

Engineering Workstation Review Roundup



Welcome

Next-Gen Computers

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While some technology segments have struggled in 2020, workstation manufacturers have seen demand increase significantly, particularly for high-powered mobile computers.



As more engineers need to work remotely or from home, these powerful mobile workstations have proven their worth. This year also saw the release of astoundingly fast new GPUs from both NVIDIA and AMD, as well as the emergence of a 64-core CPU from AMD. All of the major workstation OEMs have also unveiled new, innovative hardware.

In this Special Focus Issue, our writers take a look at new technology trends in the workstation space. We have also gathered all of the workstation reviews we have published over the past year to help our readers select the best computer for their engineering needs.

We hope you enjoy the issue.

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A Perfect Portable: MSI WS66 10TMT-207 Mobile Workstation

MSI continues to prove it is serious about CAD.

BY DAVID COHN

MSI recently launched its next generation of mobile workstations and it delivered one to us for a hands-on evaluation. It has been more than a year since we last reviewed a mobile workstation from the Taiwan-based company (*DE*, October 2019; digitalengineering247.com/r/23448), we have reviewed other MSI-built systems branded by other system integrators, notably the GoBOXX SLM 17 (a rebranded MSI WS75).

Why get excited about a new system from MSI? MSI has proven over the past several years that it was very serious about the CAD industry. Before the pandemic shut things down, MSI had a significant presence at most conferences and tradeshows.

It also joined the ranks of companies like Dell, HP and Lenovo in securing independent software vendor (ISV) certification from Autodesk, Siemens, Ansys and Dassault Systèmes, which ensures that the hardware and software are fully stable and compatible for a professional experience. MSI was also the first company to ship a mobile workstation that included an NVIDIA Quadro RTX graphics board.

Outwardly, the new MSI WS66 mobile workstation is similar to the WS65, but it is a fraction larger and no longer sports bronze accents. The WS66 comes housed in a very attractive brushed black aluminum case measuring 14.17x9.75x0.96-in. (WxDxH) and weighs 4.97 lbs.

MSI sells four WS66 configurations. We received the top-of-the-line WS66 10TMT-207, which included an NVIDIA Quadro RTX 5000 graphics processing unit (GPU). Systems incorporating that or the RTX 4000 GPU come with a 230-watt power supply (6.06x2.87x1.12-in.), adding an additional 1.95 lbs. Models equipped with an RTX 3000 graphic board come with a 180-watt power supply. Interestingly, the power supply we received was the same Chicony part included with the recently reviewed Eurocom Nightsky ARX15.



Fig. 1: The new, powerful MSI WS66 10TMT-207 15.6-in. mobile workstation is equipped with the NVIDIA Quadro RTX 5000 GPU.

Four Variations

Unlike many other OEMs, MSI does not offer custom configurations. Instead, the company sells preconfigured systems based on specific component combinations. There are currently four configurations for the WS66, all based on various models of eight-core Intel 10th-generation Comet Lake CPUs.

All four MSI WS66 systems use an MH470 chipset, feature a 15.6-in. 1920x1080 touch-enabled display capable of reproducing 72% of the NTSC gamut that in turn is powered by an NVIDIA Quadro RTX graphics board, and include an 84-key backlit keyboard, a 1TB M.2 NVMe solid-state drive (SSD), Wi-Fi and Bluetooth, an SD card reader, an IR 720p HD webcam and a four-cell 99.9Whr lithium-ion battery. All four WS66 models are virtual reality (VR) ready, with the only differences being the specific CPU, GPU and the amount of memory.

At \$2,499, the least expensive configuration (the WS66 10TKT-080) includes a 2.3GHz Intel Core i7-10875H CPU,

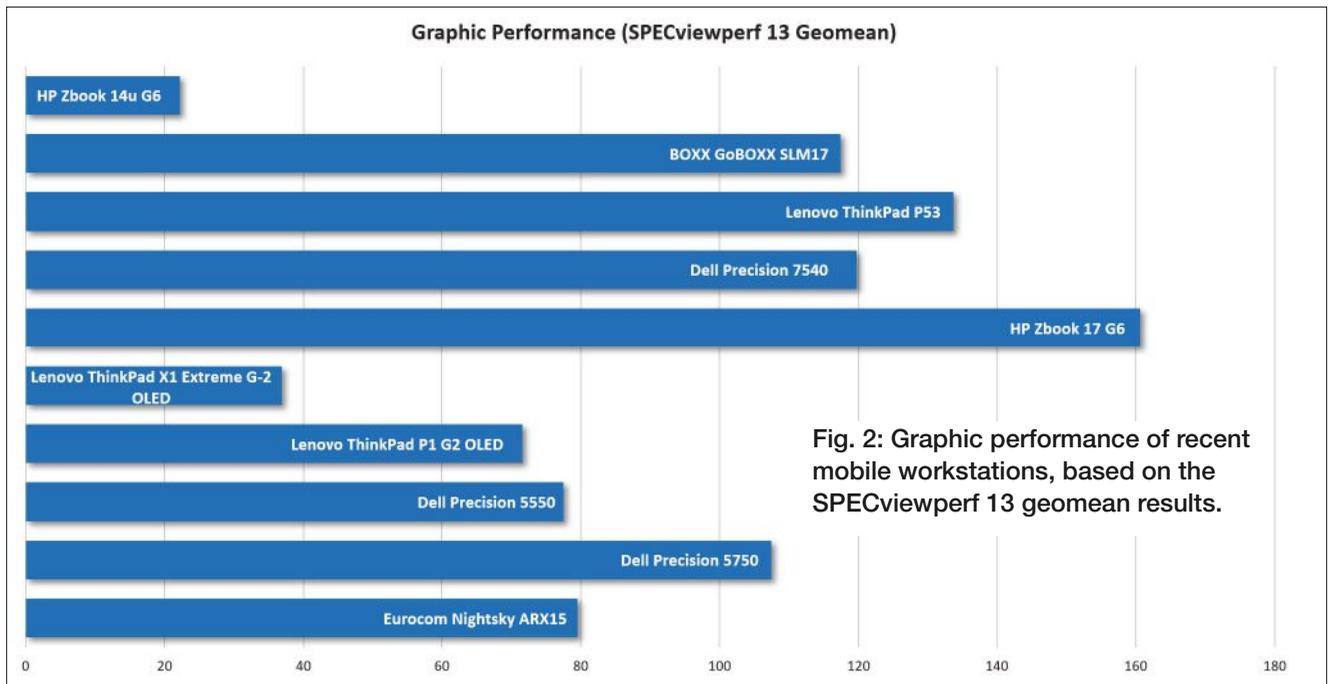


Fig. 2: Graphic performance of recent mobile workstations, based on the SPECviewperf 13 geomean results.

an NVIDIA Quadro RTX 3000 GPU with 6GB of discrete graphics memory and 32GB of RAM. Next in the lineup is the WS66 10TKT-081 (\$2,999), which uses a 2.4GHz Intel Core i9-10980HK CPU, an RTX 3000 and it comes with 64GB of memory. The WS66 10TLT-079 (\$3,299) is based on the Core i7-10875H processor but includes an NVIDIA Quadro RTX 4000 GPU with 8GB of discrete memory, and 32GB of RAM.

But for our review, MSI sent us the WS66 10TMT-207, a system built around the 2.4GHz Intel Core i9-10980HK processor. This CPU has a 5.3GHz maximum turbo frequency, a 16MB cache and integrated Intel UHD graphic, while boasting a thermal design power (TDP) rating of just 65 watts.

With a suggested retail price of \$3,999, our evaluation unit also included an NVIDIA Quadro RTX 5000 graphics board, a GPU with 16GB of discrete GDDR6 memory and featuring 3,072 CUDA cores, 384 Tensor cores and 48RT cores. Its 256-bit interface yields a 448 GB/second bandwidth while consuming a maximum of 110 watts.

As we have noted in previous reviews, MSI only sells its systems through authorized resellers who can set their own prices, so your cost may vary.

Almost Enough Ports

Lifting the lid reveals the 15.6-in. display and an excellent backlit keyboard with a standard layout. The power button is actually the key in the upper-right corner of the keyboard. An LED in that key glows white when the system is powered on and using the Intel graphics and amber when the discrete NVIDIA GPU is in use. There are also small LEDs on the Caps Lock and several function keys used to control sound and other settings.

An infrared webcam is centered above the display, flanked by a pair of microphones, and can be used with Windows Hello Face to sign into the computer. A gesture-enabled 5.5x2.63-in.

touchpad is centered below the spacebar. Although the touchpad lacks dedicated buttons, you can click in the lower-right corner to access right-click shortcut menus. A fingerprint reader is located in the upper-left corner of the touchpad.

MSI appears to be following the trend of reducing the number of ports on its latest system, but the WS66 still offers some features its competitors have eliminated. For example, the right side of the case provides a USB 3.2 Gen 2 Type-C port, an SD-card reader, a 3.5-mm combo audio jack, and a full-size RJ-45 network port.

Though the left side of the case includes just a single USB 3.2 Gen 2 Type-A port, it also contains a Thunderbolt (Type-C) port, an HDMI port, a connection for the AC adapter and a battery status light. There are no other ports—so you may need to factor in a hub, docking station or USB Type-C to Type-A adapter—and the system does not provide an attachment point for a security lock.

Like most modern thin, light-weight systems, the battery is not removable. But that battery managed to keep our system running for 9 hours and 50 minutes in our battery run-down test, just 40 minutes short of the record.

The MSI WS 66 10TMT-207 remained cool and quiet throughout our tests. At a maximum sound pressure of just 45dB, its internal fans were seldom audible above the 35dB ambient background level in our test lab. We measured a maximum temperature of 114°F on the bottom of the system during our tests.

Plenty of Power

The MSI WS66 10TMT-207 mobile workstation performed flawlessly throughout our tests. On the SPECviewperf test, which is a measure of pure graphic performance, the WS66 finished a close second to the HP ZBook 17 G6, a 17-in.

Mobile Workstations Compared	MSI WS66 10TMT	Eurocom Nightsky ARX 15	Dell Precision 5750	Dell Precision 5550	Lenovo ThinkPad P1 G2 OLED	Lenovo ThinkPad X1 Extreme G2 OLED
	15.6-inch mobile workstation (2.4GHz Intel Core i9-10980HK 8-core CPU, NVIDIA Quadro RTX 5000, 64GB RAM, 1TB NVMe PCIe SSD)	15.6-inch mobile workstation (3.5GHz AMD Ryzen 9 3950X 16-core CPU, NVIDIA GeForce RTX 2070, 64GB RAM, 2x 4TB NVMe PCIe SSD)	17.3-in. mobile workstation (2.40GHz Intel Xeon W-10885M 8-core CPU, NVIDIA Quadro RTX 3000 w/Max-Q Design, 32GB RAM, 1TB NVMe PCIe SSD)	15.6-in. mobile workstation (2.30GHz Intel Core i7-10875H 8-core CPU, NVIDIA Quadro T2000, 32GB RAM, 1TB NVMe PCIe SSD)	15.6-in. mobile workstation (2.80GHz Intel Xeon E-2276M 6-core CPU, NVIDIA Quadro T2000, 32GB RAM, 1TB NVMe PCIe SSD)	15.6-in. mobile workstation (2.60GHz Intel Core i7-9850H 6-core CPU, NVIDIA GeForce GTX 1650, 32GB RAM, 1TB NVMe PCIe SSD)
Price as tested	\$3,999.00	\$8,512.00	\$5,219	\$4,355	\$3,133	\$2,794
Date tested	10/1/20	9/2/20	8/28/20	6/24/20	2/16/20	2/16/20
Operating System	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64
SPECviewperf 13.0 (higher is better)						
3dsmax-06	174.60	183.08	132.73	91.74	76.32	85.73
catia-05	256.00	109.70	173.75	147.96	126.46	56.36
creo-02	233.21	178.81	159.58	116.59	101.20	75.12
energy-02	40.50	19.94	29.78	17.31	17.11	6.37
maya-05	228.70	249.96	153.66	112.25	102.12	100.62
medical-02	103.67	53.19	73.08	51.11	47.95	24.57
showcase-02	95.62	101.02	74.54	43.99	36.50	36.83
snx-03	291.91	15.25	189.01	144.50	191.81	11.29
sw-04	156.49	87.13	110.18	100.81	86.57	53.45
SPECapc SolidWorks 2015 (higher is better)						
Graphics Composite	5.43	n/a	3.82	3.43	2.81	n/a
Shaded Graphics Sub-Composite	3.36	n/a	1.94	1.77	1.41	n/a
Shaded w/Edges Graphics Sub-Composite	4.25	n/a	2.88	2.67	2.03	n/a
Shaded using RealView Sub-Composite	3.92	n/a	2.62	2.42	1.91	n/a
Shaded w/Edges using RealView Sub-Composite	4.69	n/a	3.47	3.28	2.60	n/a
Shaded using RealView and Shadows Sub-Composite	4.49	n/a	3.04	2.85	2.23	n/a
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	4.94	n/a	3.67	3.45	2.76	n/a
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	15.06	n/a	9.86	7.51	6.92	n/a
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	14.68	n/a	10.68	8.64	7.79	n/a
Wireframe Graphics Sub-Composite	4.08	n/a	3.85	3.53	3.13	n/a
CPU Composite	7.13	n/a	3.55	3.09	3.19	n/a
SPEC Workstation v3 (higher is better)						
Media and Entertainment	2.33	3.43	2.20	1.93	1.63	1.70
Product Development	2.38	1.56	2.29	2.09	1.62	1.57
Life Sciences	2.35	2.91	2.15	1.59	1.54	1.31
Financial Services	1.76	4.72	2.13	1.54	1.53	1.17
Energy	1.50	2.33	1.43	1.30	0.99	0.99
General Operations	2.07	2.15	1.92	1.96	1.90	1.84
GPU Compute	3.61	3.77	3.09	1.91	1.79	1.84
Time						
AutoCAD Render Test (in seconds, lower is better)	28.70	27.10	35.60	38.9	49.00	44.10
Battery Life (in hours:minutes, higher is better)	9:50	0:55	10:30	10:22	7:14	6:45

Numbers in blue indicate best recorded results. Numbers in red indicate worst recorded results.

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➔ **MORE INFO**

● **Micro-Star International:** [MSI.com](https://www.msi.com)

● **MSI WS66 10TMT-207**

Price: \$3,499 as tested (\$2,499 base price)

Size: 14.17x9.75x0.96-in. (WxHxD) notebook

Weight: 4.97 lbs. plus 1.94-lb. 230-watt power supply

CPU: Eight-core 2.4GHz Intel Core i9-10980HK w/16MB Smart Cache

Memory: 64GB DDR4 at 2666MHz

Graphics: NVIDIA Quadro RTX 5000 w/16GB GDDR6 memory

LCD: 15.6-in. FHD (1920x1080) IPS w/touch

Camera: 720p RGB/Infrared webcam

Storage: 1TB Samsung M.2 PCIe NVMe

Audio: Realtec built-in speakers, combo audio jack (microphone/headphone), built-in microphone

Network: Intel/I225 and Intel Wi-Fi 6 AX201 plus Bluetooth 5.1

Ports: one USB 3.2 Gen 2 Type-A, one USB 3.2 Gen 2 Type-C, one Thunderbolt 3 (USB Type-C), HDMI, RJ-45 LAN

Other: SD-card reader

Keyboard: Integrated 83-key backlit keyboard

Pointing device: Integrated touchpad with fingerprint reader

For more information on this topic, visit [DigitalEngineering247.com](https://www.digitalengineering247.com).

Xeon-based system priced more than \$1,600 higher. On the SPECcapc SolidWorks tests, the results were even more impressive, with the MSI WS66 yielding some of the best scores we have ever recorded for a mobile workstation.

On the very demanding SPEC workstation performance benchmark, the MSI WS66 10TMT-207 also performed exceedingly well, earning top scores on both the Product Development and storage subsystem portions of the test.

On our own AutoCAD rendering test, a multi-threaded process where fast CPUs with multiple cores have a clear advantage, the 28.7-second average rendering time was just 1.6 seconds behind the record set by the Eurocom Nightsky ARX15, which was based on a much faster CPU (3.5GHz versus the MSI's 2.4GHz) with twice the number of cores.

MSI preloads Windows 10 Professional 64-bit on all of its WS66 mobile workstations and backs them with a 3-year warranty, two years longer than what now comes standard from major vendors like Dell and Lenovo.

MSI also preinstalls a free copy of its Creator Center software, which optimizes the system for use with various programs (similar to performance tuning software from Dell, HP and Lenovo). In addition to ISV certification, most MSI mobile workstations now also meet MIL-STD-810G standards.

MSI continues to prove that it is serious about being a major player in the mobile workstation market. The new MSI WS66 10TMT-207 is a great, thin, lightweight, VR-capable system that delivers amazing performance at a very attractive price point—a mobile workstation that any engineer would be proud to own. **DE**

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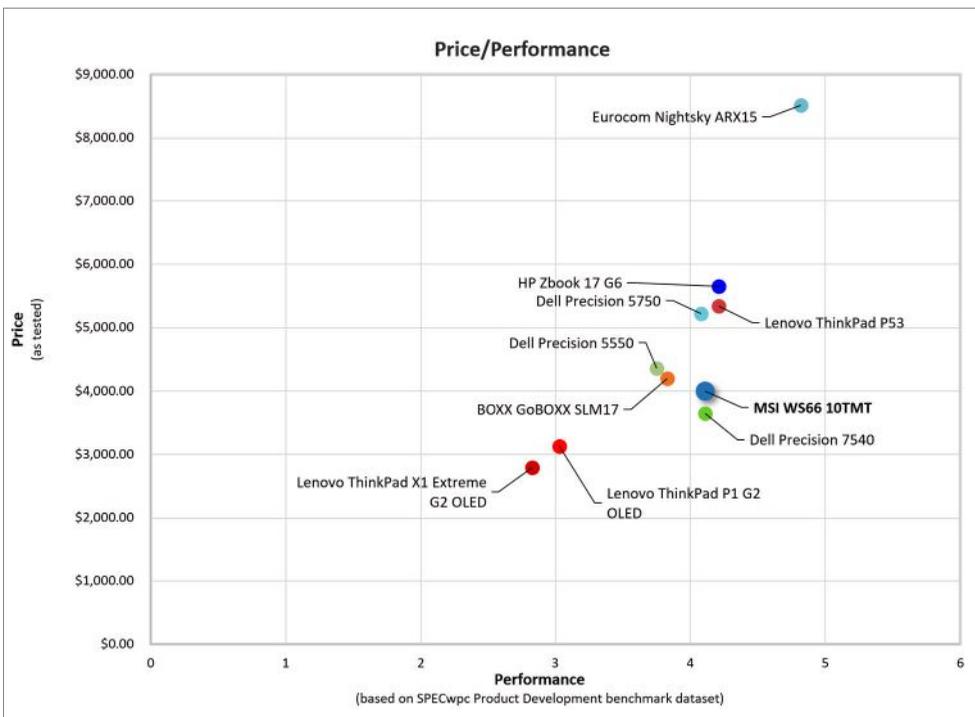


Fig. 3: Price/performance chart of recent mobile workstations, based on SPECwpc Product Development benchmark dataset.

Dell Precision 5750: The Smallest 17-in. Workstation

Dell's new Precision mobile system is small but pricey.

BY DAVID COHN

After recently reviewing the Dell Precision 5550 (*DE*, September 2020; <https://bit.ly/31fGUfZ>), the newest 15-in. addition to the company's mobile workstation offerings, Dell sent us its larger sibling. Dell touts the Precision 5750 as "the world's smallest and most intelligent 17-in. workstation," a claim that we quickly put to the test.

Like the Precision 5550, the Precision 5750 comes housed in a silver-colored case, and is less than an inch thick. The system measures at just 14.75×9.54×0.87 in. (W×D×H) and weighs a mere 5.5 lbs., plus 0.98 lb. for its 130-watt power supply (5.63×2.63×0.87 in.).



Fig. 1: The new 17.3-in. Dell Precision 5750 packs power and a gorgeous display into a thin, lightweight chassis with minimal ports.
Image courtesy of David Cohn.

No Numeric Keypad

Lifting the lid reveals a beautiful 17.3-in. display with a 16:10 aspect ratio surrounded by Dell's new Infinity Edge bezel. This feature, also found on the 15-in. Precision 5550, measures just over 1/8-in., resulting in a near borderless screen. Yet, Dell still managed to place an RGB-infrared webcam centered in the top edge of the bezel, flanked by a pair of infrared emitters, an ambient-light sensor and a camera-status light, while a pair of microphones are located on the top edge of the case. As was true for the Precision 5550, there is no webcam privacy shutter.

The Dell Precision 5750 incorporates the same 79-key backlit keyboard as its smaller sibling. This keyboard provides a very good feel and ample 1.3-mm key travel and includes an additional key in its upper-right corner that serves as the power button.

The keyboard is flanked by a pair of top-firing stereo speakers, with slots along the bottom edge on either side of the case for left and right woofers. Although the speakers provide very good sound, the configuration fills the available space, leaving no room for a separate numeric keypad, a curious omission on a 17-in. system.

A large (5.94×3.56 in.) gesture-enabled touchpad is centered in the palm rest below the keyboard. This is identical to the Precision 5550, and like that system, it lacks any dedicated buttons but recognizes the difference between left- and right-clicks. Only the Caps Lock key includes an indicator light. An LED diagnostics light is located on the front edge of the case, centered below the touchpad.

Proximity Sensor Concerns

Although the size of the Dell Precision 5750 is a welcome change from bulky 17-in. systems, the thin chassis leaves limited space for external ports. The left side provides a wedge-shaped security lock slot and a pair of USB 3.2 Gen 2 Type-

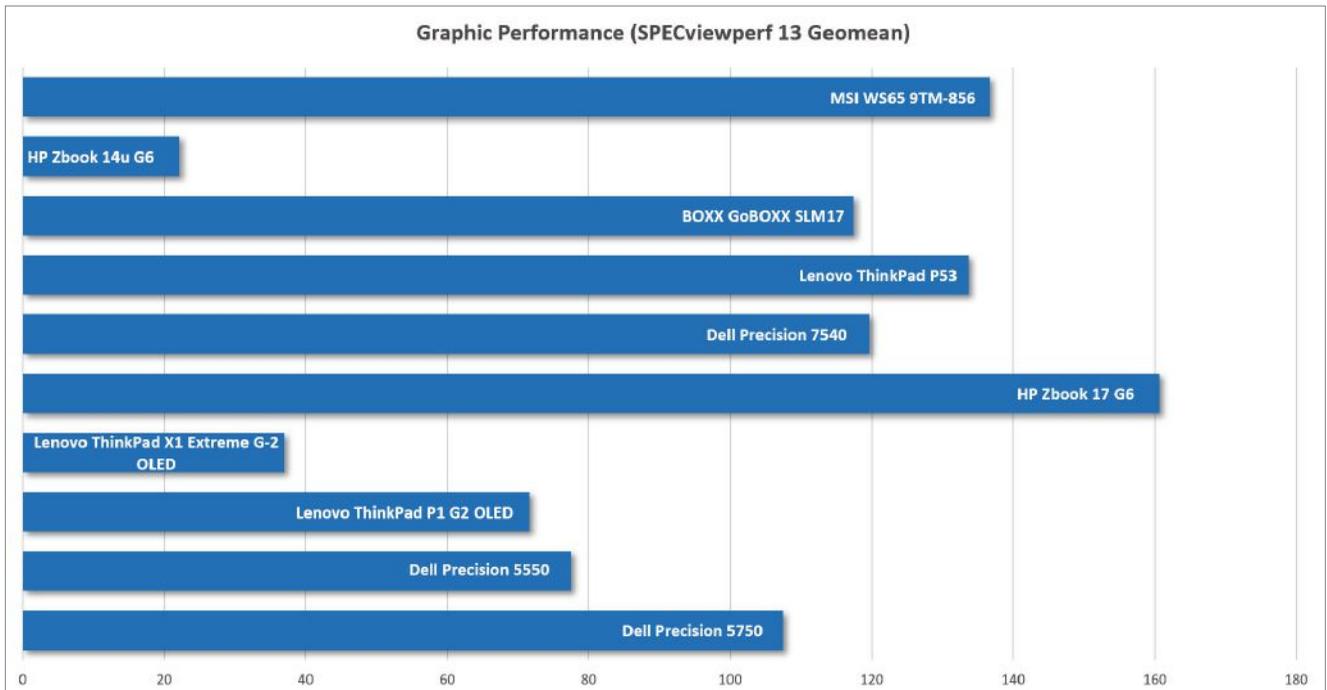


Fig. 2: Graphic performance of recent mobile workstations, based on the SPECviewperf 13 geomean results.

