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# **THE HD SURVIVAL HANDBOOK (2009-2010)**

***Essential Questions  
Practical Answers***

*A complete summary of everything a  
video professional needs to know  
about HD production, post-production  
and distribution.*



**Philip Hodgetts**

## Forward

The HD Survival Handbook was written to answer the myriad of questions that arise when a video professional moves from working in the Standard Definition world up to the more complex world of High Definition.

There is a companion blog site for this handbook at <http://blog.proappstips.com/archives/category/hd-survival> where updates and changes will be posted.

The Production section of the Handbook covers the reasons why you should be working in HD, how to interpret specifications, HD formats and a direct comparison of HD Cameras under US\$10,000

The Post Production section has everything you need to know to deal with HD through a Final Cut Pro edit, including storage requirements and technologies, capture hardware, HD workflows, 24P pitfalls and workflows, and finishes with archiving file based media

The Distribution section of the Handbook covers the issues of distributing HD when the production is complete.

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# Production

*This section starts by outlining the many reasons why you should be producing in HD : Broadcast, cable, cinema are all distributing HD programming. Any content that has a future should be in HD now.*

## What is HD?



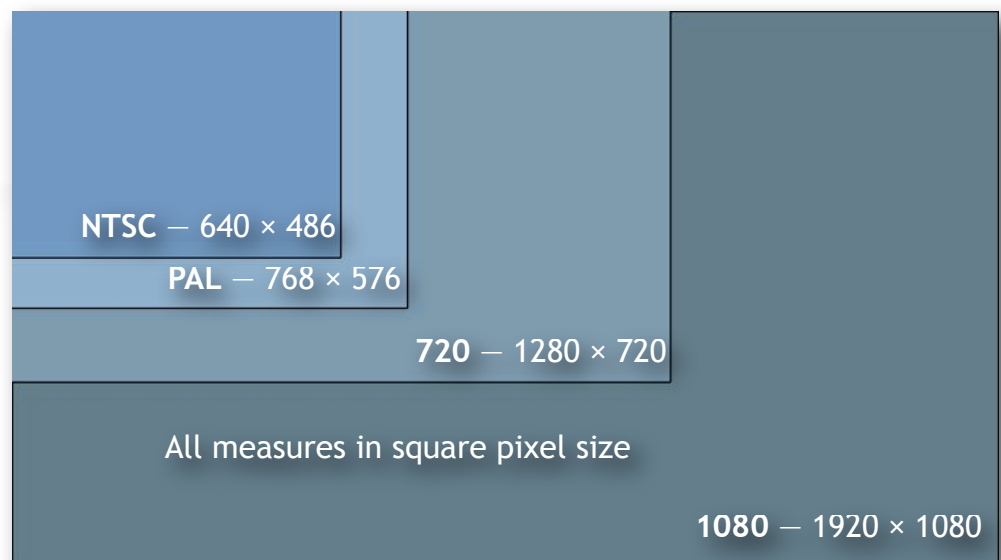
One of the things that drives me nuts is when people say “oh, that’s not ‘real HD’” as if ‘real HD’ was something different to HD. Near as I can work it out, the people who say one format or the other is not ‘real HD’ need to shoot HDCAM SR and nothing less – Sony F900, F950, F23. These are systems that cost around \$200,000 for the camera and lenses. You don’t buy them as you can only afford to rent them even if they were available to buy.

That’s not useful. The answer to the question “what is HD?” depends on who you ask. I’m happy to call HDV, “HD”. I’m happy to call DVCPRO HD, “HD” even though the resolution with DVCPRO HD is actually lower than that of HDV. I’m happy to call HDCAM HD, “HD” even though its color resolution is quite compromised in an odd 3:1:1 configuration – part of its legacy as the first viable HD format. I’m also happy to call XDCAM HD, “HD”.

I’m also not going to complain about compression. Compression, per se, is not a problem. What needs to be considered is the entire production workflow from camera to viewer. (See Sidebar.)

The Consumer Electronics Association (CEA) considers any signal or display that shows 480P or better is HD. So when you see a set labeled “HD” it may only display 480P but scale other signals down to that display size. 480P is only slightly better than NTSC, which is only ever Standard Definition (SD).

480P is also the only mandated size that has to be broadcast under the new American



Advanced Television System Committee (ATSC) digital broadcast system. Broadcasters must broadcast one signal “equal or better in quality” than their current NTSC signal. (PDFs of the 6-part standard are available at the ATSC web site.)

There is no mandate in the USA for High Definition Digital, just for digital transmission within 19 Mbits/sec per channel. To the FCC, Digital Broadcast is anything 480P or better. So the broadcaster has one 19 Mbit channel that they can use for either one HD signal, a lesser HD signal and two SD 480P signals, or some other combination up to 6 SD-equivalent channels. Which option do you think would be the most profitable for a broadcaster: one expensive revenue stream, or several cheaper revenue streams screening infomercial and repeat programming?

There is a group of people who want to dismiss 720P and say that 720P is not “true HD”. To me 720P is the sweet spot of HD, because it will scale to most monitors and still look great, and it’s progressive. I will repeat (probably to annoyance) the message that “Interlace is bad; Progressive is good.”

There is a group of people who want to dismiss 720P and say that 720P is not “true HD”. To me 720P is the sweet spot of HD, because it will scale to most monitors and still look great, and it’s progressive. I will repeat (probably to annoyance) the message that “Interlace is bad; Progressive is good.”

I’m not the sort of person to give you absolute rules. I’m inclined to be the person who says, “Well, it depends...” because “it depends” is the right answer in most circumstances.

“What format should I shoot?” “It depends...”

“What should I use to edit?” “It depends...”

But with Interlace and Progressive there is a hard rule: progressive is better than interlace. Always!

## ***Compression is not a problem***

There is no uncompressed acquisition format. Even HDCAM SR at 4:4:4 is lightly compressed to MPEG-4. Light compression like this is visually equivalent to uncompressed because very little (if any) data from the original is lost.

Compression can be your friend. Compression keeps data manageable. Compression does not always mean a quality loss. More of the time, the loss happens long before the compression happens. For example, Sony’s IMX format throws away color resolution particularly in the blue channel. They apply a low pass filter to eliminate most fine detail, and then they compress it. It’s only this last stage that manufacturers talk about when they discuss compression.

We have to look at the overall video signal and how it’s handled from image capture to image output. More work, yes, but it’s the only real way to compare formats. Sony, of course, do not say that they do compression because compression is “bad”. What they apply is “bit rate reduction”, which is remarkably similar to “compression” by a different name!



To me 720P is actually a better deal than 1080i. Even though the numbers are bigger for “1080”, delivered quality at the end of the chain will be higher with 720P. How counterintuitive is that? (For more details on why, see the discussion of Kell/Interlace factor later in this section.)

People who believe that HDCAM SR is the only “true” HD are also those who argue that 1080 – interlaced or progressive – is the only “true” HD. That’s fine. Let them believe that. They are a tiny, tiny niche market and there’s always a business in the highest quality niche. It’s called Hollywood. But that niche is not the mass market.

“Hollywood” is a niche market. The business that you are in is a much bigger business overall – in terms of dollars generated – than “Hollywood” movies and broadcast television. You are part of a much bigger industry than they are, since some time in 1999-2000 when the balance tipped from mainstream movies and broadcast television, to the “rest” of the video production market: events, corporate communications, trade shows and education.



So, what is HD? HD is whatever fills a 720P, or 1080i/P display with good to high quality images, with high quality sound.

It is the content is what people are watching and delivering significantly better quality than SD can be done with even the most modest HD setups.



# Why do HD?

There are many reasons to start producing in HD:

- SD is so 1990s;
- Broadcast is going Digital (and HD);
- Cable and Satellite are starting to support HD;
- HD is being used for film production;
- Cinema is going to digital HD projection;
- Computers love HD; and
- Consumer Electronics is catching up.



## ***SD is so 1990s***

Well, what can I say? Unless your project has no life, unless your project is going to be done and gone by the end of the year, then you need to produce in HD.

## ***ATSC Broadcast***

Another reason to produce in HD is because the American broadcast system will be going digital only – with increased HD content – from June 12, 2009. Generally speaking it will go to HD, but as noted before there is no mandate for HD within the ATSC system.

As an aside, there is only one country in the world that mandates HD broadcast: Australian broadcasters have to broadcast HD digital and SD digital at the same time, with low cost converter boxes outputting analog PAL compatible with existing sets from the digital SD stream.

The ATSC supports 480, 720 and 1080 for broadcast. In fact there are approximately 30 different “formats” – combinations of frame size, rate and whether progressive or interlace

### The Importance of Owning Content

One of the keys to long term success in a “post gatekeeper world” where we start to open up distribution directly between producers and viewers, is that having long term ownership of programming is going to be valuable. Back in Australia I had, what is by US standards, a “boutique” production business doing everything from broadcast commercials to graphics and effects to other companies thanks to an early adoption of Media 100 online digital in 1994. But mostly we did corporate and educational content.

What we did in that small business was when there was no business we created business. We found a niche in our Tertiary education system where there was a national metal trades curriculum but no video or exercise support and no budget to produce them.

Continued next page

– within the standard. They apparently decided to not set any rules and to “let the market decide”. So, some broadcasters have gone with 720P (such as ABC, ESPN, FOX, and MyNetworkTV) and some have gone with 1080i (such as NBC, CBS, The CW, HBO, Showtime, Starz!, MOJO HD, HDNet, TNT, and CNN).

1080i is an easier “sell” because the numbers are bigger. In a country where “bigger is better” and “more is always more”, it takes more effort to convince people that 720P transmissions and downloads will give better quality images for the average viewer than the, theoretically higher quality, 1080 (but interlaced).

### Frame Size and Frame Rate

The frame rate for 720P can go up to 60 frames per second (720p60), which is much better for high action sports broadcasts. The combination of high action, interlace and

compressed broadcasts does not do well for small details, like, for example, the ball! 1080 at 60 frames per second progressive (1080p60) is outside the broadcast standard so cannot be broadcast. 1080 at 24 frames per second Progressive (1080p24) is broadcast with pulldown on 1080 at 29.97 interlaced frames per second. This can be written 1080i29.97 but is usually referred to, in another attempt to make bigger numbers seem better, as 1080i59.94. Whichever way it's described it is 59.94 fields per second divided into 29.97 interlaced frames per second. This is exactly the same frame rate that has been used by NTSC for 70 years.

1080p24 resembles 24fps film as it is broadcast with 2:3 pulldown on 1080i59.94 (like film is broadcast on NTSC), so it helps with the “suspension of disbelief”. But 1080p24 production has its own issues. Be sure to read up on the different ways that “24 fps” are imposed on HDV alone, later in the book.

### Owning content (cont'd).

And yet, there was a guaranteed market among the 76 Colleges teaching that subject. There was no central source of funding so we funded the expenses and capitalizing the video production costs, using resources that would have otherwise be idle.

We could calculate the unit cost based on 50 sales to cover costs (including those otherwise-idle production assets and people) with any additional sales contributing a profit. We never sold less than 52, and usually closer to 60, of each video.

This was even after I was advised to double the price because it was the only source of any video support around a time when video support was becoming more important in education. We created a “scarce good” that had quite excellent demand inelasticity.

We applied the education design skills we'd acquired creating educational support video for clients and created high quality, high production value content.

We had a guaranteed business. Every time we produced one, we knew we would get more than 52 sales within the first year, with about 75% of sales in the first three months after release. They had long “legs”. They're probably as valid and useful today as they were in the mid 1990s when we made them. (Knowing the way government education systems work, I expect they are still being used today!)

If you're going to have programming that “lives” it's going to require HD and will be in 16:9. All HD is displayed as 16:9.



## ***Cable and Satellite are going to HD***

Like Broadcast, Cable and Satellite distribution is going to HD. We don't have anywhere near the choice in HD that we do in SD, because each HD broadcast takes up the bandwidth in the cable or on the satellite of approximately four SD channels. There is limited capacity on both types of distribution so the provision of HD content is a balancing act. The audience is smaller but it requires proportionally more of the company's most valuable limited resource. Cable and satellite companies also know that choice trumps quality for the average Joe or Joanne. It's much easier to find a channel they'll settle on within the cable or satellite's guide, instead of switching to a competing service if there is abundant choice

## ***Broadcast realities***

By the time we're getting anything broadcast we're talking about 19 Mbits/sec That's what they're allowed to broadcast. Assuming that is all dedicated to one HD signal then it's still heavy going for MPEG-2 at 1080i59.94. By comparison, 19 Mbits/sec is the data rate for HDV 1 – 720P variations – and is lower than HDV 2's allocation of 25 Mbits/sec for 1080i59.94.



MPEG-2 has traditionally been a distribution format rather than a production format, but the data rates aren't that different. Just keeping things in perspective: 25 Mbits/sec for HDV is not the "disaster" that many who don't use it seem to think.

## ***HD is being used for Film Production***

Film production is going to digital. There's as much film now produced on HD or digital cinema than there is being produced on analog film. The final distribution may still be film prints for traditional cinemas until digital cinemas are more common, but production is moving to electronic production and data centric HD workflows.

Higher end production will work with 2K (2024 pixels across) and 4K (4096 pixels across) but a lot of production starts as 1080p24: 1920 × 1080 at 23.976 frames per second. This is just a little below 2K resolution so it can be easily enlarged to fill the 2K-output size for printing to film.

## ***Convenience trumps quality***

For a large group of people, probably the majority, convenience is more important than quality. It explains why we transitioned from vinyl LP to CD – the CD is much easier to control with a remote and has multi-disc and random access capability – and also why we then replaced our CDs with MP3s! If quality was the driver to CD, it certainly wasn't to MP3, which are "good enough" but not as good as CD sounds.

The quality of CD was a very important bonus but it doesn't appear to have been the primary reason for the rapid conversion from vinyl.

## *Cinema Distribution is going HD*

I am getting to the point where I'm finding many aspects of traditional film projection are starting to impair my enjoyment of the film. Things like gate weave and grain are irritating, not to mention scratches and dirt on the average multiplex print. By comparison with digital cinema, film is compromised. Once you see "film" projected in 4K from a Sony SXR projector you'll never want to see the traditional version again!

The theoretical resolution advantage that film has — at just short of 4K digital resolution — is totally blown away by that gate weave. Sure any given frame has much higher sharpness potential



than a frame of video, but because successive frames are not aligned in the project gate, the image smears and the effective, projected resolution is reduced. A practical, effective resolution of a frame of projected film, in sequence, is about that of HD video. Film, however, has never truly been about the "sharpness". In fact many Directors of Photography go out of their way to reduce film resolution using gauze or stocking at the front, or back, of the lens to enhance the "suspension of disbelief". Even if the purpose of the stocking is to enhance blacks with a black gauze/silk, the effect is to also reduce sharpness.

Digital projection can deliver an improved audience experience and reduce distribution costs. If only the cinema owners could be convinced to spend the money for the conversion all for the benefit of the studios and audience, rather than themselves.

You'll also find that resolution that provides for sharpness isn't as important as you might think. We'll see as we examine formats, that very few camera manufacturers are using  $1920 \times 1080$  pixel imagers — CCD or CMOS — and few of the HD video formats support  $1920 \times 1080$  pixels ( $1920 \times 1080$  pixels is "full raster" square pixels for that image size). Clearly, pure resolution isn't the most important factor in "film look".



## *Computers love HD*

It should be noted that “1080” image size video will not play on most laptop computers or regular computer monitors. Only monitors with pixel sizes of  $1920 \times 1080$  or higher can play that size HD at full size<sup>1</sup>. One benefit of computer playback is that the frame size of the display can be pixel-for-pixel mapped to the display, leaving a border if necessary, for a crystal-sharp image.

## *Consumer Electronics is catching up.*

Personal Video Records (PVR), Digital Video Records (DVR) or devices like TiVo are being released in HD versions to match HD cable and satellite services.

The resolution of the HD optical disc “war” in Blu-ray’s favor will speed adoption of Blu-ray players and broadband networks are connecting fast enough (for some) to make digital downloads practical.



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<sup>1</sup>  $1900 \times 1200$  pixel monitors will fit a  $1920 \times 1080$  HD image without scaling. Apple’s 23” Cinema Display has this resolution.



# “What is HD?”

*Not all common image sizes are video standards. See table of HD formats on the next page. Even experts have some difficulty defining “HD”, so let's consider all the factors that go into defining HD.*

## Video standards

With video standards we're really only talking about “1080” and “720” sizes:  $1920 \times 1080$  and  $1280 \times 720$  pixels respectively. These are pixel counts assuming square pixels on a 16:9 display. There are, in fact, four variables that we have to take into account when considering whether something is HD or not:

- Image Aspect Ratio (always 16:9 in HD);
- Image size in Pixels (and pixel aspect ratio — square vs. non-square pixels);
- Frames per Second; and
- Whether the image is Interlaced or Progressive.

### ***Square vs. Anamorphic Pixels***

For production formats we also need to consider whether the pixels are square or anamorphic. Anamorphic pixels are used to reduce the bandwidth of a signal by using fewer pixels, but scaling those pixels wider to fill the full Image Aspect Ratio.

For example, HDCAM shoots “ $1920 \times 1080$ ” HD nominally, but in fact the format only uses  $1440 \times 1080$  pixels maximum. Each of the 1440 pixels are wider than they are tall, so that, when displayed, they fill the full space of a  $1920 \times 1080$  square pixel display.

The example on the next page shows the actual pixel dimensions in relationship to the display aspect ratio.



Actual size — 1440 anamorphic pixels



Displayed as 1920 square pixels

# HD Formats

Type	Dimensions	Frames per second	Scanning Type
720p24	1280 × 720 (960 × 720 DVCPRO HD)	23.976	Progressive
720p25	1280 × 720 (960 × 720 DVCPRO HD)	25	Progressive
720p30	1280 × 720 (960 × 720 DVCPRO HD)	29.97	Progressive
720p50	1280 × 720 (960 × 720 DVCPRO HD)	50	Progressive
720p60	1280 × 720 (960 × 720 DVCPRO HD)	60	Progressive
1080p24	1920 × 1080 (1440 × 1080 in most formats, 1280 × 1080 DVCPRO HD)	23.976	Progressive
1080p25	1920 × 1080 (1440 × 1080 in most formats, including DVCPRO HD)	25	Progressive
1080p30	1920 × 1080 (1440 × 1080 in most formats, 1280 × 1080 DVCPRO HD in 60 Hz Countries)	29.97	Progressive
1080p50	1920 × 1080 (1440 × 1080 in most formats, 1280 × 1080 DVCPRO HD in 60 Hz Countries)	50	Progressive
1080p60	1920 × 1080	59.94	Progressive
1080i50	1920 × 1080 1920 × 1080 (1440 × 1080 in most formats, including DVCPRO HD)	25 (50 fields per second)	Interlaced
1080i60	1920 × 1080 (1440 × 1080 in most formats, 1280 × 1080 DVCPRO HD in 60 Hz Countries)	29.97 (59.94 fields per second)	Interlaced



## HD Frame Rates

Within those two basic frame sizes we have a variety of frame rates:

- 23.976
- 25
- 29.97
- 50
- 59.94

in both 720 and 1080 variations with interlace and progressive variants.

Frame Rate	Medium	Geographic Area
24 fps Progressive (Actual frame rate 23.976 except film)	Film, Blu-ray, Digital Distribution, HDV, XDCAM HD/EX, DVCPRO HD, AVC-Intra, HDCAM/SR	Film – Worldwide, for video formats USA, Canada, Mexico, Japan, “60 Hz countries”, Digital OTA Broadcasts
25 fps Progressive	Blu-ray, Digital Distribution, HDV, XDCAM HD/EX, DVCPRO HD, AVC-Intra, HDCAM/SR	Europe, Australia, New Zealand, Asia, Africa, Latin America, “50 Hz countries”, Digital OTA Broadcasts
25 fps Interlaced (aka 50i)	HDV, XDCAM HD/EX, DVCPRO HD, AVC-Intra, HDCAM/SR	Europe, Australia, New Zealand, Asia, Africa, Latin America, “50 Hz countries”, Digital OTA Broadcasts
30 fps Progressive (Actual frame rate 29.97)	Blu-ray, Digital Distribution, HDV, XDCAM HD/EX, DVCPRO HD, AVC-Intra, HDCAM/SR	USA, Canada, Mexico, Japan, “60 Hz countries”, Digital OTA Broadcast
30 fps Interlaced (aka 60i) (Actual frame rate 29.97, aka 59.94i – fields per sec)	Blu-ray, Digital Distribution, HDV, XDCAM HD/EX, DVCPRO HD, AVC-Intra, HDCAM/SR	USA, Canada, Mexico, Japan, “60 Hz countries”, Digital OTA Broadcast
50 fps Progressive	HDV 1, DVCPRO HD @ 720P, XDCAM HD/EX @ 720P, HDCAM/SR	Europe, Australia, New Zealand, Asia, Africa, Latin America, “50 Hz countries”, Digital OTA Broadcasts @ 720P
60 fps Progressive	DVCPRO HD @ 720P, XDCAM HD/EX @ 720P, HDCAM/SR	No distribution or broadcast of 1080p60, only 720p60. HDCAM/SR can shoot 1080p60

In 720 these are all progressive frames, not interlaced fields. Within 1080 there are progressive rates at 23.976, 25, 29.97 and (theoretically) 59.94 Progressive, but the only format that supports 1080 59.94 progressive is the HDCAM SR. That format – 1080p59.94 – cannot be broadcast because it is a higher data rate than the MPEG-2 profile used for ATSC broadcast or for Blu-ray disc. In 1080 there are also interlaced frame rates of 1080i25 and 1080i29.97, although they are frequently written in the field rate of 1080i50 or 1080i59.94. Don't be fooled – 1080i59.94 is the same frame rate as NTSC Television – 29.97 interlaced frames per second with 59.94 fields per second and 1080i50 is 25 interlaced frames per second, the same as PAL video.

They are the standards: there are cameras that shoot each of the formats and frame rates, and all but 1080p59.94 can be broadcast. These combinations of formats and frame rates become even more complex when adding pulldown or being able to go to solid state media, DVCPRO and DVCPRO 50, such that the Panasonic HVX200 has, and there ends up being close to 80 recording modes to choose from.

However, it becomes simpler when you realize that 23.976, 29.97 and 59.94 frame rates apply in “60 Hz Countries” (like the USA, Japan and other NTSC countries) and the 25/50 variations apply in the “50 Hz Countries” (like most of Europe, Australia and other PAL countries)

## Counting Resolution

Depending on how far you are from the screen, and how large the screen is, you may not get the full benefit from even 720 HD, let alone 1080 HD. It should be obvious that 720P will meet the needs of almost all displays at common viewing distances.

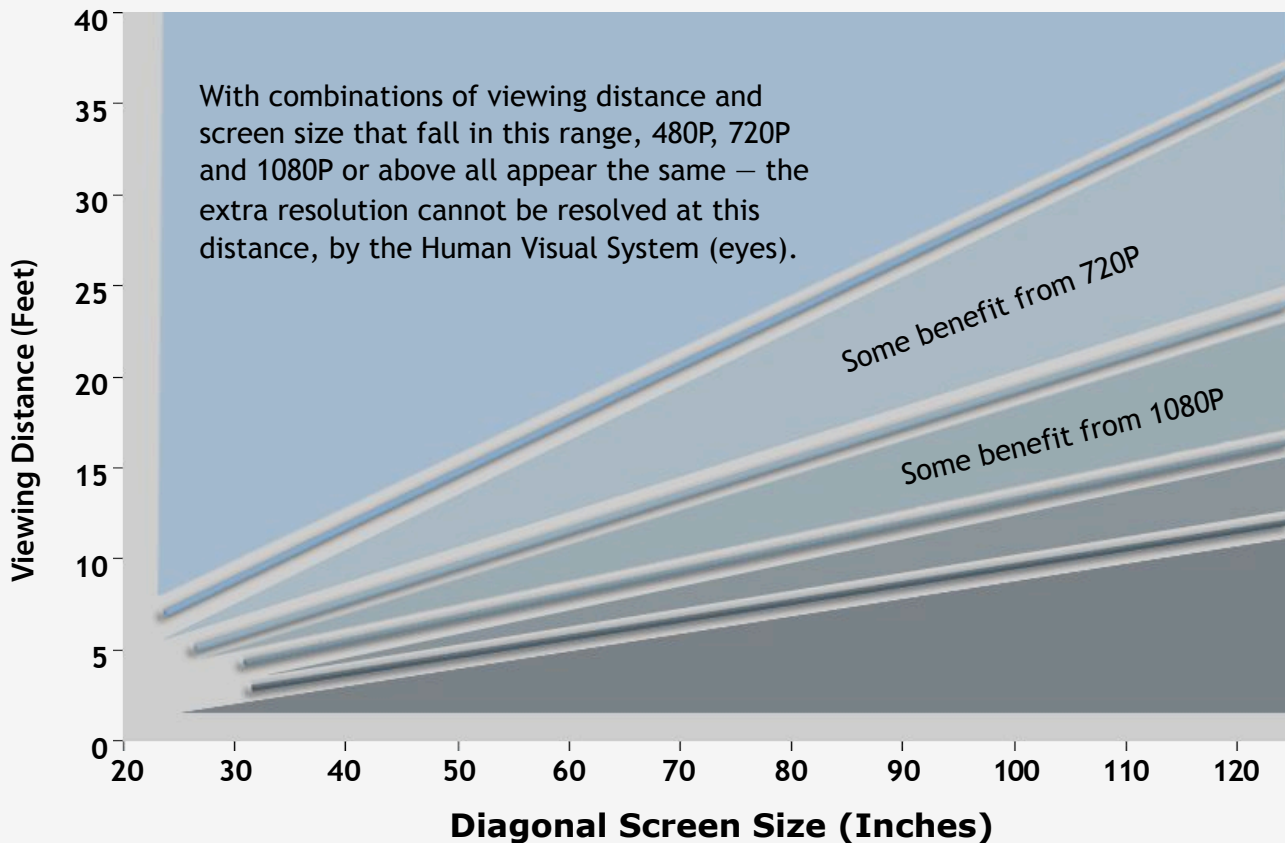
In SD most people will watch from 9 to 20 feet (3 to 6 meters) away; in HD people tend to watch from about 15 feet (4.6 meters). At that distance few can distinguish any improvement over SD-like 480P. To see the benefit of 720P you'd have to move in to 10 feet (3 meters) from the screen or increase the screen size to nearly 100 inches. A screen that size is not going to fit in my apartment!

So how much resolution do you need; how much can you benefit from? The amount of resolution that is actually required is something that geeks like to argue about in a bar, or at a conference. In practical terms the reality is that 40-50” screens won't show any benefit from a signal better than 720P, unless people sit uncomfortably close. See the Sidebar on the next page to determine how much resolution you can take advantage of in particular combinations of screen size and viewing distances.

Gizmodo recently compared the output of a Blu-ray disc, an upconverted SD DVD and an Apple TV download at 720P (of the same content) and discovered that there was not a lot of difference between the 720P download and the 1080p24 Blu-ray disc.

While 720P is definitely the sweet spot for production because it can be easily converted to 1080 when necessary and will usually deliver more useful resolution at the end viewing location than 1080i, our customers and audiences have been “sold” by the “big number” marketing of 1080. We could educate but mostly we'll simply give the customer what they ask for.

## **Screen Size vs. Viewing Distance** **Perceivable resolution**



- 1** The Full Benefit of 480P is visible. 480P is a step beyond NTSC, sometimes referred to as “Extended Definition”.
- 2** The Full Benefit of 720P is visible.
- 3** The Full Benefit of 1080P is visible. The full benefit of 1080i will be close to 720P
- 4** The Full Benefit of a proposed new standard, 1440P is visible. There are no readily available sources of 1440 vertical line televisions or projectors.

Draw a line up from your screen size and across from the viewing distance. The intersection point will indicate how much resolution you will be able to perceive from that viewing distance. For example, a 42” screen at 10’ (approximately 3× screen height), the typical viewing distance for HD, you would get some benefit from 720P but would not be able to see the full quality of 720P. To get the full benefit of 720P you’d have to move the seat closer, to about 8’ from the screen. For the full benefit of 1080P, you’d need to be an uncomfortably close 5’ from the screen.

If you examine the chart carefully, taking into note typical screen sizes and viewing distances, you’ll see that few situation can take advantage of much more than 720P quality.

It is trivial to take a 720P master (either 23.976P, 29.97P or 59.95P) and provide it to someone as 1080i60 (remembering that you cannot give it to them as 1080p60). It doesn't matter so much what we produce because we can give them whatever output format they want. The average consumer will never, ever, see the difference in quality, between 720P scaled up to 1080i and something that was 1080i throughout the process. In fact, the 720P source will probably be better because it won't have been as compromised during production.

Even where the viewer is in a home theater and could tell the difference if they could compare the two versions (720 and 1080) in an A-B comparison, most people will not tell the difference when up close, and three paces back to a normal viewing distance the difference would be imperceptible.

## EBU Testing

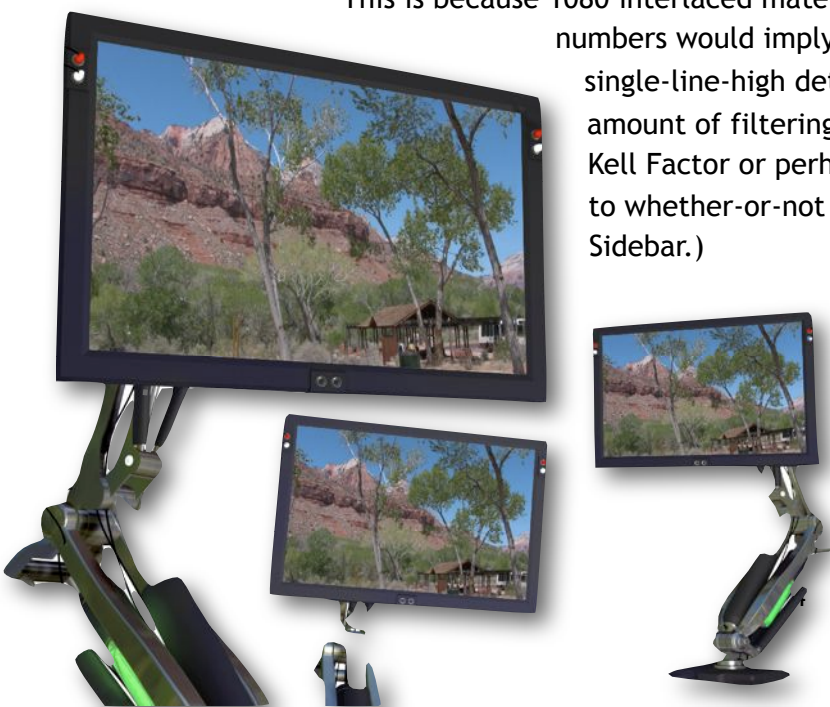
The European Broadcasting Union (EBU) at IBC has proved this over the last two years (See Sidebar above). While the 1080i master looks visibly better compared to 720P on the studio monitors, when the evaluation is done at the end of the delivery system – broadcast or Blu-ray – then the 720P material delivers more on-screen quality than 1080i under the same delivery settings. 720P delivers more real useful resolution, or sharpness, than 1080 interlaced source through a 1080i delivery channel. It's counterintuitive but that is the reality.

This is because 1080 interlaced material has lower vertical resolution than the numbers would imply. Interlaced images need to be filtered so that single-line-high detail doesn't flicker when displayed. The amount of filtering required is derived from a formula known as Kell Factor or perhaps, Interlace Factor (there is some dispute as to whether-or-not they're describing the same thing). (See Sidebar.)

## *Main conclusion from the EBU Report*

“The demonstration suggests that a progressive format for emission provides the best image quality / bitrate compromise with MPEG-4 AVC compression. EBU Members have already been advised in EBU Recommendation R-112 that the 720p/50 emission format is currently the best option. The demonstration has underlined this statement.”

“Once interlacing is applied to an image format, vertical-temporal information is lost that can never be recreated. The interlaced “footprint” causes an unnecessary burden in the digital broadcast chain, particularly since modern content-adaptive compression systems such as MPEG-4 AVC perform better with progressive signal sources than with interlaced signals. Furthermore, de-interlacing chips are not needed in flat-panel matrix displays, thus avoiding a further point of image-quality impairment and video-audio delay.”



## The Kell/Interlace Factor Effect on Resolution

For interlaced video the Factor is 0.7, which means that the equivalent interlaced resolution is only 0.7 (70%) of the progressive resolution. By this measure the 1080 interlaced lines deliver the equivalent of 756 progressive lines. That's barely more vertical resolution than 720, which has 720 progressive lines in the vertical dimension.

As we'll see later, even the 1920 dimension is compromised in most affordable cameras, with 1440 pixels across being the most common real pixel dimension for "1080" cameras. (See the [Square vs. Anamorphic](#) examples earlier.)

Has anyone used a Panasonic HVX 200? That's the one that shoots to P2 media. That camera originally had sensors that are only 960 × 540 pixels. That's fewer pixels than 720p!

And yet, by offsetting one of the chips slightly by half a pixel (see the [Pixel Shift](#) illustration later), they synthesize a "1080i59.94" signal. (In DVCPRO HD that's an image size of 1280 × 1080 in 60 Hz countries, 1440 × 1080 in 50 Hz countries.) Despite have the lowest pixel count on its chips of any of the "affordable HD cameras" the HVX 200 produces an excellent image that thousands have been happy with.

Marketing and perception is very important. The takeaway from this discussion is that you do not have to shoot in the format you plan to deliver, if that's not what works best for your equipment and workflows.



You can always take a 720P signal and scale it up to 1080p24 or convert to 1080i59.94. The conversion is trivial with the correct equipment, and the quality is transparent to the conversion. There are many service bureaus that have that capability in the major production markets, and software solutions otherwise. With HD we can scale up, and down, without compromise. It really does depend on what people are expecting: that's absolutely true. Obviously if they expect something of the nature of HDCAM you'll have to work with HDCAM to give them that. Or you may not need to shoot HDCAM. Proving the point that resolution, alone, is not all that matters.

## *The Kell or Interlace Factor*

"When interlaced scanning [drawing all the odd lines then all the even lines] is used, as in all the conventional [video] systems, the 70 percent figure applies only when the image is fully stationary and the line of sight from the viewer does not move vertically by even a small amount. In practice, these conditions are seldom met, so an additional loss of resolution, called the interlace factor, occurs under typical viewing conditions.

This additional loss depends on many aspects of the subject matter and viewer attention, so there is a wide range of opinion on its extent. Under favorable conditions, the additional loss reduces the effective value of vertical resolution to not more than 50%, that is, no more than half the scanning lines display the vertical detail of an interlaced image. Under unfavorable conditions, a larger loss can occur.

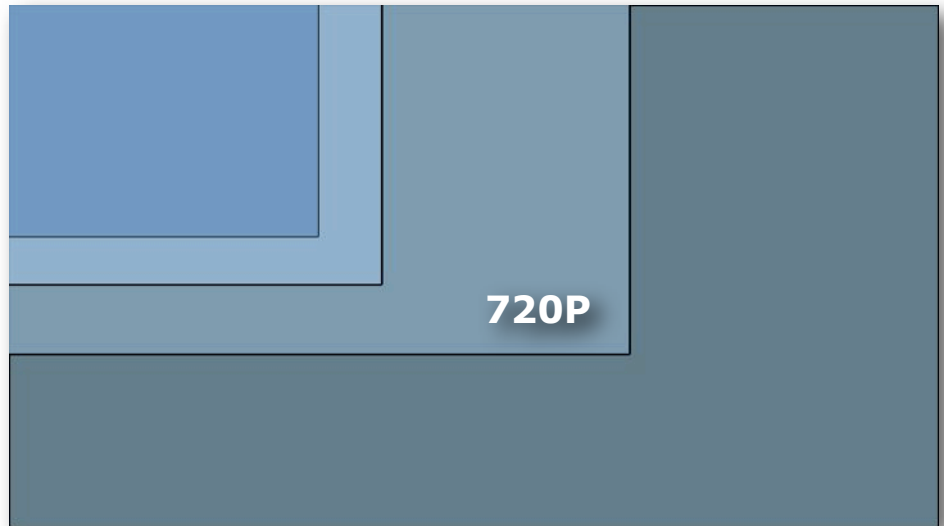
The effective loss also increases with image brightness, as the scanning beam becomes ... [fatter]."

From K. Blair Benson and Donald G. Fink, "HDTV: Advanced Television for the 1990's", 1991, McGraw Hill, NY, bracketed words added by Allan W. Jayne in his article on [Kell and Interlace Factor](#).



## What is HD for the web?

For digital delivery 720P is the most appropriate format. Anything more than that is wasted pixels except in the most extreme circumstances. If you increase the image size to 1080p24 or 1080i59.94 then you're going to get a worse result, unless you can allocate a lot more bandwidth to the download. Interlaced footage is much harder to encode than Progressive and the larger frame size is pushing 2.25× the number of pixels through. Unless you can substantially increase the allowable file size to more than double – increasing distribution cost and download time – then the larger image will be more heavily compressed and look worse on the display.



With a much larger image than even PAL SD, 720P scales well to fill HD screens with sufficient resolution, without the large file size of 1080 content.

There's also the issue of how much resolution is necessary for any given combination of screen size and viewing distance. You'd need to have a screen larger than 50" diagonal and be watching closer than the equivalent of 3.5 screen heights to be able to perceive the difference between 720P scaled to fill the screen, and native 1080i deinterlaced to progressive, even on a 1080P display. You can see this clearly in the [Screen Size vs. Viewing Distance](#) figure.

**Note:** All "60i HD screens" are, in fact progressive displays because all LCD and Plasma displays are progressive, like computer displays. With interlaced input the television de-interlaces and scales before displaying on its progressive display. The quality of the image, therefore, depends on the quality of those scaling chipsets. Often higher quality displays can be obtained by scaling elsewhere — in an Apple TV or uprezzing DVD Player — than in the display itself.



