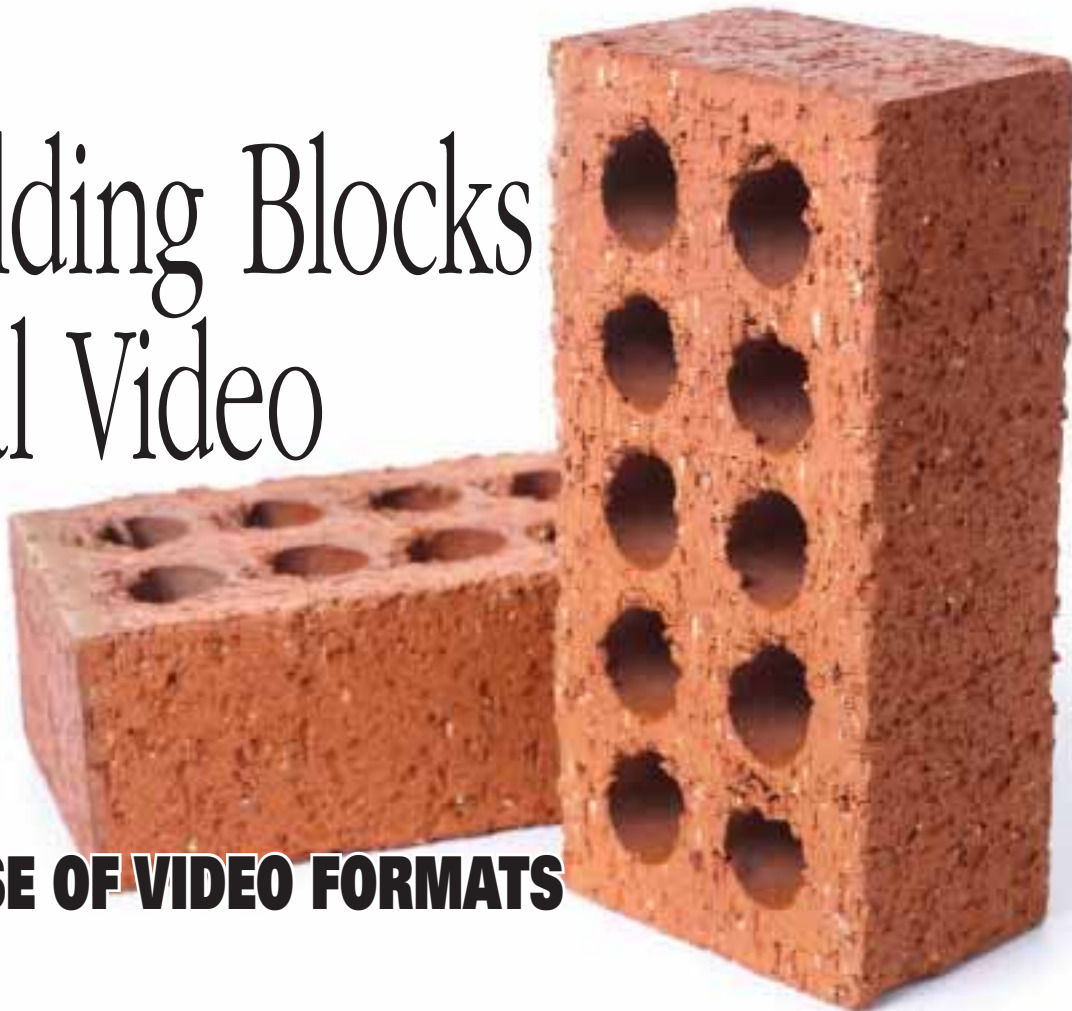


The Building Blocks of Digital Video

by Drew Labat



MAKING SENSE OF VIDEO FORMATS

It happens to all of us: you had an important event and the playback tech told you what video format she needed. Still, the file didn't play properly. What happened?

A video file has many attributes that affect its quality and compatibility. They're all important, and the better you understand them, the better your videos will look.

