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Intel® Optane™ Memory and Intel® SSD 545s combine to offer NVMe-class storage performance

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A Complex Landscape of Storage Options

Consumers and enthusiasts that want to build a new PC today have a wide array of storage options available to them. This provides a lot of flexibility for buyers that have a baseline knowledge of the storage technologies available but can introduce confusion to those that are entering with a less significant understanding of the market.

There are numerous types of storage options from legacy spinning-disk hard drives to SATA-based solid state drives to M.2 form-factor NVMe SSDs. You can put PCI Express and U.2 in the mix to stretch out the matrix of options even further. Intel® offered up another wrinkle with the introduction of a new Optane™ Memory caching technology that can accelerate hard drives and SSDs as well.

Selecting the right storage option for any particular buyer is a balancing act between storage capacity and storage speed. You can get spinning media hard drives with up to 10TB of space but they will run significantly slower than even a modest SSD. New NVMe solid state options and Intel® Optane™ 900P are blazingly fast but come with a penalty in cost per gigabyte.

Optane™ Memory Can Offer Balance

When Intel® launched Optane™ Memory it was primarily as an accelerator for traditional hard drives. Through a combination of incredibly fast Optane™-based M.2 hardware and custom drivers and caching software for Windows 10, Optane™ Memory can give a consumer the feeling of NVMe-or-faster storage with the cost-capacity benefit of the larger drive.

The Intel® SSD 545s launched in the summer of 2017 and was the first to use Intel® second-generation 3D TLC flash memory. It offered competitive performance and cost-per-gigabyte to other SATA SSDs on the market but as the development and proliferation of PCI Express NVMe drives has increased, its ability to compete has lessened.

Though originally targeted for hard drives, combining the caching performance of Intel® Optane™ Memory with an SSD is a solution that can offer improved performance in numerous consumer workloads without a significant increase in price. By utilizing 16GB and 32GB Optane™ modules with various capacities of Intel® 545s solid state drives, the competitive landscape of the consumer storage market takes on an interesting twist.

Simple Configuration

Setting up Intel® Optane™ Memory on a compatible system is a direct and simple process. Compatible Z270 and Z370 motherboards need to have the Optane™ Memory module installed in the specified M.2 location. The Intel® SSD 545s is connected to the motherboard through a standard SATA cable and Windows 10 installation is completed as it would normally be.
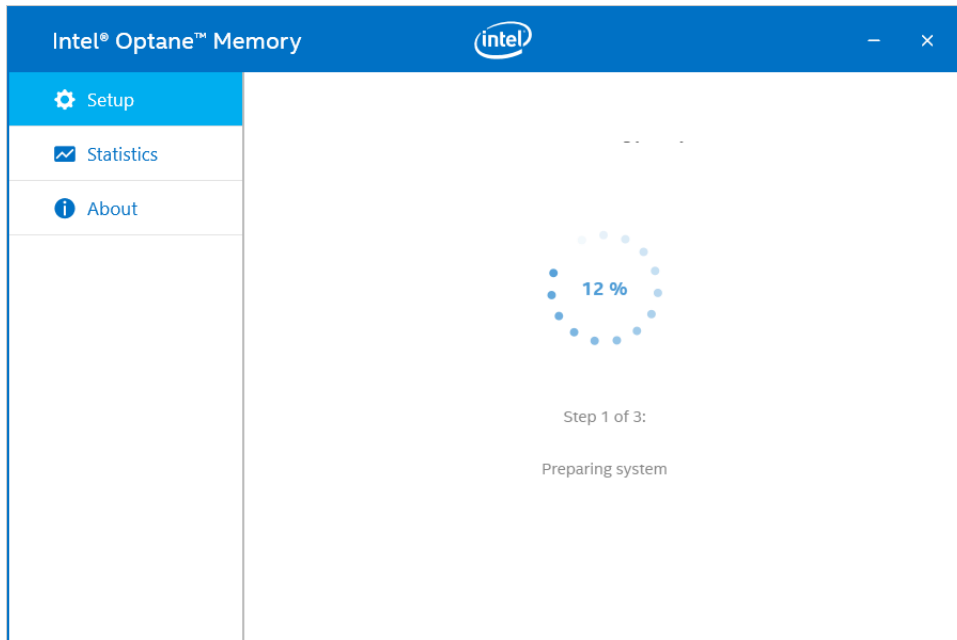
The Intel® Optane™ Memory driver installation is direct and walks the consumer through a painless setup process. Initial setup takes just a few minutes and requires a single system reboot for the caching system to enable. Once you return to Windows 10, the system is configured and functioning with the performance of Intel® Optane™ Memory and the capacity of the Intel® SSD 545s.

