



Hardware Performance Guide

Serious 4K Editing

For today's content creators, one of the biggest market trends across the entertainment industry involves larger frame resolutions, from 4K to 6K and beyond. From electronics manufacturers to Hollywood film studios, everyone is looking to 4K and 6K to be the content delivery format that takes hold as the standard. Filmmakers such as David Fincher are already redefining what "HD" truly means for the future of filmmaking.

At the same time, the field of content creation is going through enormous changes with application updates that are released faster than ever before and new cameras and formats announced almost every month. These changes offer new capabilities and functionality, but they also pose challenges to video editors, who must now incorporate new video formats and frame rates. What's more, producers often expect unrealistic turnarounds regardless of larger frame sizes exponentially increasing file render times. This leaves editors scrambling for a solution as their current hardware struggles to keep up.

This white paper will identify areas of optimization that can help increase productivity, analyzing three essential tasks:

- **Large-format video editing** – Working with 4K or 6K material with the intent to output 4K broadcast or digital cinema
- **Motion graphics/3D animations** – The creation of computer-generated graphics and titles
- **Web video output** – The creation of video exclusively output to the web, including H.264 4K output for YouTube*

Large-Format Video Editing

It starts with the acquisition of video shot at a resolution of 4K (4,096 X 2,304 pixels) or 6K (6,144 X 3,456 pixels). For many years only a handful of 4K cameras were available, but now there are dozens to choose from, each with its own form of compression. In many cases it takes time for software manufacturers to deploy updated versions that are compatible with these new formats. Their file size compared to traditional HD can be a shock to editors: a single frame of standard HD video is 1,920 X 1,080 pixels, whereas 6K is nine times larger.

Increased file size impacts three aspects of computing: the central processing unit (CPU), random access memory (RAM), and storage. Editors are used to exploring video freely on the timeline by moving a playhead back and forth. The only way that editing software can enable this is to load multiple frames into RAM before and after the playhead. In the background the CPU decompresses the video, the storage moves the frames into memory, and the RAM fills up with data. If the components can't keep up, video playback is not smooth – a frustrating experience during critical editing sessions.

Additionally, editors often employ video effects (filters) such as color correction that require even more compute power. This is because every pixel on every frame now must undergo yet another calculation before it can appear onscreen. Many production effects are calculated using 32-bit floating-point math – exponentially larger than traditional 8-bit calculations. Some effects can be offloaded to a graphics processor unit (GPU) to allow the CPU to concentrate on other tasks, but if a particular effect has not been written to run off the GPU, then the processor must do double duty.

Editors often do more than straight-cut editing; they might also do compositing, in which elements shot before a green screen are layered on top of another background. It requires yet more compute power to remove the green screen background and composite the final image.



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All of these factors – large frames, color correction, and other filters, green screen effects, and more – pose a tremendous challenge to aging workstations that could handle standard HD. With the new demands, these workstations choke and sputter as they try to keep up. It's easy to see that the demands on any computer are pushed to the limit simply by increasing the frame size of video.

The good news: today's next-generation hardware is more than capable to handle large-format editing, even in real time.

Motion Graphics/3D Animations

Motion graphics artists create visually compelling imagery, either standalone or composited into other video elements. Motion graphics can take many forms, from simple titles to high-end 3D elements such as televised sports program openings and superhero blockbusters. 3D animations can require enormous compute power when they need to be rendered on the fly. These animation elements must be made to look "photorealistic," meaning viewers should be unable to distinguish reality from CGI (computer generated imagery). GPUs can accelerate 3D elements, enabling artists and editors to preview them in real time – although they still need to be rendered by the CPU for final output.

Motion blur, the soft blending of edges on moving objects, is another area of concern. This blur is essential for making a scene look real, but adding it can increase rendering time considerably. However, today's hardware enables content creators to work with motion graphics in near real time.

