



A Primer on Electronic Imaging Archiving

April 2006

A Primer on Electronic Imaging Archiving

Primer Overview

High-speed video cameras are widely used to capture fast moving objects. The captured video is played back at a speed much slower than the real-time record rate. Real-time is often referenced as 30 frames per second (fps) but in our applications, 1000 to 250,000 fps is what we mean as real-time, the @ speed recording. After viewing the images in slow motion, you may need to save the images. The images are often megapixel size, meaning they have over 1 million pixels in the picture. Therefore, a megapixel color image can be easily over 3 megabytes per image. The total size of a large image file can easily exceed 40 Gigabytes of storage, the entire disk size of some laptops! Downloading images from a megapixel high-speed event can be very time consuming. Some useful techniques can be used to improve the download time. Also, choosing the right hardware that matches or exceeds the maximum download speed from a camera can reduce the time archiving the images. This paper will give you the background to make the tradeoffs that can help to optimize your download performance.

The paper is arranged into six (6) sections that address important topics regarding electronic image archiving. Here is a short summary of these topics.

1. **Calculating a single image & total image recording size.** Discussion on how to determine the size of any given image and how much storage capacity will be required to save the entire sequence. You will be given some specifics on how to reduce the size of your data to the minimum information you may require.
2. **Choosing an image format.** Discussion on the most popular image formats used in high speed imaging. Various pros & cons to each format is given including the portability of the format to 3rd party software.
3. **Common digital interfaces for transferring images.** Performance and other aspects to the various interfaces found on high-speed digital cameras. Some information ancillary is given on the physical standards (i.e. cable length, transmission rate) as well as exceeding a standard's limit.
4. **Where to invest in performance on your computer.** Discussion about computer performance related to transferring large images sequences for archiving. A common platform is used as a baseline and various areas that increase performance are rated relative to the baseline.
5. **Image file management.** Techniques are discussed to help manage large image data files including how to identify camera parameters later after the sequence has been archived.
6. **Fast Start Reference Table.** An outline form of the most important techniques that can improve your download rate.

Calculating a single image and total image recording size

The size of an image is dependant on the number of pixels contained within the XY area of the image, the pixel depth and color depth.

$$\text{Image Size} = X_{\text{pixels}} \times Y_{\text{pixels}} \times (\text{Bits}_{\text{pixel}} / 8) \times \text{Depth}_{\text{color}}$$

Example:

$$\text{APX-RS Image Size} = 1024 \times 1024 \times (10/8) \times 3 = 3,932,160 \text{ bytes}$$

Reducing the image size to the minimum required

1. Decrease the XY resolution to the minimum Field-Of-View needed to capture what you are trying to see. Some high-speed video systems can only reduce the resolution by increasing the frame rate resulting in no reduction of data for the same record time. The Photron Ultima cameras can reduce the resolution and keep the frame rate the same resulting in a reduction of image size. A smaller image size means that the time to download the image will be faster.
2. If the camera's pixel depth (i.e 10-bits) is greater than what is required to display your images (i.e 8-bits), select an image format (i.e. Jpeg is only 8-bits) that is only for 8-bit images. This will reduce the image size by 25%.
3. If you have a color camera and it is capable of downloading RAW images, use this format since the image size will be 1/3 that of a color image. Later, when there is time to deal with larger images after a test, the image can be reread as a RAW format and resaved as a full color image.
4. Saving an image in a compressed format will reduce the image size saved but it will also increase the time to save the image. This is due to the processing time to convert the image into a compressed format.

Example (continued – reduced):

$$\text{APX-RS Image Size} = 1024 \times 512 \times (8/8) \times 1 = 524,288 \text{ bytes or } 87\% \text{ decrease}$$

Total Image

$$\text{Recording Size} = X_{\text{pixels}} \times Y_{\text{pixels}} \times (\text{Bits}_{\text{pixel}} / 8) \times \text{Depth}_{\text{color}} \times \text{Frames}_{\text{total}}$$

Example (4000 frames):

$$\text{APX-RS Image Size} = 1024 \times 1024 \times (10/8) \times 3 \times 4000 = 15,728,640,000 \text{ bytes}$$

Reducing the total image record size to the minimum required

1. Downloading the full recording (all frames) may not be required if there are frames with no significant data. Therefore, select only the minimum number of frames. Set the starting and ending frame that you want to download.

Choosing an image format

Most high-speed video cameras have BMP, TIFF and AVI image formats for download. However, these image formats have only 8-bits per image plane (i.e. RGB color image has 3 planes: R, G & B). Further more, the AVI format can be compressed with an method (CODEC) that may not be compatible on another computer. Some image formats take more processing than other formats. As you can imagine, there is more to selecting an image format than you may expect. The Photron cameras have the following image formats:

BMP: BMP or DIB (device-independent bitmap) is a bitmapped graphics format used internally by the Microsoft Windows graphics subsystem (GDI), and used commonly as a simple graphics file format on that platform. The file format extension is .bmp.

TIFF: This is the acronym for Tagged Image File Format, a graphic file format standard (TIFF 6.0, 1992) developed by Aldus and Microsoft. TIFF described here is what is called the baseline standard. TIFF is used to exchange files between applications and computer platforms. TIFF is a flexible bitmap image format that is supported by virtually all paint, image-editing, and page-layout applications. TIFF supports RGB, CMYK, and grayscale color models, 8-bits per image plane, which means 8-bit grayscale or 24-bit color. Typically, .tif is used as the extension in Windows OS and. tiff in Macintosh OS. The standard can be found at:

<http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf>

TIFF Extensions: TIFF Extensions are TIFF features not found in a TIFF baseline image. However, all TIFF image programs may not support these extensions. Photron has taken advantage of the TIFF extensions to enable saving of 10-bit images. Photron calls this TIFF extension TIFF (2.0).

