A Digital Video Primer: Understanding and Using High-Definition Video

TABLE OF CONTENTS

Introduction

This document is for digital media professionals interested in moving to high-definition production, post-production, and distribution. It focuses on the powerful Adobe® desktop applications Adobe After Effects® and Adobe Premiere® Pro, but it also includes information about how many other tools and products can be integrated into a high-definition video production workflow.

The two goals of this document are to help you understand what's involved in making the transition to authoring and distributing high-definition content, and to help you get the best results from that transition.

What is high definition?

After years of anticipation, high definition (HD) video production has become widespread. Over-the-air HDTV is rapidly building an audience, and high definition DVD development is proceeding quickly. Even people not producing for an HD audience are using HD formats during production and post-production. For example, the pioneering DVD company, Criterion, uses HD on D5 tape for digital intermediates from their telecine captures. Suddenly, companies are finding that they have HD content to distribute and are looking for ways to distribute it.

The myth is that HD is very expensive and difficult to author. The reality is that HD has become cheaper and easier to use than standard definition (SD) was only a few years ago. Today, you can build a complete entry-level HD production system, including storage, software, and camera, for under U.S.$10,000. Higher-end and uncompressed HD editing systems can be much more expensive, but they are also declining in price as more options enter the market.

Types of HD

High definition simply means more than standard definition (SD). The highest resolution SD format is PAL, with 576 lines. Thus, almost any video frame with a vertical size greater than 576 lines is considered HD. If a final video is destined for playback on a computer monitor or a custom device, you can create your own frame dimensions. However, most HD video is either 1920 x 1080 or 1280 x 720, with a 16:9 aspect ratio.

Broadcasters have established the following standard HD formats:

TYPE	DIMENSIONS	FRAMES PER SECOND	SCANNING METHOD
720 24p	1280 x 720 pixels	23.976	Progressive
720 25p	1280 x 720 pixels	25	Progressive
720 30p	1280 x 720 pixels	29.97	Progressive
720 50p	1280 x 720 pixels	50	Progressive
720 60p	1280 x 720 pixels	59.94	Progressive
1080 24p	1920 x 1080 pixels	23.976	Progressive
1080 25p	1920 x 1080 pixels	25	Progressive
1080 30p	1920 x 1080 pixels	29.97	Progressive
1080 60p	1920 x 1080 pixels	59.94	Progressive
1080 50i	1920 x 1080 pixels	25 (50 fields per second)	Interlaced
1080 60i	1920 x 1080 pixels	29.97 (59.94 fields per second)	Interlaced

Note that the 720 sizes don't have interlaced varieties. Also note that the standards established by the NTSC (National Television Systems Committee) have frame rates that are not whole numbers. The NTSC standard, which is used in North America and Japan, reduces the frame rate by 0.1% in order to correspond to the NTSC SD rate for color broadcasts established in the early days of television. For example, 30 frames per second becomes 29.97 frames per second. While this reduction is optional in most HD products, most producers use the lower rates.

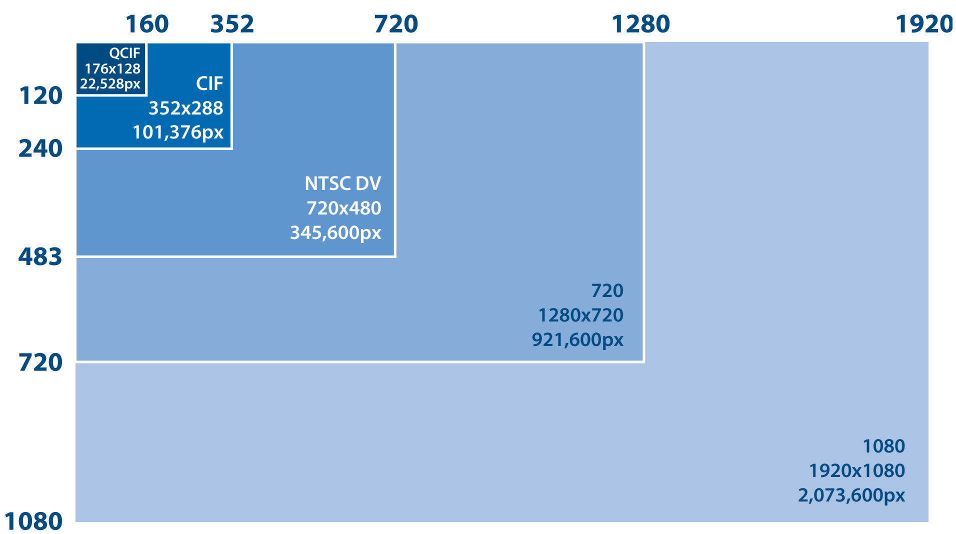


Chart illustrating the relative frame dimensions of different video formats, showing the total number of pixels for each.

A short history of HD

HD video for consumers has been around for about 20 years, even though it has only recently developed a sizable audience. To read about the fascinating history of HD, see the book *Defining Vision: How Broadcasters Lured the Government into Inciting a Revolution in Television* by Joel Brinkley of the New York Times.

The original HD broadcasting standard for consumers was Muse, created by Japan's NHK. Muse was an analog HD system intended for satellite broadcast. While it produced very good images, market realities kept Muse from becoming widely accepted.

At the time, there was a drive in the U.S. Congress to reallocate some unused UHF spectrum from broadcasters to emergency communications and other uses. In an attempt to hold on to the channels, the National Association of Broadcasters (NAB) convinced the Federal Communications Commission (FCC) to allocate the space for future HD broadcast use. The FCC agreed and committed U.S. broadcasters to convert to HD and (in theory) eventually give back their analog channels for other uses.

HD FORMATS

This document uses the following convention when describing HD formats: <frame height> <frame/field rate> <interlaced/progressive>. For example, 720 60p means a frame that is 1280 x 720 pixels and 60 progressive frames per second. For interlaced formats, the number preceding the *i* refers to fields. For example, 1080 60i means a frame that measures 1920 x 1080 pixels and scans 60 interlaced fields per second.

The 720 formats all are progressive, but the 1080 formats have a mixture of progressive and interlaced frame types. Computers and computer monitors are inherently progressive, but television broadcasting is based on interlaced techniques and standards. For computer playback, progressive offers faster decoding and better compression than interlaced and should be used if possible. In NTSC formats, the frame/field rate is actually 0.1% lower than listed, so 24P is really 23.976 frames per second, and 60i is really 59.94 fields per second. PAL formats use the listed frame rate—25p is really 25 frames per second.

In some documentation, 720 60p is called 720p and 1080 60i is called 1080i. However, those labels are ambiguous as to frame rate. 720 can run at 24P, and 1080 can run at 50i in its European version.

The FCC set up the Advanced Television Systems Committee (ATSC) to define the specification for digital television (DTV), which includes HD and SD broadcasts. The process took years longer than expected, but the standard was finally created, and broadcasters began HD broadcasts. Currently, most prime time shows are broadcast in HD, and both cable and satellite systems are introducing HD channels.

The FCC scheduled the transition from analog to DTV to be completed in 2006. However, only a minority of consumers in the U.S., and a much smaller minority in other industrialized nations, actually have HDTV receivers or screens. But HD-capable displays are selling very well now, even if many displays are used only to view standard definition (SD) content, like DVDs.

The next big milestone for HD is likely to be the release of DVD formats that support HD content. When that happens, the amount of available HD content may reach the point where the average consumer can justify making the leap to HDTV, and then we may see HDTV really succeed.

How HD is used today

Currently, HD is used primarily to deliver television content to viewers over the airwaves and cable. However, it is also growing in popularity in the film industry as a delivery mechanism for movies in theaters, and is also used for distributing intermediates and proofs. HD is also used more and more for video-editing installations, kiosks, and digital signage.

