



Optimizing Hardware Systems for Adobe® Premiere® Pro CC, After Effects® CC, SpeedGrade™ CC, and Photoshop® CC

The artist's guide to configuring or upgrading a computer to get the most out of these cornerstone video software applications.

Today's digital content creators demand more performance from their systems—especially as they take on an ever-widening array of jobs at ever-larger media sizes. However, not all editors, colorists, and graphic artists are also computer hardware specialists. This document will discuss how you—a user of Adobe Premiere Pro CC, After Effects CC, SpeedGrade CC, and Photoshop CC software—can analyze your needs based on the type of work you do. With this information, you can then either choose a new computer system or enhance an existing one with simple add-in components that will deliver optimal performance for your unique set of requirements. The goal is to balance the components of your system to deliver the performance your specific tasks require. This allows you to focus on your own creativity while efficiently delivering what your client needs.

We will explore this in three stages:

- **Hardware:** Explain the major hardware components of a computer system, and their role in the overall performance of a video workstation.
- **Software:** Discuss the hardware demands of Adobe Premiere Pro, After Effects, SpeedGrade, and Photoshop, highlighting which functions will benefit the most from specific hardware improvements.
- **Making Choices:** Summarize this information into hardware recommendations for common tasks.

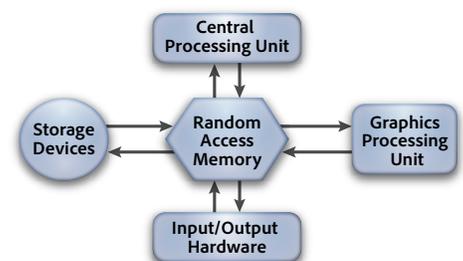
The Major Hardware Components

We will be covering four major areas of hardware when we discuss optimizing your system's performance: the Central Processing Unit, Graphics Processing Unit, Random Access Memory, and Storage Devices. If you are already well versed in the subject of computer hardware, you may skip straight to the section *Identifying Performance Bottlenecks*. If you are more of an artist than a computer wizard, it will be helpful to have an understanding of these major components so that you can feel confident making decisions about configuring the right computer system for your needs. To provide an overview, the accompanying illustration shows how these major areas are interconnected.

Central Processing Unit (CPU): This is the brain of your computer. Computers may have one or more CPU chips, and each chip may have multiple "cores" or processing units embedded in a physical chip. Generally, more physical cores means more processing power, which means software runs faster—although some software now uses the GPU (Graphics Processing Unit) as much as the CPU; more on that below.

Another issue you will hear mentioned is "hyper-threading." Using this technology, a single physical processor core may appear as two virtual cores to the operating system and the software that runs under it.

These are helpful when you have one instance of software that can take advantage of multiple processors (a capability known as "multithreading"); however, these virtual cores are not used when multiple instances of software are each looking for their own processor to run on. This is a subject we will discuss in more depth in the section on After Effects and multiprocessing.



Other Considerations

Although this document is focused on configuring your hardware for optimal performance, there are many things you can do as a user to optimize your software, operating system, and—perhaps most importantly—how you use them. One useful resource is this Adobe blog post on optimizing performance in Adobe Premiere Pro and After Effects (tinyurl.com/AdobePWP-02).

In addition to optimizing your hardware, some of the simplest actions you can take to save you time in the long run are using auto save or constantly saving your project to incremental version numbers, making it easier to go back to an earlier version of a project should disaster strike—or the client changes their mind. Also make sure you have your client's delivery requirements in writing before you start a job—then design your workflow around those requirements, such as correct image size and frame rate. It's always faster to do a job right the first time.

But whether you're doing a job for the first, second, or umpteenth time, having an optimized system means optimal efficiency. And that's what we'll be discussing in this document.

Another measure of computing power is the speed that the processing unit runs at. This "clock rate" (the master pulse that pushes along the processing steps) is usually expressed as GHz (gigahertz). When the same model of processing unit is used, a higher clock rate results in faster computation. However, newer generations of processing units often can perform more work at the same clock rate, meaning a newer chip with a lower clock rate might still run software faster than an older chip with a higher clock rate—so ask if the computer you're interested in uses the latest, fastest generation of CPU available for it (such as the Intel® Xeon® processor E5-2600v2 product family). In some cases, CPUs with higher core counts run at lower clock rates than their fewer-core cousins. Also note that "mobile" versions of CPUs for laptop and similar applications might not be as powerful as their desktop computing relatives; this is a tradeoff many hardware designers make to conserve battery usage. To sort all this out, spend some time researching benchmarks that compare relevant systems using the software you're interested in, such as MacPerformanceGuide.com (tinyurl.com/AdobePWP-18) for Adobe Photoshop on Mac OS.



Graphics Processing Unit (GPU): Today's video cards and display systems contain their own specialized processing units, capable of rapidly executing a specific set of commands for manipulating and displaying images. GPUs have hundreds or thousands of cores built for parallel processing, compared to a CPU that typically has 4 to 6 cores. Significant portions of Adobe software have been written to run on your computer's GPU rather than CPU to take advantage of this processing power. Therefore, it is often possible to realize a specific performance boost just by replacing your video card. Similarly, an otherwise powerful computer may be accidentally handicapped by an incompatible or underpowered GPU. The list of approved GPUs for your chosen software will help you select the best graphics card for your needs.

Today's GPUs are all compatible with the OpenGL (Open Graphics Library) standard. At its core, OpenGL is a means of drawing images on the screen. It can combine images or process an image, and that result can be fed back to memory to be sent for further processing by the CPU or GPU. This allows certain image processing tasks to be significantly accelerated by virtually any video card or display chip. All of the software discussed in this document take advantage of OpenGL.



NVIDIA® has developed their own parallel computing platform and programming model called "CUDA" that runs on their own GPUs (tinyurl.com/AdobePWP-17). Adobe Premiere Pro and After Effects make specific use of CUDA and its related technologies (such as NVIDIA's OptiX™ Ray Tracing Engine) to wring more performance out of specific GPUs. Therefore, when we mention that a function *requires* CUDA or OptiX, this performance acceleration is only available using NVIDIA CUDA-enabled video cards and display systems (listed later in this document).

Also of importance is OpenCL (Open Computing Language), an open standard supported by many companies such as AMD and NVIDIA. OpenCL has the ability to give any application access to the graphics processing unit for non-graphical computing. More Adobe applications—such as Adobe Premiere Pro CC and Photoshop CC, as of the time this document was updated (February 2014)—are using OpenCL to accelerate tasks previously reserved for OpenGL or CUDA.



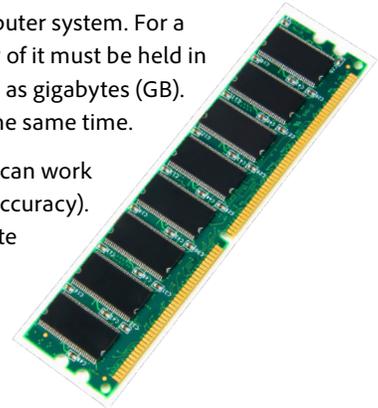
Video card software drivers are updated often. One of the best things you can do to ensure compatibility and performance is to proactively check for and update your specific video card's drivers.