FRAME SIZE

As you may already know, a digital image is a large table of discrete elements called pixels (short for "picture elements"). The frame size will dictate how detailed the resulting image looks. NTSC video is digitized at 720x486 pixels for broadcast and 720x480 for DV and DVD's. For HD, typical sizes are 1920x1080 and 1280x720.

ASPECT RATIO

The aspect ratio is the ratio between the width and height of the frame. Standard aspect ratios in television are 4:3 and 16:9. In theatrical projection they are 1.85:1 and 2.35:1.

PIXEL ASPECT RATIO

While in most cases pixels are square, they don't have to be. This feature allows a 720x480 frame to become either a 4:3 image or a 16:9 image. The "table" has the same number of cells, they're just wider.

SCAN – PROGRESSIVE OR INTERLACED?

Modern flat screen displays render a frame in its

entirety, from top to bottom. This is called "progressive scanning" and is fairly straightforward.

Cathode Ray Tube (CRT) displays, which were the only kind of television sets for decades, rely on a different system. Each frame from the camera is comprised of two "fields" captured at different points in time. Each field contains every other row in an interlaced pattern. The display uses a single beam of electrons to draw the image across the screen, skipping every other line.

This system has its benefits for CRT's but it works poorly on flat screen displays; those must deinterlace the image through built-in circuitry. CRT's seem obsolete today but they were the only kind of display available when HDTV was developed, and so the standard prevailed. In fact, the majority of HD channels in North America use interlaced scanning.

FRAME RATE

We now have our images, but what speed do we play them at? A modern computer can play any frame rate, and cell phones often record at odd or variable rates like 17fps. However, many devices, such as Blu-Ray players and Final Cut's playback engine, can only play at standard speeds. For North America those are 29.97 and 59.94 frames per second. 23.976fps is also common but is not a broadcast standard.

There is a common confusion with the term "24p" which refers to 24 progressive frames per second. A frame rate of 24.000fps is only used in movie theaters. Everywhere else, "24p" refers to 23.976fps. To add to the con-

FEATURE/Video Formats

fusion, Sony and Apple often refer to 23.976fps as 23.98.

TIME BASE

When you edit in 29.97 fps, your editing software uses “30-base timecode,” counting each second’s frames from 0 to 29. This is easy to read but inaccurate since there are 29.97 frames in a second, not 30. If you time your edit with a stopwatch, the readout will differ from the software’s counter by 0.01%. The small difference doesn’t matter for most productions but it adds up to 86 seconds per day, which is a lot if you run a TV station.

The introduction of SMPTE timecode in 1972 included a fix: Drop frame timecode skips two frame numbers every minute except every tenth minute, which aligns the timecode with the actual time. Use it if you prepare an edit for broadcast. Otherwise, it’s easier to stick with the normal “non-drop” timecode.



Final Cut Pro's Sequence Settings window contains many of the attributes described in this article. It's easy to mess things up by choosing the wrong settings!

BANDWIDTH / BIT RATE

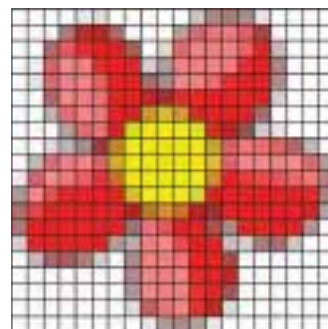
Bandwidth determines the footprint of your data – how much space it takes. There is only so much information that a device can push in a second, whether it’s a hard drive platter, magnetic tape, or an internet connection. Uncompressed video gets unruly quickly, with HD video taking over 1,016Mbps. Imagine what sort of Internet connection you would need for that! Thankfully, there are mechanisms to compress data: codecs.

CODEC


A codec—short for encoder/decoder—converts between a raw (uncompressed) data stream and a certain compression standard. Different codecs exist to satisfy different needs. Some are simple and maintain high quality; others are complex yet compress very well. Some codecs are very specific – they dictate the resolution and bit rate – while others are very flexible.