HD and the ATSC

For many consumers, HD means over-the-air ATSC content. ATSC supports 480, 720, and 1080 at all of the NTSC frame rates. It uses MPEG-2 for video and Dolby Digital (AC-3) for audio (the same codecs used on SD DVDs).

The experience of watching HD at home is still not as refined as it is for SD. For example, the amount of available content is still relatively small, and HD video recorders and personal video recorders (PVRs) are much more expensive than their SD counterparts. But vendors view HD as a growth area and are rapidly enhancing products for use with HD. In some ways, HD is easier and cheaper to work with than analog SD because you can avoid analog-to-digital conversion or compression.

While much of the rest of the world is moving toward digital broadcasting, only the U.S. and Japan have seen the broad adoption of HD as a broadcast technology. Developments in HD lag somewhat behind digital broadcasting, but some areas of Europe have begun HD broadcasting; Japan has announced it, and it should continue to be adopted worldwide.

Distributing HD over cable and satellite

Since the ATSC began, the U.S. market has become dominated by cable and satellite, with only a minority of viewers still watching television over the air. Analog cable is quickly moving toward digital cable, and Direct Broadcast Satellite (DBS) dishes are becoming very popular.

Many cable and satellite providers are adopting HD with vigor. However, HD comes with a cost. HD images look dramatically better than SD, because each pixel contains more bits and each frame contains far more pixels. The increased number of pixels translates into a much higher bit rate. Because of bandwidth constraints, cable and satellite providers may offer only a few dozen channels.

Most providers source ATSC content for their HD broadcasts, but to keep bandwidth at a manageable level, there is interest in the possible gains from a more efficient compression system than ATSC's MPEG-2. The compression systems leading the discussions are MPEG-4 AVC and Microsoft's VC1. Cablevision's satellite service uses MPEG-4 compression. New set-top boxes and other equipment required to deliver and play HD may include multiple compression systems.

HD in film production and the post-production industry

The film industry has been moving toward digital post-production for a while. Originally, people used digital video for a few special effects shots; now, digital color correction and other techniques are becoming standard. The new digital cinema cameras provide quality that goes beyond that of the HD broadcast formats. Broadcast HD uses a process called subsampling to decrease color resolution in order to reduce bandwidth needs. But, in digital cinema production, bandwidth is not an issue—quality is. Movies can be shot without subsampling (4:4:4) and with 10-bit precision per color channel.

HD in film production uses the 2K and 4K standards—respectively 2048 and 4096 pixels wide. Most professionals feel that 2K is more than good enough for typical productions, and an increasing number of producers are using 1080 24p HD video cameras and equipment.

Not all HD production for film must be done with expensive, high-end hardware. The HDV format was created to enable almost any video producer or hobbyist to enter the world of HD. HDV-based camcorders provide great results at a fraction of the price of high-end equipment. A camcorder with native support for 1080 24p rivals the image quality of 16mm film without all of the costs of film processing and other hassles associated with film.

Almost all HD production for film is done in 24P. At 24P, each video frame can be easily transferred to a frame of film. The 6.5 times increase in the number of pixels makes a huge difference, and finishing in film's native 24P frame rate makes motion much smoother.

In the post-production business, HD video is an effective method for distributing intermediates, proofs, and clips for review. A downloadable HD file looks substantially better and can be available much sooner than a Beta SP tape sent by overnight express mail.

HD and digital cinema

If an entire film can be produced digitally, why go back to film at all? Digital projectors are rapidly dropping in price and improving in quality. It is expensive to print and distribute film. A complete digital movie could be distributed to theaters on inexpensive DVDs, or transmitted via satellite or a high-speed network. In addition, a digital print doesn't lose quality each time it's played. While it's not economically feasible for every theater owner to make a complete transition to digital projection right away, the move to digital projection has started, and it will no doubt become a standard system for distribution within this decade.

The definition of digital cinema is still evolving. The quality requirements are much higher than they are for consumer HD, and Hollywood likes it this way. Producers want the theatrical experience to have an advantage over the home experience. Expect whatever standard is adopted for theatrical HD projection to go well beyond the standard that will be affordable for the mass market.

Powerful projectors that use Digital Light Processing (DLP) technology produce an experience similar to viewing film in a theater.

A digital projection system can equal or exceed the quality of film projection. It's just a matter of making those projectors affordable for theater owners. Even though this point hasn't been reached yet, many theaters are putting in lower quality video projectors for showing premovie loops, slide shows, and other content. Though the resolution is far from 1920 x 1080, many viewers don't notice the difference between this resolution and that of film.

But digital cinema is far more than a low-cost, more expedient alternative to film. Digital delivery offers choices and flexibility in everything from frame size to distribution media. For example, it would be a simple matter to transition to higher frame rates. Since the beginning of sound on film, 24 frames per second (fps) has been the standard. Any move away from that standard would require expensive updates to film cameras, projectors, and other equipment. With digital cinema, 60p isn't that much more expensive to create, distribute, or project than 24P or any other frame rate or format, and 60p can provide a vivid immediacy that is currently impossible with film. The latest Sony HDCAM supports 1080 60p and it won't be long before more equipment makers jump on board. In the future, not only will digital cinema make production and distribution more affordable, it may add a whole new dimension of realism and clarity to the movie-going experience.

HD and computer playback

Modern personal computers are viable HD playback systems, capable of rendering frame sizes of 720 or 1080. One benefit of computer playback is that the frame size of the movie can precisely match that of the display, resulting in a crystal-clear, pixel accurate image.

Microsoft has developed a playback format for distribution of HD content on a conventional DVD-ROM that uses Windows Media 9 technology. Content producers can distribute their products in two-disc sets that include a conventional DVD version of their movie and a DVD-ROM that contains an HD version in the Windows Media High Definition Video format. The technology is not exclusive to Microsoft; any content creator can make similar discs, and end-users can play the discs on their computers or a small number of compatible DVD players.

HD and consumer electronics

The number of mass-market consumer options for storing HD is increasing all the time. Many cable companies now offer HD personal video recorders (PVRs) for short-term storage. For long-term storage and distribution, the most promising solution is through the adoption of a DVD format that supports HD. At this point, two formats, HD-DVD and Blu-ray, are vying for support among the major movie studios. HD-DVD, developed by Toshiba and NEC, has the support of the DVD Forum. However, many feel that Sony's Blu-ray is a better technology. Regardless of which format emerges the winner, the industry and consumers are counting on DVDs to provide the impetus for moving HD out to a wide audience.

HD in production

Options for HD production have exploded in the last few years. As with SD, there is a broad range of products with wildly different price points and features. The HD experience is functionally very similar to SD, except for the additional bits and pixels. Equivalent cameras, monitors, and workflows are available for SD and HD, but with a higher price point for HD. Even the formats are similar with derivatives of DVCAM and D5 as the dominant high-end production formats.

HD cameras

There is a wide variety of HD cameras. Prosumer HDV camcorders, such as the Sony HDR-HC1 and JVC GR-HD1, make high-quality HD accessible to almost any producer with prices starting at US$2,000. At the other end of the spectrum are high-end cameras used in film production that cost in excess of U.S.$100,000.


The new HDV camcorders (top) provide a high-quality, low-cost alternative to the high-end professional HD camcorders (bottom) used for broadcast and film production.

To achieve the highest possible quality, the data stream from a high-end camera is recorded directly to hard disc arrays instead of tape. Even professional grade tape formats, like HDCam and D5, use some compression or subsampling. By transferring data directly from the camera's HD-SDI port to a hard disc array, uncompressed data can be recorded at the full 4:4:4 sample rate.

HD techniques and issues

The main difference between HD and SD is the significant increase in the number of pixels. Experienced SD video professionals are often startled by the detail in an HD image that SD video doesn't have. These professionals often need to tune sets, makeup, and framing to make them work well in HD. The level of detail used in film is a good starting benchmark for tuning.

