WHITE PAPER: VIDEO PROCESS

Backgrounder on Production and Post-Production Practices

This white paper explores general technical requirements for High Definition (HD), film, and video projects ("the package"). A package includes a wide definition of projects, from a parent posting his child's school play on the Internet to a 30 second commercial to a Full HD, 4k film meant for world-wide release. To further explain the rationale behind the extraordinary demand for digital storage in the making of a package, this document will touch upon contemporary cameras and their growing use of built-in or removable drives.

In the section covering post-production, topics include ingestion or transcoding of the production format (HD, film, or video), non-linear editing (NLE) software, and storage. LaCie offers superb support for the post-production side of the package due to its wide range of high-performing, large capacity hard disk drives (HDD).

While not discussed in great detail here, it should be noted that pre-production, a phase that may run from weeks to months, often requires extensive use of specialized logistical and creative software with sizable storage demands. Pre-visualization and production planning are very common from the simplest to the most ambitious packages.

I. PRODUCTION

In the professional film, commercial, and corporate industrial markets, production refers to the process of principal photography in which the package is recorded onto formats such as HD, film, analog tape, and digital tape, or directly to hard disk. Technical decisions made for production will affect the post-production process, such as the camera media format, selection of resolution, and frame rates.

Digital offers substantial benefits for many users since it allows for higher quality footage, more effective editing, and ease of content distribution. The majority of popular camcorders in today's consumer and professional markets record in a variety of digital formats to tape, flash memory, built-in hard drives, and optical discs. While digital video is now the dominant format, certain sectors, including event or corporate videographers, may occasionally use legacy, tape-based analog camcorders. Sony also maintains a small line of Hi-8 consumer models.

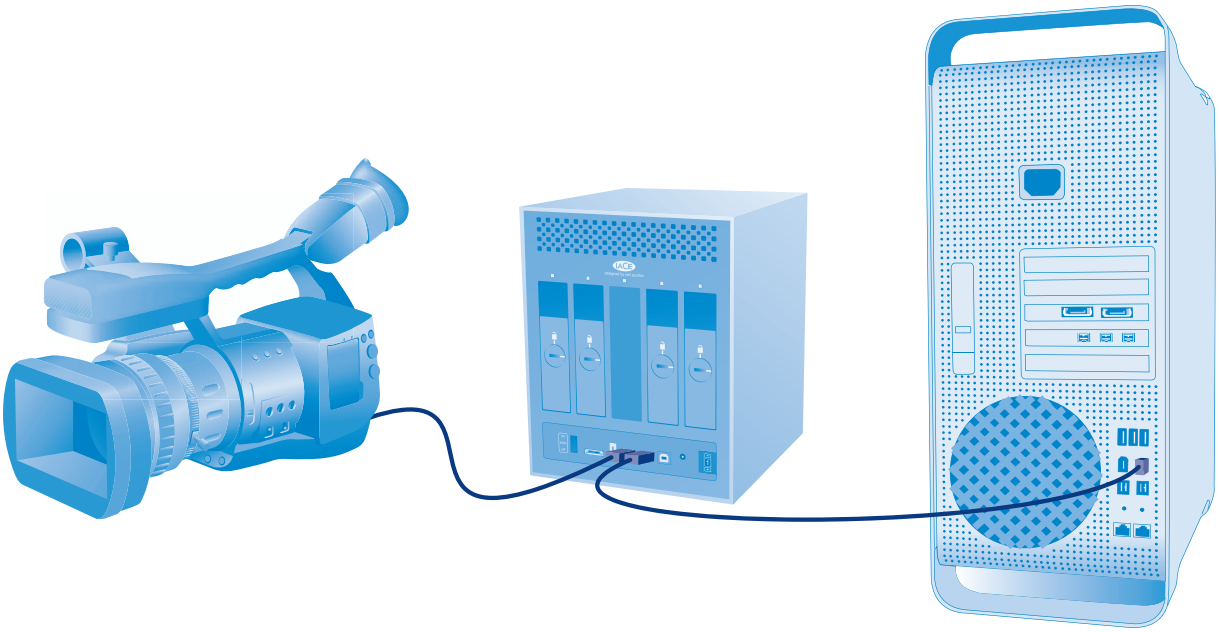
Storage Options

Many digital camcorders feature either built-in or removable storage to capture the video stream as it is created. Removable media is most prevalent in newer consumer and professional camcorders as high capacity disk drives, flash memory (compact flash or serial digital cards), and optical discs (DVD or Blu-ray). While many consumer camcorders include built-in hard drives or a combination of storage formats, professional models appear to be turning toward proprietary HDD magazines. The very popular RED camera allows for recording on its own removable storage or compact flash (CF). High-end cameras such as RED, Panasonic's HD P2, Sony's SxS, feature solid-state drives (SSDs) for maximum durability and speed.

