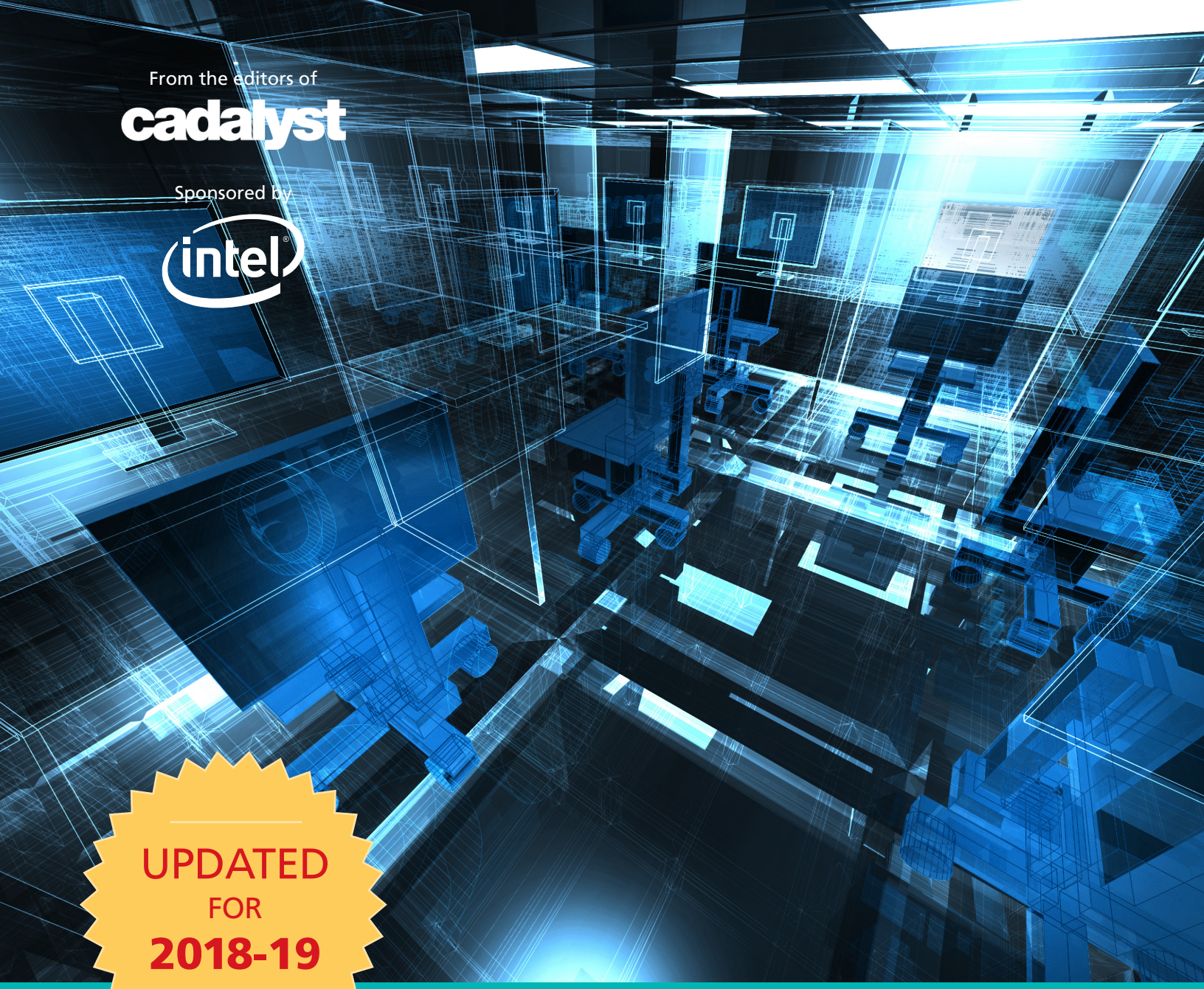
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UPDATED FOR **2018-19**

Workstation vs. PC:

In the Race to Meet Design Deadlines, Which Option Wins?

Cadalyst tests the claim that professional machines surpass gaming PCs for CAD work.

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» ***Updated for 2018–19:***
This Cadalyst white paper is updated from the version published in 2015 under the same title. Benchmark test scores and conclusions herein reflect new research based on 2018 computer models.