Testing Configuration

Evaluating the performance of Intel® Optane™ Memory with an Intel® SSD 545s can indicate what value the combination provides in today's storage market. We ran 13 system configurations through five different performance data points with five iterations each. The hardware used for this benchmarking is typical of the class of hardware used by consumers in the mainstream DIY market.

- Intel® Core i5-7500 processor
- ASUS PRIME B250-PLUS motherboard (BIOS 0608)
- 16GB DDR4-2400 memory
- NVIDIA GeForce GTX 1070 8GB (385.69)
- Windows 10 Pro 64-bit 10.0.16299 (Balanced power plan)
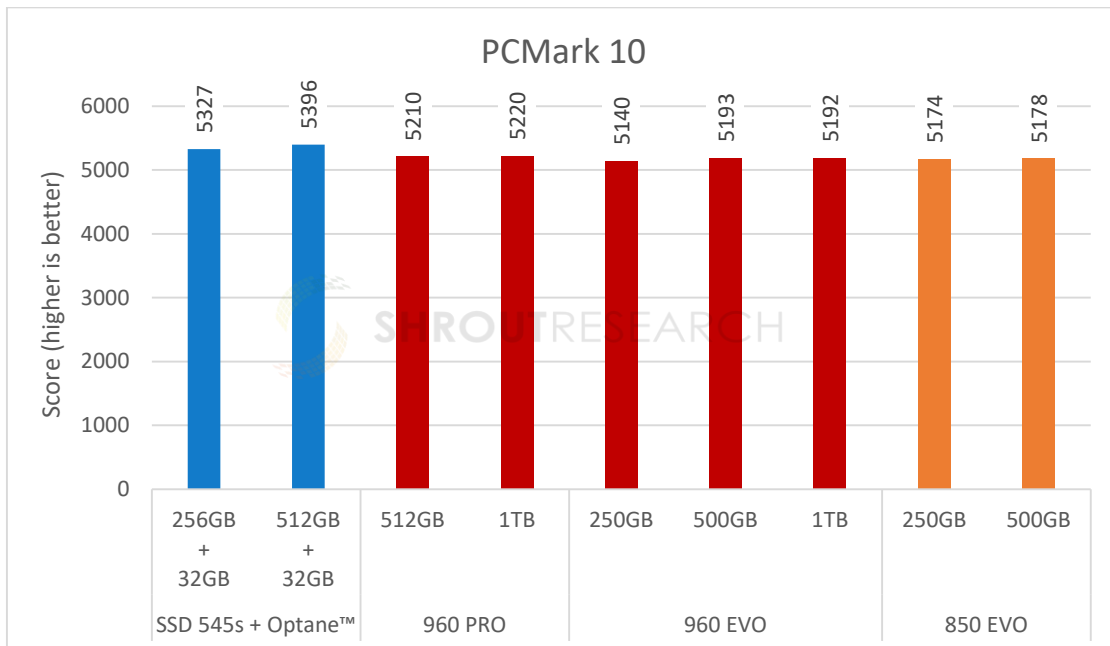
The storage options include:

- Intel® Optane™ Memory 16GB, 32GB
    - Combined Intel® SSD 545s 256GB, 512GB, 1TB
- Samsung 960 PRO 512GB, 1TB
- Samsung 960 EVO 250GB, 500GB, 1TB
- Samsung 850 EVO 250GB, 500GB

PCMark 10

PCMark 10 is the latest industry standard benchmark from Futuremark that features a wide variety of tests that cover the modern workplace. This includes:

- Video conferencing
- App load times
- Office applications
- Photo/video editing
- Rendering
- Basic gaming

PCMark 10

Score (higher is better)

Value	Configuration	Drive
5327	256GB + 32GB	SSD 545s + Optane™
5396	512GB + 32GB	SSD 545s + Optane™
5210	512GB	960 PRO
5220	1TB	960 PRO
5140	250GB	960 EVO
5193	500GB	960 EVO
5192	1TB	960 EVO
5174	250GB	850 EVO
5178	500GB	850 EVO

The performance results from PCMark 10 Overall indicate that the Intel® Optane™ Memory and Intel® SSD 545s combination is faster than the 850 EVO SATA-based SSD and both the 960 EVO and 960 PRO NVMe drives.