C ports. The right side hosts two additional USB 3.2 Type-C ports, an SD-card reader and a 3.5-mm audio port.

All four USB Type-C ports are charging ports and also support Thunderbolt 3 and DisplayPort 1.4. One of the Type-C ports must be used to connect the external power supply. There are no other ports.

Like the Precision 5550, the Dell Precision 5750 comes with a small adapter that, when plugged into a USB Type-C port, provides a single HDMI port and a single USB Type-A port. But it's still our opinion that modern systems require a minimum of two USB Type-A ports, one for a mouse and one for an external hard drive or thumb drive. Some users might also want an RJ-45 jack to connect to a gigabit network.

Dell sells several adapters, including a USB-C mobile adapter (\$70) that provides six ports (USB-A, USB-C, HDMI, VGA, DisplayPort and RJ-45) and a Thunderbolt Dock (\$275) that houses 11 ports (three USB-A, two USB-C, HDMI, two DisplayPorts, two audio combo jacks and a power connector). There are also a number of third-party adapters that would work, or you could purchase several USB Type-C to Type-A adapters. Either way, you may want to factor this into your purchase.

More troubling, however, was a feature we did not initially know existed. The Dell Precision 5750 includes a proximity sensor, located just to the left of the webcam. When you raise the lid, the system immediately boots up; there is no need to touch the power button. But we were puzzled by the fact that during our initial testing, the screen would turn off and

the system would hibernate after 1 minute, despite the fact that we had changed the power settings to one in which this should never happen.

It turns out that the latest version of the Dell Optimizer software—designed to dynamically optimize the system's performance using artificial intelligence and machine learning—is set to do this by default, to enhance privacy when you walk away from your desk. However, there was nothing accompanying the system to let a new user know that this feature existed. An email to our contact at Dell provided the solution before we resorted to calling tech support. We feel that Dell should either include some sort of hard-copy document prominently explaining this or not have this feature automatically enabled.

Lots of Options

Although external connections are limited, Dell offers quite a few internal options. With a starting price of \$2,399, the base configuration includes an Intel Core i5-10400H 2.6GHz 4-core CPU with integrated Intel HD Graphics 630, a 1920x1200 display, 8GB of DDR4 2933MHz RAM, a 256GB M.2 PCIe NVMe Class 35 solid-state drive (SSD), a 3-cell 56Whr lithium-ion battery and a 90-watt power supply, essentially identical to the base model of the Precision 5550. But again, that is just the starting point.

Dell offers a choice of seven different Intel processors. In addition to the base 4-core i5 CPU, you can opt for one of two Intel Core i7 6-core variants (the 2.6GHz i7-10750H or

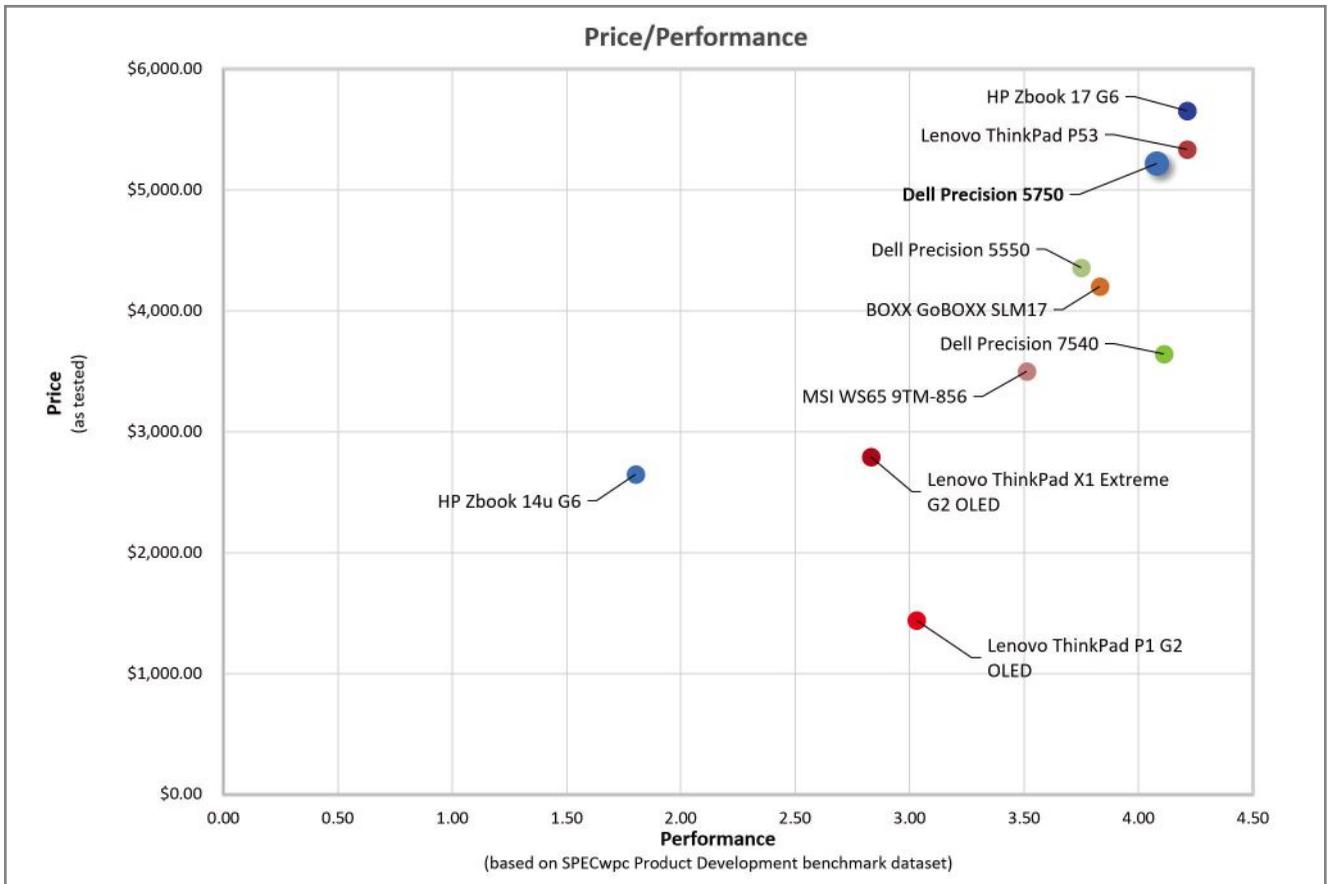


Fig. 3: Price/Performance chart based on SPECwpc Product Development benchmark dataset.

2.7GHz i7-10850H), one of two 8-core i7s (the 2.3GHz i7-10875H or 2.4GHz i7-10885H), or one of two Intel Xeon CPUs (the 6-core W-10855M or 8-core W-10885M).

All of these Comet Lake CPUs offer increased core counts and faster clock speeds than the previous generation, but the highest numbers are only achievable with what Intel calls its Thermal Velocity Boost. This means the additional speed is only available periodically when the processor is operating below its maximum temperature.

Our evaluation unit came with the Intel Xeon W-10885M CPU, an 8-core processor released in the spring of 2020. This CPU features a 2.4GHz base frequency, 5.3GHz max turbo, 16MB of Smart Cache and a thermal design power rating of 45 watts adding \$448 to the base price.

In addition to the integrated Intel graphics, Dell offers the Precision 5750 with a choice of two NVIDIA discrete graphics processing units (GPU): the Quadro T2000 (\$266) or the Quadro RTX 3000 with Max-Q (\$426), which was included in the system we received. This GPU incorporates 6GB of GDDR6 memory, 1920 compute unified device architecture cores, 30 RT cores and 240 Tensor cores.

Based on NVIDIA's Turing architecture, the RTX 3000 has a 192-bit interface, enabling it to deliver a

bandwidth of 288.05GB/second while consuming 80 watts. The discrete graphics card requires a larger (130-watt) power supply, adding \$17.

Dell also offers a choice of two displays. Our evaluation unit included the same gorgeous 3840×2400 touch-enabled display as the one in the Precision 5550, which covers 100% of the Adobe color gamut. On the Precision 5750, this display added \$348 to the total cost.

Although the new 10th-generation Intel CPUs can support up to 128GB of memory, the Dell Precision 5750's two memory sockets limit the total memory to 64GB. The system we received came with 32GB of non-error-correcting code (ECC) RAM, installed as two 16GB DDR4 2933MHz modules, adding \$420. Systems like ours, equipped with a Xeon CPU, can also use ECC memory. Dell's ECC memory costs a bit more (\$459 for 32GB) and is slightly slower (2666MHz) than the non-ECC RAM.

The Dell Precision 5750 also supports up to two M.2 solid-state drives—with optional RAID 0 and RAID 1 on systems equipped with two identical drives. Capacities range from 256GB to 2TB. The system we received came with a 1TB PCIe NVMe Class 50 SSD, which added \$735.

Although a 3-cell 56Whr battery comes standard, our

system included a 6-cell 97Whr lithium-ion battery with ExpressCharge (\$56 extra), which enables the battery to reach 80% in 60 minutes. That battery kept our Dell Precision 5750 running for an impressive 10.5 hours, slightly longer than the 5550.

The computer was nearly silent during even the most demanding tests, reaching just 56dB under heavy compute loads. But the underside reached 108°F at times and we measured a temperature of 123°F around the function keys when running some of our benchmarks.

Great Test Results

With its more powerful components, we expected the Dell Precision 5750 mobile workstation to outperform the Precision 5550, which it did quite handily. On the SPECviewperf test, which measures pure graphic performance, the Precision 5750 equipped with the NVIDIA Quadro RTX 3000 GPU turned in great results, lagging only behind mobile systems equipped with the even more powerful RTX 5000. Scores for the SPECapc SolidWorks benchmark were equally impressive.

On the very demanding SPEC workstation performance benchmarks, the Dell Precision 5750 also delivered excellent results. It turned in the top scores for four of the seven use cases (media and entertainment, product development, life sciences and energy) and scored near the top in the other three.

The 5750 also delivered the best results for CPU-dependent operations. The Dell Precision 5750 completed our multi-threaded AutoCAD rendering test in less than 36 seconds, among the fastest among all mobile workstations we have ever tested and more than 3 seconds faster than the Precision 5550.

All Dell Precision 5750 systems are independent software vendor certified for major CAD, digital content creation and scientific applications and include a copy of the aforementioned Dell Precision Optimizer. Since our system included a Xeon CPU, Windows 10 Pro for Workstations came preloaded, adding \$154. Systems based on Intel Core processors come with Windows 10 Pro. Windows 10 Home and Ubuntu Linux are also available.

Like several other vendors, Dell's standard warranty has been reduced to just 1 year of basic service. Warranties of up to 5 years are also available. Since we base our as-reviewed price on systems with a 3-year warranty, our cost includes the extra \$216 for the longer warranty. Note that the exact cost to extend the warranty will vary depending on the specific system configuration.

As configured, the Dell Precision 5750 priced out at \$5,219, making it one of the more expensive mobile workstations we have recently tested. Although it is several

pounds lighter than other 17-in. laptops, just remember that it sacrifices a separate numeric keypad and extra ports to achieve its svelte form. There are certainly faster, less expensive 17-in. systems out there, but none as thin or lightweight as the Dell Precision 5750. **DE**

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David Cohn is the technical publishing manager at 4D Technologies. He also consults and does technical writing from his home in Bellingham, WA and has been benchmarking PCs since 1984. He is a Contributing Editor to Digital Engineering and the author of more than a dozen books. You can contact him via email at david@dscobn.com or visit his website at www.dscobn.com.

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→ MORE INFO

• Dell: Dell.com

• Dell Precision 5750

Price: \$5,219 as tested (\$2,399 base price)

Size: 14.75×9.54×0.87 in. (WxDxH)

Weight: 5.5 lbs. plus 0.98-lb. 130-watt power supply

CPU: 2.40GHz Intel Xeon W-10885M 8-core w/16MB Smart Cache

Memory: 32GB DDR4-2933MHz non-ECC

Graphics: NVIDIA Quadro RTX 3000 Max-Q w/6GB GDDR6

LCD: 17.3-in. UHD+ 3840×2400 anti-glare touch-enabled

Camera: 1 megapixel RGB+infrared webcam

Storage: 1TB KIOXIA America M.2 PCIe NVMe Class 50 SSD

Audio: Realtek ALC3281-CG with built-in speakers, built-in microphone, universal 3.5-mm audio jack

Network: Intel Wi-Fi 6 AX201 plus Bluetooth 5.1

Ports: Four USB 3.2 Gen 2 Type-C with Thunderbolt 3 and DisplayPort 1.4

Other: SD-card slot

Keyboard: 79-key backlit keyboard

Pointing device: Gesture-enabled 5.94×3.56-in. touchpad

OS: Windows 10 Professional for Workstations 64-bit

Warranty: One-year basic onsite (three-year warranty included in as-tested price)

For more information on this topic, visit DigitalEngineering247.com.

ThinkStation P620: Next-Gen Workstation Power for Engineering

Solving complex engineering problems requires powerful new Lenovo workstations powered by NVIDIA RTX GPUs.



One need only to look around to see that it's clear why engineering workflows and development processes have become so complex. Whether the task is designing a modern vehicle sporting semi-autonomous operation and sophisticated electronics or creating a medical device packed with sensors and circuitry, the lines have blurred between engineering disciplines and require a collection of high-performance tools to get the job done.

It has now become more critical than ever that cross functional teams work together seamlessly across Industrial Design, Electrical and Mechanical Engineering out to production planning in the factory. Given the interconnected nature of products, engineers are continuously working in concert with other functions along with customers, suppliers, and partners to ensure all elements of a product are coordinated and to avoid late-stage surprises or design disasters.

To get it all done, the typical engineering team relies on a wide range of tools to design, engineer, and digitally test product concepts. For example, engineers can quickly simulate and test mechanical performance of key components to predict critical failure modes and make multiple design iterations, then using their own 3D printers or an on demand manufacturing platform they can source high quality physical prototypes for final design validation.

With teams regularly tasked to do more and facing greatly accelerated time-to-delivery schedules, it's critical that engineers be able to easily and effectively multi-task between resource-intensive applications so they remain productive without impacting the business.

Data and Performance-Hungry Workloads

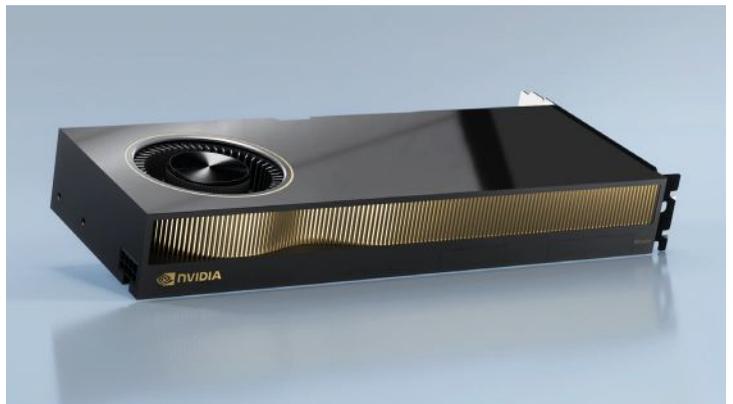
With this expanded tool set comes a much more sophisticated data management problem. As engineers become more fluent with the tools, and CAD software becomes more advanced, the 3D model is evolving into a highly detailed data set, expanding from the parameters of a single component into a feature-rich representation of all integrated systems. At the same time, engineering teams are producing a wealth of simulation data.

Engineers are highly dependent on their workstations in order to stay productive, and many times, older models simply can't keep up. Engineers need a robust workstation platform tuned for advanced multi-tasking to avoid getting hung up for hours or days on end trying to process the demands of mixed, high-performance workloads.

Advanced workstations like the ThinkStation P620

leverage more powerful GPUs such as the NVIDIA RTX A6000 to deliver the productivity boost engineers need to keep pace with demanding workflows and increased multi-tasking. Users of existing high-performance workstations may think they are well equipped to squeeze optimal performance from their applications given the horsepower of their current hardware. But the truth is, there's a new CPU/GPU combination that can best performance and boost productivity in a way that drives improved innovation.

Lenovo's ThinkStation P620 workstation buttressed with the [NVIDIA RTX A6000 GPU](#) is a game changer for how engineers work. The combination of the two technologies allow users to wrangle large-scale 3D models and simulation data sets with ease, turbocharge simulation solve times, and accelerate rendering cycles so there is no more limbo waiting on the system to perform complex tasks. In addition, the duo supports the most ad-



vanced levels of multi-tasking so engineers can easily model, run simulations, and toggle between office productivity apps simultaneously without any hit on performance.

AI-driven 3D modeling, advanced multiphysics simulation, and sophisticated real-time rendering are becoming a regular part of the engineering workflow, increasing the need for robust system performance to ensure optimal productivity. The Lenovo ThinkStation P620 and NVIDIA RTX A6000 come together to create a workstation platform uniquely and optimally tuned to handle the sophisticated demands of advanced engineering workloads. Unlike older workstations that may buckle under the strain of modern-day tasks, the P620 and RTX A6000 combo ensure engineers have the horsepower they need to be the engine for sophisticated design and unparalleled innovation.

[Learn more about the Lenovo ThinkStation P620 in this new Making the Case whitepaper.](#)



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Dell Precision 5550: Thin, Fast and Pricey

DE tests the world's smallest 15-in. mobile workstation.

BY DAVID COHN

Dell recently announced a couple of new mobile workstations in its Precision line—the 5550 and 5570—offering the portability of a laptop and the processing power of a desktop PC. The Precision 5550 is reportedly the world's smallest 15-in. mobile workstation, according to Dell. A few weeks later, we received one of these new systems and immediately put it to the test.

As soon as it arrived, the new Dell Precision 5550 grabbed our attention. Nestled inside an elegant hinged black box made with 100% recycled materials, unpacking the Precision 5550 was a treat. And the computer packed inside that box was indeed incredibly thin.

Like the Precision 7540 we recently reviewed (see *DE*, April 2020; digitalengineering247.com/r/24243), the Dell Precision 5550 comes housed in a silver-colored case. But while the 7540 was more than an inch thick, the Dell Precision 5550 is less than half that. Its case measures a mere 13.56×9.07×0.46-in. (WxDxH) and our evaluation unit weighed just 4.42 lbs., plus 0.94 lb. for its 130-watt power supply (5.62×2.56×0.88-in.).

Great Design, Few Ports

Lifting the lid reveals a 15.6-in. display with a 16:10 aspect ratio and one of the thinnest bezels we have seen. Dell calls this new design “Infinity Edge.” Measuring just over 1/8-in. surrounding a panel surfaced with Corning Gorilla Glass, the result is a near borderless screen.

Dell still managed to place an RGB-infrared (red, green and blue-infrared) webcam centered in the top edge of the bezel, flanked by a pair of infrared emitters, an ambient-light sensor and a camera-status light, while a pair of microphones are located on the top edge of the case. The bezel is too thin to accommodate a privacy shutter.

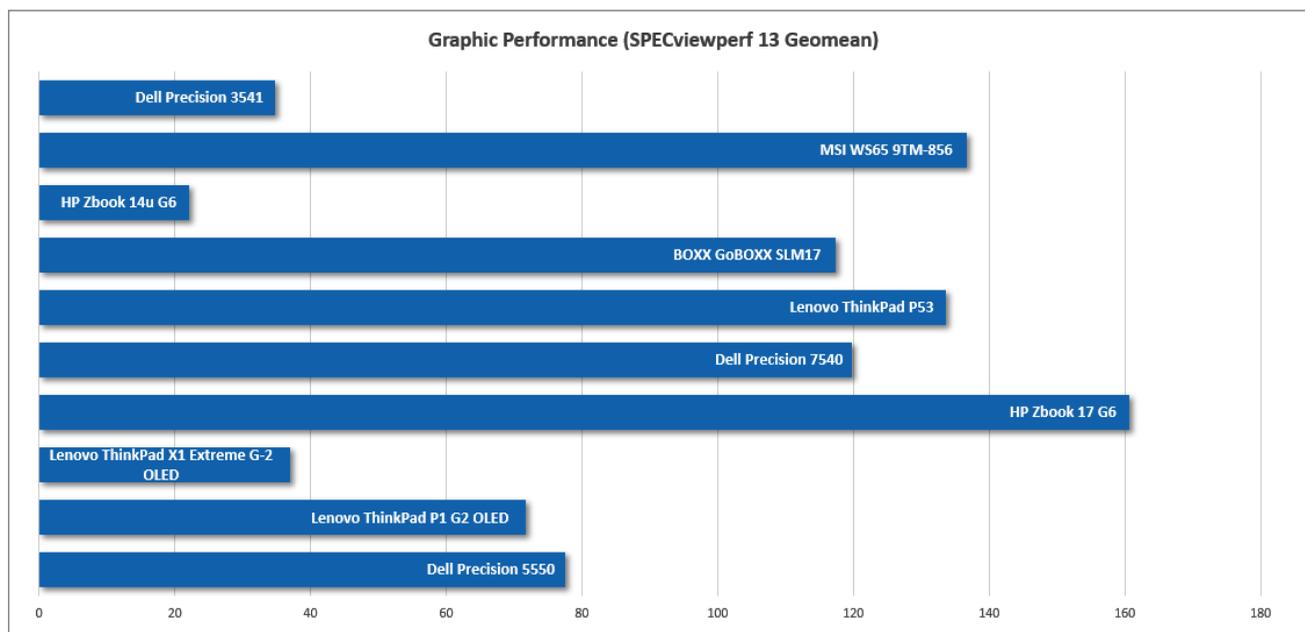
The Dell Precision 5550 incorporates a 79-key backlit keyboard with a very good feel and ample 1.3-mm key travel. An additional key in the upper-right corner of the keyboard doubles as the power button and a fingerprint reader. The keyboard is flanked by a pair of top-firing stereo speakers that provide very good sound.

There are also a pair of slots along the bottom edge on either side of the case for left and right woofers. A large (5.94×3.56-in.) gesture-enabled touchpad, centered in the palm rest below the keyboard, lacks any dedicated buttons, but recognizes the difference between left- and right-clicks. Only the Caps Lock key includes an indicator light, while a battery status light is located on the front edge of the case, centered below the touchpad.

Though the reduced size of the Dell Precision 5550 is to be applauded (the system is 6% smaller than the previous generation), the thin chassis leaves limited space for external ports. The left side provides a wedge-shaped security lock slot and a pair of USB 3.2 Gen 2 Type-C ports with Thunderbolt 3. The right side hosts an additional USB 3.2 Gen



The Dell Precision 5550 packs power and a gorgeous display into a thin, lightweight chassis with minimal ports. *Image/charts courtesy of David Cohn.*



Graphic performance of recent mobile workstations, based on the SPECviewperf 13 geomean results.

2 Type-C port, an SD-card slot and a 3.5-mm audio port. One of the Type-C ports on the left side is meant to be used to connect the external power supply, but you can plug the power supply into any of the Type-C ports.

There are no other ports—no USB Type-A ports at all—and the only air vents are located on the bottom of the case.

Our evaluation unit came with a small adapter that, when plugged into a USB Type-C port, provided a single HDMI port and a single USB Type-A port; this is simply not sufficient.