» ***Cover image:***
Joshua Resnick, Shutterstock.com

What's the right machine for CAD? A PC or a professional workstation? And how often should you replace that machine?

If you're concerned about CAD user productivity and its impact on the bottom line, those are the questions you should be asking. Unfortunately, objective answers to such questions can be hard to come by, with most attempts ultimately resorting to a lot of vague claims and hand waving. It's no surprise that workstation vendors recommend a professional workstation over a consumer-grade PC, and they coax existing workstation users to update their machines every three years at a minimum. Meanwhile, water cooler conversations, online user group posts, or simple hearsay might suggest trimming budgets and opting for a "high performance" or "gaming" PC instead, and many companies persist in keeping CAD machines in use for four or five years — or longer. How does a CAD professional separate the truth from the hype?

In the fall of 2018, Cadalyst took on the challenge not only to evaluate the two primary competing platforms for CAD proficiency, but back up conclusions with some quantifiable substance. Running real-world CAD workloads, we tested the performance of a current professional workstation vs. a machine typically marketed as a gaming PC — a high-end consumer-grade desktop system equipped with a gaming-oriented graphics card.

In addition, to help professionals get a handle on how often to upgrade machines to take advantage of newer, faster, and more reliable hardware, we benchmarked the same 2018 workstation against an identically priced model from three years prior.

This white paper will share the results of our tests, which produced objective data that lets you see first-hand how your choice of CAD machine can have a dramatic impact on software performance — and in turn on user productivity — to help you make informed decisions about which type of computer to purchase for CAD work and how often to replace it.

Why a Workstation? Because They're Built for CAD

One approach to consistently maintaining business competitiveness is to boost staff productivity wherever possible. For CAD information technology (IT), the primary avenues to drive design and development productivity are two-fold: one, to shorten the time required to complete individual tasks and improve the work-

Comparing Features: Workstation vs. Gaming PC

	Workstation	Typical gaming PC
Design rationale	CAD-optimized performance without sacrificing reliability	General-purpose performance and gaming; reliability secondary
ISV certification	Yes	No
Central processing unit (CPU)	Intel® Core™ and professional-grade Intel® Xeon® processors	Consumer-grade processors, i.e., Intel® Core™ or AMD Ryzen processors
Graphics processing unit (GPU)	Professional-grade GPU and driver: AMD Radeon Pro and NVIDIA Quadro	Gaming-oriented GPU and driver: AMD Radeon and NVIDIA GeForce
Memory	Error-correcting code (ECC)-capable	No ECC
Storage	RAID-capable	No RAID
Warranty (typical)	3 years, on site	1 year

flow overall; and two, to avoid idle time by ensuring all critical IT resources (hardware and software) are always up and running, available to users.

The former requires the best possible throughput for a range of CAD workloads, and the latter requires the most reliable computing tools. Workstations are specifically engineered to achieve both, with features PCs can't match, such as ISV certification, professional-caliber processors (CPUs) and graphics cards (GPUs), enhanced memory and storage capacity and protection, stronger power supplies (PSUs), more robust chassis design and materials, and more comprehensive warranties and support.

Purpose-built for CAD reliability. The workstation is fundamentally more reliable than its consumer- or corporate-focused siblings, as is evident in both the components inside and the enclosure housing them. Comprehensive thermal engineering of the chassis, for example, ensures workstation components stay cool under the pressure of running compute-intensive software, as hot parts are more vulnerable to failure. Workstations also deliver better shock and impact resistance than do standard PCs, thanks to more robust materials and more secure retention mechanisms.

Workstation-caliber CPUs and GPUs share a similar focus on robust design, compared to typical models found in non-workstation PCs. Workstation GPU add-in cards, for example, boast gold-plated PCI Express fingers, burlier retention mechanisms, and more robust clocking and drivers. Crafted specifically for high-availability workstations and servers, Intel® Xeon® processors deliver exclusive features such as memory error protection (in the form of error-correcting code, or ECC) and optimal clock frequencies that maximize performance without sacrificing reliability. Workstations offer protection for stored data as well, supporting RAID configurations that protect the contents of your hard drive and minimize downtime in the event of a failure.

Original equipment manufacturers (OEMs) and independent hardware vendors (IHVs) typically ship workstations equipped with their exclusive software tools that allow IT professionals to more simply,

securely, and consistently deploy and manage an enterprise-scale array of machines.