Example – 30 seconds of Motion Graphics

Adobe After Effects* Pixel Motion Blur

- Shutter Angle: 180.00
- Shutter Samples: 16
- Vector Detail: 20.0

Render Time (No Motion Blur): **1:27**

Render Time (With Motion Blur): **39:19**

Web Video Output

In terms of video formats, the web is a moving target: viewers benefit from better quality, faster streams, and smaller file sizes – but the trade-off is incompatibility and licensing issues. Uncompressed video is pristine but nearly impossible to play in real time, due mostly to the massive amount of data needed to transfer each full frame. Compressed video removes unneeded pixels so the final result looks as close to uncompressed as possible. The greater the compression, the more work done by the CPU to play that video back. The result: lower bandwidth streaming to the viewer's computer but stuttering playback. More compression also means the visual image will be degraded as the file size is reduced. The industry has standardized on several formats, H.264 being the most popular.

Quality is king in the online world, and content creators are constantly producing better-looking video with balanced compression and large frame sizes; YouTube now makes

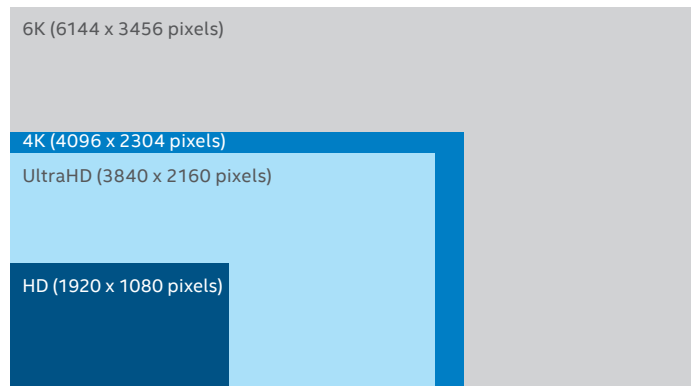


Diagram 1. Comparing screen resolutions.

2K and 4K content available. And, the trend is toward 4K computer displays and televisions, in response to the viewers' appetite for more original content.

Compressing high-quality H.264 files requires maximum CPU performance, sometimes resulting in hours-long render times for a single video.

Render Times

Workstation Used: Lenovo ThinkStation* P900 with 128 GB RAM and 28 cores (56 threads)

Time to encode 4K 51 GB UltraHD (3840 X 2160, 5-minute duration) video to YouTube: **12:25**

But, an upgrade to next-gen workstations can help cut rendering times and speed production dramatically.

Workstation Hardware Components

A workstation, like all computing devices, is an integrated system of hardware components and software programs, each doing a specific job.

Central Processing Unit (CPU)

The CPU, the main "brain" in any computer, handles all the calculations needed to process instructions before sending that information out to the user. For media creation, a fast CPU is key to increasing productivity, while multiple CPUs (dual sockets) can cut rendering time to a fraction. CPUs offer a wide range of functionality, including multiple cores and adjustable clock speeds, as content creators push boundaries to derive maximum power. Integrated graphics do not offer acceleration in Adobe Premiere Pro* and Adobe After Effects*.

It's important to note that software engineers must write specific code to take advantage of some features like multiple cores (multithreading) and virtual cores (hyper-threading). Mainstream applications like Adobe Premiere Pro and Adobe After Effects already take full advantage of these features. Often running multiple cores is more important than multiple GPUs, as not all instructions have been written to run outside the CPU. It's a common misconception that adding a GPU will automatically take and run all the regular instructions from the CPU. Software engineers must write applications to send instructions to a specific processor before they can expect speed improvements.