JPEG: JPEG stands for Joint Photographic Experts Group, a graphical format that is widely used in imaging programs. The JPEG file format is an 8-bit per image plane compressed format, with some loss of quality during compression. The size of a JPEG file is generally smaller in size than other formats. Common file formats extensions are .jpg, .jpeg, and .jpe.

PNG: PNG (Portable Network Graphics), an extensible file format for the lossless, portable, well-compressed storage of raster images. PNG provides a patent-free replacement for GIF and can also replace many common uses of TIFF. Indexed-color, grayscale, and true color images are supported, plus an optional alpha channel. Sample depths range from 1 to 16 bits. However, the format is not widely supported in common image programs.

AVI: AVI stands for Audio Video Interleave and is currently the most common file format for storing audio/video data on the PC. AVI's are 8-bit per image plane. This file format conforms to the Microsoft Windows Resource Interchange File Format (RIFF) specification, which makes it convenient for sharing the image sequence between computers. AVI files (which typically end in the .avi extension) require a specific player that supports.

RAW: A RAW image format contains minimally processed data from the image sensor. RAW literally means unprocessed or uncooked. RAW images must be processed and converted to RGB format if it is a color image. Photron however, does not limit RAW as a unprocessed image. The "Bayer" check box must be selected to save the RAW image as an unprocessed image. RAW images have 8-bits per image plane.

RAWW: A RAWW image format contains minimally processed data from the image sensor. RAWW images must be processed and converted to RGB format if it is a color image. Photron however, does not limit RAWW as a unprocessed image. The “Bayer” check box must be selected to save the RAWW image as an unprocessed image. RAWW images have up to 16-bits per image plane. Photron cameras save RAWW images with 10-bits contained within the 16-bit image plane.

FTIFF - This is a Tagged Image File Format that is specifically assigned to Photron. The format has additional data about the image, how it was created and other ancillary information that is written into what is called TAGS. These TAGS are defined by the format. FTIFF has 8-bits per image plane. This format is very similar to KODAK MASD TIFF format.

Choosing what is best for your image requirements:

Format	Advantage	Disadvantage	Maximum pixel depth per plane	Image Size (1K x 1K) KB
BMP	Compatible with all Windows viewers	-----	8	3073
TIFF (1.0)	Most compatible format with 3 rd party software programs Supports multiple images per TIFF file Supports uncompressed & compressed images	TIFF 6.0 standard limits file size to 4.3 GB	8	3077
TIFF (2.0)	10-bit format	Some 3 rd party image programs do not read 16-bit TIFF	16	6153
JPEG	Compressible with the best image quality	Compressed format meaning image quality is less than Tiff	8	860
PNG	Most widely used 10-bit format	Some 3 rd party image programs do not read PNG	16	3660
AVI	Playable on Microsoft Media Player	If not uncompressed, compatibility depends on CODEC	8	3075
RAW	Fastest download with no compression	Requires conversion back to color	8	1024
RAWW	Smallest 10-bit format	Requires conversion back to color	10	2048
FTIFF	Expanded ancillary data embedded in the format TAGS	Photron’s own format	8	1027

Common interfaces for transferring images

Most common interfaces for digital image download from high-speed cameras are FireWire and Ethernet. Some older cameras may have a SCSI interface for download but SCSI is not found in most advance cameras due to power, cable size and limited peer-to-peer networking. Therefore, we will only address the FireWire and Ethernet interfaces for digital download.

Downloading video images (analog) is also possible. These images can be recorded to videotape or captured on a video card (video port) as a digital image. Transfer rates are higher than the digital interfaces (30 fps typical). However, the analog video is resolution limited and is not frame accurate (original timing). We will cover these interfaces. In the near future, high-speed cameras will evolve with video interfaces that are commonly found in professional broadcast cameras, SDI and HD. We will briefly cover these interfaces as well.

IEEE 1394 (AKA- Firewire or I-Link)

The IEEE 1394 standard interface can be found on many consumer cameras and laptops. The concept was originally by Apple Computer. The IEEE 1394 Working Group developed the standard used today by all manufactures. IEEE 1394 is also known as FireWire (Apple trademarked name) as well as I-Link (Sony trademark name).

FireWire is a high-speed digital serial interface. FireWire is a peer-to-peer which allows multiple computers to share a peripheral without any special support in the peripheral or the computers. However, a hub may be needed if there is only one port on a computer.

You may see some reference to IEEE 1394A or IEEE 1394B. The IEEE 1394A interface supports up to 400 mega-bits per second bandwidth. The IEEE 1394B interface supports up to 800 mega-bits per second. Each version can support up to 63 devices with a maximum cable length of 4.5 meters between devices. The maximum number of peer-to-peer connections (daisy chained) is 16 for a total maximum end-to-end distance of 72 meters. This is the standard specification. However, in practice, greater distance between peers can be achieved if well-shielded and very well grounded cable construction is used. Lengths up to 16 meters have worked in practice. Please note that most high-speed cameras are not using the power connections in the cable except for the ground. The reason is the cameras typical use more power than allowed in the standard. There are two FireWire connector types, a 6-pin and a 4-pin. The difference is size and the 4-pin does not have power connections.