The targeted 16:9 aspect ratio of HD is also different. The combination of 16:9 and HD can be a boon for sports because much less panning is required to see the details of the action. Well-shot HD hockey and basketball can be a true revelation—HD sports is one of the major drivers for consumers upgrading to HD.

HD tape formats

Like SD television, only a handful of HD productions are broadcast live. Most HD is shot to tape, and then edited nonlinearly on personal computers and workstations.

Currently, there is a variety of digital tape formats used for professional HD production, with the predominant formats being Sony HDCAM and Panasonic D5. All formats use the existing physical tape formats originally designed to record SD video, but with new compressed bitstream techniques to store the additional data HD requires. Fortunately, there isn't a significant archive of analog HD tape content.

Sony HDCAM format

Sony's HDCAM supports 1080 resolutions at frame rates of 24P, 25p, 50i, and 60i. HDCAM internally stores the video at 1440 x 1080, a 33 percent reduction horizontally from 1920. It also uses unique 3:1:1 color sampling. HDCAM has a 7:1 compression ratio and only half of the color detail of other HD formats. It supports 10-bit input and output and four 20-bit audio channels.

HDCAM is a time-tested format that produces visually impressive results. The compression system has not proved to be much of a practical limitation, and, HDCAM is reasonably priced. The next generation HDCAM SR format from Sony uses the MPEG-4 Studio Profile compression to enable the recording of full-bandwidth, full-resolution, 10-bit 4:4:4 video.

Panasonic D5-HD format

Panasonic's D5-HD format uses the D5 tape shell. In addition to the formats supported by HD-CAM, D5-HD can handle 720 60p, 1080 60i, and even 1080 30p. Higher-end decks also handle 1080 24p. D5-HD supports eight channels of audio.

On the downside, the lower-end decks can't play back the 24P format. Also, older decks support only four channels and tapes recorded with eight channels will not play on them. Unlike HDCAM, D5-HD maintains full horizontal resolution, but uses a slightly higher level of compression.

Panasonic DVCPRO-HD/DV100 format

Panasonic's other HD format is DVCPRO HD (sometimes called D7-HD or DV100), and is based on the same tape shell used for DVCAM and DVCPRO. It supports 720 60p and 1080 60i. It is one of the most lightly compressed formats; it uses 1.67:1 compression and supports 10-bit per channel and eight channels of audio.

HDV format

JVC introduced the HDV format with the release of their ground-breaking, mid-range HD camera, the JY-HD1O. HDV uses an MPEG-2 transport stream (which includes a significant amount of error correction) on a miniDV tape. The format uses interframe compression to achieve a data rate of 19 Mbps for 720p or 25 Mbps for 1080i. Audio is encoded in 384 Kbps MPEG-1 Layer II stereo. The bitstream is easily transferred between camcorders, decks, and computers through an IEEE 1394 (Firewire) connection.

Since the JVC introduction, other vendors have released camcorders, related gear, and editing software that support low-end HD production using HDV. For under US$10,000, anyone can get into HD production with an inexpensive camcorder, computer, and editing software. Adobe Premiere Pro includes native HDV support, so you can begin editing your HDV production without any additional hardware or software.

Note that HDV uses the same bitstream as DVHS, but on a smaller tape.

HD storage

To edit an HD production, you need to transfer the data to a storage system that can be accessed by a computer for processing and editing. That storage system is typically a hard drive or a hard disc array. In the case of the high-end studio systems, no transferring is needed because the data from the camera is recorded directly to hard drives. For most producers, however, the next step is transferring or capturing the bitstream from a videotape.

Big numbers to store

To get better quality, HD requires many bits, which requires more storage. The following table compares DV, HDV, SD, and HD format storage requirements:

WIDTH	HEIGHT	FRAME RATE	FORMAT	MEGABITS PER SECOND	GB PER HOUR
720	480	29.97	DV25	25	11
720	480	29.97	DV50	50	22
720	486	29.97	8-bit 4:2:2	168	74
720	486	29.97	10-bit 4:2:2	210	92
1280	720	29.97	HDV 720 30p	19.2	8
1280	720	23.976	8-bit 4:2:2	354	155
1280	720	23.976	10-bit 4:2:2	442	194
1280	720	25	8-bit 4:2:2	369	162
1280	720	25	10-bit 4:2:2	461	203
1280	720	29.97	8-bit 4:2:2	442	194
1280	720	29.97	10-bit 4:2:2	552	243
1280	720	50	8-bit 4:2:2	737	324
1280	720	50	10-bit 4:2:2	922	405
1280	720	59.94	8-bit 4:2:2	884	388
1280	720	59.94	10-bit 4:2:2	1105	486
1920	1080	23.976	8-bit 4:2:2	795	350
1920	1080	23.976	10-bit 4:2:2	994	437
1920	1080	25	8-bit 4:2:2	829	365
1920	1080	25	10-bit 4:2:2	1037	456
1920	1080	29.97	8-bit 4:2:2	994	437
1920	1080	29.97	10-bit 4:2:2	1243	546
1920	1080	59.94	10-bit 4:2:2	2486	1092

This table shows the ranges of file sizes and the required storage capacities.

UNDERSTANDING STORAGE CAPACITY

The abbreviation Mbps means megabits per second (1,000,000 bits per second); MBps means megabytes per second (1,000,000 bytes per second). One MBps is eight times faster than one Mbps. GB stands for Gigabyte. A GB is properly 1,000,000,000 bytes, although many applications assume it is really 2^{30}, which is about 7% larger. The same issue is true of MB, which is really 1,000,000, but is often considered to be 2^{20} and is about 4% larger.

The SD and HD values assume the video is the native uncompressed format. As you can see, there are substantial differences in storage requirements for the different types of HD.

Required transfer rate for storage

The first issue in storage is sustained transfer rate: Can the storage system reliably move all of the bits of video from the tape to the disk in real time? Many storage systems measure "peak" transfer rate, which is a best-case performance during a short burst of activity. This measurement is helpful if you'll be using the system mainly for transferring blocks of data for local playback. However, when you stream video to or from a storage system, it is essential to know the sustained, or guaranteed, transfer rate that can be maintained long term. When the transfer can't keep up, frames are dropped from the capture, which means the video stutters during playback.

For anything other than an HDV capture, a single drive does not typically provide sufficient bandwidth for capture. In those cases, a Redundant Array of Independent Disks (RAID) system is the best solution. When playing a video stream from a drive, keep in mind that real-time effects require additional read performance.

Required capacity for storage

Once you solve the drive speed problem, you need to make sure the drive has enough storage for the intended use. To make the best use of storage space, consider capturing and editing an offline version in SD first. Then capture only the HD footage required for the final edit.

A single 300 GB drive may provide enough storage for many HDV projects, but you will most likely need a RAID solution when working with larger HD formats.

Using RAID systems for HD storage

The key to making storage for HD work is RAID technology, which ties multiple drives together into a single volume. This process increases storage while making it easy to access the media. Because RAID enables writing to multiple physical disks at the same time, throughput is increased. Also, it is possible to configure a RAID so that it automatically duplicates data from one disk to another. This redundancy provides a safety net in the event of a disk failing. When a drive fails, the array automatically substitutes the redundant data set and rebuilds it to yet another drive so that the redundancy is preserved. This rebuilding can often reduce the available throughput or can require the RAID to be taken out of service during the rebuild. RAID storage vendors build different capabilities into their systems; consequently, it is important to know the level of redundancy and rebuild performance you require when you choose a RAID to store your video.

Types of RAID systems

There are many different types of RAID that combine drives in different ways. There are four types of RAID relevant to video work:

RAID 0 uses two or more drives and splits the data between them. RAID 0 has no redundancy and offers no protection from data loss. If one drive fails, all of the data in the set is lost. However, all drives are used for storage, and performance is blazingly fast. If the source is backed up, RAID 0 performance and price can be worth its fragility. For editing with CineForm's Aspect HD, a two-drive RAID 0 is sufficient for 720 30p. More drives are needed as speed requirements go up, but the more drives you add, the greater the chance of failure.