PCMark 10 - Productivity
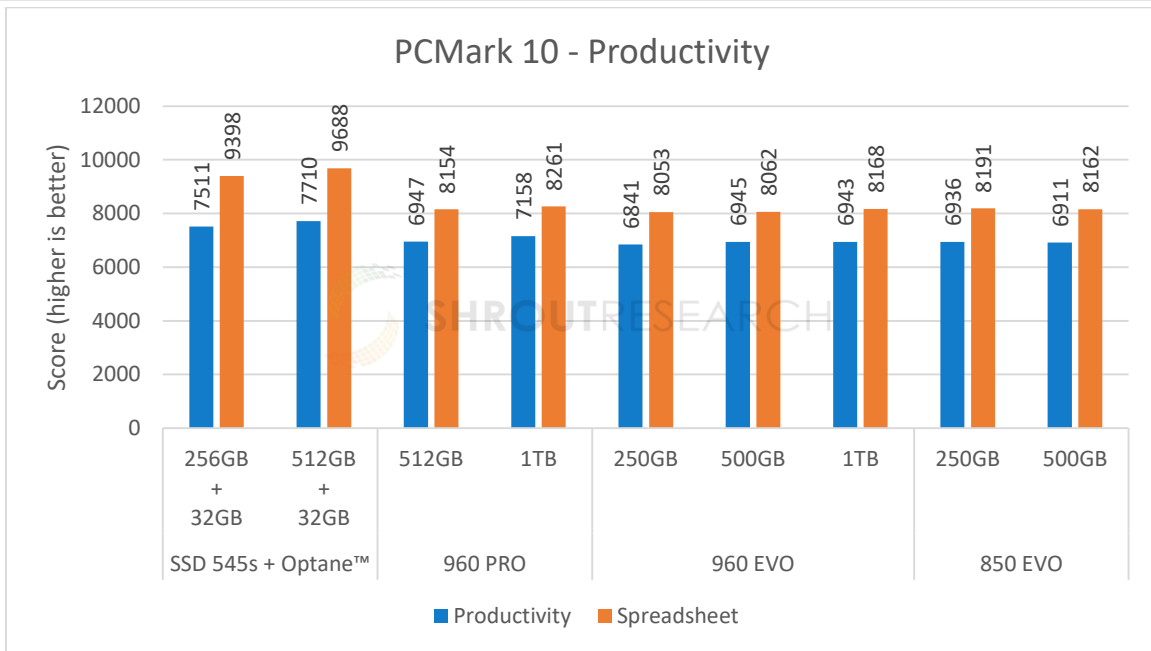
Productivity and Spreadsheet subtests in PCMark 10 indicate more significant performance advantages for the Intel® Optane™ Memory and Intel® SSD 545s configurations. With as much as a 17% advantage over the leading NVMe SSD, it is clear that for many of the consumer workloads that PCMark 10 focuses on, the advantages of the Intel® Optane™ Memory caching system provide excellent return.

