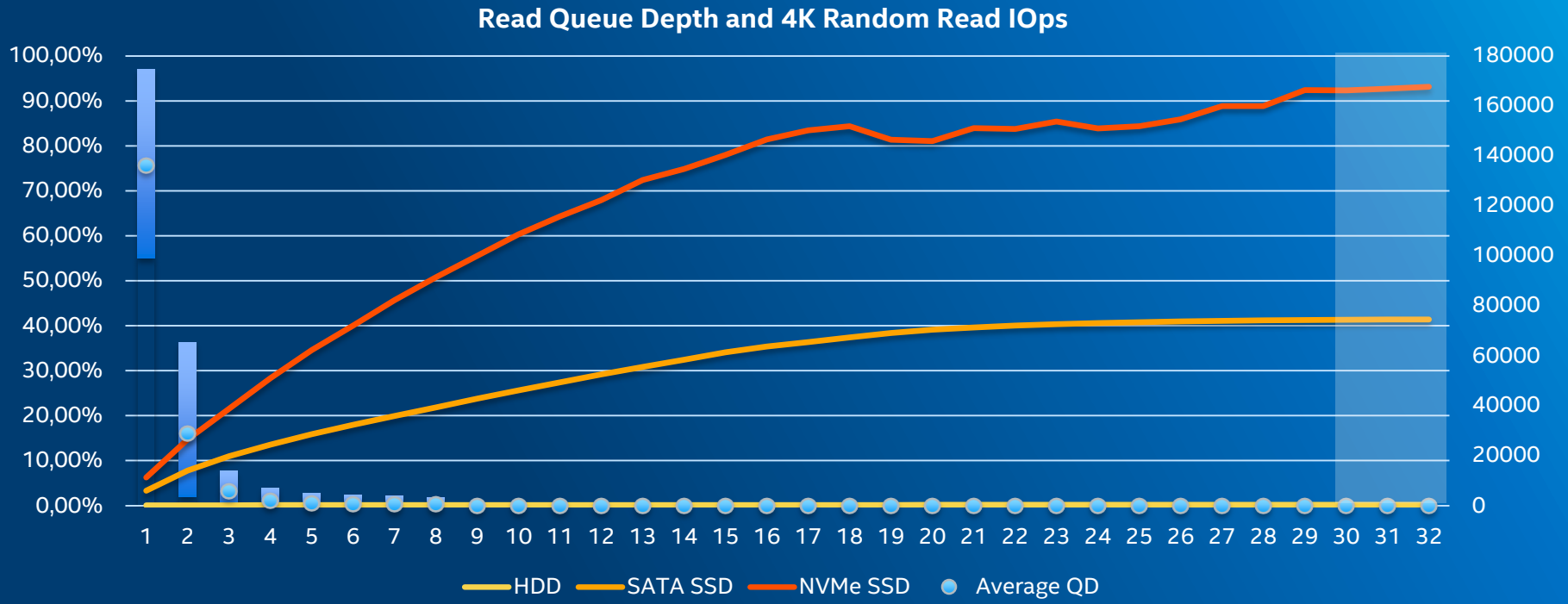


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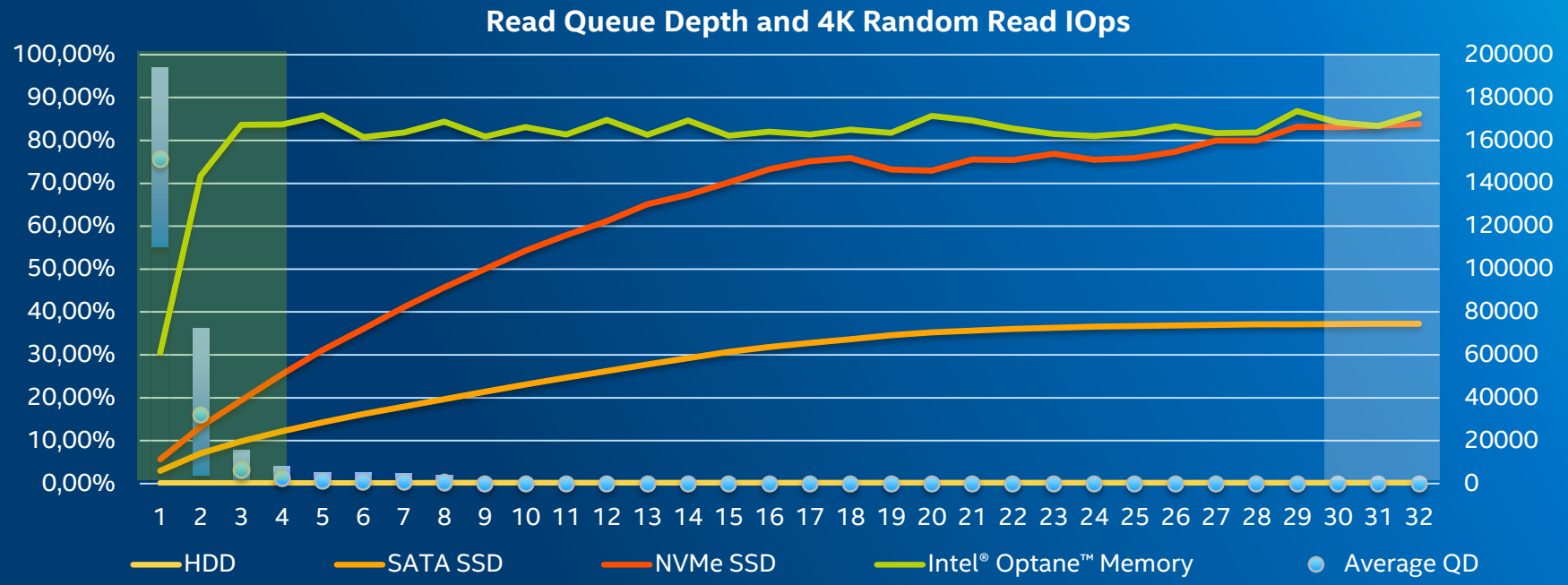