A minimum of two USB Type-A ports are often required (one for a mouse and the other for an external drive). Some users might also want an RJ-45 jack to connect to a gigabit network. Dell does sell several other adapters—including a USB-C mobile adapter (\$70) that provides six ports (USB-A, USB-C, HDMI, VGA, DisplayPort and RJ-45) and a Thunderbolt Dock (\$275) that houses 11 ports (three USB-A, two USB-C, HDMI, two DisplayPorts, two audio combo jacks and a power connector) plus both wedge-shaped and Kensington lock slots. There are also a number of third-party adapters that would work. Either way, you may want to include one of these as part of your purchase.

Ample Options

Although external connections are limited, Dell does offer quite a few internal options. With a starting price of \$1,999, the base configuration includes an Intel Core i5-10400H 2.60GHz four core CPU with integrated Intel HD Graphics 630, a 1920×1200 display, 8GB of RAM, a 256GB M.2 PCIe NVMe Class 35 SSD, a 3-cell 56Whr lithium ion battery and a 90-watt power supply. But that is just the starting point.

Dell presents a choice of five different 10th-generation 14nm processors. In response to competition from AMD Ryzen processors, these Comet Lake CPUs offer increased core counts and faster clock speeds.

In addition to the base four-core i5 CPU, you can opt for one of two Intel Core i7 6-core variants (the 2.6GHz i7-10750H or 2.7GHz i7-10850H), the eight-core i7-10875H, or the Xeon W 10855M (a 6-core CPU running at 2.8GHz).

All offer higher turbo-boost speeds than the previous generation, but the highest numbers are only achievable “opportunistically,” with what Intel calls “Thermal Velocity Boost.” This means the additional speed is only available periodically when the processor is operating below its maximum temperature.

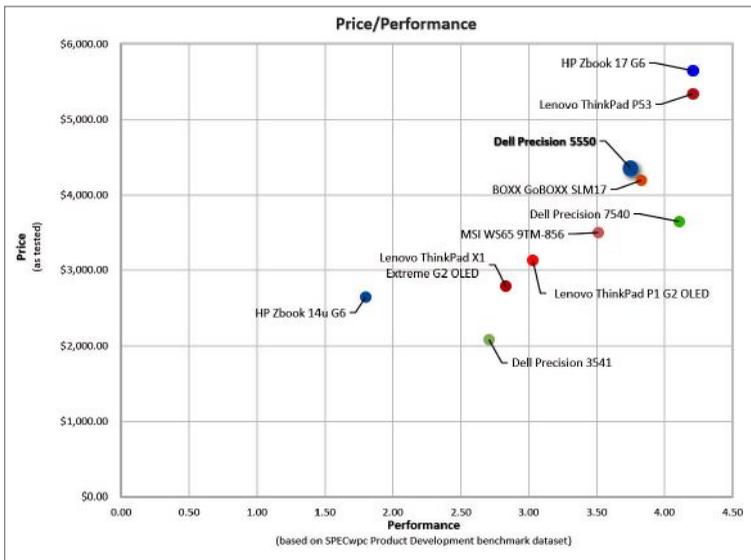
Our evaluation unit came with an Intel Core i7-10875H CPU, an eight-core processor with a 2.30GHz base frequency, 5.10GHz max turbo, 16MB of Smart Cache and a thermal design power rating of 45 watts. This CPU added \$382 to the base price.

In addition to the integrated Intel graphics, Dell offers the Precision 5550 with a choice of two NVIDIA discrete graphics processing units (GPUs)—the Quadro T1000 (\$140) or the Quadro T2000 (\$266), which was included in the system we received. This GPU includes 4GB of GDDR5 memory and 1024 compute unified device architecture cores, while consuming 60 watts. Its 128-bit interface enables it to deliver a bandwidth of 128GB/second.

You also get a choice of two different displays. Our evaluation unit included a gorgeous 3840×2400 touch-enabled display covering 100% of the Adobe color gamut, adding \$313 to the total cost.

Although the new 10th-generation Intel CPUs can support up to 128GB of memory, its two memory sockets mean that the Dell Precision 5550 is capped at a maximum of 64GB. Our system came with 32GB of RAM, installed as two 16GB DDR4 2933MHz modules, adding \$420. Dell also offers error-correcting code memory for those systems equipped with a Xeon CPU.

The Dell Precision 5550 also supports up to two M.2



Price/Performance chart based on SPECwpc Product Development benchmark dataset.

solid-state drives (with optional RAID 0 and RAID 1 on systems equipped with two identical drives). Capacities range from 256GB to 2TB. The system we received came with a 1TB PCIe NVMe Class 50 SSD, which added \$734.

While a three-cell 56Whr battery comes standard, our system included a six-cell 86Whr lithium ion battery with ExpressCharge, which enables the battery to reach 80% in 60 minutes. That battery kept our Dell Precision 5550 running for an impressive 10 hours and 22 minutes. The computer was nearly silent during even the most demanding tests, but the underside got up to 115°F at times.

Great Performance

We had a very short time in which to evaluate this Dell mobile workstation, so we started running our suite of benchmarks as soon as the system arrived. On the SPECviewperf test, which measures pure graphics performance, the Precision 5550 did quite well, easily beating the scores of similarly equipped thin, lightweight mobile systems we recently tested; SPECapc SolidWorks benchmark scores were equally impressive.

On the very demanding SPEC workstation performance benchmarks, the Dell Precision 5500 also delivered very good results. It turned in the top score for general operations and its other results rank the 5550 among the recently tested systems. The Dell Precision 5550 also completed our multi-threaded AutoCAD rendering test in less than 39 seconds, placing it among the fastest mobile workstations we have ever tested.

All Dell Precision 5550 systems are independent software vendor (ISV) certified for major CAD, DCC and scientific applications and include a copy of the Dell Precision Optimizer, which automatically tunes the system to run ISV applications. Windows 10 Pro 64-bit came pre-loaded. Systems based on a Xeon CPU require Windows 10 Pro for Workstations, which adds \$154 to the price. Windows 10 Home and Ubuntu Linux are also available.

Like several other vendors, Dell's standard warranty has been reduced to just one year of basic, onsite service. Warranties of up to five years are also available as are ProSupport with next business day onsite service, accidental damage coverage and an extended battery warranty. Since we base our as-reviewed price on systems with a three-year warranty, our cost includes the extra \$173 for the longer warranty.

As configured, the Dell Precision 5550 priced out at \$4,355, making it one of the more expensive mobile workstations we have tested recently. There are certainly faster, less expensive laptops out there, but none are as thin or lightweight as the Precision 5550. Just remember that you are paying a premium for that portability—and may need to spend a bit more for additional connectivity. **DE**

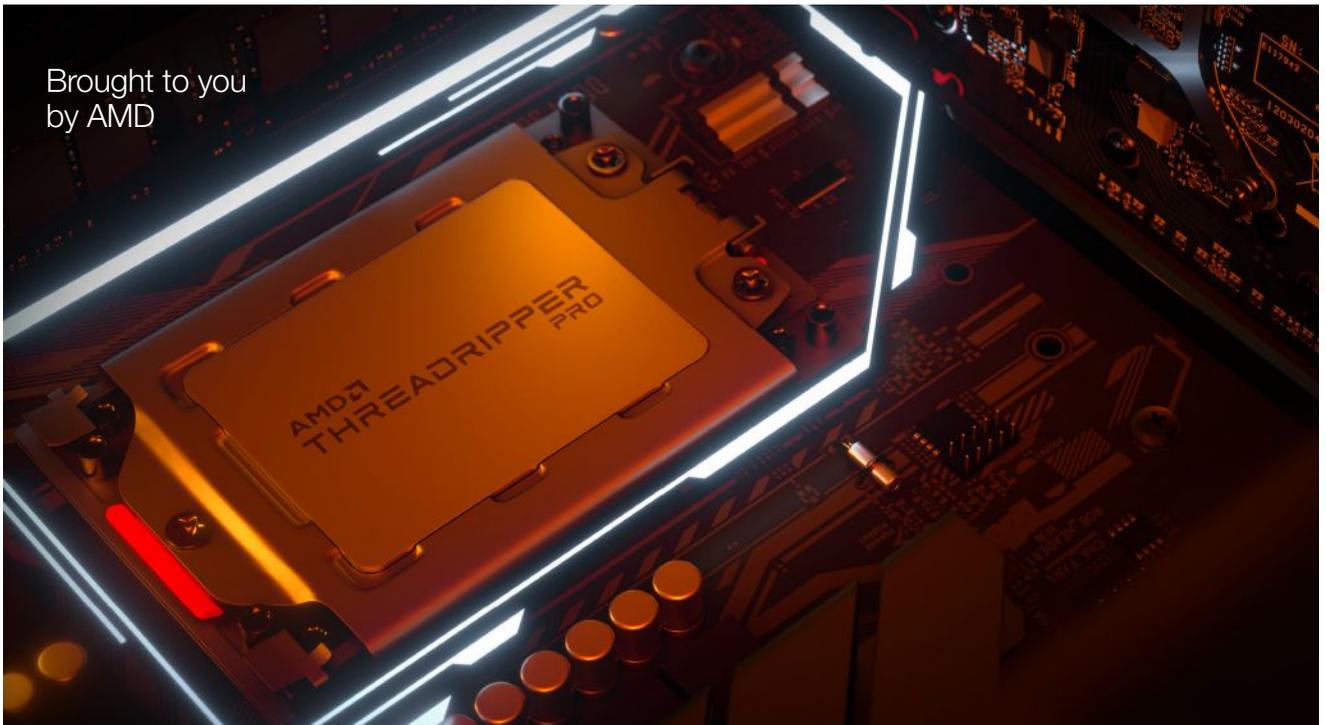
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David Cohn is the technical publishing manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA and has been benchmarking PCs since 1984. He is a Contributing Editor to Digital Engineering and the author of more than a dozen books. You can contact him via email at david@dscobn.com or visit his website at www.dscobn.com.

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→ MORE INFO

- **Dell:** Dell.com
Dell Precision 5550
 - Price:** \$4,355 as tested (\$1,999 base price)
 - Size:** 13.56x9.07x0.46-in. (WxDxH)
 - Weight:** 4.42 lbs. plus 0.94-lb. power supply
 - CPU:** 2.30GHz Intel Core i7-10875H 8-core w/16MB Smart Cache
 - Memory:** 32GB DDR4-2933MHz
 - Graphics:** NVIDIA Quadro T2000 w/4GB GDDR5
 - LCD:** 15.6-in. UHD+ 3840x2400 anti-glare touch-enabled
 - Storage:** 1TB Hynix M.2 PCIe NVMe Class 50 SSD
 - Audio:** Realtek ALC3281-CG with built-in speakers, built-in microphone, universal 3.5-mm audio jack
 - Network:** Intel Wi-Fi 6 AX201 plus Bluetooth 5.1
 - Ports:** Two USB 3.2 Gen 2 Type-C with Thunderbolt, one USB 3.2 Gen 2 Type-C DisplayPort
 - Other:** SD-card slot
 - Keyboard:** 79-key backlit keyboard
 - Pointing device:** Gesture-enabled 5.94x3.56-in. touchpad
 - OS:** Windows 10 Professional 64-bit
 - Warranty:** One-year basic onsite (three-year basic onsite warranty included in price)
- For more information on this topic, visit DigitalEngineering247.com.

Brought to you
by AMD



New Era of CPU Power

AMD Ryzen™ Threadripper™ PRO CPUs provide compute power needed to address modern design workflows.

Design workflows are rapidly evolving. Designers and engineers must produce better designs faster, incorporate simulation earlier and more frequently into the design cycle, and increasingly need to multitask across multiple applications. That has put greater demand on engineering workstations, as users toggle between modeling, simulation, and rendering tasks that require larger amounts of computational horsepower.

All of these factors have made CPU selection critical when purchasing a properly balanced workstation. Design tasks are typically lightly threaded and benefit most from a higher clock speed. Emerging generative design tasks, however, are multi-threaded and will require higher core counts. Likewise, compute-intensive simulation and rendering tasks can benefit greatly from larger core counts.

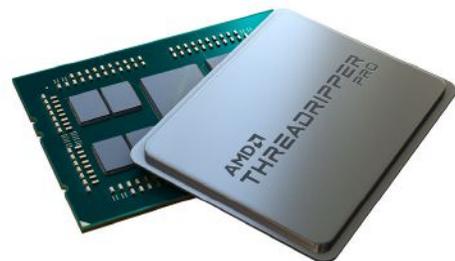
Enter the AMD Ryzen Threadripper PRO CPUs, which provides a wide variety of options that allow engineers to balance the need for high-performance in single-threaded operations, with ability to massively increase core counts for more intensive simulati

Unparalleled Performance

The AMD Ryzen Threadripper PRO family provides full spectrum compute capability with class-leading performance in both single-threaded² and multi-threaded work-

loads.³ Users can take advantage of up to 64-cores on the 3995WX processor for simulation and rendering tasks and a boost clock speed of up to 4.3GHz on the Threadripper PRO 3955WX processor¹ for lightly threaded 3D design tasks.

Each CPU can accommodate up to 2TB of memory, and PCIe 4.0 support means that the CPUs provide 128 lanes of bandwidth. The CPUs also provide 8-channel memory support.



By integrating AMD PRO Technologies into the Ryzen Threadripper PRO platform, the new CPUs offer both improved security and manageability. AMD PRO security helps protect engineering workstations from increasingly sophisticated cyber-attacks using a modern security-based architecture, full memory encryption, and AMD PRO manageability helps IT managers support an

increasingly dispersed workforce, and can help reduce maintenance costs and accelerating patch and software update deployments via a full suite of remote management tools.

The AMD Ryzen Threadripper PRO CPUs are the only professional workstation processors to support PCIe® 4.04, which doubles the bandwidth available to next-generation GPUs, high-speed storage devices, and Ethernet cards. PCIe 4.0 support helps accelerate engineering workflows and enables advanced workstation configurations.

Accelerate Engineering Workflows

What do these performance enhancements mean when it comes to engineering workflows? The combination of advanced core performance, high core counts, large memory capacity and fast clock speeds is ideal for a variety of scenarios:

3D Modeling & Design: Traditional design and modeling tasks tend to be single-threaded and utilize few CPU cores. The AMD Ryzen Threadripper PRO CPUs provide higher frequencies for improved productivity, as well as high core count options for emerging multi-threaded generative design methodologies.

Simulation: The use of simulation is gradually shifting from a task assigned to a handful of specialists, to an integral part of the design cycle for non-specialists that need to validate multiple iterations. The Threadripper PRO CPUs address the requirements of multi-threaded FEA and CFD solutions with high core counts, which can help slash solve times significantly. In instances where simulation software licenses limit the number of usable cores, the individual core performance of the Threadripper PRO helps maintain productivity.

Manufacturing: Multi-threaded performance is critical both for generating toolpaths in CAM solutions, and for the utilization of 3D printing slicer software. As design and manufacturing operations become more tightly coupled, the compute power provided by the high core counts of the AMD Ryzen Threadripper PRO platform will be critical.

Rendering: CPU-based rendering engines have emerged as an important tool for designers that need to create photorealistic images for design reviews, customer presentations, and advertising/marketing purposes. The AMD Ryzen Threadripper PRO CPUs provide the high

World's First 64-Core Professional Workstation

The new AMD Ryzen Threadripper PRO CPU is at the heart of the recently announced Lenovo ThinkStation P620 — the world's first 64-core professional workstation platform.

Leveraging the Threadripper PRO processors equips this new powerhouse workstation with clock speeds up to 4.3GHz¹, 128 lanes of PCIe 4.0 bandwidth and 8-channel memory support. The Lenovo ThinkStation P620 provides engineers with unmatched core counts⁵ for multi-threaded workloads in a single socket platform that can exceed the performance of dual-socket solutions³.



core counts required by these engines, while also providing the high clock speeds needed for single-threaded design workflows.

That balance of best-in-class single-threaded² and multi-threaded³ performance makes the AMD Ryzen Threadripper PRO platform a perfect fit for modern engineering workflows — both today, and in the future.

Resources

- Learn more about the [AMD Ryzen Threadripper PRO Family](#).
- Watch [this video](#) to see how the Threadripper PRO can accelerate manufacturing workflows.

Footnotes:

1. Max boost for AMD processors is the maximum frequency achievable by a single core on the processor running a bursty single-threaded workload. Max boost will vary based on several factors, including, but not limited to: thermal paste; system cooling; motherboard design and BIOS; the latest AMD chipset driver; and the latest OS updates. GD-150.

2. Based on AMD performance lab testing on June 8, 2020 using the Cinebench R20 1T benchmark test to compare the single-thread performance of Ryzen Threadripper PRO 3945WX reference system vs. Intel Xeon W-2295 processor. Results may vary. CPP-19

3. Based on AMD performance lab testing on June 8, 2020 using the Cinebench R20 nT benchmark test to compare the multi-thread performance of a Ryzen Threadripper PRO 3995WX reference system vs. (2) Intel Xeon Platinum 8280 processors. Results may vary. CPP-14

4. Based on AMD internal analysis June 1, 2020, comparing the PCIe(R) specifications of the AMD Ryzen Threadripper Pro to the Intel Xeon Platinum 8280 processor and the Intel Xeon W-3275 processor. CCP-10

5. The AMD Ryzen™ Threadripper™ PRO 3995WX has up to 64 cores compared to the highest core count Intel Xeon Scalable workstation processor, the 8280 at 28-cores. CPP-03

A Perfectly Portable Pair: Lenovo P1, X1 ThinkPads

These latest P-series laptops provide a great combination of performance, portability and price.

BY DAVID COHN

When we first reviewed the ThinkPad P1 (DE, March 2019; <https://bit.ly/2W2JoMf>), we deemed it to be the perfect combination of performance, portability and price. So, when Lenovo offered to send us the latest version of its powerful little mobile workstation, we jumped at the opportunity.

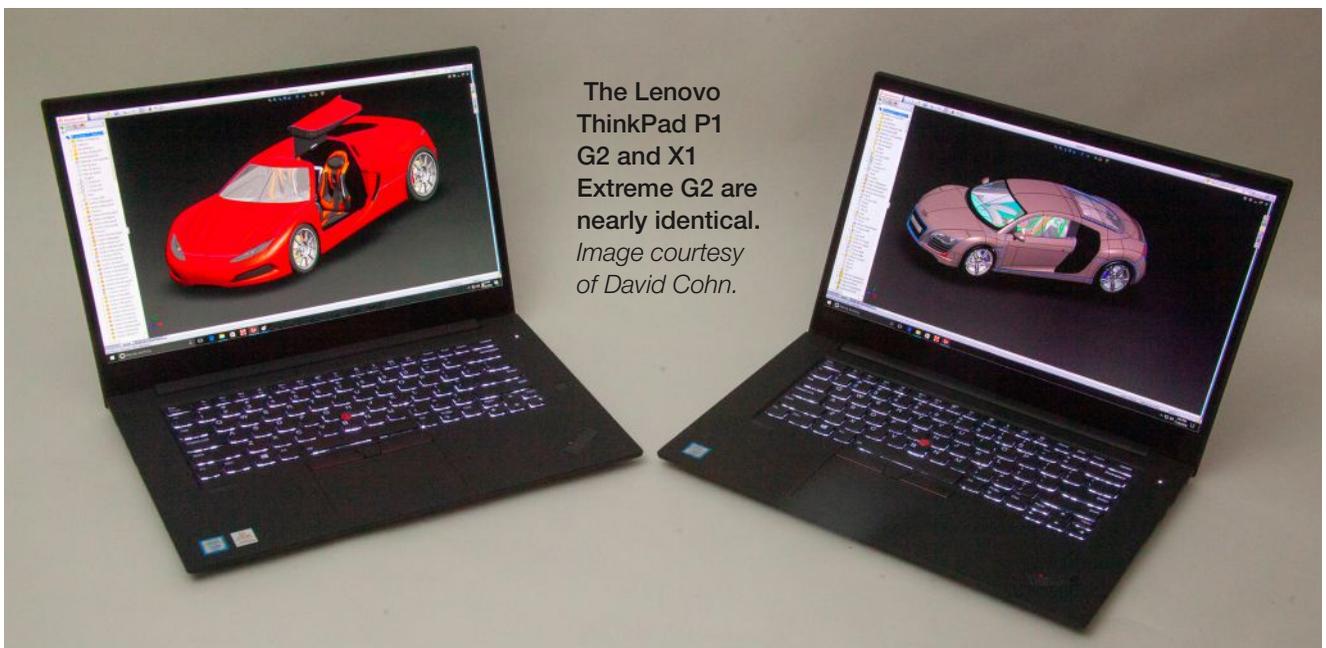
To sweeten the arrangement, in addition to the ThinkPad P1 G2, the company sent us the second generation of its ThinkPad X1 Extreme. Although not classified as a workstation (due to its consumer-grade graphics and lack of independent software vendor [ISV] certification), the X1 Extreme G2 would make for a fascinating comparison—particularly since both systems we received were equipped with discrete

NVIDIA graphics processing units (GPUs) powering organic light-emitting diode displays.

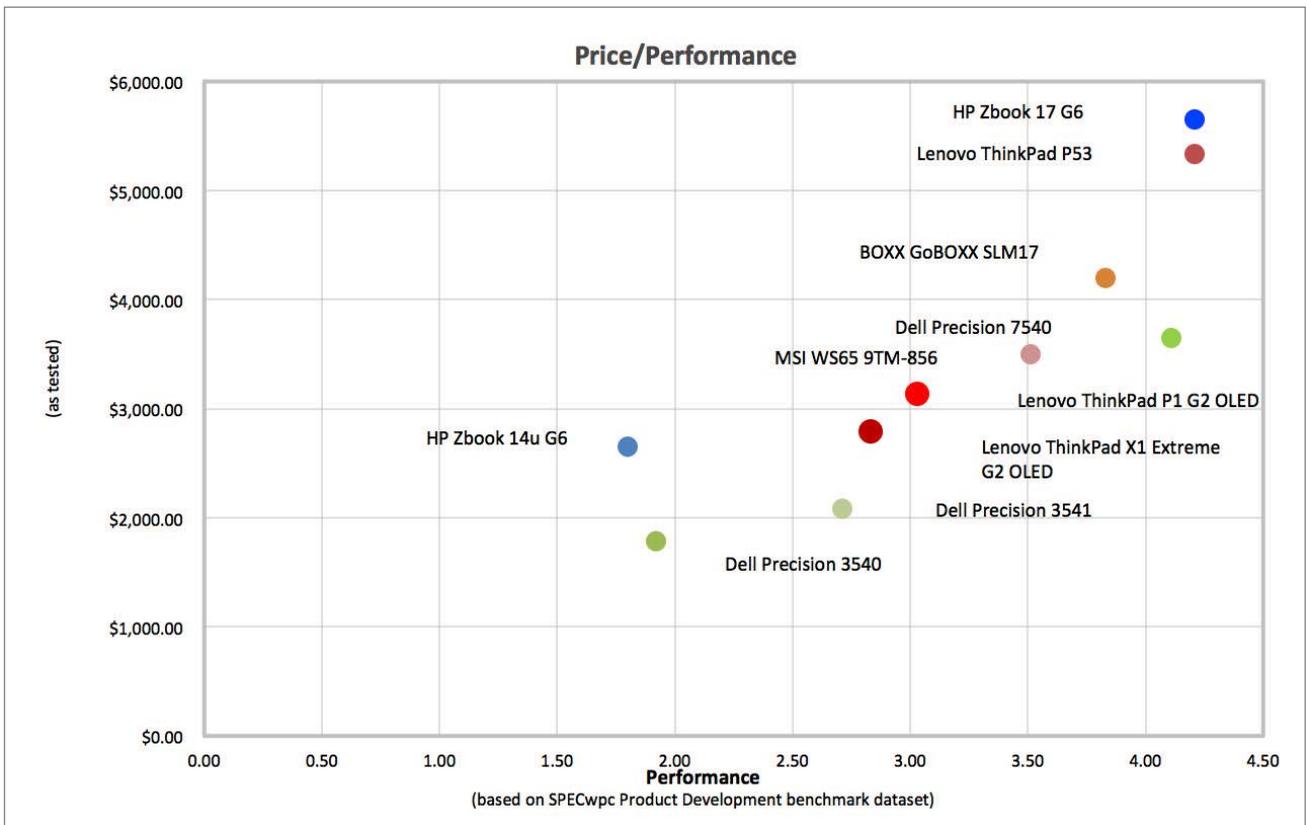
Based on their outward appearance, there is no discernible difference between the two computers other than an X1 model ID in addition to the ThinkPad logo with its glowing red dot over the “i.”