Perhaps the workstation's most important feature is its most differentiating: independent software vendor (ISV) certification by companies such as Autodesk and Dassault Systèmes, wherein the hardware OEMs and ISVs team up to verify the complete workstation system — hardware, applications, and drivers. Comprehensive regression testing ensures every certified workstation reliably runs the most popular CAD applications. More robust hardware designs combined with ISV certification lead to increased uptime thanks to reduced chances of crashes, bugs, memory errors, and repairs.

In the unlikely event of a system failure, a workstation's longer (and typically on-site) warranty means less machine downtime. And, finally, should a machine for any reason become unserviceable, the longer lifecycles that workstation OEMs support would make finding an identical replacement a simple exercise, while replacing a PC a year or two after its purchase date may be impossible. In fact, it's not uncommon for a workstation vendor to be able to replace a workstation five years or more after purchase — which is nice if you prefer consistency among the lineup of CAD machines being maintained, and a lifesaver if you manage an installation requiring exact machine specifications (for example, a government-certified system and process).

Purpose-built for CAD performance. Reliability and manageability are hallmark workstation traits, but for many users, performance is ultimately where the rubber meets the road. A workstation's design and choice of software and hardware components not only make it more reliable than a general-purpose PC, they also let it churn faster through demanding CAD workloads.

How Workstation Features Fulfill CAD Needs

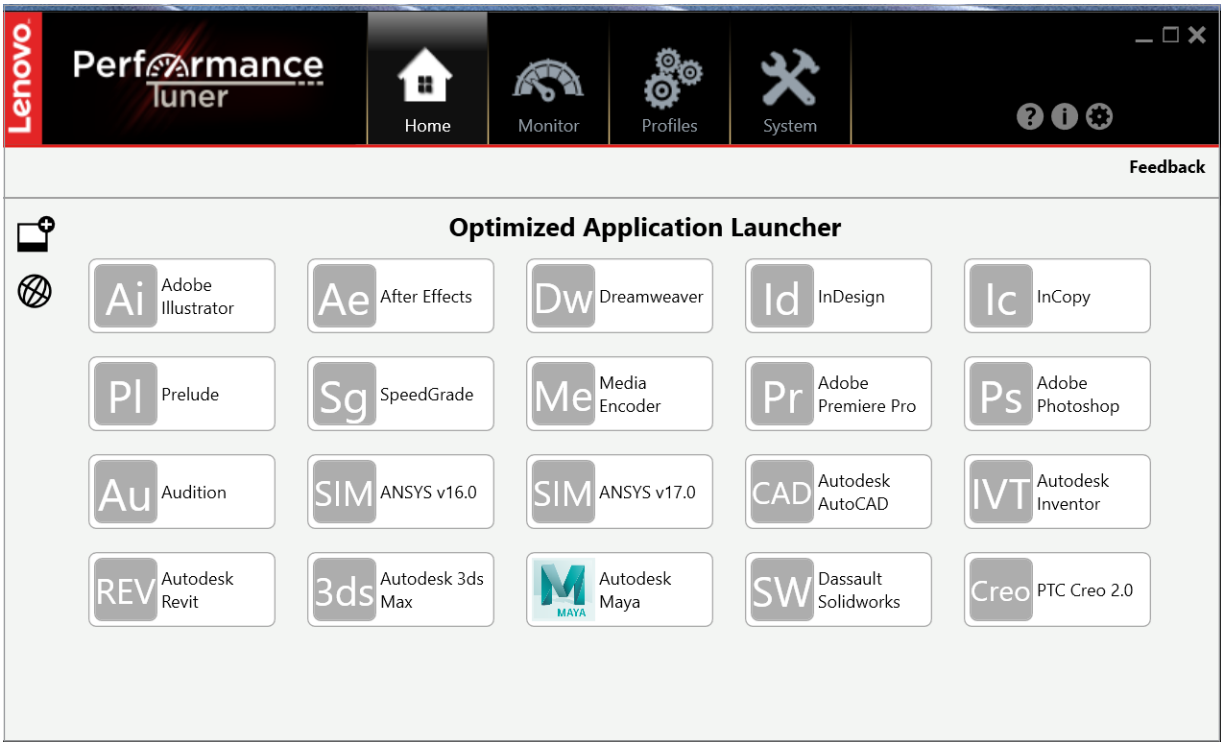
	CAD-optimized performance	Reliability and uptime
Chassis design	More slots, more bays, bigger and beefier power supply units (PSUs)	Comprehensive thermal engineering, more efficient PSUs
ISV certification	Optimized application/driver interface	Ensures robust combination of software, hardware, and drivers
Professional-grade Intel® Xeon® CPU	More cores, more cache, more memory capacity, dual-socket support	ECC memory, conscientious clocking
Professional-grade GPU	Application-tuned driver, larger graphics memories	Higher-quality materials and retention, conscientious clocking
RAID-capable storage	Boost I/O read bandwidth	RAID redundancy ensures storage is never the cause of system failure
Longer lifecycle	N/A	Guaranteed replacement years down the road
Extended, on-site warranty	N/A	Minimize downtime and total cost of ownership
Workstation-caliber software	Application-specific drivers, performance-tuning tools, and profiles	Tools to simplify deployment and management