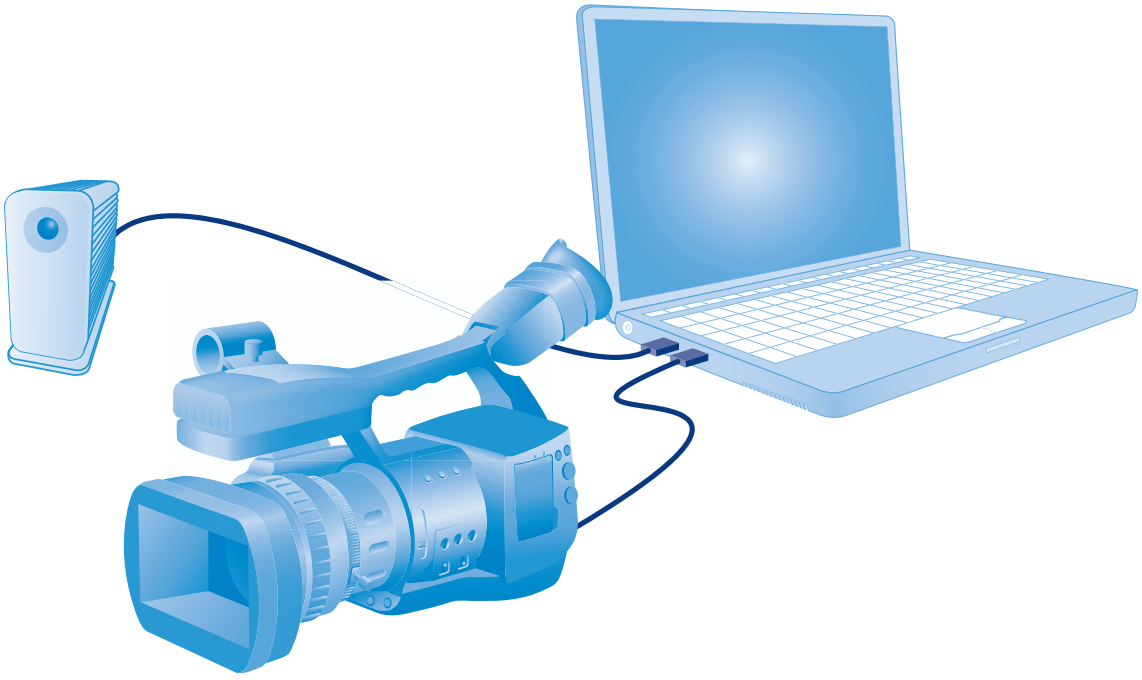
Host Interfaces

Once a production is complete, the media is transferred to one or more computers that have multiple NLE hardware and software solutions specifically targeted for post-production. Generally, in preparation for large stores of media files, the editor or engineer will attach high performance, large capacity external HDD to the editing workstation(s) before ingesting media (also referred to as "capture" or "digitization"). For ingest, several different host interfaces exist, the most widespread being IEEE 1394, frequently known by two proprietary implementations: FireWire 400 & 800 (Apple) or i.Link (Sony). This interface provides high sustained data transfer rates, which makes it ideally suited for video editing. Depending on the manufacturer, camcorders use s100, s200, or s400 data rates, approximately 12MB/s, 25MB/s and 49MB/s, respectively, over the FireWire bus.

Hi-Speed USB 2.0 is another popular interface, mostly due to the ubiquity of USB ports on host computers. However, tests have shown that the sustained data transfer rates are higher for IEEE 1394 than for USB 2.0. In fact, transfer speeds may run slower than real time. Therefore, when transferring video to the computer via USB 2.0, users have the option to eject the attached storage media (i.e. serial digital or SD card) in order to prevent the camcorder from being tied to the computer for too long.



Professional daisy-chain configuration for video editing: A camcorder is connected via FireWire to a scratch disk, in this case a LaCie 4big Quadra, which is connected to a computer.



Consumer-level configuration for video editing: A camcorder and an external hard drive (in this case, a LaCie Little Big Disk Quadra) are attached separately to a computer via via FireWire. Direct connections such as this example are also compatible with USB 2.0.