(Install the CUDA driver when using NVIDIA cards; the performance is often better than using OpenCL as a default on their cards.) Also check the system requirements for your chosen software to see if any additional GPUs have been added to the qualified list; this list is different for each.

For maximum performance, video cards must have a high-speed connection to your CPU. In workstation-style computers, this is governed by the speed of the physical slot the card is inserted into. If you are installing your own graphics card, make sure you put it in a slot marked "16x" or "16 lane"—not a smaller number like 8x or 4x, which transfer data at slower speeds.

Random Access Memory (RAM): This is the hub of your computer system. For a program to be executed or an image to be manipulated, a copy of it must be held in your computer's memory. The amount available is often stated as gigabytes (GB). More memory means more software programs can be run at the same time.

Memory also has a direct connection to the size of images you can work on—both in terms of pixel dimensions and in bit depth (color accuracy). Larger amounts of memory are also often required to composite multiple images together, or to perform certain operations on them. If you don't have enough memory to hold the images being manipulated, the system must "swap out" portions of memory to and from your computer's hard drive, which slows down your computer considerably.



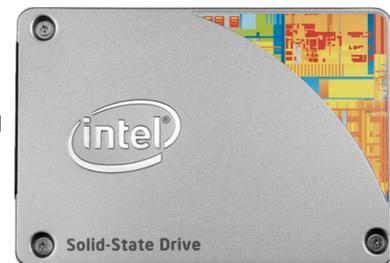
Both your CPU and GPU have their own dedicated RAM; GPU-specific memory is often referred to as VRAM (Video RAM) or texture memory. You cannot add VRAM to your GPU, so choosing a card with more memory on it means it can process larger images more quickly. However, you can usually add more RAM to your computer for its CPU. This is particularly an issue when taking advantage of multiprocessing with After Effects, which we will discuss later.

Storage Devices: There are two parameters to think about when considering disk drives and other storage devices: size, and speed. Size—stated in gigabytes (GB) or terabytes (thousands of gigabytes, abbreviated as TB)—is obvious: The more storage you have, the more media you can have connected at one time. Some media formats—such as HDV and AVCHD—are heavily compressed, meaning you can fit a large amount of running time of footage onto a relatively modest-sized drive. However, as you upgrade to larger frame sizes, lighter compression, and data-rich formats such as Camera Raw, you will need correspondingly larger drives.

Larger file sizes also require higher transfer speeds to be able to play back one or more streams of video in real time. File transfer speed is a function of both the drives themselves, and the physical connection to those drives. For internal storage connections, most computers use a variation of the Serial Advanced Technology Attachment (SATA) standard, which is very fast. Once you start connecting to external drives, you need to worry more about the speed of the connection you're using, with fiber channel being the fastest, followed by Thunderbolt, USB3, and FireWire 800.

There are several components that affect a drive's transfer speed. One important number to look for is the drive's internal platter rotational speed, stated as RPM (Revolutions Per Minute). Although RPM is similar to a CPU's GHz rating—not all drives or CPUs are created equal—a higher number is generally better. You should consider at least 7200 RPM drives for video work. The other major component that affects a drive's speed is its "seek time" which defines how long it may take the drive's "head" which reads and writes data to move between different sections of the same drive to access different pieces of data.

These physical limitations are why Solid State Drives (SSDs) are becoming popular for high performance applications: There is no platter to spin, and essentially no time is required to seek between different pieces of data. SSDs are currently more expensive than spinning-platter drives, but are excellent choices for cache drives, as well as for your software and operating system.



Multiple drives may be used to deliver higher performance. A simple technique is to install multiple single drives in a desktop workstation computer, and dedicate each to specific tasks: for example, one for the operating system, one for your files (with potentially separate drives for your

sources and output, especially for Adobe Premiere Pro), and one for your temporary storage caches. Some laptop users also replace their optical drive with a second drive—usually an SSD. This particularly helps overcome the problem of a single drive seeking back and forth to deliver different pieces of requested data.

An alternate solution is to connect multiple drives together into a Redundant Array of Inexpensive Drives (RAID), which delivers maximum performance. RAID Level 0 system is the simplest, delivering higher performance with no additional functionality. A RAID Level 1 copies the same data to redundant drives, so that if one drive fails, you still have another copy of your data. However, note that RAID 1 has no performance advantage over ordinary individual drives. Higher RAID levels provide both higher performance and additional data protection, including the ability to rebuild missing data when a failed drive has been replaced. A RAID 5 system with three or more drives is a common high-end choice for both increased performance and data protection.



Hardware Solutions

Now that you have an understanding of the major hardware components, let's look at the basic hardware capabilities and expansion possibilities for some commonly available computer systems. Some users will go as far as to build their own workstations from individual components in an attempt to optimize performance. As the possibilities are near-infinite—and outside of the core skill set of many video and graphics artists—we will focus on common commercially-available systems in this document.

In many cases, the quest for performance leads to solutions that may be more readily available in workstation computers than laptops or other all-in-one systems. Two common examples of workstations popular among video artists are the HP Z820 and the previous generation of the Apple Mac Pro. Here are the expansion options for these two systems (as of February 2014):



HP Z820

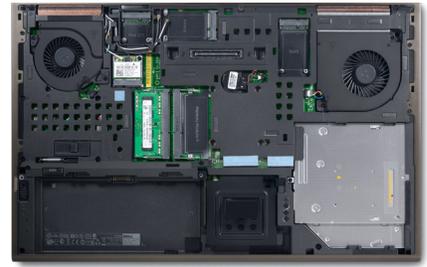
- **CPU:** 4 to 16 physical cores; 16 core clock rates up to 3.1 GHz
- **GPU:** May be pre-ordered from HP with a large selection of NVIDIA or AMD video cards. Contains 3 PCI Express Gen3 "16 lane" slots suitable for video cards; 7 slots total.
- **RAM:** 16 DIMM slots capable of holding up to 512GB of memory; 4 memory channels per CPU (installed memory should be identical for each processor core for maximum performance)
- **Storage:** Three externally-accessible 5.25" drive bays plus four internal 3.5" drive bays. Up to five 3.5" or six 2.5" drives may be installed, in addition to optical storage device.



Apple Mac Pro ("2010" generation)

- **CPU:** 4 to 12 physical cores; 12 core clock rates up to 3.06 GHz
- **GPU:** May be pre-ordered from Apple with choice of two different AMD video cards. Contains 2 PCI Express Gen2 "16 lane" slots suitable for video cards; 4 slots total.
- **RAM:** 8 DIMM slots capable of holding up to 64GB of memory*; 3 memory channels per CPU (installed memory should be identical for each processor core for maximum performance; Apple makes available a "Memory DIMMs DIY" PDF with suggested configurations)
- **Storage:** Two externally-accessible 5.25" drive bays plus four internal 3.5" drive bays. Third-parties offer brackets to use one 5.25" bay to hold additional storage devices.