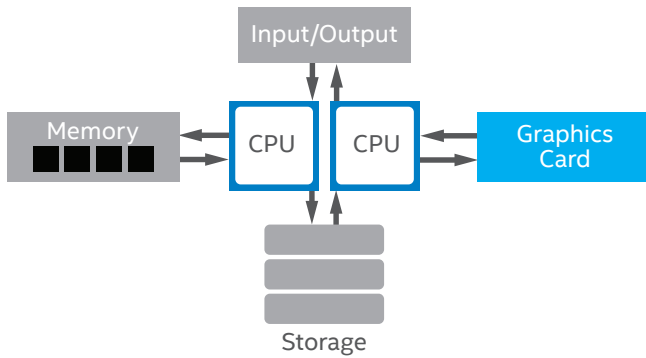


Diagram 2. Workstation architecture.

CPU advancement continues to move at blinding speed with new processors available often. The clock speed of newer CPUs may be listed as slower than an older CPU, but the new version might outpace the older CPU in overall performance.

Graphics Processing Unit (GPU)

A GPU is typically a video card that contains its own processing unit for parallel processing or calculating large blocks of data. This works well for operations such as color correction, but software must be written to send instructions to this external processor.

GPUs also typically hold more cores than a CPU; an application like Adobe Premiere Pro can render color correction in real time with the proper GPU. A CPU working in concert with the GPU gives users the best advantage in today's media creation world.

GPUs, like CPUs, come in many different configurations. This can be a concern for users who opt for inexpensive low-end cards, especially when the results lack the accuracy and reliability of higher-end cards. Content creators must also be diligent about keeping their drivers updated.

Random Access Memory (RAM)

RAM is the main holding area of the computing system, receiving instructions and passing them on to the correct location. The "random" part allows the computer to quickly access anything currently stored in RAM and that makes everything faster. Users who work with 4K video sometimes encounter the problem of "running out of RAM"; or, rather, not having enough RAM installed to work efficiently. RAM is faster than hard drive storage, so the goal is to keep as much information in RAM as possible. But, RAM in any computer is also being shared by other running applications as well as the operating system itself. Although 8 GB (gigabytes) of RAM sounds like a lot, closer examination might reveal that one-quarter of that is being used by the operating system, leaving only 6 GB for editing. Unless it's a dedicated workstation, a user might be running a video-editing program, a browser, email, a music program, and a social network program that are all grabbing the available RAM. Computers are designed to accommodate this, but it can still result in slower performance when working this way.

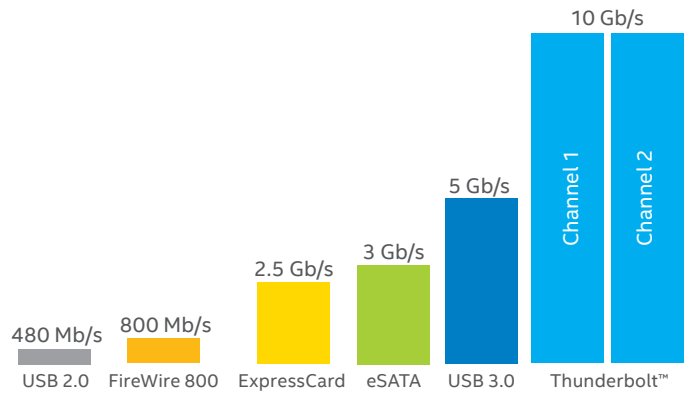


Diagram 3. Comparing throughput of data transfer interfaces.

Storage

It's important to stress the fact that efficient editing depends on the speed at which media is made available. SSD performance is essential when moving massive amounts of data such as large video frames.

Users today benefit from advanced storage technology and inexpensive options. The cost per GB is at an all-time low for hard drives, and the emergence of solid-state drives (SSDs) has dramatically accelerated storage access.

In a video-editing environment, storage is a huge concern because 4K and 6K video files require massive storage. In addition, media programs benefit greatly in performance by caching information that might be reused later. For example, if a program calculates an actor's skin tone to be "less red," the rendered result is saved to the cache. Later, if editors decide to change back to "less red," the adjustment happens faster because the computer has already calculated that effect before. But, caching multiple versions of an image file requires enough disk space to hold that information. This is why using a separate SSD as the cache makes a significant performance difference.