RAID 3 uses three or more combined drives and dedicates one to be used for redundancy. The volume can survive any one drive failing. RAID 3 doesn't perform quite as well as RAID 0 on total throughput, but the fault tolerance is well worth it. Because the parity is dedicated to one drive in RAID 3, there is no effective limit to how you size your blocks for transfer.

RAID 5 uses three or more drives in a set, and the redundancy is shared across all of the drives by dedicating equal space on each drive to parity, or redundant, data. RAID 5 provides aggregate transfer rates that are better than RAID 3.

RAID 5+0 uses two or more RAID 5 sets combined into one RAID 0. Typically, each of the RAID 5 sets is on its own drive controller, allowing bandwidth to be split over two controllers. This division of bandwidth provides better performance than RAID 5, while still providing redundancy (one drive per RAID 5 set can fail without data loss). RAID 5+0 is the optimal mode for most HD use.

Comparing SCSI drives and ATA drives

The battle between SCSI and ATA drives (a class of IDE drives) for high-performance storage has being on-going for over a decade. Historically, SCSI drives were faster than ATA drives, and ATA required more CPU power to run. Currently, however, Serial ATA has, for the most part, caught up with SCSI. Even uncompressed 1080 60i 10-bit video plays well off of a very fast ATA RAID. And because the cost of fast IDE drives is so much less than SCSI and cabling is easier with Serial ATA, the industry has continued the rapid transition to ATA, even in the HD world.

Either way, HD performance requires a stand-alone hard drive controller card (potentially several for throughput). The RAID controllers on many motherboards aren't up to the task of 1080 uncompressed video. For the most reliable video performance, software RAID controllers are not recommended. Hardware RAID controllers for video work often contain onboard caches that are essential for efficient management of data transfers.

HD and connectivity

RAID systems work well for storing files locally. But when you need to split the work among multiple workstations, for example, between an Adobe Premiere Pro editor and an After Effects compositor, you need a system that can handle high bandwidth and high speed networking.

Transferring HD content via Ethernet

The simplest way to move files is by means of Ethernet networks. Transferring files between two or more computers is easy by means of Server Message Block (SMB). Mac OS X 10.3 and later make it easy to transfer between Macintosh computers and computers running Microsoft® Windows®.

Ethernet speeds vary widely. For HD work, you should use Gigabit Ethernet, which can typically support several hundred Mbps of bandwidth with good cables and a fast switch.

Transferring HD content using SAN

When a workgroup wants to share content for editing without transferring it to a local drive first, a storage area network (SAN) is a good solution. SANs allow multiple computers to access the same storage as if they were on local drives on each computer. A SAN is much faster and provides more reliable data access for real-time playback than Ethernet. You can even capture HD content directly to stored media without transferring it after the capture. (This isn't recommended because network traffic can cause dropped frames.) There is a higher cost per workstation to connect, but storage isn't much more expensive, and the workflow advantages are well worth it.

Transferring HD content using sneakernet

The final solution for transport is "sneakernet," or rather, simply transporting media physically from one computer to another (for example, using FireWire drive, a tape, or a whole RAID system). Overnight mail can move 300 GB across the country in 24 hours. That would take two weeks with a T1 line.

Capturing HD content

How does the content move from tape to storage? That's the role of capture, which is ably handled in Adobe Premiere Pro. You can use one of two dominant protocols to capture HD content: the high-end formats use High Definition Serial Digital Interface (HD-SDI), and HDV uses FireWire.

Capturing using the HD-SDI protocol

HD-SDI is a straightforward extension of the Standard Definition Serial Digital Interface (SD-SDI) protocol. It supports all of the standard HD frame sizes and rates with 4:2:2 10-bit sampling.

The main drawback is that HD-SDI is always uncompressed. Consequently, the bit rate of a compressed format, like HDCAM or DV100, balloons when transferring via HD-SDI. The increase in bit rate also increases the storage requirement, and the need for higher processor and bus speeds. A number of capture devices, such as the XENA LH from Aja, enable real-time capture and playback of uncompressed HD content on a computer running Microsoft Windows XP by performing much of the processing of the HD data. Other solutions tackle the problems of compression, such as capture devices that compress the HD data as it is captured, and mass storage, such as very large and fast RAID arrays.

Capturing using AES/EBU

You can embed audio into an HD-SDI bitstream or transport it externally over an AES/EBU connection. AES/EBU is an uncompressed audio bitstream that can transport the full quality of the information on the HD tape.

The only disadvantage of using AES/EBU over embedded HD-SDI audio is that AES/EBU requires more cables.

Capturing with FireWire

IEEE-1394 (also known as FireWire and i.Link) took the video world by storm as a transport connection for the popular DV video format. FireWire, which has a theoretical peak of 400 Mbps, has the transfer speed to handle many formats. The 1394b standard, which has also begun to appear in computers, has a peak of 800 Mbps. However, the only formats currently supporting FireWire are DV and HDV, which stream at 25 Mbps, and DVCPRO HD, which streams at 100 Mbps.

Frame size and HD capture

Some capture cards can support on-the-fly upsampling and downsampling to convert between 720 and 1080. On-the-fly sampling can be very useful when you're creating a project from mixed HD sources or a 720 project from 1080 sources. Other capture cards can only capture at the native frame size, which may be all that some people require. A few solutions support only 720 or 1080.

Capturing 8-bit versus 10-bit video

Video formats use either 8 or 10 bits per channel. Video with 8 bits per channel has 256 steps from black to white, and 10-bit video has 1024 steps. The extra steps in 10-bit video mean higher quality and more detail. HD-SDI video uses 10 bits per channel. However, compressed delivery formats, like MPEG-2 and Windows Media, use only 8 bits per channel. If your destination video is compressed, therefore, you don't need to capture in 10 bits.

Most HD production formats are 10-bit, but most HD delivery formats are 8-bit. Converting from one to another can be tricky. Some tools might truncate the least-significant 2 bits. This process normally works fine, but in content with very smooth gradients, some banding might occur. Some capture cards can dither on-the-fly to 8 bit while capturing, which reduces storage requirements and provides a better dither than many software exporters.

Audio capture support

Audio for HD can be virtually any bit depth and sampling rate. Professional video editors frequently use the old standards of 48 kHz 16 bit. Higher bit depths, such as 20 bit and 24 bit, and higher sampling rates, such as 96 kHz, are becoming more common.

Audio for HD is often mastered in a multichannel format, such as 5.1 surround sound (five speakers plus a subwoofer) or 7.1 surround sound (seven speakers plus a subwoofer). Most HD tape formats support at least four channels of audio and many support eight. When delivering HD content, Dolby Digital audio can support 5.1 channels of 48 kHz audio; and Windows Media Audio 9 Professional can deliver 5.1 and 7.1 channels at 96 kHz.

HD solutions compatible with Adobe Premiere Pro

Adobe Premiere Pro currently offers two great HD solutions and others are coming soon. As of NAB 2005, the following companies have introduced or committed to providing hardware, software, or both to support HD video editing with Adobe Premiere Pro:

- 1 Beyond (www.1beyond.com)
- BlackMagic Design (www.blackmagic-design.com)
- Bluefish 444 (www.bluefish444.com)
- Boxx Technologies (www.boxxtech.com)
- Canopus (www.canopus.com)
- CineForm (www.CineForm.com)
- Matrox (www.matrox.com/video/home.cfm)

For a current list of all third-party vendors for Adobe Premiere Pro, visit the Adobe Premiere Pro third-party resource page on the Adobe website at www.adobe.com/products/premiere/dvhdwrdb.html.

Post-production for HD content

After you've acquired the content, post-production begins. In the Adobe production workflow, post-production is the domain of Adobe Premiere Pro for editing, Adobe Audition® for sound mixing and sweetening, and After Effects for compositing and finishing.