Many users enjoy the flexibility and freedom of using laptop computers or mobile workstations. Previously, laptop computers did not have the performance as desktop systems, but that has been changing. For example, here are configuration options for the Dell Precision mobile workstation:



Dell Precision™ M6800 Workstation

- **CPU:** 4 physical cores; clock rates up to 3.0 GHz
- **GPU:** May be pre-ordered from Dell with an NVIDIA Quadro K5100M, K4100M, K3100M, or AMD Firepro M6100
- **RAM:** Up to 32GB of memory
- **Storage:** Up to three internal 2.5" internal drive bays, optional SSD, mSATA solid state storage and support for RAID 0, 1, or 5

In general, to optimize a laptop or desktop all-in-one computer (such as an HP Z1 or Apple iMac) for digital video work, you should get the fastest CPU available, check the available GPU options to make sure they align with the requirements of the software you plan to use, maximize the installed RAM, and consider adding a second drive—an SSD, if possible. If your laptop or mobile workstation supports it, configuring the internal storage as a RAID can also greatly enhance performance. You can also add external drives using Thunderbolt, eSata, FireWire 800, or USB.

The new generation ("2013") Apple Mac Pro is a hybrid system, in that it features workstation power (4 to 12 core Intel Xeon E5 CPUs, 12 to 64 GB of RAM, and dual AMD FirePro D300, D500, or D700 GPUs), but has some restrictions on user expandability: It contains six Thunderbolt 2 and four USB3 ports, but no PCI slots, internal hard drive bays, or user-changeable GPUs. However, Adobe Premiere Pro can already take advantage of the dual GPUs in the 2013 Mac Pro for rendering and exporting. Compared to running in CPU-only mode on a 2.7 Ghz 12-core 2013 Mac Pro, joint Adobe/AMD tests have found that common Adobe Premiere Pro tasks run 5.9 to 6.5 times faster using one A700 GPU, and 11.0 to 11.6 times faster using both GPUs. The internal PCIe flash drive is also extremely fast (roughly twice as fast as a top-of-the-line SATA SSD) for system and software access as well as for media and caches.



Those with previous-generation Mac Pro computers who are not in a position to buy a new computer need not despair; you can upgrade your current computer. According to NVIDIA, for a common set of tasks in Premiere Pro, adding a pair of their Quadro® K5000 cards and an SSD to a 12-core 2010 Mac Pro will yield slightly greater performance than a 2013 12-core A700 Mac Pro.

And that is the point of this paper: To inform you of the decisions you can make to optimize your chosen system for the tasks you're performing with Adobe video software.

Identifying Performance Bottlenecks

Adobe Premiere Pro, After Effects, SpeedGrade, and Photoshop each place unique demands on the major hardware components discussed above. Even different tasks performed inside the same software may vary these requirements drastically. In this section, we will state the basic system requirements for each software package, and then discuss specific demands and potential performance bottlenecks that may lead you to go beyond those basic requirements to optimize your own experience.



Adobe Premiere Pro CC

Basic System Requirements:

Windows

- Intel® Core™2 Duo or AMD Phenom™ II processor; 64-bit support required
- Microsoft® Windows® 7 with Service Pack 1, Windows 8, or Windows 8.1 (all 64-bit versions)
- 4GB of RAM (8GB recommended)
- 4GB of available hard-disk space for installation; additional free space required during installation (cannot install on removable flash storage devices)
- Additional disk space required for preview files and other working files (10GB recommended)
- 1280x800 display
- 7200 RPM hard drive (multiple fast disk drives, preferably RAID 0 configured, recommended)
- Sound card compatible with ASIO protocol or Microsoft Windows Driver Model
- QuickTime 7.6.6 software required for QuickTime features
- Optional: Adobe-certified GPU card with at least 1GB VRAM for GPU accelerated-performance
- Internet connection and registration are necessary for required software activation, membership validation, and access to online services. †

Mac OS

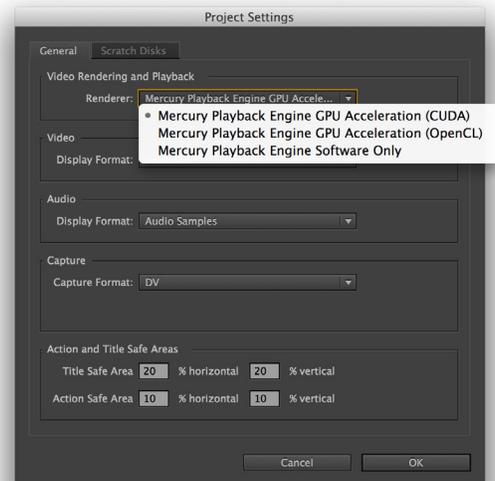
- Multicore Intel processor with 64-bit support
- Mac OS X v10.7, v10.8, or 10.9
- 4GB of RAM (8GB recommended)
- 4GB of available hard-disk space for installation; additional free space required during installation (cannot install on a volume that uses a case-sensitive file system or on removable flash storage devices)
- Additional disk space required for preview files and other working files (10GB recommended)
- 1280x800 display
- 7200 RPM hard drive (multiple fast disk drives, preferably RAID 0 configured, recommended)
- QuickTime 7.6.6 software required for QuickTime features
- Optional: Adobe-certified GPU card from list on the next page with at least 1GB VRAM for GPU accelerated-performance
- Internet connection and registration are necessary for required software activation, membership validation, and access to online services. †

Check the Adobe Premiere Pro CC technical specs web page on Adobe.com (tinyurl.com/AdobePWP-04) for updates.

A core performance feature in Adobe Premiere Pro is the Mercury Playback Engine (MPE), which optimizes video processing calculations during previewing, exporting, scrubbing, and other functions in addition to playback. MPE employs multithreading to take advantage of multiple CPU cores (both real and virtual) to accelerate these functions. The speed of encoding and decoding the wide range of media types Adobe Premiere Pro can handle is also dependent on your CPU.

Additionally, if your computer has an OpenCL-compatible AMD or CUDA-enabled NVIDIA graphics card or chip installed, it can also take advantage of a qualified GPU to greatly accelerate a number of functions by a factor of up to eight times that of high-end multicore CPUs. As noted on the previous page, Adobe Premiere Pro can also take advantage of multiple GPUs installed inside the same computer—including the new 2013 model Apple Mac Pro—for even greater performance.

Functions that are accelerated include a growing list of effects and transitions (see the sidebar on the next page), scaling including different pixel aspect ratios, deinterlacing, frame rate differences, blending modes, color space conversions, and alpha channel interpretation. Additionally, LUT (color lookup table) processing is accelerated by OpenGL, OpenCL, and/or CUDA.