PCMark Vantage

PCMark Vantage is a slightly older benchmark suite from Futuremark that attempts to measure storage performance with similar consumer-based workloads. The HDD Suite focuses on tasks like virus scanning, game data streaming, photo importing, video time shifting, and more.
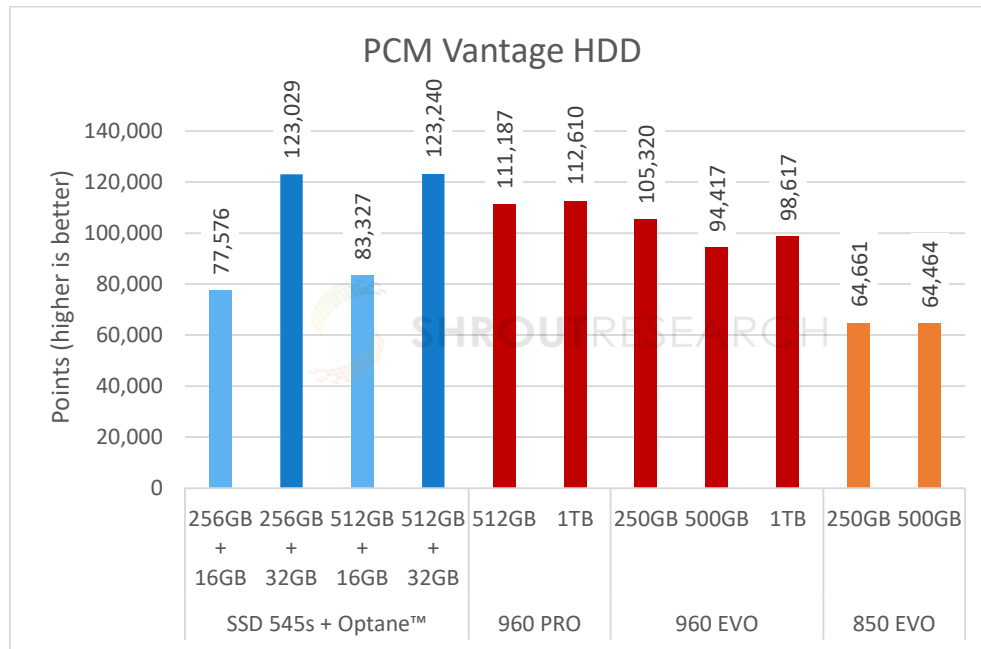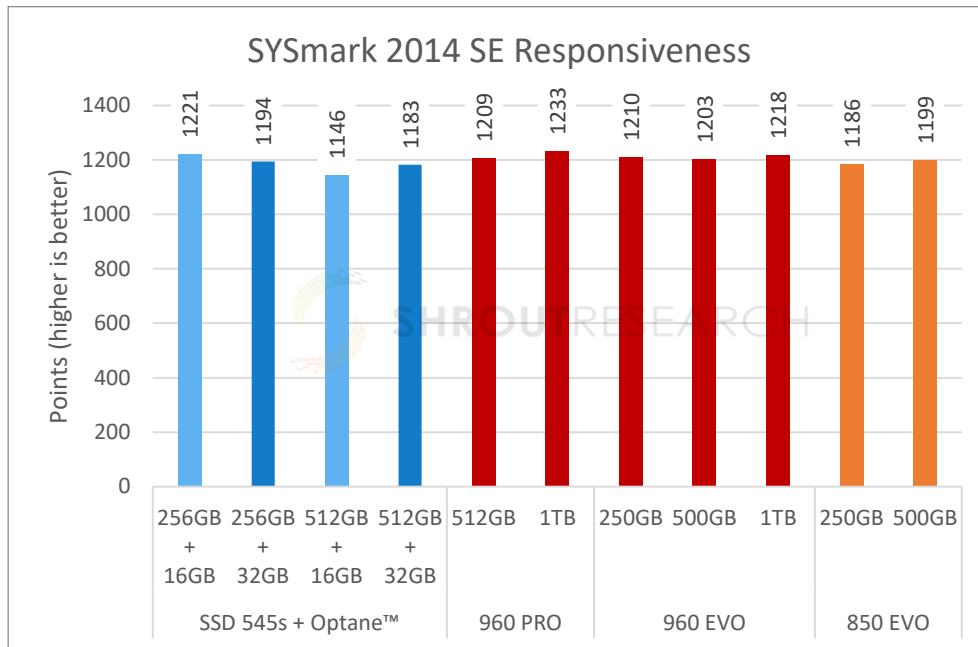

The Intel® Optane™ Memory + Intel® SSD 545s combination results have two distinct designations. The 16GB module paired with the various capacities of 545s exceed the performance of the 850 EVO. Moving to the 32GB module with the same Intel® SSD 545s puts the combination above the performance of the 960 PRO and 960 EVO.