SSDs are now a standard component in new computers, especially for the boot drive to allow almost immediate start-up. SSDs differ from traditional hard drives in that they don't use spinning platters and moving arms to access data; instead they are essentially a collection of chips on a card. The trade-off is that they are not as large as hard drives and can be more expensive.

Many storage manufacturers offer multiple SSDs in a single box called a RAID (Redundant Array of Inexpensive Disks). Available as either an internal or external device, a RAID is fast because the path of information is larger than that of a single disk – the difference between a single-lane highway versus a multiple-lane interstate. When working with 4K video, a RAID is a must.

Finally, video editors must choose how to format their RAID; the two most popular formats are level 1 and 5. Level 1 offers full speed but no protection, so that if a disk fails, some data might be lost. For this reason, many editors choose level 5, which designates one drive as a fail-safe. It's a small trade-off: a slightly smaller RAID in return for data protection. And, the failed disk can be swapped out while the system is still up and running.

The Right Workstation For The Right Job

Large-Frame Video Editor

Use case configuration information:

- Two high-frequency, high core-count processors
- Graphics card with 4 GB of memory
- 64 GB memory
- SSD configuration

With all this in mind, it's time to make some decisions on performance and efficiency in editing. In the first example, the large-frame video editor is facing issues with CPU clock speed plus the number of cores, RAM, and storage as the main areas of concern.

One of the quickest ways to alleviate the load on a CPU is to spread the work across multiple CPUs, or dual-socket processors. The next obvious option is to optimize the use of multiple cores, especially if software is written to take advantage of them. Adobe Premiere Pro and Adobe Media Encoder* both take advantage of real and virtual cores (hyper-threading). So now when video is played, data decompression is spread over multiple cores for faster rendering and less stuttering playback.

Caching multiple versions of an image file requires enough disk space to hold that information. This is why using a separate SSD as the cache makes a significant performance difference.

Equally as important is RAM, but how much is enough? A minimum of 16 GB of RAM for HD is fine, but with 4K or 6K editing, that minimum rises to 32 GB or more.

Data must be quickly accessible to both the CPU and RAM so storage speed is crucial. Otherwise, starving the CPU and RAM of data results in slow performance, no matter how fast those other components are. This is where high-speed storage solutions such as SSDs and RAID configurations come into play. And, dedicating a separate cache space using inexpensive SSDs will help significantly. Next, make sure that media files are on a storage medium that is separate from the main internal drive (C: on Windows,* and Macintosh HD on the Mac*). The media access speed is also tied to what operations are happening on that drive. For example, the main storage drive runs the operating system and applications, and that drive is busy all the time, constantly accessing information from completely different parts of memory. The obvious choice is to have all media on a separate drive. It can be internal in a workstation or external via high-speed connection such as USB 3 or a Thunderbolt™ connector. Today, many manufacturers offer SSDs in a RAID; for large-format video editing, it's clearly the best option.

When using a program like Adobe Premiere Pro and incorporating multiple accelerated effects, then adding a supported GPU will make a big difference as the CPU and GPU work together in a complete solution. Adobe recommends a GPU with at least 768 MB of RAM, but 1 GB or more is a real-world benchmark. Remember that higher priced video cards do make a difference over inexpensive gaming cards.

“Better” and “Best” Base System Requirements for Large-Format Video Editing Systems

Recommended “Better” Base System		
Intel® Xeon® processor E5 v3 family	1 CPU – 12 cores	Minimum to playback 4K video and any other operations encoding.
Memory	32 GB RAM	4K frames require a large amount of memory to play back smoothly.
Graphics	1 GB of video RAM	The minimum for accelerated effects.
Storage	8 TB SSD RAID	Local, fast storage to hold media and output renders. Must be fast enough to deliver media for smooth playback.
Typical base workstations: Lenovo P900,* HP Z840,* Dell Precision* 7910, Boxx Apex* 4, Apple Mac* Pro		