Below is a list of approved video cards and chips to maximize the performance of the MPE as of February 2014; check Adobe Premiere Pro's technical specs on Adobe.com (tinyurl.com/AdobePWP-04) for updates to this list to reflect new hardware:

OpenCL and CUDA Accelerated Effects and Transitions in Adobe Premiere Pro CC:

- Additive Dissolve
- Alpha Adjust
- Basic 3D
- Black & White
- Brightness & Contrast
- Color Balance (RGB)
- Color Pass
- Color Replace
- Crop
- Cross Dissolve
- Dip to Black
- Dip to White
- Directional Blur
- Drop Shadow
- Extract
- Fast Blur
- Fast Color Corrector
- Feather Edges
- Film Dissolve
- Gamma Correction
- Garbage Matte (4, 8, 16)
- Gaussian Blur
- Horizontal Flip
- Invert
- Levels
- Luma Corrector
- Luma Curve
- Lumetri
- Noise
- Proc Amp
- RGB Curves
- RGB Color Corrector
- Sharpen
- Three-way Color Corrector
- Timecode
- Tint
- Track Matte
- Ultra Keyer
- Video Limiter
- Vertical Flip
- Warp Stabilizer

Supported graphics cards for GPU of Mercury Playback Engine acceleration in Adobe Premiere Pro CC (as of February 2014):

OpenCL for Windows:

- AMD Radeon 6650M, 6730M, 6750, 6750M, 6770, 6770M, 6950, 6970, 7510M, 7530M, 7550M, 7570, 7570M, 7590M, 7610M, 7630M, 7650M, 7670, 7670M, 7690M, 7730M, 7750, 7750M, 7770, 7770M, 7850, 7850M, 7870, 7970M, 7950, 7970, 8470, 8550M, 8570, 8570M, 8670, 8670M, 8690M, 8730M, 8740, 8750M, 8760, 8770M, 8790M, 8870, 8950, 8970, 7480D, 7540D, 7560D, and 7660D
- AMD FirePro M2000, V3900, M4000, V4900, W5000, V5900, M5950, M6000, S7000, W7000, V7900, W8000, S9000, W9000, and S10000

OpenCL for Mac OSX:

- AMD Radeon HD 6750M, 6770M, and 7950; FirePro D300, D500, and D700
- NVIDIA GT 650M and 670M; GTX 675MX, 680, and 680MX; Quadro K5000

NVIDIA CUDA for Windows:

- Tesla™ C2050, C2070, C2075, M2050, M2070, K10, and K20 (when paired with a Quadro cards as part of an NVIDIA Maximus™ configured system)
- Quadro CX, FX 3700M, FX 3800, FX 3800M, FX 4800, FX 5800, 2000, 2000D, 2000M, 3000M, 4000, 4000M, 5000, 5000M, 5010M, 6000, K1100M, K2000, K2000M, K2100M, K3000M, K4000, K4100M, K4000M, K4100M, K5000, K5000M, and K6000
- GeForce GT 650M or 750M; GTX 285, 470, 570, 580, 675MX, 680, 680MX, 690, 770, 780, and Titan

NVIDIA CUDA for Mac OSX:

- Quadro CX, FX 4800, 4000, and K5000
- GeForce GT 650M and 750M; GTX 285, 675MX, 680, and 680MX

(*M designates mobile solution for laptops and all-in-one computers)

For maximum performance, make sure any add-in video card is installed in a 16x PCI slot inside the host computer. Adobe Premiere Pro CC may also take advantage of multiple compatible GPUs installed in the same computer. And again, check the Adobe Premiere Pro CC technical specs web page on Adobe.com (tinyurl.com/AdobePWP-04) for updates; software updates may add support for new hardware.

This—*together with the speed of your storage devices (discussed below)*—has a direct impact on the number and size of streams of video that may be played back in real time. It also affects rendering time of your final output. For example, NVIDIA performed a test using a timeline consisting of six layers of video with Tint effects, 3-way color correction, Gaussian blurs, the Ultra keyer, text layers, and layer blend effects. This was rendered for H.264 BluRay output with MRQ (Maximum Render Quality) enabled. The times required for this job were (times are stated as minutes:seconds):



Render Times for Example Timeline in Adobe Premiere Pro:

4:50.4	CPU only (dual 8-core 3.1 GHz Xeon E5 2687W PC)
0:59.8	NVIDIA Quadro K2000
0:31.8	NVIDIA Quadro K4000
0:25.8	NVIDIA Quadro K5000
0:17.7	NVIDIA Quadro K6000
0:13.8	dual NVIDIA Quadro K6000

As a natural consequence of the above, Adobe Premiere Pro is as sensitive to the amount of GPU memory available as normal CPU memory. Whether the OpenCL or CUDA hardware acceleration portion of the Mercury Playback Engine can process a frame depends on the size of the frame compared to the amount of GPU memory. To be processed with OpenCL or CUDA, a frame requires (width x height) ÷ 16,384 megabytes. If that value exceeds the available memory, Adobe Premiere Pro will use the CPU for rendering of that current segment. This becomes a consideration for larger digital cinema formats: For example, a 5120x2700 pixel "5k" frame from a RED camera requires 843MB of free GPU memory. This is on the edge of what can be supported by a card with 1GB of total GPU memory (as some memory needs to be reserved for other display functions), but would work comfortably on a card with 1.5 or 2GB of GPU memory. Bottom line: If you plan to be working with large image sizes, get a GPU with more than 1GB of VRAM.

Adobe Premiere Pro is highly dependent on the speed of your storage media. You will enjoy better performance and fewer dropped frames if you use multiple drives to spread the work load. At a minimum, you should consider a two-drive system, with one drive containing your operating system, software, and media cache, while the other is used for your source files, previews, and final exported renders. Preferred is a four-drive system, with one dedicated to the operating system and software, the second for source media and project files, the third for the media cache, and the fourth for previews and exports.

To play back digital cinema files or multiple streams of HD (High Definition) video files without dropped frames or other interruptions, you should consider a RAID. A RAID can be used in lieu of additional drives for everything except your operating system and software. To give an example of performance, a RAID system such as a G-Technology G-SPEED eS PRO with four 7200 RPM drives can play back:

- 4 streams of 1080i AVCIntra footage
- 6 streams of 1080p H.264 Canon 5D footage
- 8 streams of RED 4k R3D files
- 14 streams of 1080i XDCAM EX, 1080p DVCPROHD, or 1080i HDV
- 40 streams of DV NTSC

(In addition to file size demands, different codecs require differing amounts of processing power to decode and play back in real time. That's why so many more streams of DVCPROHD can be played back than Canon 5D H.264 footage.)

Some hardware cards may also be used to accelerate media encoding and decoding. For example, RED Digital Cinema makes the RED ROCKET that enhances transcode and playback abilities of R3D files in various resolutions in real time speeds. Multiple RED ROCKET cards may be used in one system to boost system performance when working with R3D files.

Adobe's Mercury Transmit technology gives Adobe I/O hardware partners, such as AJA, Black Magic Design, Bluefish444, Matrox, and MOTU, direct access to the Mercury Playback Engine, so you experience better playback performance. When using external broadcast monitors, you'll get full-screen playback while maintaining all the real-time performance benefits of the Mercury Playback Engine. Note that some NVIDIA and AMD video cards allow for 4K hardware monitoring via HDMI and Display Port. By adding a 4K monitor with one of these ports to your work flow, you now monitor in full 4K resolution.

As stated in the introduction, Adobe has created numerous documents and videos that go into more detail on how to improve performance when using Adobe Premiere Pro (tinyurl.com/AdobePWP-02).