SYSmark 2014 SE Responsiveness

SYSmark 2014 SE is an application-based benchmark reflecting usage patterns of business consumers. The Responsiveness test addresses specific "pain points" for these users including application launch times, multi-tab browsing, file copying and encryption, application installs, and more.

SYSmark 2014 SE Responsiveness

Points (higher is better)

| Category	Configuration	Value
SSD 545s + Optane™	256GB + 16GB	1221
SSD 545s + Optane™	256GB + 32GB	1194
SSD 545s + Optane™	512GB + 16GB	1146
SSD 545s + Optane™	512GB + 32GB	1183
960 PRO	512GB	1209
960 PRO	1TB	1233
960 EVO	250GB	1210
960 EVO	500GB	1203
960 EVO	1TB	1218
850 EVO	250GB	1186
850 EVO	500GB	1199

Results from this test are similar across the board, indicating that the Intel® Optane™ Memory and Intel® SSD 545s combination is just as performant as the 960 PRO and 960 EVO NVMe options.

Game Load: Ashes of the Singularity

For this test, we took a stopwatch and measured the load time for Ashes of the Singularity after a fresh boot.
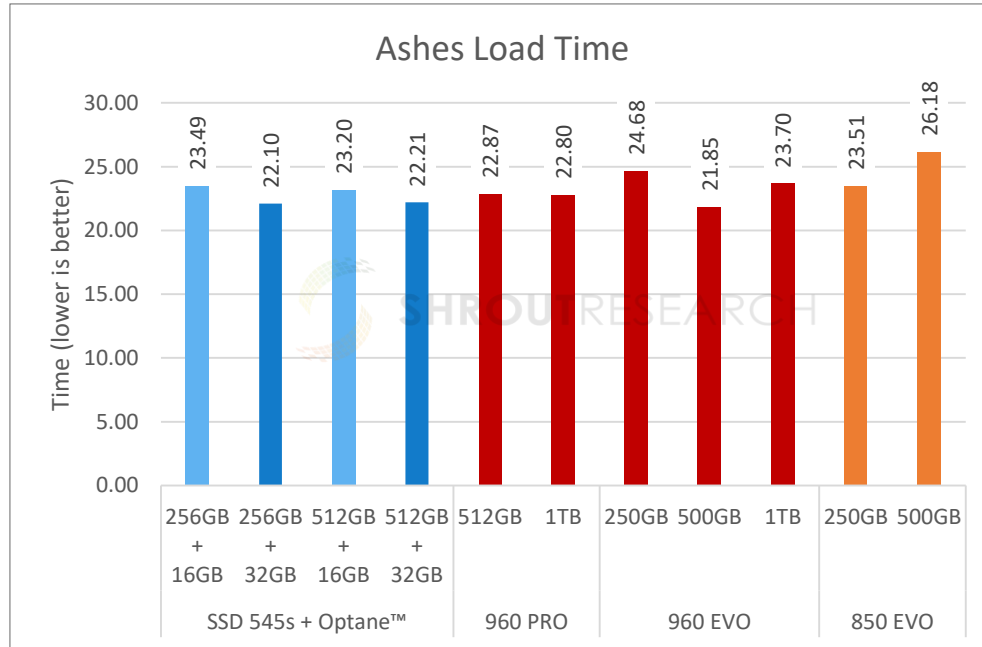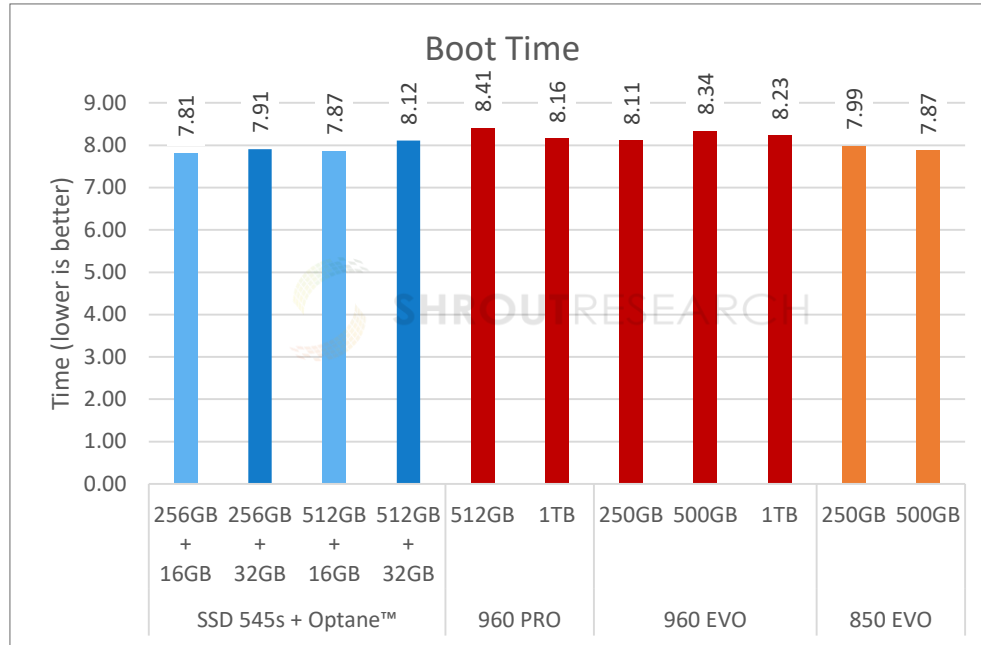