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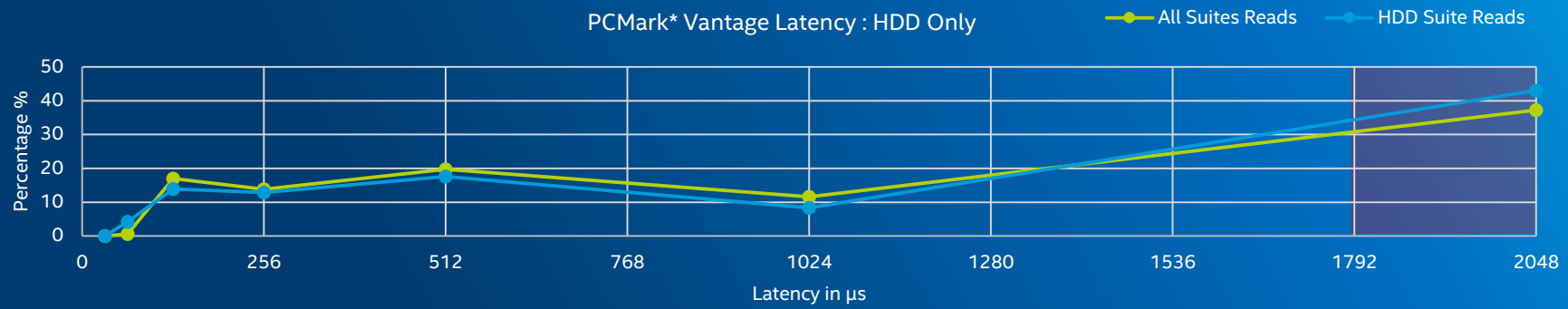
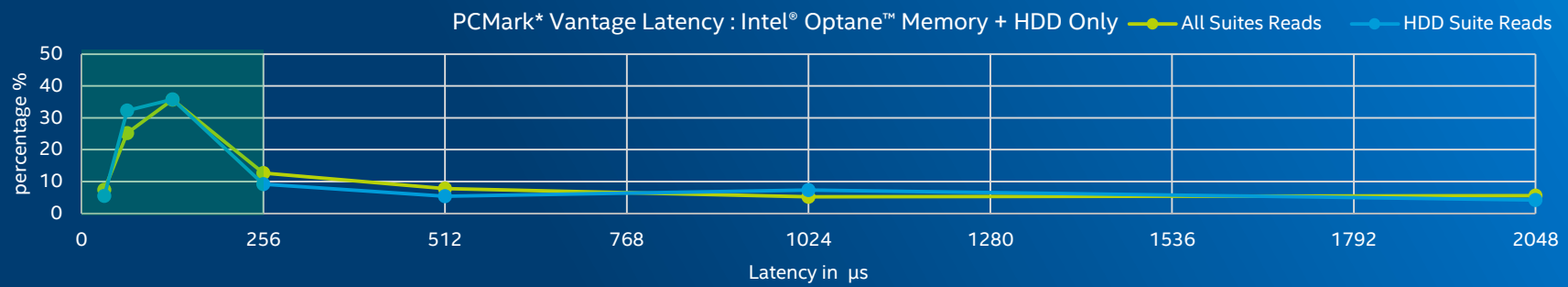
# LATENCY