The 6-pin connector is usually what you will find on the high-speed cameras that Photron manufactures. Two pairs of wires are for signals and one pair of wires to provide power to external equipment. However, as mention previously, the high-speed cameras from Photron do not require power. The power pin on the camera side is not connected in the camera except for ground. Therefore, the cameras will not damage a hub or computer

that is trying to supply power to the peripheral (camera). Many FireWire computer peripherals do require power from the interface such as repeaters used to extend the length of a cable.

The 4-wire FireWire connector is smaller. This is good for consumer electronics such as camcorders, where space savings is important. Some computers such as Sony laptops will have a 4-pin interface. If you have a 4-pin interface on one end and a 6-pin interface on the other, use a 6-pin-to-4-pin cable or adapter to connect. Photron supplies this adapter with each camera.

The connector pin-outs are shown below:



ETHERNET

Ethernet was developed jointly by Xerox®, DEC®, and Intel® in the mid-1970s as a 10-Mbps (Megabits per second) networking protocol. The 10-Mbps Ethernet is not really suitable for downloading video. It is best to use Gigabit Ethernet (1000 Mbps or GigE). International standards group, IEEE 802.3, defines Ethernet. It enables the connection of up to 1024 nodes over coax, twisted-pair, or fiber optic cable. The most common Ethernet interfaces used in high-speed cameras include 100 & 1000 Mbps Ethernet. Let's briefly look at the performance differences.

100BASE-T

100BASE-T is compatible with 10baseT. There are two cable standards for twisted pair wiring and one for fiber. The bandwidth is 100 mbps. Many end users have some confusion over how many images can be transmitted over this interface. There are many factors that influence the image transmission rate, packet size, re-transmits (error sense), network traffic or collisions, cable length, computer performance, image size and color depth to mention a few. In practice, the overhead (protocol & control information) tacked on to each transmission cuts the available number of packets that can be sent at any given time. The performance of this interface varies from about 2 fps to 5 fps.

Gigabit Ethernet

Like Ethernet and Fast Ethernet before it, Gigabit Ethernet works with earlier versions of the IEEE 802.3 standard, both 10 and 100 Mbps. The Gigabit Ethernet standard (IEEE 802.3z) was approved in June 1998, and its speed of 1000 mega-bits

per second is 10x that of previous standards. Gigabit Ethernet increases frame sizes. Frame sizes or packets over 1514 bytes are known as jumbo frames. Not all interface cards support large packets. This is an important point when selecting a card since the larger packets sizes will have a dramatic improvement in sequential image downloads of large sequences.

Ethernet Connection

Standard	Cable Type	Maximum Distance (hub-to node)	Frequency	Characteristic impedance	Delay Skew per 100 Meters
10baseT	Cat5	100 m	10 MHz	100 ohms	-----
100baseT	Cat5	100 m	100 MHz	100 ohms	-----
100baseT	Cat5E	100 m	100 MHz	100 ohms	45 ns
1000baseT	Cat6	100 m	250 MHz	100 ohms	45 ns
1000baseT	Cat7 (future)	~ 100 m	600 MHz	100 ohms	20 ns
Fiber (sm)	Single mode	10 km			
Fiber (mm)	Multi mode	2 km			

Ethernet Packet

Preamble	SFD	Destination Address	Source Address	Type	Data	CRC
7 bytes	1 byte	48 bits	48 bits	16 bits	46-1500 bytes (9000 for Jumbo Frames)	32 bits

RJ-45, 8-pin Ethernet cable, Straight Through



RJ-45, 8-pin Ethernet cable, Crossover



The wiring order for a straight-thru cable when viewing the RJ-45 connector from the topside of the connector (latch side down) is left to right. This cable is used between a computer and a hub or switch or between a standard hub/switch port and the uplink port of a cascaded hub/switch. Both ends of the cable are wired identically.

A Crossover cable is needed to connect between two hubs/switches and to make a direct connection between two computers. To implement a crossover, the green and orange wire pair positions are swapped. Thus one end of the cable would be wired just a

straight-thru while the other end would be swapped. In actuality, only pin/conductor numbers 1,2, 3, & 6 are used for data transmission in 10base-T and 100base-T Ethernet, therefore, it is not uncommon to see built-up cables only having these four wires. Please note there is another way to wire a crossover, the green and orange wire pairs are swapped. Thus, both ends of a straight-thru cable would be wired as the crossover.

Types of Ethernet Cables

There are (4) solid cable types and (2) fiber optic types of cables for Ethernet.

1. Category 5 (CAT5) cabling is the most common, solid cable for 10 or 100-Mbps Ethernet interfaces. The Category 5 has been used since 1991.
2. Category 5e (CAT5e), also known as Enhanced Category 5, has available since 1999. An improvement over the standard cat 5 with less crosstalk & attenuation. Use Cat 5e when the highest performance possible is desired for 100baseT Ethernet or mixed nets which include Gigabit Ethernet (1000baseT).
3. Category 6 (CAT6) has been in use since 2002. For Cat6 cabling to be effective, the entire physical connection must be Cat6 rated, meaning the jacks, patch panels, wall plates and user cables must also be rated Cat6. If Cat5 is mixed into the net with Cat6, the net will perform at Cat5e level. Cat 6 bandwidth is 2x (200 MHz) that of Cat5 class. Use Cat6 when the very best performance is desired with Gigabit Ethernet.
4. Category 7 (CAT7) is still in the standards group and not released. Cat7 will have 3x (600 MHz) bandwidth of Cat6 and will be slated for the 10 Gigabit Ethernet cabling.
5. Single Mode Fiber is used over distances longer than a few miles. Single-mode cable features an 8.5-micron glass core.
6. Multi Mode Fiber can be used for most general fiber applications. Use multimode fiber for bringing fiber to the desktop, for adding segments to your existing network, or in short run imaging applications. Multimode cable comes with two different core sizes: 50 micron or 62.5 micron.