When we say 1080P we're almost-always referring to 1080p24 (29.97), because there is no distribution format for 1080p59.94. So what is distributed is 24P with 2:3 pulldown, just like it is done in NTSC. The better progressive displays will remove the pulldown to get the 23.98 fps progressive frames, and then display those frames at 48 or 72 Hz — i.e. two or three displays for each frame of video. This is exactly what a film projector in a cinema does: displays each film frame 2 or 3 times to reduce the perception of flicker.

The hottest new displays display all inputs at 120 Hz – the lowest frequency that can natively display 24, 30 or 60 fps (or their video equivalents of 23.976, sometimes written as 23.98, 29.97 and 59.94).



## ***Lenses Matter***

This is without taking into account the lens variables. Put a great lens on a lesser quality camera and the end result will challenge a great camera with a poor quality lens. Lens, pixel density of imagers, pixel aspect ratio and resolution of the format and compression all contribute to the variables that govern perceived image quality.

This is why I said earlier that I can rarely give unequivocal answers, because there are all these variables that influence the perception of image quality.

## ***The Benefits of Over-sampled Source***

There were times during my production life in Australia where I wondered why some materials that were client provided (a tourist organization) and often only available on VHS, looked far better than my much-better-than-VHS 3-chip camcorder. Well, the reason is that the source for this content was off 35 mm film – well above the quality of most HD and certainly better than VHS. Because the source had so much resolution, the perception of higher quality carries on down through the distribution channel, such that, while it was soft off VHS, it still looked great.

This is also why any of the current budget-priced HD camcorders outputting in SD make much nicer images than their very much more expensive SD counterparts of just a few years ago. The HD source is over-sampled for the SD signal, and the quality continues higher as a result.

It's almost impossible to buy bad gear anymore: the cost of the good stuff has come down so far that there's no market for poor quality gear. While there are different price/performance points for different needs, it's not possible to buy something that is outright bad. This applies to camcorders, editing gear, lighting and sound gear. It depends on what your goals are and what your needs are as to which budget point and products you choose.

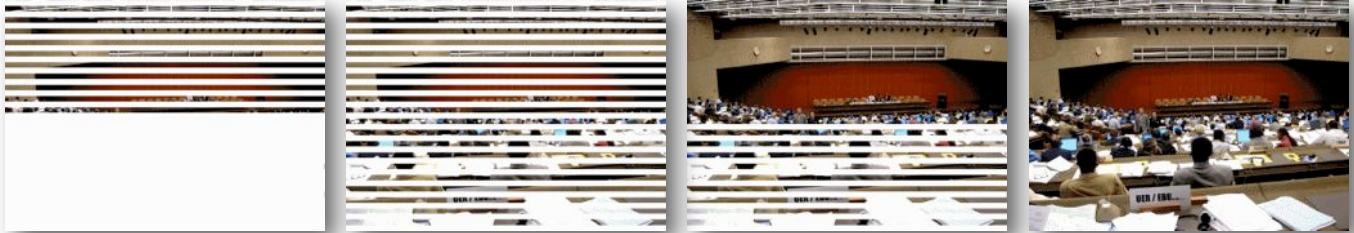


High Definition from even the most modest camera, makes a great Standard definition image. (Images proportional and to scale.)

## Progressive Good, Interlace Bad

This is one of the rare times when I can be unequivocal: Progressive scanning of the image is good; interlaced scanning of the image is bad.

### Interlaced



### Progressive



This series of images are derived from animations in an article from the EBU on why they strongly prefer progressive called [HDTV Format Wars](#). This article is strongly recommended and I thank them for their excellent animated illustrations.

We should never have had interlace in HD. We would have been much better off without interlace in any of the ATSC broadcast formats. There were a couple of factors that led to its inclusion: the established broadcasters didn't want the expense of converting existing 29.97 interlaced frames per second material to a new format. The other potential reason is that Microsoft entered the ATSC process and pushed heavily for an all-progressive version of HD. Reportedly, because Microsoft was in favor of all-progressive, everyone else felt the need to support interlace in HD! That may not be true in fact, but it is true in spirit.

## *The Advantages of progressive scan*

- Progressive scan has a higher vertical resolution than interlaced video with the same frame rate
- The perceived vertical resolution of displayed video is traditionally adjusted using a [Kell/Interlace Factor](#) coefficient (as [mentioned earlier](#)). When interlaced video is compared to progressive video with the same number of scan lines, interlaced video delivers lower perceived vertical resolution at a lower frame rate.
- There is no inter-line twitter or flicker associated with fine details.
- With progressive there is no need for anti-aliasing, which degrades image quality but helps eliminate flicker on interlaced material.



- Progressive scan gives much better results scaling to higher resolutions than equivalent interlaced video, such as upconverting 480P to display on a 1080P [HDTV](#). This is because scaling works best on full frames. In order to scale interlaced frames the frame must first be de-interlaced before it is scaled. This runs the risk of further degradation from the de-interlace process, or combing artifacts due to offsets on moving objects as they move across the screen.
- Frames have no interlace artifacts and can be used as still photos.

More information on progressive scanning can be found in the Wikipedia article "[Progressive Scan](#)."

## *Encoding is easier with progressive scan*

Encoding to various compression schemes happens across the whole production chain: from compressing in the camera to a record format through editing to final distribution. Progressive

source is easier to encode and maintain quality on, than is interlace.

I also remind you that interlace has lower effective resolution than progressive footage with the same number of scan lines. So a 1080i scan (raster) will have approximately 0.7 of that, or effectively the same as 756 scan lines in a progressive system. (Remembering that 720P has 720 scan lines in progressive format.)



Produce 1080 or 720

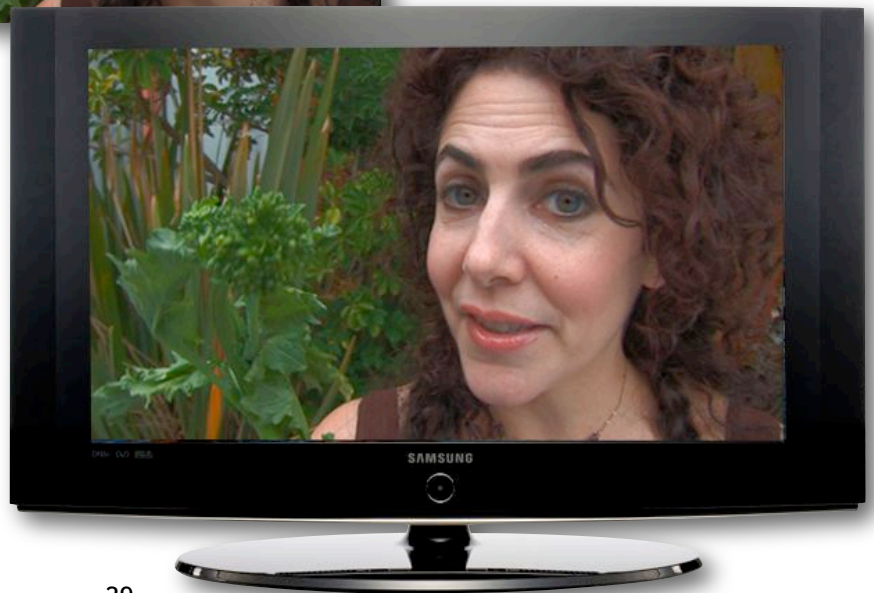


Distribute 720P

Images courtesy of Shiva Entertainment from "The Enlightened Cook"

So a 720P signal has almost as much vertical resolution as a 1080i signal, and you can scale the 720P up to fill the 1080 raster and deliver a higher quality 1080P image than if 1080i had been delivered through the same amount of bandwidth.

Display at 1080 or 720P



# HD Acquisition Technologies

*There are a number of technologies that are important to understand to be able to intelligently read format and camera specifications. Manufacturers have a number of technological decisions to make when developing a format and a camera. We'll consider these important technologies:*

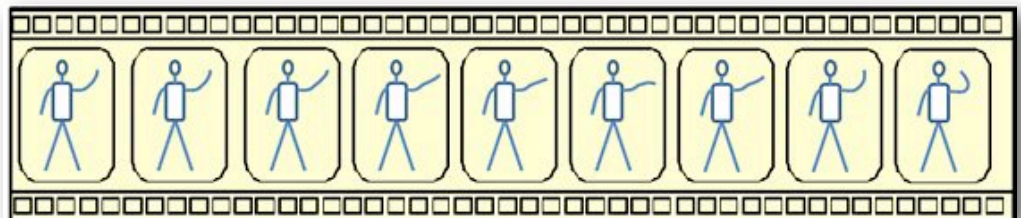
- *Long Group Of Pictures (GOP) or Intraframe recording*
- *HD Colorspace*
- *Color subsampling*
- *Camera Sensors and Resolution*

## Long GOP

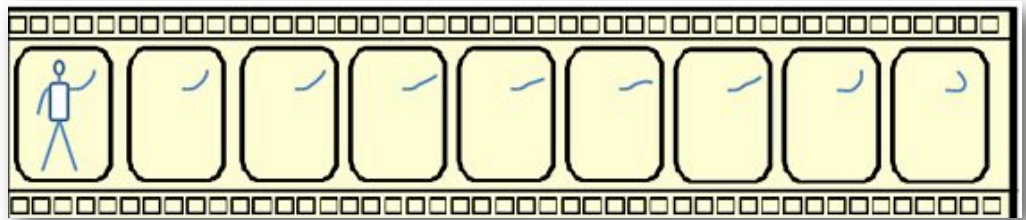
The discussion over the relative merits of all I-frame formats, like DVCPRO HD, DV, HDCAM and HDCAM SR, and Long GOP formats like HDV, AVCHD, AVC-Intra, MPEG-4 H.264 and XDCAM HD/EX is not as simple as some would make out. Anyone who has been listening to “common wisdom” would have learnt how “bad” Long GOP is — mostly on the basis of how theoretically bad HDV “must be”. Rarely are these people those who have used the formats in question.

HDV and XDCAM HD are Long GOP formats in the camera. What is coming off the imaging chips is being processed and encoded to an MPEG-2 signal, which is recorded on a tape or to a solid state card.

A Group of Pictures describes how multiple frames are encoded together so that the common parts of the images are not encoded multiple times. It usually refers to MPEG-2 encoding, but similar principles are applied for the more modern H.264 codec.



**Intra-frame Compression:** Every frame is encoded entirely within the frame. Each frame encodes the full image, even the parts that have not changed.



**Inter-frame Compression:** Only the differences between frames are encoded, based on an initial full frame — a keyframe in Delta codecs (Animation, Sorenson Video, etc.) or an I frame in Long GOP formats like MPEG-2 and H.264. Delta codecs send changed pixel information; Long GOP codecs examine the image, break it into blocks and track where the blocks move or change.

Images from the [Trusted Reviews](#) article “The Codec Primer: Part One”, which is recommended reading.

In all-I-frame formats, all the information about the body and background are transmitted in every frame, but in a Long GOP format, the background and body are transmitted once, and then the rest of the P and B frames are used to communicate that the blocks of pixels representing the hand we're moving, and which direction they were moving. Long GOP is used because it is a much more efficient encoding method than all-I-frame formats.

## GOP Structure



**I** — Complete frame (keyframe) contains the whole image.

**P** — Predictive Frame — looks forward to where pixel blocks are moving

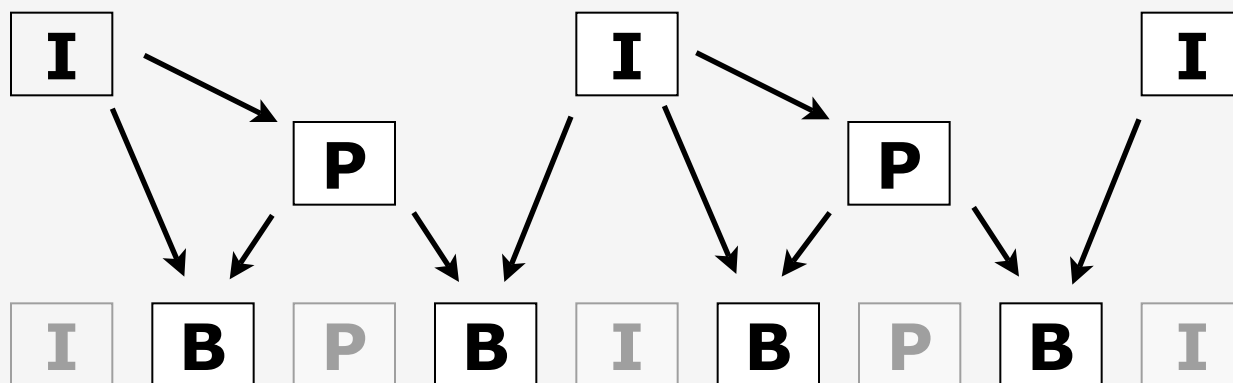
**B** — Backward Predictive Frame — looks back to where pixel blocks have moved.

Frames are transmitted out of order so the B frames can be included in the calculation.

## GOP recording or transmission order



**Frames are reconstructed by referring to multiple IPB frames**



In practice all IPB frames in a GOP are used to reconstruct all images. This is a simplified representation of how the GOP draws on I, P and B frames to construct an image.

A Group of Pictures has a single keyframe (I-frame in MPEG-2 speak) followed by 14 other frames (in 60 Hz countries like the USA) to make up a 15 frame Group Of Pictures. (There are no Elephants associated with this GOP.) The frames in-between are calculated by looking at blocks of pictures and figuring out where those blocks move between the frames, then processing those blocks and the information about how they move. Some of the information is presented as (P)redictive forward frames, and some as (B)ackward prediction. Together they make up the IPB structure of an HDV datastream. A typical HDV GOP of 12 frames will be: I B B P B B P B B P B B, where only the I-frame holds the full picture information.

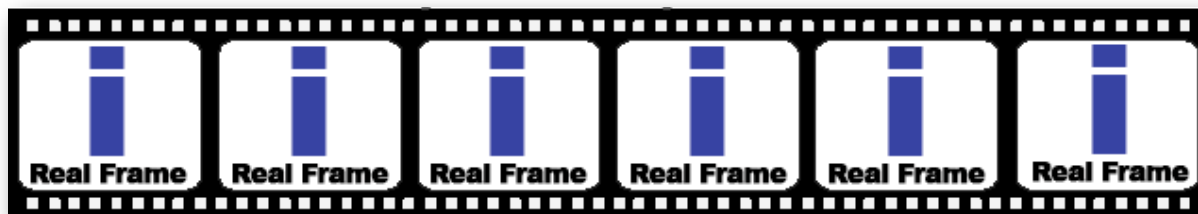
Not surprisingly, calculating any given frame in the Group is processor and memory intensive, as all frames in the GOP have to be used to calculate any given frame from within the Group. It is much more practical now that computer processing power has increased to the point where working on 15 frames of IPB frames out of sequence, and building them into the correct frames in real time is practical.

Long GOP is more complex for the technology to work with, but in practice can be more efficient than all I-frame formats. Or, to put it another way, just because something is all-I-frame, doesn't mean it will automatically be better than a Long GOP alternative.

(20,000 MPEG engineers are horrified with the world's least technical explanation of Long GOP MPEG-2 ever, but it's close enough for our purpose.) Steve Mullen gives a deeper explanation of Long GOP at [Digital Content Producer](#).

## *Problems with Long GOP*

DV, DVCPRO HD and all “analog” formats, kept the information for each frame within the frame. Every frame carries all the information needed for that frame and is not dependent on other frames in order to be played back. Every frame is its own entity. Whatever detail is in that frame needs to be encoded within the finite amount of bandwidth available for that frame. For DVCPRO HD, for example, you have to compress all the detail of every frame into every frame.



With all I frame codecs each frame is self contained making editing easier

At “30” fps and 1080 that’s about 420 KBytes a frame.



With Long GOP editing on B or P frames requires the processor construct the frame from the entire Group of Pictures — a huge load on the processor.



A Group of Pictures must be intact or all 15 frames will be compromised: damage an I frame and the rest of the information in the GOP is useless and there's a 15 frame dropout — that's half a second. It's half a second in either the PAL or NTSC worlds because a GOP in PAL is 12 frames. The P and B frames don't carry enough information to reconstruct the picture without the I frame.

Therefore it's highly advisable to use the higher quality, "guaranteed" HDV tape even though miniDV tape will work and be reliable more than 99% of the time.

The "lose a single I frame, lose a GOP" problem seems to be more theoretical than practical, but avoid the chance of a problem by:

- Using new tape for important recording;
- Not recording important content on the first two minutes of the tape, nor the last two minutes. This is the area of tape that gets most damaged.
- Rewinding the tape to the beginning before removing it from the camcorder. This way you limit any risk of tape damage to that first two minutes of unimportant content.

**Note:** I prefer to remove tape from a camera during a shoot and never rewind to avoid the possibility of over-writing good footage. If you're like me, record some black past the end of the good material on the tape, or just assume that the last 30 seconds will probably not be useable (although it probably will) and take the tape out where it ends.

## Fast Motion

Long GOP systems, like HDV and XDCAM HD, do tend to have problems predicting the motion vectors for P and B frames when there are lots of changes between frames, and insufficient bandwidth to encode those changes. This is one of the big advantages of XDCAM HD/EX over HDV: there is a 35 Mb/s/sec Variable Bitrate (VBR) version as well as the HDV compatible 25 Mb/s/sec Constant Bitrate (CBR) format. There would be few times you would not choose the higher bitrate for XDCAM HD/EX. (There is a 50 Mb/s/sec version on high end XDCAM HD camcorders that is 4:2:2 and higher quality again than 35 Mb/s/sec "HQ" mode available on the XDCAM EX-1.)



In this example frame, the MPEG compressor is struggling to work out where all the blocks of pixels should be moving. Compare this to an all-I-frame from the same sequence in an [article by Jim Feeley at Studio Daily](#).

## Low Bitrate

It should also be noted that the type of visible artifacts you'll see in HDV or AVCHD (and to a lesser degree in XDCAM HD) are quite different than what you might have seen in images that were too complex to encode to DV (mostly in the early days of DV or around titles).

When we had a Dish network service, I recall watching Star Trek Voyager. The character Chicote has a tattoo on his forehead. Many times I recall seeing the tattoo floating with slightly different motion than the rest of his face and head. This is one of the consequences of reducing bitrate with Long GOP encoding.

I do not have any pretensions that I truly, deeply understand MPEG-2 Long GOP encoding. I am a geek, but I am not in that league of geek. I understand enough to be aware of the advantage and shortcomings of the format and the role it plays in production. You don't need to understand this deeply to use the knowledge to your advantage. It is probably enough to know that we make computers work harder when we work in Long GOP formats. Fortunately there is always someone ready to sell you a more powerful computer to work with the latest and greatest.

## *Improving Encoders*

Most modern codecs — including XDCAM HD/EX, HDV, DV, MPEG-2 and H.264/AVC — are designed so that innovation can happen on the encoder side, without requiring changes to the decoders already “in the field”. This way, manufacturers are free to innovate to improve the encoder while maintaining compatibility with the format and existing equipment.

The format is defined as being “any signal” that the standard decoder is capable of decoding. Within those bounds anything that decodes correctly is in that format.

We saw enormous improvements in the DV encoders between the early VX 1000 and later DSR-300s. Some of the improvement came from better cameras, but the encoders themselves got better and better. Likewise we're in an era where MPEG-2 encoders are continuing to improve. MPEG-2 is considered to be between two and four times more efficient now, than it was when first released in the early 1990's.

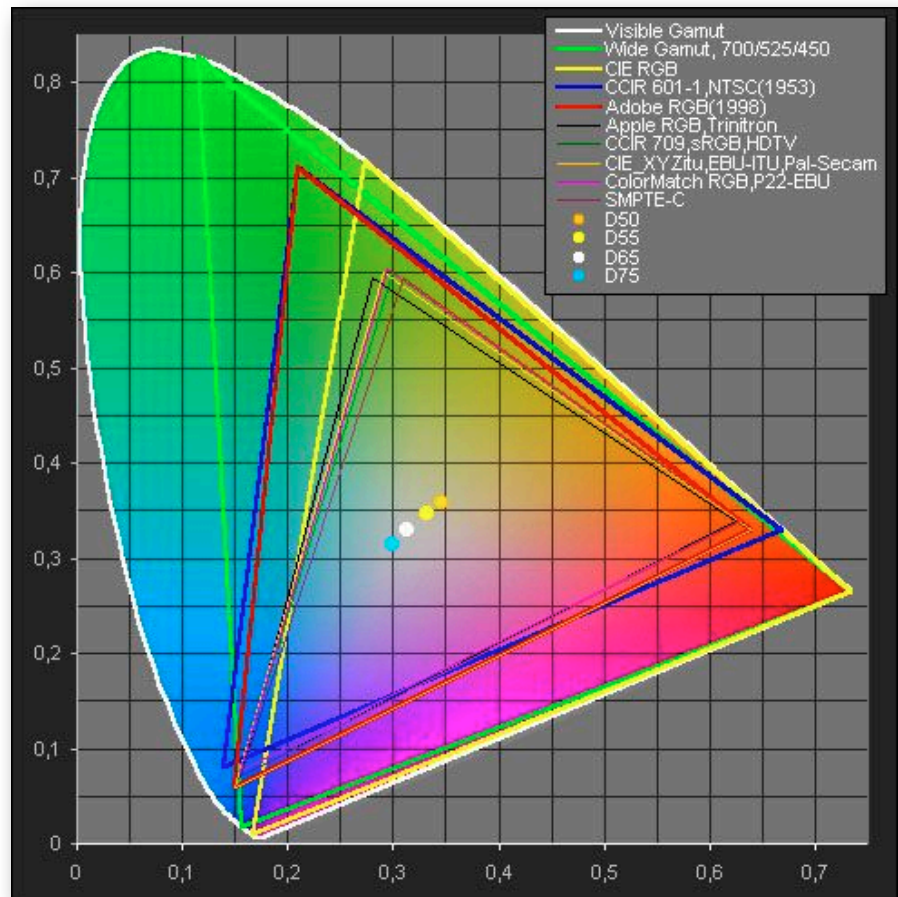
You will see camera manufacturers focusing on the efficiency of their encoders, particularly for the Long GOP MPEG-2 and H.264 formats, because the encoder does make a lot of difference to the quality of the format. Between the release of JVC's KY-HD100 and the announcement of the KY-HD200/250 JVC claimed a “100% improvement” in the quality of the MPEG-2 encoder in these HDV format cameras. That would be a theoretical doubling in quality. Likewise, at the release of the XL-H1, Canon focused on the MPEG-2 encoder being “the best available” at the time for HDV.

We can expect to see continued improvement of the encoder side of the equation, particularly with HDV and XDCAM HD/EX, and AVCHD/AVCCAM where the “format” will improve in quality over time.

# HD Colorspace

As you can see from the illustration, the colorspace differences between SD ITU 601 and HD ITU 709 are slight and around the edges: the majority of colors reproduce in both colorspace and look the same. We've been living with differences like this for years in the SD world. SD digital video has worked in the ITU 601 colorspace and yet our monitors have been almost universally calibrated with SMPTE C phosphors. (See the difference between the 601-colorspace boundary and the SMPTE C colorspace boundary.)

The main reason to be aware of this difference is if you are color correcting an HD program on an SD screen. That's not something the more critical of editors will be doing, but is probably acceptable practice in event videography where "looking good" is more acceptable than "locked to a standard."



The good news is that most software handles these colorspace conversions transparently, although if you were to do several passes between Final Cut Pro and Adobe After Effects (for example) then minor conversion errors might compound. This would be a rare situation because mostly it's a single round trip for footage from the NLE, through a compositing application and back to the NLE and mostly it will be HD-to-HD or SD-to-SD. The only situation where this presents any problem is in integrating SD footage into an HD project.

When you work in a native video color space tool, such as Final Cut Pro, where you capture, edit, and deliver in the same color space (for example, 709), color accuracy and fidelity are maintained. It's true that the native filters in Final Cut Pro assume that you're using 601 color space, but this assumption rarely has much effect on the math used in video processing.

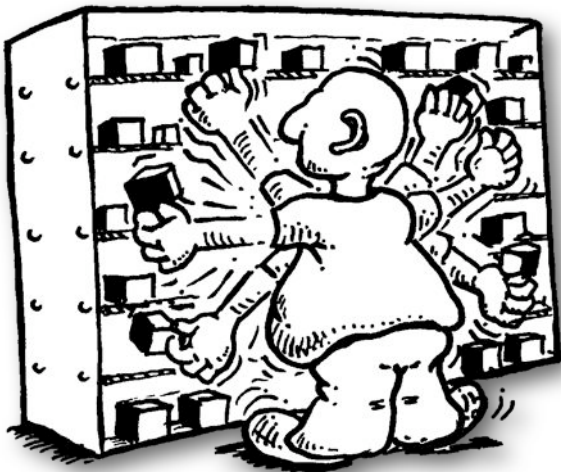
Our recommendation is to monitor HD on an ITU-709 calibrated monitor when editing HD. See the section on Monitoring HD in the next module of this book. The good news is that the video scopes within NLE applications are useful guides for both HD and SD content. For the highest level of quality control you will want to have HD scopes on the output of your HD system. Most folk will monitor in their NLE.

## Color Sampling (or subsampling)

You've seen numbers quoted in technical specifications or reviews like 4:2:2, 4:1:1 and 4:2:0. If you've wondered what they mean then read on.

The only format that is capable of recording full resolution Red, Blue and Green channels is HDCAM SR at 440 Mbits/sec (dual link HD SDI or 3 Gb HD SDI is required). All other video formats encode the signal with a luminance signal and color signals, because the human visual system is far more sensitive to detail in the black and white part (luminance) than in the color part (chrominance) of the image.

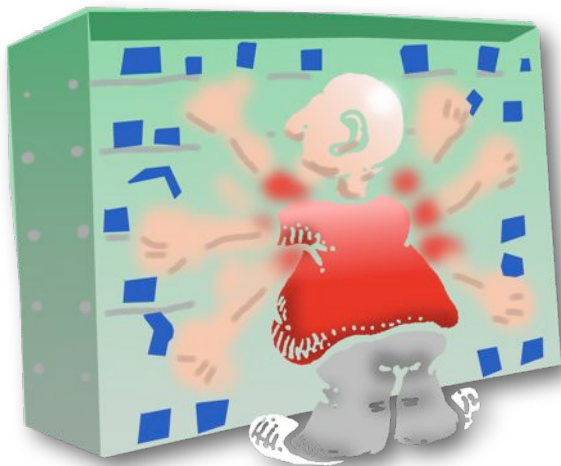
When color was added to black and white television, it was added as this color overlay, very much like a hand washed color print from the middle of last century: the print was monochrome but someone hand washed colors over it.



The Luminance channel carries the most detail.

+

=



Because the detail comes from the Luminance (Y) channel we need much less detail in the color channels.

In video formats we describe these signals as Y – luminance – and color difference signals U and V. (There are other ways to express these components more accurately for different systems, but this is enough to understand color sampling. There's deeper information on YUV and color encoding at [Wikipedia](https://en.wikipedia.org/wiki/YUV).)

In theory we would have to sample U and V as often as we sample for Y but in practice, because the human visual



When combined we don't miss the detail in the color channels.

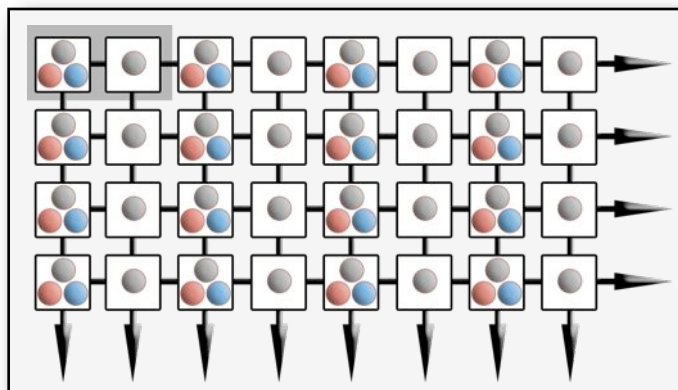
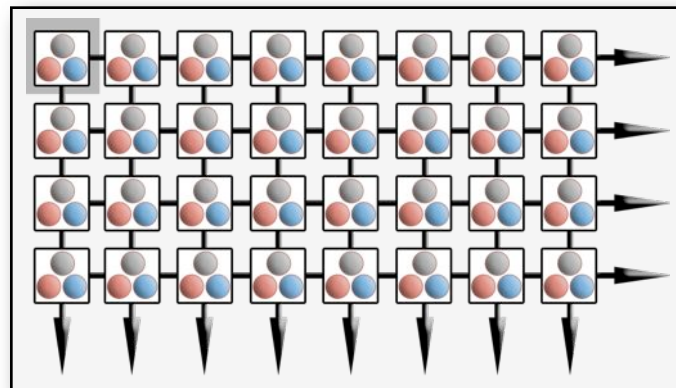
system is less sensitive to the color part of the signal, we sample U and V less often than Y, and we describe the ratio between how many times we sample U and V for every 4 times we sample Y.



## Color subsampling

### 4:4:4

In a **4:4:4 system** there are 4 color samples each for U and V for every four Y samples (pixels on the chip). Each of the three color channels has full  $1920 \times 1080$  or  $1280 \times 720$  resolution.

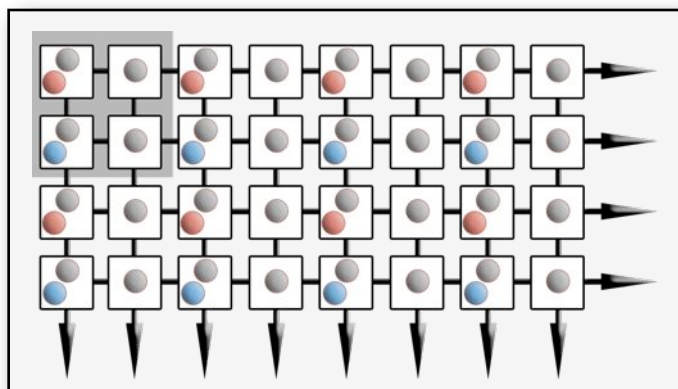
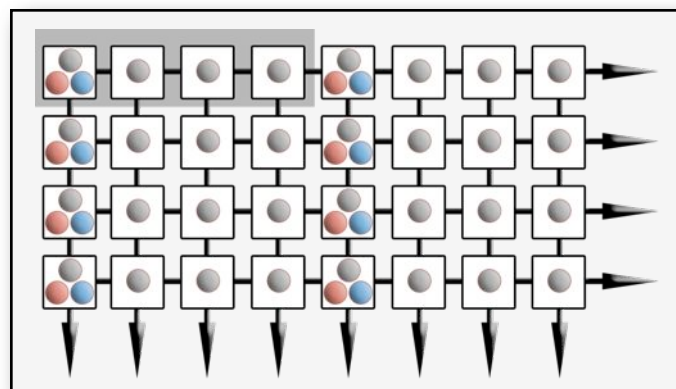


### 4:2:2

In a **4:2:2 system** there are 2 color samples each for U and V for every four Y samples. So while the Y component might be at  $1920 \times 1080$ , the U and V components will only be  $960 \times 1080$  each or in 720, that would be  $640 \times 720$  each for U and V.

### 4:1:1

In a **4:1:1 system**, there will be only 1 color sample each for U and V for every four Y samples, so there is only one each U and V pixel for every four Y samples. Against a Y resolution of  $1920 \times 1080$  U and V would only be  $480 \times 1080$  and in 720,  $320 \times 720$  pixels for the U and V channels.



### 4:2:0

In a **4:2:0 system** there is still only one each U and V for each four Y pixels, but the location is slightly different than 4:1:1 as you can see in the illustration. 4:2:0 is also half resolution in both directions, like 4:1:1. Between 4:2:0 and 4:1:1, the 4:1:1 distribution is slightly more accurate for color reproduction (see Results of Subsampling on the next page). Certainly in interlaced systems 4:2:0 can be very problematic, although again these are technical

issues that only affect a small number of people. Practically speaking, the issues surrounding 4:2:0 are a headache for developers of codecs, encoders and digital effects hardware but less of an issue for users. Adam Wilt has a [good explanation](#) on his website.

Formats with 4:1:1 or 4:2:0 are not an excellent choice for Chroma keying or for deep color correction, but amazing results can still be had — particularly from HD source.

## Analog Oranges, Digital Apples

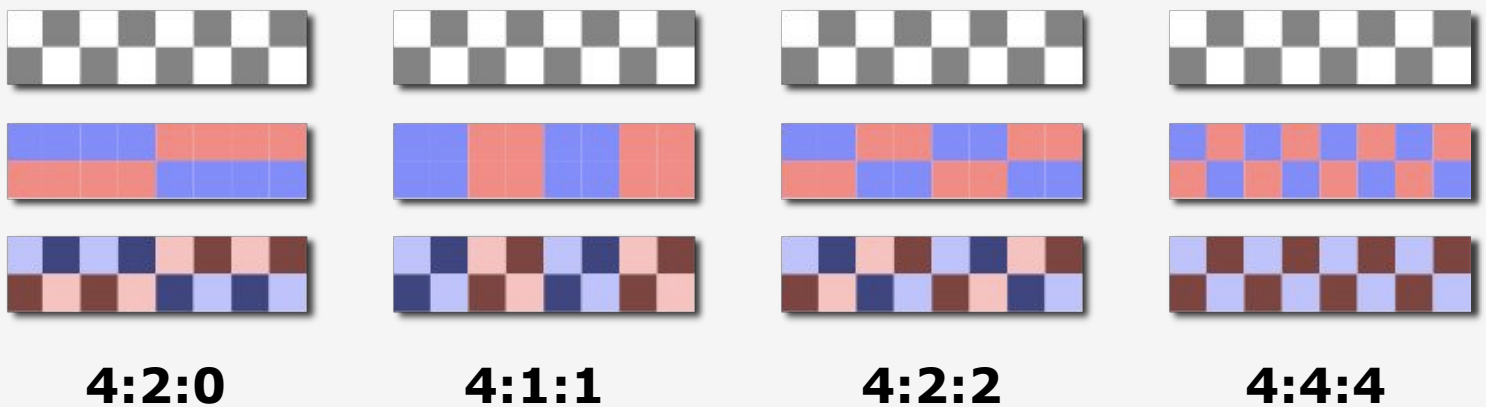
If we could compare digital apples with analog oranges (i.e. a comparison that really isn't quite fair), then Beta SP would fall somewhere around 3:1:1 for luminance vs. chrominance. The "3" comes about because the luminance resolution is substantially below that of digital systems (at least in theory). Color sampling in Beta SP was significantly subsampled in the record system so that the two U and V color signals could be written in the same space on tape as a single Y signal.

In HD each individual pixel is less important. As a percentage of the total image, in HD each pixel is much less important to the accurate rendition of the image, so we can get away with these sorts of tricks to fool the visual system.

The video system has to reduce colorspace in order to preserve bandwidth. Cutting from 4:2:2 to 4:2:0 reduced the bandwidth requirements by 25%. This is before compression is applied and not counted in the compression ratio quoted for a format. That way manufacturers keep their "compression level" down, but still throw away a lot of data, which is why compression information alone for a format isn't enough information to determine whether it is suitable for our needs or not.

By way of comparison, standard DVD is encoded with MPEG-2 at 4:2:0.

### Results of subsampling



In the top row we see the pixels, as sampled by the Y, or Luma, component.

In the middle row are the samples for results of the color samples.

In the bottom row is the result.

Only the 4:4:4 is a true representation, but when the errors displayed in the subsampled format are reduced down to their actual size, the results are reasonable. Image adapted from the one in the article on [Color Subsampling](#) at Wikipedia

# Camera sensors and resolution

## (Check what the numbers really mean)

Another way that camera manufacturers and video format developers reduce the amount of data that has to be encoded and recorded is to reduce the Luminance (Y) resolution.

### ***Full Raster***

So-called “Full Raster” is  $1920 \times 1080$  for the 1080 format family and  $1280 \times 720$  for the 720 format family. Many newer affordable cameras or formats record the full resolution of the format. Cameras that work at this resolution are referred to as Full Raster. Full raster HD uses square pixels.



### **Real World**

In the real world, some formats are full raster and even affordable cameras now have full raster chipsets. However, many 1080 cameras encode to  $1440 \times 1080$  interlaced. Some have  $1920 \times 1080$  CCD or CMOS chips, while others use the pixel shift technology (see next section) to achieve the appearance of higher pixel chipsets.

Panasonic's DVCPRO HD in 60 Hz countries (US, Canada, Mexico, Japan et al.) runs at  $1280 \times 1080$  for nominal 1080. That's only 67% of the full raster and a huge bandwidth saving. This pixel count reduction is done by using anamorphic pixels that stretch out to fill the full raster for display: 1280 pixels are stretched wide and fat to fill the space of  $1920 \times 1080$  square pixels. In 720P, Panasonic processes at 960 pixels internally, or 75% of the full raster resolution. It's worth noting that in 50 Hz (or PAL) countries, DVCPRO HD 1080 is, like HDCAM, HDV and XDCAM HD/EX @ 25 Mbits,  $1440 \times 1080$ . The new AVC-Intra 100 Mbit codec is full raster. The 50 Mbit version of the AVC-Intra codec uses anamorphic pixels at  $1440 \times 1080$  (1080) and  $960 \times 720$  (720) like the DVCPRO HD codec does.

Full Raster 1080 has 1920 actual pixels.  
(Shown proportional)



Most formats represent 1080 at  $1440 \times 1080$  anamorphic pixels. (Shown proportional to previous illustration)

Except for DVCPRO HD, 720P is usually at full raster  $1280 \times 720$  – from the chips and in the recording.