After Effects CC

Basic System Requirements:

Windows

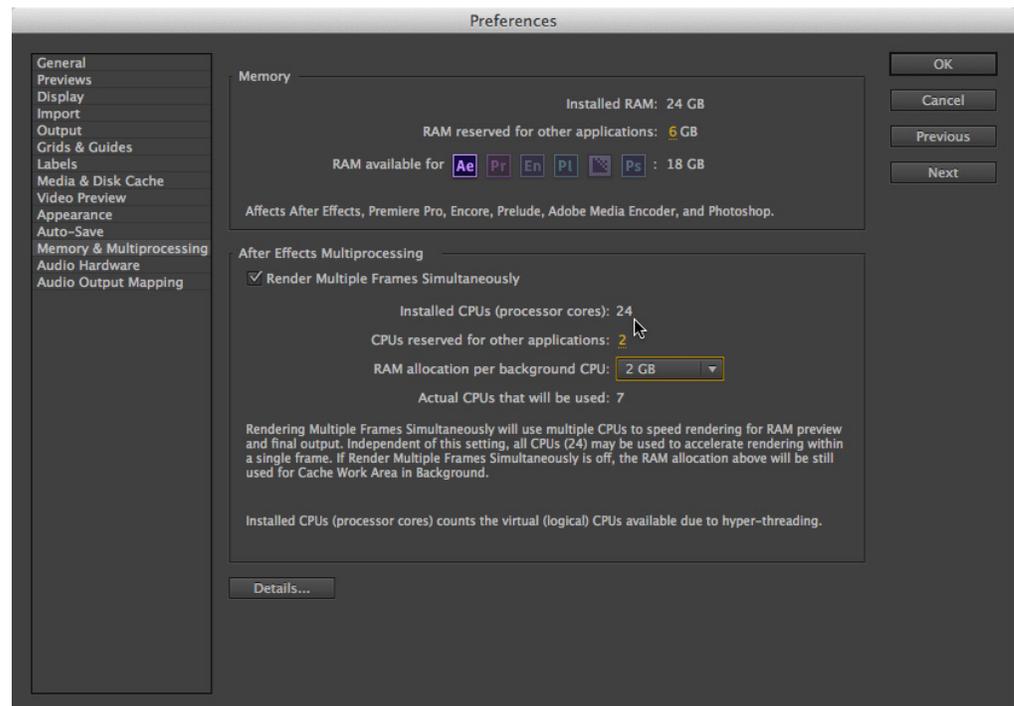
- Intel® Core™2 Duo or AMD Phenom™ II processor; 64-bit support required
- Microsoft® Windows® 7 with Service Pack 1, Windows 8, or Windows 8.1 (all 64-bit versions)
- 4GB of RAM (8GB recommended)
- 5GB of available hard-disk space; additional free space required during installation (cannot install on removable flash storage devices)
- Additional disk space for disk cache (10GB recommended)
- 1280x900 display
- OpenGL 2.0–capable system
- QuickTime 7.6.6 software required for QuickTime features
- Optional: NVIDIA GPU card with at least 1GB VRAM for GPU-accelerated ray-traced 3D renderer*
- Internet connection and registration are necessary for required software activation, membership validation, and access to online services. †

Mac OS

- Multicore Intel processor with 64-bit support
- Mac OS X v10.7.4, v10.8, or 10.9
- 4GB of RAM (8GB recommended)
- 5GB of available hard-disk space for installation; additional free space required during installation (cannot install on a volume that uses a case-sensitive file system or on removable flash storage devices)
- Additional disk space for disk cache (10GB recommended)
- 1440x900 display
- OpenGL 1.5- or 2.0–capable system
- QuickTime 7.6.6 software required for QuickTime features
- Optional: NVIDIA GPU card with at least 1GB VRAM and CUDA 5.0 for GPU-accelerated ray-traced 3D renderer
- Internet connection and registration are necessary for required software activation, membership validation, and access to online services. †

Check the After Effects CC technical specs web page on Adobe.com (tinyurl.com/AdobePWP-06) for updates.

After Effects CC takes advantage of all the CPU power available to it. Many After Effects features are accelerated on a multiprocessor system through the use of multithreading, where it employs all of the cores—both real and virtual—available to it in order to process imagery.



In addition, After Effects may also be set in Preferences > Memory & Multiprocessing to Render Multiple Frames Simultaneously. When this multiprocessing option is enabled, After Effects will launch additional copies of itself in the background, each processing individual frames for RAM Previews and final renders. Note that multiprocessing can only use physical processor cores, not virtual cores created by hyperthreading; you should also reserve at least two physical cores for the operating system and other software running at the same time. To translate this theory to a

Note: A small subset of functions in After Effects—including the Ray-traced 3D rendering engine and some third-party effects that need to access multiple frames across time to render the current frame—disable multiprocessing, but in these instances After Effects still takes advantage of multithreading to use all available processor cores to render a single frame.

typical application, a computer with 12 physical cores may appear to the operating system as having 24 cores, but in reality you can safely assign a maximum of 10 CPUs (processor cores).

Certain functions in After Effects CC are accelerated by the GPU in your computer using OpenGL, including some Fast Previews settings for 3D compositions and the drawing of images to the Composition, Footage, and Layer panels. Additionally, the Ray-traced 3D rendering engine introduced in After Effects CS6 is massively accelerated by the presence of a compatible CUDA-enabled NVIDIA graphics card or chip set.

Supported graphics cards for GPU for Ray-traced 3D Renderer in After Effects CC (as of February 2014):

NVIDIA CUDA for Windows:

- Tesla C2075 (when paired with a Quadro cards as part of an NVIDIA Maximus configured system)
- Quadro CX, FX 3700M, FX 3800, FX 3800M, FX 4800, FX 5800, 2000, 2000D, 2000M, 3000M, 4000, 4000M, 5000, 5000M, 5010M, 6000, K2000, K2000M, K2100M, K3000M, K3100M, K4000, K4000M, K4100M, K5000, K5000M, K5100M, and K6000
- GeForce GTX 285, 470, 570, 580, 590, 670, 675MX, 680, 680MX, 690, 760, 770, 780, and Titan

NVIDIA CUDA for Mac OSX:

- Quadro FX 4800, 4000, and K5000
 - GeForce GT 650M; GTX 285, 675MX, 680, and 680MX (*M designates mobile solution for laptops and all-in-one computers)
- For maximum performance, make sure any add-in video card is installed in a 16x PCI slot inside the host computer.

Check the After Effects CC technical specs web page on Adobe.com (tinyurl.com/AdobePWP-06) for updates; software updates may add support for new hardware.

As is the case with the Mercury Playback Engine in Adobe Premiere Pro, if a supported CUDA card is not installed, the ray-traced renderer will fall back to using the available processor cores. However, if a CUDA-enabled card is present, After Effects CC uses NVIDIA's CUDA to massively speed up ray-tracing calculations:



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Render Times for a Suite of Five Compositions with Ray-traced 3D Layers in After Effects:

65:42.3	CPU-only (8-core 3.47 GHz Intel Xeon 5690 PC)
12:21.1	NVIDIA Quadro K2000
06:18.8	NVIDIA Quadro K4000
04:39.7	NVIDIA Quadro K5000
02:20.3	NVIDIA Quadro K6000
01:40.7	dual NVIDIA Quadro K6000

After Effects users have also been quite active in performing their own benchmark tests for a variety of configurations; you can download these results here: tinyurl.com/AdobePWP-16.