Examples of its attention to CAD-specific performance abound. Workstation chassis tend to be larger, offering more expansion slots for add-in cards, more bays for storage, and beefier PSUs to power them all. ISV certification, in addition to enhancing reliability, ensures the most optimal application-to-driver interface. Workstation-geared Intel Xeon CPUs tend to populate more CPU cores, supported by larger caches and coupled to more ample memory footprints, making them better equipped to tackle large CAD datasets and modern multithreaded workloads.

Professional-caliber GPUs tend to offer more graphics memory than consumer-class cards, such that ever-larger CAD models don't choke rendering due to a lack of local storage. Optimized for the specific types of graphics operations most commonly employed in CAD, workstation-class GPU drivers outperform drivers tuned for gaming or general-purpose graphics applications. For example, professional GPU drivers optimize drawing of smooth 3D lines and Gooch-shaded surfaces, common in CAD drawings but virtually nonexistent in games and other consumer-oriented applications.

Workstation vendors now commonly offer supporting software tools designed to optimize performance and reliability, perhaps the most popular and useful of which allow users to control how different applications run on their machines. One example, the Lenovo Performance Tuner, has default values specified to deliver sound performance in the majority of use cases, while giving users and IT administrators the option to fine-tune the allocation of hardware resources, down to a specific selection of which applications run on which CPU cores.

» ***Below:*** *One example of performance-optimizing software available from workstation developers, the Lenovo Performance Tuner allows users to optimize workstation performance for common CAD and M&E applications. (Source: Lenovo)*



Does a workstation offer substantially higher throughput running common CAD workloads than a PC?

Performance for CAD: Workstation vs. Gaming PC

How does all that CAD-specific, performance-oriented design pay off? Does the workstation offer substantially higher throughput running common CAD workloads than a PC? And if so, how much faster is it?

To answer those questions, we measured the performance of two machines running the same CAD-oriented workloads. Representing a professional workstation in our comparative testing, we used the Lenovo® ThinkStation® P330, an excellent example of the application-tuned performance and capabilities that can be had today at an entry-level price. We configured the workstation with a balance of components, specifically chosen to result in a price of about $2,000, right around the average workstation sales price today, according to Jon Peddie Research.