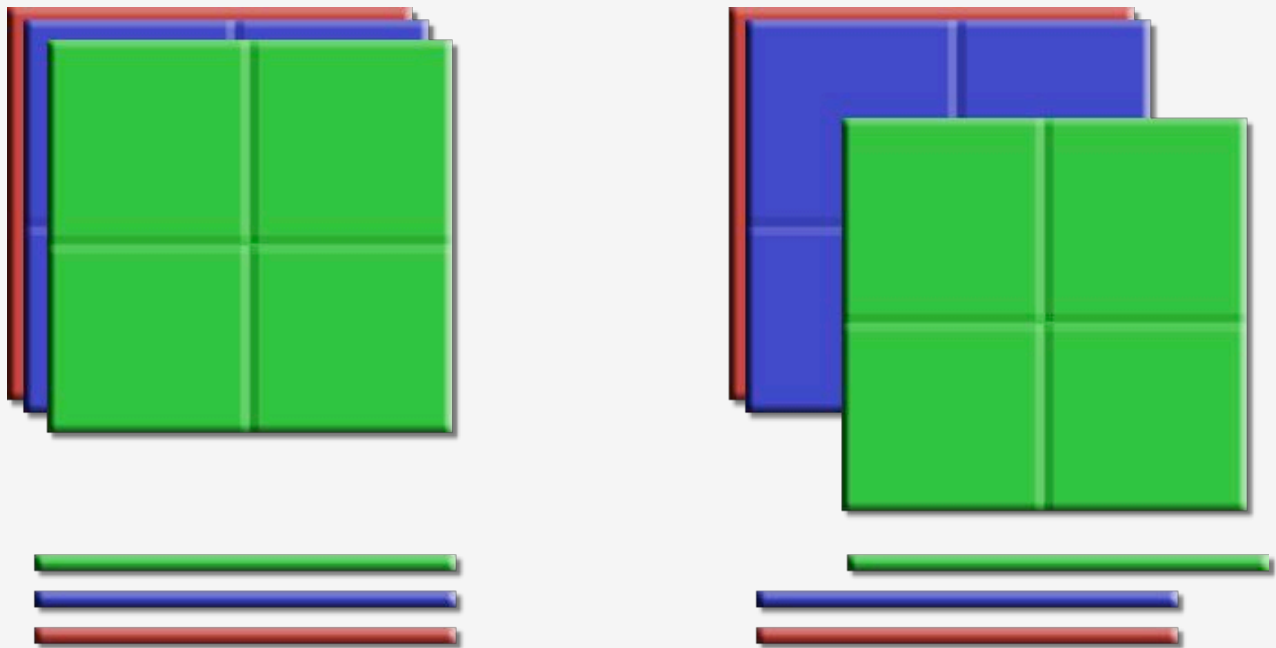
XDCAM HD at 35 Mbits/sec (HQ setting) is full raster  $1920 \times 1080$  from full raster chips. In the 50 Mbits/sec version it is 4:2:2. Unfortunately the 50 Mbits/sec version is not available on affordable cameras, yet!

You can see the difference between actual pixel display and “square pixel equivalent” in Final Cut Pro under the Zoom pop-up menu in the top center of the Canvas or Viewer (the View size menu). Show As Square Pixels means that Final Cut Pro should show this image displayed at the display size it would have if it were comprised of square pixels and will display as 16:9. With that setting off, the native pixel size is mapped 1:1 with the square pixels of the computer display. This will show the image without the anamorphic display and the display will not be 16:9. For Media Composer, select the “16:9 Square Pixel” in the Display Aspect Ratio window.

## ***Pixel Shift***

A very common technique used by camera manufacturers is to use lower pixel count CCD or CMOS chips and slightly offset one pixel – usually the green chip – by half a pixel in each direction.

### **Pixel shift improves perceived resolution**



On the left, the pixels on all three layers are in alignment.

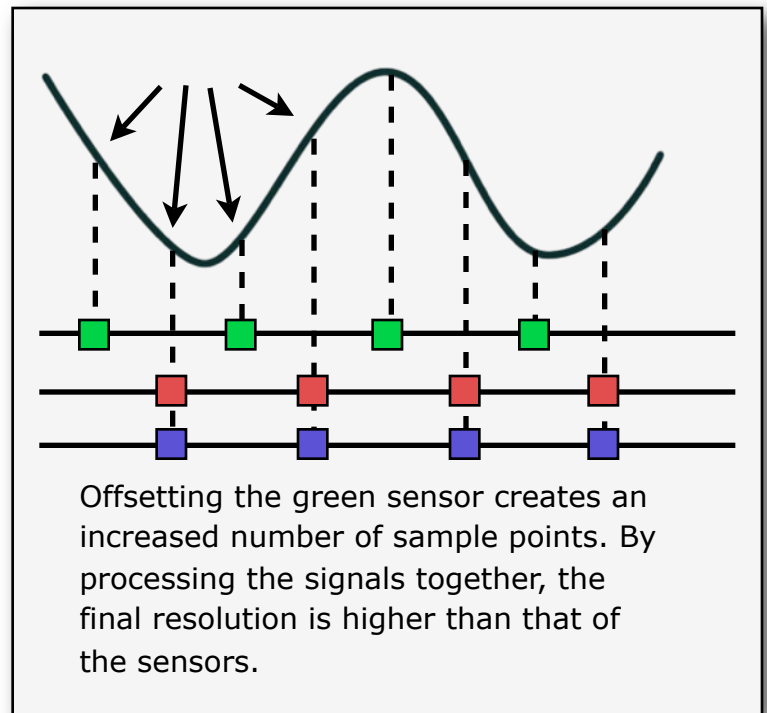
On the Right, the green imager has been shifted half a pixel horizontally and vertically relative to the red and blue sensors. The green sensor samples in the “gaps” of the other pixels, which is processed into the overall luminance signal with an overall higher resolution than the other two sensors.



This chip samples “in between” the other chips, and by processing the image with powerful Digital Signal Processing (DSP) chips, an effective resolution results that is significantly higher than the actual resolution of the chips.

This pixel shift technique is very common. Currently it is in use by Panasonic’s HVX-200, Sony’s V1U, Canon’s H1 and many more. This is not an issue to get hung up over: it’s a proven technique for improving the visual resolution from low pixel density chips and keeping the cost of the camera down. Lower pixel density chips are also more sensitive to light because each pixel can be larger and accept more light.

The HVX 200 started with three CCD imaging chips that are each  $960 \times 540$  – barely higher than PAL SD resolution ( $720 \times 576$  pixels, displayed at  $768 \times 576$  pixels)<sup>2</sup>. However the HVX 200 manages to produce great looking 1080 and 720 images by offsetting the green imager one half pixel in each direction and processing the image accordingly. The output looks like HD because it is HD, despite coming from much lower resolution chips.

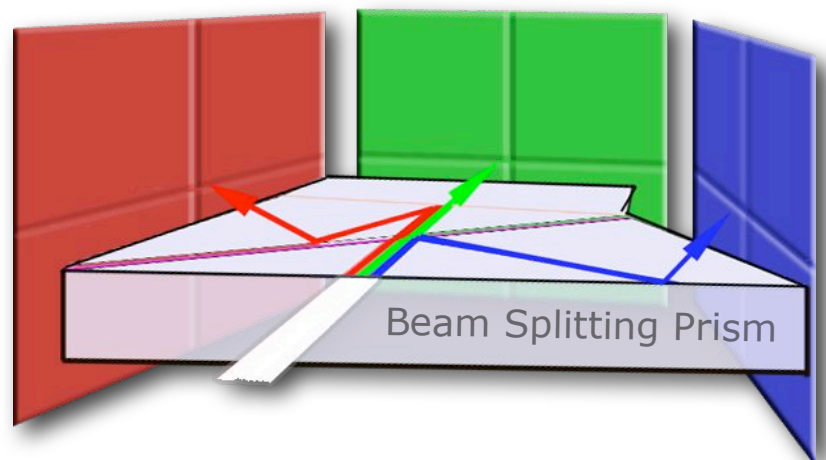


## One chip vs. three

As little as five years ago there was a strong visible difference between a single CCD and three CCDs, particularly in color quality. Fifteen years ago the difference between single tube cameras and three tube cameras was even more dramatic.

However in 2009, it’s much harder to draw the distinction. Three imagers are generally better than one imager, but some very high end digital cinema cameras – RED One, Silicon Imaging and Phantom – all use a single CMOS device to simulate the single plane focus of film.

There is a distinction between where a film lens focuses light – all frequencies on the one piece of film – and where lenses for

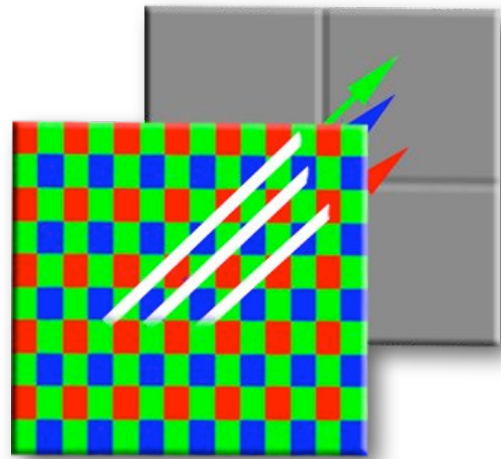


Three sensor arrays (3 chip) have a sensor for each primary color, and a beam splitting filter that separates the incoming light into Red, Green and Blue. Each sensor records full resolution (although the green sensor may be offset to increase perceived detail).

<sup>2</sup> The HVX 200A released at NAB 2008 improved the resolution of the chips.

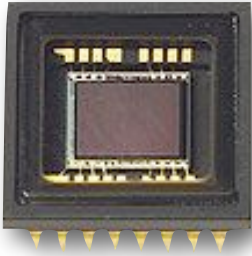
video cameras focus light. Because the light is split into Red, Blue and Green for the three imagers, the paths are slightly different for each group of frequencies and critical focus requires the lens to adapt to that. This is why there are film lenses and video lenses and they are generally not interchangeable without complex conversion equipment (usually only used to put film lenses on video cameras).

That is why we're seeing large format CMOS chips in high end cameras — those aimed at digital cinema — but mostly three chips (CCD or CMOS) in more affordable and mid-range cameras, not aimed at digital cinema production techniques.

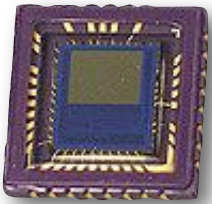


A single chip sensor determines color by filtering through a Bayer Filter. Green has twice as many pixels for maximum luminance resolution, but overall resolution and color are determined by averaging values in blocks of four pixels. (Note the similarity to color subsampling.)

## CCD or CMOS?



1/3" CCD Sensor



1/4" CMOS Sensor

A CCD is an analog device, converted to digital immediately the signal comes off the chip, while a CMOS is an actual digital imager. CMOS chips were more expensive to create until quite recently and tend to be a little less sensitive to light than equivalent sized CCD chips. That has now changed and the cost to manufacture is close and the light sensitivity also close.

However, there is no single “best” choice between CCD and CMOS, and most likely other factors will influence the choice between one or the other. These other factors would include the overall image quality, recording format of the camera and the size of the chip.

CMOS chips tend to consume less power and be slightly lighter, which makes them more attractive in very small camcorders. The decision to put one type of imager in any given camera seems to be about balancing price, performance and image quality for a particular market.

CMOS chips can scan and offload their footage more quickly than CCD, which is why they are very suitable for high speed cameras. A CMOS chip can suffer from a “rolling shutter” artifact. CCDs use a global shutter that exposes the whole chip at the same time. While CMOS chips can use either a global or rolling shutter, so far only rolling shutter chips have been released.

With a rolling shutter, different parts of the CMOS chip are exposed progressively over time, during the exposure. If there is dramatic change in the image (through panning, for example) the motion will be apparent as tilted verticals or double exposure of objects in the shot.

Barry Green has a great explanation of the problem at [dvxuser.com](http://dvxuser.com). I should also point out that I know six people with the CMOS-based EX-1, who report that the rolling shutter is a non-issue for them. You should check for yourself, with the type of footage you shoot.

## ***$\frac{2}{3}$ " , $\frac{1}{2}$ " , $\frac{1}{3}$ " or $\frac{1}{4}$ " — what's the difference?***

As a rule of thumb, bigger chips are better than smaller chips.



The RED One Mystery sensor is just over 1" diagonal.

However bigger chips go into more expensive cameras and therein lies the dilemma. As the chip gets smaller two phenomena happen:

It is harder to limit depth of field because depth of field increases as sensor size decreases; and

Smaller chips still have high pixel densities so each pixel ends up being much smaller on the smaller chips sizes. Therefore each pixel doesn't get as much light as on bigger chips and the smallest chips are much less light sensitive than their larger brethren. Small chips tend to be less light sensitive and have more visual noise than larger chips of either type.

If you plan on doing a lot of low light shooting then avoid  $\frac{1}{4}$ " and  $\frac{1}{3}$ " chips if you can afford to.

With the increased depth of field of these small chips, it becomes more difficult to isolate just one point of focus between the camera and infinity. The common method of reducing depth of field is to reduce aperture by using Neutral Density filters, but with a lower sensitivity, small chip camera, that may only serve to increase noise.

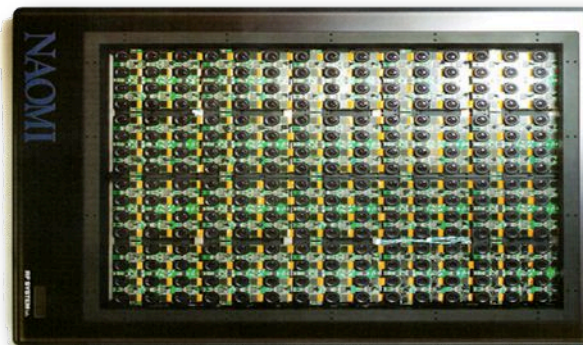
There are HD and SD chips at each of the imager sizes, and the HD version is going to be less sensitive to light and have greater depth of field issues than the SD version because the HD version has more pixels packed into the same physical surface size of the SD chip.

It is arguable that a significantly larger single imager will give a better quality image, particularly in available light, than a three imager camera where each imager is much smaller: a single  $\frac{1}{2}$ " chip could (all else being equal, which it never is) produce more satisfying images, particularly under available light, than a camera with three  $\frac{1}{4}$ " chips.

Comparison sizes of CCD sensors, shown here approximately 16x actual size.



Actual size of  $\frac{2}{3}$ ",  $\frac{1}{2}$ ",  $\frac{1}{3}$ " and  $\frac{1}{4}$ " sensors (Top to bottom.)



$\frac{2}{3}$ " Sensor (16x)



$\frac{1}{2}$ " Sensor (16x)



$\frac{1}{3}$ " Sensor (16x)



$\frac{1}{4}$ " Sensor (16x)

# Acquisition Formats

*Before we get into a specific comparison of acquisition (and editing) formats, let's consider the format choices. Remember that you cannot judge the format by any particular camera in that format. Some formats, like DVCPRO HD, XDCAM HD/EX, HDCAM or HDCAM SR are associated with just one manufacturer. Multiple manufacturers support HDV and AVCHD.*

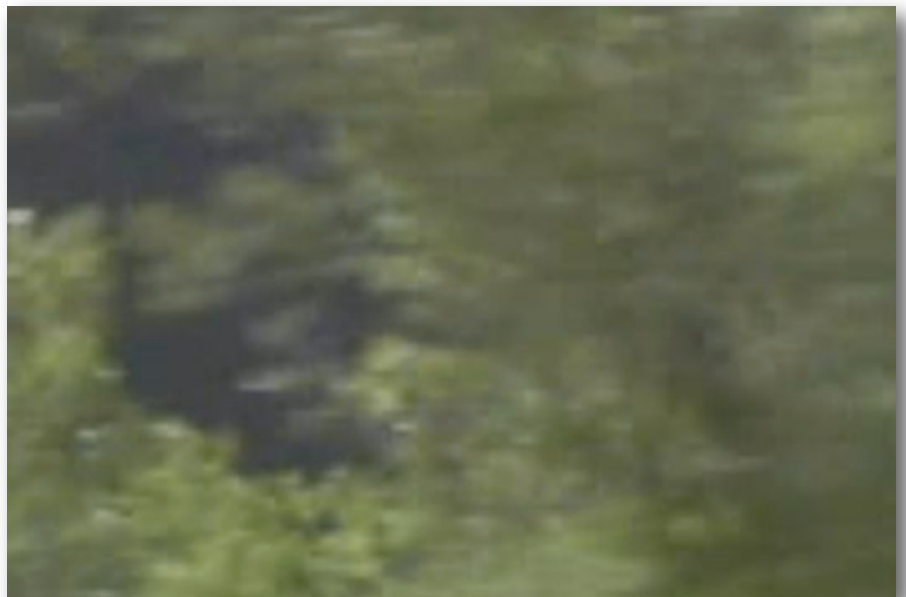
If you had seen JVC's JY-HD10 back in 2003 you would have assumed that there was no future in the HDV format. History has proven that the format is a whole lot more robust than that particular example. The JY-HD10 was interesting, but not a great camera, nor great pictures. Subsequent cameras from a variety of manufacturers have shown vastly improved cameras and recording quality within the same format specifications.

The reason this is possible is because digital formats are defined by the decoder: anything that a standard decoder will decode is within specification for the format. The great thing about this approach is that camera manufacturers are free to innovate with encoding technologies, while remaining true to the format.

It is also not possible to identify formats by media: XDCAM HD uses optical disc (Blu-ray) as its media format, while XDCAM EX places the exact same formatted signal onto SxS solid state media. DVCPRO HD can be recorded onto tape or P2 solid-state media.

## ***Digital quality vs. Analog quality***

Another important consideration is how image content affects quality in digital formats. With analog formats, like Betacam SP, there was a guaranteed quality, regardless of the image content. Not so with digital, where some image content compresses very easily while other image content is much more difficult to compress and may show artifacts on those systems that are more compressed. Typically, fine detail with a lot of motion will show artifacting. This type of content might be a wide shot of a tree with wind-blown leaves, or the highlight reflections of the sun across an afternoon pond under a light breeze.



The compression artifacts will depend on the format. In this Long GOP HDV shot, the format cannot determine where the leaves are moving, so it becomes an uncorrelated blur. In all-I-Frame codecs, artifacts will appear more like "mosquito" noise, or blockiness.



The movements of the leaves, or reflections on the water, are serious challenges for digital compression. These are good tests if you want to determine if a given format will work for your needs. Look for a tree backlit by reflections of the sun off the water.

High action sports are difficult to compress and are another good test.

## ***Formats and their uses***

**Panasonic's D5** format is rarely used for acquisition because of the lack of a field recorder or single-unit camcorder in the format. It is popular as a mastering and delivery format because it can carry eight audio tracks, which are frequently required for modern production delivery. D5 is firmly at the high end of the market and usually only seen in high-end post houses and broadcast stations.

**HDCAM and HDCAM SR** are popular formats for digital field production. They are firmly entrenched in Network series, Episodic Television and direct-to-DVD feature production. The cameras and decks are expensive and generally only rented for the production needs. The camcorders available for this format are way, way above our self-imposed limit of considering camcorders \$10,000 and under, so there are no HDCAM or HDCAM SR camcorders in the camera reviews. Although the HPX-300's MSRP is just over the limit, generally the camera will be available "street price" within the limit, or close enough. Frankly, it's too good a camera to leave out on a technicality like a couple of hundred dollars extra!

**XDCAM HD and XDCAM EX** are essentially the same format, although the two versions use different format wrappers around the same codec. At 25 Mb/s XDCAM HD/EX are identical to HDV 2. These formats are dominating reality television production. JVC also has a camera that records the same codec to QuickTime .mov files ready for direct editing in Final Cut Pro. There are two XDCAM EX models that come into our price range — EX-1 and EX-3, along with the JVC HM100 in this year's guide.

**Panasonic's proprietary P2 media cameras**, originally with the (now aging) DVCPRO HD codec and now with AVC-Intra (available in one sub-\$10K model) are very popular for series production where data wrangling can be managed nearby. The newer codec significantly outperforms DVCPRO HD, which should now be considered a "legacy" codec (i.e. not a codec one would choose for acquisition or editing if buying new in 2009).

**HDV 1 and 2** have been the "affordable acquisition (and, for some, editing) format for many years now, with a range of camera styles and quality supporting the format. The encoders have improved in every generation of HDV camcorder, which is very important to note when comparing models. According to JVC the MPEG-2 encoder in the HD200 is "100% better" than the MPEG-2 encoder in the HD100/110 introduced about 18 months earlier. No new HDV camcorders have been released in the last two years and those on the market should be considered obsolete for new buyers.

Although introduced as a Prosumer format — haven't we heard that before? — **AVCHD** provides excellent quality by adopting a Long GOP H.264 AVC codec<sup>3</sup>. Like most high performance prosumer gear, it's a bear to work with in postproduction. Apple and Avid have taken the approach that all AVCHD be converted to ProRes 422 or DNxHD (respectively) on ingest.

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<sup>3</sup> The MPEG-4 Advanced Video Codec is used by AVC-Intra in an all-I frame version. The same codec, in a more traditional Long GOP implementation, drives AVCHD and AVCCAM.

Panasonic muddled the waters around AVCHD in 2008 by introducing the **AVCCAM** format. This is essentially AVCHD at standard, and higher, data rates, with a more professionally-oriented camcorder (although still in the “prosumer” form factor).

I had acknowledged that AVCHD/AVCCAM at the same data rate as HDV would, in theory, look better because the AVC H.264 codec is 2-4 times more efficient than MPEG-2 on the same source. At NAB 2009 I am now convinced that the practical implementation matches the theory and I feel that the HMC150 would be a very good choice for a prosumer form-factor budget HD camcorder over similarly featured HDV camcorders. Assuming the postproduction workflow is acceptable!



This image from Panasonic shows how AVCHD (AVCCAM) deals with stressful encoding situations better than HDV.

# Panasonic D5

**Manufacturer:** Panasonic

**Media:** Tape based using the D5 shell (also used for SD)

**Formats:** 720p60, 720p59.94, 720p50, 1080i60, 1080i59.94, 1080p30, 1080p29.97, 1080i50 and 1080p25, with 1080p24, 1080p23.98 support on higher-level decks.

**Color Sampling:** 4:2:2

**Audio:** Eight 48 kHz, 24 bit channels of uncompressed audio, useful for masters with multi-language potential.

**Record Time:** Up to 124 minutes per tape

**Compression:** D5-HD uses a mild intra-frame (each frame is self contained) compression with the data rate varying for each supported format:

- 323 Mbits/s (1080/59.94i/8CH, 720/59.94P/8CH, 480/59.94i/8CH)
- 319 Mbits/s (576/50i/8CH)
- 300 Mbits/s (1080/59.94i/4CH, 720/59.94P/4CH, 480/59.94i/4CH)
- 258 Mbits/s (1080/23.98P/8CH, 1080/24P/8CH)
- 269 Mbits/s (1080/50i/8CH, 1080/25P/8CH, 576/50i/8CH)

Panasonic's D5-HD has no field recorder nor are there any camcorders supporting this format directly. It is a mastering format only.

As a mastering format it competes with XDCAM, XDCAM SR and Panasonic's own DVCPRO HD. As a mastering format it is widely used among the top end of the video production marketplace.



# Sony HDCAM



<b>Manufacturer:</b>	Sony
<b>Media:</b>	Tape based using the HDCAM shell
<b>Formats:</b>	1080i60, 1080i59.94, 1080i50 and 1080p25, 1080p24, 1080p23.98 (24/23.98 limited to more recent models)
<b>Color Sampling:</b>	3:1:1 (8 bit)
<b>Audio:</b>	Four 48 kHz 24 bit channels of uncompressed audio.
<b>Record Time:</b>	Up to 48 minutes at 1080i50 and 40 minutes at 1080i60 (59.94)
<b>Compression:</b>	Records 3:1:1 at 1440 × 1080 (33% reduction) at approximately 7:1 compression to 144 Mbits/sec (by comparison Apple's ProRes 422 and Avid's DNxHD codecs are 145 Mbits/sec at their lowest setting). The output is upsampled to 1920 × 1080 on playback.

Sony's HDCAM format is widely used for field and studio acquisition of network and cable production and for some film production. It is part of Sony's high end, CineAlta line. Although input and output are at 10-bit, the format internally is 8-bit. The mild compression is not a limitation with this format.

**Note:** HDCAM tapes are black with an orange lid: HDCAM SR tapes are black with a cyan lid. HDCAM and HDCAM SR are expensive: a Sony F23 with SRW-1 recorder is approximately \$200,000 for the package.





# Sony HDCAM SR

<b>Manufacturer:</b>	Sony
<b>Media:</b>	Tape based using the HDCAM shell
<b>Formats:</b>	1080i60, 1080i59.94, 1080i50, 1080p25, 1080p24, 1080p23.98, 720p59.94 (24/23.98 limited to more recent models, not all decks support all formats)
<b>Color Sampling:</b>	4:2:2 or 4:4:4 (10-bit)
<b>Audio:</b>	Twelve 48 kHz 24 bit channels of uncompressed audio.
<b>Record Time:</b>	Up to 48 minutes at 1080i50 and 40 minutes at 1080i60 (59.94) for the S shell: 124 minutes in 1080i50 for the L shell. At 1080p24 fps (including 23.976) the runtime is 50 and 155 minutes respectively.
<b>Compression:</b>	Records 4:2:2 or 4:4:4 at full raster 1920 × 1080 at 440 Mbits/sec in MPEG-4 Studio Profile compression. Some HDCAM SR VTRs can also use a 2× mode with an even higher video bitrate of 880 Mbits/s, allowing for a single 4:4:4 stream at a lower compression or two 4:2:2 video streams simultaneously. 440 Mbits/s mode is known as SQ, and 880 Mbits/s mode is known as HQ,

HDCAM SR is the most common mastering format for HD Television, Cable and “Film” production because the 12 channels of audio provide for great flexibility for future and International versions. The dual 440 4:2:2 mode is being used for stereoscopic (3D) production to record both “eyes” on the one tape. Some HDCAM SR decks can record and/or play HDCAM; some play (and upconvert) Digital Betacam.

HDCAM tapes are black with an orange lid: HDCAM SR tapes are black with a cyan lid.

HDCAM and HDCAM SR are expensive: a Sony F23 with SRW-1 recorder is approximately \$200,000 for the package. The older F900 and F950 cameras, which also records using the SRW-1, are somewhat less expensive than the F23.

Adam Wilt has [written a comparison](#) of the RED One, F23 and XDCAM EX-1 that is worth a read.





## Sony XDCAM HD / XDCAM EX

<b>Manufacturer:</b>	Sony
<b>Media:</b>	Blu-ray disc in protective case (XDCAM HD) or SxS solid state media (XDCAM EX)
<b>Formats:</b>	1080i60, 1080i59.94, 1080i50, 1080p30, 1080p25, 1080p24 and 1080p23.98 (24/23.98 limited to more recent models, not all decks support all formats). XDCAM EX also supports 720p60.
<b>Color Sampling:</b>	4:2:0 (except for the latest generation, PDW-700, which sells for US \$35-38,000, which supports 4:2:2 at 50 Mb/s/sec, known as XDCAM HD422).
<b>Audio:</b>	Four 48 kHz, 16-bit channels of uncompressed audio.
<b>Record Time:</b>	A 23.3 GB Blu-ray disc can store between 45 and 90 minutes depending on which bitrate is selected. A single 8GB SxS card holds 38 minutes of 25 Mb/s/sec material, or 28 minutes of HQ (35 Mb/s/sec) recording.
<b>Compression:</b>	The format uses four MPEG-2 Long GOP compression levels: 19 Mb/s/sec (rarely used); 25 Mb/s/sec Constant Bitrate (HDV compatible); the HQ mode compresses to 35 Mb/s/sec while the HD422 version works at 4:2:2 at 50 Mb/s/sec. (Not all data rates are available on every camera or deck.)



XDCAM HD and XDCAM EX are positioned between Sony's CineAlta line and the "Prosumer" HDV models they offer. Both feature tapeless workflow, with a built-in backup for the solid-state media version: files can be copied back to a Blu-ray XDCAM HD optical disc for archiving. The discs can be used for archives or recycled, like tape. This is an advantage over P2 solid-state media, which has no specific backup path. Like P2, SxS media can be archived on hard drive – [RAID 5](#) recommended.

XDCAM HD and the newer EX format are gaining popularity for field production, particularly for reality television in HD, corporate and documentary work. The XDCAM EX-1 has an MSRP of US\$6,995 while other XDCAM HD cameras are in the \$30,000 upward range.



# DVCPRO HD



<b>Manufacturer:</b>	Panasonic
<b>Media:</b>	Tape and P2 solid-state media.
<b>Formats:</b>	1080i60, 1080i59.94, 1080i50, 1080p30, 1080p25, 1080p24 and 1080p23.98 and 720p60. Not every DVCPRO HD camera supports all modes.
<b>Color Sampling:</b>	4:2:2
<b>Audio:</b>	Four 48 kHz 16-bit channels of uncompressed audio
<b>Record Time:</b>	<p><b>On Tape:</b> DVCPRO tapes are the same for DVCPRO 25, 50 or 100 but the durations run half (DVCPRO 50) and ¼ (DVCPRO HD/100) the nominal “standard” speed. A “60-minute” DVCPRO tape will run 16.5 minutes with DVCPRO HD at 100 Mbits/sec. There are two shell sizes – M and L. The longest record duration for the M size is 16.5 minutes, for the L size 63 minutes.</p> <p><b>On P2 Media</b> the record time depends on the format being recorded and the size of the P2 card: a 16 GB card will provide between 40 minutes of 720p24 (23.98) recording and 16 minutes of 720p60 or 1080i60. Cards are now available in 32 GB and 64 GB with twice and four-times the record times respectively. At NAB 2009 Panasonic announced the E series P2 media cards that are faster at ‘up to’ 1.2 Gbit/sec but more importantly, it is a more economic series, with 64 GB coming in under \$1000 (\$998); 32 GB \$625 and 16 GB just \$420. Unlike the original P2 media, the E series has a limited life of five years. The 16 and 32 GB cards will be available in May with the 64 GB coming in August. This significantly changes the cost dynamics of P2 media making it much more affordable to a wider range of people.</p>
<b>Compression:</b>	<p><b>DVCPRO HD</b> uses all intra-frame compression to reduce the data rate to 100 Mbits/sec for 1080i60 and 720p60. 24P recorded to the P2 media card works at a lower data rate because it does not include redundant frames (approximately 80 Mbits/sec). Because it is an all I-frame codec every frame has to be completely compressed within each frame.</p> <p>DVCPRO HD pre-filters the 720P image to a recorded size of 960 × 720, and 1080i is pre-filtered to 1280 × 1080 for 59.94i and 1440 × 1080 for 50i. The final compression ratio is about 7:1.</p>



With AVC-Intra, the 50 Mbits/sec data rate is sub-sampled to  $1440 \times 1280$  for “1080” while the 100 Mbits/sec version is full raster  $1920 \times 1080$ .

DVCPRO HD has become a very popular acquisition format, particularly with the release of the sub US \$10,000 HVX-200 in late 2006. A lot of Television is shot on DVCPRO HD and mastered on DVCPRO HD. The HVX-200 has been a favorite of Indie film producers for budget film production, now replaced by the HPX-170 (without the DV format tape transport).

Newer “DVCPRO HD camcorders” have the option of using Panasonic’s more modern AVC-Intra codec. This is an all I-Frame version of the MPEG-4 Advanced Video Codec (a.k.a. H.264). Panasonic provide two bit rates for AVC-Intra: a 50 Mbit version that provides image quality comparable to DVCPRO HD at 100 Mbit or a 100 Mbit version that provides higher quality through lower compression. The HPX-300 supports AVC-Intra and is close enough to the \$10,000 limit to be included this year.

The Panasonic DVCPRO HD family support non-standard frame rates for under- or over-cranking for speed effects. The Varicam model can work between 4 and 60 frames/second. DVCPRO HD is codified as SMPTE 370M; the DVCPRO HD tape format is SMPTE 371M, and the MXF Op-Atom format used for DVCPRO HD on P2 cards is SMPTE 390M.

**Important:** Always use the 24PN mode (or any of the “N –native” modes) when shooting frame rates other than 29.97/59.94 or 25/50 fps. There is NEVER any need for any pulldown when recording 24 fps material to P2 media. Never.



HPX 500

DVCPRO HD P2-based workflows require some forethought as to how to handle data wrangling during production and how to provide for long-term storage and security for this data-centric workflow. DVCPRO HD from solid-state media can be played back to DVCPRO HD on tape in real time.

Panasonic makes several DVCPRO HD cameras from the sub US\$5,000 HVX-200A up to the \$66,000+ [AJ-HDC27H Varicam](#). In between the HPX-500 at about \$14,000 plus lens features  $\frac{2}{3}$ " sensors for higher sensitivity under low light and greater dynamic range. At under US\$10,000 the HPX-300 is the logical step up from the HVX-200A.



## HDV 1 and 2

Most people aren't even aware that there are two versions of HDV. HDV 1 is for 720P and is only supported by JVC. HDV 2 supports 1080i. Neither version directly supports 24P (23.976) so we have three completely different ways to work with 24P in HDV! See the [section on 24P](#) later in this book. HDV Transfers over FireWire like DV.

**NOTE:** All HDV camcorders also do DV/DVCAM/DVCPRO (collectively called DV25 as they all use the same codec) as well as HDV in either NTSC or PAL (depending on model). I have not specifically noted this capability in the camera reviews, but it's there. Many Sony and Canon models can also output DV from an HDV recording.

An HDV camcorder makes an excellent SD/DV camcorder because of the oversampling from an HD imager. See section on [oversampling](#).

### HDV 1

<b>Manufacturer:</b>	JVC
<b>Media:</b>	Tape — miniDV size. MiniDV tape will work although there are formulations with improved drop-out resistance.
<b>Formats:</b>	720p30, 720p29.97, 720p60, 720p59.94 and (on limited cameras) 720p23.98.
<b>Color Sampling:</b>	4:2:0
<b>Audio:</b>	Four 48 kHz channels of 384 Kbps MPEG-1 Layer II compressed audio.
<b>Record time:</b>	63 minutes on a 63 minute miniDV tape.

**Compression:** MPEG-2 Long GOP at 19 Mbits/sec.

JVC is the only manufacturer supporting only 720P HDV, however they have many models with interchangeable lenses and a “shoulder” form factor that is preferred by professional shooters.

The HDV format is a low cost HD format that sells to both consumers and professionals across a wide range of camcorders. It can be considered the “DV” of the HD world, as it records to the same tape format, at the same data rate



(or slightly lower in the case of HDV 1). It also works with the same hard drives and general equipment as many people used for standard definition DV. While it is quite heavily compressed there have been projects shot on HDV go to film output and distribution. HDV is very popular in the sub-\$10,000 camcorder market. All HDV format camcorders are under \$10,000.

## HDV 2

**Manufacturers:** Sony and Canon

**Media:** Tape — miniDV size. MiniDV tape will work although there are formulations with improved drop-out resistance.

**Formats:** 1080i59.94, 1080i50 and (on limited cameras) 1080p23.98.

**Color Sampling:** 4:2:0

**Audio:** Four 48 kHz channels of 384 Kbps MPEG-1 Layer II compressed audio.

**Record time:** 63 minutes on a 63 minute miniDV tape.

**Compression:** MPEG-2 Long GOP at 25 Mb/s/sec. HDV 2 is sub-sampled at  $1440 \times 1080$  non-square pixels (like most other affordable camcorders), and displayed at  $1920 \times 1080$ .

Sony and Canon manufacture a range of 1080i HDV camcorders, in both shoulder mount and “Prosumer style” form factors. There is limited support for “24” as it was never part of the specification. Therefore different manufacturers have implemented 24P in their products. Some, like the earlier Z1U synthesized a signal from the interlaced 60i, but the results were not considered acceptable. Recent cameras do work in 24P, although Canon has a 24F variant that changes acquisition but not recording to tape. (24F=24P other than minor technical variations). Check 24P support carefully for the compatibility between any specific camera and your proposed workflow. See later section on [24P](#).

As noted for HDV 1, the HDV format is the logical successor to DV in the type of cameras available and record times. However, it is likely that AVCHD/AVCCAM will succeed HDV because of the higher image quality for any given bandwidth. Both AVCHD/AVCCAM and HDV work with the same hard drives and general equipment as many people used for standard definition DV. While it is quite heavily compressed there have been projects shot on HDV go to film output and distribution. HDV is very popular in the sub-\$10,000 camcorder market. All HDV format camcorders are under \$10,000.





## HDV Limitations

HDV quality is largely dependent on the quality of the camera (lens and imagers), the signal processing and the quality of the MPEG-2 encoder. See the section on [Improving Encoders](#) earlier in this book. It is capable of creating and recording great HD images.

However, the Long GOP encoding format at 19 or 25 Mbits/sec can run out of bandwidth on fast moving or random movement (such as leaves or reflections from water). Encoding artifacts for HDV look different than DV and are generally not very obvious while the footage is in motion.

The reduced color sampling also means that HDV is not a “first preference” choice for chroma keying or blue/green screen work. The color resolution means there is not a lot of data for the keyer to work with<sup>4</sup>. For the same reason HDV does not have a lot of latitude for color correction.

Conventional wisdom is that you should convert to something other than HDV for editing. I’ve experienced no problems editing HDV on recent model computers but there are good reasons to convert to ProRes 422 or DNxHD during capture (or as a [Batch Export](#)).

If your project involved significant amounts of compositing or color correction, then conversion to ProRes 422 is desirable before final render (if not for the entire project). If you wish to use Apple’s Color software, you will have to convert to ProRes 422 before exporting.

For Media Composer, convert to DNxHD during capture, even though Media Composer can work with HDV natively. The Avid will thank you for that. You will thank me for that tip!