## Latency is the time required to process a data request

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# SUMMARY

- All Trace Data indicates, Performance needed at Low Queue Depths where it matters for most client workloads
- Performance where it matters, no Queue Depth dependency for client workloads with Intel® Optane™ Memory installed in the system
- Comes with a smart acceleration software to make the PC increasingly more responsive to every individual user

intel experience what's inside™

# APPENDIX I

CCG MARKETING

# CONFIGURATION

**Baseline (HDD)**
Intel® Core™ i5-7500 Processor, 65W TDP, 4C4T, Turbo up to 3.8GHz, Memory: 2x4GB DDR4-2400, Storage: Western Digital* 1TB 7200RPM WD1003FZEX, Intel HD Graphics 630, OS: Windows* 10

**Intel® Optane™ Memory**
Same configuration as above with 16GB Intel® Optane™ Memory Module (Engineering Sample)

**Gaming workloads were tested with same configuration, except using a discrete graphics card (NVIDIA* (EVGA) GTX 1080) with and without 16GB Intel® Optane™ Memory Module**

**Tested with 16GB Intel® Optane™ Memory Engineering Samples. Results may vary in final product, but we have a high confidence level that there will be no significant differences in performance.**
Note: All, Intel® Optane™ memory testing was conducted on 7th Gen Intel® Core processors. All Queue Depth testing was conducted on 6th Gen Intel® Core™ processors.

# WORKLOADS

SYSmark* 2014 SE - benchmark from the BAPCo* consortium that measures the performance of Windows* platforms. SYSmark* tests four usage scenarios: Office Productivity, Media Creation, Data/Financial Analysis, and Responsiveness. SYSmark* contains real applications from Independent Software Vendors such as Microsoft* and Adobe*.

PCMark* Vantage (HDD Suite) - Benchmark from Futuremark* that measures Windows* everyday computing performance. PCMark Vantage is made up of several benchmarking suites: PCMark Suite (produces "PCMark" Score), Memories Suite, TV and Movies Suite, Gaming Suite, Music Suite, Communications Suite, Productivity Suite and HDD Suite. The HDD Suite contains an operating system start-up workload that is sensitive to HDD versus SSD boot devices.

Browser Launch Workload – Workload developed by Intel® measuring the time elapsed to launch Google* Chrome

OS Load Time Workload – Workload developed by Intel® measuring the time elapsed from initiating power-on (from powered-off state) until the operating system has completed loading

Game Launch & Level Load Workload – Workload developed by Intel® measuring the time elapsed to launch Bethesda Softworks* Fallout 4 and reach the Main Menu with intro videos disabled (Launch), and the time elapsed from the Main Menu to completion of level loading (Level Load)

Email Launch Workload – Workload developed by Intel® measuring the time elapsed to launch Microsoft* Outlook 2016 and load with a 250mb local data file

File Search Workload – Workload developed by Intel® measuring the time elapsed using Microsoft* Windows File Search to locate a specified file in a non-indexed directory

Presentation Launch Workload – Time elapsed to launch the Microsoft* Powerpoint 2016 application with a 3.5MB presentation file

Media Project Load Workload – Time elapsed to load a 500MB video project file in Adobe* Premiere Pro (CS6)


*Other names and brands may be claimed as the property of others

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# APPENDIX II

CCG MARKETING

# CONFIGURATION

Note: All, Intel® Optane™ memory testing was conducted on 7th Gen Intel® Core processors.
All Queue Depth testing was conducted on 6th Gen Intel® Core™ processors.