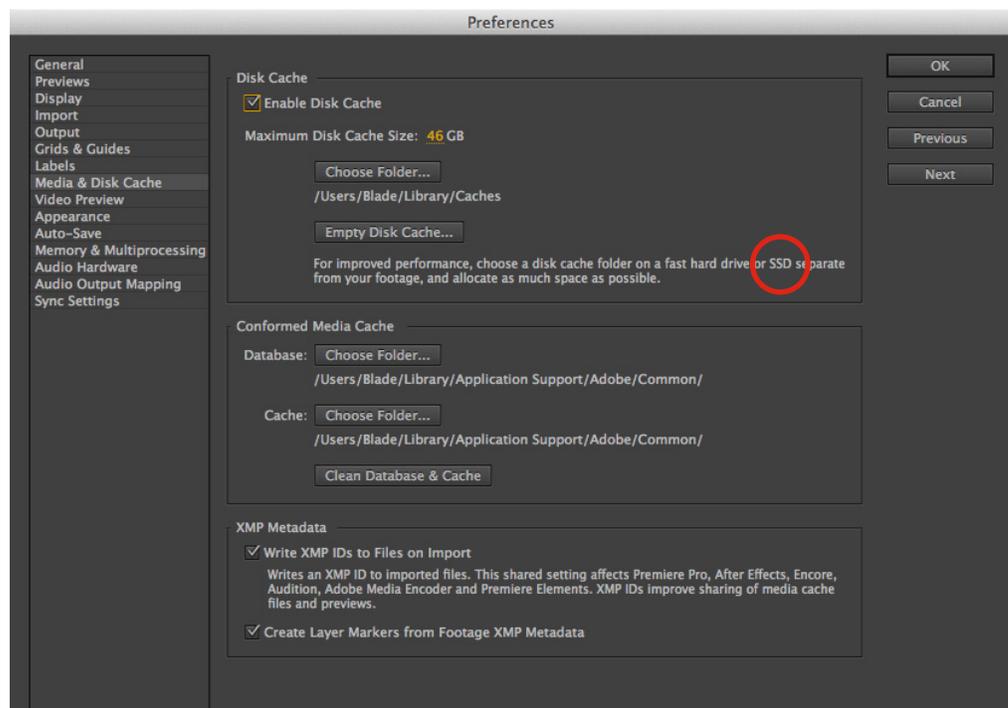
Note that ray-traced 3D in After Effects can take advantage of multiple GPUs running the same version of CUDA in the same system, as is the case with the Maximus configurations or dual Quadro GPUs. (Check the NVIDIA website tinyurl.com/AdobePWP-07 for the CUDA version supported by various cards: For example, a Quadro FX 4800 supports CUDA 1.3, while a Quadro 4000 supports CUDA 2.0—so you cannot combine these two different-generation cards and expect a performance gain over the fastest single card.)

Another consideration is how much VRAM the video card supports: Among other things, more VRAM means larger images can be used for Environment Layers in After Effects, which allows higher-quality renderings of these panoramic wrap-around worlds.

Global Performance Cache

After Effects also benefits from having more RAM installed. Available memory is used to store the RAM Preview cache for real-time playback, including the Global RAM Cache feature that remembers previously-previewed frames and compositions even from other projects. More RAM increases the amount of time and frame size that can be cached for playback or later recall. Enabling multiprocessing also uses additional RAM. At least 2 GB (preferably 3 GB) should be assigned to each background process. In the scenario mentioned earlier, if you want to use 10 cores for multiprocessor previews and rendering, you will need 30 GB of RAM installed in addition to RAM reserved for the normal foreground copy of After Effects, the operating system, and any other software currently running.

Since After Effects uses RAM instead of drives for real-time playback, it is not as sensitive to storage speed as Adobe Premiere Pro or SpeedGrade. Nonetheless, storage speed still affects how fast sources can be read into memory to be composited, as well as how fast rendered frames can be rendered back to disk. Drive speed becomes more of an issue when considering the Global Performance Cache: The speed of your cache drive directly affects how fast frames can be swapped between the RAM and disk caches, plus a faster cache drive means more frames are retained as opposed to re-rendered if needed.



At a minimum, place your media and cache on a separate drive than used by the system, so that normal system memory swapping does not compete with After Effects for disk access. Ideally, you would also dedicate a separate very fast drive such as an SSD or Fusion ioFX for the Persistent Disk Cache in After Effects CC, as it uses this to save already-previewed frames to reuse later. If you do not plan on enabling multiprocessing, you can use the same drive for both source media and your render destination, as After Effects does not read and write at the same time; if you do plan on enabling multiprocessing, then it is best if the sources were on their own drive separate from your render destination as the different background rendering processes may be trying to read and write at the same time.

As noted in the introduction, don't overlook software settings and work habits as another source of increased performance and productivity. The After Effects online Help file (tinyurl.com/AdobePWP-08) contains an extensive list of suggestions and links to related resources.



SpeedGrade CC

Basic System Requirements:

Windows

- Intel® Core™ i5 or i7 processor with 64-bit support
- Microsoft® Windows® 7 with Service Pack 1, Windows 8, or Windows 8.1 (all 64-bit versions)
- 4GB of RAM (8GB recommended)
- 2 GB of available hard-disk space for installation
- 1440x900 display required; 1920x1080 display and second professionally calibrated viewing display recommended
- OpenGL 2.0–capable system
- Dedicated GPU card with at least 1GB VRAM is required: (NVIDIA Quadro 4000, 5000, or 6000 recommended for optimal performance)
- QuickTime 7.6.8 software required for QuickTime features
- Optional: Tangent Element control surface recommended. Tangent CP200 family and Tangent Wave control surface are also supported.
- Internet connection and registration are necessary for required software activation, membership validation, and access to online services. †

Mac OS

- Multicore Intel processor with 64-bit support
- Mac OS X v10.7, v10.8, or 10.9
- 4GB of RAM (8GB recommended)
- 2 GB of available hard-disk space for installation
- 1440x900 display required and second professionally calibrated viewing display recommended. 15" Retina version Mac Book Pro with NVIDIA GeForce GT 650M processor recommended
- OpenGL 2.0–capable system
- Dedicated GPU card with at least 1GB of VRAM recommended (NVIDIA Quadro 4000 for optimal performance)
- QuickTime 7.6.8 software required for QuickTime features
- Optional: Tangent Element control surface recommended. Tangent CP200 family and Tangent Wave control surface are also supported.
- Internet connection and registration are necessary for required software activation, membership validation, and access to online services. †

Check the SpeedGrade CC technical specs web page on Adobe.com (tinyurl.com/AdobePWP-09) for updates.

The Lumetri Deep Color Engine in SpeedGrade CC uses massive parallel processing in a single GPU running OpenGL for optimum graphics performance. This makes SpeedGrade unique among the software discussed here in that virtually the entire program runs on the GPU in your computer, rather than the CPU. The power of your single GPU will affect how many layers of color grading—including masking, filters, and effects—you can apply to a clip and still be able to preview the results in real time; other computationally intensive processes such as de-Bayering ARRIRAW footage are also performed on the GPU. A card such as the NVIDIA Quadro 4000 provides a good baseline for most color grading tasks. Similarly, SpeedGrade is more sensitive to the amount of VRAM on your GPU than RAM available to your CPU; 1 GB of VRAM and at least 4 GB of system RAM will suffice.