Post-production for HD is similar to post-production for SD. One difference is that with HD you're dealing with significantly more data and consequently increasing the load on the CPU and video card. However, if you have worked in Adobe Premiere Pro and After Effects for SD, you can use the same tools and enjoy the same workflow in HD.

A complete HD post-production suite can include a workstation for acquisition and editing, and another for scene-by-scene color correction and effects. With two workstations, an Editor and Colorist can work on different parts of the production at the same time. One or more videotape playback decks may be located near the editing workstation for acquisition, depending on the formats used in production. To ensure that high quality is maintained throughout the process, a suite should include at least one high-resolution monitor. High performance computers and a RAID array are used for fast processing, and reliable mass storage.

Choosing an HD monitor

HD video monitors can be quite expensive, especially models with an HD-SDI input. However, a true professional-grade HD video monitor is essential for any producer working with HD destined for broadcast.

For some tasks, a computer monitor is a less expensive way to view the actual HD output, especially for projects that use progressive scanning. However, computer monitors use a different color temperature from true video monitors, so it's beneficial to use a video monitor to ensure that you see the true representation of the video as it will be delivered. A number of vendors offer HD-SDI to Digital Video Interface (DVI) converters to drive computer monitors. High-quality 1920 x 1200 LCD monitors are now available for around US$2000, so this converter is cost effective. Because computer monitors are natively progressive, these converters are not a good solution for natively interlaced projects in Adobe Premiere Pro. (Conversion isn't an issue with After Effects because the preview is progressive.)

Another advantage of using broadcast monitors is calibration. These monitors provide features that easily set them to the canonical 709 color space of HD. While this setting is possible with a computer monitor as well, correctly setting the calibration can be difficult or inaccurate. Even systems with a colorimeter for automatic color configuration don't always include 709 presets.

Adobe Premiere Pro, with the proper hardware, can also send previews directly to a video or computer monitor. Sending previews directly is the optimum way to work if hardware that supports this feature is available.

HD can be slow!

The additional throughout and processing power required for HD production often exceeds the capabilities of even the fastest computers. A computer that handles SD video simply cannot be expected to provide the same performance with HD, without a little help. The good news is that modern tools give you a number of techniques to get around these limitations.

Specifying rendering quality and compression

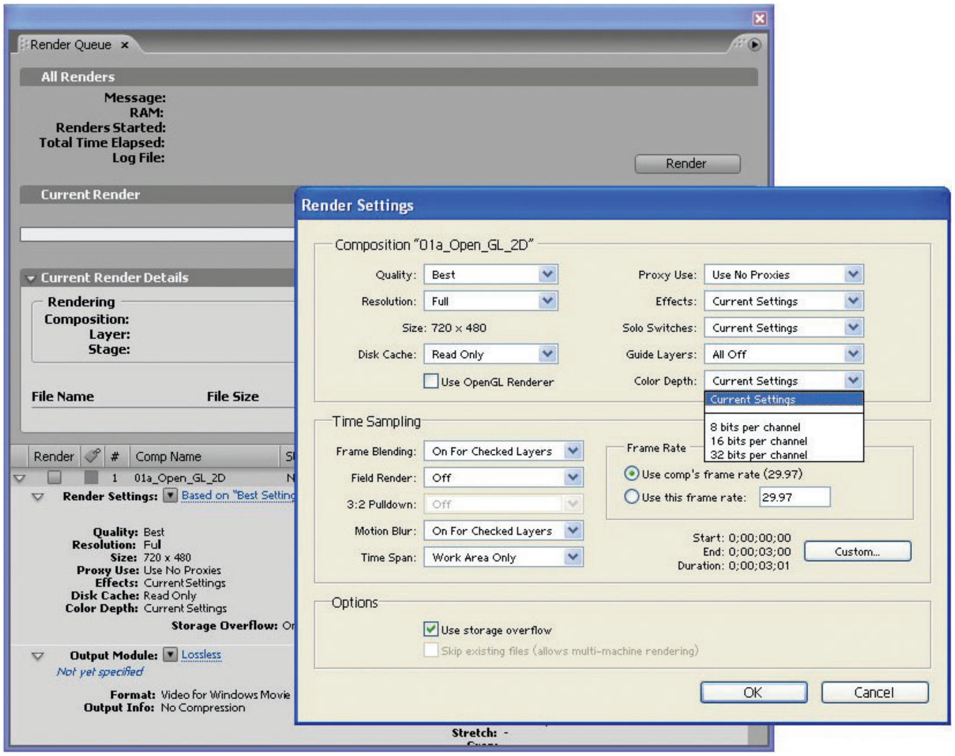
After Effects has several rendering modes. For final output, you should always use the highest quality mode, especially when your final product is to be compressed. High-quality mode can increase compression efficiency, resulting in fewer image artifacts.

Rendering in After Effects

16-bit per channel (bpc) rendering was introduced in the After Effects Production Bundle and is now available in both After Effects Standard and After Effects Professional. The 16-bpc rendering process doubles the number of bits available for each channel, which greatly increases the precision of the video rendering. That extra precision is quite useful, especially in reducing the appearance of banding in an image with subtle gradients. This precision has a cost. 16-bpc rendering takes twice the time and requires twice as much RAM as 8-bpc rendering.

16-bit per channel rendering is adequate for most video, and After Effects also features 32-bit rendering for high dynamic range (HDR) footage. Floating-point numeric values allow the same number of bits to describe a much wider range of values than fixed-point values; 32-bits per channel allow for much greater precision than do 8- or 16-bits per channel. This flexibility enables you to work with images that have a very wide range of brightness levels, more like the range of levels found in the real world.

Rendering in 16 or 32 bpc isn't necessary when encoding to an 8-bpc delivery format like Windows Media or MPEG-2. It does, however, provide a very welcome quality boost when going back out to 10-bpc formats like D5.



You can render in 16 or 32 bits, instead of the default 8 or 10 bits, to achieve the highest possible quality.

Support for real-time effects

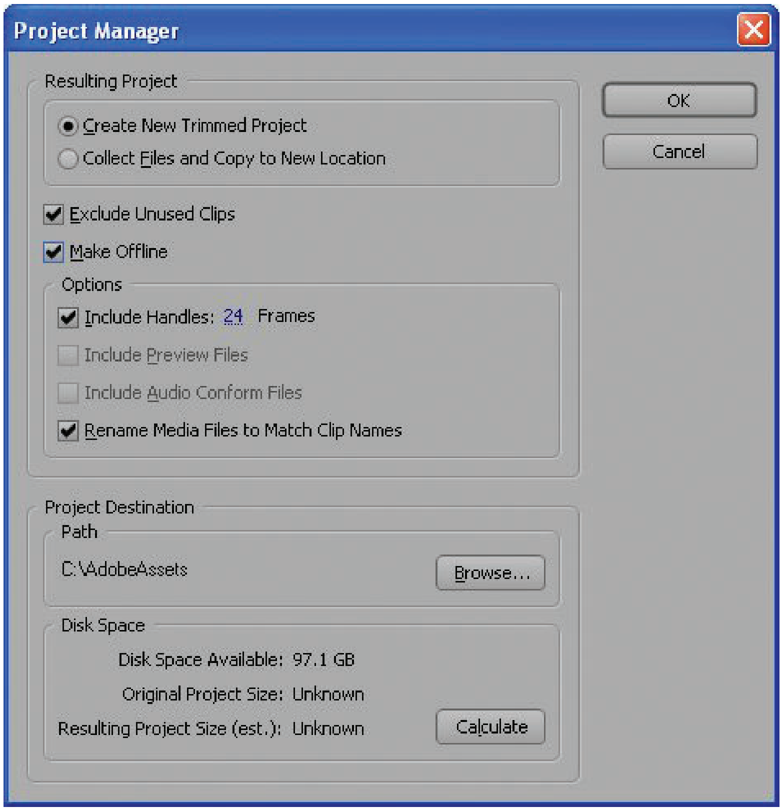
Many content creators have become accustomed to real-time effects in SD, which were made possible by advancements in nonlinear editing software tools. Currently, achieving similar functionality in HD is not as easy. Common HD workflows include uncompressed video streams the amount of data required to be transferred to and from the storage subsystem and the load on the CPUs make real-time performance nearly impossible with software alone.