Host Video Storage Challenges

While many digital camcorders are capable of recording quality, high resolution images, they also produce very large media files that pose challenges for data transfer and storage. The resolution recorded by a camera determines the amount of storage space required for post-production. For example, camcorders shooting Digital Video (DV) use standard definition, lossless compression to consume approximately 13.8 GB per hour when ingested into a computer. Though built on the DV tape standard, High Definition Video (HDV), offering better quality due to its efficient use of MPEG-2 encoding, consumes slightly more storage space at 14 GB per hour. When ingested into a computer for editing, the data required may expand to 30GB or more per hour, as many NLE programs convert the source format to an intermediate or proprietary format for the edit. Advanced Video Codec High Definition (AVCHD) uses the MPEG-4 H.264 codec that allows for very good quality image despite its higher rate of compression. AVCHD generally consumes a seemingly economical 8 GB of storage per hour. For comparison, one hour of uncompressed HD requires up to 450 GB of storage space. Since a 52-minute documentary may start with nine to 20 hours of raw video, plenty of hard drive space will need to be available for the edit. In addition to the many hours of footage shot during the production, elements from the editing process, such as visual and audio effects, will demand further room on the HDD. As a result, filmmakers and editors aiming to produce a 60 to 90 minute package will require many terabytes (TB) of hard disk space.

It is quite clear that storing media on the internal hard drive of a host computer is impractical due to size restrictions. Furthermore, the overhead associated with running the operating system may hinder the performance of NLE software. The edit will usually run more efficiently when footage is located on a separate or "scratch" volume, such as an external hard drive or storage system.

II. POST-PRODUCTION

The goals of post-production are the removal of unwanted footage, the isolation of desired footage, and the arrangement of footage in time to create a package. In the professional market, the post-production phase of a project usually runs longer than pre-production and production. In fact, it often takes several months to assemble a rough cut ("offline"), build effects (computer-generated imagery, or CGI), and record and mix the audio components (dialogue, sound effects, ambient sound, etc.). Once all elements of the package have been approved, the post-production stage moves toward finalization, or the online. This step generally includes color correction of the picture, mixing every single audio element, and putting the package together on one workstation before distribution.

Due to the copious amount of media from all phases of the package during post-production, editors and engineers will generally plan to attach large capacities of storage to one or all of the workstations involved in the project. While post-production for the prosumer and consumer markets are not as complex, both segments still require storage that can provide excellent transfer rates and plenty of room for amateur or semi-professional NLE packages.

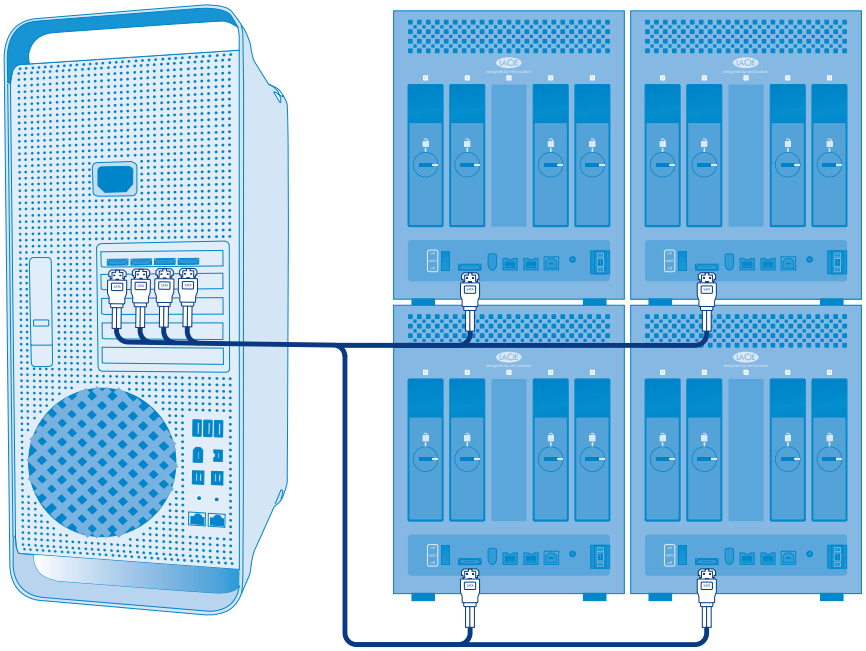
Resolution, Capacity, and Transfer Rates			
TYPE	FORMAT	GB/hour	MB/second
SD	DV25	11	25
	DV50	23	50
	Uncompressed 8-bit NTSC (720x486)	76	168
	Uncompressed 10-bit NTSC (720x486)	94	208
HD	HDV 720p60	9	20
	HDV 1080i60	11	25
	DVCPROHD 720p24	25	56
	DVCPROHD 1080i60	50	111
	ProRes 422 1280x720 (24fps)	27	59
	ProRes 422 1920x1080 (24fps)	53	117
	ProRes (HQ) 422 1280x720 (24fps)	40	88
	ProRes (HQ) 422 1920x1080 (24fps)	79	176
	Uncompressed 8-bit 720p30	199	442
	Uncompressed 8-bit 1080i60	448	995
	Uncompressed 10-bit 720p60	497	1104
	Uncompressed 10-bit 1080i60	562	1248
	Uncompressed 10-bit 1080p24	446	992
2k	2048x1080 10-bit (24fps)	716	1592
	2080x1556 10-bit (24fps)	1048	2328