Both come housed in a charcoal gray carbon fiber and magnesium alloy case with an updated carbon fiber weave that provides a subtle touch to the design. The systems measure 14.25x9.69x0.81-in. and weigh just 3.8 lbs., a few ounces less than the first-generation ThinkPad P1. Both also include identical 135-watt power supplies, which measure 4.9x3.0x0.9-in. and weigh a mere 0.9 lbs.

The ThinkPad P1 G2 base configuration has a start-



The Lenovo ThinkPad P1 G2 and X1 Extreme G2 are nearly identical. Image courtesy of David Cohn.



Price/Performance chart based on SPECwpc Product Development benchmark dataset.

ing price of \$1,439 for a system with a 2.5GHz Intel Core i5-9400H quad-core processor, integrated Intel ultra high-definition (UHD) graphics, a full high-definition (1920x1080) in-plane switching anti-glare display with a rated brightness of 300 nits, 8GB of RAM, a 256GB PCIe solid-state drive (SSD), Wi-Fi and Windows 10 Home, backed by a one-year warranty.

The ThinkPad X1 Extreme G2 has a slightly higher starting price of \$1,475 for a system with a 2.4GHz Intel Core i5-9300H quad-core processor and a discrete NVIDIA GeForce GTX 1650 GPU with 4GB of memory and 896 compute unified device architecture (CUDA) cores, but otherwise has the identical display, memory, storage, accessories, operating system and warranty.

But, of course, those are just the starting points.

Lots of Similarities

Raising the lid on either system reveals the same seamless spill-resistant keyboard with 84 mostly full-size keys as found on the original P1. Two levels of backlighting can be toggled by pressing the Fn key and spacebar. Although the systems lack a separate numeric keypad, the keyboard offers an excellent feel.

A round power button is located to the upper-right of the keyboard and a 4x2.75-in. touchpad with three buttons is centered below the spacebar. There is also the familiar red

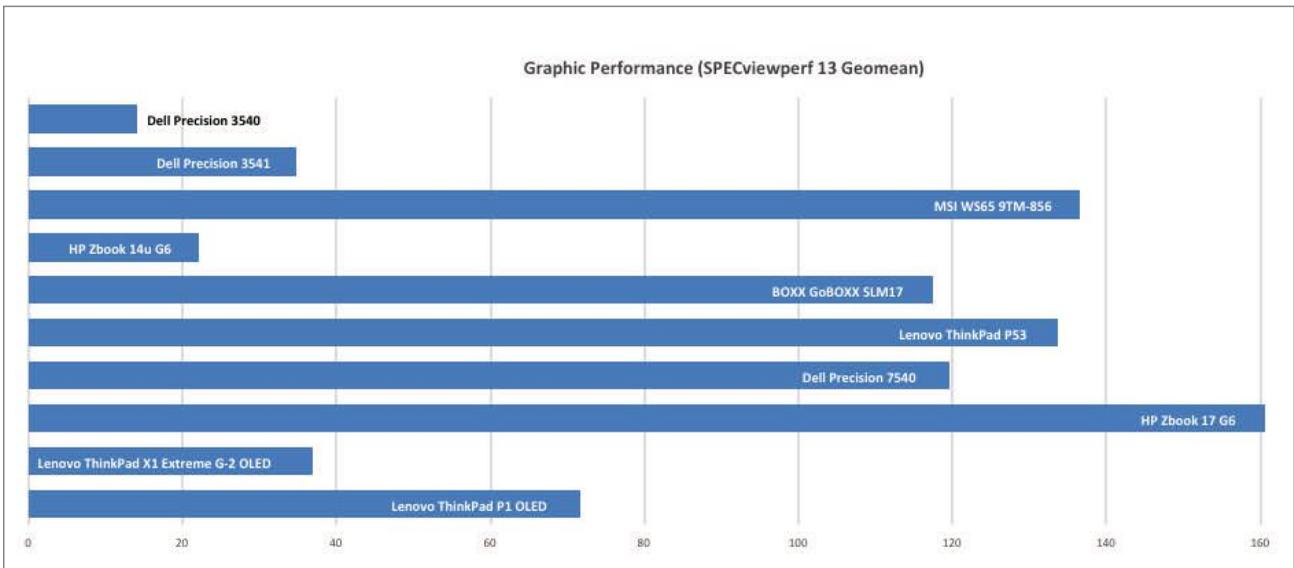
Lenovo pointing stick nestled between the G, H and B keys. The caps lock key has its own LED, as do the keys dedicated to the speakers, microphone and function lock. Both systems also include a fingerprint reader to the right of the keyboard.

A narrow bezel surrounds the display panel, yet still provides space above the panel for a 720p webcam, which now includes a privacy shutter. Lenovo offers a choice of four different display panels, including brighter (500 nits) full high-definition (1920x1080) and UHD (3840x2160) IPS anti-glare displays with Dolby Vision HDR.

Both of the Lenovo ThinkPad systems we received came equipped with 15.6-in. ultra high-definition (UHD) OLED touchscreen displays with Dolby Vision HDR that were stunning, with more vibrant colors and deeper blacks than we've ever seen in a mobile workstation. The OLED panel adds \$345 to the cost of the P1 while increasing the X1 Extreme's price by \$380.

The similarities start to disappear, however, once you dive beneath the hood. On the ThinkPad X1 Extreme G2, Lenovo offers a choice of four additional CPUs, ranging from the same 2.5GHz Core i5-9400H in the base-model P1, to a 2.3GHz Core i9-9880H eight-core processor. Our evaluation unit came with an Intel Core i7-9850H, a six-core 2.6GHz Coffee Lake CPU (4.6GHz max turbo), which added \$531 to the base price.

For the ThinkPad P1 G2, however, Lenovo also offers



Graphic Performance chart based on SPECviewperf 13 Geomean.

a Xeon CPU. Our evaluation unit included an Intel Xeon E-2276M six-core 2.8GHz processor (4.7GHz max turbo). Xeon-based P1 systems have a starting price of \$2,029, \$590 more than the base-model with an Intel Core processor, but also include an NVIDIA Quadro T1000 discrete GPU with 4GB of memory and 768 CUDA cores.

Although the GeForce GTX 1650 is the only graphics card available in the X1 Extreme, P1 customers can choose the NVIDIA Quadro T2000, a GPU with the same 4GB of memory and same Turing graphics chip as the T1000, but with 1024 CUDA cores, yielding faster graphic performance.

Some Significant Differences

Although the P1 and X1 Extreme offer similar memory configurations, the cost and options vary. Both can accommodate a maximum 64GB of 2666Mhz RAM. For our evaluation, Lenovo equipped the ThinkPad X1 with 32GB, installed as a pair of 16GB DDR4 memory modules, an option that added \$455. But for the Xeon-powered ThinkPad P1, we received 32GB of error-correcting code memory, which added \$310.

The amount of onboard storage also differs between the two systems. In addition to the 256GB SSD in the base model X1, Lenovo offers just two other choices: a 512GB drive and the 1TB PCIe NVMe M.2 drive in our evaluation unit, a \$591 option.

For the ThinkPad P1 G2, however, there is a choice of SSDs up to 2TB and the P1 can be equipped with up to two M.2 drives, for a total of 4TB of onboard storage. And the 1TB drive in the P1 we received added just \$205 to the total cost.

In addition, by upgrading the display in the ThinkPad P1 to the UHD OLED display, the webcam was automatically upgraded to one that includes an infrared camera, adding \$20.

Both the P1 and X1 Extreme provide identical ports. The left side includes the power input, a pair of USB Type-C Thunderbolt 3 ports, HDMI, a headphone/microphone combo audio jack and a special jack for an RJ45 Ethernet extension connector. This connector is \$35 extra when included with the X1 Extreme but only \$20 when ordered as part of the P1 configuration.

The right side provides a security lock slot, a pair of USB 3.1 Type-A ports (including one that is always on when the system is plugged in), a SD card reader and a slot for an optional SD card reader (a \$20 option).

Both systems include an Intel Wi-Fi 6 AX200 adapter with Bluetooth and come with the same four-cell Li-Polymer 80Whr battery with Lenovo's Rapid Charge technology that can bring the system back up to 80% capacity in just an hour.

Battery life for the second-generation ThinkPad P1 was slightly improved—our evaluation unit lasted 7.25 hours on our battery run-down test. The ThinkPad X1 Extreme G2 fared a bit worse, shutting down after 6.75 hours. Both systems remained cool and nearly silent throughout our tests, even when under heavy compute loads.

Still Great Performance

We've come to expect Lenovo workstations to deliver excellent performance. Both systems matched or outperformed the first-generation P1 on most of our tests, delivering great results for a 15.6-in. thin, lightweight laptop.

On the SPECviewperf test, which focuses almost exclusively on graphic performance, the ThinkPad X1 Extreme G1 actually outperformed the ThinkPad P1 G2, often by a significant margin. Unfortunately, the X1's GeForce graphics card meant that we could not run the SPECapc SolidWorks benchmark, because the GPU does not support the SolidWorks RealView feature, which is an integral part of the test.

On the demanding SPEC workstation benchmark, the ThinkPad P1 outperformed the X1 Extreme, thanks to its faster CPU and more robust GPU. But the ThinkPad X1 Extreme G2 averaged 44.1 seconds to complete our multi-threaded AutoCAD rendering test, compared to 49 seconds for the ThinkPad P1 G2.

Although both systems come with Windows 10 pre-installed, Windows 10 Professional in the P1 is included when you opt for a Xeon processor (\$35 extra). On the X1, Windows 10 Pro is a \$59 option.

Lenovo's standard warranty only covers the system for one year, with depot carry-in service. Additional coverage is available at the time of purchase that can extend the warranty for up to five years.

Our as-tested price includes an additional \$109 to extend the warranty to three years. Other warranty options include onsite repairs, premier support, accidental damage protection and battery replacement warranties.

As a workstation, the Lenovo ThinkPad P1 G2 is ISV-certified for a wide range of applications from Autodesk, Dassault Systèmes, PTC and Siemens. It has also passed military certification tests and quality checks to ensure it can perform in extreme conditions. The ThinkPad X1 Extreme G2 does not include these certifications.

As tested, our Lenovo ThinkPad X1 Extreme G2 priced out at \$2,794, while the ThinkPad P1 G2 we received totaled \$3,133.

As you can see in our price/performance and graphic performance charts, the extra money yields improved performance and peace of mind of knowing that the P1 is guaranteed to run even your most demanding applications. Either way, however, these two second-generation ThinkPads deliver plenty of performance in an attractive, portable package. **DE**

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David Cohn is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA and has been benchmarking PCs since 1984. He's a Contributing Editor to Digital Engineering and the author of more than a dozen books. You can contact him via email at david@dscobn.com or visit his website at www.dscobn.com.

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→ MORE INFO

- **Lenovo:** Lenovo.com

- **Lenovo ThinkPad P1 G2 OLED**

Price: \$3,133 as tested (\$1,439 base price)

CPU: Intel Xeon E-2276M 2.8GHz 6-core w/ 12MB cache

Memory: 32GB ECC DDR4 at 2666MHz

Graphics: NVIDIA Quadro T2000 w/4GB GDDR5 and 1024 CUDA cores

Camera: 720p with IR

- **Lenovo ThinkPad X1 Extreme G2 OLED**

Price: \$2,792 as tested (\$1,475 base price)

CPU: Intel Core i7-9850H 2.6GHz 6-core w/ 12MB cache

Memory: 32GB DDR4 at 2666MHz

Graphics: NVIDIA GeForce GTX 1650 w/4GB GDDR5 and 896 CUDA cores

Camera: 720p

- **Both systems share the following:**

Size: 14.25x9.69x0.81-in. (WxHxD) notebook

Weight: 3.82 lbs. (plus 0.84-lb. external 135-watt power supply)

Display: 15.6-in. UHD (3840x2160) OLED touchscreen w/Dolby Vision HDR

Hard Disk: 1TB SSD M.2 PCIe NVMe

Floppy: None

Optical: None

Audio: Built-in Dolby Atmos speakers, headphone/microphone jack, built-in microphone array

Network: Intel Wi-Fi 6 AX200 plus Bluetooth

Modem: None

Other: Two USB-A 3.1, one USB-C Thunderbolt 3 (with power delivery and DisplayPort), Ethernet extension connector, HDMI 2.0, SD card reader, fingerprint reader

Keyboard: 84-key spill-resistant backlit keyboard

Pointing device: Pointing stick and touchpad with three buttons

Standard warranty: One-year parts and labor (as-tested price includes three-year warranty)

For more information on this topic, visit DigitalEngineering247.com.

HP ZBook 17 G6 Mobile Workstation: A Record Setter

This 17-in. system claims the prize for the world's most powerful mobile workstation.

BY DAVID COHN

Last year, HP unveiled its next-generation ZBook mobile workstation, the ZBook 17 G6. The company billed the system as the world's most powerful mobile workstation. With a claim like that, we were quite eager to put one through its paces. Equipped with the latest 9th-generation Intel Core i9 or Xeon processor and a discrete graphics processing unit (GPU), the system is clearly designed to handle complex, multi-threaded apps, single-threaded programs and virtual reality (VR).

The 17-in. mobile workstation comes housed in a magnesium/aluminum alloy chassis with a stylish metallic finish. The system measures 16.37x11.31x1.5-in. and weighs 7.59 lbs., plus another 1.37 lbs. for its external 200-watt power supply (6.5x3.0x0.94-in.) Although the ZBook 17 is neither thin nor lightweight, its heft belies the power within.

Stylish Design

The center of the lid has a stylized HP logo. Raising that lid reveals a spill-resistant 102-key backlit keyboard that includes a separate numeric keypad. Most keys are full size, except a row of half-height function keys above the number row and small arrow keys in the bottom row. A black point stick input device is nestled between the G, H and B keys and has its own set of three buttons, while a 4.5x2.250-in. touchpad is centered below the spacebar.

The touchpad has its own set of buttons, supports multi-touch and includes a dedicated scroll zone. For systems equipped with near-field communication, the touchpad also has an area that lets you wirelessly share information when you tap it with a near-field communication-enabled device.

There is also a small colorimeter sensor in the touchpad's upper right corner on systems equipped with a Dream Color display to help you recalibrate a color preset without the use of an external device.

A small power button, located in the upper left above the keyboard, glows white when the system is powered up. Function keys—that mute the volume of the Bang & Olufsen sound system, mute the microphone and enable airplane mode—glow amber when enabled. The caps lock and number lock keys also have their own white LEDs to indicate when they are selected. A fingerprint reader is located below the numeric keypad. A pair of function keys lets you answer Skype calls and hang up when you're done.

The grille above the keyboard conceals a pair of 74dB speakers. A webcam with an integrated privacy shutter is centered above the display, flanked by a pair of antennas for HP's extended-range wireless LAN. Physical shielding built into the system eliminates signal peaks and valleys as you move about to maintain a faster connection.

In addition to traditional front-facing microphones, the ZBook 17 G6 includes a world-facing microphone on the back side of the lid. This is great for conference calls, but also works with the system's built-in noise cancellation circuitry to eliminate background noise. Our system also included a 1080p infrared webcam.



Fig. 1: The HP ZBook 17 G6 packs amazing power into a stylish package. Images courtesy of David Cohn.

Lots of Options

Prices for the HP ZBook 17 G6 start at \$2,343 for a system equipped with a 2.6GHz Intel Core i7-9750H six-core processor, a full high-definition (1920x1080) display with a rated brightness of 300 nits, an NVIDIA Quadro T1000 GPU, 16GB of RAM and a 256GB PCIe NVMe solid-state drive (SSD). But that's just the starting point, and the evaluation unit we received included much more.

HP offers a choice of six different CPUs. Intel Core processors range from the quad-core 2.4GHz Core i5-9300H to the eight-core 2.3GHz Core i9-9880H. But our system included an eight-core Intel Xeon E-2286M processor. That 2.4GHz Coffee Lake CPU (5.0GHz max turbo) includes a 16MB cache and has a 45-watt thermal design power rating, adding \$896 to the system price.

Our evaluation unit also included a 17.3-in. ultra-high-definition (3840x2160) Dream Color display. The improved color gamut (100% AdobeRGB) and 400 nits brightness was well worth the additional \$588. A touchscreen version is also available for \$164 more.

All ZBook 17 G6 systems include a discrete GPU plus integrated Intel graphics and HP offers a choice of five graphic boards. Our system came with an NVIDIA Quadro RTX 5000 with 16GB of dedicated GDDR6 memory. This GPU provides 3072 compute unified device architecture cores, 384 Tensor cores and 48 RT cores. Although it adds a whopping \$2,780 to the price, it enables the ZBook 17 to power through any VR project.

The HP ZBook 17 G6 can support up to 128GB of memory. The Xeon-based system we received included 32GB of 2666MHz error-correcting code memory, which increased the cost by an additional \$855. There is room for up to four storage devices. Primary storage is handled by solid-state M.2 drives ranging from 256GB up to 2TB, and the ZBook 17 provides two M.2 connections, which also support RAID.

You can add a third drive in the form of a standard SATA hard drive (up to 2TB) or a 1TB SATA SSD. There is also an optical drive bay that can house either a Blu-ray/DVD-writer or a 2TB 5400rpm hard drive. Our evaluation unit included a single 512GB PCIe NVMe M.2 drive and an optical drive, adding \$270 and \$109, respectively.

There is also an abundance of ports on the HP ZBook 17 G6. The right side includes the optical drive bay, a combo



Fig. 2: A removable bottom panel makes it easy to access the interior.

microphone/headphone audio jack, HDMI port, mini-DisplayPort, a pair of USB Type-C Thunderbolt ports, the power connector and a battery indicator. The left side provides a security cable slot, full-size RJ-45 network jack, three USB 3.0 ports, an SD card reader and a smart card reader.

HP continues to make interior access easy. A sliding latch releases the bottom of the case. Once removed, you can change the battery and access the M.2 slots, drive bays and memory sockets. Though the six-cell 95.6 Whr battery is pretty robust, with all the power-hungry components in our evaluation unit, it could only sustain our ZBook 17 G6 for 4.75 hours. Happily, the HP Fast Charge capability returned the battery to 50% in just 45 minutes.

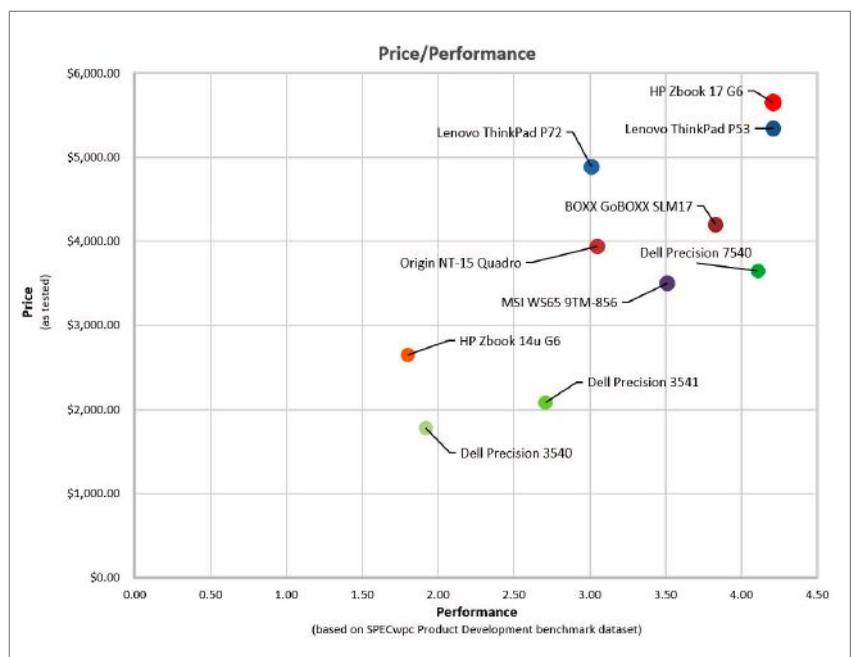
HP also sells several accessories for the ZBook 17 G6, including a Thunderbolt dock that provides three USB 3.0 Type-A ports, two USB Type-C ports, a Thunderbolt 3 port, two DisplayPorts and a VGA port, while requiring just a single USB-C cable connecting the dock to the computer.

Record-Setting Performance

We expected great performance, but the HP ZBook 17 G6 exceeded our expectations. On the SPECviewperf test, which focuses on graphics, the ZBook 17 turned in the best results to date for a mobile workstation, thanks largely to its incredibly powerful NVIDIA RTX 5000 GPU.

On the SPECape SolidWorks benchmark, it also scored at or near the top in every category. The HP ZBook 17 G6 also turned in excellent results on the very demanding SPEC

Fig. 3: Price/Performance chart based on SPECwpc Product Development benchmark dataset.



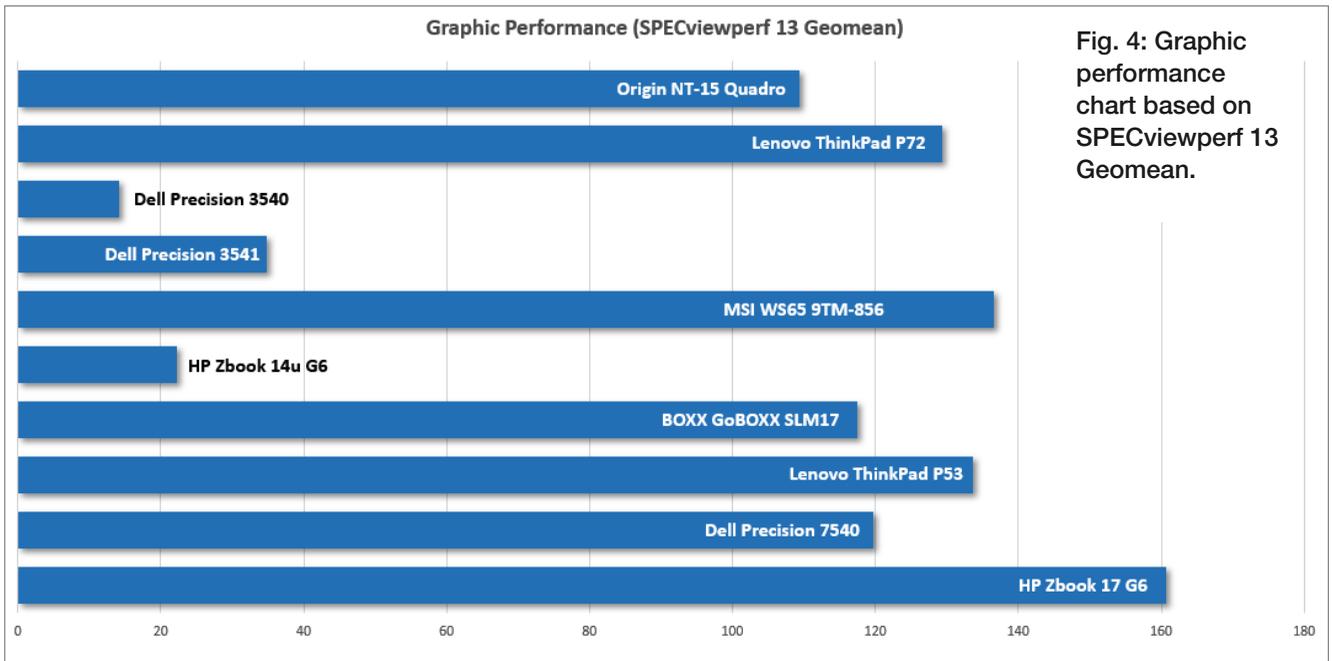


Fig. 4: Graphic performance chart based on SPECviewperf 13 Geomean.

workstation performance benchmark, with results near the top in every category, including most subsystem scores—except for its storage subsystem scores, which were the lowest we’ve recorded in the past year.