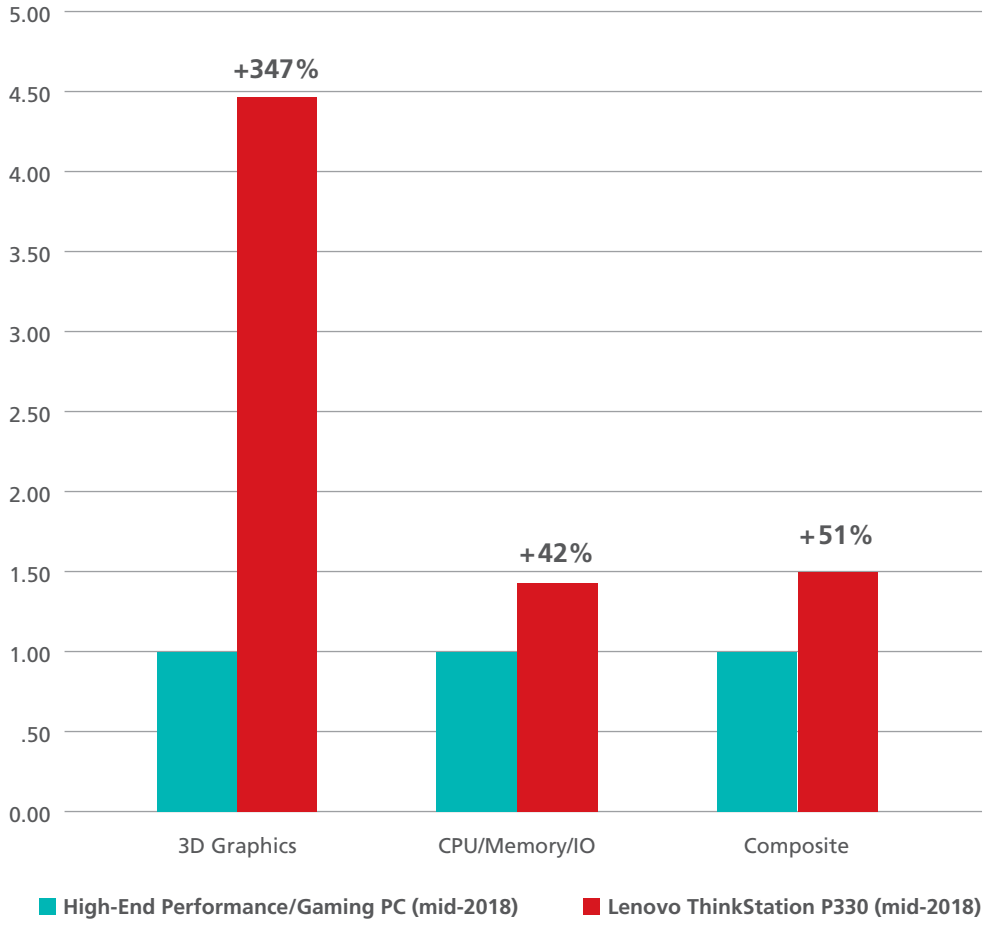
To compare the test results of our ThinkStation P330, we called on a machine typically marketed as a gaming PC — one that box store salespeople or online word-of-mouth may point CAD buyers toward, given CAD's needed graphics support. Positioned and perceived as a performance-oriented 3D machine, our test PC represents the classic alternative to a branded professional workstation often employed to run mainstream CAD applications such as AutoCAD, Autodesk Revit, and SOLIDWORKS. At around $2,100, this machine carries a price substantially higher than the average corporate or consumer PC, suggesting that it should deliver the performance a CAD user demands. Importantly, that price tag also puts the PC on equal footing with our ThinkStation P330, making this a dollar-for-dollar price comparison.

Both machines feature the Windows 10 64-bit operating system, with the gaming PC running Microsoft Windows 10 Home and the workstation Windows 10 Pro, as they would most likely be equipped in real-world models — another edge that workstations

Specifications for an Entry-Level Workstation vs. a High-Performance Gaming PC

	Lenovo ThinkStation P330 workstation (mid-2018)	Typical gaming PC (mid-2018)
CPU	Intel® Xeon® E-2146G, 6 cores @ 3.50 GHz	Intel® Core™ i5-7600K, 4 cores @ 3.80 GHz
GPU	NVIDIA Quadro P4000 with 8 GB graphics memory	NVIDIA GeForce GTX 1080 with 4 GB graphics memory
Memory	16 GB DDR4-2400 with ECC	32 GB DDR4-2400
Storage	1 TB M.2 PCI Express SSD (boot) + 1 TB SATA hard drive @ 7,200 RPM	240 GB SSD (SATA)
Operating system	Windows 10 Pro 64-bit	Windows 10 Home 64-bit
Warranty	3 years	1 year
Professional performance-optimization tools	Lenovo Performance Tuner	None
Price	$2,250	~$2,100

Comparing Performance: 2018 Gaming PC vs. 2018 Professional Workstation



» ***Figure 1 (above):*** *Overall CAD performance of a typical mid-2018 workstation, compared with that of a mid-2018 high-performance gaming PC (based on SPECwpc v2/ Product Development test suite).*

have over PCs, although the exact gains, if any, would require further testing to determine.