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<sup>4</sup> However, HDV makes a very affordable, high quality acquisition format for Standard Definition Keying, much better than DV in that application.

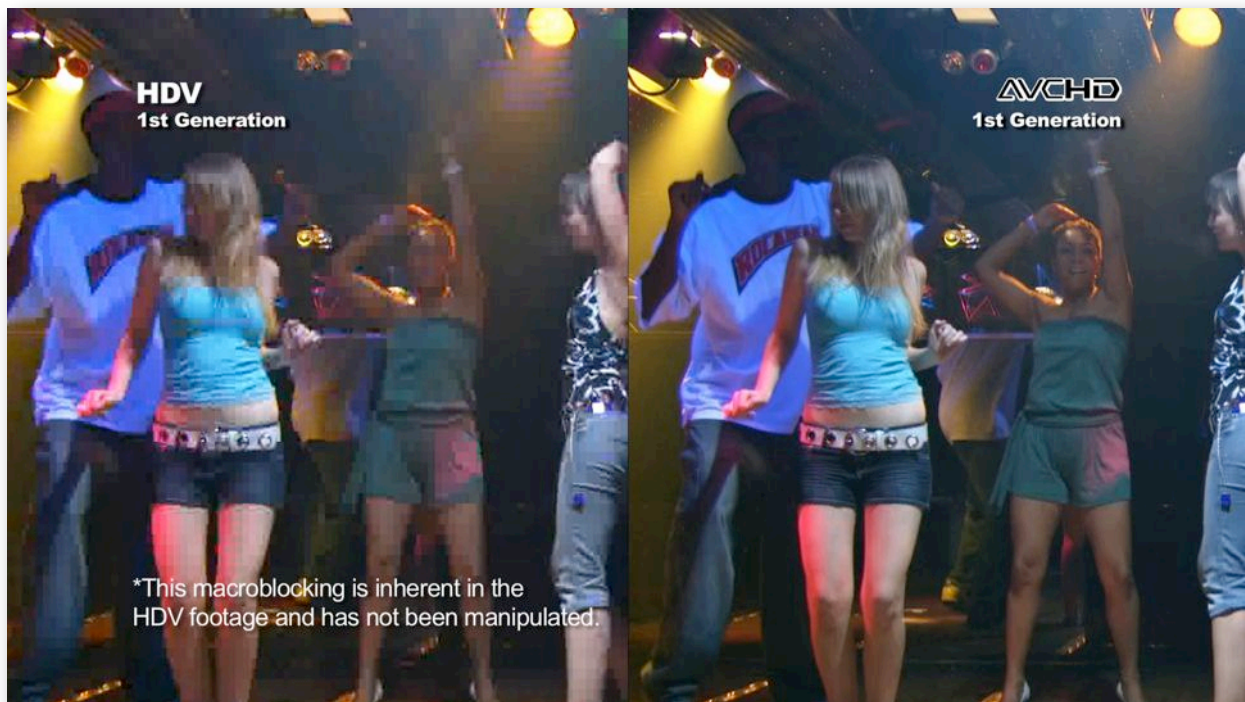
## AVCHD a.k.a. AVCCAM (Panasonic)

Standing for Advanced Video Codec High Definition, AVCHD is based on the same H.264 codec used in MPEG-4 distribution and on Blu-ray disk. This is a Long GOP file recording that is significantly better quality at HDV bandwidth, than HDV itself. This is because the H.264 AVC codec is much more efficient than the MPEG-2 codec used by HDV (and XDCAM in both flavors).

Unlike HDV, only a few NLEs work natively with this format. Premiere Pro claims native support (but not all modes work equally well). Edius and Vegas support AVCCAM/AVCHD natively. For Media Composer Avid users must convert to DNxHD and Apple's Final Cut Pro users will need Final Cut Pro 6.0.3 when support for AVCHD/AVCCAM was added to Log and Transfer.

While the quality is higher than HDV, the lack of native workflow, and therefore larger file sizes, may preclude its use as a primary camera.

While AVCHD/AVCCAM is compressed further than HDV, the improved efficiency of the AVC codec over MPEG-2 results in higher quality recordings with fewer artifacts than HDV.



This image from Panasonic shows how AVCHD (AVCCAM) deals with stressful encoding situations



Panasonic never signed on to the HDV consortium and it appears they are positioning their more professional AVCHD models as AVCCAM in direct competition with HDV2 Camcorders, starting with the AG- HMC150 and HMC 40.

**Manufacturers:** Sony, Canon and Panasonic

**Media:** MiniDV size tape, hard drive, DVD ,compact Flash or SDHC memory card, with the HDSC cards rapidly taking over.

**Formats:** 1080i59.94, 1080i50 and 1080p24 (on limited cameras).

**Color Sampling:** 4:2:0

**Audio:** Two channels of uncompressed 7.1 linear PCM or compressed AC-3 5.1

**Record time:** Varies as to whether you're recording to tape, hard drive, DVD or flash memory card.

**Compression:** AVC codec, which is a Long GOP H.264 codec, at approximately 24 Mbits/sec for "normal" quality to compact flash, hard drive or tape or about 18 Mbits/sec recording to DVD or Blu-ray. These equate to about 3 MB/sec for recording (2.25 MB/sec for DVD). A mini DVD (80mm/3.6" approx) holds about 20 minutes according to Sony. MiniDV tapes hold about 60 minutes, as they do for DV and HDV.

AVCHD camcorders using hard disks or flash memory such as SD or Memory Stick overcome this constraint and typically offer USB connections to access their content.

The compressed audio, subtitle streams and video data are encapsulated in an MPEG-2 Transport stream called BDAV. This stream format and most of the structure of AVCHD are derived from the Blu-ray Disc BDMV format. Combine this with the ability to do still slide shows from the HD footage from cameras, support for menus and subtitles, and it is probably a better choice for home use than HDV. The fact that most AVCHD recordings can be played – without modification other than appropriate media – in most set-top Blu-ray Disc players, such as the Sony BDP-S1, Panasonic DMP-BD10, and the PlayStation 3 is another bonus in the consumer space.





It is a reasonable quality HD format that has many inexpensive (sub \$1000) models that could be used as a “Crash Cam” (a camera that is exposed in a high-risk situation and is likely to be destroyed). That said, Panasonic do have models of AVCHD camcorders they consider “professional” – in the same sense that other companies consider HDV “professional”. The greater efficiency of the H.264 AVC codec over MPEG-2 would theoretically provide higher image quality than HDV and we’re seeing this on the HMD-150.

AVCHD was not designed for professional production, but neither were DV or HDV! Panasonic upped the bar with the HMC-150 and upcoming HMC-40.

It is not generally recommended as a professional format in the same way that HDV was never recommended as a professional format. The results from the AG-HMC150 are superior to HDV2 but the workflow is problematic: both Media Composer and Final Cut Pro require conversion to their respective intermediate codecs for editing. Despite the workflow challenges there is no doubt it will be used in some professional production. Keep in mind that DV was not intended as a professional format either!

AVCHD or AVCCAM can be imported to Final Cut Pro 6.0.3 or later via the Log and Transfer window, which will convert the AVC-based material to ProRes 422. Import and consolidate with AMA for Media Composer.=

**Note:** AVC-Intra is also based on the same AVC/H.264 codec but with an all-I-frame structure where every frame is complete, reducing the load on the host processor during playback and editing.

## Dealing with Customers’ format choices

It’s both useful and important to make informed format choices, particularly when equipping a facility where the workflow is determined in advance and is controlled. We often have to deal with clients who have chosen a format based on “an expert told me”, advertising or price. These clients can be a challenge because we might not have a suitable source deck and be in an area of the country where rentals are not readily available

(pretty much anywhere outside of major production markets). The chance of having the right equipment for every client is slim.

With no standardization of HD formats on the horizon, or even likely, there is no choice other than to ask the customer to bring their camera to use as a source deck. This has the unpleasant side effect of making the production company seem less “professional”.

Managing this perception is a marketing issue for most companies. If you feel that



the customer may be less impressed with a lack of support for their format you could use a statement like:

“There are many HD video formats and we cover the most important professional formats here at Phil’s video shop. We’re happy and able to work with any format provided to us, but we’d have to raise prices to have a working deck of every format in the studio. Therefore from time to time we ask clients to simplify the process, and save the cost of renting equipment, by bringing in the camera the material was shot with so we can import it to our system to work with it on your behalf.”

Put more bluntly “If it were a professional format we’d be OK, but since it’s not, you’ll have to bring in your camera!”

Fortunately the proliferation of formats guarantees that no-one will have support available for every format, so you won’t be at a disadvantage from a business perspective when you have to ask clients to bring in their own equipment for ingest (and possible output).

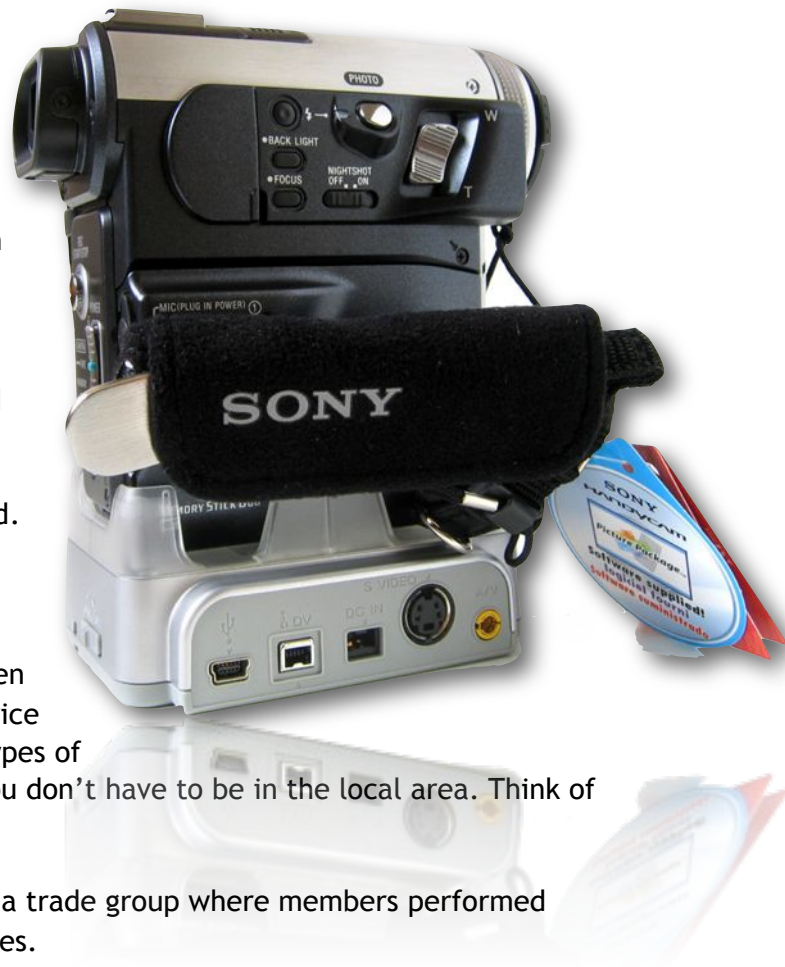
Final Cut Studio, and Media Composer, have good non-native workflows where everything is converted to a common format for post-production, when mixed formats are encountered. It’s only the first step – ingesting the material – that there is a problem with.

If the client does not actually have the camera, then renting a deck is the only alternative, or use a service like the [Digital Service Station](#) to convert. Those types of businesses will turn captures around remotely – you don’t have to be in the local area. Think of them as the Kinko’s of video input and output.

An alternative to renting would be participation in a trade group where members performed conversion services for each other at wholesale rates.

There will also be times when the client does not know the specifics of their format, knowing only that it’s “HD”! There will always be a customer education component to a video business, but you should be able to determine the format from the size of the tape and any color-coding. The exception would be HDV where there is no way, other than playing the tape, to know if it was shot with HDV 1 or HDV 2; at 29.97, 23.976 or 25 fps, interlaced or progressive.

If it is an HDV tape, you should try playing it in whatever deck(s) you have as some will play the alternate HDV format even though they can’t record it.





# Affordable HD Cameras

*This section will compare those sub-\$10,000 camcorders (camera and recording device in one case) based on the features of the camera. You should know I'm not a shooter. (I don't even play one on the Internet!) I tried but I realized I liked to edit great pictures, and they came from someone other than me. So I won't be comparing these from an ergonomic or operators perspective. I'll be covering their technical capabilities, what are their special features and what they might be best suited for in production terms.*

The good news is that there are no “bad” cameras in this collection. Every one makes great looking pictures in HD.

The sub-US\$10,000 camcorders we're going to be specifically considering are all HDV, XDCAM EX or DVCPRO HD. We will not be considering HDCAM SR, HDCAM or XDCAM HD because there are no sub-\$10K camcorders for those formats. We are also not considering any AVCHD camcorders because they generally lack professional features, but the Panasonic HMC-150 AVCCAM camcorder is included.

I skipped the RED One camera because it is neither below \$10K nor is it a “video production camcorder”. RED One is a digital cinema camera and has very different workflows and controls than the camcorders we're dealing with here. RED Digital Cinema's Scarlet will be included when sufficient details are available, but it's increasingly looking like that will be in the 2010 edition!

Specifically, we'll be considering:

## P2 Cameras

- [Panasonic's AG-HVX200](#),
- [Panasonic's AG-HPX 170](#), and
- [Panasonic's AG-HPX-300](#).

## XDCAM

- [Sony's XDCAM EX1](#), [EX-3](#)
- [JVC's GY-HM100](#) and
- [JVC's GY-HM700](#).

## HDV 1 and 2

- [Sony's HVR -S270U](#) and [HVR-Z7U](#) (different bodies but similar internally);;
- [Sony's HVR-V1U](#); and
- [JVC's GY-HD200 and 250](#).
- [Canon HV20/3p0/40](#)

## AVCCAM

- [Panasonic's HMC-150](#); and
- [Panasonic's HMC-40](#) (scheduled for release in August 2009)

There are several XDCAM HD and P2 camcorders above this price range that are excellent value.

For this edition I have dropped the reviews of:

- Canon's XL-H1, A1, and G1;
- Sony's diminutive HVR-A1U ; and
- JVC's KY-110U.

These camcorders are not current state-of-the art and there are better performing camcorders that have been more recently updated. Panasonic's HVX-200 is only included because it got a revision in 2008.

The excluded camcorders are fine devices and if they can be found second hand at a reasonable price they should still be considered, but I cannot recommend them for purchase as new cameras: they're simply too old in design.

Adam Wilt has been doing a series of comparisons between the sub \$10,000 cameras and their more expensive counterparts. [He compared](#) the Canon XL H1, JVC KY100 (since replaced by the KY 110), Panasonic AG-HVX200 and the Sony HVR-Z1U (a much older camera).

More recently, as noted earlier, [he compared](#) the RED One and Sony F23 Digital Cinema cameras with the XDCAM EX1. Where I can find comprehensive reviews of each of the cameras the links will be included.

# Panasonic AG-HVX200/HVX200A

<b>Status:</b>	Released late 2005; chipset updated to HVX200A with new sensors at NAB 2008 – released in May 2008.
<b>Format:</b>	DVCPRO HD (also DVCPRO 25 and DVCPRO 50) native; hard drive recording available from third parties like Focus Enhancement's FireStore FS100.
<b>Form Factor:</b>	Handheld
<b>Media:</b>	MiniDV tape (DVCPRO 25 only) and P2 Media (DVCPRO 50 and HD) with 2 card slots.

## Supported Sizes and Frame Rates:

**1080:** 59.94i, 50i, 29.97P, 25P, 23.98P (16:9 aspect ratio)

**720:** 59.94P, 50P, 48P, 36P, 32P, 30P, 26P, 25P, 24P, 22P, 20P, 18P, 12P (16:9 aspect ratio)<sup>5</sup>. There are more frame rates available for 720P because it's easier to move the data off the chip at manageable data rates for 720P.

23.98 frame rates can be recorded to the P2 card in native format or output with advanced pulldown.

**480:** 60i, 50i, 30P, 24P, in either DVCPRO 25 (i.e. regular DV) or DVCPRO 50. (4:3 aspect ratio).

There are more than 80 combinations of frame size, frame rate, and whether or not the signal is progressive or interlaced.



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<sup>5</sup> The odd frame rates are used for speed effects when played back at normal speed (23.976, 25 or 29.97 fps). Frame rates higher than playback speeds create slow motion; frame rates lower than playback speed create fast motion.

<b>Camera Imagers:</b>	<p><b>HVX200:</b> Three <math>\frac{1}{3}</math>" CCDs with 960 × 540 resolution each, using pixel offset on green to derive HD resolutions.</p> <p><b>HVX200A:</b> Three <math>\frac{1}{3}</math>" CCDs with improved progressive 3-CCD imagers, a DSP that increases sensitivity while lowering noise and smear.</p>
<b>Lens:</b>	<p><b>HVX200:</b> Fixed Leica Dicomar lens: 13× zoom from 4.2 to 55mm (equivalent to 32.5 – 423mm on a regular 35mm camera). Auto/manual focus, with focus assist (even during recording) down to very close focus. Camera-driven manual zoom.</p> <p><b>HVX200A:</b> An “improved” 23× zoom lens with the same nominal 4.2 to 55mm nominal range, but subjectively the view is slightly wider, suggesting the new chipset is slightly larger than the original sensors.</p>
<b>Minimum Illumination:</b>	3 lux. The HVX200A has reduced noise in low light/dark areas.
<b>Audio:</b>	Four-channel s of 48 kHz 16-bit PCM audio uncompressed recorded for DVCPRO HD. Two channels come from the top-mounted stereo microphone and two channels from the auxiliary XLR inputs at microphone levels at -50dB to -60dB, which should suit most professional microphones, although a pad may be required to adapt some professional microphones for use on the HVX200. There is no way to feed four channels of audio from a mixer.
<b>Viewfinder:</b>	Flip out 3.5" LCD screen with 210,000 pixels and 0.44 inch (about 1 cm) B&W/Color Switchable viewfinder.
<b>MSRP/Street Price:</b>	US\$5995 with one 16GB P2 card/ \$3500 – \$5,500 with one 16GB P2 card street price. Prices lower than \$3500 are unlikely to be genuine.
<b>Power Consumption:</b>	14 Watts (max.)
<b>Dimensions:</b>	6.7 × 7.1 × 15.2 Inches
<b>Weight:</b>	5.3 lbs

### Special features:

- 14-bit DSP for A/D conversion and 19-bit internal processing
- CineSwitch™ technology for variable frame rates in 720P mode: 12, 18, 20, 22, 24, 26, 30, 32, 36, 48, 60fps (Additional frame rates can be unlocked with a “hack”).
- 24PN records true 23.976 fps to the P2 card, no pulldown or repeated frames required.
- 2× Focus Assist that magnifies the center of the image in the viewfinder and swing-out LCD display to make focusing the HD image much easier.
- Thumbnail display for easy searching and file information.

- Standard definition down-converts from HD recordings.
- Analog component (Y, Pb, Pr) output.
- Transfer data over FireWire 400 from cards in the camera.
- Advanced gamma functions and eight gamma settings including two CineGamma™ modes and NewsGamma™ mode
- Advanced image adjustments: color matrix, detail, chroma phase, color temp, knee points
- Customizable scene files with control over gamma and image adjustments.

## ***Assessment:***

The HVX-200 was a revolutionary camera when it was launched. But the value of the format's lower compression and colorspace are offset by the under sampled imagers, which are only HD by using pixel offset and image processing. The chipset in the 200A has some resolution improvements and produces an improved picture, particularly at the 1080 settings but not improved enough.

The camera has the widest-angle standard lens (4.2mm) and limited four-channel 16-bit PCM audio.

The price of the HVX200 should take into account the cost of P2 media and other workflow tools, like card readers or adapters. The P2 media also requires investment in backup strategies and data wrangling in production mode.

The P2 form factor requires an adapter as the older PC-Card (PCMCIA) slot is replaced with ExpressCard slots in newer laptops, those that have them. Panasonic reduced the price of P2 Media by introducing the E (economy) series at NAB 2009, available since May 2009.

The HVX200 was once a good choice for a field production camera. It would be a good buy if purchased second hand for less than \$2,000, otherwise it is not a recommended purchase in 2009.

### **Reviews of HVX200:**

- Andrew Burke, [Videomaker](#)
- Ben Wolf, [CNET](#)
- Barry Braverman, [Digital Content Producer](#)
- [DV Magazine](#)
- David Tamés, [Kino-Eye Blog](#)

### **Review of HVX200A:**

Barry Green, DVX User — compares the HVX200A to his HVX200, focusing on the updated sensor chipset.

Because this was an update to the HVX200, the HVX200A does not have any further reviews. Use the HVX200 reviews as a guide and top off with Barry Green's comparison.





# Panasonic AG-HPX-170

<b>Status:</b>	Announced at NAB 2008 and released in September 2008
<b>Format:</b>	DVCPRO HD (also DVCPRO 25 and DVCPRO 50) native; hard drive recording available from third parties like Focus Enhancement's FireStore FS100. No tape drive.
<b>Form Factor:</b>	Handheld/Prosumer
<b>Media:</b>	P2 Media (DVCPRO, DVCPRO 50 and DVCPRO HD) with 2 card slots.

## Supported Sizes and Frame Rates:

**1080:** 59.94i, 29.97P, 23.98P, 23.98PA (16:9 aspect ratio)

**720:** 59.94P, 48P, 36P, 32P, 30P, 26P, 23.98P, 23.98PN, 22P, 20P, 18P, 12P (16:9 aspect ratio)<sup>6</sup>. There are more frame rates available for 720P because it's easier to move the data off the chip at manageable data rates for 720P. The lack of support for 50i/50P or 24P suggests a different version for 50Hz (a.k.a. PAL) countries.

23.98 frame rates can be recorded to the P2 card in native format or output with advanced pulldown.

**480:** 60i, 50i, 30P, 24P, in either DVCPRO 25 (i.e. regular DV) or DVCPRO 50 (4:3 aspect ratio).

There are in fact more than 80 combinations of frame size, frame rate, and whether or not the signal is progressive or interlaced.



<sup>6</sup> The odd frame rates are used for speed effects when played back at normal speed (23.976, 25 or 29.97 fps). Frame rates higher than playback speeds create slow motion; frame rates lower than playback speed create fast motion.

<b>Camera Imagers:</b>	Three $\frac{1}{3}$ " 16:9 CCDs with improved progressive 3-CCD imagers, a DSP that increases sensitivity while lowering noise and smear.
<b>Lens:</b>	Fixed Leica Dicomar lens: 13× zoom from 3.9 to 51mm (equivalent to 28 – 364mm on a regular 35mm camera). Auto/manual focus, with focus assist (even during recording), and focus down to very close. Camera-driven manual zoom.
<b>Minimum Illumination:</b>	3 lux.
<b>Audio:</b>	Four-channels of 48 kHz 16-bit PCM audio uncompressed recorded for DVCPRO HD. Two channels come from the top-mounted stereo microphone and two channels from the auxiliary XLR inputs at microphone levels at -50dB to -60dB, which should suit most professional microphones. The camera supports 48v Phantom power.
<b>Viewfinder:</b>	Flip out 3.5" LCD screen and viewfinder. Details on the viewfinder and LCD screen have not yet been released as of June 2008.
<b>MSRP/Street Price:</b>	MSRP US\$6,995. Street price in July 2009 at B&H Photo is US\$5199 (with a \$500 mail in rebate, reducing net price to \$4699). Prices under \$4500 are unlikely to be genuine.
<b>Power Consumption:</b>	10.9 watt without LCD; 11.7 watt with LCD in use; 13.8 watt maximum.
<b>Dimensions:</b>	The HVX200 is 6.7 × 7.1 × 15.2 Inches and the HPX170 is slightly smaller.
<b>Weight:</b>	4.2 lbs (1.9 KG) body; 5 lbs (2.25 KG) with supplied battery and P2 card.

### Special features:

- Five Year warranty.
- HD-SDI output with embedded Timecode and Audio.
- Mini-D connector for component analog output (SD and HD).
- Delete last clip function.
- Built in Waveform Monitor and Vectorscope (in viewfinder).
- 14-bit DSP for A/D conversion and 19-bit internal processing
- CineSwitch™ technology for variable frame rates in 720P mode with 20 steps instead of the 11 of the HVX200. (Additional frame rates can probably be unlocked with the same "hack" that unlocks them for the HVX200).
- 24PN records true 23.976 fps to the P2 card, no pulldown or repeated frames required.
- 2× Focus Assist that magnifies the center of the image in the viewfinder and swing-out LCD display to make focusing the HD image much easier now with histogram and Focus

- Assist bar. All three focus assist options can be used together.
- Security cable hole to lock down the camera and prevent it being stolen.
- Thumbnail display for easy searching and file information.
- Standard definition down-converts from HD recordings.
- Transfer data over FireWire 400 or USB 2.0 from cards in the camera.
- Advanced gamma functions and eight gamma settings including two CineGamma™ modes and NewsGamma™ mode
- Advanced image adjustments: color matrix, detail, chroma phase, color temp, knee points
- Customizable scene files with control over gamma and image adjustments.



## Assessment:

DVCPRO HD is a sometimes less compressed than HDV, and gives a full 4:2:2 signal, so it records more color information, making it easier to use for effects work, such as chroma keying. However it must compress each frame within 100 Mbits, which can be more heavily compressed than some Long GOP formats.

The camera provides the widest-angle standard lens (3.19mm) and limited four-channel 16-bit PCM audio.

The P2 form factor will likely require adapters as the PC-Card (a.k.a. PCMCIA Card) slot is being phased out for the ExpressCard34 slot, although even that is not as widely available on laptops as it was.

Although one P2 card is usually included — two during special deal periods — the cost of additional cards and ancillary equipment needed to offload cards inflates the necessary investment. The P2 media also requires investment in backup strategies and data wrangling in production mode.

The HPX170 is a good choice for a field production camera where data wrangling can be handled nearby.

## Reviews:

Dan Brockett [reviewed](#) the HPX170 at kenstone.net in October 2008.

Barry Braverman reviews “[a compelling entry level P2 camera](#)”.

Adam Wilt has an [in depth review](#) at Pro Video Coalition.

Philip Bloom has a [video review](#) at exposureroom.com.

# Panasonic AG-HPX-300

**Status:** Announced in February 2009 and shipping from late March 2009.

**Format:** DVCPRO HD and AVC-Intra (10 bit 4:2:2) for HD, DVCPRO 50, DVCPRO and DV for SD. No tape drive.

**Form Factor:** Shoulder Mount

**Media:** P2 Media with 2 card slots.

**Supported Sizes and Frame Rates:**



## DVCPRO HD

**1080:** 59.94i, 29.97P, 23.98P, 23.98PA (16:9 aspect ratio)

**720:** 59.94P, 29.97P, 29.97PN, 23.98P, 23.98PN, (16:9 aspect ratio). In 720p mode, a user can choose between 20 variable frame steps between 12p and 60p.

23.98 frame rates can be recorded to the P2 card in native format or output with advanced pulldown.

## DVCPRO 50, DVCPRO and DV

**480:** 60i, 50i, 29.97P, 23.984P, 23.98PA in either DVCPRO 25 (i.e. regular DV) or DVCPRO 50 (4:3 aspect ratio).

## AVC-Intra — choice of 100 Mbit/sec or 50 Mbit/sec<sup>7</sup>

**1080:** 59.94i, 29.97P and 23.98P (native 24p/30p), and

**720P:** 23.98PN, 29.97PN and 59.94P.

Variable frame rates in 20 steps between 12p and 60p for fast- or slow-motion effects (undercranking/overcranking)

There is a 50Hz version of the HPX-300 designated the HPX-301. An HPX-300 for “60 Hz” can be upgraded for 50 Hz (PAL) compatibility for an additional \$800 as of July 2009. Another July 2009 firmware update reduces [the affect of flashes on CMOS cameras from a “rolling shutter”](#).

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<sup>7</sup> AVC-I at 50 Mbit/sec approximately equals the quality of DVCPRO HD at 100 Mbit/sec.

- Camera Imagers:** Three  $\frac{1}{3}$ " 16:9 3-MOS<sup>8</sup> with 2.2 Mpixel images and, a new 20-bit DSP that increases sensitivity while lowering noise and smear for full native resolution image capture.
- Lens:** Fujinon 1/3" Bayonet Mount (17x Optical)
- Minimum Illumination:** 0.8 lux.
- Audio:** Four-channels of 48 kHz 16-bit PCM audio uncompressed recorded for DVCPRO HD and AVC-I. Three XLR audio jacks (one in the front, two on the rear). The camera supports 48v Phantom power.
- Viewfinder:** Flip out 3.2" Widescreen Color LCD (921,000 Pixels) and LCOS Color Viewfinder (1.22 MegaPixels).
- MSRP/Street Price:** MSRP US\$10,700. Street price in July 2009 at B&H Photo is US\$8,495 (but may be under \$8K if you have them "email a better price"). Prices under \$7,500 are unlikely to be genuine. Lower prices may attempt to charge for the (included) lens.
- Power Consumption:** 18 watts.
- Dimensions:** W 6.7" x H 6.9" x D 21.6" (24.6 x 25.1 x 54.9cm)
- Weight:** 8 lbs (13 lbs/ 6KG with lens and battery)



<sup>8</sup> Panasonic use the term 3-MOS or 3MOS for their 3 CMOS cameras. The technology is the same as CMOS.



## Special features:

- Five Year warranty.
- The camera also supports 1080/23.98PsF output (via HD-SDI) for use in high-end movie production.
- The output of the camera can be set for down-conversion or cross-conversion with letterbox, 4:3 crop or anamorphic squeeze.
- A less expensive studio version is coming “later in 2009”.
- Shutter speeds from 1/6 to 1/2000 sec (Range depends on Record Mode).
- Advanced gamma functions that address eight different shooting scenarios. Included are the Cine-Like Gamma, which gives recordings the characteristic warm tone of film recordings, and a cooler, harder-edge News Gamma that's designed especially for news gathering.
- HD-SDI output with embedded Timecode and Audio.
- Genlock input,
- Four-position ND optical filter controls,
- Wireless microphone slot (two-channel UniSlot wireless receiver compatible)
- Programmable user buttons
- 24PN records true 23.976 fps to the P2 card, no pulldown or repeated frames required.



- Standard definition down-converts from HD recordings.
- Transfer data over FireWire 400 or USB 2.0 from cards in the camera.
- Advanced gamma functions and eight gamma settings including two CineGamma™ modes and NewsGamma™ mode
- Remote controllable with AJ-RC10G (via 10-pin RCU terminal)
- Advanced image adjustments: color matrix, detail, chroma phase, color temp, knee points
- Customizable scene files with control over gamma and image adjustments.

## Assessment:

Although the most expensive of our “under \$10K” cameras (and then only because street prices is lower than MSRP) this is the camera to beat. AVC-Intra, with 10 bit, 4:2:2 full raster recording, is the highest quality source available from a one-piece camcorder. (Comparable HDCAM SR and the Ki Pro from AJA, recording in ProRes 422.)

The P2 form factor will likely require adapters as the PC-Card (a.k.a. PCMCIA Card) slot is being phased out in favor of the ExpressCard34 slot, although even that is not as widely available on laptops as it was.

Although one P2 card is usually included — two during special deal periods — the cost of additional cards, even the new low-cost E-series, and ancillary equipment needed to offload cards inflates the necessary investment. The P2 media also requires investment in backup strategies and data wrangling in production mode. The advent of 64 GB P2 media simplifies the on-shoot data wrangling. With two or more slots, recording can be continuous, bridging from Card to Card.

The HPX300 is an excellent choice for a field production camera.

## Reviews:

Adam Wilt wonders if the HPX-300 “[will be the ‘it’ camera for 2009](#)”.

Kyle Doris [reviews the HPX-300](#) for B&H Photo.

DP Peter Nelson and Director Bryan Gunnar Cole [field test the HPX-300](#).

Barry Braverman [took it to the back alleys for a practical test](#).



# Sony XDCAM EX-1

**Status:** The EX-1 has been available since Fall 2007.

**Format:** XDCAM HD (Long GOP MPEG-2)

**Form Factor:** Prosumer Hand held/Handycam

**Media:** SxS solid state media (ExpressCard34 form factor)

## Supported Sizes and Frame Rates:

**1080:** 59.94i, 50i, 29.97P, 25P, 23.98P (16:9 aspect ratio)

**720:** 59.94P, 50P, 25P, 23.98P (16:9 aspect ratio)

The PMW-EX1 can capture images at frame rates selectable from 1 fps (frame per second) to 60 fps in 720P mode and from 1 fps to 30 fps in 1080P mode, in increments of 1 fps.

In 1920 × 1080/23.98P mode, and 1280 × 720/23.98P mode, images are handled and recorded as native 23.98P signals.

In 1440 × 1080/23.98P mode, images are handled as 23.98P and recorded as 59.94i signals through means of 2-3 pull-down.

**Camera Imagers:** Three ½-inch type “Exmor” CMOS Sensors with full 1920 × 1080 pixel count without any pixel shift — all sensors are 1920 × 1080.

**Lens:** Wide-angle Fujinon 14× Zoom Lens. 5.8 mm to 81.2 mm (equivalent to 32.5 – 423mm on a regular 35mm camera). The lens has two independent focus positions: slide the focus wheel forward and you’re in auto focus with Full AF, One-push AF, MF and AF/MF modes. Slide the focus wheel back and you have an “absolute position” focus wheel. Separate rings for Focus, Zoom and Iris on the lens. Optical Image Stabilizer.



- Minimum Illumination:** Sony say “0.14 lux (Typical) at 1920 × 1080/59.94i mode, f/1.9, +18 dB gain, with 64-Frame Accumulation” but that’s a cheat in a slow shutter mode that would smear badly. A more “real world” answer would be approximately 1 lux. It is definitely more sensitive under low light than the HVX200. See screen shots at [this site](#).
- Audio:** Two channels of 16bit 48 kHz uncompressed audio recorded to the SxS card. Use the built-in Stereo Microphone or Two XLR Audio Inputs switchable from microphone to line level.
- Viewfinder:** 0.54 inch LCD viewfinder with 250,000 pixels, switchable between color and monochrome. 3.5-inch\* Color LCD Screen folds from handgrip with a full 1920 × 1080 resolution; can be rotated to view from any angle.
- MSRP/Street Price:** US\$6995/\$6150 Prices below \$5500 are unlikely to be genuine.
- Power Consumption:** Approx. 13 W (while recording, with color LCD OFF, 1920 × 1080/59.94i mode)
- Dimensions:** 7⅞ × 7 × 12⅜ inches (178 × 176 × 311.5 mm)
- Weight:** Approx. 6 lb 2 oz (2.8 kg) (with lens hood, large eye cup, BP-U30 battery, one SxS PRO memory card)

### Special features:

- Full Raster CCDs and full 1080p23.98, 1080i49.94 recording at HQ (35 Mbits/sec) mode;
- Thumbnail search
- Clips can be paused, played at normal speed, and at 4× or 15× forward or reverse. You can jump to the previous and next clips.
- Selectable Gamma Curves
- Interval Recording Function
- Frame Recording Function
- Shutter Angle Settings
- Slow Shutter Function
- Shot Transition™ function to smoothly transition from two settings during shooting for applying a color balance shift.
- Frequently used functions can be programmed onto four assignable buttons
- HD/SDI or SDI output, HD or SD analog component output, S-video and iLink outputs.

## Assessment:

Sony position the EX1 in their *CineAlta* range previously reserved for high-end gear like HDCAM and HDCAM SR. The EX1 justifies the inclusion in that product group by its high quality and flexibility. XDCAM HD and EX is well supported in NLE systems. In Final Cut Pro you can work natively or transcode to ProRes for editing. Likewise in Avid you can transcode to DNxHD for editing.

CMOS sensors can be susceptible to image smearing under some (fairly extreme) conditions, if possible do a test on your typical content to determine if you even notice the issue, and if you do, if you can live with it.

The EX1 is the sharpest camera in its class: only two other camcorders have full raster 1920 × 1080 chips with no pixel offset: Panasonic's \$48,000 HPX 3000 and Sony's \$180,000 F23. Sony claim, and Adam Wilt's testing supports, 1000 TV lines of resolution, which is very high.

Although relatively new the XDCAM EX1 has been very well received, with the only negatives being related to the form factor and some lightweight connectors.

The camera is best summed up by this reviewer's comment:

"It has set a new standard for solid state, low-cost, fully-professional cameras. In size and appearance the EX1 looks like a Z1 or an HVH200, but it delivers far superior image quality. For car aficionados, it would be the equivalent of the engine of a 12-cylinder GT Ferrari in the body a Lexus."

## Reviews:

- Adam Wilt, [Pro Video Coalition](#)
- Film director/videographer Antonio Tibaldi, [B&H Photo](#)
- David Leitner, [Digital Content Producer](#)
- Ned Soltz, [DV Magazine](#)





# Sony XDCAM EX-3

**Status:** EX-3 has been shipping since June 2008.

**Format:** XDCAM HD (Long GOP MPEG-2)

**Form Factor:** Semi-shoulder configuration, reminiscent of Canon's XL "chainsaw" form factor.

**Media:** SxS solid state media (ExpressCard 34 form factor)

## Supported Sizes and Frame Rates:

**1080:** 59.94i, 50i, 29.97P, 25P, 23.98P (16:9 aspect ratio)

**720:** 59.94P, 50P, 25P, 23.98P (16:9 aspect ratio).

The PMW-EX3 can capture images at frame rates selectable from 1 fps (frame per second) to 60 fps in 720P mode and from 1 fps to 30 fps in 1080P mode, in increments of 1 fps. Frame rate is set by a physical dial on the side of the camera

In 1920 × 1080/23.98P mode, and 1280 × 720/23.98P mode, images are handled and recorded as native 23.98P signals.