Most imaging applications will use duplex multimode or single-mode if the interface requires simultaneous, bidirectional data transfer. Even if the transmission is only Simplex (one direction or one cable), it is not much more expensive to have a duplex cable. This provides redundancy if one cable breaks in a Simplex configuration. Duplex is available in single- and multimode.

Although 50-micron fiber cable features a smaller core, which is the light-carrying portion of the fiber, both 62.5- and 50-micron cable feature the same glass cladding diameter of 125 microns. Both sizes can be used, although 50-micron cable is recommended for higher performance applications since 50-micron can hand 3X bandwidth compared to the 62.5-micron cable. Both types can use either LED or laser light sources.

50 micron vs. 62.5 micron

Fiber Type	Bandwidth (min)	Operating at 850 nM	Operating at 1310 nM
50/125 um	500 MHz/km	500 m	500 m
62.5/125 um	160 MHz/km	220 m	500 m

Fiber Compared to Copper

Parameter	Fiber	Copper
Bandwidth	10-Gigabit and future standards	Gigabit
Distance	40 km or more at 10 Gigabit	100 m at 1 Gigabit
Conducted Noise	immune	Subject to EMI/RFI interference & crosstalk
Security	Very difficult to tap	Easy to intercept

As shown above, fiber has many advantages. Fiber has greater than copper and has proven performance at rates up to 10 Gbps. Also, fiber optic cable can carry more information with greater reliability than copper wire. Fiber also has greater distance because the signal is light, and has very little signal loss in transmission. Image data can move at higher speeds and greater distances. Fiber does not have the 100-meter distance limitation of unshielded twisted-pair copper. Fiber distances can range from 300 meters to 40 kilometers, depending on the style of cable, wavelength, and network. Fiber is immunity and reliability. Fiber is immune to many environmental factors that affect copper cable. The fiber is made of glass, which is an insulator, so no electric current can flow through. It is immune to electromagnetic interference and EMI/RFI, crosstalk, impedance problems, and more. Fiber is also less susceptible to temperature fluctuations than copper is and can be submerged in water.

There is one last point about fiber cable selection that needs to be made. If possible, use connectors that have ceramic ferrules. They perform better than composite ferrules. A ferrule is the insert in the connector that the fiber is held.

Some precautions with fiber

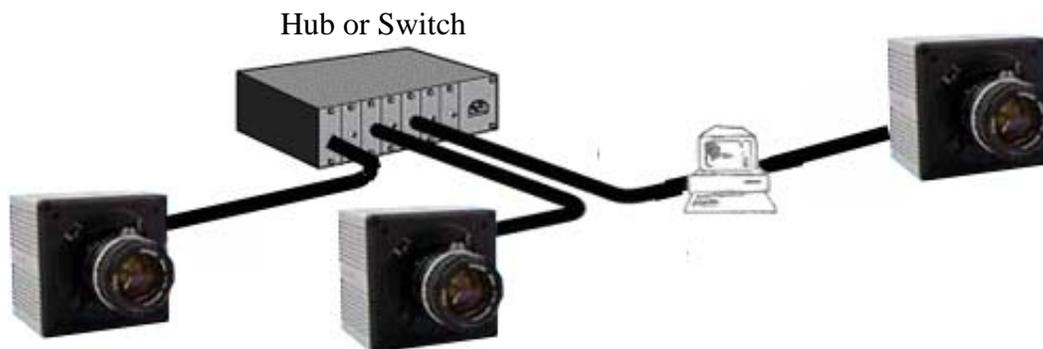
A few precautions should be exercised when using fiber cable. Since power loss will degrade the bandwidth performance, the loss due to absorption, reflection, and scattering should be avoided. Microbends can cause power loss due to small deviations in fiber from excessive bends, pinches, and kinks. Try not to bend the cable.

Use clean components. Keep dirt and dust to a minimum. Don't pull the cable excessively or bend it too sharply around any corners. That way, your fiber optic installation can serve you well for many years.

How Ethernet Works

Ethernet is a serial interface that is shared in a network. Signals are transmitted from a node (camera), one bit at a time, to every other node on the network. The data is broadcast and access by a method called Carrier Sense Multiple Access/Collision Detection (CSMA/CD). This means that every node on the network hears every transmission, but each node only acts on transmissions intended (designation address) for it. Each node can talk (send a message) at any given time but in most high-speed camera applications, the transmission is one camera at a time. This means the entire camera is downloaded before another camera can be download. No permission is needed for any node to talk on the network. A computer or another camera will recognize when a message is intended for it by the unique address (designation address, i.e IP192.176.0.10 subnet 255.255.255.0). The message also contains the address of the sending computer or camera, so the message can be acknowledged.

If two nodes send messages at the same time, a retransmit must happen since a collision occurred, interfering with the signals. A node can tell if a collision has occurred when it does not hear its own message within a given amount of time. When a collision occurs, each of the colliding nodes waits a random amount of time before resending the message. This is a retransmit and increases the download time if this error occurs often. This is one reason many high-speed cameras will download from one camera at a time to minimize network collisions. It is also a reason to have a closed network rather than a general open network with non-imaging users attached.



- The maximum length of one cable is 100 meters.
- The maximum total length of all segments is 2500 meters.

Where to invest in performance on your computer

If you were buying a new computer or upgrading an existing computer, where do you get the most benefit in performance for your investment? This is an important question that is not asked often enough. Let's begin with the specific areas within a PC where performance investment is the most beneficial.