To gauge overall system performance for CAD, we employed specific CAD-oriented tests from SPECwpc v2, the open, de facto standard benchmark from the Standard Performance Evaluation Corporation that tests performance for a wide range of system-level and GPU-specific tasks common to workstation applications. Given our focus on CAD, we ran a subset of the SPECwpc battery, specifically the Product Development test, which reflects many of the most common CAD-oriented computation and 3D graphics operations. For ease of viewing and comparison, we bucketed individual tests into two categories: those primarily stressing the system's 3D graphics performance and those focusing more on CPU, memory, and I/O components. Shown in addition is the overall composite score weighting all Product Development tests.

The results are clear: Normalized to the scores from our similarly priced gaming PC, the ThinkStation P330 performs 51% faster overall; approximately 42% better on tests focused on CPU, memory, and I/O; and a whopping 347% faster on common 3D model interactive viewing (**figure 1**).

How often should you retire the old workstation and invest in a new one?

2018 Workstation vs. 2015 Workstation

Based on its purposeful design for reliability and its proven design for CAD-specific performance, today's workstation platform is the compelling choice for CAD computing. For those already convinced of a workstation's merits, however, there's another salient question to be answered in pursuit of optimal productivity and ROI: How often should you retire the old workstation and invest in a new one?

With its performance and capabilities driven up rapidly by advances in silicon technology, a new workstation can offer dramatic improvements in performance for typical CAD workflows. Each generation of key workstation component — CPU, GPU, memory, and storage — benefits from each evolutionary step in silicon transistor speed, density, and power efficiency. Chip design engineers employ faster and more plentiful transistors to increase performance and capacity, often dramatically and across the board. Next-generation CPUs and GPUs justifiably garner the most attention in consideration of a new workstation's potential performance, but silicon technology evolution can be just as valuable in memory and storage. Consider solid-state storage, for example: In the past few years, the SSD has transitioned from exotic and extravagant to mainstream, must-have workstation technology.

In addition to silicon-driven advancements, workstation platform architecture and interfaces continue to progress, contributing to a range of new throughput-boosting features. Introduced in the past few years, for example, we now have higher core-count CPUs, DDR4 memory technology, PCI Express Gen 3 I/O — aiding both graphics and SSD performance — and a host of ISA (Instruction Set Architecture) extensions to streamline instruction execution and data computation.

Of course, to take advantage of recent technology advances requires periodic upgrades to your workstation hardware. All critical internal components could be individually upgraded, with varying degrees of difficulty, to give a machine a sensible midlife kick to extend its usefulness. However, upgrading parts rather than the entire machine will eventually get more costly, more cumbersome, and less effective, because a healthy balance of the entire system is more important to overall performance than supercharging any individual component. Before long, it's justifiably time to replace the system with a modern workstation model.

Quantifying the Gains in CAD Workstation Performance: 2018 vs. 2015

The right time to swap out the old workstation in favor of a new model will depend on the user, the workflow, and the budget. But an effective replacement cycle — one long enough to allow adequate amortization of the current asset, but short enough to ensure that productivity doesn't fall too far behind the curve — will typically be in the 18- to 36-month range. To illustrate how quickly system performance can fall behind, we compared our mid-2018 Lenovo ThinkStation P330 with a similarly priced predecessor,