In 1440 × 1080/23.98P mode, images are handled as 23.98P and recorded as 59.94i signals through means of 2-3 pull-down.

**Camera Imagers:** Three ½-inch type "Exmor" CMOS Sensors with full 1920 × 1080 pixel count without any pixel shift — all sensors are 1920 × 1080.

**Lens:** Interchangeable ½-inch type EX mount, wide-angle Fujinon 14× Zoom Lens included: 5.8 mm to 81.2 mm (equivalent to 31.4 – 440mm on a regular 35mm camera). The lens has two independent focus positions: slide the focus wheel forward and you're in auto focus with Full AF, One-push AF, MF and AF/MF modes. Slide the focus wheel back and you have an "absolute position" focus wheel. Separate rings for Focus, Zoom and Iris on the lens. Optical Image Stabilizer.



Also supplied lens adaptor to allow use of other ½-inch lenses. Additional lens adaptors will allow use of ⅔-inch, digital cinema and digital stills lenses.

**Minimum Illumination:** Sony say “0.14 lux (Typical) at 1920 × 1080/59.94i mode, f/1.9, +18 dB gain, with 64-Frame Accumulation” but that’s a cheat in a slow shutter mode that would smear badly. A more “real world” answer would be approximately 1 lux. It is definitely more sensitive under low light than the HVX200. See screen shots at [this site](#).

**Audio:** Two channels of 16bit 48 kHz uncompressed audio recorded to the SxS card. Use the built-in Stereo Microphone or Two XLR Audio Inputs switchable from microphone to line level.

**Viewfinder:** 0.54 inch LCD viewfinder with 250,000 pixels, switchable between color and monochrome. 3.5-inch\* Color LCD Screen folds from handgrip with a full 1920 × 1080 resolution; can be rotated to view from any angle.

**MSRP/Street Price:** US\$9,999/\$8,320. Prices below \$7,500 are unlikely to be genuine.

**Power Consumption:** Approx. 13 W (while recording, with color LCD OFF, 1920 × 1080/59.94i mode)

**Dimensions:** 9⅞ × 8¼ × 15¾ inches (250 × 210 × 400 mm) — with lens without projection

**Weight:** Approx. 7 lb 9 oz (3.6 kg) (with lens hood, large eye cup, BP-U30 battery, one SxS PRO memory card)

### Special features:

- Timecode In, Timecode Out
- Genlock
- The PMW-EX3 offers professional remote control of various camera features via standard Sony 8-pin control interface
- Full Raster CCDs and full 1080p23.98, 1080i49.94 recording at HQ (35 Mbits/sec) mode
- Thumbnail search
- Clips can be paused, played at normal speed, and at 4× or 15× forward or reverse. You can jump to the previous and next clips.
- Selectable Gamma Curves
- Interval Recording Function
- Frame Recording Function
- Shutter Angle Settings
- Slow Shutter Function

- Shot Transition™ function to smoothly transition from two settings during shooting for applying a color balance shift.
- Frequently used functions can be programmed onto four assignable buttons
- HD/SDI or SDI output, HD or SD analog component output, S-video and iLink outputs.

## Assessment:

The PMW-EX3 is ideal for multi-camera operation and entry level HD studio use, particularly where the cameras need to serve double duty in field production.

Sony position the EX3, along with the EX-1, in their *CineAlta* range previously reserved for high-end gear like HDCAM and HDCAM SR. The EX3 justifies the inclusion in that product group by its high quality and flexibility. XDCAM HD and EX is well supported in NLE Systems. In Final Cut Pro you can work natively or transcode to ProRes for editing. Likewise in Avid you can transcode to DNxHD for editing or work natively.

CMOS sensors can be susceptible to image smearing under some (fairly extreme) conditions, if possible do a test on your typical content to determine if you even notice the issue, and if you do, if you can live with it.

The EX3, since it shares the same opticals, sensors and processing is expected to be, like the EX-1, the sharpest camera in its class: only two other camcorders have full raster 1920 × 1080 chips with no pixel offset: Panasonic's \$48,000 HPX 3000 and Sony's \$180,000 F23. Sony claim, and Adam Wilt's testing supports, 1000 TV lines of resolution, which is very high.

## Reviews:

- Nigel Cooper [spends a day with an EX-3](#).
- Philip Bloom does [a video review](#).
- Adam Wilt, summarizes his review [“under the skin it's an EX-1. But goodness, what a different skin”](#).

As this is, as Adam Wilt says, substantially similar to the EX-1, reviews of the EX-1 are also likely to provide useful information on the EX-3.



## JVC's GY-HM100

This camcorder can record both 720p and 1080i/p directly to SDHC cards in QuickTime files ready for immediate use in Final Cut Pro.

**Note:** This makes the GY-HM100 less suitable for those editing with Premiere Pro, Media Composer or Edius. Vegas users would be able to use these files natively.



**Status:** The GY-HM100 has been shipping since April 2009.

**Format:** XDCAM HD (Long GOP MPEG-2) in a QuickTime wrapper ready for Final Cut Pro.

**Form Factor:** Ultra compact Prosumer (hand held) format.

**Media:** SDHC solid state media

### Supported Sizes and Frame Rates:

**1080:** (1440x 1080 25 Mbits/sec) 59.94i, 50i, 29.97P, 25P.(16:9 aspect ratio)

**1080:** (1920x 1080 35 Mbits/sec (HQ)) 59.94i, 50i, 29.97P, 25P, 23.98P (16:9)

**720:** (1280 x 720 19 Mbit/sec) 59.94P, 50P, 25P, 23.98P (16:9).

**720:** (1280 x 720 19 Mbit/sec) 59.94P, 50P, 25P, 23.98P (16:9).

**720:** (1280 x 720 35 Mbit/sec (HQ)) 59.94P, 50P, 25P, 23.98P (16:9).

No SD recording modes but the camcorder can output SD via composite or component output.

**Camera Imagers:** Three 1/4-inch CCDs – 16:9 progressive with spatial offset.

**Lens:** Fixed Fujinon 10x Lens, 3.7-37mm (39-390mm 35mm Equivalent) F/1.8 with Optical Image Stabilizer

**Minimum Illumination:** 3 lux

**Audio:** Uncompressed 16bit 48Khz LPCM 2 channel. Balanced XLR input, internal mic and 1/8" mini jack. Built-in 48v Phantom Power.

**Viewfinder:** 0.54 inch LCD viewfinder with 250,000 pixels, switchable between color and monochrome. 3.5-inch\* Color LCD Screen folds from handgrip with a full

1920 × 1080 resolution; can be rotated to view from any angle.

**MSRP/Street Price:** US\$3,995/\$3,495. Prices below \$3,000 are unlikely to be genuine.

**Power Consumption:** Approx. 7.2 W

**Dimensions:** 5-7/16" x 7" x 14-3/8" (138 × 178 × 365 mm) including boom microphone.

**Weight:** 3.1 lbs (1.4 kg) (with battery)

### Special features:

- Digital still camera that records jpegs. 1/4 to 1/8000 shutter speed. ISO100,200,400,1000, up to 1920x1080 resolution.
- Wireless remote control
- HDMI Output.
- SD Composite output
- HD/SD Component Output
- Digital Signal Processing similar to GY-HD200 with Detail, Knee Auto-80-85-90-95-100%, Gamma off-standard-cinema, Gamma level, Color Matrix, White balance A, B, preset and RAW.
- Shutter 1/4 ~1/10000
- Gain 0,3,6,9,12,15,18dB ALC
- Three User Buttons assignable as Focus Assist, Color Bars, TC Setting, Tele-Macro, Lolux, Zebra, Clip: Continuous, Off, None.
- Newly designed JVC's original Optical Image Stabilization
- JVC patented Focus Assist (in-focus edge has color)
- USB 2.0 interface





## Assessment:

If you are editing with Final Cut Pro, the HM100 is an excellent low budget choice as the files from the SDHC cards can be used immediately without conversion, rewrapping or transcoding. The files are XDCAM files in a QuickTime container so they may work with other NLEs with an import or transcode.

Like XDCAM, at 25 Mbits/sec this camera is recording HDV (in a QuickTime wrapper). The higher quality 35 Mbit/sec codec is VBR and much higher quality than the 25 Mbit/sec version shared with HDV.

The small size and form factor of this camcorder make it an excellent B-camera or “must have it with me always” camera. It would be a fine camera for a small documentary production. It is on the recommended list for 2009.

## Reviews:

- Luminance Landscape have a [review of the HM100 from July 2009](#).
- Jeremy Stamas has a [first-impressions review](#) at camcorderinfo.com.
- Rick Young has a [hands-on video review of the HM100](#).
- Philip Bloom [has a thorough review](#) on his blog.



## JVC GY-HM700

This camcorder can record both 720p and 1080i/p directly to SDHC cards in QuickTime files ready for immediate use in Final Cut Pro. The HM700 is the shoulder-mount sibling to the HM100.

**Note:** This makes the GY-HM700 less suitable for those editing with Premiere Pro, Media Composer or Edius. Vegas users would be able to use these files natively.



- Status:** The GY-HM700 has been shipping since March 2009.
- Format:** XDCAM HD (Long GOP MPEG-2) in a QuickTime wrapper ready for Final Cut Pro.
- Form Factor:** Compact Shoulder mount format.
- Media:** SDHC solid state media  
Optional SxS Media Recorder for native XDCAM EX .mp4 files.

### Supported Sizes and Frame Rates:

- 1080:** (1440x 1080 25 Mbits/sec) 59.94i, 50i, 29.97P, 25P.(16:9 aspect ratio)
- 1080:** (1920x 1080 35 Mbits/sec (HQ)) 59.94i, 50i, 29.97P, 25P, 23.98P (16:9)
- 720:** (1280 x 720 19 Mbit/sec) 59.94P, 50P, 25P, 23.98P (16:9).
- 720:** (1280 x 720 19 Mbit/sec) 59.94P, 50P, 25P, 23.98P (16:9).
- 720:** (1280 x 720 35 Mbit/sec (HQ)) 59.94P, 50P, 25P, 23.98P (16:9).

No SD recording modes but the camcorder can output SD via composite or component output.

- Camera Imagers:** Three 1/3-inch CCDs – 16:9 progressive with spatial offset.
- Lens:** Canon F1.6, 14x4.4, (4.4-61.6mm or in 35mm equivalent:32 to 448mm) with 1/3" bayonet mount.
- Minimum Illumination:** 3 lux

**Audio:** Uncompressed 16bit 48Khz LPCM 2 channel. Balanced XLR input, internal mic and 1/8" mini jack. Built-in 48v Phantom Power.

**Viewfinder:** 0.45-inch 1.22 million pixel LCOS panel (852 x 480)

**MSRP/Street Price:** US\$7,996/\$6,995. Prices below \$6,000 are unlikely to be genuine.

**Power Consumption:** 22 W with no optional accessories.

**Dimensions:** 8-13/16" x 15-29/32" x 9-9/16" (224) x 404 x 243 mm)

**Weight:** Approx. 3.6kg (8lbs) (Including lens, viewfinder, microphone, battery)

### Special features:

- Variable frame rate recording (over crank, under crank)
- HD-SDI output (also downconverted SD SDI)
- Pre Rec (retro cache) function prevents "missed shots"
- SD Composite output
- HD/SD Component Output
- Digital Signal Processing similar to GY-HD200 with Detail, Knee Auto-80-85-90-95-100%, Gamma off-standard-cinema, Gamma level, Color Matrix, White balance A, B, preset and RAW.
- Shutter 1/4 ~1/10000



- Gain 0,3,6,9,12,15,18dB ALC

- Three User Buttons assignable as Focus Assist, Color Bars, TC Setting, Tele-Macro, Lolux, Zebra, Clip: Continuous, Off, None.

- Newly designed JVC's original Optical Image Stabilization

- JVC patented Focus Assist (in-focus edge has color)

- USB 2.0 interface

## Assessment:

If you are editing with Final Cut Pro, the HM700 is an excellent low budget choice as the files from the SDHC cards can be used immediately without conversion, rewrapping or transcoding. The files are XDCAM files in a QuickTime container so they may work with other NLEs with an import or transcode.

Like XDCAM, at 25 Mbits/sec this camera is recording HDV (in a QuickTime wrapper). The higher quality 35 Mbit/sec codec is VBR and much higher quality than the 25 Mbit/sec version shared with HDV.

The shoulder mount and small size make this a great run and gun camera for documentary and news gathering. The workflow is particularly suitable for new editing with Final Cut Pro.

## Reviews:

- Technotalks.com has a [short review](#).
- Tim Dashwood has [an in-depth first look](#) over at DVinfo.net .
- Philip Bloom [has a thorough review](#) on his blog.





# Sony HVR-S270U

The HVR-S270U and the HVR-V7U share much of the same electronics but the S270U is an interchangeable lens, shoulder mount camcorder, while the V7U is a camcorder/handycam style unit with fixed lens.

**Format:** HDV2 1080i

**Form Factor:** Shoulder mount

**Media:** Mini DV/HDV tape

**Supported Sizes and Frame Rates:**

**US Model:** 1080i59.94, 1080p29.97 and 1080p23.98

**European model:** 1080i50 and 1080p25.

**Camera Imagers:** Three  $\frac{1}{3}$ " ClearVid CMOS (same as the V1U)

**Lens:** Interchangeable Zeiss 12× zoom 4.4mm-52.8mm. The lens has two independent focus positions (like the EX1): slide the focus wheel forward and you're in auto focus with Full AF, One-push AF, MF and AF/MF modes. Slide the focus wheel back and you have an "absolute position" focus wheel. Separate rings for Focus, Zoom and Iris on the lens.

**Minimum Illumination:** 1.5 lux (conditions not specified)

**Audio:** 4 channels of MPEG1 Audio Layer II (48 kHz, 384 kbps), 4 channel MPEG2 Audio Layer II (48 kHz, 384 kbps) with built-in stereo microphone with four XLR inputs for external sources, switchable between microphone and line level.





**Viewfinder:** Sony XtraFine LCD viewfinder and a 3.2in. 16:9 XtraFine LCD. The Electronic Viewfinder (EVF) delivers 1,226,880 pixels compared with only 252,000 for the EX1 and Z1.

**MSRP/Street Price:** US\$10,500/\$7,400 (B&H Photo, July 15, 2009). Prices under \$7,000 are unlikely to be genuine

**Power Consumption:** HDV: 12.5W, DVCAM/DV: 11.9W

**Dimensions:** Unavailable

**Weight:** 13.9 lbs (6Kg)

### Special features:

- 14 second cache continually buffering new audio/video in memory until the record button is pushed or auto-repeat a clip on playback.
- The S270 records to CF cards using a detachable 4oz. module — the HVR-MRC1 (Memory Recording Unit). Standard Compact Flash cards are used (with size and speed restrictions).
- HD-SDI output
- Record tape only; CF only, both at once (tapeless workflow from the CF card with a tape as archive and backup); record tape and use the CF when the tape runs out, or record HD to tape and simultaneously an SD downconvert to the CF card.
- Shot Transition™ function to smoothly transition from two settings during shooting for applying a color balance shift.
- [xvYCC](#), or eXtended Video YCC, an expanded color gamut promoted in consumer gear, which doubles the amount of reproducible spectrum. Since this cannot be displayed on the camera and requires an xvYCC-compliant NLE, it's not a feature that is important.
- Supports larger size cassettes for up to 4.5 hours of recording

### Assessment:

While these are both competent camcorders from Sony, it's hard to recommend them based on the price differential with the XDCAM EX1. The EX1 is virtually the same prices as the cheaper Z7U while the S270 is nearly \$3,000 more, records only 25 Mb/s HDV and has fewer formats available.

If you want to record HDV to Compact Flash card in a shoulder-mount camera, then this one is worth considering.

### Reviews:

- David Leitner, [Digital Content Producer](#)
- Adam Wilt [reviewed the HVR 270U and 7U in the same review](#) at Pro Video Coalition.

# Sony HVR-V7U

The HVR-S27U and the HVR-V7U share much of the same electronics but the S27U is an interchangeable lens, shoulder mount camcorder, while the V7U is a camcorder/handycam style unit with fixed lens.

**Format:** HDV2 1080i

**Form Factor:** Camcorder/Handycam

**Media:** Mini DV/HDV tape

**Supported Sizes and Frame Rates:**

**US Model:** 1080i59.94, 1080p29.97 and 1080p23.98

**European model:** 1080i50 and 1080p25.

**Camera Imagers:** Three  $\frac{1}{3}$ " ClearVid CMOS (same as the V1U)

**Lens:** Non-removable Zeiss 12× zoom 4.4mm-52.8mm. The lens has two independent focus positions (like the EX1): slide the focus wheel forward and you're in auto focus with Full AF, One-push AF, MF and AF/MF modes. Slide the focus wheel back and you have an "absolute position" focus wheel. Separate rings for Focus, Zoom and Iris on the lens.

**Minimum Illumination:** 1.5 lux (conditions not specified)

**Audio:** 4 channels of MPEG1 Audio Layer II (48 kHz, 384 kbps), 4 channel MPEG2 Audio Layer II (48 kHz, 384 kbps) with built-in stereo microphone with two XLR inputs for external sources, switchable between microphone and line level.

**Viewfinder:** Sony XtraFine LCD viewfinder and a 3.2in. 16:9 XtraFine LCD. The Electronic Viewfinder (EVF) delivers 1,226,880 pixels compared with only 252,000 for the EX1 and Z1.

**MSRP/Street Price:** US\$6,800/\$5,500  
— \$6,500 Prices less than \$5,000 are unlikely to be genuine.



**Power Consumption:** HDV: 12.5W, DVCAM/DV: 11.9W

**Dimensions:** Unavailable

**Weight:** 13.9 lbs

### Special features:

- 14 second cache continually buffering new audio/video in memory until the record button is pushed or auto-repeat a clip on playback.
- The S7U records to CF cards using a detachable 4oz. module — the HVR-MRC1 (Memory Recording Unit). Standard Compact Flash cards are used (with size and speed restrictions).
- HDMI output
- Record tape only; CF only, both at once (tapeless workflow from the CF card with a tape as archive and backup); record tape and use the CF when the tape runs out, or record HD to tape and simultaneously an SD downconvert to the CF card.
- Shot Transition function to smoothly transition from two settings during shooting for applying a color balance shift.
- [xvYCC](#), or eXtended Video YCC, an expanded color gamut promoted in consumer gear, which doubles the amount of reproducible spectrum. Since this cannot be displayed on the camera and requires an xvYCC-compliant NLE, it's not a feature that is important.

### Assessment:

While these are both competent camcorders from Sony, it's hard to recommend them based on the price differential with the XDCAM EX1. The EX1 is virtually the same prices as the cheaper Z7U while the S270 is nearly \$3,000 more, records only 25 Mbits/sec HDV and has fewer formats available.

If you want to record HDV to Compact Flash card in a handycam-style camera, then this one is worth considering, otherwise, give the EX1 a close look.

### Reviews:

- David Leitner, [Digital Content Producer](#)



# Sony HVR-V1U

**Format:** HDV2 1080

**Form Factor:** Prosumer/Handycam

**Media:** Mini DV/HDV Tape

**Supported Sizes and Frame Rates:**

**US Model** 1080i59.94, 1080p29.97, 1080p23.98 with 2:3 pulldown embedded in either regular or advanced pulldown modes (advanced only should be used for production).

**European Model** 1080i50, 1080p25.

**Camera Imagers:** Three 1/4" ClearVid CMOS (RGB) (same as Z7U/S270U) with the same diagonal pixel layout to fill more of the chip with sensors.

**Lens:** 20× (30× digital) 3.9-78mm (35mm equivalent – 37.4-748mm at 16:9) with free-spinning servo zoom and focus rings

**Minimum Illumination:** 4 Lux f1.6 at 18 dB

**Audio:** 2 channel MPEG1 Audio Layer II (48 kHz, 384 kbps) with two XLR inputs for external audio.

**Viewfinder:** Color 0.44" 252K pixel 16:9 viewfinder/3.5: LCD screen

**MSRP/Street Price:** US\$4,800/\$3,300 – 3,500 Prices under \$3,000 are unlikely to be genuine.

**Power Consumption:** 6.8 watts in HDV mode.

**Dimensions:** Unavailable

**Weight:** 3.4 lb (1.5 kg)



## Special features:

- Still images up to HD resolution to memory stick
- HDMI output for monitoring and uncompressed capture with Blackmagic Design Intensity card.
- HD Focus assists: Focus Expansion button that temporarily enlarges the center part of the image, and a Peaking indicator that outlines high contrast areas of the subject that approach sharpness
- Supports DVCAM in DV25 mode.



## Assessment:

The successor to Sony's very successful Z1U, the V1U is a good choice within the sub-\$10,000 HDV camcorders. The V1U's smaller imagers, even with the "Clear Vid" layout, isn't as sensitive under low light as some of its competitors but overall the pictures deserve the including in the *CineAlta* product line.

Unfortunately there are unique models between the US and Europe – no 50/60 Hz switching.

Overall, the HVR-V1U is a great combination of features, performance and price.

## Reviews:

- Brian Peterson, [Videomaker Magazine](#)
- Lori Grunin, [CNET](#)
- Adam Wilt, [DV Magazine](#)
- Douglas Spotted Eagle, [VASST](#)





## JVC KY-HD200U/HD200UB and HD250

The GY-HD200U and HD250 are basically the same camera and use the same accessories as the earlier GY-HD110U but with new  $\frac{1}{3}$ -inch mount HD lenses. The main differences are that the HD250U can also be configured with a remote CCU for studio configurations by adding support for Genlock input (synchronizing cameras), Timecode input and output, and HD/SD-SDI output with embedded audio and Timecode and Varicam flags. The HD200B replaced the HD200 in April.

**Format:** HDV1 and support for HDV2 in live output.

**Form Factor:** Shoulder Mount

**Media:** MiniDV/HDV Tape

**Supported Sizes and Frame Rates:**

**To Tape:** 720p59.94, 720p29.97, 720p50, 720p25, and 720p23.98.

**Live Output** (not to tape) and playback of 1080i59.94 and 1080i50.

**Camera Imagers:** Three  $\frac{1}{3}$ " interline transfer CCDs with 1280 × 720 (square) pixels

**Lens:** Interchangeable Fujinon Th16× 5.5mm – 88 mm BRM lens

16mm PL (Positive Lock) lenses are supported with the optional JVC HZ-CA13U lens adapter (\$4,395 list). (Camera body is sold alone for approximately \$1,000 less than with included lens)

**Minimum Illumination:** 6 lux with F1.4, at 18 dB



**Audio:** 2 channel MPEG1 Audio Layer II (48 kHz, 384 kbps) with two XLR inputs for external microphones (no line level). On camera mini shotgun.

**Viewfinder:** Detachable LCD color viewfinder/3.5" LCD fold out display with three modes: video, video plus information, information only.

**MSRP/Street Price:** **HD200** US\$4,995/\$3,900 Prices under \$3,000 are unlikely to be genuine.

**HD250** US\$10,995/\$8,950/ prices under \$5750 are unlikely to be genuine

**Power Consumption:** 23W in Record mode.

**Dimensions:** 9-9/16" × 9-3/16" × 16-5/16" (242 (W) × 233 (H) × 414 (D))

**Weight:** 8.16 lbs. (3.7 kg) (including viewfinder, microphone and tape)

### **Special features:**

- With price drop in early April 2008, now includes the Anton-Bauer Trimpac battery/charger system at no additional cost.
- Control over key gamma and color settings. Nearly total control over all the gain, threshold and rotation settings of key image quality parameters like black, gamma, white balance, white clip, knee and detail.
- Selectable 60P and 60i acquisition in 720P (HD200UB)
- Enhanced Cinema Gamma
- Camera Settings on an SD card.
- HD-SDI output of 1080i from built-in cross converter.
- Remote CCU for HD250 in studio configuration via an industry standard 26-pin multicore cable for power, gen lock, R/B gain, black level, and intercom up to 330 feet. An optional pan and tilt head and 16:9 LCD studio viewfinder make it ideal for educational, religious, cable, and broadcast studios.
- Built-in speaker

The selected IEEE 1394 output signal can also be recorded into the ProHD DR-HD100 Hard Disk Recorder as either .m2t or .mov QuickTime files.

## Assessment:

There are HD201/251 models that accept HDV and DV input. The HD200/250 have only HDV/DV output.

The HD200 or HD250 are professional-level camcorders capable of providing excellent quality images and manual control of key functions. Given that forgoing the lens only saves \$1,000, I would buy the lens and use it as a “spare” even if it was planned to purchase a better lens.

The ability to convert to a studio configuration is a powerful addition to the HD250. In any case, the HD200/250 are a worthwhile step up from the HD110 because of the much improved MPEG-2 encoder, improved warranty, standard Anton Bauer mount and 60P recording.

Shooting 60P has two unique advantages. First, it captures high-speed motion far better than 60i because it lacks interlace artifacts. That makes 60P ideal for shooting sports and news and at this frame rate the frame rate is getting close to the limit of the Human Visual System.”

All that said, the HD200 or 250 cannot be recommended over Panasonic HPX-300 and Sony EX-3 in a similar price range. Either alternative model records more formats, in higher quality than this HDV-only camcorder.

## Reviews:

- Brian Peterson, for [Videomaker](#) (HD200)
- Steve Mullen, for [Digital Content Producer](#) (HD250)
- Marc Franklin, for [Event DV](#) (HD200)
- Robert M. Goodman, for [DV Magazine](#)



## Canon HV-40 (HV 20/30)

The 2007 HV-20 and the 2008 HV-30 are almost identical, other than the color. The HV-20 is silver and the HV-30 is black. The biggest improvement over the HV-10 was the addition of a microphone input. The main innovation of the HV-30 was an improvement to the zoom control – a full rocker instead of small plastic strip.

**Format:** HDV2 1080i

**Form Factor:** Palmcorder (small)

**Media:** Mini DV tape/HDV tape

**Supported Sizes and Frame Rates:**

US Version supports 1080i59.94 1080p29.97 and 1080p23.98;

European version supports 50i and 25P.

**Camera Imager:** Single 1/2.7" CMOS with optical image stabilizer

**Lens:** 10x 6.1mm – 61mm (Digital Zoom to 20×)

**Minimum Illumination:** 0.2 lux (conditions not specified)

**Audio:** 2 channel MPEG1 Audio Layer II (48 kHz, 384 kbps), 4 channel MPEG2 Audio Layer II (48 kHz, 384 kbps) with built-in stereo microphone and 3.5 mm Stereo Mini-jack.

**Viewfinder:** 0.27" Color Viewfinder; Flip out 2.8" color LCD with transport controls.

**MSRP/Street Price:** US\$999.99/\$850 Prices under \$750 are unlikely to be genuine.

**Power Consumption:** Unavailable.

**Dimensions:** 3.5" × 5.4" ×  
3.2 inches

**Weight:** 1.2 lbs



## Special features:

- Still images can be captured to MiniSD card in the following resolutions: 2048 × 1536 (4:3), 1920 × 1080 (16:9), 1440 × 1080 (4:3), or 640 × 480 (4:3) in memory mode. Normal, Fine, and Superfine are the quality options, and shooters can capture stills during playback or recording at 1920 × 1080 or 848 × 480.
- Flash and video light
- Digital Image Effects like Fade in and out of a shot, Wipe (opens and closes the shot like saloon doors), Black and White, Sepia, and Art, which is really just a nifty little posterize effect.
- HDMI uncompressed output for monitoring or capture via Blackmagic Design Intensity card.

## Assessment:

The HV-40, and the earlier HV-20 and 30, are great little single CMOS “disposable” cameras that record 59.94i and 23.98P (with 2:3 pulldown added and encoded in the signal) (European version shoots 50i and 25P). Great for b-roll or “disposable” camera or for when large numbers of cameras are needed to cover an event with audience/user participation, particularly HV20/30 from the second hand market.

There is no gain control to assist in low light shooting, being a consumer-oriented camcorder.

## Reviews:

- David Kender, [CamcorderInfo](#)
- Lori Grunin, [CNET UK](#)
- Nick Strayer, [Videomaker](#) (HV-20)
- Joseph Nilo, [Mac Mediacast](#)





# Panasonic AG-HMC150

**Status:** Announced at NAB 2008 and shipping from October 2, 2008

**Format:** AVCCAM (same format as AVCHD).

**Form Factor:** Handheld

**Media:** SD Memory card in 32GB, 16GB, 8GB, 4GB, 2GB and 1GB sizes.

**Supported Sizes and Frame Rates:**

**1080:** 59.94i, 29.97P, 23.98P native

**720:** 59.94P, 23.98P native. The lack of support for 50i/50P or 24P suggests a different version for 50Hz (a.k.a. PAL) countries.

23.98 frame rates are recorded to the SD memory card in native format.

**Data rate and quality:**

There are four recording modes:

**PH mode** with the highest quality at an average 21 Mb/sec and a maximum of 24 Mbps records full raster 1920 x 1080 or full raster 1280 x 720. 180 minutes of this highest quality version of the codec can be recorded onto one Class 4 32 GB SD memory card (cost under US\$100 and dropping).

**HA mode** records full raster 1920 x 1080 at an average of 17 Mb/sec.

**HG mode** also records full raster 1920 x 1080 at an average of 13 Mb/sec.

**HE mode** captures using 1440 x 1280 anamorphic pixels (not full raster) at about 6 Mb/sec and would be suitable only for very low action content (such as talking heads).



The recorded AVCHD files can also maintain metadata for individual recorded clips.

**Camera Imagers:** Three 1/3" 16:9 CCDs.

**Lens:** Fixed Leica Dicomar lens: 13× zoom from 3.9 to 51mm (equivalent to 28 – 364mm on a regular 35mm camera). Auto/manual focus, with focus assist (even during recording), and focus down to very close. Camera-driven manual zoom and optical image stabilization. (This lens has the same specifications as the lens on the HPX-170)

**Minimum Illumination:** 6 lux.

**Audio:** Two locking XLR inputs with switches for mic/line, +48V Phantom Power, Auto/Manual level, and internal/external assignment

**Viewfinder:** Flip out 3.5" LCD screen and color viewfinder. 3.5-inch color LCD monitor that displays content in thumbnail images for quick viewing

**MSRP/Street Price:** MSRP US\$3,995. Street price is US\$3,495. Prices under \$3000 are unlikely to be genuine.

**Power Consumption:** 9.8 watts.

**Dimensions:** 6.1 x 6.5 x 15.6" (15.4 x 16.4 x 39.7cm).

**Weight:** 3.7 lbs

### **Special features:**

- Three Year limited warranty (upon registration).
- SMPTE time code generator/reader.
- Transfer recordings via USB 2.0 or by SD/SDHC card reader in PC or Macintosh.
- Built in Waveform Monitor and Vectorscope (in viewfinder).
- 14-bit DSP for A/D conversion and 19-bit internal processing (same as HPX170)
- Time/date stamp for legal depositions or surveillance.
- Histogram display.
- Time code/user bits.
- Recording functions include pre-record, interval and shot marker, as well as new modes including last-clip delete and Rec check, which allows immediate review of the most-recently recorded clip.
- HDMI (uncompressed) output.

- 2× Focus Assist that magnifies the center of the image in the viewfinder and swing-out LCD display to make focusing the HD image much easier.
- CineGamma™ mode
- Composite out, component out via mini-D and audio out.
- Thumbnail display for easy searching and file information.
- Free downloadable AVCHD Transcoder for conversion to DVCPRO HD available at [www.panasonic.com/avccam](http://www.panasonic.com/avccam) (PC only)
- The HMC150 offers a host of selectable gamma tools including Cine-like gamma to produce warm film-like images, as well as helpful shooting functions such as a waveform monitor and a vectorscope display, focus assist and Dynamic Range Stretch (DRS).

## Assessment:

While AVCHD/AVCCAM is compressed further than HDV, the improved efficiency of the AVC codec over MPEG-2 results in higher quality recordings with fewer artifacts than HDV. The downside is the Final Cut Pro and Media Composer require conversion to an all-I-frame codec before editing. Final Cut Pro converts AVCHD/AVCCAM to ProRes 422 while Media Composer converts to DNxHD. Premiere Pro claims native support (but not all modes work equally well). Edius and Vegas support AVCCAM/AVCHD natively.

Most modern NLE systems can work with AVCHD/AVCCAM footage by converting it to an all I-frame format on import. Like HDV it is a 4:2:0 format.

The HMC150 appears to use the same chips and lens as the HPX-170 so it shares the wide lens but records only two channels of audio.

SD memory cards are much cheaper and more widely available than P2 cards and will work with card adapters available for all computers.

## Reviews:

- Mark Montgomery [reviewed the HMC-150](#) for Videomaker.
- Lori Grunin writes the [editor's take](#) for CNET
- David Kender [wrote the review for camcorder.info](#).
- Rick young has a [video review](#) at his MacVideo.tv site.
- The DV Show [also has a video review](#) with text notes at the DV Show site.



# Panasonic AG-HMC40

**Status:** Announced in NAB 2009 and shipping in August 2009.

**Format:** AVCCAM (same format as AVCHD).

**Form Factor:** Handheld/prosumer

**Media:** SD Memory card in 32GB, 16GB, 8GB, 4GB, 2GB and 1GB sizes.



## Supported Sizes and Frame Rates:

**1080:** 59.94i, 29.97P, 23.98P native

**720:** 59.94P, 23.98P native. The lack of support for 50i/50P or 24P suggests a different version for 50Hz (a.k.a. PAL) countries.

23.98 frame rates are recorded to the SD memory card in native format.

## Data rate and quality:

There are four recording modes:

**PH mode** with the highest quality at an average 21 Mb/sec and a maximum of 24 Mbps records full raster 1920 x 1080 or full raster 1280 x 720. 180 minutes of this highest quality version of the codec can be recorded onto one Class 4 32 GB SD memory card (cost under US\$100 and dropping).

**HA mode** records full raster 1920 x 1080 at an average of 17 Mb/sec.

**HG mode** also records full raster 1920 x 1080 at an average of 13 Mb/sec.

**HE mode** captures using 1440 x 1280 anamorphic pixels (not full raster) at about 6 Mb/sec and would be suitable only for very low action content (such as talking heads).

The recorded AVCHD files can also maintain metadata for individual recorded clips.

**Camera Imagers:** Three 1/4" Full raster, 16:9 3MOS<sup>9</sup> comparable to those on the HMC150.

**Lens:** Fixed Leica Dicomar lens: 12x zoom – range unknown but it will have Optical Image Stabilization (O.I.S.)

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<sup>9</sup> 3MOS is Panasonic's brand labeling for 3 CMOS chips.

**Minimum Illumination:** 3 lux.

**Audio:** Detachable XLR inputs record level adjustment dials.

**Viewfinder:** Flip out 2.7" LCD. Many of the camcorder's features and controls are activated using the touchscreen.

**MSRP/Street Price:** MSRP US\$2,295. Street price is expected to be around \$2,000 when it ships.

**Power Consumption:** Unknown.

**Dimensions:** Unknown, but small

**Weight:** Unknown, but it will be light.

### Special features:

- High-resolution 10.6-Megapixel still photo capture.
- Three Year limited warranty (upon registration).
- Transfer recordings via USB 2.0 or by SD/SDHC card reader in PC or Macintosh.
- Dynamic Range Stretch (DRS) that helps compensate for wide variations in lighting, and a Cine-Like Gamma mode which gives recordings a more film-like aesthetic.
- HDMI (uncompressed) output.
- HD component (Y/Pb/Pr BNC) connection via mini-D connector (adapter required).





- Free downloadable AVCHD Transcoder for conversion to DVCPRO HD available at [www.panasonic.com/avccam](http://www.panasonic.com/avccam) (PC only).

## Assessment:

While AVCHD/AVCCAM is compressed further than HDV, the improved efficiency of the AVC codec over MPEG-2 results in higher quality recordings with fewer artifacts than HDV. The downside is the Final Cut Pro and Media Composer require conversion to an all-I-frame codec before editing. Final Cut Pro converts AVCHD/AVCCAM to ProRes 422 while Media Composer converts to DNxHD. Premiere Pro claims native support (but not all modes work equally well). Edius and Vegas support AVCCAM/AVCHD natively.

Most modern NLE systems can work with AVCHD/AVCCAM footage by converting it to an all I-frame format on import. Like HDV it is a 4:2:0 format. SD memory cards are much cheaper and more widely available than P2 cards and will work with card adapters available for all computers.

The HMC40 is a lower cost brother to the HMC150 and a fine budget camera for field production for those who don't mind the prosumer form factor. It has the higher AVCCAM bitrates, so record quality at the highest rates will easily exceed HDV record quality.

## Reviews:

As the camera has not been released or previewed to individuals, no reviews are available.



# Camera Comparison Summary and Recommendations

Last year this was an easy section to write: the XDCAM EX-1 from Sony was clearly the quality and value leader. Since then Sony have released the EX-3, Panasonic the HPX-300 at one end and the HMC150 at the other end, in addition to the HPX-170 and HVX-200A. Then JVC add in their Final Cut Pro-specific camcorders – HM700 and HM100 – and recommending a clear winner is hard.

The good news is that there is not a really bad choice in the entire group. What is interesting is how few of the camcorders are tape based. The HVX-200 has a tape recorder but it's for SD DVCPRO quality only: all HD is recorded to P2 media. Other than that, the only tape-based camcorders are HDV.

This is the first year I'm going to recommend against buying HDV. Sure, if you need to expand an existing all-HDV operation then the GY-HD200 or HD250 from JVC, or HV270 or Z7U from Sony might be the way to go, but there is better record quality available from less expensive cameras like the HMC150 (AVCCAM) or HD100 (QT wrapped XDCAM). The HV40 is an inexpensive beginner camera or

Any of the XDCAM compatible cameras (including the HM700 and HM100) can produce HDV-format video by choosing the 25 Mbit/sec setting. The 35 Mbit/sec Variable Bitrate codec is significantly higher in quality than the HDV/25 Mbit/sec recording. The sub-\$10K cameras do not (yet?) support the 4:2:2 50 Mbit/sec version of the XDCAM codec leaving the HPX 300 the clear quality king in the middle of 2009.