In addition to processing images, for proper evaluation of your footage during grading you need a storage system capable of playing back at least a single stream of your chosen media format in real time; it is best to plan on playing back two streams so you can use two timeline playheads for shot matching. Using Direct Link, Speedgrade CC utilizes Adobe Premiere Pro's Mercury Playback engine; indeed, it can even load its .prproj files. Therefore, all of the advice stated earlier about configuring a system for Adobe Premiere Pro CC applies to Speedgrade CC as well. If you are working in typical compressed High Definition (HD) formats such as HDV, AVCHD, or H.264, a single 7200 RPM or faster drive with a FireWire 800 or faster connection will work well. For digital cinema applications, consider a RAID with a fast interface and data rates high enough to sustain full-speed playback.



Photoshop CC

Basic System Requirements:

Windows

- Intel® Pentium® 4 or AMD Athlon® 64 processor (2GHz or faster)
- Microsoft® Windows® 7 with Service Pack 1, Windows 8, or Windows 8.1
- 1GB of RAM
- 2.5GB of available hard-disk space for installation; additional free space required during installation (cannot install on removable flash storage devices)
- 1024x768 display (1280x800 recommended) with OpenGL 2.0, 16-bit color, and 512MB of VRAM
- Internet connection and registration are necessary for required software activation, membership validation, and access to online services. †

Mac OS

- Multicore Intel processor with 64-bit support
- Mac OS X v10.7, v10.8, or 10.9
- 1GB of RAM
- 3.2GB of available hard-disk space for installation; additional free space required during installation (cannot install on a volume that uses a case-sensitive file system or on removable flash storage devices)
- 1024x768 (1280x800 recommended) resolution display with OpenGL 2.0, 16-bit color, and 512MB of VRAM
- Internet connection and registration are necessary for required software activation, membership validation, and access to online services. †

Check the Photoshop CC technical specs web page on Adobe.com (tinyurl.com/AdobePWP-10) for updates.

As is the case with After Effects, Photoshop CC makes significant use of the CPU. Most Photoshop CC features are faster on a multiprocessor system, with some features taking particular advantage of additional cores including Adobe Camera Raw (ACR) processing, Lens Blur, Radial Blur, Field Blur, Iris Blur, and Tilt/Shift. Only a few functions—such as reading PSD files, or the healing brush—are limited to single core due to the algorithms they use.

Beyond the CPU, the Mercury Graphics Engine in Photoshop CC includes features that use your single GPU for acceleration. In Photoshop CC this engine delivers near-instant results when editing with key tools such as Smart Sharpen, Liquify, Blur Gallery, Warp, Lighting Effects and the Oil Paint filter, plus delivers a more responsive, fluid feel as you work. The Mercury Graphics Engine uses both the OpenGL and OpenCL frameworks.

OpenGL GPU-accelerated display and image processing functions in Photoshop CC include the Adobe Color Engine (ACE), Pixel Grid, Smooth Pan/Zoom/Scrubby Zoom, Bird's Eye View, Flick Pan, Rotate Canvas, the Heads-Up Display (HUD) Color Picker, on-canvas brush resizing and rich cursor info, Bristle Tip Preview, 3D (including Extrude, formerly known as Repoussé), Liquify, Adaptive Wide Angle, Lighting Effects Gallery, Oil Paint Filter, new 3D enhancements such as Draggable Shadows, Ground Plane and ground plane reflections, Roughness, On-canvas UI controls, Light widgets, and the image-based light controller, plus GPU previews for Warp and Transform including Puppet Warp and Content Aware Scale. Additionally, Photoshop CC can take advantage of OpenCL acceleration for Iris Blur, Field Blur, Tilt-Shift, and Smart Sharpen. OpenCL acceleration is also used for mouse-down interactive previewing in the Blur Gallery features (1GB of VRAM required).

In order to take advantage of the Mercury Graphics Engine in Photoshop CC, you must have a supported video card and updated driver. If you do not have a supported card, performance may be degraded. In most cases the acceleration is lost and the feature runs in the normal CPU mode. However, there are some features that will not work without a supported video card. Also, mixing multiple video cards of different models in the same computer may cause problems in Photoshop.

Tested and Approved Video Cards for Photoshop CC (as of February 2014):

- NVIDIA Quadro 2000, 4000, 5000, 6000, K600, K2000, K4000, and K5000
- NVIDIA GeForce 400, 500, and 600 series
- AMD Radeon 5000, 6000, 7000 series, and 7950
- AMD FirePro A300, A500, A700, 3800, 4800, 5800, 7800, 8800, 9800, 3900, 4900, 5900, and 7900
- AMD FireGL W5000, W7000, and W8000
- Intel HD Graphics P3000, P4000, and P4600/P4700

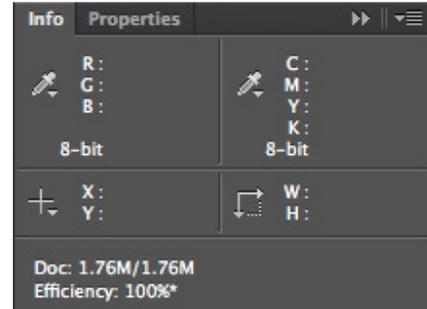
The benefit of using the GPU for image processing can be significant for some functions. For example, AMD has found that enabling OpenCL can increase Smart Sharpen tasks by over twentyfold, with choice of video card making a large difference:

Render Times for Smart Sharpen in Photoshop CC (Intel Xeon 2.13 GHz E5506 PC)

8:49.5	CPU-only (OpenCL off)	0:23.5	OpenCL with AMD FirePro W5000
8:43.8	CPU-only (OpenCL off)	0:16.8	OpenCL with AMD FirePro W7000
8:46.7	CPU-only (OpenCL off)	0:12.3	OpenCL with AMD FirePro W8000
8:42.0	CPU-only (OpenCL off)	0:11.2	OpenCL with AMD FirePro W9000

Another factor to keep in mind is that Photoshop utilizes RAM to process images. If Photoshop has insufficient memory, it uses the connected storage device designated in its Preferences as a "scratch" disk to process information. Therefore, increasing the amount of RAM in your computer will enable you to work on more and larger images inside Photoshop.

How much RAM is enough? Watch the Efficiency indicator (available at the bottom of each image's window) while you work in Photoshop to determine when Photoshop maxes out on RAM and starts using the scratch disk, which slows performance. Click the pop-up menu at the bottom of the image window and choose Efficiency. (You can also view the Efficiency status in the Info panel.) If the Efficiency value is below 100%, Photoshop is using the scratch disk and, therefore, is operating more slowly. If the efficiency is less than 90% to 95%, allocate more RAM to Photoshop in Performance Preferences or add additional RAM to your system. 4GB will cover most digital photography uses; 8GB leaves room for other apps and fits huge documents in RAM.



If you are unable to add more RAM to your computer, then install or connect a fast drive and designate it as your scratch disk. An SSD (Solid State Drive) or the PCIe flash storage in the new generation Apple Mac Pro are the fastest solutions; an external RAID 0 system connected by Thunderbolt, USB3, or FireWire 800 is a workable alternative if you are unable to add internal storage.