Specification Comparisons for 2018 vs. 2015 Workstations

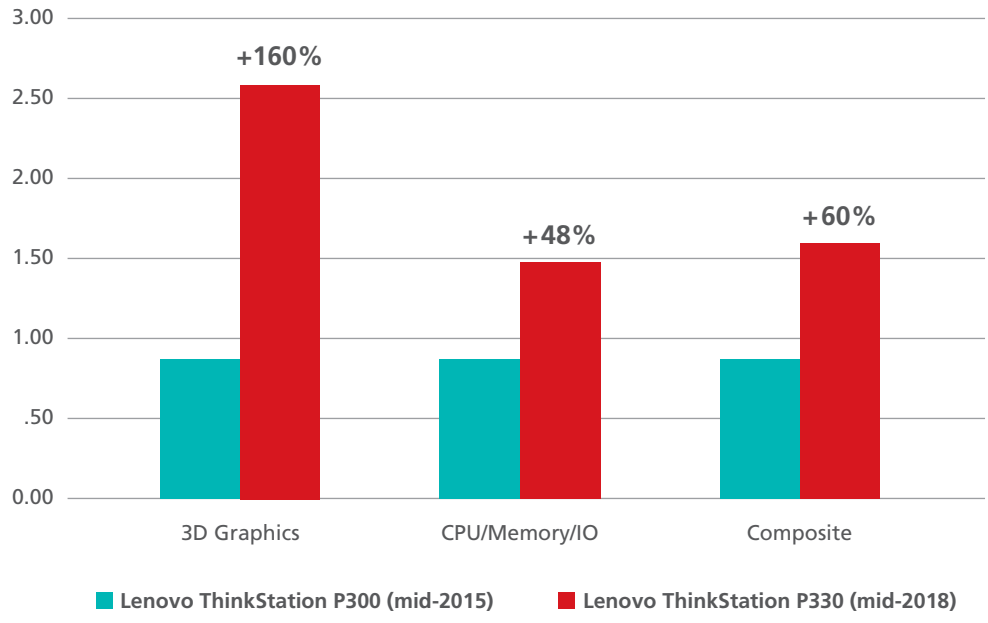
	Lenovo ThinkStation P330 workstation (mid-2018)	Lenovo ThinkStation P300 workstation (mid-2015)
CPU	Intel® Xeon® E-2146G, 6 cores @ 3.50 GHz	Intel® Xeon® E3-1271 v3, 4 cores @ 3.60 GHz
GPU	NVIDIA Quadro P4000 with 8 GB graphics memory	NVIDIA Quadro K2200 with 4 GB graphics memory
Memory	16 GB DDR4-2667 with ECC	8 GB DDR3-1600
Storage	1 TB M.2 PCI Express SSD (boot) + 1 TB SATA hard drive @ 7,200 RPM	180 GB SATA (6 Gb/s) SSD + 1 TB SATA hard drive @ 7,200 RPM
Operating system	Windows 10 Pro 64-bit	Windows 7 Professional 64-bit
Price	~$2,250	~$2,075

a ThinkStation P300 workstation built and tested three years prior, in mid-2015.

As reflected in the results of the SPECwpc Product Development test suite (this time v1.02; see **figure 2**), upgrading a 2015 workstation to a similarly priced 2018 model can deliver an overall speed-up running CAD-relevant workloads of roughly 60%. For those tests emphasizing CPU, memory, and I/O, the 2018 workstation outperformed its predecessor by close to 50%. And for interactive visualization of the usual 3D content produced in CAD packages like SOLIDWORKS, CATIA, and NX, the results get even more convincing, with the 2018 model delivering an average performance boost of around 160%.

» ***Figure 2 (below):*** *Relative CAD workload performance of a typical $2,000 mid-2018 entry-level CAD workstation compared to a typical $2,000 mid-2015 model (based on results of SPECwpc 1.02/Product Development test suite).*

Comparing Performance: 2015 Professional Workstation vs. 2018 Professional Workstation



Translating Higher Benchmark Scores into Improved Productivity

Solid-looking numbers all, but how do they translate into the day-to-day gains a user might expect in CAD productivity? While no benchmark can exactly emulate the content and workloads of any particular user, each does at least point to how much faster a machine will respond to the tasks given. For example, an edge in one 3D viewset subtest indicates how much faster that machine will rerender, zoom, and rotate a 3D model, with very little in the way of other computation or overhead. Accordingly, if your workflow is predominantly and consistently bottlenecked by interactive visualization of complex 3D models, SPECwpc's 3D viewset tests would give a reasonable indication of how much faster your machine will perform those primary tasks.

Even more convincing are the relative purchase prices, which in this exercise are roughly the same. But it's worth considering that the ultimate end-game should not be about an asset's acquisition cost, but rather its total cost of ownership (TCO). With its attention to reliability and manageability, a workstation's maintenance often is far less demanding of time and dollars than that of a PC.

In the end, a new workstation provides the most compelling IT investment, when compared to its two common alternatives.