AVCHD in its AVCCAM variation from Panasonic produces image quality that is definitely better than HDV quality, although both are, like XDCAM 4:2:0 formats. AVCCAM is long GOP AVC/H.264 which is a much more modern codec than XDCAM and HDV's MPEG-2 recording, so for the same bitrate (24 or 25 Mbit/sec) [AVCCAM is dramatically better than HDV](#).

## Workflow

HDV requires capturing from tape in most cases, although the two Sony HDV camcorders – Z7U and 270U – can optionally record to Compact Flash cards. All other formats start as data files. Clearly the industry is moving toward a file-based workflow (a.k.a Tapeless, IT centric, data-centric workflow, etc) and away from tape.

The two JVC cameras, specific for Final Cut Pro, produce files that require no Log and Transfer or Log and Capture to Final Cut Pro, but they really don't make a lot of sense if you're editing with Media Composer, where the files would need to be transcoded. I would expect Premiere Pro and Sony Vegas to use these files without additional conversion.

XDCAM EX cameras require Log and Transfer in FCP to rewrap the files as QuickTime media file that keeps the original data intact but structures it as a QuickTime media file. Media Composer 3.5 includes native XDCAM EX support through Avid Media Access. Adobe Premiere Pro CS4 software provides native support for Sony XDCAM, XDCAM EX, and XDCAM HD cameras and content with no transcoding, and great metadata support. ([Not all metadata from the source files is shown](#) in most NLEs.)

## Recommendations

The leader for recorded image quality has to be Panasonic's HPX-300, with support for AVC-I for 4:2:2 10 bit acquisition. All other formats record natively as 4:2:0. (See the next section on the Ki Pro Factor for another alternative.)

I recommend not buying HDV at this time: go for an EX-1 or HMC150 as alternatives. If you edit with Final Cut Pro then the HM100 or HM700 would be better alternatives than HDV.

Beyond that, read the summaries, read the reviews and peruse the chart to make your decision.<sup>10</sup>

Manufacturer	Model	Body Style	Format	Media	Lens	Street Price
<b>Recommended</b>						
Panasonic	AG-HPX300	Shoulder	DVCPRO HD/ AVC-I	P2	Changeable	\$8,500
Sony	XDCAM EX-3	Shoulder	XDCAM HD	SxS	Changeable	\$8,500
Sony	XDCAM EX-1	Prosumer	XDCAM HD	SxS	Fixed	\$6,250
Panasonic	AG-HPX170	Prosumer	DVCPRO HD	P2	Fixed	\$5,200
JVC	KY-HM700	Shoulder	XDCAM HD QT	SDHC	Fixed	\$8,000
Panasonic	HMC150	Prosumer	AVCCAM	SDHC	Fixed	\$3,500
JVC	KY-HM100	Prosumer	XDCAM HD QT	SDHC	Fixed	\$3,500
Panasonic	HMC40	Prosumer	AVCCAM	SDHC	Fixed	\$2,000
<b>Not Recommended</b>						
Panasonic	AG-HVX-200A	Prosumer	DVCPRO HD	P2	Fixed	\$5,500
Sony	HVR-270U	Shoulder	HDV	HDV Tape + CF	Changeable	\$7,500
Sony	HVR-Z7U	Prosumer	HDV	HDV Tape + CF	Fixed	\$5,500
Sony	HVR-V1U	Prosumer	HDV	HDV Tape	Fixed	\$3,500
JVC	GY-HD200	Shoulder	HDV	HDV Tape	Changeable	\$3,900
JVC	GY-HD250	Shoulder	HDV	HDV Tape	Changeable	\$8,950
Canon	HV40	Prosumer	HDV	HDV Tape	Fixed	\$850

<sup>10</sup> If anyone cares, my current personal choice would be the HM100: better quality than HDV, a small form factor, FCP native and SDHC media. I should note that my requirements are modest and not for Broadcast or Cable.

## The Ki Pro Factor

If you edit with Final Cut Pro then AJA have the [Ki Pro](#). Announced at NAB 2009 and shipping about the time we locked this edition off at the end of July 2009, the Ki Pro is a small (it's really small) hard drive or Compact Flash recorder that records natively in Apple's ProRes 422 codec: 10 bit 4:2:2 recording on a quality par with the HPX-300.

The Ki Pro has just about every input you can imagine – from SD composite to HDMI or HD SDI – so it will work with almost every camera. As long as the camera has a video output that splits off before the compression then the Ki Pro gets an uncompressed signal to record. Most camcorder's video outputs are before the encoding stage.

So every one of the cameras in this edition are potentially able to record 10 bit 4:2:2! The Ki Pro carries an MSRP of \$3995 so will likely be available for a little below that once backorders are caught up. That means that the Ki Pro and a Sony V1U, Canon HV20/30/40, Panasonic HMC150 and JVC HM100 would all be on a recording quality quality par with the HPX-300. There is the added security of a camera-native recording, in addition to the higher quality ProRes 422 recording on the Ki Pro.

It even has available a very solid cradle for mounting between camera and camera support such as a tripod.

Use the camera native recording when you need portability and rapid setup. Use the same camera with a Ki Pro for the highest quality source footage.

10 bit 4:2:2 recording at ProRes 422 HQ quality and data rates is equal to the highest record quality available from HD cameras. Of course the camera head – sensors and processing – will also have an influence on overall image quality, but for pure record quality, the Ki Pro is on a par with the best.





## A tape-free future

In just a year it's become clear that tape is almost over, and solid state is the future. Solid-state media – Sony's SxS card, Panasonic's P2 media, Compact Flash for some Sony HDV camcorders and RED and SDHC memory chips – bring their own complications to workflow and archiving.



Given the prices of SxS and P2<sup>11</sup> media, cards are recycled during production by being offloaded to hard drives at or near the production location. This can add up to one additional person to the crew for data management and requires a degree of control over location where power needs to be available. There are dedicated download devices from Panasonic and Sony but most people use a laptop for moving the data from the solid-state media so it can be recycled.

However, SDHC cards are rapidly approaching the cost/duration of tape and increasingly people are simply storing the SDHC cards as if they were tape media: shoot once and hold as archive. (I would recommend additional copies, of course.)

The one thing that we can't do is leave the data in only one place, with no backup. Most production folk immediately do a duplicate backup. The most prudent load directly to small [RAID 5 storage](#) so that a drive can fail and not lose data, but many do a duplicate copy after the day's shoot.

The inclusion of standard Compact Flash cards for HDV footage on Sony's S270 and V7U cameras; the AVCCAM HMC150 and the QuickTime-native XDCAM recording of the HM100 and HM700 on SDHC

cards, provides a lower cost entry into tapeless workflows without the high cost of SxS or P2 media. However, it should be noted that the EX1 with two 16GB cards is less than the S270 and produces better recorded image quality.



Hoodman, among others, offer a SxS adapter that uses [SDHC cards](#) and reduces the cost significantly, although it's not suitable for the fastest frame rates.

A year ago it looked like there would be significant support for hard drives in the future but the trend has been toward solid state media. Sony and JVC provide direct options for some of their cameras (although the JVC units are rebranded FireStore devices). Focus Enhancements have [FireStore hard-drive recorders](#) available for all the cameras in this round up. Hard drive storage has only two disadvantages: a return to the "two unit" – camera and "hard drive" – and a hard limit to capacity. Sony and JVC's devices mount to the camera, while the FireStore (and its competitors at [Shining Technology](#)) are lightweight enough to hang off a belt without noticing.

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<sup>11</sup> In May 2009, Panasonic started shipping their "E" (Economy) series P2 media with faster transfer times and significantly lower cost, with the downside that the cards are only good for a limited period.



Hard drives provide random access and instant editing access at the end of the shoot, they suffer from a hard limit. If you have a 3 hours unit and need to record 3 hours and 15 minutes (or even 3 hrs 1 minute) you're out of luck. While tape is readily available, particularly miniDV tape, additional hard drive units are not. (If you plan on renting these units, be very careful as they do not always stand up well to the rental process.) The same issues of long term storage affect hard drives as well as solid state media.

It's clear that the era of "rust on plastic", a.k.a. tape<sup>12</sup> is coming to an end. Whether we acquire on proprietary media, CF, SDHC or hard drive long term archiving and media management will become increasingly important.



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<sup>12</sup> Yes, it is sophisticated rust but essentially, tape is just grown up rust on a plastic backing.

# Post Production

*Everything you need to know about HD data rate, storage, capture hardware, HD workflows by format, 24P and archiving file-based media. In this section of the book we'll be tracking through PostProduction workflows for both tape and non-tape media.*

Before we discuss specific workflows for Media Composer and Final Cut Pro we'll be consider Storage, Capturing HD and Monitoring HD. After considering the workflows for both Final Cut Pro and Media Composer we'll consider 24P issues before finishing the section with a chapter on storing non-tape media.

# Storage

*Before we get to the actual capture, edit and output phases of Post Producing High Definition video, we have to consider where we're going to store our digital assets. We'll consider data rates required, storage types, types of connector and issues like RAID and SAN.*

There are three considerations:

- the type of interface,
- the way the drives are formatted, and
- whether the drives are local or on a Storage Area Network (SAN).

The choices made here will affect the editing experience. You absolutely need the minimum speed for the type of footage you'll be working with (see requirements table on the next pages). Beyond the minimum, faster drives will enable more layers of real time performance, because more data can be pulled off the drives at the same time. Faster drives will also make rendering and all operations smoother.

## Formats and data rates

The decisions can be made in two ways: consider the minimum acceptable specifications for the type of workflow you have, or go for something that provides faster speeds and some degree of redundancy. Redundancy from formatting as RAID 3, 5 or 6 (see section on [RAID](#) coming up) provides protection if one drive fails.

## *Data Requirements*

The data throughput you will require from your drives depends on the HD format, or formats, you work with. Compressed formats like HDV, ProRes 422, DVCPRO HD, AVC-Intra, DNxHD and XDCAM HD have very modest data throughput rates but they require more powerful processors to deal with the compressed footage in real time, since each stream of video has to be decompressed and played or layered with other streams and played.

## About the Charts

The data rates for the ProRes 4444 codec do not include an alpha channel. Due to the addition of additional codecs and formats the 60Hz family of frame rates (23.976, 29.97 and 59.94) are in one table and the 50 Hz family of frame rates (25, 50) are in the table on the next page.

ProRes — in all its variations — is 10 bit (if fed 10 bit source) or 8 bit (if fed 8 bit source). DNxHD is 8 bit or 10 bit depending on which version of the codec is chosen.

The ProRes 4444 codec supports 12 bit images.

## 720P Data Rates (60Hz)

Width	Height	Frame Rate	Format	Mbits/sec	GB/hour
1280	720	29.97	HDV 720p30	19.2	8
1280	720	23.976	ProRes 422 LT	41	18
1280	720	23.976	ProRes 422	59	27
1280	720	23.976	ProRes 422 (HQ)	88	40
1280	720	23.976	ProRes 4444	132	59
1280	720	23.976	DNxHD 60	58	25.2
1280	720	23.976	DNxHD 90	88	38
1280	720	23.976	DNXHD 90X (10bit)	88	38
1280	720	23.976	8 bit 4:2:2	354	155
1280	720	23.976	10 bit 4:2:2	442	194
1280	720	29.97	ProRes 422 LT	51	23
1280	720	29.97	ProRes 422	73	33
1280	720	29.97	ProRes 422 (HQ)	110	49.2
1280	720	29.97	ProRes 4444	165	74
1280	720	29.97	DNxHD 60	72	29
1280	720	29.97	DNxHD 90	110	46
1280	720	29.97	DNXHD 90X (10bit)	110	46
1280	720	29.97	8 bit 4:2:2	442	194
1280	720	29.97	10 bit 4:2:2	552	243
1280	720	59.94	ProRes 422 LT	101	46
1280	720	59.94	ProRes 422	147	66
1280	720	59.94	ProRes 422 (HQ)	220	99
1280	720	59.94	ProRes 4444	330	148
1280	720	59.94	DNXHD 145	145	61
1280	720	59.94	DNXHD 220	220	92
1280	720	59.94	DNXHD 220X	220	92
1280	720	59.94	8 bit 4:2:2	884	388
1270	720	59.95	10 bit 4:2:2	1105	486

## 720P Data Rates (50Hz)

Width	Height	Frame Rate	Format	Mbits/sec	GB/hour
1280	720	25	HDV 720p35	19.2	8
1280	720	25	ProRes 422 LT	36	16
1280	720	25	ProRes 422	61	28
1280	720	25	ProRes 422 (HQ)	92	42
1280	720	25	ProRes 4444	118	53
1280	720	25	DNxHD 60	60	25
1280	720	25	DNxHD 90	92	38
1280	720	25	DNXHD 90X (10 bit)	92	38
1280	720	25	8 bit 4:2:2	369	162
1280	720	25	10 bit 4:2:2	461	203
1128	720	50	ProRes 422 LT	44	20
1280	720	50	ProRes 422	122	55.2
1280	720	50	ProRes 422 (HQ)	184	82.8
1280	720	50	ProRes 4444	275	124
1280	720	50	DNxHD 115	115	48
1280	720	50	DNxHD 175	175	73
1280	720	50	DNxHD 175X	175	73
1280	720	50	8 bit 4:2:2	737	324
1280	720	50	10 bit 4:2:2	922	405



## 1080 Data Rates (60 Hz)

Width	Height	Frame Rate	Format	Mbits/sec	GB/hour
1920	1080	29.97	HDV 1080i30	25	11
1920	1080	23.976	ProRes 422 LT	82	37
1920	1080	23.976	ProRes 422	117	52.8
1920	1080	23.976	ProRes 422 (HQ)	176	79.2
1920	1080	23.976	ProRes 4444	264	119
1920	1080	23.976	DNxHD 115	116	49
1920	1080	23.976	DNxHD 175	176	74
1920	1080	23.976	DNxHD 175X (10 bit)	176	74
1920	1080	23.976	8 bit 4:2:2	795	350
1920	1080	23.976	10 bit 4:2:2	994	437
1920	1080	29.97i/59.94i	ProRes 422 LT	102	46
1920	1080	29.97i/59.94i	ProRes 422	147	66
1920	1080	29.97i/59.94i	ProRes 422 (HQ)	220	99
1920	1080	29.97i/59.94i	ProRes 4444	330	148
1920	1080	29.97i/59.94i	DNxHD 145	145	61
1920	1080	29.97i/59.94i	DNxHD 220	220	92
1920	1080	29.97i/59.94i	DNxHD 220X (10 bit)	220	92
1920	1080	29.97i/59.94i	8 bit 4:2:2	994	437
1920	1080	29.97i/59.94i	10 bit 4:2:2	1243	546
1920	1080	59.94P	ProRes 422 LT	204	92
1920	1080	59.94P	ProRes 422	147	66
1920	1080	59.94P	ProRes 422 (HQ)	220	99
1920	1080	59.94P	ProRes 4444	330	148
1920	1080	59.94P	10 bit 4:2:2	1326	597
1920	1080	59.94P	12 bit 4:4:4	2237	1007

Compare 12 bit 4:4:4 at 2237 Mbit/sec (over 1 TB an hour of storage space) with ProRes 4444 at 330 Mbit/sec or about 148 GB an hour.

## 1080 Data Rates (50 Hz)

Width	Height	Frame Rate	Format	Mbits/sec	GB/hour
1920	1080	50i,25P	HDV 1080i25	25	11
1920	1080	50i,25P	ProRes 422 LT	85	38
1920	1080	50i,25P	ProRes 422	122	55.2
1920	1080	50i,25P	ProRes 422 (HQ)	184	82.8
1920	1080	50i,25P	ProRes 4444	275	124
1920	1080	50i,25P	DNxHD 120	121	51
1920	1080	50i,25P	DNxHD 185	184	77
1920	1080	50i,25P	DNxHD 185 (10 bit)	184	77
1920	1080	50i,25P	8 bit 4:2:2	829	365
1920	1080	50i,25P	10 bit 4:2:2	1037	456
1920	1080	50P	ProRes 422 LT	170	77
1920	1080	50P	ProRes 422	245	110
1920	1080	50P	ProRes 422 (HQ)	367	165
1920	1080	50P	ProRes 4444	551	248
1920	1080	59.94P	8-bit 4:2:2	1658	730
1920	1080	59.94P	10 bit 4:2:2	2486	1029

**NOTE:** Data throughput is usually expressed as Megabits per second, but when we talk about file size, we use MegaBytes per second. There are 8 bits to a byte, so Megabits measures will be 8 times larger than MegaBytes. Megabits is usually written with a small “b”, as in Mb/sec, while MegaBytes uses MB/sec as the shorthand. (Unfortunately not everyone supports this convention 100% so we do need to be careful.) For example, while DV and HDV 2<sup>13</sup> are 25 Mb/sec, they require about 3.6 MB/sec of storage space: the same data rate, measured with the two systems.

On the charts, note that we use Megabits per second for data rate, but GigaBytes per hour as a measure of the drive capacity needed.

<sup>13</sup> As noted in Section One, HDV 1 is the 720P variation @ 19 Mbits/sec, while HDV 2 is the 1080i version @ 25 Mbits/sec.

You need the Megabits/sec to determine if the storage you're choosing is fast enough for the format(s) you're using. You need the GB per hour to determine how much storage space you'll need for your project. Ten hours of HDV 1 (1280 × 720 at 29.97 fps) will require 10 × 8 GB, or 80 GB of storage. (Add extra storage for renders, animations and graphics.) Ten hours of 1920 × 1080 59.94 fps (rare, but possible with HDCAM SR) at 10-bit 4:2:2 is going to take 10,920 GB to store, plus the additional needed for renders, animations and graphics. Keep in mind that color correction of the entire project will add the project's duration to the required storage.

Using ProRes 422 or DNxHD for that 1080p59.94 project would drop the storage requirements to around 100 GB an hour, even at the higher 220 Mbts/sec ProRes 422 data rate. Both versions of ProRes 422 preserve 10-bit source if it is presented.

## Compressed vs Uncompressed

Most of the time you do not need to work in uncompressed. You would need to work in uncompressed instead of ProRes 422 or DNxHD (or even natively in DVCPRO HD) if there was a contractual requirement for uncompressed that was carefully audited.

There is no way a network Quality Assurance person would be able to detect the use of ProRes 422 or DNxHD in the post-production process once laid back to D5, HDCAM or other mastering format. These modern codecs are much higher quality than even excellent earlier codecs like Media 100's, and a lot of Media 100 compressed footage went to air. Heck, over the years even Avid's old AVR 77 was broadcast and Avid never claimed anything near Broadcast Quality (whatever that actually might be)!

## Drive Size

Complicating things further is the fact that hard drive size is expressed two ways: based on 1000 or based on 1024 per thousand. This is one reason why a 1 GB drive (1000 MB) only contains about 960 MB once formatted. Formatting also reduces the useable space on a drive.

You should always plan on keeping a couple of hundred MegaBytes free on a drive, preferably 1-2 GB, so there is room for directory activity. Some people advocate leaving 10% of the drive free, but my own research with reputable drive manufacturers does not confirm that. As long as there is room for the directory to be written a drive can be filled, with the caveat that it slows down, particularly in that last 20% of capacity.

Be aware that drive performance is not linear. As a drive (or RAID) fills up, it slows down. As a drive gets more fragmented it slows down. For these two reasons it is not advised to decide on storage that barely meets the minimum requirement. Assume the drive will work at 70% of rated speed, or the same percentage of the speed of an empty drive.



This 500 GB drive formats to 465 GB after taking into account the 1000/1024 distinction and space taken by formatting.

# Types of Drive Connections

## Physical storage layer — types of connections and speeds

The common types of connectors in use for video editing systems ranked by speed (slowest to fastest) are:

- USB 2.0
- FireWire 400 and FireWire 800
- Parallel ATA (old style internal drive)
- SCSI (still used at the high end)
- Serial ATA (newer, faster replacement for Parallel ATA, written “SATA” or “eSATA”)
- Fiber Channel
- Direct PCIe bus connection.

## USB 2.0

The original version of the Universal Serial Bus (USB) ran at a slow 11 Mbits/sec — perfectly fine for keyboards and mice, but not for video or audio.

Version 2.0 of the standard upped the speed to 480 Mbits/sec making it usable as a video storage device for DV, HDV, XDCAM HD/EX, DVCPRO HD and AVCP-I in native formats and some variations of DNxHD and ProRes 422 but it is not ideal. In theory USB 2.0 should be faster than FireWire 400, in practice FireWire 400 is faster for video. [Bare Feats](#) did some testing and, regardless of the host, FireWire 400 was Megabytes per second faster than USB 2.0 — in fact FireWire 400 was almost twice as fast as USB 2.0 in their tests.

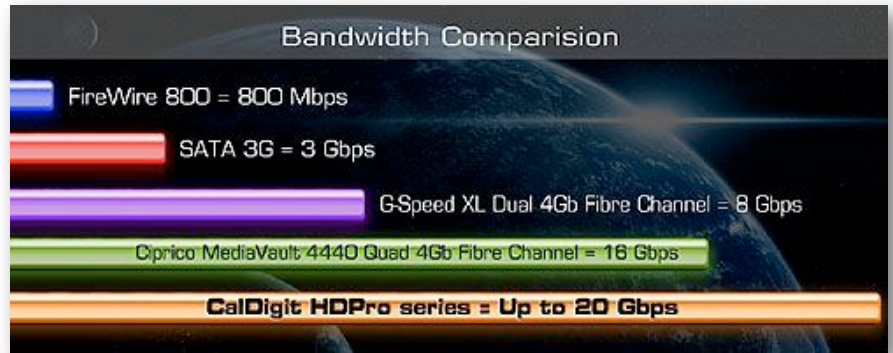


Image courtesy [CalDigit](#)

Like FireWire, USB slows down to the speed of the slowest device on the bus, so if a USB 1 device is connected then it slows all devices to 11 Mbits/sec.

USB connectors have different connectors on computers and devices. They do not connect in a daisy chain fashion, like FireWire, but require hubs. The power available on the USB connector is limited and not usually enough to power a small portable drive, although some such drives come with a special cable to pull power from two USB sockets.

Like FireWire there are no dedicated USB drives — drives that connect to the system using USB. Like FireWire they are usually SATA inside. USB drives are hot swappable and the connectors' design makes it less likely that a connector could be put in backward.

USB 2.0 is not recommended for use in post-production (although many find it quite acceptable for non-stressful work). It can be used for long term or archive/backup storage with the same caveat that drives should be powered on and mounted at least once every three months.



## FireWire 400 and 800 (IEEE 1394)

FireWire is Apple's brand name for the IEEE 1394 standard, just as Sony's name for the standard is iLink. They are all compatible and essentially the same. FireWire's success came when it was adopted for DV camcorders, allowing a simple, one-wire connection between camera and computer for audio, video, Timecode and device control. Before FireWire, connecting a deck or camera to a computer required a hardware card to convert analog to digital, and separate cables for audio, video, and RS422 control.



FireWire is a serial bus interface standard, for high-speed communications and isochronous real-time data transfer. Isochronous is good for video because it ensures that packets of data are delivered in real time sequence, which is why FireWire 400 is faster for video work, in practice, than the theoretical speed advantage of USB 2.0. FireWire is also auto-configuring, as are all modern interfaces, so there is no need to set unit numbers as there is with SCSI or Parallel ATA.

FireWire 400 uses two types of connector: the small 4-pin version (top-right in the picture above) carries data only and is most commonly used on camcorders where the small size is an advantage; and a 6-pin version with power (top-left). The 6-pin version is used to power small drives directly from the computer using two additional pins to carry power. FireWire 800 uses a squarer plug. Adapter cables are common and it is possible to go from 4-pin to FireWire 800 connectors on the one cable. The drives, and bus, slow down to the speed of the slowest device.

FireWire is also an excellent choice for hard drives, particularly for portable units as they can move from computer to computer and are, at least in theory, hot-swappable, meaning you do not need to shut down the computer to connect or disconnect a drive. In practice, it's at least a good idea to power down the drive (after unmounting it) before unplugging it.

Also be **very** careful to plug a FireWire 400 connector the right way around otherwise you may damage the drive or computer.

**WARNING:** Be aware that a FireWire bus will slow to the speed of the slowest device. Most computers have only one bus, despite having multiple connectors and supporting both FireWire 400 and 800. Many cameras are functionally slower devices —

Image courtesy [CalDigit](#)





I have a JVC consumer deck that identifies as FireWire 100 in System Profiler — so the whole bus slows to the speed of the camera. This can be problematic when capturing from FireWire cameras to FireWire drives. Sometimes it's more stable to capture to the internal drive then copy to the FireWire drive after capture because of this bus slow-down with some devices.

FireWire interfaces are common on computers since the late 1990's either built on the motherboard or via an inexpensive card. There are no native FireWire drives — that is drives that connect directly to the FireWire bus. Instead FireWire drives are either Parallel ATA or SATA inside the case, with a FireWire bridge card. The quality of the bridge chipset was particularly important in the early days, as the first bridge chips for FireWire to Parallel ATA, were quite slow. These days bridge chips allow for about 70% of the rated speed of the interface, in the practical world, where FireWire 400 is good up to about 250 Mbits/sec and FireWire 800 is consistent up to about 500 Mbits/sec, well short of the theoretical limit.

FireWire drives are good portable storage and quite suitable for DV and HDV editing, and can be made to work (particularly FireWire 800) for DVCPRO HD and ProRes 422. They can also be used for long-term storage, but all drives for long term storage should be powered up and tested every 3 months. I have more than 1 Terabyte of FireWire storage from ProMax, OWC and Maxtor, although they are only the manufacturers of the case, not the drives inside, except with Maxtor who do make drives.

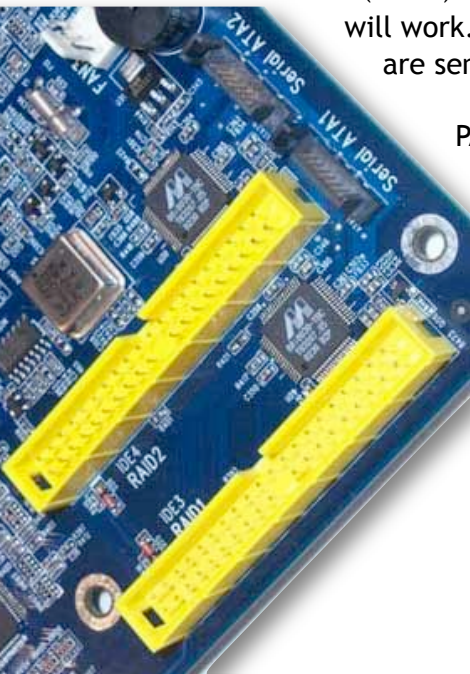
## *Parallel ATA*

The Advanced Technology Attachment (ATA) was the standard interconnect for personal computers from the early 1990's until around 2005. ATA was renamed Parallel ATA (PATA) after the release of the Serial ATA specifications in 2003. ATA drives were also called Integrated Drive Electronics (IDE) drives and Advanced Technology Attachment Packet Interface (ATAPI) interchangeably.

PATA was designed for internal drives with allowable cable lengths up to 18" (46cm) although cables twice that long can be purchased and will work. However the parallel nature of the cable — where data bits are sent at the same time, or "in parallel" — makes the cables unwieldy.

PATA drives became popular for internal storage when companies like the original ProMax (under Charles McConathy) made available cards around the end of last century to add-in additional drives and fool the operating system to see them as SCSI and make them viable for internal storage. PATA drives require the computer to be shut down to add or remove a drive. They are not hot swappable.

These days PATA has faded in popularity and is no longer recommended as a storage technology, assuming you can even buy them.



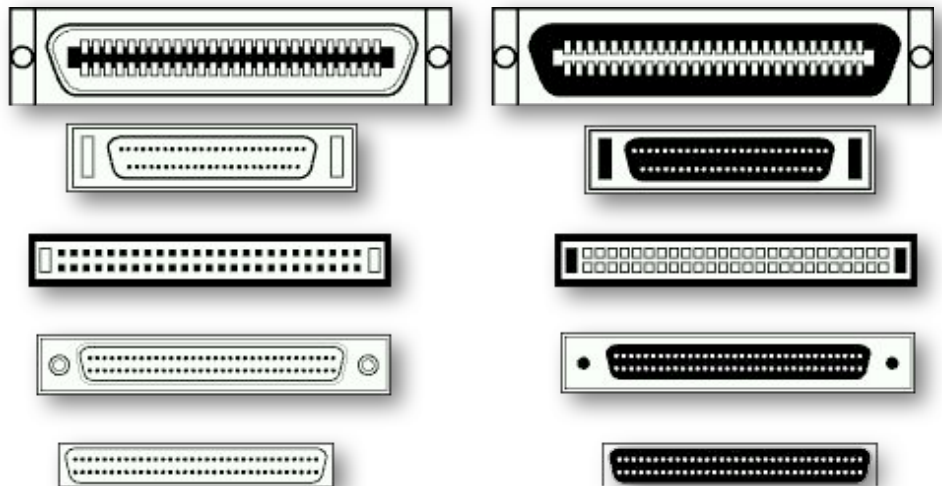
## SCSI

I have to confess, if I never work with SCSI again, my life will be richer for it. For many years, particularly during the time I started in Digital Video in the mid 1990's, the Small Computer Serial Interface (SCSI) was the only drive interface fast enough for digital video. We grew through the original SCSI, SCSI 2 then Fast SCSI, Wide SCSI, Fast and Wide SCSI, and Ultra SCSI and all the variations on that. [Wikipedia](#) identifies ten SCSI variations, with throughput up to 640 MBytes/sec for Ultra-640 SCSI. SCSI drives are manufactured with a SCSI interface and are generally considerably more expensive than the commodity SATA drives.

SCSI usually required an interface card (Host Bus Adapter or HBA) and was finicky about having device IDs set and having the cabling properly terminated. Even so, SCSI drives would unmount, or fail to mount, without apparent rhyme or reason, usually at the most inconvenient time. SCSI drives could not be added or removed without shutting down the computer.

These days there is still some use for Ultra-320 or Ultra-640 SCSI for uncompressed HD work, but for the majority it is overkill. Similar speeds can now be obtained with direct-connect PCI bus connections (see below) for local storage. Storage Area Networks require Fiber channel, although there are some Fiber-to-SCSI bridges to allow fast SCSI drives to be used in a SAN configuration.

SCSI is not essential for HD with compressed video and is not the best choice for uncompressed HD in local or SAN configuration. SCSI was always expensive, but because volume sales have dropped SCSI is becoming more expensive and used less often.



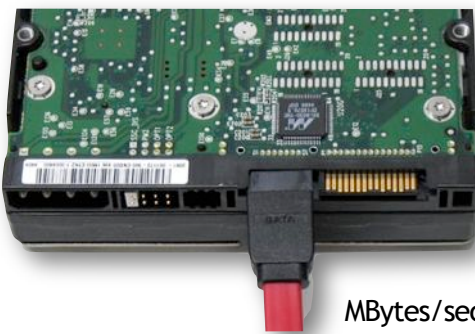
The current incarnation of SCSI — Ultra SCSI, has many different connectors, but the same parallel signal path. SCSI is fussy to work with and modern SATA, Fibre and Direct PCI bus connections are faster.

## Serial ATA

Serial Advanced Technology Attachment (SATA) sends the bits in the signal in series, rather than in parallel. SATA drives are faster than ATA, are hot swappable and use thinner cables. SATA is also more reliable in operation because it has tighter integrity checks on the data.

SATA is intended to replace PATA in all applications. Most computers shipping since 2005/6 will have SATA drives as their primary internal drive and the drives going into FireWire and USB cases are now almost exclusively SATA.

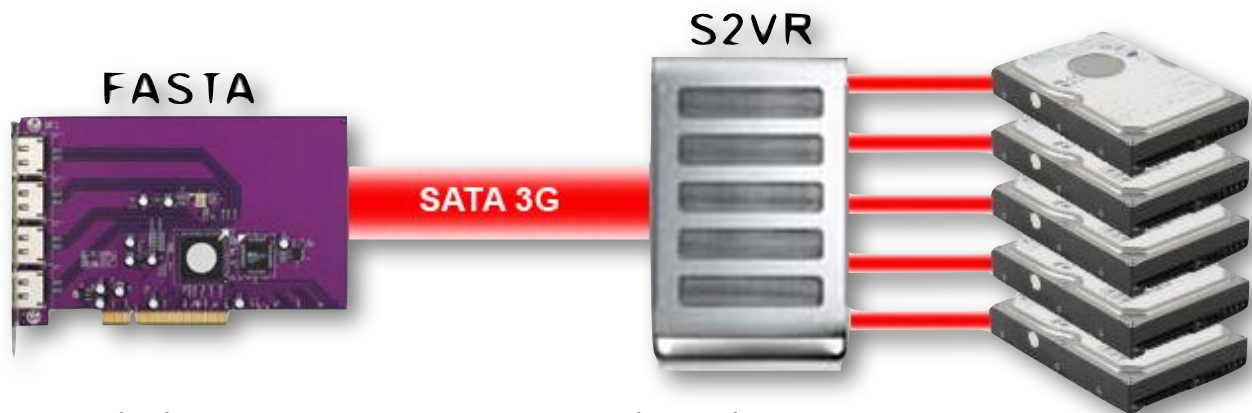
SATA is fast, at a theoretical maximum 3 Gbits/sec (3000 Mbits/sec) or 375 MBytes/sec, on each connection.



## Port Multiplication

The earliest, and still fastest, SATA configurations used a SATA port to communicate one-to-one with each drive. This is the default configuration and makes it theoretically possible to get faster throughput than a single SATA connection allows. This theoretical advantage is hampered by the PCIe bus in the computer being limited to 3 Gbits/sec per “lane”. If the SATA interface card (Host Bus Adapter) is only a single lane card, then multiple connections between the HBA and the drive enclosure will not help speed. If the HBA is a two or four lane card then direct connections to the drives is an advantage. Remember, though, that you need at least a six drive RAID to exceed the 3000 Mbits/sec of a single SATA interface.

In order to simplify the cabling in multi-drive arrays, a technology was developed for SATA called Port Multiplication. Port Multiplication must be supported by the HBA and the drive enclosure, but it allows a single SATA port to be shared among multiple drives. Port Multiplication is now the default connection for SATA



Port multiplication on SATA connections reduces the number of cables required, with a small reduction in total throughput capacity.

Image courtesy [CalDigit](#)

SATA-based storage is now the default configuration for mid-level production facilities. There are small two-drive enclosures available from most of the major vendors (I enjoy CalDigit and FirmTek SATA RAID in two drive enclosures) in both direct connect and Port Multiplied configurations. Storage solutions based on SATA scale up through to eight and ten drive RAID.

There are ExpressCard34 adapters available for SATA, so it can be used with laptops and leave the FireWire port free for devices like an AJA IoHD.

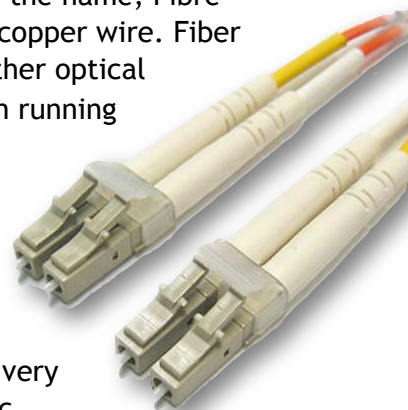
SATA storage is highly recommended for ProRes 422, DNxHD, DVCPro HD, XDCAM HD/EX, uncompressed SD and uncompressed 8 or 10-bit HD up to 720p59.94 at 1105 Mbits/sec. It is marginal for 1080p59.94, but it's unlikely anyone reading this will ever need support for that format! SATA drives, like all drives, need to be considered “fragile” and spun up every quarter, unless configured into RAID 3, 5 or 6. (See next section.)



## Fibre Channel

Fibre Channel is a gigabit-speed network with variants up to 4 Gbits/sec. Despite the name, Fibre Channel networking can be carried on optical fiber (always “er”) or twisted pair copper wire. Fiber Channel always denotes optical while the technology, Fibre Channel, could be either optical or copper. Optical Fiber is somewhat fragile and should be treated carefully when running “cable” to avoid kinking (and breaking) the optical fiber strands. Optical Fiber carries further and faster.

Apple’s Fibre Channel card (HBA) is configured for twisted pair copper but (in)expensive transducers convert copper to optical and back again.



Fibre Channel storage is very fast, and the 4 Gbits/sec version is necessary for uncompressed 10-bit HD at 1080p59.94, but is more commonly used in SAN configurations where Fibre Channel is a requirement. (8 Gbit Fibre Channel HBAs are now available.) There are a number of topographies and networking solutions with Fibre Channel, and once again [Wikipedia](#) has good descriptions.

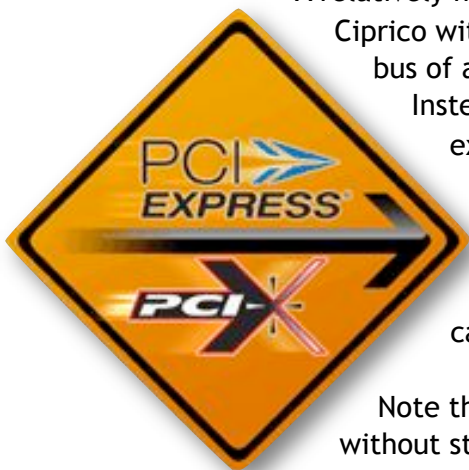
Fibre Channel systems are expensive: about 30% more than similar SATA RAIDs. Use Fibre Channel if you need the benefits of a SAN, but for all other uses SATA or direct PCIe connect will meet storage needs for HD.