Photoshop performance is discussed in greater detail in this Adobe Knowledge Base article (tinyurl.com/AdobePWP-11). For more on video card usage in Photoshop CC, visit the relevant Help page (tinyurl.com/AdobePWP-13).

Summary: Choosing the Right Tools for the Job

Now that you have an understanding of the major hardware components, and how Adobe Premiere Pro, After Effects, SpeedGrade, and Photoshop interact with them, you can make informed decisions on what options to order for your next computer system, or how to upgrade your existing computer to work more efficiently.

CPU: After Effects CC and Photoshop CC benefit the most from faster CPUs and more CPU cores. Indeed, given sufficient RAM (discussed earlier), After Effects CC is capable of running multiple copies of itself on individual physical cores to speed previews and rendering. Although Adobe Premiere Pro CC's Mercury Playback Engine (MPE) also benefits from faster CPU configurations, as noted earlier using an approved AMD OpenCL or NVIDIA CUDA-enabled GPU accelerates MPE by an even larger amount and is preferred. On the other hand, if you are relying on the relatively few functions in Adobe Premiere Pro that are not accelerated by the MPE—for example, if you are primarily converting media from one codec to another, rather than combining multiple streams of different-sized media—then CPU power is more important to you. SpeedGrade CC runs almost entirely on the GPU rather than the CPU, so if that is the only software you intend to use, then the CPU is far less important.

Note that Adobe Premiere Pro CC, After Effects CC, Speedgrade CC, and Photoshop CC run locally on your computer—not over the internet—so the speed of your internet connection will not affect the performance of these applications.

GPU: A faster compatible OpenGL video card will allow you to perform more real-time processing with the Lumetri Deep Color Engine in SpeedGrade CC, and will also accelerate numerous functions (outlined earlier) with the Mercury Graphics Engine in Photoshop CC. It will also give incremental performance boosts to Adobe Premiere Pro and After Effects.

As detailed earlier in this document, to really get performance improvements with the Mercury Playback Engine (MPE) in Adobe Premiere Pro CC you need to use an approved CUDA-compatible GPU from NVIDIA or an OpenCL-compatible AMD GPU. Note that Adobe Premiere Pro can also take advantage of multiple GPUs in the same system (such as a new generation Mac Pro). As a bonus, both Adobe Premiere Pro and SpeedGrade can utilize an NVIDIA Quadro SDI Output card. If an approved OpenCL or CUDA-enabled card or chipset is simply not an option for you, then choose a computer with the maximum number of CPU cores available to help make up the difference.

Note that if you rely heavily on ray-traced 3D in After Effects CC, it requires an approved CUDA-compatible GPU from NVIDIA for true acceleration. After Effects can also take advantage of multiple cards running the same version of CUDA. For example, if we compare the render times for the transparent and reflective logo seen earlier in this document (times in minutes:seconds):

44:30	CPU-only (12-core 2.93 GHz Xeon Mac Pro)
14:30	one NVIDIA Quadro FX4800
6:15	one NVIDIA Quadro 4000
3:37	two NVIDIA Quadro 4000s

In short, it is worth upgrading to newer generation cards, and installing multiple cards if possible. In that vein, note that an HP Z820 has three 16-lane PCIe slots that can accept GPUs. Again, for maximum performance make sure any add-in video card is installed in a 16x PCI slot inside the host computer. For more on choosing the right GPU, refer to this blog (tinyurl.com/AdobePWP-12) by Adobe Pro Video & Audio Field Team manager David Helmlly. Both AMD (tinyurl.com/AdobePWP-14) and NVIDIA (tinyurl.com/AdobePWP-15) also have web pages dedicated to helping you choose the right GPU for your Adobe Creative Cloud video application.

RAM: If you plan to primarily run After Effects CC, then you will directly benefit from installing more RAM. Although the stated minimum is 4 GB of memory, if you plan on taking advantage of multiprocessing, you should consider installing as much as 48 GB for a 12-core system and 64 GB for a 16-core system (check with the manufacturer for optimal memory configurations to complement your CPU). You can install even more RAM for longer previews and Global RAM Cache memory, and to run other programs at the same time as After Effects.

If you plan to use Adobe Premiere Pro, 4 or 6 GB of RAM is minimum, while 8 or 12 GB is suggested for most users. SpeedGrade is the least RAM-dependent of the applications discussed here; 4GB is the minimum recommended amount, with 8 GB preferred. Although Photoshop's Minimum System Requirements states only 1 GB is needed, you should consider allocating 4 GB, with 8 GB allowing you to work on very large documents.

Remember that each of these numbers are for the software running alone (along with the operating system); add at least their minimum requirements together if you plan on having them open at the same time.

Storage: A recurring theme you may have noticed in this document is that employing multiple drives is the secret to optimizing performance. As stated earlier, you should consider a two-drive system as a minimum configuration, with one drive containing your operating system, software, and media cache or scratch disk, while the other is used for your source files, previews, and final exported renders. Preferred is a four-drive system, with one dedicated to the operating system and software, the second for source media and project files, the third for the media cache or scratch disk, and the fourth for exports and final renders. You can use a RAID (Redundant Array of Inexpensive Drives) in lieu of multiple non-system individual drives. An SSD (Solid State Drive) is an excellent choice for your media cache/scratch disk; PCI-based storage devices such as the Fusion ioFX provide even higher performance.

Although Adobe Premiere Pro, After Effects, Speedgrade, and Photoshop all benefit from faster drive configurations, Adobe Premiere Pro (and by extension, Speedgrade CC as it uses Premiere Pro's playback system and can load its project files) is the most sensitive as you will inevitably want to play multiple media streams in real time. A drive system that isn't fast enough doesn't just mean a longer wait, it means dropped frames and jumpy playback. Although you can do a remarkable amount with a single source drive (7200 RPM or faster) with a speedy connection, if you plan to work with larger digital cinema formats, you need to consider moving up to a RAID. In addition to transfer speed, look at the specification for disk seek times as well: For example, for a single stream of 2k-pixel 10 bit DPX frames, your drive system will need to transfer frames of data at 270 MB per second while also performing a head seek potentially on every frame—every 42 msec for 24 FPS (frames per second) source.

Keep in mind that your computer system is an interconnected unit; not just a collection of individual components. The goal is a balanced system with sufficient performance in every area required, rather than a system that's really fast in one area but deficient in others. For example, there is little point in having a large number of processor cores if you don't have enough RAM installed to use multiprocessing in After Effects—if you are on a budget, you may be better off spending it on more RAM rather than a hotter CPU. Similarly, the GPU can be even more important than the CPU if you plan to edit multiple streams of media in Adobe Premiere Pro, use ray-traced 3D rendering in After Effects, or are a colorist interested in SpeedGrade.

And as we mentioned in the introduction, there are many things you can do as a user to optimize your software, operating system, and—perhaps most importantly—how you use them. A good starting point is the Adobe video team's blog (tinyurl.com/AdobePWP-02), as well as the online Help files for each program as well as the numerous blogs dedicated to each program published by Adobe personnel (blogs.adobe.com).

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