With an average time of 35.4 seconds to complete our multi-threaded AutoCAD rendering test, however, the HP ZBook 17 G6 missed the mobile workstation record by just 0.6 seconds.

Throughout our tests, the HP ZBook 17 G6 was nearly silent, barely exceeding the 29dB ambient background noise in our test lab. HP preinstalled Windows 10 Pro 64-bit. Windows 10 Home and FreeDOS 3.0 are also available.

Like all its other workstations, the ZBook 17 G6 is independent software vendor certified, has passed 21 military standard tests and more than 120,000 hours of testing, and is backed by a three-year warranty.

The ZBook 17 G6 also includes HP Sure Sense for enhanced ransomware protection, Sure Click to protect against malware entering your PC through a browser or common office files, and technologies like HP Sure Start (self-healing BIOS), Sure Run and Sure Recover.

With its powerful CPU, VR-ready NVIDIA Quadro graphics, lots of memory and ample expandability, the HP ZBook 17 G6 is clearly built for the most demanding workflows. Although its size and price may not appeal to everyone, it’s difficult to beat its performance. We agree with HP’s claims: the HP ZBook 17 G6 is currently the world’s most powerful mobile workstation. **DE**

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David Cohn is the technical publishing manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA and has been benchmarking PCs since 1984. He’s a Contributing Editor to Desktop Engineering and the author of more than a dozen books. You can contact him via email at david@dscobn.com or visit his website at www.dscobn.com.



➔ **MORE INFO**

HP: HP.com

HP ZBook 17 G6 mobile workstation

- **Price:** \$5,654 as tested (\$2,343 base price)
- **Size:** 16.37x11.31x1.50-in. (WxDxH) notebook
- **Weight:** 7.59 lbs. plus 1.37 lbs. for 200W power supply
- **CPU:** Intel Xeon E-2286M 2.4GHz (5.0 max turbo) 8-core w/ 16MB cache
- **Memory:** 32GB DDR4 2666MHz ECC (2x16GB) 128GB max
- **Graphics:** NVIDIA Quadro RTX 5000
- **Display:** 17.3-in. UHD (3840x2160) Dream Color
- **Webcam:** 1080p plus IR
- **Storage:** 512GB M.2 PCIe NVMe SSD
- **Floppy:** None
- **Optical:** Blu-ray/DVD-writer
- **Audio:** Bang & Olufsen with built-in 74dB speakers, three-microphone array, combo audio jack, noise cancellation
- **Network:** Intel Wi-Fi 6 AX200 802.11AC 2x2 and Bluetooth 4.2
- **Modem:** None
- **Other:** Three USB 3.0, two USB 3.1 Type-C (Thunderbolt/DisplayPort), one min-DisplayPort, HDMI, RJ-45, SD card reader, SmartCard reader, fingerprint reader, colorimeter, NFC
- **Keyboard:** 102-key backlit spill-resistant backlit keyboard
- **Pointing device:** Touch stick and touch pad each with 3 buttons
- **Standard warranty:** Three-year parts and labor

For more information on this topic, visit DigitalEngineering247.com.



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*Based on testing by AMD performance labs on June 17, 2020, using Creo Generative Design to test the AMD Ryzen Threadripper PRO 3995WX reference system vs. two (2) Intel Xeon Platinum 8280 processors. Results may vary. CPP-40

Lenovo ThinkPad P53: Power-Packed ThinkPad

Lenovo delivers the fastest 15-in. laptop we have ever tested.

BY DAVID COHN

Lenovo recently sent us its ThinkPad P53, the P51's successor and the latest addition to its P-Series mobile workstation lineup. Designed for professionals who need the highest performance in a mobile workstation, the ThinkPad P53 delivers lots of features in a 15.6-in. form factor.

Like the ThinkPad P72 we reviewed earlier this year (*DE*, August 2019; digitalengineering247.com/r/22956), the Lenovo ThinkPad P53 comes housed in a charcoal gray case with a glass-reinforced polymer top and a magnesium aluminum alloy bottom cover to dissipate heat.

The system measures 14.86x9.93x1.16-in. (WxDxH) and weighs 5.89 lbs. At 6.63x3.38x1.0-in., the 230-watt power supply is 35% smaller than the previous generation and adds just 1.95 lbs., including its cables. The dot over the "i" in the ThinkPad logo on the lid glows red when the system is powered up.

Raising that lid reveals a 15.6-in. display and 105-key backlit spill-resistant keyboard with separate numeric keypad. The consistently reliable Lenovo keyboard is once again one of the best available in any laptop, with nicely sculpted keys and a great feel. Lenovo offers a choice of four in-plane switching anti-glare displays.



The base configuration includes an HD 1920x1080 panel with a brightness rated at 300 nits. Our evaluation unit included a brighter 500-nit display with Dolby Vision HDR 400, which added \$25. Lenovo also offers ultra-high-definition (3840x2160) displays—a 500-nit version (\$200 extra) or a 300-nit panel with multi-touch (\$270).

A round power button is located on the upper-right corner of the numeric keypad, while a fingerprint reader is positioned to the lower left of the keyboard, just below the cursor keys. A 4x2.25-in. touchpad with three dedicated buttons is centered below the spacebar. There is also a red pointing stick nestled between the G, H and B keys with its own three buttons directly below the spacebar. A pair of stereo speakers are concealed beneath a perforated screen just above the keyboard. The caps lock and number lock keys each have their own lights, as do the function keys dedicated to the speakers and microphone as well as the ESC key, which doubles as FnLock. There are also hard drive activity and Wi-Fi lights in the hinge area below the center of the display.

Preconfigure, Then Add Options

Lenovo offers a number of preconfigured systems, including a \$1,489 base model equipped with a 2.5GHz Intel Core i5-9400H 4-core CPU, a 1920x1080 15.6-in. display, 8GB of RAM, a 256GB M.2 solid-state drive (SSD), an NVIDIA Quadro T1000 graphics processing unit (GPU) and a 720p web cam. That's the starting point.

The company offers a choice of four different Intel Core processors as well as a Xeon CPU. The ThinkPad P53 can accommodate up to 128GB of memory and up to 6TB of storage. All models include a discrete NVIDIA graphics card in addition to integrated Intel graphics, and customers have a choice of five different NVIDIA Quadro GPUs—the Quadro T1000 in the base unit, the slightly

Fig. 1: The Lenovo ThinkPad P53 is a powerful 15.6-in. system with a top-of-the-line Xeon CPU and NVIDIA Quadro RTX GPU. Image courtesy of David Cohn.

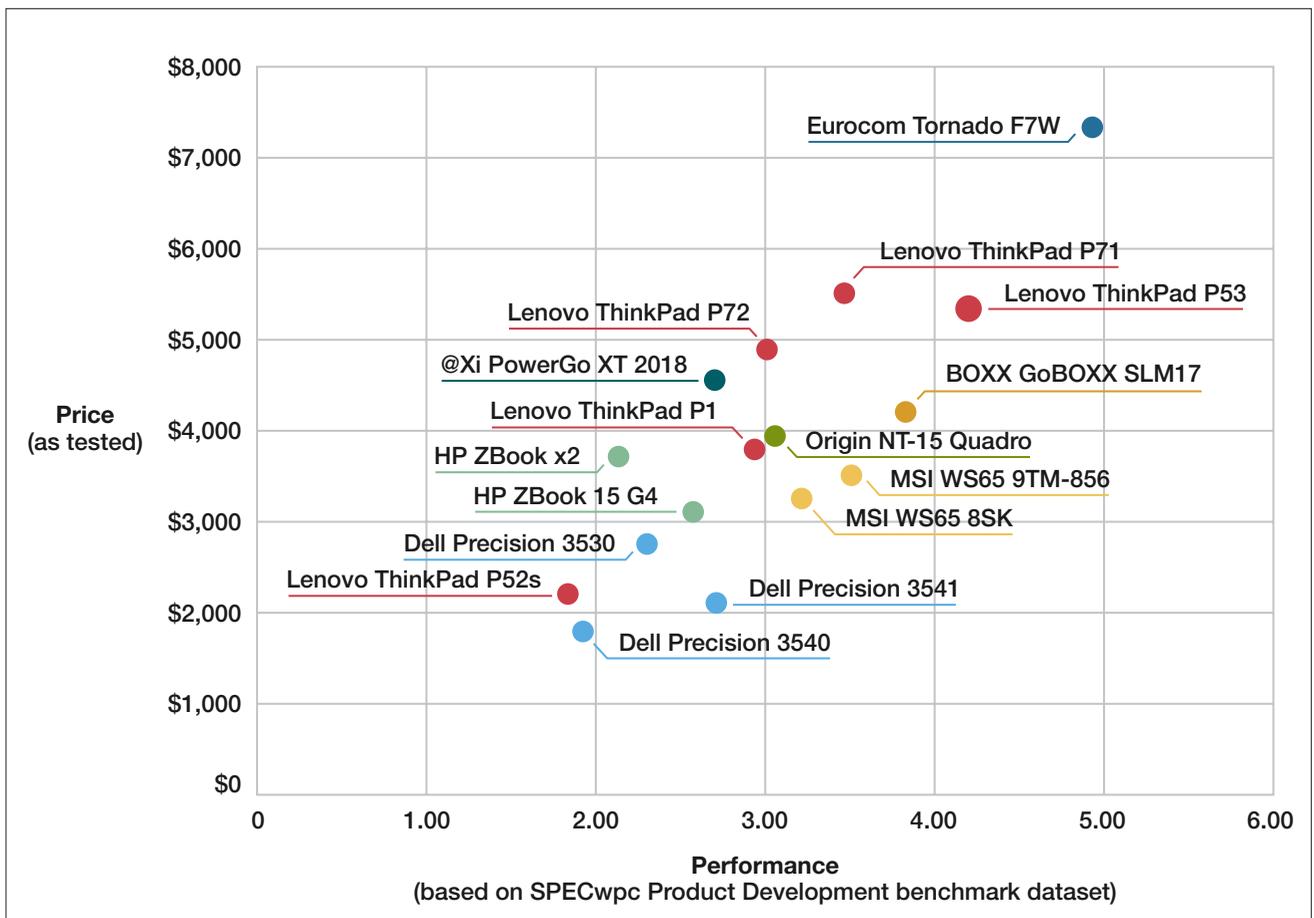


Fig. 2: Price/Performance chart for recently reviewed workstations.

more powerful T2000 or three VR-ready Quadro RTX GPUs: the RTX 3000, 4000 or 5000.

Configuration choices depend on whether you choose an Intel Core or Xeon processor. The system we received was based on a 9th-generation Coffee Lake 2.8GHz Intel Xeon E3-2276H six-core processor with up to 4.7GHz turbo boost, a 12MB cache and a thermal design power (TDP) rating of 45 watts.

That system, which includes an NVIDIA Quadro RTX 5000 graphics card, costs \$4,289 after online discounts, but our system included several enhancements. For example, our evaluation unit came with 64GB of memory, installed as a pair of 32GB DDR4 2666MHz error-code correcting memory modules, which added \$690 and left two memory sockets available for future expansion.

The NVIDIA Quadro RTX 5000 graphics card in our evaluation unit provides 3,072 compute unified device architecture processing cores, 48 RT cores, 384 Tensor cores and includes 16GB of GDDR6 memory, while consuming 80-110 watts. Its 256-bit memory interface provides a 448 GB/second memory bandwidth.

All ThinkPad P53 systems include two M.2 drive sockets, while some systems based on Intel Core processors also can accommodate a third 2.5-in. data drive. Our evaluation unit came with a 1TB Samsung M.2 PCI3-NVMe Opal2 drive, which added \$205. A similar 2TB SSD costs \$465. A second 1TB M.2 drive would have added an additional \$325 and you

can have the second drive configured as a RAID array. Our system also included an infrared and 720p camera (\$20).

Unsurprisingly, the P53 offers lots of connectivity. The left side provides an HDMI port, a pair of USB 3.1 ports (including one always-on port to charge a USB device whenever the computer is connected to AC power) and a four-in-one media card reader. The right side includes a security lock slot, a SIM tray, a USB Type-C port and a combination microphone/headphone audio jack. The rear panel provides an RJ45 Ethernet jack, two USB Type-C Thunderbolt ports, and the connector to the external power supply.

Dual-band Wi-Fi and Bluetooth come standard and the system is powered by a six-cell 90 watt-hour battery that kept our ThinkPad P53 running for 5 hours and 30 minutes, about the same as the P72 we tested earlier this year. The Lenovo mobile workstation remained cool and quiet throughout our tests.

Great Performance

Lenovo workstations have a history of delivering great performance and the ThinkPad P53 continued to live up to expectations.

On the SPECviewperf benchmark, which focuses on graphics, the P53 scored near the top on all datasets, turning in the best results we have ever recorded on several of those tests. The 15.6-in. Lenovo also did very well on the SPECapc SolidWorks benchmark. In fact, the only systems that outper-

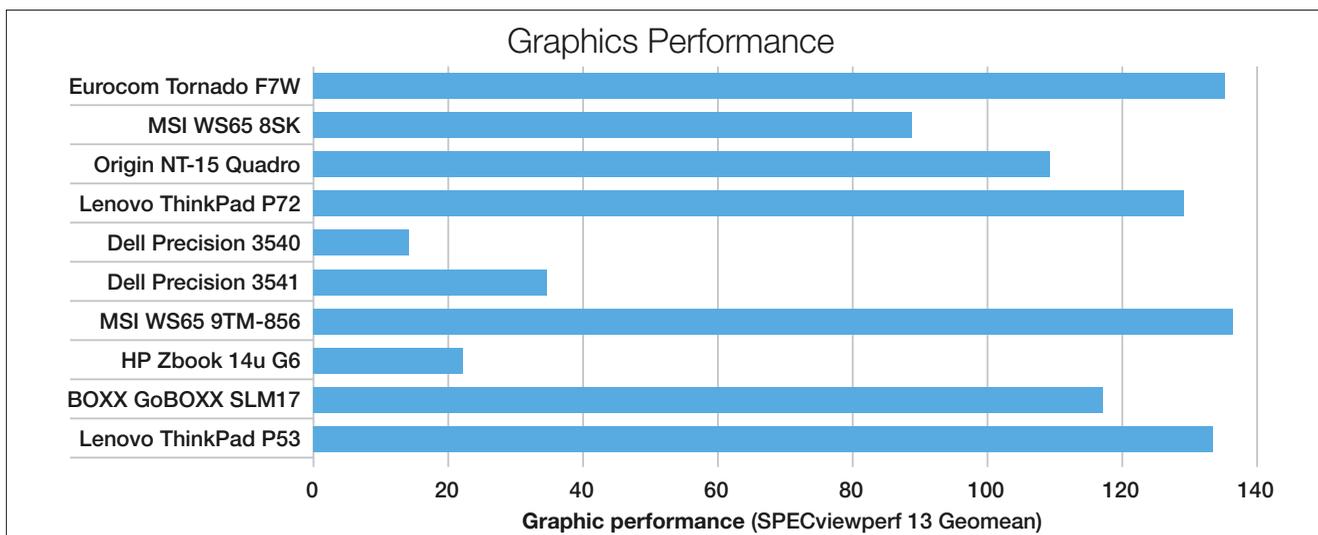


Fig. 3: Graphics performance chart based on SPECviewperf 13 Geomean.

formed the P53 were 17-in. systems with over-clocked CPUs.

On the very demanding SPECwpc workstation benchmark, the Lenovo ThinkPad P53 also delivered excellent results, again garnering top marks in several categories. Its graphics subsystem score was the best for any mobile workstation and its storage score was much better than the ThinkPad P72, thanks to Lenovo’s switch back to a Samsung M.2 drive.

Although its 49.2-second average to complete our Auto-CAD rendering test was a few seconds slower than some of the other mobile systems we have tested recently, those systems were equipped with faster CPUs with more CPU cores, giving them a decided edge on this multi-threaded test.

Although base configurations with Intel Core processors come with Windows 10 Home, Lenovo also offers Windows 10 Professional for just \$35 more. Since the system we received included a Xeon CPU, our evaluation unit included Windows 10 Pro for Workstations.

Lenovo’s standard warranty now covers its systems for just one year, with depot or carry-in service. Additional coverage is available at the time of purchase that can extend the warranty for up to five years, including accidental damage protection, on-site service and premier support. Since most other workstation-class machines come with a three-year warranty, we boosted the standard warranty to three years for pricing purposes, which added \$109.

The ThinkPad P53 is certified for applications from vendors including ANSYS, Autodesk, Dassault Systèmes, PTC and Siemens. You can purchase a preconfigured system or build a custom configuration on the Lenovo website, where our P53 priced out at \$5,338 after an automatic online discount, making it one of the more expensive systems we have tested recently.

But its performance elevates it to rarified air—we’ve tested only one other mobile workstation that outperformed the P53 and it cost several thousand dollars more.

The P53 configuration we tested certainly isn’t for everyone. Less expensive components could significantly reduce the price without dramatically reducing perfor-

mance. But if you require a top-of-the-line mobile CPU and GPU, the Lenovo ThinkPad P53 certainly delivers. **DE**

David Cohn is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA, and has been benchmarking PCs since 1984. He’s a contributing editor to Digital Engineering and the author of more than a dozen books. You can contact him via email at david@dscobn.com or visit his website at www.dscobn.com.

→ MORE INFO

Lenovo: Lenovo.com
Lenovo ThinkPad P53

- **Price:** \$5,338 as tested (\$1,489 base price)
- **Size:** 14.86x9.93x1.16-in. (WxHxD) notebook
- **Weight:** 5.89 lbs. (plus 1.95-lb. external power supply)
- **CPU:** Intel Xeon E3-2276M 2.80GHz 6-core w/12MB cache
- **Memory:** 64GB ECC DDR4 at 2666MHz
- **Graphics:** NVIDIA Quadro RTX 5000 w/16GB GDDR6 memory
- **LCD:** 17.3-in. HD (1920x1080) IPS
- **Hard Disk:** 1TB SSD M.2 2280 PCIe NVMe Opal2
- **Floppy:** None
- **Optical:** None
- **Audio:** Built-in speakers, headphone/microphone jack, built-in microphone array
- **Network:** Integrated Intel AX200 11ax 2x2 plus Bluetooth 5.0, one RJ45 gigabit Ethernet port
- **Modem:** None
- **Other:** Two USB-A 3.1, one USB-C, two USB-C Thunderbolt 3, HDMI, 4-in-1 media card reader, SIM tray, IR camera and 720 web cam
- **Keyboard:** Integrated 105-key full-size backlit keyboard with numeric keypad
- **Pointing Device:** integrated touchpad with three buttons, pointing stick with three buttons, fingerprint reader

For more information on this topic, visit DigitalEngineering247.com.



Shutdown's Impact on Workstation Purchase, Electronics Manufacturing



BY KENNETH WONG

In June, The Verge reported, “The pandemic has made it harder to buy a new laptop.” The authors attributed the shortage to two converging factors: higher demand and lower supply.

Speaking on how the pandemic has affected the GPU shipment in 2020 Q1, analyst Jon Peddie from JPR also recounted, “For a brief period, in the U.S., UK, and parts of western Europe, retail shops were completely depleted of laptops ... The people were buying and depleting the PC retailers’ inventory, but the new parts for inventory refill weren’t readily available from the supply side, but the semiconductors had already shipped their chips out, so they were already on their way.”

Could engineers and designers working from home possibly face a mobile workstation shortage? To find out, we spoke to Rob Herman, General Manager, Executive Director of Workstation & Client AI Group, Lenovo; and Misha Govshsteyn, CEO of MacroFab, a distributed electronics manufacturing service provider.

[LISTEN TO THE FULL PODCAST HERE.](#)

High-Performance Radeon Pro

We compare the AMD Radeon Pro WX 8200 and W5700 GPUs.

BY DAVID COHN

It has been quite a while since we last looked at new graphics board from AMD (*DE*, April 2017; [AMD Radeon Pro Review](#)). Back then, the Radeon Pro WX series, based on the company's new Polaris graphics processing unit (GPU), and we wrote about the Radeon Pro WX 4100, WX 5100 and WX 7100. However, since we only received a Radeon Pro WX 5100, that was the only one we were able to test.

AMD has long been known as a competitor to Intel in the CPU market, but the California-based company moved into graphics in a big way in 2006 when it acquired Canadian graphics card manufacturer ATI and took over the development of the ATI FirePro graphics boards. AMD continued to use the FirePro name on its professional workstation-class cards until 2016, when it introduced the Radeon Pro WX series.

We recently received two new AMD boards, the Radeon Pro WX 8200 and the Radeon Pro W5700. The WX 8200, first introduced at the SIGGRAPH 2018 conference, represented the second high-end addition to the WX workstation graphics lineup, coming one year after the WX 9100's release.

The WX 8200 also became the first professional GPU based on AMD's long-awaited "Vega" GPU architecture and 14nm FinFET process that reduces active power consumption and provides more transistors to allow for more compute units and cache. The WX 8200 delivered real-time visualization, virtual reality and photorealistic rendering capabilities for under \$1,000.

The Radeon Pro W5700, first announced at Autodesk University 2019, became the world's first 7nm professional PC workstation graphics card; the first to feature the company's latest high-performance, energy-efficient AMD RDNA architecture; and the first to support high-bandwidth PCIe 4.0 technology.

According to AMD, the RDNA architecture features a



Fig. 1: AMD Radeon Pro WX 8200 (left) and W5700. Image courtesy of David Cohn.

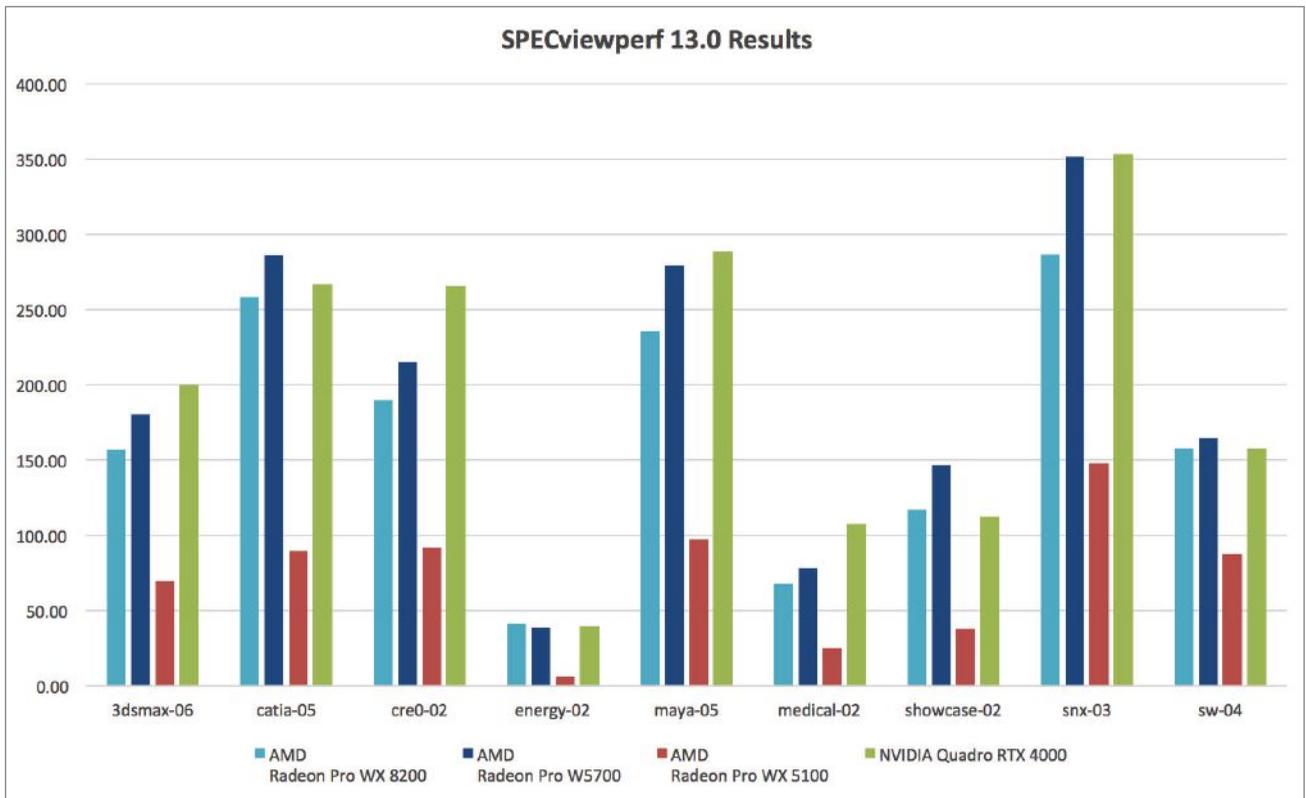


Fig. 2: SPECviewperf 13.0 performance results.

redesigned geometry engine and compute units, delivering up to 25% higher performance per clock and up to 41% higher average performance per watt than the previous generation Graphics Core Next (GCN) architecture.