Using additional dedicated hardware that can take much of the heavy-lifting tasks away from the CPU is the key to working with very high-bandwidth, CPU-intensive HD data. For example, the Matrox Axio HD editing platform provides turnkey solutions that integrate Adobe Premiere Pro, a high-end computer, and Matrox hardware enhancements to enable an editor to work with compressed and uncompressed HD in real time. Additional solutions that work with Adobe Premiere Pro are available from other manufacturers.

If uncompressed video streams are not a firm requirement, you can use advanced compression techniques to produce visually lossless media at data rates that allow various levels of real-time editing, including multiple streams, effects, filters and graphics. Adobe Premiere Pro provides native support for HDV, which means that you can log, batch capture, and edit HDV footage in real time without a need for additional HDV plug-ins.

Working offline in SD

By using a hardware solution or software-based compressed solution, you can bypass the offline step entirely. Alternatively, you can capture and edit a project in SD, and then conform the final edit to HD. Adobe Premiere Pro makes this process quite easy. When you use this technique, the standard real-time effects of Adobe Premiere Pro are available when you're editing the offline version. This option allows you to work quickly with real-time visual feedback.



The Project Manager in Adobe Premiere Pro helps you conform an offline SD edit to HD.

You can use the Project Manager in Adobe Premiere Pro to expedite the offline process. First, capture and edit in a lower-resolution format, such as SD or DV. Second, use the Project Manager to make a new project containing placeholders (offline files) for only those assets that were used. Then, open this new project. Finally, use Batch Capture to recapture, in full resolution, only the HD footage that is necessary to reassemble the project for quick finishing and delivery.

In After Effects, using low-resolution compositions while roughing out a piece provides similar advantages in speed. As with Adobe Premiere Pro, you can apply the work made with low-res copies to HD copies of the same files.

Taking advantage of network rendering

After Effects includes grid rendering, which can improve workflow for HD production, especially with complex projects. After Effects has supported network rendering for a number of years, but the new grid model makes the process much easier. It also enables network rendering for previews, not just final rendering in the render queue—a great enhancement. You can set up a four-node render farm for less than the cost of a single high-end HD capture card, and it can pay off enormously in a more efficient workflow.

Choosing progressive or interlaced output

Unlike broadcast TV, which is natively interlaced, HD is natively progressive in many cases. The choice of scanning modes was a contentious issue during ATSC's development because the computer industry was lobbying very strongly to drop interlaced entirely from the specification, and the traditional video engineers were fighting hard for interlaced to remain. In the end, the 720 frame sizes are always progressive, and the 1080 frame sizes can be either progressive or interlaced.

It is always best to perform postproduction in the same format that you intend to use for delivery. Consistency in formats prevents the need for transcoding, which can add artifacts and require long rendering sessions.

If you're creating content to be used in a variety of environments, working in 24P is a great universal mastering format. The 24P format easily converts to both NTSC and PAL, as well as back to film. Also, the lower frame rate reduces hardware requirements.

SD color space versus HD color space

SD and HD define colors differently. Specifically, SD uses International Telecommunication Union (ITU) 601, and HD normally uses ITU 709.

Typically, the only time you'll run into problems is when converting between SD and HD. If a conversion method does not also automatically convert the color space, you will see a slight shift in the colors. The easiest way to check for problems is to use a 709-calibrated monitor.

The good news is that color space conversion happens transparently in most cases. For example, when After Effects converts from RGB to Y'CbCr in a video codec, the codec handles the transformation internally. Therefore, exporting from the same After Effects project to both an SD and an HD output should work well.

When you work in a native color space tool, such as Adobe Premiere Pro, and capture, edit, and deliver in the same color space (for example, 709), color accuracy and fidelity are maintained. The native filters in Adobe Premiere Pro assume that the 601 color space is used, but this assumption rarely has much effect on the math used in video processing. Still, it's a good idea to use a 709-calibrated monitor for previews when using Adobe Premiere Pro.

HD and distribution

True mass distribution of HD content is awaiting the emergence of technologies that have all the qualities necessary to make it succeed in the marketplace; there are many different medias and formats to choose from, depending on workflow needs.

Deciding on distribution media for HD content

There are a variety of ways that you can distribute HD content to customers and clients, but at the moment, the best choice is DVD.

High-definition DVD delivery

The great promise for HD delivery is the DVD. The DVD has many advantages over tape and other methods. DVDs are inexpensive to manufacture, their small size makes them easy to distribute, they are durable, and the audio and video quality is high and does not deteriorate with use. DVD players are small and inexpensive, and the average consumer can use them easily. It would seem that the DVD is also the perfect answer for HD delivery. The only problem is that HD requires over twice as much storage space than is available on a standard DVD, and a much higher data rate than standard DVD hardware can handle.

A number of technologies have been developed to squeeze more data onto a DVD and currently two are vying for supremacy in the marketplace: HD-DVD (supported by the DVD Forum) and Blu-ray. The HD-DVD expands on the current DVD format. The Blu-ray format takes a different approach with a blue laser. A two-layer HD-DVD formatted disc can hold up to 30 GB. Blu-ray offers up to four layers, which can hold a total of 100 GB. With the new HD formats, producers are not locked into one compression method, as they are with SD DVDs. Both competing formats offer the choice of three video codecs: MPEG-2, Microsoft's VC1, and H.264/MPEG-4 AVC.

As far as the consumer is concerned, there is very little difference between formats. The technologies around both formats are solid. The only issue blocking the move of DVD players that support HD to the marketplace is the format battle being waged in Hollywood over which to use for distributing full-length motion pictures. The major studios are taking sides and there is currently no clear winner. Each format has advantages for cost, quality, and reliability. It appears that the studios will decide which format will emerge the winner.

SD DVD-video distribution

If you can't wait for an HD standard for DVDs, you can distribute your HD content as SD on a standard DVD. The output will be SD, but because the original content was HD, it's possible to achieve very high-quality SD results. The MPEG-2 engine in both Adobe Premiere Pro and After Effects can output DVD-compliant MPEG-2 content from HD content. It accomplishes this output by scaling and, in some cases, some frame-rate trickery.

By using the Adobe Media Encoder, you can specify a target frame size for the video. Before the HD video frames are compressed to MPEG-2, the encoder scales them down to the target frame size. Because this scaling occurs at the end of the production process, it can achieve the highest quality compression. In the case of 23.976 fps content, the Adobe Media Encoder can insert data in the MPEG-2 stream so that the video plays back interlaced data on a standard TV and DVD player, and progressive data on a progressive scan DVD player and TV. This is the same technique that is used with most Hollywood DVDs.

After the SD MPEG-2 content is created, you can output to DVD either straight from Adobe Premiere Pro or by using Adobe Encore® DVD software.

DVHS and HDV delivery

VHS tape was the preferred consumer delivery method for years, and the industry built on the success with SVHS (Super VHS), and then DVHS (digital VHS). Neither format was a successful mass distribution medium, but the formats have found a niche market with video enthusiasts and prosumers. Given the overwhelming success of DVDs, however, interest in mass delivery via tape is waning.

DVHS uses an MPEG-2 bitstream recorded on high-grade tape, and packaged into the familiar VHS tape shell. The MPEG-2 engine built into both Adobe Premiere Pro and After Effects is capable of making DVHS compatible MPEG-2 bitstreams.