Ingestion and Transcoding

NLE software allows small and large groups of media to be selected and placed on a timeline in order to meet the demands of a story. When footage is imported (captured or ingested) into the workstation, it is frequently transcoded into an intermediate format to allow for faster editing and to conserve storage. This is almost always true when a package is shot on superior quality, uncompressed HD formats such as 2k or 4k. NLE software, upon ingesting the media, will convert the high resolution footage into fine quality media proxies. For example, Apple's Final Cut Pro uses its proprietary ProRes 422 for the offline edit.

Media can be ingested in two ways: import or digitization. Digital media is often recorded in a format that the NLE software can understand, thus allowing for conversion via a direct import. However, many cameras mandate a conversion via playback of video, often referred to as digitization. While standard connections such as FireWire or USB may be sufficient, there are many hardware solutions for video transcoding during playback, including standalone video converters from companies such as AJA, Thomson Grass Valley, and Blackmagic Design.

Capturing media for editing requires extremely high bandwidth in the connections between: a camera and the computer for ingestion; and one or multiple scratch disk(s) and the computer for storage. While FireWire 400 or Hi-Speed USB 2.0 are adequate for transferring and storing consumer video from a camcorder, many professional editors prefer the superior bandwidths offered by FireWire 800 and eSATA 3Gb/s. If bandwidth is insufficient, the ingestion process can cause frames from the footage to be dropped, resulting in corrupted and unusable media. Speed requirements for working with uncompressed HD can exceed 130MB/s, which necessitate a host interface with superior transfer rates, such as eSATA 3Gb/s. An example is a workstation that manages a LaCie 24TB RAID0 4x4big Quadra Bundle using eSATA 3Gb/s (see figure below). Burst transfer rates with this configuration have run as high as 700 MB/s in certain striped configurations.



The ideal RAID configuration for professional editors: Four LaCie 4big Quadra arrays (8TB each) for a total of 24TB of available storage when using RAID 50. Burst transfer rates reach as high as 700 MB/s.

Comparison Chart of Resolutions

Factors Affecting Bandwidth Requirements

- Capture Resolution(s) for project
- Total number of Video and Audio tracks
- Effects and Graphics
- Workstations (single editor or multiple NLEs in a workgroup)
- For a workgroup, percentage of footage to be used simultaneously (Networked Storage)

Typical Bandwidth Requirements by Resolution

- DV = ~ 3.1 MB/Sec per video track
- SD = ~ 26 MB/Sec per video track
- HD = ~156 MB/Sec per video track
- 2k = ~291 MB/Sec per video track

Storage Capacity Calculations

DV = 3.1 MB/Sec x 60 = 186 MB/Min.

10 Hours DV = 600 Min. x 186 MB/Min = 112,000 MB = 112 GB Storage

SD (10-bit) = 26 MB/Sec x 60 = 1560 MB/Min

1 Hour = 1560 MB/Min x 60 Min = 93,600 MB/H = 93.6 GB Storage

HD 1080i60 (10-bit) = 156 MB/Sec x 60 = 9360 MB/Min

1 Hour of HD 1080i60 = 562 GB Storage

To accommodate effects, transitions, audio, and graphics, add 50% storage to each figure.