Comparing the Boards

The AMD Radeon Pro WX 8200 is actually quite similar to the WX 9100, with 12,500 million transistors and a base clock speed of 1200MHz. Both boards use HBM2 memory with error-correcting code support.

But while the WX 9100 came with 16GB of memory and a launch price of \$1,599, the WX 8200 includes 8GB of memory and a suggested retail price of \$999. Like the WX 9100, the Radeon Pro WX 8200's thickness consumes two expansion slots and the board's 230-watt thermal design power (TDP) requires a six- and eight-pin external power connector. You must have a workstation with a large power supply to support the WX 8200.

The WX 8200 has a 2048-bit memory interface and a memory bandwidth of 512GB/s. The board provides four mini-DisplayPorts and can support up to four simultaneous monitors at up to 3840x2160 resolution, three at 5120x2880 and one at 7680x4320, all at a 60Hz refresh rate. The board incorporates 3584 shading units, 224 texture mapping units, 64 render output units (ROPS)

and 56 compute units to deliver 10.75 TFLOPs of peak single precision (FP32) and 672 GFLOPs of double-precision (FP64) floating point performance. The WX 8200 also incorporates a high-bandwidth cache controller (HBCC) that lets you work beyond the 8GB of physical memory on the graphics processing unit (GPU) by allocating a portion of the workstation's system memory, similar to the way data pages to the hard drive when system memory becomes full.

The even newer AMD Radeon Pro W5700 also offers 8GB of onboard memory, but uses less expensive GDDR memory and lacks the HBCC controller. This board, however, is based on an even newer AMD architecture.

The W5700 delivers incredibly fast performance with 10,300 million transistors and a base clock speed of 1243MHz. The board features a 256-bit memory interface and a memory bandwidth of 448GB/second. With 2,304 shading units, 144 texture mapping units, 64 ROPS, and

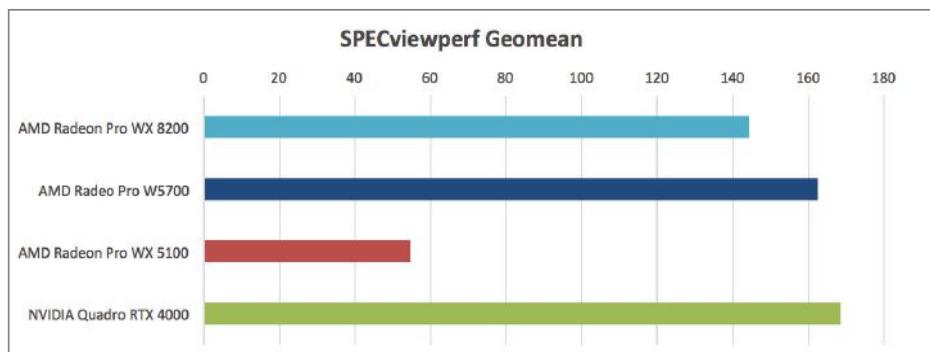


Fig. 3: SPECviewperf Geomean.

AMD 2020 Radeon Pro WX 8200 and W5700 Graphics Board Data				
	AMD Radeon Pro WX 8200	AMD Radeon Pro W5700	AMD Radeon Pro WX 5100	NVIDIA Quadro RTX 4000
Price at launch	\$999	\$799	\$499	\$899
Average street price	\$970	\$799	\$399	\$899
Specifications				
Architecture	Vega	RDNA	Polaris	Turing
Lithography	14nm	7nm	14nm	12nm
Number of transistors	12,500 million	10,300 million	5,700 million	13,600 million
Clock Speeds				
Base clock	1200 MHz	1243 MHz	713 MHz	1005 MHz
Boost clock	1500 MHz	1930 MHz	1086 MHz	1545 MHz
Memory clock	1000 MHz (2000 MHz effective)	1750 MHz (14000 MHz effective)	1250 MHz (5000 MHz effective)	1625 MHz (13000 MHz effective)
Memory				
GPU memory	8 GB (HBM2)	8GB (GDDR6)	8GB (GDDR5)	8GB (GDDR6)
Memory interface	2048-bit	256-bit	256-bit	256-bit
Memory bandwidth	512 GB/s	448 GB/s	160 GB/s	Up to 243 GB/s
ECC support	Yes	No	No	No
Processors				
Shading units	3584	2304	1792	2304
Texture mapping units	224	144	112	144
ROPs	64	64	32	64
Compute units	56	36	28	n/a
NVIDIA tensor cores	n/a	n/a	n/a	288
NVIDIA RT cores	n/a	n/a	n/a	36
Theoretical Performance				
Pixel rate	96 GPixels/s	123.5 GPixels/s	34.75 GPixels/s	98.88 GPixels/s
Texture rate	336 GTexels/s	277.9 GTexels/s	121.6 GTexels/s	222.5 GTexels/s
FP16 (half) performance	21.50 TFLOPS	17.79 TFLOPS	3.892 TFLOPS	14.24 TFLOPS
Single-precision performance (FP32) float	10.75 TFLOPS	8.893 TFLOPS	3.892 TFLOPS	7.1199 TFLOPS
Double-precision performance (FP64)	672 GFLOPS	555.8 GFLOPS	243.3 GFLOPS	222.5 GFLOPS
Board Design				
System interface	PCIe 3.0 x16	PCIe 4.0 x16	PCIe 3.0 x16	PCIe 3.0 x16
Power consumption (total board power)	230-watt	205-watt	75-watts	160-watts
Extra power required	Yes (14-pins)	Yes (14-pins)	No	Yes (8-pins)
Form factor (HxW)	4.4" x 10.5"	4.4" x 10.5"	4.4" x 6.8"	4.4" x 9.5"
Slots used	2	2	1	1
Maximum simultaneous displays	4 x 3840x2160 @ 60Hz 4 x 1920x1080 @ 60Hz 3 x 5120x2880 @ 60Hz 1 x 7680x4320 @ 60Hz	6 x 3840x2160 @ 60Hz 6 x 1920x1080 @ 60Hz 3 x 5120x2880 @ 60Hz 3 x 7680x4320 @ 60Hz	4 x 3840x2160 @ 60Hz 4 x 1920x1080 @ 60Hz 2 x 5120x2880 @ 60Hz 1 x 7680x4320 @ 60Hz	4 x 4096x2160 @ 120Hz 4 x 5120x2880 @ 60Hz 2 x 7680x4320 @ 60Hz
VR ready	Yes	Yes	No	Yes
Number of DisplayPort connectors	4 x Mini-DisplayPort 1.4	5 x Mini-DisplayPort 1.4	4 x DisplayPort	3 x DisplayPort
VirtualLink (USB-C) connector	No	Yes	No	Yes
Stereo 3D support with stereo connector	Yes		Yes	Yes
Graphics APIs	DirectX 12.0 Shader Model 6.4 OpenGL 4.6 Vulkan 1.0	DirectX 12.0 Shader Model 6.5 OpenGL 4.6 Vulkan 1.1	X DirectX 12.0 Shader Model 6.4 OpenGL 4.6 Vulkan 1.1	DirectX 12.0 Shader Model 6.5 OpenGL 4.6 Vulkan 1.0
Compute APIs	OpenCL 2.0	OpenCL 2.0	OpenCL 2.0	Open CL 1.2 CUDA 7.5 DirectCompute

36 compute units, the W5700 delivers 8.8993 TFLOPs of single-precision (FP32) performance and 555.8 GFLOPs of double-precision (FP64) floating point performance.

Although it has a slightly more modest 205-watt TDP demand, like the WX 8200, the W5700 requires a six- and eight-pin external power connector and its thickness consumes two expansion slots. But the W5700 provides five Mini DisplayPorts plus a high-speed USB-C connector that can support an additional monitor or virtual reality head-

set, enabling it to support up to six simultaneous displays at up to 3840x2160 resolution or up to three displays at up to 7680x4320 resolution, all at a refresh rate of 60Hz.

With a street price of \$799, the AMD Radeon Pro W5700 is a bit more affordable than the WX 8200.

Relative Performance

To see how well these new GPUs performed, we installed each in turn in the same workstation equipped with 16GB

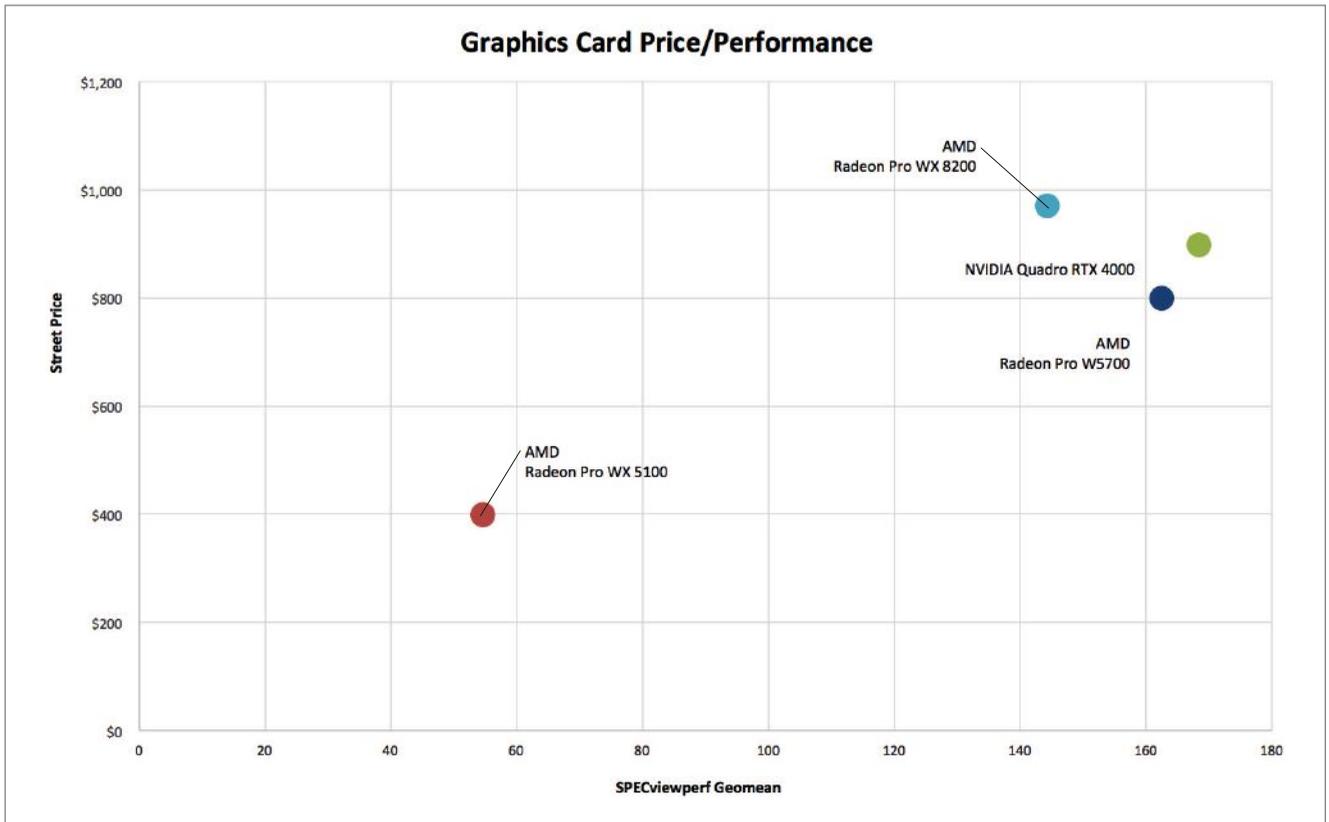


Fig. 4: Price/performance of the new AMD Radeon Pro WX 8200 and W5700 compared with the AMD Radeon Pro WX 5100 and NVIDIA Quadro RTX 4000 graphics boards (based on estimated street price).

of memory, running the latest build of Windows 10 Pro, and using the latest version of the unified AMD driver. We ran version 13 of the SPECviewperf benchmarks.

For comparison purposes, we also retested the AMD Radeon Pro WX 5100 as well as the NVIDIA Quadro RTX 4000 in this same workstation, again using the latest driver software, so that the only variable was the GPU.

As expected, the performance improvement of the WX 8200 and W5700 over the WX 5100 was quite dramatic. For double the cost of the WX 5100, the W5700 proved to be three times faster. But on average, the new W5700 was slightly faster than the more expensive WX 8200, thanks in part to its higher base clock and much higher boost clock, yielding a much higher effective memory clock than the WX 8200.

However, in our tests, the slightly more expensive NVIDIA Quadro RTX 4000 outperformed the AMD Radeon Pro WX 8200 and Radeon Pro W5700.

Like previous AMD boards, the WX 8200 and W5700 are fully certified with most CAD and DCC applications. The new AMD boards use the latest Radeon Pro Software Enterprise Driver, which is available for 64-bit Windows 10, Windows 7 and Linux x86, and are covered by a three-year warranty.

Choosing between these boards comes down to intended use. The high-bandwidth cache controller in the WX 8200 gives it an edge for those doing serious multi-tasking or GPU computing. Both AMD boards deliver more raw computing power than the NVIDIA Quadro RTX 4000 in theoretical performance, although the RTX 4000 turned in better results

on our graphics performance benchmarks—but just barely, and for \$100 more than the W5700.

The AMD W5700 has the edge in terms of future-proofing—since it is PCIe 4.0 ready, it offers 1,969MB/second per lane when matched with a motherboard and processor offering PCIe 4.0 (currently only available in AMD’s latest-generation CPUs). As AMD continues to go head to head with NVIDIA, it’s the customers who reap the rewards in improved performance and competitive prices. **DE**

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David Cohn is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA and has been benchmarking PCs since 1984. He’s a Contributing Editor to Digital Engineering and the author of more than a dozen books. You can contact him via email at david@dscohn.com or visit his website at www.dscohn.com.

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➔ **MORE INFO**

- **AMD:** AMD.com
- **AMD Radeon Pro WX 8200**
Price: \$999 (suggested retail), \$970 (average street)
- **AMD Radeon Pro W5700**
Price: \$799 (suggested retail), \$799 (average street)

For more information on this topic, visit DigitalEngineering247.com.

Dell Precision 7540: Mobile Workstation Put Through Paces

This new 15-in. mobile workstation is a price and performance leader.

BY DAVID COHN

We were quite impressed with the pair of Dell entry-level mobile workstations we reviewed earlier this year (see *DE*, September 2019; digitalengineering247.com/r/23068). When the company sent us one of its premium 7000-series systems, we were happy to put it through its paces.

The new Dell Precision 7540 is a 15-in. mobile workstation featuring a 9th-generation Intel processor. Depending on the configuration, the 7540 can house three hard drives and up to 128GB of memory. With a starting price of just \$1,269, the base configuration includes a 2.5GHz Intel Core i5-9400H four-core CPU, integrated Intel ultra-high definition (UHD) graphics, 8GB of RAM, a 2.5-in. 500GB 7200rpm SATA hard drive and a 1920x1080 display, but that's just the starting point.



Unlike the thin, dark gray case of the 3000-series systems we recently reviewed, the Dell Precision 7540 comes housed in a silver-colored case measuring 14.86x9.89x1.12-in. (WxDxH), noticeably thicker than the 3540 and 3541 we tested in September. At 6.2 lbs., plus an additional 1.36 lbs. for the larger (6.0x2.94x0.88-in.) 180-watt power supply, the Precision 7540 also outweighs those systems by several pounds.

Well-Designed

Lifting the lid reveals a 15.6-in. display with a webcam centered in the top edge of the bezel, flanked by a pair of microphones and a camera status light. The webcam and microphone are optional—their inclusion depends on the specific display configuration—but even the base model comes with a camera and microphone. Our evaluation unit also included an infrared camera and a privacy shutter.

The larger size of the Precision 7540 compared with the 3000-series means that there is much room for expansion. The right side provides a headphone jack, two USB 3.1 Gen 1 ports (one power-enabled) and a security lock slot. The left side hosts two Thunderbolt 3 USB Type-C ports, an SD card reader and an optional SmartCard reader.

There are also ports on the rear of the 7540, including an RJ-45 network jack, a mini DisplayPort, an HDMI port and a round power adapter port. The bottom only includes a fan vent and a pair of speakers for the built-in MaxAudio Pro by Waves sound system. A Qualcomm dual-band wireless adapter with Bluetooth 4.2 comes standard on the base configuration, but the system we received substituted a more powerful Intel Wi-Fi 6 AX2000 dual-band adapter with Bluetooth 5.0.

The new Dell Precision 7540 15.6-in. mobile workstation is a great choice for serious design, engineering and virtual reality on the go. Image courtesy of David Cohn.

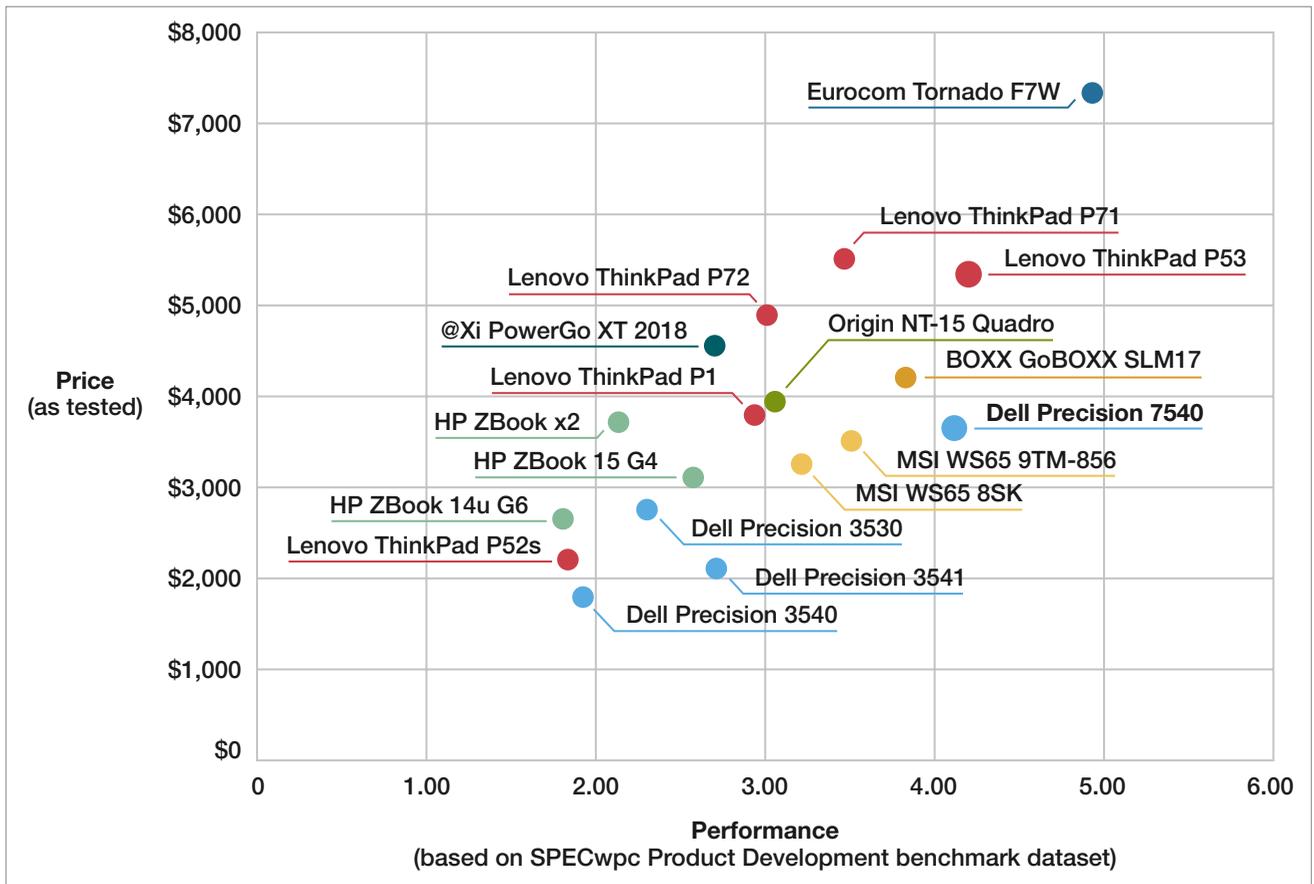


Fig. 2: Graphic performance of recent mobile workstations, based on the SPECviewperf 13 geomean results.

Lots of Options

The extra thickness of the 7000-series means that you can pack more components inside the chassis. CPU options range from the 2.5GHz quad-core processor in the base unit to the 2.4GHz Intel Core i9-9980H 8-core Coffee Lake CPU included in our evaluation unit. This processor contains a 16MB cache, a 5GHz maximum turbo speed and integrated Intel UHD graphics 630.

Dell also offers the 7540 with a choice of a six-core 2.8GHz Intel Xeon E 2276M processor or an eight-core 2.4GHz Xeon E 2286M CPU (which increase the price by \$290 or \$514, respectively).

Dell has a choice of discrete graphics cards, including an AMD Radeon Pro WX 3200 with 4GB of GDDR5 memory (a \$56 option), or a choice of five different NVIDIA Quadro GPUs, ranging from the T1000 (\$215) to one of three RTX GPUs including the high-end RTX 5000 (\$2,346).

Our evaluation Precision 7540 came with an NVIDIA Quadro RTX 3000 graphics board with 6GB of GDDR6 memory. This virtual reality (VR)-ready GPU provides 1920 compute unified device architecture (CUDA) cores, 30 RT cores and 240 Tensor cores, backed by a 192-bit interface, enabling it to deliver a bandwidth of 336GB/second while consuming a maximum 80 watts.

Dell also offers a choice of nine different display configurations, ranging from a 1920x1080 in-plane switching (IPS) anti-glare panel with a carbon fiber cover supporting 42%

of the Adobe color gamut to the 3840x2160 IPS anti-glare premium panel with aluminum cover and 100% Adobe color gamut included in our evaluation unit, a \$340 option that also included an infrared camera.

The Precision 7540 can support up to 128GB of RAM, and 666MHz and 3200MHz memory modules are available. Our evaluation unit came with 32GB of 2666MHz memory, installed using four 8GB modules (\$419). Systems based on Xeon processors can also be equipped with 2666MHz error-correcting code (ECC) memory.

Storage options are also abundant, and the 7540 can support up to three M.2 PCIe solid-state drives (SSDs) or two M.2 drives and one 2.5-in. SATA drive. Solid-state options range from 256GB to 2TB, whereas Dell offers 2.5-in. drives ranging from 500GB to 2TB, so you could configure a system with 6GB of onboard storage. The mobile workstation we received came with a 512GB M.2 NVMe PCIe Class 50 Hynix drive, which added \$419. Systems equipped with two M.2 drives can also be configured as a redundant array of independent disks.