Recommended “Best” Base System		
Intel Xeon processor E5 v3 family	2 CPUs – 12 cores each	Dual-socket workstation for maximum power to decode, encode and calculate non-accelerated effects.
Memory	64 GB RAM	More memory for loading more frames into memory.
Graphics	4 GB video RAM	More and faster memory to handle more video effects in real time.
Storage	12 TB SSD RAID	Hold even more data for playback and rendering.
Typical base workstations: Lenovo P900, HP Z840, Dell Precision 7910, Boxx Apex 4		

Motion Graphics/3D Animations and Compositing

Use case configuration information:

- Two high-frequency, high core-count processors; enable all available cores for rendering in Adobe After Effects
- Graphics card with 12 GB of memory
- 256 GB memory
- SSD configuration

Animators face many of the same issues, but one to address first involves CPU cores. Most 3D modeling and 2D animation programs require more computing power than a typical video editor would ever need. Even if they are using a GPU for faster previews, they'll still need a fast CPU for final rendering and compositing. Dual-socket CPUs, with software written to take advantage of multiprocessing, will make an immediate difference to workflow performance. Basically, more cores and threads help enable faster, better performance. The choice between faster clock speed/fewer cores versus slower clock speed/more cores is not as clear-cut; the recommendation is for faster clock speed.

RAM is much more critical for video editing because much of the content created in this workflow is virtual or computer-generated. Motion graphics artists typically create content that is so computationally intensive that smooth, real-time playback is only possible by pre-rendering the content into available RAM. But, RAM can fill up quickly and if users try to preview a 30-second animation with a minimum amount of RAM, they may only see five seconds because the RAM was filled to capacity. It's important to remember that the RAM

is holding not only the work created by the artist, but also the program, the operating system, and any other secondary programs running at that time.

Adobe After Effects can use all of a system's available cores for rendering, with significant performance results. But, this feature is not enabled by default, since every system might not have the required amount of RAM. The critical factor is the amount of RAM chosen in After Effects and the amount available in the workstation. Although users can select as little as 1 GB of RAM, the minimum recommended amount is 3 GB per core or thread. For example, a typical system with eight cores needs 3 GB per core, which equals 24 GB of RAM required by After Effects to run multiprocessing properly. Although that fits into a 32 GB computer, After Effects may still hold as much as 6 GB of RAM for other applications, bringing the full amount of RAM left for After Effects to 24, which is already close to the limit. This is noted because historically a large number of After Effects users will enable multiprocessing on systems with limited resources, resulting in slower rendering.

A minimum of 3 GB per available core is recommended, and it can be set as high as 6 GB.

Fast storage is also important to read information quickly, but it's not as critical as CPUs and RAM. A GPU will help with previewing 3D graphics using OpenGL, but final rendering will still be the job of the CPU. When using ray tracing in After Effects (with elements created in After Effects, not imported 3D models) then an NVIDIA GPU will allow faster previews.

“Better” and “Best” Base System Requirements for Motion Graphics/3D Animation Systems

Recommended “Better” Base System		
Intel Xeon processor E5 v3 family	1 CPU – 12 cores	Recommended CPU to process visual effects, filters, animations.
Memory	64 GB RAM	Recommended amount to facilitate real-time previews to RAM.
Graphics	2 GB video RAM	Recommended amount of RAM for 3D rendering and playback.
Storage	8 TB SSD RAID	Recommended fast media storage and rendering.
Typical base workstations: Lenovo P900, HP Z840, Dell Precision 7910, Boxx Apex 4, Apple Mac Pro		

Recommended “Best” Base System		
Intel Xeon processor E5 v3 family	2 CPUs – 24 cores each	More power to render more complex animations.
Memory	256 GB RAM	3 GB per thread for Adobe After Effects* multi-processing support.
Graphics	12 GB video RAM	GPU rendering power needed for high-end 3D animation and effects.
Storage	12 TB SSD RAID	Recommended fast media storage and rendering.
Typical base workstations: Lenovo P900, HP Z840, Dell Precision 7910, Boxx Apex 4		