## Direct connection to the PCIe Bus

A relatively new development, initially by CalDigit with the HDPro, but also now from Ciprico with the Media Vault 5100, this configuration adds a card to the internal PCIe bus of a tower-style computer (like a Mac Pro or G5 tower) that has no electronics. Instead it merely provides an easy connector to bring four lanes of PCIe to the external RAID controller. Four 3Gbit lanes, meaning there is potentially a 12Gbit connection to the RAID controller — faster than Fibre Channel.

These direct-connect systems are recommended for uncompressed HD at 8 or 10-bit. They are only suitable for local (one computer) storage and cannot be used for shared storage on a SAN.

Note that direct connections to the PCIe Bus cannot be mounted or unmounted without starting up (mount) or shutting down (unmount) the computer. PCIe connects are effectively the same as plugging in hardware cards, something that can only be done when the computer is off.



# RAID Storage — Speed and Security

Most video editing configurations will choose RAID over single drives. Single drives are capable of decent throughput — around 60 MBytes/sec (480 Mbits/sec, just faster than FireWire 400 and around the speed of USB 2.0). But for comfortable, multi-channel editing, a single drive does not have enough throughput for comfortable overhead or multiple streams of video.

A RAID — Redundant Array of Independent (or Inexpensive, depending who you ask) Disks — is a method for providing faster throughput than single drives. It can also be used for providing access to larger pools of storage than single drives, as a result the RAID appears as one logical drive to the computer. The third advantage of using a RAID is that it can be set up with some degree of redundancy. Redundancy means that one of the drives can fail, without losing any data. Redundancy is available in RAID 1, 3, 5 and 6.

There is a detailed explanation of RAID at [Wikipedia](http://en.wikipedia.org/wiki/RAID) for those who want to get further into the technicalities. Here I'm going to summarize the important issues and make some recommendations, without being too detailed or technical.

## *Why is Redundancy Important*

Redundancy gives us the ability to have a drive fail without losing valuable data. How valuable is this? Well, a client recently went through the loss of a 3TB RAID 0 on Mac OS X, and it cost over \$8,000 to recover the data. Like a lot of modern, data-centric workflows, this footage was not available on tape as it had been collected over many years and archived.

With data-centric (or IT-centric) workflows, there is no “tape” to rely on in case of disaster; therefore we need to have multiple copies of our data, preferably in multiple locations. It is also preferable to have any long-term storage happen on RAID 5 or RAID 6 systems, so that one (or two) drives can be lost without losing the data.

## *Useful Levels of RAID*

Disks that are going to make up a RAID are usually housed in a common enclosure, or completely internally inside the host computer.<sup>14</sup> In fact, without being configured (a.k.a. striped) as a RAID, these box-contained drives would go by the acronym JBOD: Just a Bunch Of Disks! In a JBOD, the drives share an enclosure with power supply and fans, and probably a common connection to the computer, but each drive shows as a volume on the desktop with no speed improvement or redundancy. They are indeed just a bunch of independent disks.

There are also differences between software-based RAIDs and those reliant on a hardware controller. That discussion follows.

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<sup>14</sup> Apple's 2008 series of Mac Pro computers will take 3 additional SATA drives that simply slide into the cradle and use the available power and data connectors. The three drives (excluding the boot drive) can be striped into a RAID 0 configuration with up to three 1TB drives. Some users have been known to add an additional drive to the spare optical drive bay for the system (a.k.a. boot) drive and using four drives in a RAID 0 stripe. With Apple's optional RAID card for the Mac Pro, these three or four additional drives can be striped as RAID 1, RAID 3 or RAID 5 to provide some redundancy. CalDigit offer a competing card to Apple's RAID card that is better value.



## RAID 0

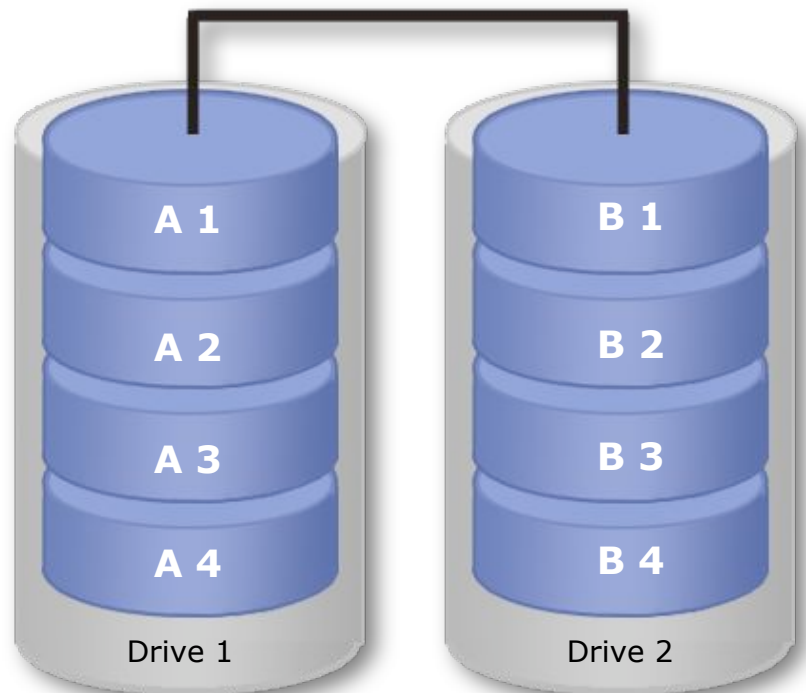
RAID 0 provides no redundancy but increases speed. Two or more drives are striped together to make one logical drive. The controller splits incoming data to each of the drives, so each drive has more time to write the file, increasing throughput. Think of it like a card dealer dealing to multiple players: first card to first player, second card to second player, third card to third player, fourth card to first player (assuming three players), and so on.

The more drives there are in a RAID 0 configuration, the faster the results. There is no lost capacity in a RAID 0 configuration.

**IMPORTANT:** If any drive in a RAID 0 configuration fails, all the data on all the drives will be lost.

RAID 0 is supported at the system level in Mac OS X and Windows without additional hardware or software.

## RAID 0 No Redundancy

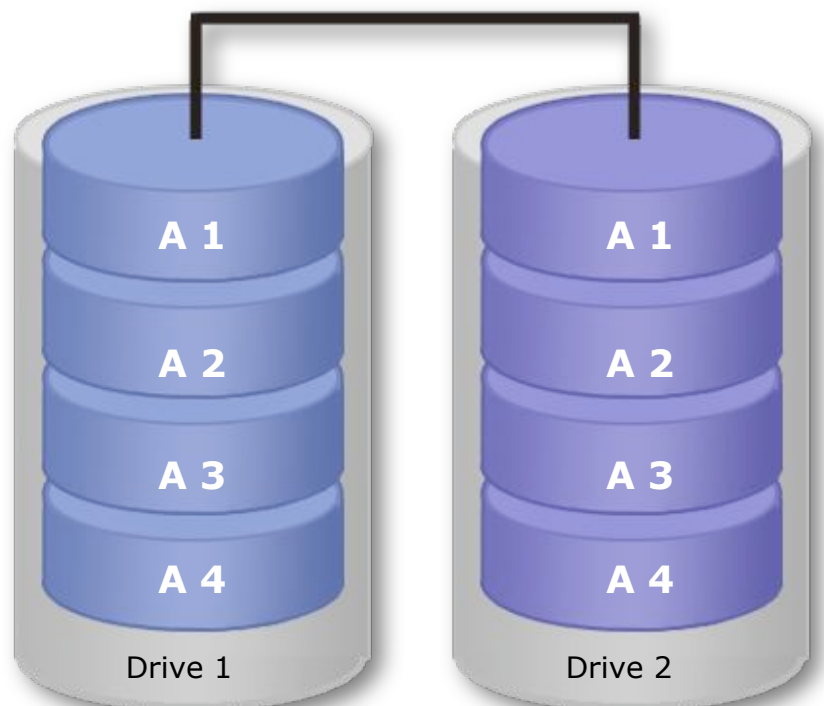


## RAID 1

RAID 1 takes two drives and mirrors the contents of one to the other making a duplicate (or backup) copy. One of the drives can fail and the other drive will still have all the content. In a RAID 1 configuration, replacing a failed drive results in the contents of the remaining drive being automatically copied to the new drive, providing redundancy only after the failed drive has been replaced and has rebuilt from the remaining drive.

RAID 1 reduces capacity to half that of the native drives. Two 500 GB drives in a RAID 1 configuration will have slightly under 500 GB of storage available, because all data is being stored twice.

## RAID 1 Drive 1 is mirrored to Drive 2



RAID 1 has improved read speed over single drives but no speed increase on writing.

RAID 1 is used predominantly when redundancy is required and only two drives are available for the configuration. RAID 1 requires a dedicated housing and are usually configured in hardware.

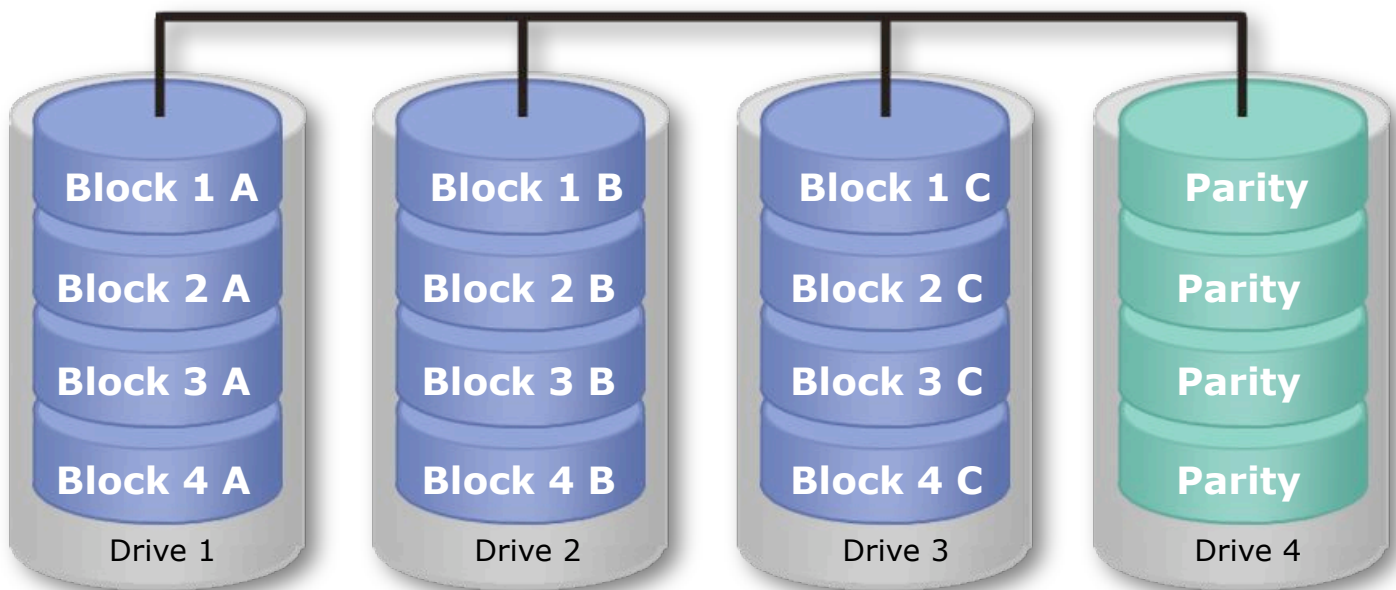
## RAID 3

There is a RAID 2 but it's not used for video work. RAID 3 is configured with at least three drives: two drives carry the data and the third drive carries "parity" information.

Parity information creates a cross check to ensure that data is not damaged. This built-in error checking information is used to detect errors.

RAID 3 provides some speed increase, although not as fast as three drives in a single RAID 0 stripe, with the advantage that one drive can be lost and yet all data will be intact. The dedicated parity drive becomes a bottleneck during writing, making a RAID 3 configuration slower to write to than RAID 0 or 1.

### RAID 3 Parity on separate disk



## RAID 5

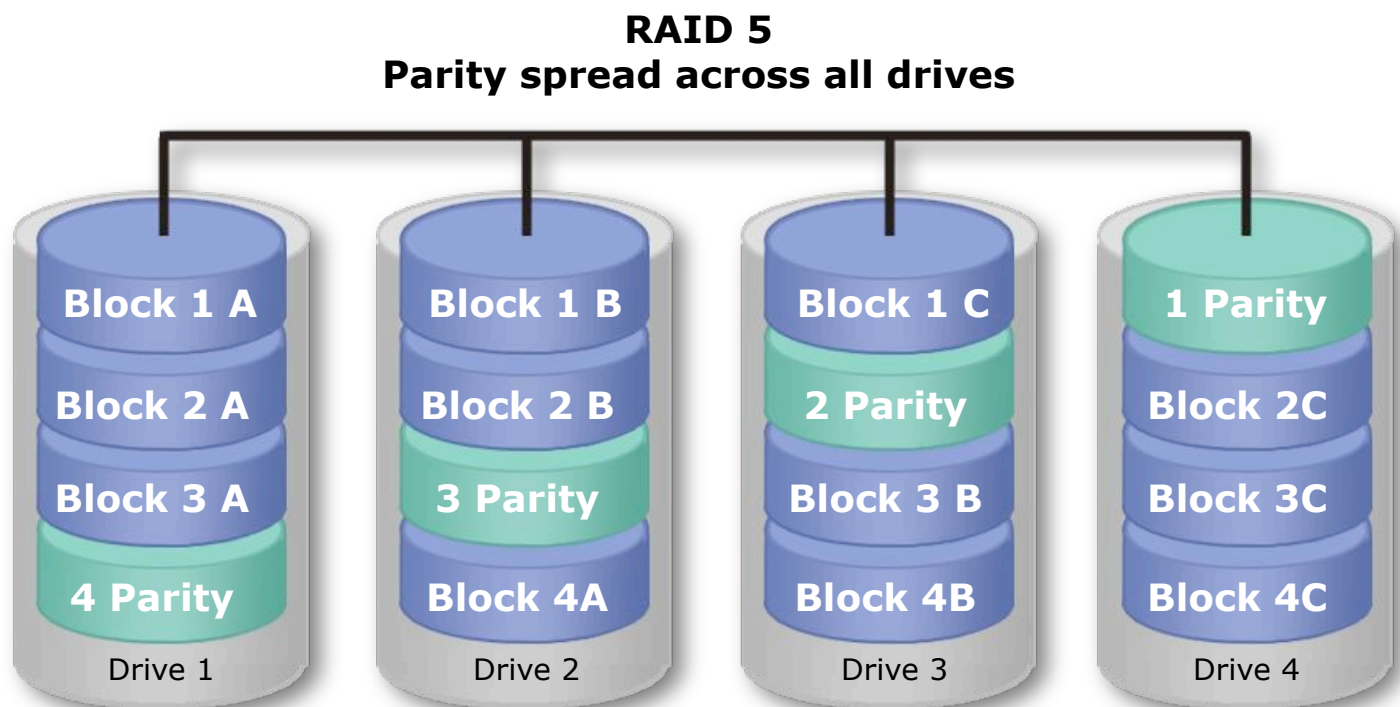
The configuration used most in video post-production where there needs to be a combination of speed and redundancy. Instead of a dedicated disk for parity, causing a bottleneck during disk write, the parity information is distributed across all the drives in the RAID 5 configuration. The disk write is slower than RAID 0 but not as slow as RAID 3.

RAID 5 requires at least three disks, but is much more commonly used with five drives in the array. While it does not store redundant information, therefore only losing the equivalent of one drive's capacity (or 20% in a five drive configuration) the data can be rebuilt from the parity information, so a RAID 5 system will tolerate the failure of one drive without losing data.

RAID 5 configurations can be slow to rebuild after a failed drive is replaced (24 or more hours depending on the size of the array) during which time the system is vulnerable to another drive failure. A second failure before the replacement drive has rebuilt, will result in lost data. The chances of losing two drives within 30 or so hours is low, but those with the most valuable data will want to consider RAID 6.

RAID 5 is slower to write than to read, so it is very suitable for multi-user systems with video data, which needs to be read many more times than it is written.

**Note:** RAID 5 requires that all drives be the same size. If drives of different capacity are used, the "common size" will be used. For example if a RAID 5 array was built from four 500 GB drives and one 750 GB drive, the 750 GB drive will be considered to be 500 GB and 250 GB of capacity will be unavailable.



## RAID 6

Very similar to RAID 5 but requires at least five drives. The parity information is written across multiple drives, which allows two drives to fail at once, without losing data. RAID 6 is recommended for the highest level of fault and drive-failure tolerance.

Speeds are similar to RAID 5, but a five drive RAID 6 will have approximately 20% less storage space than the same stripe configured as RAID 5.

## RAID 50, 60

A RAID 50, also written RAID 5+0 takes two RAID 5 configurations and stripes them as a RAID 0 array for the speed increase. Within each RAID 5 array, one drive can be lost without losing data. If more than one drive is lost in either RAID 5 array, the entire combined array's data will be lost. This configuration is necessary to get appropriate speed for uncompressed 10-bit HD.

RAID 60, as I'm sure you've guessed, is two RAID 6 arrays, striped in a RAID 0 configuration to increase speed. RAID 6's fault tolerance (two drives per array) continues into the RAID 60 configuration.

RAID 50 or RAID 60 is necessary for working with uncompressed 10-bit HD.

## Summary

In summary, RAID 0 for speed but no redundancy; RAID 5 for speed and "usual" levels of redundancy and protection against data loss; and RAID 6 for those paranoid about data loss. RAID 3 is less common in video post-production.

There are excellent units in all of these configurations, across multiple types of interfaces from [CalDigit](#), [Dulce Systems](#), [G-Tech](#), [MAXX Digital](#) and others.

## Software or Hardware RAID

From a user's perspective there's no difference between hardware and software RAIDs during normal operation. The difference comes down to performance and reliability.

In a software RAID, whether it's using the system-level RAID software for Mac OS X or Windows, or a third-party addition, the work for managing the RAID is done entirely by the main CPU. It is theoretically possible to have a host processor hiccup that causes some data interruption but I've never seen nor heard of it happening. Data loss is extremely uncommon and remains a risk in theory more than in practice.

With a software RAID, the host processor has a direct connection to each drive and controls each drive independently, building the RAID capability in software.

Software RAID 3, 5 or 6 is definitely preferable to having no RAID at all, but a dedicated hardware RAID is faster because it takes processor load off the CPU, which otherwise has to control the RAID as well as other tasks, and system independent.

Hardware RAID controllers are printed circuit boards that are built into the drive unit. The drive unit presents itself as a single logical unit to the host – the host sees one drive. The hardware controller handles all the RAID work. These units generally have some sort of switch to select the type of RAID configuration required. Hardware RAID controllers come already configured into a RAID from the manufacturer.

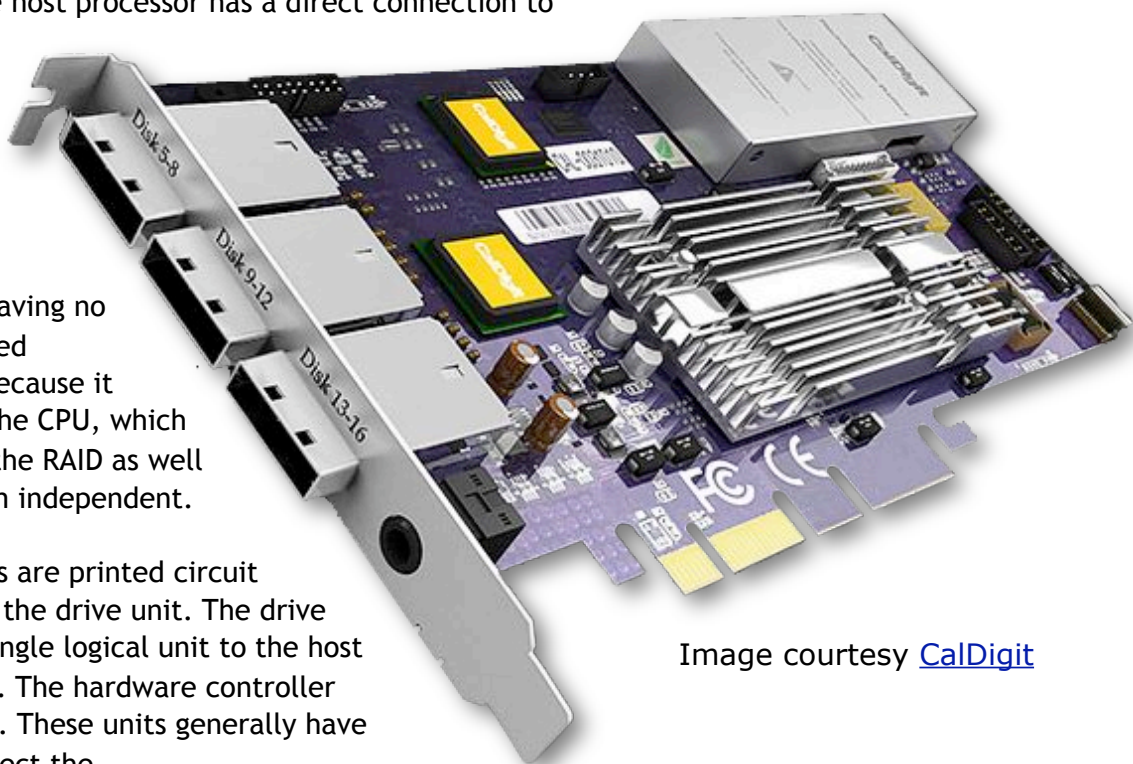


Image courtesy [CalDigit](#)

CalDigit's June 2008 Hardware RAID card supports RAID 1, 3, 5, 6, 50 and 60 with up to 4 internal and 12 external drives.

Hardware RAIDs can be moved from system to system, and theoretically at least, from operating system to operating system. Hardware RAIDs definitely support more system configurations without needing to reformat the RAID, than do software RAIDs.

Hardware RAID controllers are slightly more expensive than software.



## DAS, NAS, or SAN?

Historically, and in the vast majority of configurations, storage is directly attached to the host computer and serves the needs of that one computer. This configuration is known as Direct Attached Storage (DAS) among those who care to give these things names other than “hard drives”! For DAS most people will select FireWire, SATA or Direct PCIe solutions.

Network Attached Storage (NAS) is used extensively in corporate networks but is less suitable for production storage because it is limited by the speed of the Local Area Network (LAN). The fastest LAN in common use is Gigabit Ethernet, which is theoretically 1000 Mbits/sec (125 MBytes/sec) but in practice is much slower. I know of people using NAS on a Gigabit Ethernet network for DV successfully, but it will depend on what other traffic is carried on that network. A dedicated (not shared with everyone else in the office) network is required and it can be a relatively inexpensive way to share media to multiple workstations in a facility.

However, for video post-production, a Storage Area Network (SAN) is the preferred method for sharing storage. Modern SANs have

traditionally been universally based on Fibre Channel connections through a Fibre Channel switch to (usually) Fibre Channel Storage. Although some vendors showed previews of PCI-bus based SAN as far back as NAB 2008, none have yet to deliver. However, with increased throughput on Ethernet people like Bob Zelin and Maxx Digital have developed the inexpensive [Final Share](#). Bob wrote about a build-it-yourself version [at CreativeCow.net](#)

Shared storage is more efficient than local storage because it avoids situations where one workstation may be pushing the limits of available storage while another has plenty. By sharing the storage in a central location, all the storage is available to everyone, or those that have permission to use it. All modern SAN systems have the ability to limit particular workstations to specific folders on the SAN.

The main advantage of shared storage, in addition to the efficiency of having a single pool of storage are:

- Centralized drives are quieter and easier to control for temperature;
- Simplified management and allocation of resources; and
- Improved scalability.

The efficiency improvement for a group working on a common project is hard to quantify but very real. Even single-employee post houses can gain efficiency if they are a multi-tasker that can keep more than one computer busy with rendering and encoding tasks, because the same media is available on any other computer on the SAN.

There are two primary variations in SAN systems. The simpler and less expensive systems use volume level access control while Avid's Unity and Apple's Xsan, [Editshare](#) and a new version of [Facilis' Terrablock](#) use file level access control. Editshare also has the ability to share (certain types of) media between Media Composer and Final Cut Pro simultaneously.



## Volume level SAN

With a volume level SAN the pool of storage is partitioned into volumes and each volume has read and write permissions. Read and write permissions are managed so that (typically) everyone can read from all volumes (or all relevant volumes) but only one person/workstation can write to a specific volume at a time. One workstation handles all digitizing (and some editing), while the others edit that material only.

This type of SAN is available from [Studio Network Solutions](#), [Facilis Technology](#), [CommandSoft](#) and [EditShare](#).



SAN MP systems can be configured with components from many manufacturers, held together with the SANmp software.

## File Level SAN

With a File level SAN the pool of storage is only partitioned for management purposes. It is not necessary to partition for access control. With this type of configuration one editor can be writing to a file at a time, but all others can read that file, or write to other files on the SAN. Only one file at a time is blocked from writing by everyone.

File Level SANs like [Unity](#) and [Xsan](#) are more complex to set up and maintain, requiring attention from specialists.

**Note:** Final Cut Pro will work with Avid Unity as a full client but Avid clients will not work on Apple's Xsan.



# Capturing HD

There are six ways of capturing HD:

- Component Analog
- HD-SDI
- Dual Link HD-SDI
- HDMI
- Data Transfer (USB 2.0 or FireWire)
- Solid State media card

Component Analog, HD-SDI, Dual Link HD-SDI and HDMI capture all require the addition of some third party box or card to convert the incoming signal into something that an NLE can use. For Final Cut Pro, Blackmagic Design and AJA both have a range of solutions for capture.

Direct data transfer over USB 2.0 or FireWire, or plugging in a solid-state media card directly to a computer's ExpressCard34 or PC Card slot requires no additional hardware.

**Note:** Sony's SxS media plugs into the more modern ExpressCard34 slot available on MacBook Pros while Panasonic's P2 media card fit the older PC Card (a.k.a. PCMCIA or Cardbus) slot. There are [adapters available](#) to convert from one to the other.

## ***8 or 10 bits?***

One thing that comes up regularly is a choice between 8- and 10-bit capture. What is being measured here is the accuracy of the analog-to-digital conversion. When a sample is taken, is it measured in 8 bits or 10 bits? The same signal can be measured in both, but the 10-bit version will more accurately represent the source. The accuracy of the sampling is unrelated to "color sampling" expressed as a ratio measuring how often the color is sampled on the screen, compared with how often the color signals are sampled on the screen. These are the common [4:2:2, 4:1:1 and 4:2:0](#) ratios we're all familiar with. The ratio defines how often the samples are taken, while the bit-depth defines the accuracy of each sample.

8-bit codecs can define 256 levels (per channel) between black and white. That's the limit that can be encoded in 8-bits and can lead to banding on smooth gradients. Traditionally the fix for smooth gradients and 8-bit codecs was to add a small (1-3%) of Gaussian, monochrome noise. All delivery codecs are 8-bit. Most acquisition codecs are 8-bit. The sole exceptions are those that use AVC-I (Panasonic) or capture with the AJA [Ki Pro](#), which both capture 10 bit source.

However, a better solution is a 10-bit codec. The extra two bits gives 1024 steps between black and white in each color channel for much smoother gradients and improved accuracy in compositing because there is more "working room" during compositing.

Of course, nothing comes for nothing, and 10-bit files are about 25% bigger and therefore higher



8 bit images can cause banding on subtle gradients. 10 bit images can render smooth gradients, at the cost of larger files and higher bandwidth.

data rate throughput is required of all storage, and more storage is required. 10-bit HD is challenging to work with and definitely needs the “Rolls Royce” of storage and hardware. It is common with 10-bit 1080 to work with RAID 50 or 60 (Two RAID 5 or RAID 6 units in a RAID 0 stripe).

It’s also important to note that converting down from 10-bits to 8-bits is, as they say, non-trivial to do correctly. Simply cutting off the two least significant (over at the right) bits is only used by the most crude down-converting tools and banding is bound to occur. The better tools dither when down-converting to disguise the loss of the extra accuracy.

To work in HD at 10-bits means working in uncompressed or ProRes 422 because DVCPRO HD, XDCAM HD/EX and HDV are all 8-bit codecs.

## Are ProRes 422 and DNxHD 8 or 10 bits?

Apple’s ProRes 422 and ProRes 422 (HQ) are 10-bit codecs. This is explicitly stated in [Apple’s White Paper](#):

“Normal ProRes 422 provides excellent preservation of either 8-bit or 10-bit source quality at an economical bit rate.”

Avid’s DNxHD family of codecs have specific 8 bit and 10 bit versions. The 10 bit version of the codec is delineated by an “X” at the end of the codec name. For example DNxHD 220 is an 8 bit codec, while DNxHD 220X is the 10 bit version.

**Note:** The 10 bit versions of the DNxHD family use the same data rate as the 8 bit version, so the 10 bit version is very, very slightly more compressed. This is similar to what happens with the ProRes family where 8 or 10 bit source both conform to the same data rate.

## ***Embedded Audio, AES/EBU or Analog?***

You'll find that audio for HD comes into the computer in five ways:

- Analog, usually with XLR professional connectors;
- Embedded in the HD-SDI data, which has the advantage of putting audio and video on the same (single) cable;
- As AES/EBU digital audio data;
- Included in the HDMI signal; or
- As part of the digital transfer via Log and Transfer (DVCPRO HD, AVCHD), the XDCAM utility or via FireWire.

### **Analog**

If your source is HD analog video, then it's likely your audio will be analog as well. Analog audio via XLR connectors for signal input and output is common on capture cards. Most capture cards that support analog audio also provide an unbalanced signal on RCA connectors for local monitoring.

### **Embedded in the HD-SDI data**

The HD-SDI specification provides for 16 channels of embedded audio — on the same cable as the digital video. HD-SDI embeds up to 8 pairs of channels (16 total) but most interfaces support only 8 channels. Each channel is 48 kHz, 24-bit uncompressed audio. A dual-link interface can carry 16 channels per link for 32 channels total on one cable with the video.

### **AES/EBU**

This digital audio standard is also called (officially) AES3, but every capture card or device refers to it as AES or AES/EBU. S/PDIF is a consumer version of AES/EBU. One of the things that makes AES/EBU audio appear complicated is that it can be carried on three different types of connectors:

- Balanced XLR connectors, the same as used by analog audio;
- Unbalanced 2 conductor, 75 Ohm coaxial cable with RCA type connectors, mostly used in consumer audio; and
- An optical fiber connector, also used in consumer applications.

AES/EBU signals are a Pulse Code Modulated (PCM) at 48 kHz or 44.1 kHz uncompressed. The AES/EBU format supports both rates by officially supporting neither. The data can be run at any rate, because the clock rate is also encoded. Clocking and re-clocking of AES/EBU signals is important.

### **HDMI**

With a number of capture hardware supporting direct HDMI input from those cameras that provide it the HDMI audio is also captured from the uncompressed source.



# Getting video into the computer world

## *Component Analog HD*

Many decks, including the inexpensive Sony HDR-M10, provide component analog HD video. This can be fed to a capture card that converts analog HD component to digital signals for encoding to an appropriate codec (compressed or uncompressed HD), including ProRes 422.

The component HD signals are a variation on YUV signals used in Standard Definition analog video. While there are many YUV variations, you can think of HD component signals as being like an HD version of the Betacam component outputs.

HD Component signals, because they pass through an analog stage from digital and then back to digital again, do not maintain as much signal integrity as HD-SDI, but there are situations where the component analog provides a nicer looking image than direct digital transfer. Component analog from the HDR-M10 provides a useful signal path for real-time capture to codecs other than

HDV although that is somewhat less necessary with Final Cut Pro 6.0.2 onward, where even a dual G5 can capture directly from HDV to ProRes 422 in software, over the FireWire cable. This is not a real-time capture on low-end systems, but rather the incoming signal is buffered so it can be converted to ProRes 422.



Component Analog HD has its uses but it is no longer a mainstream requirement.

Component Analog HD input for Final Cut Pro is available on the [DeckLink HD Series](#) from Blackmagic Design (BMD), [Multibridge Pro](#) (BMD), [Kona LH series](#) (AJA), [Io HD](#) (AJA), [MXO2](#) (Matrox) and [V4HD](#) (MOTU).

Component Analog HD input for Media Composer is available on Nitris DX.

## *HD-SDI and Dual Link HD-SDI*

It might look like a regular composite video cable, but it's not. HD-SDI is a high-speed serial interface between video equipment that carries digital video and multiple channels of digital audio. The video signal carried on the cable is both uncompressed and unencrypted. HD-SDI is transmitted at 1.485 Gbits/sec or, in a new standard for dual-link over a single cable, 3 Gbits/sec. HD-SDI is standardized in SMPTE 292M. The 3 Gbits/sec version supports the older standard but is designed for all 4:4:4 RGB workflows over a single connector (instead of dual-link HD-SDI) or full resolution 2K film playback at 2048 × 1556 pixels (at 24 fps).

HD-SDI is a convenient connection carrying HD video and up to 8 channels of uncompressed 48 kHz audio on one cable.

**IMPORTANT:** SDI cables may look like composite coax and both use a BNC connector, but the impedance of cable and connector is different for HD-SDI. Attempting to use a regular composite BNC cable A 75 Ohm Composite video cable with 75 Ohm BNC connectors will probably work over short distances (up to 6' for example) if used on HD-SDI equipment, but over longer distances the Composite cable and connectors will give failed connections, lost sync or other transfer issues.

HD-SDI is not suitable for very long distance transmission as it has been designed for short distances and the high data transmission rate would fail over extended distances. HD-SDI interfaces tend to be found in the higher end, more expensive decks, supporting “professional” formats or professional versions of decks.

HD-SDI provides a standardized, format-independent way of interconnecting HD equipment. Sony's HDV format HVR-1500 provides an HD-SDI signal that could be recorded by a Panasonic AJ-1400 DVCPRO HD deck. Both could feed into Final Cut Pro via an AJA or Blackmagic Design hardware interface and can be compressed to any format supported by Final Cut Pro in software. HD-SDI is the universal video interchange format but is not provided on inexpensive decks or cameras designed for direct FireWire connection to the computer. HD-SDI transfer maintains the highest signal integrity when copying from format to format, tape-to-tape, computer input or computer output.



See section following on [Video Interface and Capture cards](#).

HD-SDI input for Final Cut Pro is available on the [DeckLink HD Series](#) from Blackmagic Design (BMD), [Multibridge Pro](#) (BMD), [Kona LH](#) (AJA), [Io HD](#) (AJA), [Io Express](#) (AJA), [MXO2](#) (Matrox) and [V4HD](#) (MOTU).

HD-SDI for Media Composer is available on Mojo DX and Nitris DX.

## Dual Link HD-SDI

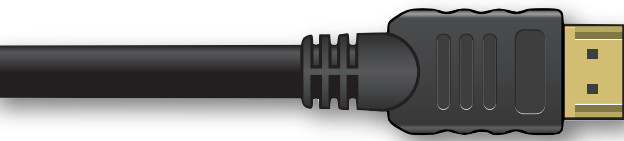
Until the advent and adoption of 3 Gbits/sec HD-SDI, two connections working in parallel were used to carry 4:4:4 RGB (full bandwidth) from XDCAM SR to a computer. A Kona 3 or Blackmagic Design Multibridge Pro/Eclipse are needed to capture Dual Link HD-SDI to Final Cut Pro.

Unless you have a need to deal with 4:4:4 RGB you can ignore Dual Link HD-SDI.

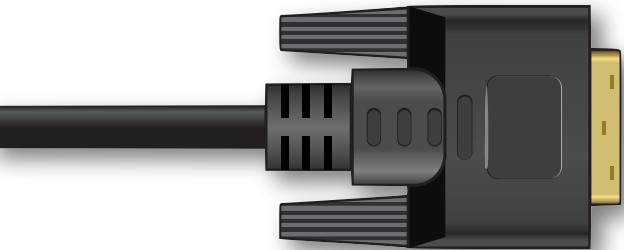
Dual Link HD-SDI is available on the Decklink HD Extreme (BMD) and all Multibridge models. From AJA the Kona 3 supports Dual Link HD-SDI. There is no dual-link HD-SDI hardware for Media Composer: Avid reserves it for DS Nitris DX.

## HDMI — High Definition Multimedia Interface

HDMI is an interface that anyone can license and incorporate into their products. Originally intended for high quality digital hookup between devices like HD players and Televisions, HDMI has been appearing on more and more inexpensive cameras, providing an uncompressed signal, similar in quality to HD-SDI, although on a multi-strand cable and a very small 19-pin connector.



HDMI supports standard, enhanced definition and all HD formats supported within the US ATSC broadcast system (23 or 34 formats, depending on who you ask) with up to 8 channels of audio. Audio up to 192 kHz sample rate at 24bit sample depth is supported. (Compare that with “CD quality” at 48 kHz sample rate at 16bit sample depth.)



At the time of writing, HDMI input is supported on the Blackmagic Design [Intensity or Intensity Pro](#) or AJA's [Io HD](#). With either of these and Final Cut Pro, HDMI uncompressed output from the camera can be captured to an uncompressed file<sup>15</sup>, ProRes 422 or other codec during capture. (With some minimum hardware requirements.)

The advantage of HDMI on cameras is that, as with those cameras with HD-SDI out, like Canon's XL-H1S and XH-G1, live video is sent out the HDMI port without being compressed first. This is perfect for a multi-camera situation using Blackmagic's [On-Air](#) software for a live studio switcher. Recorded HDV is decompressed for output through the HDMI port, but it still retains any compression artifacting caused by the compression to record. (Only live video comes out in uncompressed quality.)

HDMI was built to support content protection via HDCP (High-bandwidth Digital Content Protection). Intel developed HDCP to protect digital video and audio as it travels from player/output device to the screen. Both ends of this connection must support the same level of HDCP otherwise the output is restricted to standard definition, or blocked completely. This usually won't affect production folk unless they attempt to capture HDCP-protected content over HDMI. It won't work because HDCP is designed to prevent any further use of the protected material.