Although a four-cell 64 watt-hour (Whr) battery comes standard, the inclusion of the UHD display panel and RTX graphics in our evaluation unit meant that we also received a six-cell 97Whr Lithium-ion battery with ExpressCharge. That battery kept our Precision 7540 running for 7 hours and 51 minutes. A long-lifecycle Lithium Polymer version of this battery with a three-year warranty is also available.

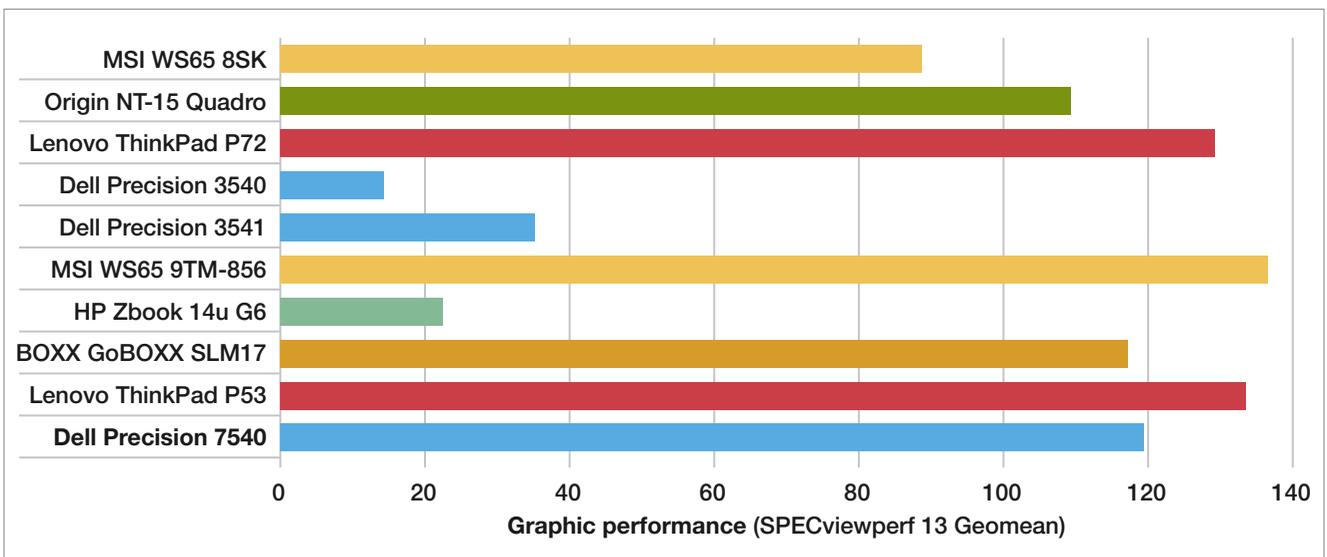


Fig. 3: Price/performance chart of recent mobile workstations, based on the SPECwpc Product Development benchmark.

Great Performance

The Dell Precision 7540 mobile workstation remained cool and nearly silent throughout our testing, with fan noise barely audible even under heavy compute loads. As expected, on the SPECviewperf test, which evaluates pure graphics performance, the Precision 7540 scored at—or near—the top on every dataset, losing only to systems equipped with the even more powerful NVIDIA Quadro RTX 5000 GPU. Scores for the SPECapc SolidWorks benchmark were equally impressive.

This Dell system also delivered excellent results on the very demanding SPEC workstation performance benchmarks. Although its CPU and graphics scores placed it near the top among systems we have tested recently, its storage subsystem score was the lowest we have recorded since we began using the latest version of this benchmark. The Dell Precision 7540 also completed our AutoCAD rendering test in less than 35 seconds, the best result we have recently recorded for any mobile workstation.

Windows 10 Pro came preloaded. Systems based on a Xeon CPU include Windows 10 Pro for Workstations, which adds \$154 to the price. Ubuntu Linux and Windows 10 Home are also available.

All Dell Precision workstations come with a three-year warranty with on-site service after remote diagnosis. As configured, the Dell Precision 7540 priced out at \$3,646, making it a price/performance leader. Though it is a bit larger and heavier than some mobile workstations, it delivered the best performance of any system we have tested under \$4,000. Simply put, the Dell Precision 7540 is a great choice for serious design, engineering and VR on the go. **DE**

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David Cohn is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA, and has been benchmarking PCs since 1984. He's a contributing

editor to *Digital Engineering* and the author of more than a dozen books. You can contact him via email at david@dscobn.com or visit his website at DSCobn.com.

→ MORE INFO

Dell: Dell.com

Dell Precision 7540

- **Price:** \$3,646 as tested (\$1,269 base price)
- **Size:** 14.86x9.89x0.112-in. (WxDxH) notebook
- **Weight:** 6.2 lbs. plus 1.36-lb. power supply
- **CPU:** 2.4GHz Intel Core i9-9980H eight-core w/16MB Smart Cache
- **Memory:** 32GB (4x8GB DDR4-2666MHz non-error-correcting code SDRAM)
- **Graphics:** NVIDIA Quadro RTX 3000 w/6GB GDDR6 memory
- **LCD:** 15.6-in. UHD 3840x2160 anti-glare IPS non-touch
- **Storage:** 512GB M.2 PCIe NVMe Class 50 SSD
- **Audio:** MaxAudio Pro by Waves with built-in speakers, built-in microphone array
- **Network:** Intel Wi-Fi 6 AX2000 2x2 .11ax 1600MHz plus Bluetooth 5.0
- **Other:** Three USB 3.1 Gen 1 (one with PowerShare), two USB Type-C/Thunderbolt 3, HDMI, mini DisplayPort, headphone jack, microSD card reader, SmartCard reader, RJ-45 LAN port, integrated 720p IR webcam, fingerprint reader
- **Keyboard:** Integrated 103-key full-size backlit keyboard with numeric keypad
- **Pointing device:** Gesture-enabled multi-touch touchpad with three buttons and pointing stick with three buttons

For more information on this topic, visit DigitalEngineering247.com.

Performance Without Breaking the Bank: **Velocity Micro ProMagix HD60 ATX AMD Review**

This system integrator delivers a price/performance winner.

BY DAVID COHN

We recently received a new tower workstation from Velocity Micro, the third system the Richmond, VA-based system integrator has sent us in the past year-and-a-half. Although similar in appearance and name to the computer we reviewed earlier this year (DE, August 2019), the ProMagix HD60 ATX AMD is based on an AMD Ryzen CPU, as was the first system the company sent us last year (DE, July 2018). This marks only the second AMD Ryzen-based system we have looked at since that CPU was first release in March of 2017, and the first to use the new 7nm Ryzen 9 processor.

In other words, if you purchased the parts and built it yourself, you could save around \$1,200 (compared to the as-tested price, minus the 3-year warranty). Of course, that assumes you have the requisite skill, confidence, and time to do it yourself. Buying a system assembled by trained technicians and backed by a warranty from a reputable company is likely worth the 28% markup when it comes with the peace of mind of knowing that the system is guaranteed to work when it arrives.

The Velocity Micro ProMagix HD60 ATX AMD workstation comes housed in a large charcoal gray tower case measuring 7.25-in. x 21.0-in. x 20.0-in. (WxDxH) and weighing 26.75 lbs. The monolithic front features an optical drive bay near the top and a Velocity Micro logo cutout near the bottom. The power button, a pair of USB 3.1 ports, plus

microphone and head-phone jacks are located on the top of the case, set several inches back from the front edge. A pair of cooling fans are also visible below vents on the top of the case and both the fans and front panel logo glow blue when the system is powered up. Like the other ProMagix HD60

we reviewed in August, the system ran quiet, averaging less than 50dB at rest and climbing to just 64dB under heavy compute loads.

The rear of the case provides a total of 12 USB ports—four USB 3.2 Gen 1 ports, seven USB 3.2 Gen 2 Type-A ports, and one USB 3.2 Gen 2 Type-C port—as well as a pair of RJ-45 ports for the integrated Intel gigabit LAN, antenna connectors for the build-in Wi-Fi, an S/PDIF port, and five audio jacks (microphone, line-out/front speaker, line-in/side speaker, rear speaker, and center/sub-woofer). There are also CMOS Clear and USB BIOS Flashback buttons. The thin left side panel, with a large window etched with the Velocity Micro name and logo, is held in place with ten snap connectors. Once removed, you have complete access to the very well-organized interior with five internal drive bays, one of which was filled.

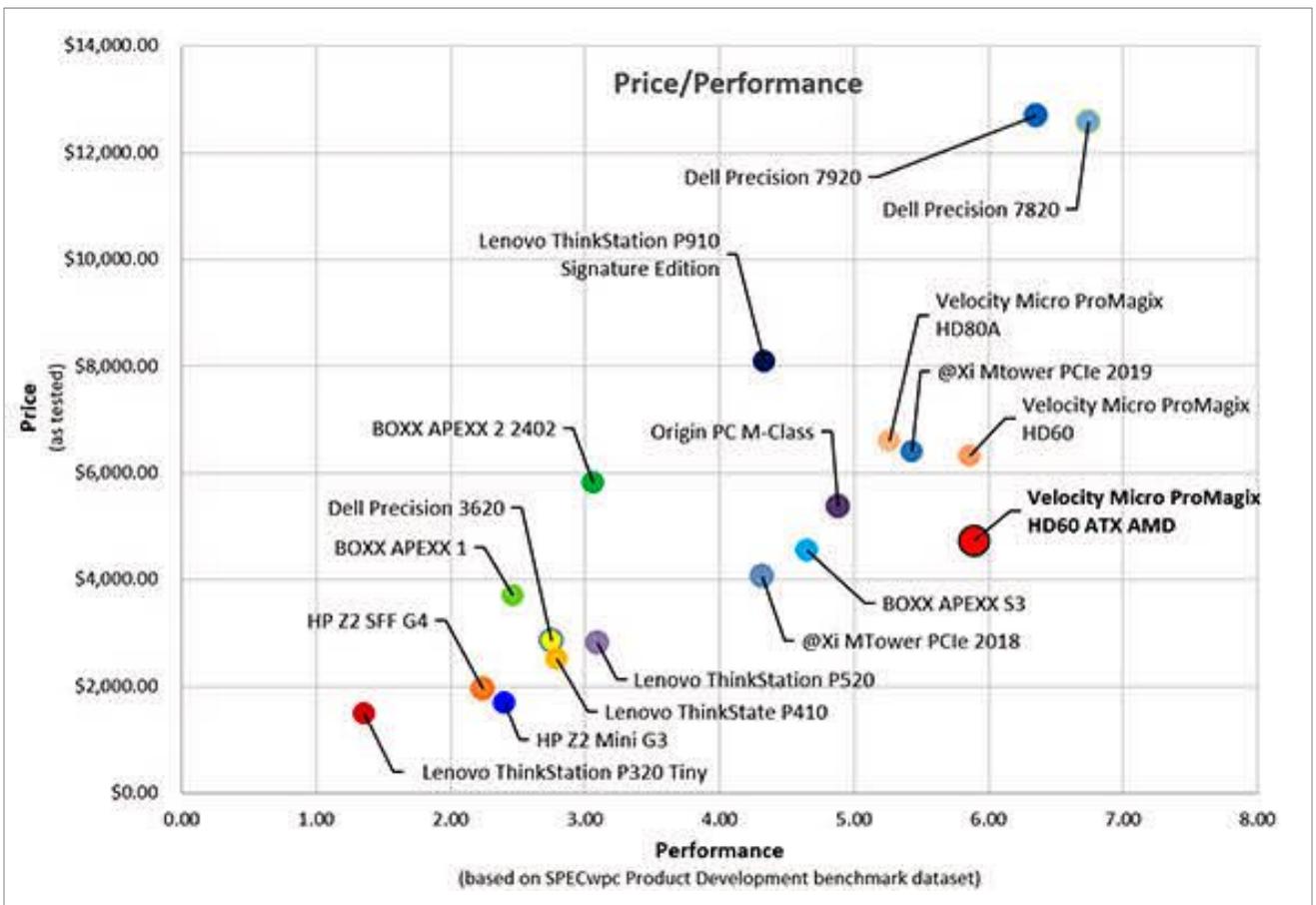
Lots of Options

Velocity Micro now sells four different versions of the ProMagix HD60—mid-towers or full-towers with either AMD or Intel CPUs. Based on that new nomenclature, the full designation of this system is the ProMagix HD60 ATX AMD, which has a starting price of \$1,599. That selection gets you an extended-depth ATX aluminum chassis manufactured by Lian Li, with a power supply mounted at the bottom rear.

The base configuration includes a 750-watt power supply, an Asus X570 motherboard, an AMD Ryzen 5 3600X 6-core 3.8GHz CPU, 8GB of 2666MHz memory, an NVIDIA Quadro P400 GPU, a 250GB M.2 SSD, and a 24X DVD+/-



The Velocity Micro ProMagix HD60 is an extremely powerful workstation housed in a simple, mid-tower case. The well-organized interior provides ample room for expansion. Images courtesy of David Cohn.



RW dual-layer optical drive, plus a copy of Windows 10 Home, all backed by a 1-year warranty. But as we have come to expect from Velocity Micro, that is just the starting point. There are lots of configuration options available on the Velocity Micro website.

For example, the company offers a choice of six different power supplies, ranging from 650 to 1600-watts. The system we received came with an 850-watt EVGA SuperNOVA 80Plus Gold certified power supply, which added \$100. You also can choose from among five different motherboards. Our evaluation unit was built around the top-of-the-line offering, an Asus Crosshair Hero VIII motherboard, a \$285 option, that provides four DIMM sockets, supporting a maximum of 128GB of non-ECC unbuffered memory. Our system came with 32GB, installed using two 16GB Crucial Ballistix DDR4-3200MHz memory modules, which added \$155 to the price. That motherboard also provides three PCIe 3.0 x16 slots and a single PCIe x1 slot. An Intel wireless AX2000 adapter, which supports 802.11 a/b/g/n/ac/ax plus Bluetooth 5.0, is also integrated into the motherboard.

The motherboard also supports a wide range of AMD Ryzen processors, and Velocity Micro offers a choice of five CPUs. The system we received contained a 3.5GHz AMD Ryzen 9 3950X processor, a 16-core CPU with a 4.7GHz maximum turbo boost frequency and a 64MB L3 cache. While the base configuration includes just a simple heat sink, Velocity Micro offers four additional cooling options. Our

evaluation unit came with a closed-loop liquid cooling system with a pair of blue lighted fans, a \$130 option, as well as using IC Diamond thermal interface material, adding \$25 more.

Since the new Ryzen CPU does not include integrated video, Velocity Micro offers a choice of 22 different video cards, ranging from NVIDIA GeForce gaming cards to high-end NVIDIA workstation-class GPUs. Our evaluation unit included an NVIDIA Quadro RTX 4000 GPU (\$930). This board provides 2,304 CUDA cores, 288 Tensor cores, and 36 RT cores and 8GB of dedicated GDDR6 memory. With a 256-bit interface, the board can deliver a memory bandwidth of up to 416 GB/second, enabling it to achieve 7.1 trillion single-precision floating point operations per second and to perform real-time ray tracing. The RTX 4000 provides three DisplayPort 1.4 connectors and one VirtualLink connector and can support four displays at up to 3840x2160 resolution at 120Hz, four displays at 5120x2880 resolution at 60Hz, or two displays at 7680x4320 at 60Hz.

The system also supports a massive amount of storage, with multiple M.2 slots and support for up to eight SATA drives. While the base ProMagix configuration comes with a 256GB SSD, Velocity Micro offers solid state drives of up to 2TB and SATA drives up to 8TB capacity. Our evaluation unit included a 1TB Gigabyte Aorus PCIe 4th generation NVMe M.2 drive (a \$270 option) as well as a 2TB 7200rpm SATA 600 HD drive with a 64MB cache (adding another \$85). A 24X DVD+/-RW dual-layer drive is standard, or you can opt for a 16X Blu-ray burner.

Stellar Performance

With its powerful CPU and GPU, we expected excellent performance from this Velocity Micro workstation, but were still surprised by the results we recorded on our tests. On the SPECviewperf benchmark, which focuses on graphic performance, the ProMagix HD60 ATX AMD turned in great results. The only systems that surpassed its performance were those equipped with even more powerful (and more expensive) RTX GPUs. On the SPECcapc SolidWorks benchmark, the Velocity Micro system also performed well.

On the very demanding SPECwpc workstation performance benchmark, the performance was nothing short of amazing, earning top scores on many individual tests and turning in results that were only surpassed by systems equipped with over-clocked CPUs with many more processor cores. Its CPU and storage subsystem scores were the highest we've ever recorded. And on our own AutoCAD rendering test, the 23.9 second average time was just 0.1 second behind the fastest system we have ever tested.

While the base configuration includes Windows 10 Home, Windows 10 Professional came pre-installed on our system, adding \$70. Alternatively, you can save \$80 by ordering the system without an OS and install your own. Velocity Micro does not include a mouse or keyboard unless you specifically add one to your order. We included a basic Microsoft USB keyboard (\$20) and optical mouse (\$15) in our as-tested price.

The standard Velocity Micro warranty only covers the system for one year. Since many OEMs warrant their work-

stations for three years, our as-tested price includes a \$399 charge to extend coverage to three years for parts, labor, and depot repair service. Velocity Micro also includes a lifetime upgrade plan that allows you to return your system for maintenance, upgrades, and testing.

As configured, our system priced out at \$4,733, making it a clear price/performance winner—the fastest system we have ever tested for under \$5,000. Although equipped with certified hardware, the system itself lacks ISV certification. It that is not an issue for you, Velocity Micro has again proven that it knows how to assemble high-end workstations. Quite simply, this latest Velocity Micro HD60 workstation is a winner. **DE**

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David Cohn is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA and has been benchmarking PCs since 1984. He's a contributing editor to *Digital Engineering* and the author of more than a dozen books. You can contact him via email at david@dscobn.com or visit his website at www.dscobn.com.

→ MORE INFO

Velocity Micro: www.velocitymicro.com

Velocity Micro ProMagix HD60 ATX AMD workstation

- **Price:** \$4,733 as tested (\$1,599 base price)
- **Size:** 7.25x21.0x20.0-in. (WxDxH)
- **Weight:** 26.75 lbs.
- **CPU:** 3.5GHz AMD Ryzen 9 3950X 16-core w/64MB L3 cache
- **Memory:** 32GB DDR4-3200MHz
- **Graphics:** NVIDIA Quadro RXT 4000 w/24GB GDDR6
- **Storage:** 1TB Gigabyte Aorus PCIe 4.0 NVMe M.2 SSD and 2TB Seagate 7200rpm 3.5-in. SATA
- **Floppy:** none
- **Optical:** 24X DVD+/-RW
- **Audio:** onboard integrated high-definition audio (microphone and headphone on top panel; microphone, line-out, line-in, rear, center/subwoofer, and S/PDIF on rear panel)
- **Network:** integrated Intel I219V Gigabit LAN, Intel wireless AX2000, and Bluetooth
- **Modem:** none
- **Other:** Two USB 3.1 Gen 1 on top panel; four USB 3.1 Gen 1, seven USB 3.2 Gen 2 Type-A, one USB 3.2 Gen 2 Type-C
- **Keyboard:** none included (optional Microsoft keyboard added to price)
- **Point device:** none included (optional Microsoft optical mouse added to price)
- **OS:** Windows 10 Professional 64-bit
- **Warranty:** 1-year parts and labor, with depot service and regular business hour support standard (3-year warranty added to price)

For more information on this topic, visit DigitalEngineering247.com.

Buy It or Build It Yourself?

Since Velocity Micro is a system integrator rather than an OEM, the company builds computers using readily available parts manufactured by others. That begs the question, what would you save if you simply purchased all the components and assembled the computer yourself. Here's the price breakdown for the components used in the ProMagix HD60 ATX AMD:

- Lian Li case: \$150
- ASUS Crosshair Hero VIII motherboard: \$400
- AMD Ryzen 9 3950X CPU: \$749
- 32GB DDR4-3200 Crucial memory: \$166
- 850W EVGA SuperNOVA gold certified power supply: \$147
- Velocity Micro 240 liquid CPU cooler: \$130
- IC Diamond thermal compound: \$17
- 1TB Gigabyte Aorus PCIe 4th Gen NVMe SSD: \$210
- Seagate 2TB 7200rpm SATA hard drive: \$50
- NVIDIA Quadro RTX 4000 graphics card: \$879
- Windows 10 Professional 64-bit: \$200
- Keyboard and mouse: \$30
- TOTAL: \$3,128

BOXX GoBOXX SLM 17: VR-Ready Power to Go

This new lightweight mobile workstation performs great, but for a price.

BY DAVID COHN

BOXX Technologies has developed a well-deserved reputation for building high-quality, high-performing workstations for 24 years. The Austin, TX-based company also sells mobile systems, which are typically re-branded versions of computers built by other original equipment manufacturers.

The GoBOXX SLM 17 we recently received continues that tradition. A quick check confirmed that the SLM 17 was indeed the same system as MSI's recently introduced WS75 system.

First announced in August at SIGGRAPH 2019 in Los Angeles, the new BOXX GoBOXX SLM 17 is a thin, lightweight 17.3-in. mobile workstation based on a 9th-generation Intel Core i9-9880H processor and a discrete NVIDIA Quadro RTX graphics board; it's dubbed an RTX Studio laptop.



Fig. 1: The GoBOXX SLM 17 mobile workstation from BOXX Technologies delivers great performance in a thin, lightweight package. Image courtesy of David Cohn.

The GoBOXX SLM 17 measures 15.63x10.25x1.0-in. (WxDxH) with an attractive brushed black aluminum case and bronze accents on the side air grilles. Despite its larger size, it weighs just a bit more than its smaller sibling—4.89 lbs.—plus an additional 1.41 lbs. for the 180-watt power supply (5.75x3.0x0.87-in.).

Unlike some of the mobile systems from BOXX we have previously reviewed, however, BOXX does not have many customization options. Instead, the company sells three different pre-configured versions of the GoBOXX SLM 17.

All come with the same CPU, 32GB of RAM and the same 1920x1080 HD display. The only difference is the specific graphics processing unit (GPU) and the capacity of its solid-state hard drive.

For this review, BOXX sent us its least expensive configuration, a \$3,850 system equipped with a virtual reality-ready NVIDIA Quadro RTX 3000 graphics board and a 512GB solid-state drive (SSD).

A similar system with a 1TB SSD costs just \$119 more (\$3,969), while systems equipped with the more powerful RTX 4000 GPU and a 1TB SSD sell for \$4,923.

Well Equipped

Raising the lid on the GoBOXX SLM 17 reveals a 102-key backlit keyboard with a separate numeric keypad. Although the key tops are flat, the keyboard has a good feel with adequate travel.

A multi-touch enabled 5.5x2.5-in. touchpad with built-in fingerprint reader is centered in the palm rest, which means it is not centered on the spacebar. Although the touchpad lacks dedicated buttons, you can still right-click by tapping the lower-right corner of the touchpad.

A perforated grille above the keyboard conceals the built-in stereo speakers. A small power button, centered above this grille, is nearly invisible.