| |
|---|
| CPU: Intel® Core™ i7-6700 processor @ 3.5 GHz |
| Motherboard: ASUS Z170-Deluxe Rev. 1.03 (Model: D33005) |
| Operating System: Windows 10 x64 Pro (Version 1511 Build 10586) |
| Intel® RST Driver: Intel® RST 7166/RST_15.0.0.9083 (Pre-Alpha for emulator) |
| DRAM: Corsair Vengeance LPX DDR4 8GB x 2 (reduced as needed for testing, two sticks for Dual Channel performance) (Model: CMK16GX4M2A2666C16R) |
| Western Digital Blue 1TB 2.5" HDD (Model: WD10JPVX) |
| Stony Beach/Intel® Optane™ Memory: Pre-Production Samples |
| SATA SSD: Intel 540s 480GB SSD (Model: SSDSC2KW480H6) |
| NVMe SSD: 256GB PCIe M.2 NVMe SSD: Samsung* 950 Pro PCIe based Gen 3x4 SSD |

- All Intel® Optane™ memory based System Acceleration data is based on Pre-Production samples; subject to change.
- All numbers preliminary, subject to change
- *Other names and brands may be claimed as the property of others

# WORKLOAD DESCRIPTIONS QUEUE DEPTH TRACE ANALYSIS

Read Queue Depth and 4K Random Read Iops compiles the average access sizes found below into a single visual graph. The values selected (x-axis) represent roughly 80% of all accesses with the majority of the remaining 20% falling below 32KB.

**Consumer Demo**
Intel demonstration script meant for showcasing the speed difference between storage mediums. Uses WinAutomation that simulates a consumer workload by running a virus scan to stress the HDD then opens an instance of iTunes with a 25GB library before searching for and playing a song. Next, it opens Outlook (containing a single user with 25MB data file) on top of both the virus scan and iTunes for a multiple application scenario and searches for an email within Outlook. Finally, it saves an attached image from Outlook and uses finder open and view various pictures. These simple tasks with the background virus scan stress the drives responsiveness while under multiple applications similar to an average user.

**Office Demo**
Intel demonstration script meant for showcasing the speed difference between storage mediums. Uses WinAutomation to open five PowerPoints (ranging from 1-20MB), open saved pdf documents in Adobe Acrobat (ranging from 5-40MB), scan through the rows of an Excel spreadsheet, view a 1MB saved HTML Document in Internet Explorer, open five Word documents all while playing five movies (both MP4 and WMV) in Media Player Classis: Hom Cinema. Similar to the Consumer Demo, the multiple running applications simulate how a normal user does many things at once thus stressing the drive with more requests. These specific applications focus more on a corporate user's workload as opposed to a personal/consumer one.

**SolidWorks Demo**
Intel demonstration script meant for showcasing SolidWorks speed difference betw storage mediums. Uses WinAutomation to open an instance of SolidWorks followed by start a SolidWorks script. This script opens various SLDPRT and model files pertaining to 6 differ cars, a wheeled backhoe, a tesla tower and a small CNC machine. All the assemblies were downloaded from https://grabcad.com/library/software/solidworks. By opening many inter windows each with different a solid model or assembly the SolidWorks script tests how responsive the storage media is with requests of different sizes and in different locations (since assemblies are made up of many small SLDPRT's). This simulates the workload of a mechanical designer as they load and work on various solid models and their respective pa The average assembly size is between 20-30MB while the individual SLDPRT's were between and 6MB.

**Developer Demo**
Intel demonstration script meant for showcasing the speed difference in Visual Stud Community between different storage mediums. Uses WinAutomation to open a three instances of Visual Studio 2015 Community and compile four different types of projects. The initial Visual Studio app launch is the primary point of focus as it must load a wide range of assets and libraries to be ready for the developer. Once loaded, the opening and compiling projects test how well it loaded the initial assets and what it still needs to link. Furthermore by opening more than one instance of the Visual Studio suite, it tests how well a drive performs while a user works on different projects in different programming languages (C++ C# and Visual Basic represented here).

**Application Launches**
These tests consisted of taking trace data as an application launched. This was don by starting the trace then double clicking a desktop link to start each program. The trace w then ended once any sign of loading (pinwheels or missing menu items) left the screen.


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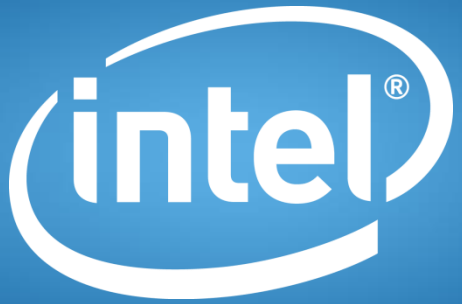


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