As mentioned earlier, HDV uses the same bitstream as DVHS, only on a smaller cassette. HDV camcorders and decks are currently available with prices starting at the upper end of the consumer market.

DVD-ROM delivery

A mid-range PC and monitor provide a platform for playback of HD content. Because the installed base of computers is far higher than that of dedicated HD players and displays, there is a ready-made audience for HD content. A number of titles have been distributed commercially using DVD-ROM delivery. Users can also burn their own HD content onto DVD-Rs.

MPEG-2 and Windows Media are the most popular formats for HD DVD-ROMs in use today, and both can work well. The Windows Media HD format was the first to be used in commercial products. It can compress a 2.5-hour HD title on a dual-layer DVD. MPEG-2 requires much higher bit rates for equivalent quality.

One drawback to Windows Media is that it doesn't work at HD frame sizes on Macintosh computers. If you want playback on anything other than a computer that runs Windows, another format, such as MPEG-2, is appropriate. Note that there are issues with the availability of MPEG-2 playback software.

Because you can play back the files on a computer, you can build various levels of complexity into the user interface. However, it's a good idea to allow users to pick their own player for the raw files because users commonly have their own preferences for players.

Hard drive delivery

For kiosk and laptop presentations, playback from the hard disk is the simplest and most reliable way to go. Space is plentiful, and a hard drive is more durable for continual use than a DVD-ROM drive. Additionally, because peak data rates are so fast from a hard drive, the only real limitation is the system's decode performance. For delivery of compressed content, any modern hard drive is more than good enough.

Progressive download delivery

Progressive download is the original form of web video delivery. Unlike real-time streaming, progressive download transfers the file using the same protocols as web pages. There are no buffering errors or image glitches due to dropped packets, but there is also no guarantee of real-time performance and users with slow connection speeds will have to wait. With progressive download, you can encode the content at higher data rates than the viewer's connection speed. Only the portion of the file that has been transferred plays, but the viewer can watch that portion and decide whether or not to continue the download.

Real-time streaming delivery

While it is technically possible to stream HD in real time, bandwidth remains a barrier. A visually pleasing 720 24p video requires at least 4 Mbps, even in high-end formats. This data rate is not available in homes today and is more than most intranets can sustain. However, high-bandwidth streaming is currently being used in a number of scenarios using dedicated networks, such as hotel pay-per-view and IPTV (Internet Protocol Television) systems. An IPTV system, which is typically operated by a telecommunications provider, delivers a cable TV-like experience to customers over a DSL connection.

There have also been impressive demonstrations of HD streaming over the academic Internet2 network. The fastest consumer Internet connections are only around 8 Mbps at best today, but the combination of improved codecs and increased bandwidth should make HD streaming to users a feasible market later this decade.

Broadcast delivery

You can broadcast HD as ATSC. In most cases, you provide broadcasters with master tapes of the programs, and then they handle the encoding themselves. However, local broadcasters may be able to accept programming as MPEG-2 transport streams.

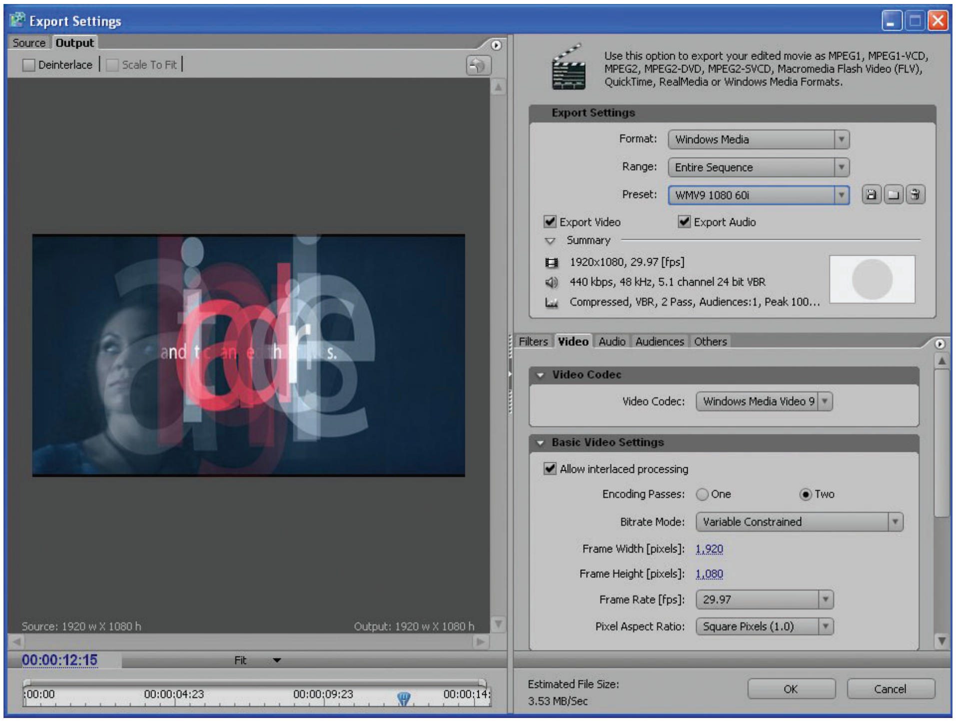
Most HD broadcasting that occurs during the day is often in the form of loops of compressed MPEG-2 content. Enterprising HD producers might be able to get some airtime by providing free, high-quality HD MPEG-2 content for local broadcasters to include as part of their loop.

Distribution formats for HD content

A variety of distribution file formats are available for delivering HD, either for final distribution to consumers or for distribution of proofs of work-in-progress for review. You can also use the following codecs to produce DVDs in either the HD-DVD or Blu-ray format.

Windows Media format

The leading format for computer-based distribution of HD content so far is Microsoft's Windows Media format. Many titles have been released in the format, which demonstrates excellent quality and compression efficiency, and includes digital rights management (DRM) to help prevent piracy.



Detailed video encoder settings for the anamorphic 1080 24p WMVHD

Currently, WMVHD works well only on computers that run Windows 2000 or XP. There is a Windows Media Player for Mac OS, but it doesn't have sufficient performance capabilities for HD playback.

To reduce file size and improve the compression efficiency when rendering WMVHD, you can use one of the anamorphic encoding templates. The template actually renders a video with a 4:3 aspect ratio, such as 1440 x 1080 pixels. If you were to play back the file as is, the video would appear squeezed horizontally. However, when played in a properly configured player, the image is stretched back out to the normal 16:9 ratio, by using pixels with a wider pixel aspect ratio. You can also render WMVHD with square pixels at an HD frame size, such as 1280 x 720.

Because Windows Media has no fixed frame dimension requirement, you can tailor the frame size to fit the source frame exactly. By rendering with the source dimensions, you don't waste encoding time and storage on letterbox bars. The frame you get is exactly the same size as the original. And you can use the anamorphic technique on top of that to save additional storage. For example, you could encode a 2.35:1 movie from a 1080 source at 1440 x 816 with nonsquare pixels.

Microsoft's VC1, which can be used to compress in either the HD-DVD or Blu-ray format, is the standard version of the WMV9 codec.

MPEG-2 format

The standard MPEG-2 used for HD is called Main Profile @ High Level or MP@HL. This mode uses the standard techniques for MPEG-2 that are used on DVD and other media but with much higher limits for frame size and data rate.

One drawback of MPEG-2 is that HD-compatible decoders don't ship by default with most computers. These decoders are commercially available for US$30 or less, but you have to either distribute the HD MPEG-2 content with a licensed player or ask the end users to acquire a player themselves. There are a number of freeware HD-compatible MPEG-2 players. One of the most successful is the VideoLAN Client (VLC). However, it is unclear if it is legal to distribute those players on a DVD-ROM without paying an MPEG-2 licensing fee.