Examples of Proprietary HD Compression Rates

DVCPRO HD (Panasonic 1080i60)	~14 MB/s	~50 GB/hr
D5 (Sony HD 1080i60)	~38 MB/s	~137 GB/hr
HDCAM (Sony 1440x1080p24)	~18 MB/s	~65 GB/hr
HDCAM SR (Sony 1920x1080p24)	~110 MB/s	~396 GB/hr

Example of a Non-Linear Editing HD Project

- HD 1080i60 (10-bit) = 156 MB/Sec x 2 tracks = 312 MB/Sec
- 50% for audio, effects, graphics, etc = 156 MB/Sec
- Total per Minute = 468 MB/Sec x 60 =28,080 MB/Min = 28 GB/Min
- 4 Hours = 240 Min x 28 GB/Min = 6.7 TB

Configuration Requirements:

- Bandwidth = 468 MB/Sec
- 4 Hours Storage (including audio, effects and graphics) = 6.7 TB

RAID

There are many ways in which to configure scratch disks to attain optimal levels of speed and security. While high rates of transfer are important, an editor working with an extensive library of ingested media does not want to lose footage due to an unfortunate HDD failure. Before starting the ingestion, the post-production team must consider the many levels of RAID (random array of independent or inexpensive disks) best suited to the needs of the package. While RAID 0 offers the greatest speed, it does not provide any protection, which means that all data would be lost in the event of disk failure. Though requiring some compromise in transfer rates, RAID levels 3, 5, and 6 provide speed and security. (Please read the LaCie RAID Technology White Paper for further details on RAID.) A RAID configuration generally demands: multiple external hard drives; a hardware controller; and the OS drive utility or proprietary software from the manufacturer of the controller. Some storage devices, however, free the computer from arduous processes demanded by a RAID controller. An example of such a product is the LaCie 4big Quadra which supports RAID 0 or RAID 5 via a simple switch. Using an eSATA 3Gb/s interface, a stand-alone 4big Quadra is capable of providing remarkable burst transfer speeds of 230MB/s with sustained speeds of approximately 160MB/s.

Editing Software

Professional and semi-professional NLE software includes: Avid's Media Composer and Symphony; Apple's Final Cut Pro and Final Cut Studio; Sony's Vegas Pro; and Adobe Premiere Pro. There are many choices for prosumer and consumer NLE as well. A few examples are Avid's Pinnacle Studio, Adobe's Premier Express, CyberLink's PowerDirector, and Sony's Vegas Movie Studio. Additionally, simple yet limited NLE software is bundled with Windows (Movie Maker) and OS X (iMovie).

Preparing Media for Delivery

Upon completing post-production, the amateur video enthusiast or veteran editor must consider delivery of the package. The popularity of online distribution has surged, thanks to low initial overhead and ease of distribution. In this case, editing software can export a highly compressed video file, which will be posted to a web server for streaming or download. Online distribution has its disadvantages for the amateur, however, such as the high costs of server hosting and the compromise in picture quality due to bandwidth constraints.

Distribution on optical media continues to be extremely popular, particularly for commercial video and situations when the high overhead associated with replication and delivery is less a factor than video quality. DVD is the most widespread format for digital video distribution, storing MPEG-2 media at a high resolution and data rate. Thanks to decreases in the price of hardware, DVD replication at the consumer level has become commonplace. Creating a DVD generally involves exporting the final or online version from the editing program into a file format recognized by DVD burning software, such as Apple's DVD Studio Pro and Roxio's Toast Titanium. Contemporary NLE software features export presets that simplify the creation of packages that are meant to be distributed on DVD. Standard export settings mandate MPEG-2 video with resolution choices of 720×480 (NTSC) or 720×576 (PAL) at 29.97, 25, or 23.976 frames per second (FPS).

Blu-ray discs feature a capacity of up to 50 GB, which facilitates the distribution of HD. Offering substantial upgrades in resolution and data rate, Blu-ray constitutes a major improvement to the DVD format. Unfortunately, Blu-ray burners remain somewhat cost-prohibitive for most consumers, and therefore replication is generally handled by a professional service. As with DVDs, NLE software exports a file format compatible with Blu-ray burning software, such as Roxio Toast Titanium or Easy Media Creator 10. The Blu-ray creation software burns discs in MPEG-2 H.264, MPEG-4 AVC, or VC-1 file formats.

MORE INFORMATION

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ABOUT LACIE

Through a combination of cutting-edge engineering and a rich history of unique design aesthetics, LaCie has earned an excellent reputation for producing products that are the perfect synthesis of form and function. Our hard disks, network and RAID solutions, optical drives, displays, and accessories are created to enhance and expand your computing environment, no matter its platform or configuration.

Featuring the exclusive styles of world-renowned designers such as Neil Poulton, Ora-Ïto, Karim Rashid and Sam Hecht, LaCie's award-winning products look stunning and perform with unparalleled reliability and versatility. LaCie is a global leader in manufacturing top-of-the-line tools that are often first-to-market, constantly raising the bar and re-establishing industry standards.

Please visit our website: www.lacie.com, for up-to-date product specifications—available in multiple languages for worldwide accessibility. Use it to purchase items online, contact our excellent technical support or locate the sales office or reseller nearest you.

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