Examples of codecs:

- IEC 61834 – more com-



A frame consisting of 20x20 square pixels




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Canton, OH Multi-site



or go to: nextind.com/newpointe

DIFFERENT SCAN METHODS:



The individual fields



The combined interlaced frame



The same frame in a progressive scan system

monly known as DV – is a very common codec for standard definition video, lightly compressed.

- Avid 1:1 is an uncompressed codec used in Avid systems.
- Apple ProRes is a lightly compressed codec optimized for post-production.
- H.264 / AVC / MPEG4 Part 10 is a sophisticated codec which employs a variety of tricks to achieve very high compression (300:1 or more) while still maintaining a very watchable quality.
- JPEG2000 offers very high quality but is tough to encode. It's used mostly in digital cinema distribution; any digitally-projected movie at your local cineplex is encoded in JPEG2000.

WRAPPER / CONTAINER / FILE

You can send a lot of things via FedEx, but you've got to put them in a box. In the video world, we refer to a container. A container may fit just one video track, or contain multichannel audio, timecode, and even multiple video tracks and other metadata. While we mostly talk about files, a container might as well be a cassette tape.

A container's design can

make a big difference. For example, AVI files have their descriptive data in the end, so a program can't interpret the file until it can read it in whole. In contrast, Quicktime's "Fast Start" feature puts the descriptive data in the beginning of the file, which allows the software to start playing a clip before it finished downloading.

Transcoding happens when a program decodes the video and encodes it again (usually into another codec). Rewrapping just replaces the "box." For example, video in H.264 codec can live inside Quicktime, AVI, or MP4 containers. To convert between them the software just "unwraps" the file, and wraps the H.264 data in a new

wrapper. This process is much faster than transcoding.

Examples of containers:

Quicktime is one of the most well-known containers and a powerful one. It supports a wide variety of audio and video codecs, multiple tracks, even captions and interactive animation. (This doesn't mean it's perfect – Quicktime had numerous issues with gamma over the years, which resulted in video having different brightness in different programs.)

AVI is Microsoft's version of an all-around media platform.

Blu-Ray Disc – a container that uses H.264 or MPEG2 codecs for video.

MXF is a robust container, favored by broadcast equipment as well as Avid editing systems.

DV is an example of a format that's both a container and a codec. The codec can be written to tape in a standard DV (IEC 61834) cassette, or in a file.

Thoroughly understanding digital video can easily fill a book. There are more "building blocks", like color space, chroma subsampling, and bit depth, but the basics were covered in this article. If you're interested in further reading, I recommended *How Video Works* by Marcus Weise. ◆

Drew Labat is an L.A.-based video engineer whose experience ranges from worship facilities to TV stations and Hollywood studios. He is currently the Lead Engineer at Precision Productions+Post in Culver City, CA.

Dominic Jackson knows a thing or two about video formats. He was the lead engineer at Telestream and now manages the company's transcoding products, like FlipFactory and Episode.

What kinds of misconceptions do people have when it comes to video formats?

DJ: The biggest single misconception is, people assume that if they tell you the container, that's enough information to decide how to handle that file. If you tell me "I have a Quicktime file", that actually tells me almost no useful information. That file could have ProRes 220Mbps master quality video inside it, or it could have a 320x240 low bit rate H.264 video that was intended for web download.

Was it easier in the "old days" of tape?

DJ: Much easier. It's very difficult to mess up tape based workflows. You connect cables between devices and hit 'play' on the deck. [It's] inefficient but very intuitive.

In a world of progressive displays, why do we still have interlaced video?

DJ: [Laughs] I ask myself that question every single day. The primary reason is because it's a hangover from the days of analog video. But in fact there is still an argument for interlacing: [using fields] gives very good results in terms of perceived motion. It's a pretty good 2:1 video compression technique.

I'd be much happier if we got rid of interlacing and fractional frame rates, but I'm going to have to live with them for many years to come. As we say here, if it was easy, everyone would do it.