The MPEG-2 specification has Layer II as the standard audio codec, but most HD MPEG-2 delivery systems, such as ATSC, use the Dolby Digital (AC-3) audio codec. An advantage of using AC-3 is that it natively supports multichannel audio, whereas most Layer II implementations are stereo only.

MPEG-4 Part 10/AVC/H.264

The MPEG-4 Part 10 codec is better known as AVC or H.264. This codec was redesigned with the primary goal of optimizing compression efficiency. It has been adopted for use in computers, broadcast television throughout the world, and Direct Broadcast Satellite TV. The improved efficiency makes it a good candidate for HD compression.

The focus on compression efficiency means that AVC takes more computational power to decode than competing formats. One open question with AVC is how well quality holds up at HD and high data rates. The initial implementations have some difficulty preserving fine details, like film grain. Indications suggest that it doesn't do as well as WMVHD, but a definitive answer to that question is still to be determined.

Computer playback and HD

To get the most out of computer playback with HD media, you'll need to consider the best display device, system performance configuration, and audio solution for your workflow.

Display devices for HD

You can use a variety of display devices for computer playback. Each device has its own strengths and weaknesses. You can create content that plays well on all standard HD devices or you can target a specific display.

Using CRT computer monitors

The most common type of computer playback is the venerable CRT monitor that uses a VGA connector. Most CRTs can handle a variety of resolutions.

Because CRTs use the analog VGA connector, they can be sensitive to analog noise, especially at high resolutions like 1920 x 1440. By using short runs of high-quality cable, you can avoid this problem. Look for cables with ferrites (barrels near each end). Running through a K Virtual Machine (KVM) switch or using long runs of cables can result in soft images ghosting or other artifacts. If you need long runs or switching, you can use digital DVI connections and a DVI-to-VGA converter at the display to keep the image in digital form as long as possible. The inexpensive DVI-to-VGA adaptors won't help; they simply put the analog VGA signal on the DVI cable instead of converting the signal into true DVI.

Most CRTs are 4:3, so 16:9 HD content displays in letterbox format.

Using flat panel displays

There are some important differences among CRT, LCD, and other flat panel displays. The flat panels have a single native resolution, but CRTs can handle a variety of resolutions. And modern flat panels use the digital DVI connector instead of VGA. Avoid using any flat panel by means of VGA. The analog noise produced by the VGA connector results in a degraded image.

To get the crispest image and avoid scaling when producing content for display on a particular flat panel, you should try to encode content using that panel's native resolution.

Using laptop displays

For demonstration work, using a laptop's built-in screen works well. However, keep in mind that performance on a laptop may be slower than that of a high-end desktop PC. You can generally play back 720 24p video on today's fastest laptops, but it can be problematic and difficult to achieve 1080 laptop playback.

When authoring content specifically for playback on a laptop, try to encode at the native resolution of the screen.

HD playback on a fast laptop

Using HDTV displays

HDTV devices like televisions and projectors typically play HD content from a tuner connected to an antenna or cable. However, by using a DVI interface and properly configuring the computer drivers, a computer can deliver content to an HDTV device. For example, a computer can be configured to act as a home theater center and stream HD or SD video from a DVD, CD, hard drive, or tuner card. A computer equipped with Microsoft's Media Center Edition is a ready-made home theater system that includes a menu, remote control, media library, mass storage, and recording capability.

Computer playback configurations

Turnkey entertainment computer systems, such as Media Center Edition PCs, make it easy to get started playing HD with a computer. When building an HD-capable system or updating an existing system, however, there are some configuration issues to be aware of.

Optimizing system performance

The fuzziest requirement of all is system performance. Traditionally, CPU speed has been used as the measurement of performance, but there are many other elements that are also important, such as RAM capacity.

Microsoft's Windows Media HD DVD-ROM titles recommend a minimum of a 3 GHz CPU. Microsoft also recommends at least a Pentium 4 CPU because that processor comes with a minimum memory bus speed that HD playback requires. Also, note that frame size and frame rate matter. Playing back 720 24p is less than half as challenging as playing back 1080 60i.

For laptop applications, note that the GHz rating of Pentium® M computers may understate their actual performance. Usable 720 playback results have been reported with 1.7 GHz Pentium M systems. The faster the system, the better the performance experience. If you intend to work with HD content of any type, get the most powerful system your budget will allow.

Using high-bandwidth video cards

A fast video card is critical for good HD playback performance. Ideally, you should use an Accelerated Graphics Port (AGP) 8x or PCI Express bus. Three-dimensional performance doesn't matter for video playback. It's really a matter of the bus speed and the size of the memory in the card. High-end 3D cards also come with those features.

There are a number of laptops available, which attempt to provide desktop performance using components with similar specifications. These systems can be used for HD production, and many of them have DVI output for easy presentation of HD content.

Configuring an audio playback system

Playing audio content from an HD video source in a computer isn't very different from playing audio associated with SD video. Stereo audio files tend to be the same bandwidth no matter where they are used. However, HD video is often accompanied by multichannel audio, such as 5.1 surround sound.

Playing analog stereo audio

Playing back stereo audio is very simple because it works with any stereo equipment. The biggest issues are sound card quality and analog noise. Inexpensive sound cards with mini jacks can introduce line noise. It is better to use an external audio breakout box, which leaves the digital-to-analog conversion outside of the computer chassis where there is much less noise.

Playing analog matrix surround audio

The older Dolby Pro Logic system provided matrix surround audio where two channels of audio used phase and frequency tricks to encode surround information for four channels: left, right, center, and surround. This system works reasonably well, although it doesn't offer the precise spatial accuracy that discrete channel encoding does.

There is a massive library of matrix-encoded titles available, and they work on the oldest computers. Unfortunately, there is no good way to detect whether or not content is matrixed without playing it through a Pro Logic decoder and listening for directional effects. Stereo played in Pro Logic mode can sound audibly altered, although this is rarely annoying to the casual listener.

Some systems might offer the ability to down-convert multichannel audio codecs into Pro Logic for playback. This process does work, but it produces lower quality audio and more separation than a discrete solution as described earlier.

Playing analog multichannel audio

With analog multichannel, there is one analog output per channel of audio, typically 5.1, with 7.1 available in the high end. As with analog stereo, an external breakout box can provide better quality than mini jacks on a consumer-grade sound card inside a computer.

Depending on the solution, output is either in stereo pairs, or one per channel, that can be connected to an amplifier, or directly connected to powered speakers. 5.1 speaker setups for gaming are becoming popular.

Playing digital stereo and multichannel audio

The ideal solution for playing back audio from an HD source is an all-digital system. Digital delivers the highest quality, so you don't have to worry about noise or make adjustments.

Digital audio can be carried over a TOSLink optical or coax cable, using either the professional AES/EBU or consumer-type S/PDIF connection. Either type of connection can stream stereo or Dolby Digital multichannel surround sound.

Normally, the Dolby Digital AC-3 solutions only work with AC-3 encoded audio tracks. One feature of some of NVIDIA's nForce motherboards is that they support real-time transcoding from any multichannel audio source into AC-3 for easy integration with existing AC-3 decoders. This option is not as optimal as having multichannel audio out, but it works well in practice. Another option for multichannel digital is the Windows Media Audio Professional codec, which can output audio through an S/PDIF port.

Conclusion

By understanding the basics of the HD formats and the equipment that supports them, you can make informed decisions about which HD solutions meet your production and postproduction needs, whether you're a hobbyist or a feature film editor.

The advances in technology and the growth in the number of manufacturers providing HD solutions continue to lower prices to the point where choosing to edit in HD is a real option for almost anyone who produces video.

FOR MORE INFORMATION

For a comprehensive overview of Adobe Premiere Pro, please visit www.adobe.com/products/premiere/main.html.

For a comprehensive overview of Adobe After Effects, please visit www.adobe.com/products/aftereffects/main.html.

Adobe Systems Incorporated • 345 Park Avenue, San Jose, CA 95110-2704 USA • *www.adobe.com*

Adobe