System OS

Most high-speed cameras have a user interface written to run on a Windows platform. Mac OS and Linux are not really supported. Therefore, our discussion will be limited between the choices of 32-bit or 64-bit platform. Currently, all the high-speed cameras user interfaces run off 32 bit Windows.

The most significant difference between 64-bit and 32-bit processors is the address space. The 64-bit has a much larger address space and has virtual address space. A 32-bit processor can directly address a maximum of 4 gigabytes (GB) of memory.

A 64-bit processor running Windows XP x64 supports 128 GB of physical memory, and 16 terabytes (TB) of virtual memory. Working with larger and larger images will benefit from the 64-bit OS because of the address space. There are other differences between 64-bit processors and 32-bit processors. Some of these differences, more registers, can boost the execution of a well-written application in the native format. But the reality is that most high-speed camera user interfaces will not run much faster in Windows XP Pro x64 than they run in 32-bit Windows XP Pro, even if they are rewritten as native 64-bit applications. What they will have is the ability to do things that just haven't been possible in 32-bit Windows.

In terms of performance, the Windows XP Pro or Windows XP Pro x64 will both do a good job. In the future, manufactures may release 64-bit native programs that will run much faster when dealing with the larger images and file formats.

Motherboard

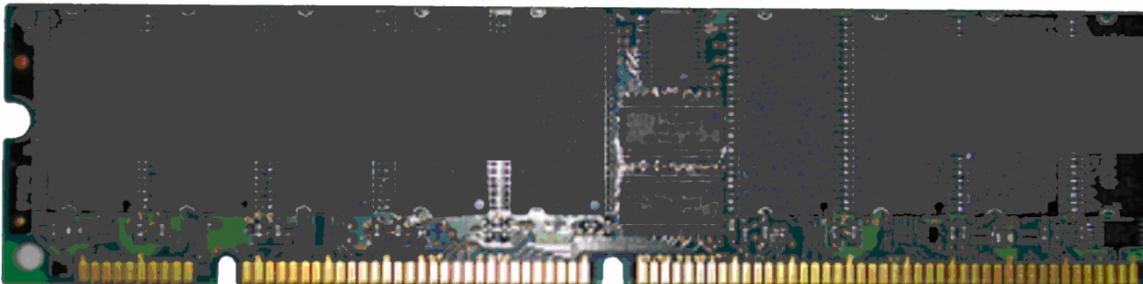
A computer's motherboard is the backbone or foundation that runs the entire system. Many tradeoffs could be listed concerning how to select an appropriate motherboard. If you are not building a fast computer, the selection of the motherboard will be limited to the choice made by the manufacture of the PC. Therefore, a few performance points to look for in the PC would be the type of bus architectures available. PCI Express is becoming more popular and provides good throughput. Motherboards with two separate PCI or PCI Express buss architectures would be good for high throughput. Some motherboards used in servers may have a dual processor. This will improve performance but the gain is only marginal in throughput for the expense. The motherboard's highest frequency for the CPU will be an indicator for upgrading in the future to higher CPU speeds when available. AGP 4x or 8x is a good interface for faster graphic support for displays.

CPU

There are two major CPU manufactures to select from these days, AMD and Intel. Typically, AMD has offered lower price and in certain CPU test, the best performance. Dual core and hyper threading technology are two key architectures that will improve the image processing and transfer rate in a PC. My recommendation is to use the hyper threading technology found in the Intel CPUs. Try to get the fastest CPU speed possible for your computer. Again, faster is always better.

Memory

Memory is used by the computer to store information that is needed to process data and run applications. Memory comes in two forms: volatile and non-volatile. Volatile memory is cleared whenever it loses power, and nonvolatile can sustain its information when it no longer has power applied to it. These terms are also used to describe random access memory (RAM) and read-only memory (ROM), or which RAM is volatile, and ROM is nonvolatile. However, when the term "memory" is used, most of the time, system memory is being referenced. System memory is a number of chips of RAM memory, attached into slots on the motherboard, which allow the computer to store data required to run programs and operate. Any portion of memory can be accessed at any time, and at a consistent data rate. A memory chip can be seen here.



The more complex the program, the more memory it uses. As long as a program is running, it is consuming some memory, and large amounts of memory are useful when running many programs at a time.

- Speed- Memory modules have two important factors that should be known: speed and size. Speed is measured in Megahertz (MHz) and represents how fast data can be sent to and received from the memory. When installing different modules of memory, it is important to ensure that every module is the same speed to ensure the best performance of every chip. The motherboard will determine what speed of memory is compatible, and it is important to get the right speed memory for a computer system.
- Size - The size of memory is fairly self-explanatory; it is the amount of data that a computer can store in memory. The more programs that will be running at a time, and the more complex these programs, the more memory they will consume. Imaging applications can consume large amounts of memory. The more programs

running at once, the more memory is required for the computer to run properly. Memory is measured in either megabytes (MB) or gigabytes (GB). One gigabyte is equal to exactly 1024 megabytes, though conversions often use 1000 because of the ease of use.

When it comes to a computer system: you can never have too much memory. It is normally just an issue of balancing cost with what will be used. Memory is also an easy component to upgrade at a later date, and it is recommended that you purchase a single chip rather than two chips of half the size. It is normally best to use memory modules of all the same size to ensure best performance.

Memory Slots

There are two different slot types for memory, which are seen on modern systems: Dual Inline Memory Module (DIMM), and Rambus Inline Memory Module (RIMM).