Web Video Output

Use case configuration information:

- Two high-frequency, high core-count processors; enable all available cores for rendering in Adobe After Effects
- Graphics card with 4 GB of memory
- 64 GB memory
- SSD configuration

The most critical part of web video output is the speed of compression for web formats such as H.264; larger format output such as 4K for YouTube will push the limits of computing even further. To that end, fast dual-socket CPU solutions such as the Intel® Xeon® processor E5 are an ideal choice. RAM and fast storage are equally as important for loading as much data into RAM as possible and to write the final output file to disk. A GPU will help if any accelerated effects are used in the timeline in Premiere Pro or if the video has been scaled at all. And, video editors should understand that adding a GPU does not help with general playback or editing.

“Better” and “Best” Base System Requirements for Web Video Output Systems

Recommended “Better” Base System		
Intel Xeon processor E5 v3 family	1 CPU – 12 cores	Recommended cores for encoding highly compressed web video formats like H.264.
Memory	32 GB RAM	Recommended amount to hold more frames in memory.
Graphics	1 GB video RAM	Minimum required for rendering accelerated effects.
Storage	8 TB SSD RAID	Fast local storage for projects before and after encoding.
Typical base workstations: Lenovo P900, HP Z840, Dell Precision 7910, Boxx Apex 4, Apple Mac Pro		

Recommended “Best” Base System		
Intel Xeon processor E5 v3 family	2 CPUs – 12 cores each	Dual-socket workstation delivers more computing power for encoding.
Memory	64 GB RAM	More memory to process more frames.
Graphics	4 GB video RAM	More and faster GPU for processing effects and scaling.
Storage	12 TB SSD RAID	Fast local storage for projects before and after encoding.
Typical base workstations: Lenovo P900, HP Z840, Dell Precision 7910, Boxx Apex 4		

Conclusion

The media creation industry is advancing rapidly and the only way to keep ahead of the curve is to have the hardware to support larger formats and richer content. Hardware vendors are delivering workstations that will give content creators the speed and power required to efficiently work with 4K media, and software vendors are writing software that fully takes advantage of multiple CPUs, massive RAM, and GPUs. Whether you're outputting the next blockbuster feature film or creating a new UltraHD web series, the power exists today to deliver the performance needed to keep your production on time and realize your creative vision.

For More Information

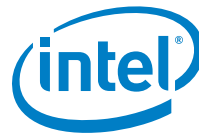
Adobe Creative Cloud* – www.adobe.com/creativecloud.html

HP Workstations – www8.hp.com/us/en/campaigns/workstations/overview.html

Lenovo Workstations – shop.lenovo.com/ca/en/workstations/thinkstation/p-series/p900/#tab-features

Current Video Editing Workstations

HP Z840* Workstation	
Processor	Dual Intel® Xeon® processors E5 (up to 36 total processor cores in one system)
Memory	Up to 2 TB RAM
Hard Drive	Up to 600 GB SAS (15000rpm) and up to 10 internal drive bays
PCI Slots	7
Lenovo ThinkStation* P900 Tower Workstation	
Processor	Dual Intel® Xeon® processors E5 v3
Memory	Up to 512 GB RAM
Hard Drive	Up to 600 GB SAS (15000rpm) and up to 10 internal drive bays
PCI Slots	8 PCI slots
Apple Mac Pro*	
Processor	3.0 GHz 8-core Intel® Xeon® processor E5
Memory	Up to 64 GB RAM
Hard Drive	Up to 1 TB of PCIe*-based flash storage
Video	Dual AMD FirePro* D300 (no NVIDIA options)
PCI Slots	All storage and cache is external via Thunderbolt™ connectors
Promise Pegasus2* Series Storage	
RAID Array	Windows* and Mac* compatible



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