In this graph, we are measuring wall time, so lower is better. The Intel® Optane™ Memory and Intel® SSD 545s combinations are consistently on-par or faster than the best NVMe SSD options on the market including the 960 PRO and 960 EVO.

Windows 10 Boot Times

Using our stopwatch, we measure the boot times from power on until the Windows 10 desktop is first displayed.

Boot Time

Time (lower is better)

SSD 545s + Optane™				960 PRO		960 EVO			850 EVO	
256GB + 16GB	256GB + 32GB	512GB + 16GB	512GB + 32GB	512GB	1TB	250GB	500GB	1TB	250GB	500GB
7.81	7.91	7.87	8.12	8.41	8.16	8.11	8.34	8.23	7.99	7.87

Once again, the combination of Intel® Optane™ Memory and Intel® SSD 545s proves to be competitive with the highest performing SSDs on the market including the 960 PRO and 960 EVO NVMe options.

Disruptive Technology Doing as Intended

Our performance evaluation of Intel® Optane™ Memory when paired with Intel® SSD 545s indicates in consumer workloads an ability to match or exceed the performance of the top SSDs on the market. This includes other SATA-based drives as well as PCIe and NVMe solutions like the 960 PRO. Across a variety of applications and benchmarks with a goal of simulating environments and computing tasks ranging from gaming to rendering to office and productivity, our results show value in the addition of Optane™ Memory to lower-cost storage solutions.

Intel® Optane™ technology promised to be a disruptive force in the storage markets, across different areas of consumer, enterprise, and enthusiasts segments. The release of the P4800X for the data center and the 900P for enthusiasts and workstations complement the Optane™ Memory product by offering speed and reliability for mainstream consumers. Though caching is not a new method to improve the storage performance of PCs, Optane™ Memory is able to advance dramatically on that formula by lowering costs, improving the simplicity of setup and configuration, and making it blazing fast with 3D XPoint.

Consumers and enthusiasts that desire the performance of flagship NVMe SSDs but also need the largest capacity possible within a specific budget, should consider the Intel® Optane™ Memory and Intel® SSD 545s solution as a viable alternative. Intel® has built a broad range of storage options for system builders and enthusiasts, though the addition of Optane™ Memory may not get as much attention as it deserves.

Author: Ryan Shrout, President and Analyst at [Shrout Research](#)

Editor: Allyn Malventano, Technology Analyst at [Shrout Research](#)

Please direct questions about this paper to ryan@shroutresearch.com.

Appendix

The following test system configuration was used in the preparation of this paper:

Component	Product / Version
CPU	Intel® Core™ i5-7500
Motherboard	ASUS Prime B250-PLUS (BIOS 0608)
RAM	Corsair 16GB (8GB x 2) DDR4-3000 C15
GPU	NVIDIA GeForce GTX 1070 8GB (385.69)
OS	Windows 10 Pro RS3