DIMM

The most common and most popular slot for memory, the DIMM is the second oldest type of slot behind SIMM. Most memory on the market today falls into this category, although there are several different varieties of DIMM modules today. There are currently two types of DIMM slots being used today: DDR-SDRAM, and DDR2-SDRAM.

- DDR-SDRAM - Stands for double data rate synchronous dynamic RAM. DDR memory is the current standard for memory, and is nearly identical to traditional SDRAM, but allows reading and writing operations to occur simultaneously, thus increasing the speed of the memory. DDR modules also come in larger sizes than their SD counterparts.
- DDR2-SDRAM - Another advancement to DDR memory, it is capable of sustaining much faster data transfer rates, and consumes less power. However, DDR2 memory is also more expensive than DDR in sizes under 1GB (although prices are dropping), but 1 GB and above are becoming cheaper and more readily available than with DDR. Currently, Intel's newest systems all use DDR2 memory, but their chief competitor AMD is switching from DDR to DDR2 later this year.

RIMM

Stands for Rambus inline memory module, this was a type of memory developed by a company called Rambus. The transfer rate of RIMM modules far exceeds that of even DDR2, but the cost is significantly higher. Most Intel Pentium 4 systems used to use RDRAM (Rambus Direct RAM, the technical name for the memory itself), but due to the high cost of this memory, have switched over to DDR2 modules.

Registered/Unregistered

Often, the descriptions of memory modules will have the term "registered" or "unregistered" when describing the chip. These terms can be in changed with either "buffered" or "unbuffered," respectively. Registered RAM chips include additional components that help remove some of the electrical load from a computer's memory controller (the northbridge). Registered memory modules offer more stable memory as the amount of memory increases. Unregistered RAM becomes less and less stable as greater amounts of memory are added. However, registered RAM chips are also slower than unregistered RAM, and cost more.

ECC or Non-ECC

Error Checking and Correction (ECC) is a term used for memory that is able to correct data errors that may occur during operations. ECC memory is able to detect most errors and restore the value of these bits to their correct value. This memory is considerably more expensive than non-ECC memory (memory without error checking).

In summary, you should:

1. use the memory recommended by your Motherboard manufacture
2. buy 1 memory rather than two smaller ones
3. use registered memory if you have a lot of memory (>2GB)
4. have a least 1 GB of memory with today's OS

Hard Disk Controller

On most computers, the disk controller may be built into the motherboard. However, if you use a "RAID disk configuration, SCSI, Fiber Channel or SATA interface, you may need to choose a controller. Research the various controllers available for your drive's interface. Reports published by trade journals on computer hardware such as CNET or others can give a good review about these controller cards. Another point to consider is having multiple bus architecture on your motherboard that shares the system memory. This allows for higher transfer rates when using controllers such as a RAID configuration.

Internal Hard Disk

The performance of your hard disk greatly influences the archiving process. If your hard drive is not very fast, it can be a bottleneck in the download process. Typically, laptops do not have very high performance drives. Drives (hard drives) performance can be qualified with a few specifications commonly listed on a computer system.

1. **Drive Speed:** The drive's speed (cylinder or disk rotation speed) is a good leading indicator. Today's fastest drives will be operating at 10,000 to 15,000 RPM. Laptops may have a 5400-RPM or 7200 RPM drive. The key here is faster is better.

2. **Access Time:** The drive's access time is an indication of how fast a given location can be located from a known location. Drive access times of 10 mS to 20 mS are slow. Today, access times under 10 mS is considered fast. Again, the lower the access time the faster data can be written or retrieved.
3. **Internal Buffer:** Some drives will have an internal buffer or cache, which optimizes the sustained transfer time between the computer and the drive. Cache sizes of 4 MB to 8 MB are common. A drive without a cache, which has a fast drive speed vs. a slow drive with a big cache, the former, is a better choice.
4. **Interface Type:** There are a number of drive interfaces. There are tradeoffs on various drive interfaces other than speed that influence a PC manufacture's drive choice- power, size, cabling and cost. Today, some of the fastest drives can be found with a Fiber Channel, SATA or SCSI interface. SCSI will draw more power and is the least popular for these reasons. Fiber Channel drives is found mostly in servers. SATA are becoming popular in industrial and consumer PCs. One last point about interfaces – using multiple drives in a RAID configuration can optimize the transfer rate throughput. RAID (0) will be the fastest but there is no redundancy for backup. This means if one drive develops a problem, you have lost your data. RAID (5) configuration provides redundancy and reasonable performance.

External Hard Disk

What was described about drive performance under internal hard drives also applies for external drives. However, most external drives are limited on the type of interface that is available. Typically, you will find drives that have a USB 2.0 or IEEE 1394A (FireWire interface). Some drives may have a Ethernet connection if they are intended for shared use or backup. In either case, make sure the drive has the fastest interface possible for your computer.

Cooling

Most people do not think about the cooling found in your PC. However, if you are using RAID configurations and/or high performance CPUs, make sure the system has sufficient fans to cool the system. If the PC has a high wattage power supply greater than 450 watts, there usually will be additional fan ports for adding cooling. You may need to add additional fans or even a PCI card that has fan blowers on it to port the hot air out. Why is it important to look at your cooling? The first time your drives heat up or memory where you begin to lose data, the afterthought concerning your PC cooling may pop up. At that time, it is too late. Also, your environment greatly determines the need for additional cooling. Working in the field in a desert or a hot factory floor will stress a high performance PC as an example.