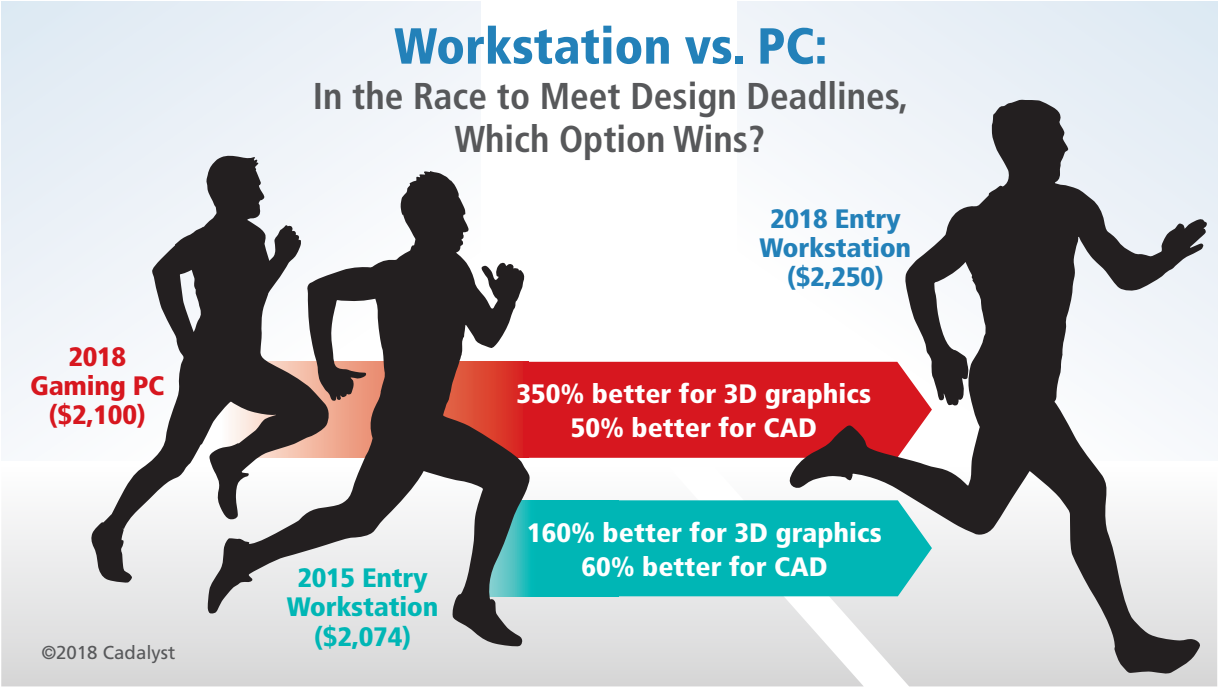
New Workstation, Old Workstation, or PC?

In the end, a new workstation provides the most compelling IT investment, when compared to its two common alternatives: purchasing a machine commonly marketed as a high-performance or gaming PC, or sticking with an older workstation. In both cases, our research shows that investing in a new workstation is the better avenue to shorten development times and improve productivity without breaking the bank.

With design features specifically geared to the priorities of CAD professionals, a workstation can deliver what a PC cannot. A focus on reliability permeates a workstation build, while performance tuned to CAD applications and workload delivers compelling speed-ups over the typical performance PC. Test results show superior throughput for workstations — often dramatically so —especially when tasked with 3D-oriented CAD workloads (**figure 3**). And, with competitive purchase prices combined with superior reliability and management, the workstation often turns out to be the less-expensive option over the life of the asset.

Waiting too long to upgrade an old workstation can also undermine the pursuit of optimal CAD productivity and business-case ROI. Thanks to the rapid, incessant advances in silicon technology, investing in a new workstation will deliver a radical leap in performance and capability over the same-priced machine of just three years ago. A current, updated workstation performs substantially faster on CAD-specific workloads and viewsets than an identically priced machine of three years ago.

Businesses depend on high-performance, reliable IT to deliver for customers, on schedule and to specification. They can't afford to waste time and money on a new resource that handcuffs productivity or one that has been pushed beyond its useful life. As supported



» ***Figure 3 (above):*** *A workstation offers plenty of performance-boosting reasons to choose it over a typical high-performance or gaming PC — and to refresh it before too long.*

both by the examination of its features and the results of its testing, a current workstation is definitively the superior tool for businesses that require an effective, productive CAD workflow. ◆

With more than 30 years of engineering, marketing, and management experience in the semiconductor industry, **Alex Herrera** *is a consultant focusing on high-performance graphics and workstations. Author of frequent articles covering both the business and technology of graphics, he is also responsible for the Workstation Report series, published by Jon Peddie Research.*

This white paper was produced by Cadalyst, the leading source of information about software and hardware technologies that support design and engineering workflows in the AEC, civil engineering, and manufacturing markets.

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