A 720p webcam, flanked by microphones and an LED, is centered above the 17.3-in. 1920x1080 ISP display. A small

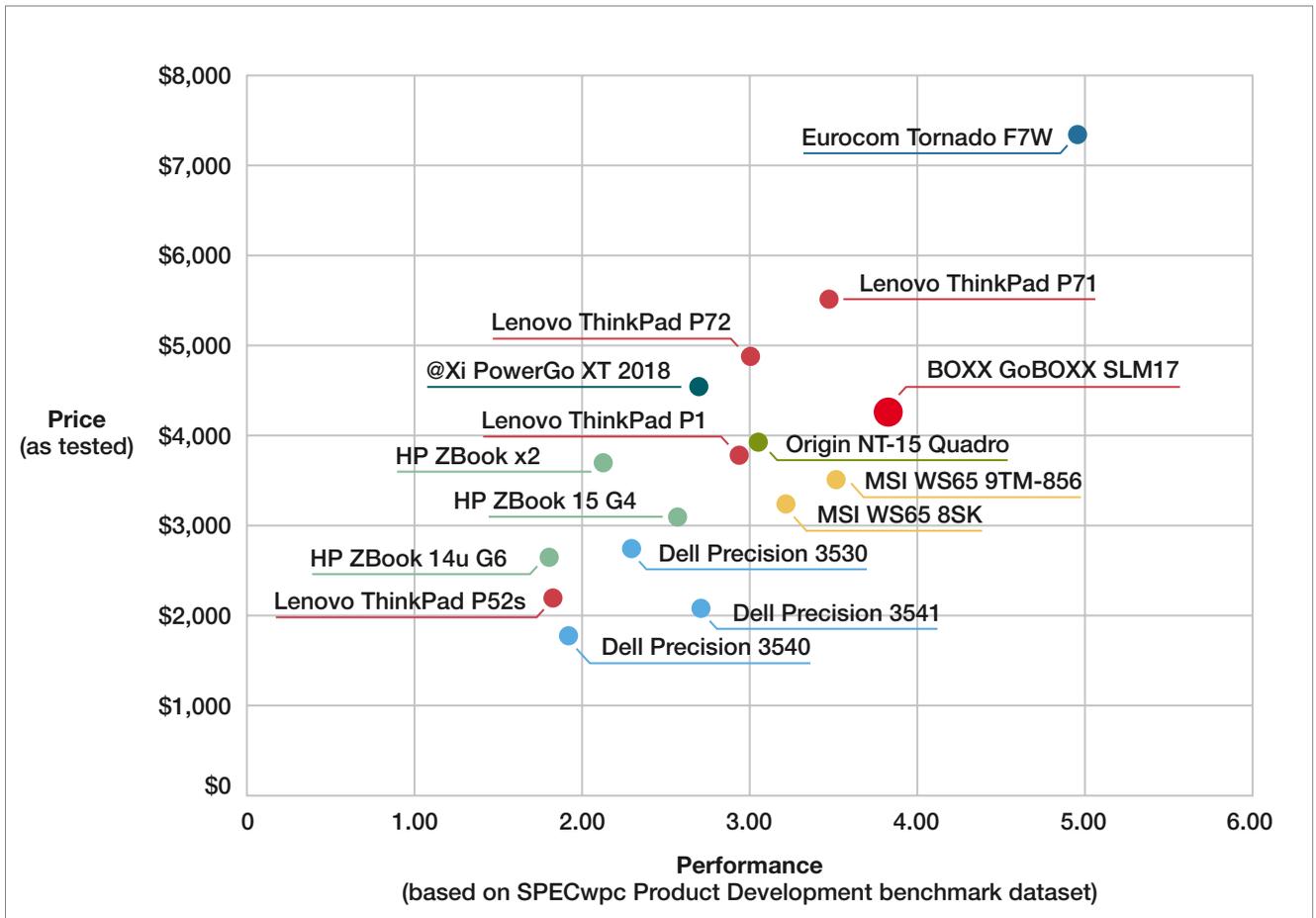


Fig. 2: Price/Performance chart based on SPECwpc Product Development benchmark dataset.

LED to the left of the keyboard indicates the Caps Lock status, but unlike most other laptops, there is nothing else to indicate when you have engaged the Number Lock or other keyboard-enabled functions.

In fact, other than a small light to the left of the power button—which glows white when the system is on and using the Intel graphics, and amber when the discrete NVIDIA GPU is in use—the only other light of any kind on the SLM 17 is a battery status indicator near the front right edge of the case that blinks if the battery fails.

The SLM 17 also uses the same somewhat awkward keyboard layout found on similar laptops, though it certainly doesn't take long to get used to the odd location of some keys.

The GoBOXX SLM 17 includes an excellent selection of ports. Along the left side is an air vent, the power connector, an RJ-45 network jack, a USB 3.2 port, a card reader and a pair of audio jacks (headphone and microphone) for the built-in Realtek high-definition audio. The right side has a security cable slot, another air vent, HDMI port, a USB 3.2 Type-C/Thunderbolt port, two additional USB 3.2 ports and a second USB 3.2 Type-C port. There are no other ports on the rear of the system. Additional speakers, a large ventilation grille and a battery reset hole are located on the underside of the system.

Few Choices

All three versions of the GoBOXX SLM 17 are powered by a 2.3GHz Intel Core i9-9880H eight-core Coffee Lake CPU with a 4.8GHz maximum turbo boost. This processor, which has a 45-watt thermal design power rating, features a 16MB cache and integrated Intel UHD Graphic 630.

All SLM 17 systems also include a discrete NVIDIA Quadro RTX GPU. The RTX 3000 included in our evaluation unit has 6GB of dedicated GDDR6 memory, 1920 CUDA cores, 30 RT cores and 240 Tensor cores while consuming a frugal 80 watts. Coupled with its 192-bit interface, the RTX 3000 delivers a maximum bandwidth of 336 GB/second.

All three versions of the SLM 17 include 32GB of DDR4 2666MHz memory, installed as two 16GB small outline dual-inline memory modules. Our evaluation unit also came with a 512GB Samsung NVMe M.2 SSD installed in the single M.2 slot.

Excellent Performance

With its relatively fast CPU and powerful GPU, we expected this BOXX mobile workstation to perform extremely well, and the BOXX GoBOXX SLM 17 delivered.

On the SPECviewperf tests, it turned in excellent results on every dataset, outperformed only by systems equipped

The BOXX Difference

We reached out to BOXX regarding the price difference between this BOXX mobile workstation and the MSI-branded version of this same system we found online. Matt Priest, GoBOXX Product Manager, responded:

“Unlike our APEXX desktop workstations and RAXX servers, GoBOXX mobile workstations are manufactured and branded for BOXX by MSI. But just like our workstations and servers, these laptops are then subjected to rigorous BOXXlabs testing to ensure that they are indeed certified to run specific software applications. In some instances, configurations are modified to ensure that each GoBOXX delivers maximum performance and is qualified to wear the BOXX mantle of ‘purpose built.’ To ensure rapid repair or replacement, we stock spare parts and back GoBOXX laptops with U.S.-based, legendary BOXX Technical Support.”

“The MSI laptop price, as found on Newegg, Amazon or other retail sites is commonly referred to as a ‘street price’ and is the final price whereas the GoBOXX price on box.com is an MSRP or starting price required by government, GSA and other entities. BOXX offers discounts on this MSRP—especially with bulk corporate purchases. Therefore, comparing the two system prices is not an ‘apples-to-apples’ comparison. In addition, BOXX only serves the professional market, not consumers, and as such, we provide professional services (loading a corporate image, system validation, etc.) under the mantle BOXX for Enterprise. We also offer terms so business customers can purchase through an account and not just via credit card.”

with even more powerful NVIDIA graphics boards. The SLM 17 delivered equally impressive results on the SPECapc SolidWorks tests. On the demanding SPEC workstation performance benchmark, the BOXX GoBOXX SLM 17 led the pack among mobile workstations we have tested recently.

On our own AutoCAD rendering test, the 45.9-second average rendering time was one of the fastest we’ve ever recorded for a mobile workstation. Despite its performance, the GoBOXX SLM’s four-cell 82-WattHour battery still managed to keep the system running for 8 hours and 37 minutes. The system remained cool and quiet throughout our tests.

BOXX preloads Windows 10 Professional Edition or you can opt for Windows 10 Professional Workstation Edition for \$84 more. Our only complaint was that BOXX only backs the system with a one-year warranty though essentially the same system from MSI comes with a three-year warranty.

Since most workstation-class systems typically include a three-year warranty, our as-tested price includes the \$350 BOXX charges for the longer warranty, which brought the total price to \$4,200.

The BOXX GoBOXX SLM 17 is clearly a great choice for any engineer or designer who needs a thin, lightweight VR-ready system they can depend on whether they’re in the office or on the road.

But potential buyers should also consider the MSI-branded version of this same system, which we found online for \$1,000 less. **DE**

David Cohn is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA, and has been benchmarking PCs since 1984. He’s a Contributing Editor to Digital Engineering and the author of more than a dozen books. You can contact him via email at david@dscobn.com or visit his website at dscobn.com.



→ MORE INFO

BOXX Technologies: BOXXTech.com

BOXX GoBOXX SLM 17

- **Price:** \$4,200 as tested (\$3,850 base price)
- **Size:** 15.63x10.25x1.00-in. (WxDxH) laptop
- **Weight:** 4.89 lbs. plus 1.41 for 180W power supply
- **CPU:** Intel Core i9-9880H 2.3GHz eight-core w/ 16MB cache
- **Memory:** 32GB DDR4 at 2666MHz
- **Graphics:** NVIDIA Quadro RTX 3000
- **Storage:** Samsung 512GB SSD M.2 PCIe drive
- **Floppy:** None
- **Optical:** None
- **Audio:** Realtek High-Definition audio with stereo speakers and build-in microphone, headphone-out and microphone-in
- **Network:** Integrated 10/100/1000 Intel Dual-Band Wireless-AC 9560 with Bluetooth and RJ45 jack
- **Modem:** None
- **Other:** Three USB 3.2, USB 3.2 Type-C/Thunderbolt, USB 3.2 Type-C, HDMI, card reader
- **Keyboard:** 102-key backlit keyboard with numeric keypad
- **Pointing device:** Integrated touchpad with multi-touch and fingerprint reader

For more information on this topic, visit DigitalEngineering247.com.

HP ZBook 14u G6 Mobile Workstation: Compact Road Warrior Workstation

This new 14-in. workstation is a great choice for on-the-go engineers.

BY DAVID COHN

Over a year has lapsed since we last reviewed an HP workstation—and more than four years since we reviewed one of HP's 14-in. mobile workstations. So, we were understandably excited when the latest HP ZBook 14u arrived at our test lab.

The HP ZBook 14u G6 is the thinnest, lightest ZBook mobile workstation the company has ever created. Designed specifically for often on-the-go power users, the evaluation unit we received measured 12.84x9.22x0.71-in. (WxDxH) and weighed just 3.34 lbs., plus 0.67 lbs. for the 65-watt external power supply and cord.

Based on an 8th-generation Intel Core processor with built-in UHD 620 graphics, the HP ZBook 14u G6 also can be equipped with an optional AMD Radeon Pro WX 3200 discrete graphics processing unit (GPU) and up to 2TB of storage and 32GB of RAM.

Compact Design

The HP ZBook 14u G6 comes housed in a sleek aluminum and magnesium alloy chassis with an HP logo centered in the lid. Raising the lid reveals a spill-resistant 86-key backlit keyboard with a pointing stick nestled between the G, H and B keys, and a 4.3x2.3-in. gesture-enabled touchpad with two large buttons centered below the spacebar. A very small power button is located above the upper-left corner of the keyboard, while a fingerprint reader is positioned below the lower-right corner of the keyboard.

Lights on various keys—speaker mute, microphone mute, number lock, wireless antenna, sharing/presenting, caps lock, function lock, call answer and call end—illu-



Fig. 1: The new HP ZBook 14u G6 is a great choice for engineers who are constantly on the go. *Image courtesy of HP.*

minate when those functions are active. Additional lights along the front edge of the system indicate power, wireless connection and disk activity. A perforated grille extends the width of the system above the keyboard with a pair of stereo speakers beneath.

The base configuration includes a 1920x1080 display, but our evaluation unit came with a gorgeous 3840x2160 anti-glare display with an HD infrared webcam centered above the display. The webcam is flanked by an ambient light sensor, a pair of microphones, and a pair of camera lights and also includes a privacy slide. A pair of Wi-Fi antennas are located above the corners of the display. There is a third microphone located in the center of the case's front edge.

HP includes a modest selection of ports. Along the left side is a security cable slot, an air vent, a USB 3.0 port with charging capability and a SmartCard reader. On the right side are a SIM card slot, an audio combo jack, a second USB 3.0 port, an HDMI port, an RJ-45 network jack, a docking connector, a USB Type-C port that supports both Thunderbolt and DisplayPort, the power connector and a battery light.

Ample Options

Prices for the HP ZBook 14u G6 start at \$1,399 for a system equipped with an Intel Core i5-8265U 4-core 1.6GHz CPU, 8GB of RAM, a 256GB PCIe NVMe solid-state drive (SSD), a 1920x1080 250-nit display, a discrete AMD Radeon Pro WX 3200 GPU, Intel Dual Band Wi-Fi AX200 plus Bluetooth 5, a 720-HD webcam with implanted reality SmartCard reader, backlit keyboard, fingerprint reader and Windows 10 Pro 64, all backed by a three-year warranty.

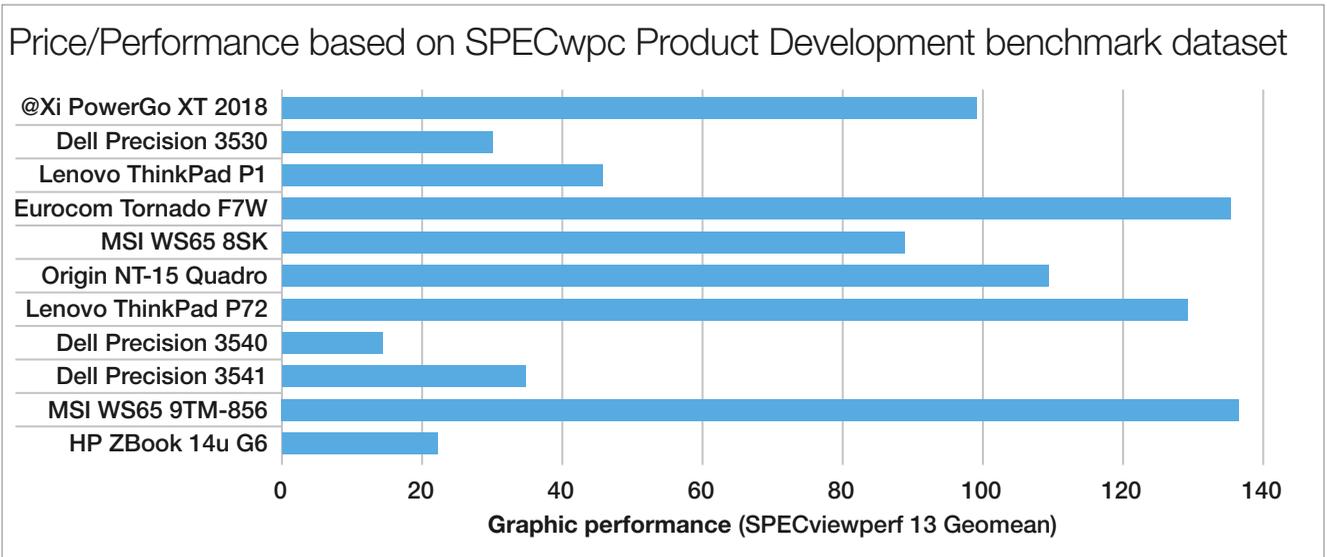


Fig. 2: Price/Performance chart based on SPECwpc Product Development benchmark dataset.

But that's just the starting point. You can even omit components (such as the webcam, keyboard backlighting, fingerprint reader and Wi-Fi), reduce the amount of memory, reduce the length of the warranty, or substitute Windows 10 Home or FreeDOS to further reduce the cost.

HP offers a choice of three CPUs; you can choose whether to include the discrete AMD Radeon Pro GPU. Our evaluation unit came with an Intel Core i7-866U Whiskey Lake CPU as well as the AMD GPU, which added \$694 to the price. That 1.9GHz CPU has a maximum turbo speed of 4.8GHz, an 8MB Smart Cache and a frugal 15-watt thermal design power rating. A 1.8GHz Core i5-8586U CPU is also available.

Other display options include a 1920x1080 panel with touch capabilities (\$240) and two different 3840x2160 panels with brightness ratings of 400 or 600 nits. Our evaluation unit came with the top-of-the-line 3940x2160 600 nit display, which added \$566. There is no touch option on the high-resolution displays. The AMD Radeon Pro WX 3200 includes 4GB of GDDR5 discrete memory, 640 cores and a 128-bit interface to deliver a bandwidth of 96GB/second.

The base system comes with 8GB of RAM, though our system came with 32GB of 2400MHz memory, installed as a pair of DDR4 dual in-line memory modules, adding \$550. Or, you could max the system out with 64GB of memory for \$1,350.

HP offers lots of internal storage options. You could save \$110 by downgrading to a 128GB M.2 SATA SSD or add \$712 by opting for a 2TB PCIe NVMe SSD, the largest storage option currently offered. Our evaluation unit included a Samsung 512GB PCIe NVMe SSD, which added \$230 to the system price. A 1TB drive would add \$652 to the base price.

HP also offers several other options, including nearfield communication and broadband wireless components. The company also sells various docks, which range from \$149 to \$262.

Decent Performance

Because we always expect great performance from HP workstations, we knew that as an ultra-lightweight system, the ZBook 14u G6 was not going to set any records. The three-cell 50Whr battery kept the system running for just 5.5 hours, considerably less than many of the mobile workstations we have tested recently.

On the SPEC Viewperf test, which focuses on graphics, The ZBook 14u performed about as well as we expected. Its AMD Radeon Pro WX 3200 was no match for the NVIDIA GPUs provided in most of the larger mobile workstations, but the graphic performance of the ZBook 14u did surpass that of the Dell Precision 3540, the only other AMD-equipped mobile workstation we have tested recently.

Although the ZBook 14u G6 turned in decent results on the SolidWorks benchmark, its results on the very demanding SPECwpc benchmark placed it at the bottom of the pack; its storage performance was quite good, but its CPU and graphics performance reduced its overall scores on this test. With an average time of 140.4 seconds to complete our AutoCAD rendering test, the HP ZBook 14u G4 took twice as long as the next slowest system we have tested in the past year.

Throughout our tests, the HP ZBook 14u G6 was practically silent. As mentioned, HP preloaded Windows 10 Pro 64, but offers Windows 10 Home and FreeDOS as less-expensive options. Like all its other workstations, the ZBook 14u G6 is independent-software vendor certified and backed by a 3-year warranty that covers parts, labor, but not onsite service.

With the ZBook 14u G6, HP has once again delivered an excellent mobile workstation. As configured, our evaluation unit had a total cost of \$2,649, making it slightly more expensive than the Lenovo ThinkPad 52s and Dell Precision

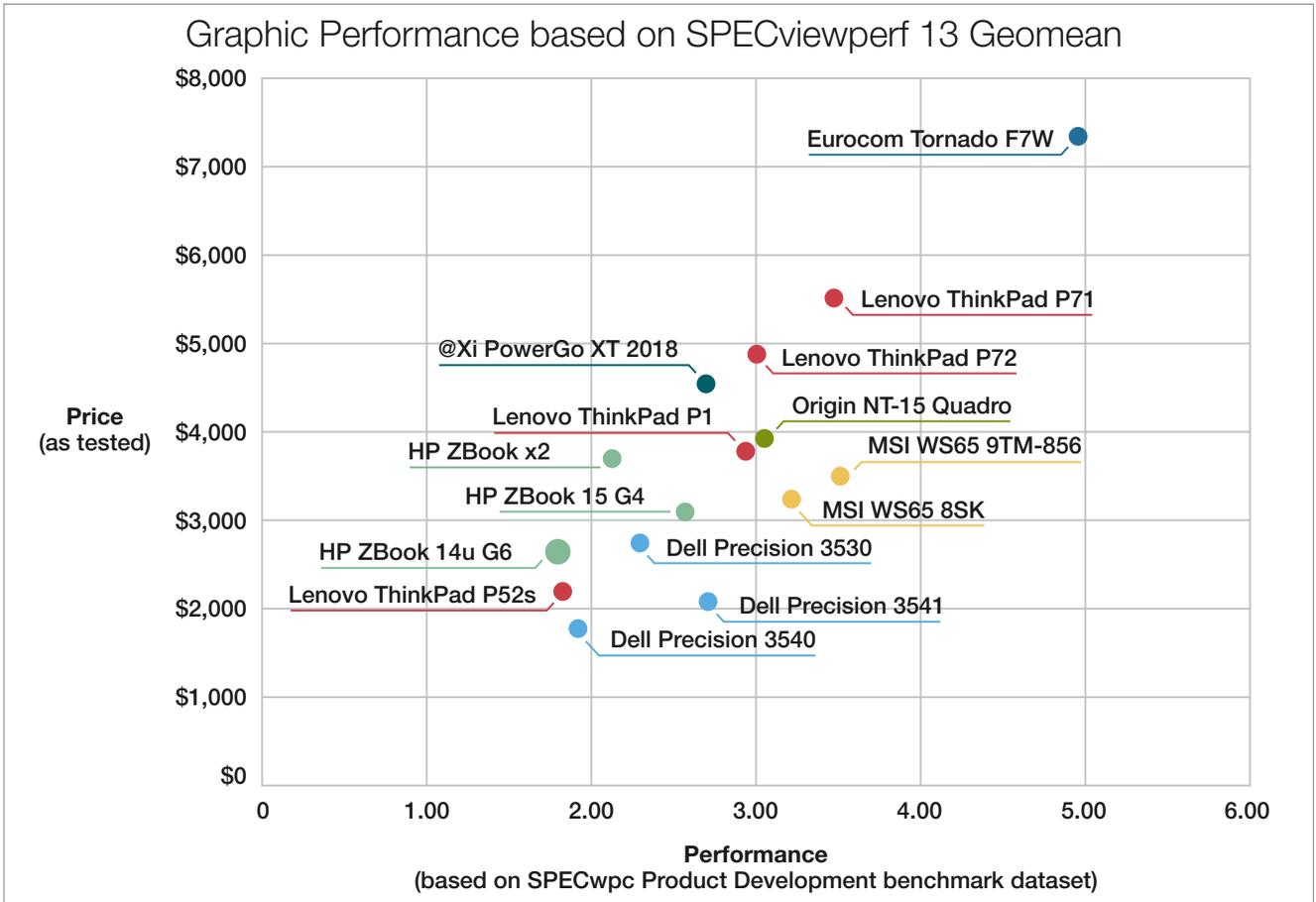


Fig. 3: Graphic Performance chart based on SPECviewperf 13 Geomean.

3540 while delivering similar performance. But as a 14-in. system, the HP ZBook 14u is smaller and lighter than those Dell and Lenovo systems, making it a great choice if you are a true road warrior. **DE**

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David Cohn is the technical publishing manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA, and has been benchmarking PCs since 1984. He's a contributing editor to Desktop Engineering and the author of more than a dozen books. You can contact him via email at david@dscohn.com or visit his website at www.dscohn.com.

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MORE INFO →

- **HP:** HP.com
- **HP ZBook 14u G6 Mobile Workstation**
Price: \$2,649 as tested (\$1,399 base price)
Size: 12.84x9.22x0.71-in. (WxDxH) notebook
Weight: 3.34 lbs. plus 0.67 for 65W power supply

- CPU:** Intel Core i7-8665U 1.9GHz 4-core w/ 8MB cache
- Memory:** 32GB DDR4 2400MHz (2x16GB) 32GB max
- Graphics:** AMD Radeon Pro WX 3200
- Storage:** 512GB M.2 PCIe NVMe SSD
- Floppy:** None
- Optical:** None
- Audio:** Bang & Olufsen with built-in speakers and microphone array, combo audio jack
- Network:** Intel Dual Band Wi-Fi AX2000 and Bluetooth 5
- Modem:** None
- Other:** Two USB 3.0, one USB 3.1 Type-C (Thunderbolt/DisplayPort), HDMI, RJ-45, SmartCard reader, SIM card slot, docking connector, fingerprint reader
- Keyboard:** 86-key backlit spill-resistant keyboard
- Pointing Device:** Touch stick and touchpad with two buttons
- Warranty:** Three-year parts and labor

For more information on this topic, visit DigitalEngineering247.com.