Graphic Card

Graphic controllers are sometimes integrated onto the motherboard. These internal graphic controllers can be turned off if a higher performance card is required. However, most graphic controllers that support Intel 218 graphic processors or AGP 4x or 8x will be sufficient for your needs. One additional point for those who need the highest bit depth display capability is to look for a card that has 10-bit per color plane (RGB = 30 bit) display capability.

Display Monitor

There are many technology choices today for imaging displays. There are analog displays that are CRT based, LCD & Plasma displays and video displays that support various video standards (NTSC, PAL, HD, est.). Thin Film Transistor Liquid Crystal Display (TFT LCD) are the most popular display used with computers & built into a laptop. Therefore, we will limit our discussion to TFT LCD.

How do they work?

LCDs use a backlight, florescent tubes, as their light source, and then control how much of this light is allowed to reach the dots (pixels) by selectively blocking the path of that light. If you then place colored glass over each pixel you can create color images on the display. Liquid crystals remain transparent unless a voltage is placed across them. While the voltage is applied, the portion of the display under its influence remains opaque. The speed at which the liquid crystal can be switched on and off is relatively slow.

Resolution

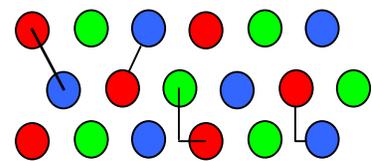
TFT LCD have a fixed number of pixels built into the display and are therefore designed to operate at a specific resolution, called the native resolution of the display. Typically, a 17-inch monitor will be limited in resolution to about 1280 x 1024. If you want higher resolution, you may need to use a 20-inch monitor that supports 1600 x 1200 resolution as an example.

Response Time

Many LCD screens response time is too slow and this leads to ghosting and jagged pixel effects on you display. Ghosting is when the previous image displayed on the screen can still be seen for moments after the image has changed. This effect is sometimes related to the sensor technology but it can also be related to the response time of the monitor. TFT LCD's typically operate at 60Hz and when the image on the screen changes, only the affected pixels on the display are altered. The rest remain unchanged. But changing pixels takes time to alter from one state to another; this is commonly called rising and falling. The time the pixels take to rise or fall is then referred to as the response time. The smaller the response time, the faster the pixels can change and this will result in less of the ghosting effect. This response time is given in milliseconds on the specifications for the display. However, gray-to-gray response time is much more important for determining if an LCD is the best for imaging, rather than rising and falling response time. Unfortunately, grey-to-grey response time is rarely given on specifications. A good response time will be under 20 mS.

Dot Pitch/Pixel Size

Dot pitch is the distance between phosphor dots (sub-pixels) or between TFT LCD cells of the same color on a display screen. A smaller number generally means that the image on the screen is sharper, as there are more dots in any given area. Dot pitch must be examined carefully. It is used to represent the distance between the centers of two adjacent dots within a color mask. Some manufacturers are reporting the dot pitch



Dot pitch distance

as an equivalent measurement. Shown here is a graphic representation of how some dot pitches may be specified. Comparing monitor specs are more difficult with all the various methods of measurement. The most consistent method is from the center-to-center spacing from adjacent dots. A pitch below 0.28 will be good.

Contrast

Contrast is the ability for the monitor to vary brightness between the foreground and the background. It is expressed in a ratio (i.e. 500:1). Typically the higher the ratio, the better the image quality will be as the display will be able to show bright colors next to dark without washing out the black or dulling the colors. If your camera has a 10-bit dynamic range, this means the image could show a range 1024 shades of gray. If your display is limited to a contrast of 500:1, you will only be able to see half of the gray scale range. Therefore, Contrast is very important for image quality in a display.

Brightness

Display brightness can be expressed in candelas (cd) but usually it is expressed in NITs. A display with 100 NITs will not be suitable for use in bright sunlight. Most laptops have a display brightness that is under 200 NITs. A display brightness of 400 to 800 NITs will be suitable for use in bright sunlight.

I/O Interfaces

Talking to a camera and downloading image data is something that will be frequently done. Therefore, pick a computer that has the appropriate interfaces built into the system. As an example, choosing a laptop with a Firewire interface would be much better than choosing a laptop that requires a PCMCIA adapter for a Firewire interface. Another example is putting a 512PCI high-speed camera card using an external PCI bridge to interface through a PC card port on a laptop vs. using a desktop PC with the card running on a PCI bus. Just look at the peak transfer rates for a PCMCIA slot vs. a PCI-33.

PCI-33	133MBytes/sec
PCI-66	533MBytes/sec
PCMCIA (word mode, 16 bits)	20MBytes/sec
CARD Bus (double word mode, 32 bits)	132MBytes/sec

Clearly, if you are not using a CARD Bus, your transfer rate will be diminished!

Shown below are published maximum (peak) transfer rates for various interfaces. Please note that the maximum transfer rate does not mean this is the rate at which an image can

be transferred. The interface protocol requires a fair amount of overhead (control information) to be transmitted with many of these interfaces.

Floppy	0.062MBytes/sec
Serial ports (COM)	0.014Mbytes/sec
Parallel ports (IEEE 1284), PCI	2.5MBytes/sec
USB 1.0	1.5MBytes/sec
USB 2.0	60MBytes/sec
Firewire IEEE-1394A	50MBytes/sec
Firewire IEEE-1394B	100MBytes/sec
PCMCIA (word mode, 16 bits)	20MBytes/sec
CARD Bus (double word mode, 32 bits)	132MBytes/sec
ATA2	16.6MBytes/sec
Ultra DMA ATA/33	33MBytes/sec
Ultra DMA ATA/66	66MBytes/sec
Ultra DMA ATA/100	100MBytes/sec
10BASE-T Ethernet	1.25MBytes/sec
100BASE-T Ethernet	12.5MBytes/sec
1000BASE-T Ethernet	125MBytes/sec
10000BASE-T Ethernet	1250MBytes/sec
SCSI-1	5MBytes/sec
SCSI-2	20MBytes/sec
SCSI Ultra2 Wide	80MBytes/sec
SCSI Ultra3 160	160MBytes/sec
SCSI Ultra3 320	320MBytes/sec
SCSI Ultra3 640	640MBytes/sec
SATA 1	150MBytes/sec
SATA 2	300MBytes/sec
PCI-33	133MBytes/sec
PCI-66	533MBytes/sec
PCI-e (single lane)	250MBytes/sec
PCI-X (133)	1066MBytes/sec
PCI-X 2.0 (266)	2133MBytes/sec

Image file management

The old saying, “it is better to work smart than work hard” applies here. Thinking ahead a strategy for managing your images will pay great dividends later when you need to move or retrieve the images. Here are some discussion points to help you think what you may want out of image file management.

1. **FORMAT:** What file format is best suited for your use. RAW or RAWW may be the most compact file size and the fastest to download. However, later you will need to convert the raw or RAWW back into color mages. Tiff or avi images may be most transportable to 3rd party software. With Tiff, you can lose one image and still read the sequence (minus one image). If you have an error in the download with AVI, you most likely will have to start over. Also, AVI standard says that no AVI over 2GB is compatible with media player. Photron will automatically break a large image sequence over 2 GB into segments that are 2 GB or less. This will always assure the image sequence can be viewed with common software. AVI can be played on most computers with a standard media player.
2. **IMAGE SEQUENCE SIZE:** What is the typical sequence size in megabytes? If your image sequence is equal to or less than 2 gigabytes, most any disk format will work. However, if you have huge image sequences over 2 GB, then pay attention to your disk format. If the disk has been formatted as FAT32, you may have a problem if the sequence goes over 4 GB since a directory can not be larger than 4 GB under FAT32 format on a hard disk. NTSF formatting is a much better choice for large image sequences since there is no limitation.

Also, the number of image sequences needs to be considered regarding disk capacity. NTSF is limited to around 138 GB disk size unless there is a BIOS patch or driver that spans larger disk sizes (i.e 400 GM SATA drives).

3. **NAMING CONVENTION:** When creating a name for a directory and/or image sequence, keep in mind that long path names are often truncated when viewing a sequence. This just makes it harder to determine where the sequence may be located. Short paths and reasonable name conventions is just good practice.
4. **DOANLOAD ONLY WHAT IS NECESSARY:** If you choose to download all images recorded even though the significant event takes up a small portion of the image sequence, you will be needlessly increasing your download time, the space available for further image sequence downloads as well as wasting your time in playing images that are not significant. Remember that playing images slow is a time magnification. This means if 1000 frames are capture in 1 second (1000 fps) and played back at 5 fps second, it will take 200 second or just over 3 minutes to view the 1 second of data.

Fast start reference table

An outline form of the most important techniques that can improve your download rate and quality of images displayed.

Which Image Format to Use

- Use Tiff when color is ok, no future image adjustment is required and you want to look at individual image files. This format is safe to use on long downloads because a power loss or PC crash should not corrupt images already downloaded.
- Use AVI when the color is OK and distribution to many end users is needed. AVI under 2GB can play on any Windows Media Player (assumes a common CODEC is used such as Cinepac or MS Video 1).
- Use RAW if you need to download images as fast as possible as 8-bit monochrome images and can reconstruct them into color images later when you have time.
- Use RAWW if you need to download images as 10-bit mono and can reconstruct them into color images later when you have time.

Display FAQs

- LCDs will have a better contrast than Plasma.
- RGB settings are typically 0.55 or the inverse of 1.8
- Contrast ratios are very important for good looking color images on LCD displays. As an example, a LCD monitor with 200:1 contrast can not display an 8-bit image. Use LCD monitors with 400 to 512:1 contrast ratio.
- LCD displays should have a brightness setting of at least 400 NITS for outdoor use (800 NITS is better). LCDs are brighter than Plasma displays
- Video (analog) displays have a different gamma setting than RGB computer monitors (typically 0.45 or the inverse is 2.2)

Reducing Image Down load Time

- **Download only the import image frames if possible**
- **Minimize playback image to as small as possible (minimize)**
- **Use a fast (7500, 10,000 or 15,000 rpm) external disk that has a Firewire interface. Select in the PFV a directory on the external drive. Laptop drives typically are 5400 rpm or slower with slow head access (12 - 15 ms vs. 3.5 to 6 ms on higher speed external drives)**
- **Use a USB 2.0/Firewire hub instead of a Firewire PC card if a Firewire connection is not available on a laptop**
- **If uncompressed images are required**
- - o **use Tiff or PNG (PNG can be used for 10-bit images)**
 - o **use AVI & make sure you have selected in the PFV 100% quality**
- **If compressed images can be used**
 - o **use JPEG & adjust compression quality in the PFV ~ 60 to 90%**
 - o **use AVI & adjust compression quality in the PFV ~ 75 to 90%**
- **Download images in Bayer format if image color reconstruction at a later time is acceptable or if storage space is very limited.**
- **Make sure the drive with the PC Windows (usually drive C;) with a minimum of 500 MegaBytes of free memory**
- **Run only PFV program if possible when downloading since other programs may have a need for shared PC access time. This will reduce the time that the PFV has to write images.**
- **Avoid downloading over long (> 5m) Firewire cables**
- **Use a fast PC if possible**