HDMI output from a camera, in combination with a capture interface card (or box) makes a very powerful capture tool (and interface to HDMI monitors as well). Intensity and Intensity Pro (BMD) supports HDMI on Intel-based Mac Pros. AJA supports HDMI input and output on the Io HD and Io Express.

There is no HDMI input on any supported Avid hardware for Media Composer.

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<sup>15</sup> The AJA Io HD only supports ProRes 422 directly. It is possible, but not recommended because there is no benefit, to decompress the ProRes 422 to uncompressed within the computer.

## *Data Transfer (FireWire and USB 2.0)*

### FireWire



Since the advent of DV and the near-simultaneous adoption of the FireWire, or IEEE 1394, interface, direct data transfer of digital formats has become common. DV (DVCAM and DVCPR0 25), DVCPR0 50, HDV and P2 cameras and XDCAM EX all allow transfer of data from the camera, or deck, to computers equipped with FireWire interfaces.

Data transfers are just file copies, although in some cases Final Cut Pro and Media Composer need to transcode the footage to a different format, or rewrap the source into a file container/swapper. Rewrapping to a new container (from, say, XDCAM EX's MP4 to QuickTime in Final Cut Pro).

Whether the digital file is on a tape, solid state media, hard drive, optical disc or other media format, this type of ingest (capture, digitize or import) is a bit-for-bit copy from

the source to the computer format unless transcoding is required. Some data is reformatted. For example, the native DV format would use the .dv suffix on a Mac, but when Final Cut Pro captures DV it demultiplexes the audio, video and Timecode data and puts each in their own track in a QuickTime movie. The data is not changed, just the way it's packed.

However, because it's a file copy, no modification of the signal is possible. Expecting to adjust video level, color or saturation for a data transfer would be a similar mistake to expecting that a Word document could be spell-checked as it was copied from a USB memory stick to a hard drive. It's just not possible.

Several devices use the FireWire bus to communicate with their outboard hardware: AJA Io and Io HD and Avid's Mojo and Adrenaline. These devices pass compressed video between computer and the input/output connectors on the external bus. The FireWire bus **cannot** be used for storage or camera communication when these devices are plugged in and active.

**IMPORTANT NOTE:** The FireWire bus slows down to the speed of the slowest device as we noted when discussing FireWire for storage.

Most modern computers come with FireWire built-in. To use an Io or Io HD and FireWire storage, a second FireWire bus must be provided via a PCI/PCle card.

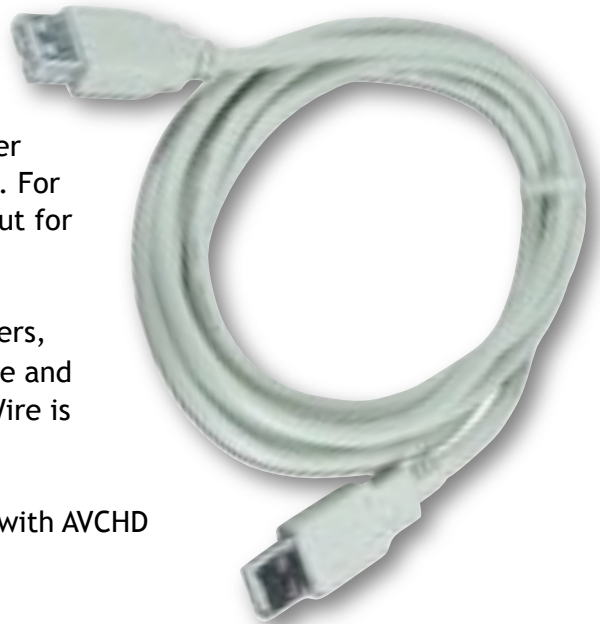


## USB 2.0

As I've [noted earlier](#), although USB 2.0 is theoretically faster than FireWire 400, in practice it's not the way it works out. For real-time delivery of video USB 2.0 isn't the best choice, but for data transfer it is quite fast enough for import functions.

USB 2.0 is becoming common on [AVCHD](#) consumer camcorders, probably because it is cheaper for the chipset than FireWire and because USB 2.0 is ubiquitous on Windows PCs where FireWire is often an add-on card.

USB is available on all modern computers and can be used with AVCHD cameras and the Log and Transfer window.



## *Solid State Media — P2 and SxS*

Both P2 Media cards and SxS cards will plug directly into certain laptops for direct data transfer from the card to hard drive(s) without needing to connect via FireWire or USB.

Panasonic's P2 media conforms to the older PC-Card (PCMCIA, Cardbus) design last used on Apple's PowerBook series (and other laptops of that era) and is based on a PCI-X style interface.

Sony's SxS media uses the more modern ExpressCard 34 design. These card slots are based on a PCIe design and are currently available on Apple's MacBook Pro series.

As noted earlier, there are adapters to convert between the two physical formats and electrical connections to allow a P2 card to be plugged into a modern computer, and to allow SxS to work in an older laptop.



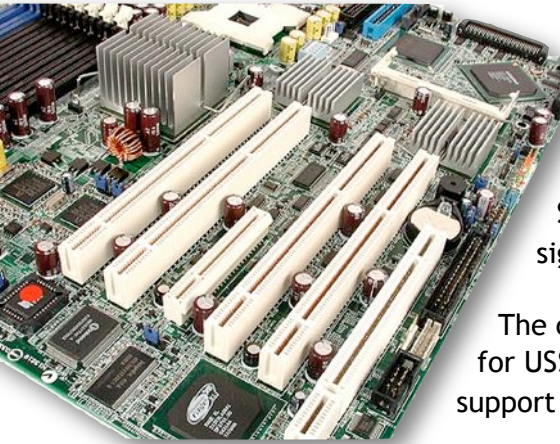


# Video Interface and Capture cards

So-called “Capture cards” have evolved into three broad groups: internal cards, FireWire Bus connected and external PCIe connected.

## *Internal PCI, PCI-X or PCIe card*

The traditional approach to a capture card was to install a PCI, PCI-X and now PCIe card inside the computer, which connected through a multi-pin connector to a breakout box with input and output connectors, or to a pigtail of connectors.



They improve Final Cut Pro performance by shifting some of the work to the card, leaving more processor power to devote to real-time effects. For example, the Kona LH series will downconvert HD to SD on the card. Final Cut Pro sends the images from the Sequence as they are to the card, which scales and outputs the signal, converting to analog if necessary.

The cards vary in price and capability from the Decklink HD Extreme card for US\$995, through to cards, from both Blackmagic Design and AJA, that support analog input and output and on to the Kona 3 and Multibridge series.

Old style PCI slot

## **PCI, PCI-X and PCIe**

Since it was first adopted in 1992, the PCI bus — Peripheral Component Interconnect if you care — grew as the demands of personal computers grew. The original version went through 33 MHz and 66 MHz variations. PCI is based on parallel pathways. PCI was introduced as a 32-bit pathway, but later added a 64-bit version. The 64bits/66MHz version was capable of 532 MBytes/sec data transfer through the bus.

In 1998 IBM, HP, and Compaq submitted a proposal for PCI-X, Peripheral Component Interconnect eXtended. This version only supported 64-bit pathways and was introduced at 100 MHz but later evolved to 133 MHz. At 64bits/133MHz, PCI-X could sustain 1 GByte/sec data transfer through the bus.

Unlike PCI and PCI-X, PCI-Express (PCIe) is not based on a parallel data path. PCIe is built around the concept of “lanes”. Each lane is unidirectional (one way) connection between two points in the computer. This is just about the opposite of the earlier versions where all devices shared access to the same bi-directional (two way) parallel signal path. Obviously the point-to-point connections are created and released as needed.



PCIe Slots

The speed of a single lane depends on the version of PCIe being used. PCIe 1.1, probably the most common on computers before the end of 2007, carries data at 2 Gbits/sec (250 MBytes/sec) point-to-point. PCI 2.0, shipping in Mac Pros since late 2007 doubles the speed of a single lane to 4 Gbits/sec (500 MBytes/sec) and eventually PCI 3.0 will take the speed higher some time around 2010.

Each PCIe slot carries either one, two, four, eight, sixteen or thirty-two lanes of data between the card and the motherboard. In a Mac Pro sixteen lanes connect every slot, but only a limited number of slots can be allocated between cards. (On 2007-2008 Mac Pros, there are 24 or 25 total lanes available to be allocated to cards.) Lane allocation is done with the Expansion Slot Utility. The documentation that comes with your capture card will recommend slot configuration.

**Tip:** The Expansion Slot Utility should run when a new card is detected, but in some situations, where there are not sufficient slot allocations free to trigger the recognition of the card you can run the Utility manually. The application can be found in *Your Hard Drive>System>Library>CoreServices*. Run it and change the allocation of lanes.

The more lanes that are added to a card the faster the communication: two lanes is twice as fast as one, and four (the usual minimum for a capture card) is twice as fast again.

To put the speed differential between PCIe and its predecessors into perspective, a single lane has more than twice the data rate of the original PCI standard, and four lanes will give the same data transfer as the fastest — 64bits/133MHz — version of PCI-X.

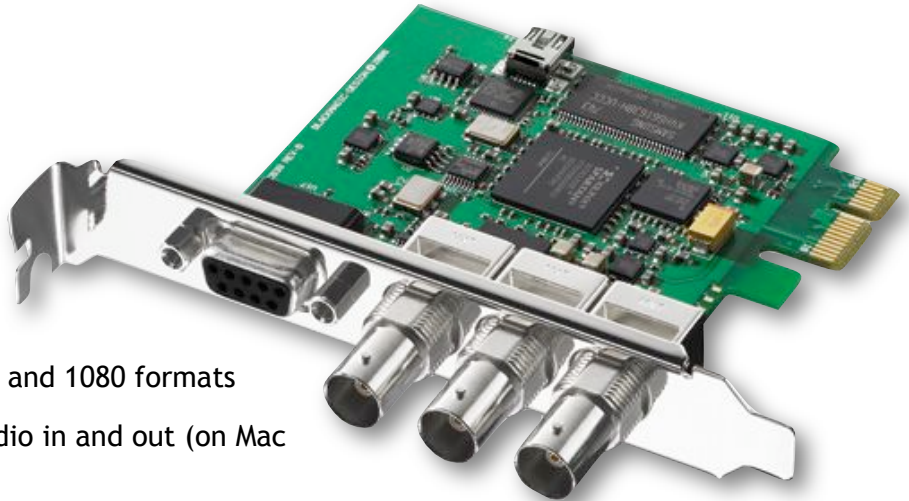


# *The HD Internal PCIe Cards for Final Cut Pro*

## Blackmagic Design

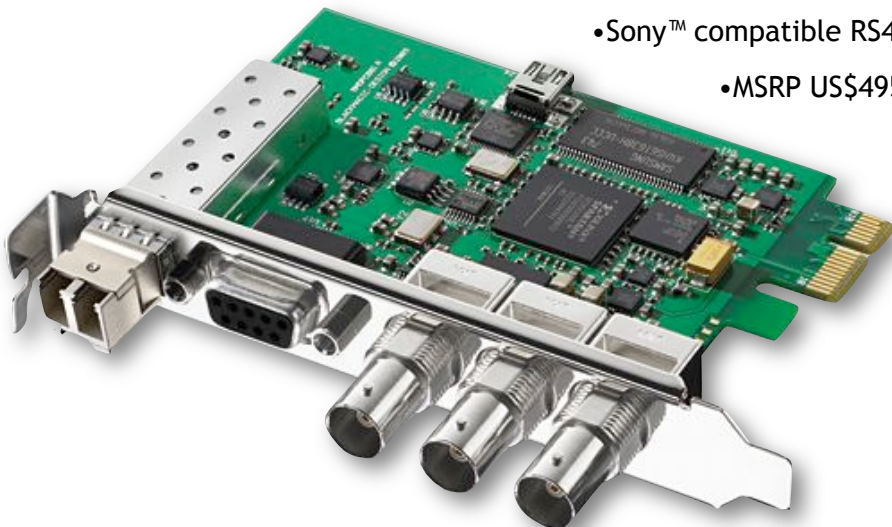
### Decklink SDI

- SD/HD-SDI input and output
- SD/HD analog input and output
- Supports PAL, NTSC, 720 and 1080 formats
- Eight channels of SDI audio in and out (on Mac OS X)
- Real-time up conversion from 720HD to 1080HD during video capture
- Sony™ compatible RS422 deck control ports
- MSRP US\$295 (Street \$280)



### Decklink Optical Fiber

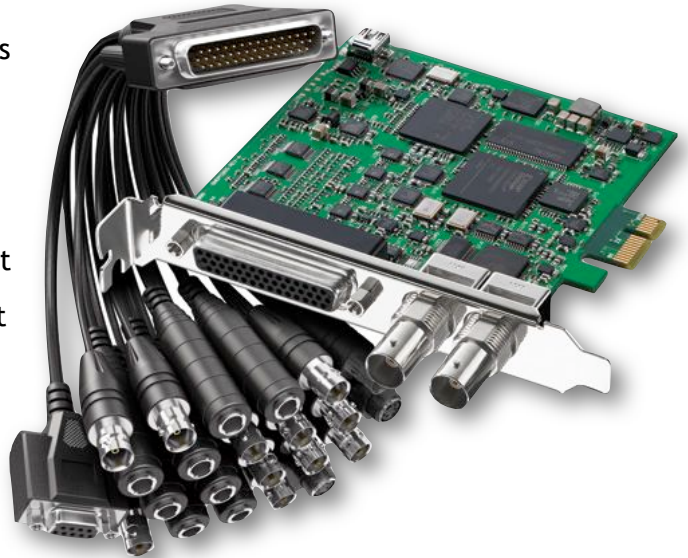
- SD/HD-SDI input and output
- SD/HD analog input and output
- Supports PAL, NTSC, 720 and 1080 formats
- Eight channels of SDI audio in and out (on Mac OS X)
- Optical Fiber Video in and out SD/HD switchable
- Eight channels of Optical Fiber audio in and out embedded on the HD SDI signal
- Real-time up conversion from 720HD to 1080HD during video capture
- Sony™ compatible RS422 deck control ports
- MSRP US\$495 (Street \$470)





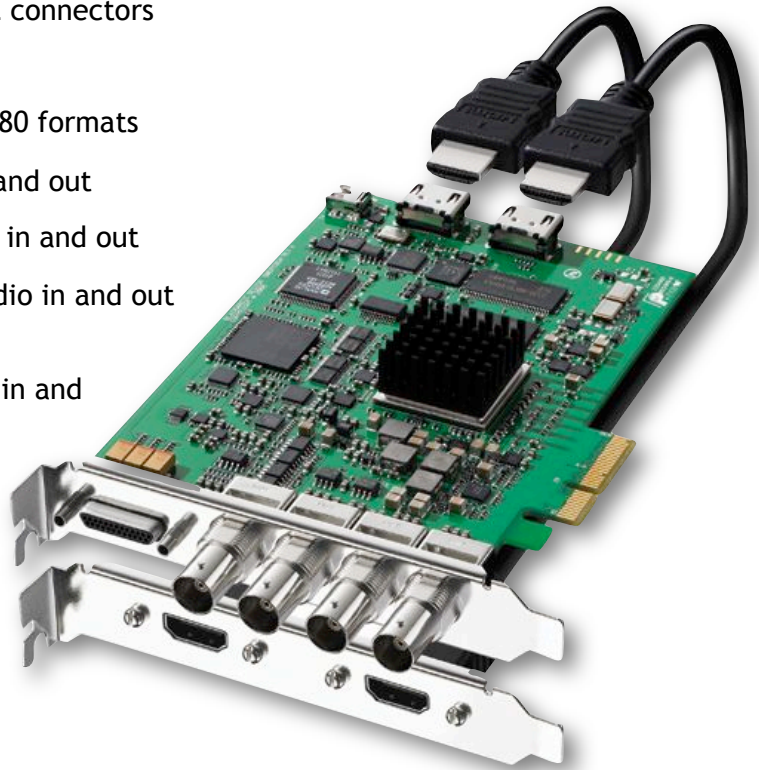
## Decklink Studio

- SD/HD-SDI input and output
- SD/HD analog input and output
- Supports PAL, NTSC, 720 and 1080 formats
- Eight channels of SDI audio in and out (on Mac OS X)
- Analog component HD video in and out
- Analog Composite and S-video<sup>16</sup> in and out
- Two channels of AES/EBU audio in and out
- Four channels of balanced analog in and out (on 1/4" connectors)
- Real-time up conversion from 720HD to 1080HD during video capture
- Sony™ compatible RS422 deck control ports
- MSRP US\$695 (Street \$660)



## DeckLink HD Extreme

- SD/HD-SDI input and output – 2 connectors
- SD/HD analog output
- Supports PAL, NTSC, 720 and 1080 formats
- Analog component HD video in and out
- Analog Composite and S-video<sup>16</sup> in and out
- Two channels of HDMI video/audio in and out – 4:2:2 10 bit output
- Two channels of AES/EBU audio in and out
- Two channels of balanced analog in and out (on XLR connectors)
- Sixteen channels of SDI audio in and out (on Mac OS X)



<sup>16</sup> Composite and S-video signals share connectors with the Component analog inputs. You cannot have S-Video and Component simultaneously connected.

- Two channels of AES audio in and out
- Simultaneous HD 1080 and SD on DeckLink HD Pro 4:4:4 PCI-X model only
- TriSync (HD) Sync input
- 2K video support — 2048 x 1556 at 24fps and 23.98fps capture and playback via SDI
- Device control and software comes with all models
- MSRP US\$995 (Street \$770)

## From Blackmagic Design in HDMI SD/HD:

### Intensity Pro

- HDMI uncompressed in and out
- Two channels of HDMI audio in and out
- Component, Composite PAL or NTSC, and S-video in and out in SD or HD (the same three BNC connectors are shared between Component, Composite and S-video input and output)
- Intel Macintosh with PCIe only
- MSRP US\$199 (Street \$190)





## From AJA:

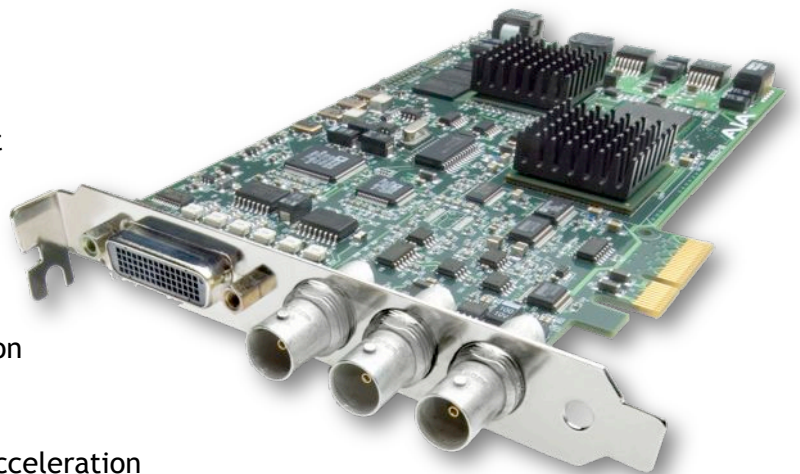
### Kona LHi

- 3G/HD/SD SDI input/output
- 12-bit HD analog component input/output
- 12-bit SD analog component, composite, or S-Video input/output
- Eight Channels of SDI in and out
- Two channels of balanced XLR analog audio out
- Two channels of AES audio in and out
- HD/SD Genlock
- DVCPRO HD hardware acceleration
- HDV hardware acceleration
- Dynamic RT Extreme hardware acceleration
- 10-bit Hardware-based realtime up/down/cross-conversions
- LTC Input (on Reference input)
- RS422 Device control
- MSRP US\$1499 (street price \$1200)

This is a great new card from AJA that includes all the features of the Kona 3, except support for 2K film resolution.

### Kona LHe (PCI-X and PCIe)

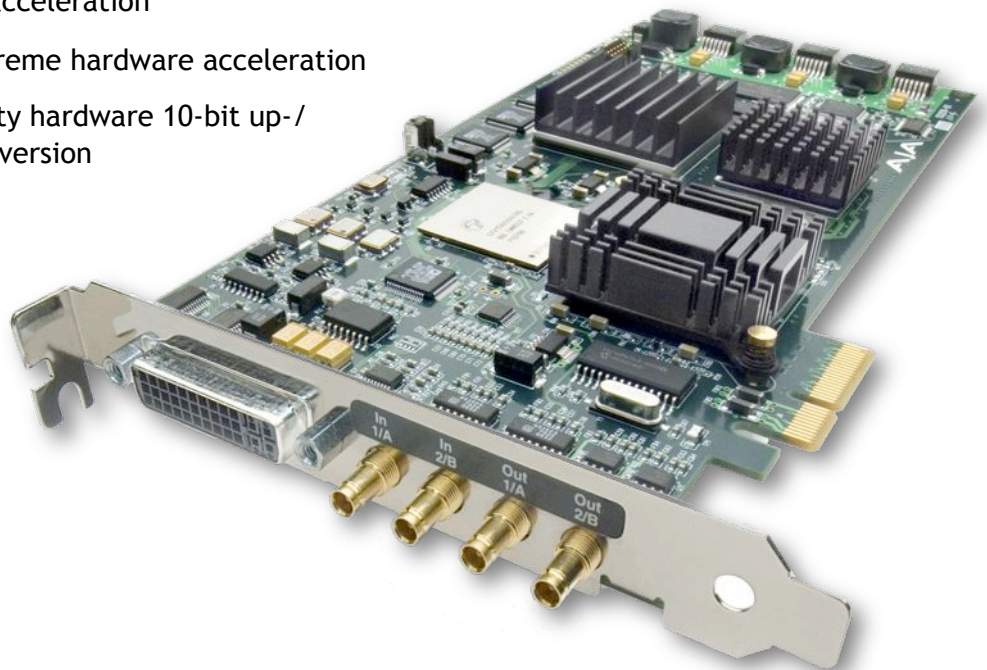
- SD/HD-SDI in and out
- SD/HD Analog SD output only
- Eight Channels of SDI in and out
- Two channels of analog audio out
- Two channels of AES audio in and out
- Genlock
- DVCPRO HD hardware acceleration
- HDV hardware acceleration
- Dynamic RT Extreme hardware acceleration
- Downconversion only
- MSRP US\$1199 (Street \$990)



The Kona LHe has been effectively replaced by the LHi, even though it remains for sale.

### Kona 3 (PCI-X and PCIe)

- SD/HD-SDI in and out
- Dual Link HD-SDI 4:4:4, and 4:4:4:4, 2K
- SD/HD Analog SD in and out
- Eight Channels of SDI in and out
- Two channels of analog audio in and out
- Two channels of AES audio in and out
- Genlock
- DVCPRO HD hardware acceleration
- HDV hardware acceleration
- Dynamic RT Extreme hardware acceleration
- Broadcast-quality hardware 10-bit up-/cross-/downconversion



## ***FireWire bus connected for Final Cut Pro***

FireWire connected interface boxes work because they have some form of compression in the external device. Although FireWire 800 can (just) work with Standard Definition uncompressed, uncompressed High Definition requires much higher data rates than can be carried on FireWire 400 or 800. Therefore devices like the Io HD and V4HD have codecs in the external device and send only compressed video to the computer.

AJA's Io HD compresses to, and decompresses from, Apple's ProRes 422 and ProRes 422 (HQ) and is therefore transmitting either 150 Mbits/sec or 220 Mbits/sec across the FireWire bus. The MOTU V4HD works with Panasonic's DVCPRO HD with a maximum data rate of 100 Mbits/sec. All these compressed data rates are carried comfortably on FireWire 800 connections.

**NOTE:** Storage cannot be used on the same FireWire interface as either the Io HD or the V4HD. This presents no real problem on a tower, as eSATA storage is now the de facto standard. On a laptop, however, the ExpressCard34 slot needs to be used for external storage using an eSATA ExpressCard adapter. Capture to the internal drive is possible, but limited in capacity.

Of the two I consider the Io HD the more appropriate solution for Final Cut Pro editing as it has full raster capture, and output and the ProRes 422 codec family is much higher quality than the DVCPRO HD codec family.

## Io HD

At NAB in 2003, AJA and Apple released the Standard Definition Io, an outboard box connected to the computer via FireWire 400. One stream of uncompressed SD will carry over FireWire so functionally the Io was like an SD video card. It's important to note that, although FireWire 400 was being used for transport of the uncompressed video signal, at no time is the signal converted to DV in any flavor.

However, the use of a FireWire bus in the Io, and also in the much-more-expensive Avid Adrenaline, causes a small delay. Initially 7 frames, AJA reduced the delay to 4 frames for the Io.

At NAB 2007, AJA announced the Io HD in concert with Apple's announcement of Final Cut Studio 2, and delivered it in late September 2007. The Io HD also connects via FireWire, FireWire 800 in this case, but does not do uncompressed.

The Io HD works with Apple's original ProRes 422 codecs, which are built into firmware in the Io HD box. All of the many inputs are converted to ProRes 422 in the Io HD and sent at 140 or 220 Mbits/sec to

the host computer. In reverse, the Io HD takes ProRes 422 from the host computer and outputs it to the many output options on the Io HD. So if, for example, you wanted DVCPRO HD, capturing through the Io HD would mean that the video is first converted to ProRes 422 in the Io HD, transferred to the host computer, which would decode the ProRes 422 and re-encode it to DVCPRO HD in software on the CPU. This would not be optimal, but quality would still be high.

The Io HD is most valuable for workflows that revolve around ProRes 422. I'm very comfortable recommending ProRes 422 and ProRes 422 (HQ), as a core post-production workflow in Final Cut Studio. It is high quality, low bandwidth, lossless for all intents and purposes and it has great multi-generational quality (although that is not as important with Final Cut Pro because Final Cut Pro always renders from the source media, never with an interim "video mixdown").

With that single caveat, and the likelihood of a slight processing delay, the Io HD provides a lot of flexibility with support for SD and HD and for just about every type of input and output imaginable.



- SD/HD-SDI input and output
- SD/HD component YUV analog input and output
- SD Composite and S-video on dedicated connectors
- HDMI input and output
- Supports PAL, NTSC, 720 and 1080 formats in full raster using ProRes 422 and ProRes 422 (HQ)
- Real Time cross conversion between all formats: up-, down- and cross-conversion using hardware
- Eight channels of SDI audio in and out
- Eight channels of HDMI audio in and out
- Four channels of balanced analog audio in and out, two channels of unbalanced audio output
- Eight channels of AES/EBU audio in and out
- Genlock with loop through
- Linear Timecode Input and Output
- RS-422 device control

The Io HD will also function as a stand-alone converter when not connected to the host computer. The Io HD retails for US\$3450 (Street \$2750).





## MOTU V4HD

MOTU's V4HD was announced just a year after the original V3HD — shortly after NAB 2008. The V4HD adds direct support for Apple's ProRes 422 codec family, in addition to the original support for DVCPRO HD. This is a big improvement because DVCPRO HD is not a full raster codec. ProRes 422 or ProRes 422 (HQ) is preferable over DVCPRO HD because they are full raster  $1920 \times 1080$  or  $1280 \times 720$ . DVCPRO HD at 1080i is either  $1440 \times 1080$  (50Hz/25Hz signals) or  $1280 \times 1080$  (59.94Hz/29.97Hz signals). At 720 the image is scaled down from  $1280 \times 720$  to  $960 \times 720$  and is the only format to scale 720 down.

However, unlike the lo HD, the V4HD can also work with Adobe Premiere Pro CS3 (and later) on Mac or Windows. The V4HD will work with FireWire 400 or FireWire 800.

**Note:** Owners of a V3HD can exchange it for a V4HD for no additional cost.

- Separate connectors for SD-SDI in and out and for HD-SDI in and out
- HDMI output
- Supports PAL, NTSC, 720 and 1080 formats in full raster using ProRes 422 or at lower data rates using DVCPRO and DVCPRO HD.
- Real Time cross-conversion between all formats: up-, down- and cross-conversion using hardware
- SD/HD component YUV analog input and output
- SD Composite and S-video on dedicated connectors
- Eight channels of SDI audio in and out
- Eight channels of analog in and out (Four on standard XLR connectors, eight with a breakout cable)
- Eight channels of AES/EBU digital in and out (Four on XLR connectors, eight with a breakout cable)
- Eight channels of HDMI embedded audio output
- Eight channels of ADAT optical digital audio in/out — includes a second bank of optical connectors for 8-channel operation at sample rates up to 96KHz
- Genlock with loop through
- Linear Timecode Input and Output
- RS-422 device control

The MOTU V4HD MSRP \$2450. (Street \$1950)



## ***Directly connected to the PCIe Bus, but external for Final Cut Pro***

Instead of connecting an external box with FireWire, Blackmagic Design and Matrox have taken a different approach. The Matrox MXO and two Blackmagic Design Multibridge products are external boxes that connect directly to the PCIe bus inside the computer with a bridge card. The card contains no significant electronics and is simply a means of bridging the internal bus to the external breakout box that carries the connectors and conversion/codec hardware. Like an internal video card, which these appear to be to the computer, the computer must be shut off to connect or disconnect these devices. They cannot be powered on after the computer boots and should not be powered off while the computer is active.

### **Multibridge Pro**

- SD/HD-SDI input and output including support for dual link HD-SDI for 4:4:4 or 2K work
- SD/HD component YUV analog input and output: SD Composite and S-video on connectors shared with the switchable SD/HD component signals
- HDMI input and output
- Supports PAL, NTSC, 720 and 1080 formats in full raster, with software support for all installed codecs, including ProRes 422 and ProRes 422 (HQ)
- Real Time cross-conversion between all formats: up-, down- and cross-conversion using hardware
- Sixteen channels of SDI audio in and out in HD, eight channels in SD
- Two channels of HDMI audio in and out
- Two channels of balanced analog audio in and out, two channels of unbalanced audio output
- Four channels of AES/EBU audio in and out
- RS-422 device control
- MSRP US\$1595 (Street \$1520)



The Multibridge Pro will also function as a stand-alone converter when not connected to the host computer.

Includes DVI connection for monitoring video from the host application with colorspace conversion to simulate the look of a video monitor (similar to the stand-alone HD-Link converter).

## Multibridge Eclipse

- SD/HD-SDI input and output including support for dual link HD-SDI for 4:4:4 or 2K work
- SD/HD component YUV analog input and output: SD Composite and S-video on connectors shared with the switchable SD/HD component signals
- HDMI input and output
- Supports PAL, NTSC, 720 and 1080 formats in full raster, with software support for all installed codecs, including ProRes 422 and ProRes 422 (HQ)
- Real Time cross-conversion between all formats: up-, down- and cross-conversion using hardware
- Sixteen channels of SDI audio in and out in HD, eight channels in SD
- Two channels of HDMI audio in and out
- Four channels of balanced analog audio in and out, two channels of unbalanced audio output
- Six channels of AES/EBU audio in and out
- RS-422 device control
- MSRP \$2395. (Street \$2275)

The Multibridge Eclipse will also function as a stand-alone converter when not connected to the host computer.

Includes DVI connection for monitoring video from the host application with colorspace conversion to simulate the look of a video monitor (similar to the stand-alone HD-Link converter).



## Io Express

- HD/SD-SDI input/output
- HDMI v1.3a with Deep Color support at 30 and 36 bits per pixel
- HD/SD Component Video output
- 2-Channel RCA audio output
- Linear TimeCode I/O (selectable LTC Input/Reference Video Input)
- RS422 Device Control
- Expresscard34/PCIe interfaces
- Direct support for:
  - DVCPRO HD
  - DV25/DV50
  - SD Uncompressed
  - Apple ProRes 422 (Mac Pro and MacBook Pro only)
- MSRP US\$995. (Shipping Q3 2009, so no street price yet)



## MXO2

- SD/HD-SDI in and out
- HDMI in and out
- SD/HD component YUV analog input and output
- SD Composite and S-video on dedicated connectors in and out
- Supports PAL, NTSC, 720 and 1080 formats in full raster
- Real Time cross-conversion between all formats: up-, down- and cross-conversion using hardware
- Eight channels of SDI audio in and out
- Four channels of analog in and ten channels out  
**Input:** Two balanced audio inputs on standard XLR connectors, two inputs on unbalanced RCA connectors  
**Output:** Four balanced audio outputs on XLR connectors, six unbalanced audio outputs on RCA connectors
- Two channels of AES/EBU digital in and four out (Four on XLR connectors, eight with a breakout cable)
- Eight channels of HDMI embedded audio output
- Genlock with loop through
- RS-422 device control

Works with Final Cut Pro, Apple Color, Adobe Premiere Pro and all QuickTime applications that support the V-out component





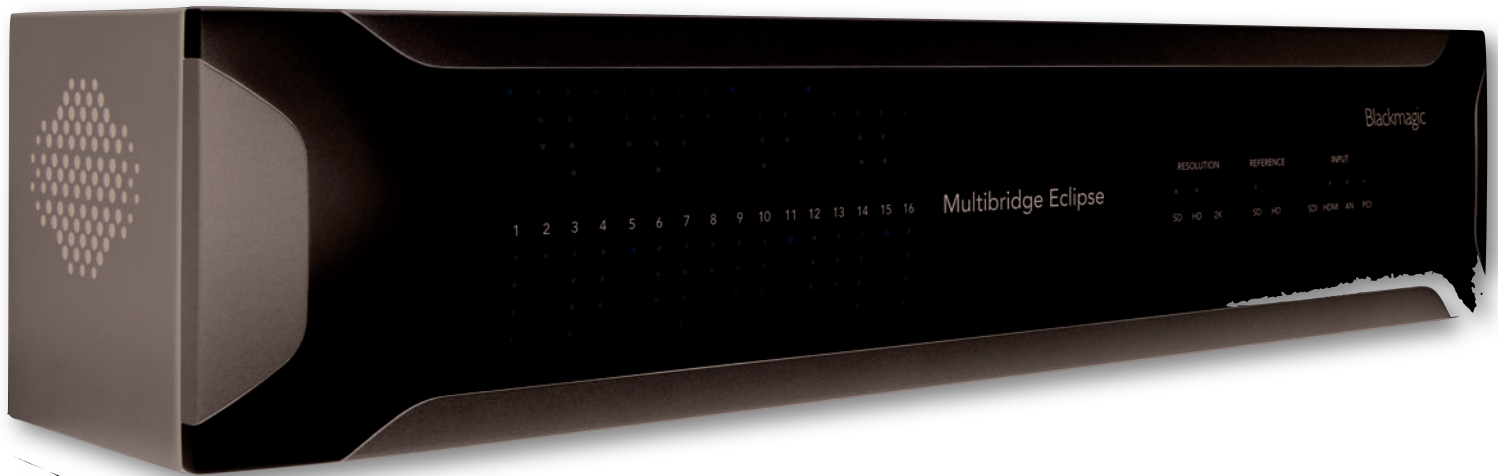
## Summary

It's hard to find a bad product in this category. I have a Multibridge Pro on a Quad G5 that does everything expected of it. I've recommended and installed Kona LH cards for clients and found them to do everything expected. For other clients I've recommended and installed Decklink HD Extreme cards for simple HD-SDI monitoring output. I have another client for whom the "everything in on its own connector" nature of the Io HD will almost certainly sway the decision in that direction when he replaces his aging CineWave system some time this year.

It's hard to go wrong.

If budget considerations are dominant, then the DeckLink HD Extreme meets the needs for SDI in and out. If analog is required in addition to SDI, then the DeckLink HD Pro or Kona LH, Multibridge Pro or MX02 are a good fit.

The Multibridge Eclipse offers more features than the Kona 3, especially for those who need analog input, at a lower price point, while the Io HD has the broadest range of connectors and is the perfect companion for Final Cut Studio's ProRes 422-centric workflows.



## *Directly connected to the PCIe Bus, but external for Media Composer*

### Mojo DX

- SD and HD SDI I/O (combined connector)
- HDMI output
- Reference Sync Black&Burst and HD TriLevel input (combined connector)
- 8 channels SD-SDI embedded digital audio I/O
- 16 channels HD-SDI embedded digital audio input
- 16 channels HD-SDI embedded digital audio output
- 2 channels optical S/PDIF digital audio I/O
- 8 channels optical ADAT digital audio I/O
- 2 channels 1/4" TRS analog audio I/O
- Headphone stereo 3.5mm TRS output
- Wordclock output
- MSRP US \$7495 (less if bundled with Media Composer) (Street \$7295)



## Nitris DX

- SD SDI I/O
- HD SDI I/O
- HDMI output
- SD YCbCr Component I/O
- HD YCbCr Component I/O
- SD S-Video I/O
- SD Composite I/O
- Reference Sync Black&Burst and HD TriLevel input (combined connector)
- Reference Sync loop-through
- 8 channels AES/EBU digital audio I/O (on DB25 connector)
- 8 channels SD-SDI embedded digital audio I/O
- 16 channels HD-SDI embedded digital audio input
- 16 channels HD-SDI embedded digital audio output
- 2 channels optical S/PDIF digital audio I/O
- 8 channels optical ADAT digital audio I/O
- 4 channels XLR analog audio I/O
- 2 channels RCA analog audio input
- 2 channels 1/4" TRS audio output
- Headphone stereo 1/4" TRS output
- LTC XLR I/O
- Wordclock output
- MSRP US\$14,995



# Monitoring HD Video

## Monitor Picture

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 or where finished quality is paramount.

While using a computer monitor, with resolution of  $1920 \times 1080$  or higher, seems to be an easy solution, there are a number of problems with regular computer monitors:

- Most importantly, the colorspace and gamma are very different between HD video and a computer display
- LCD displays change brightness and color as the angle of view changes making accurate color decisions difficult, if not impossible.
- LCD displays also have difficulty displaying a true black because they work by obscuring light.

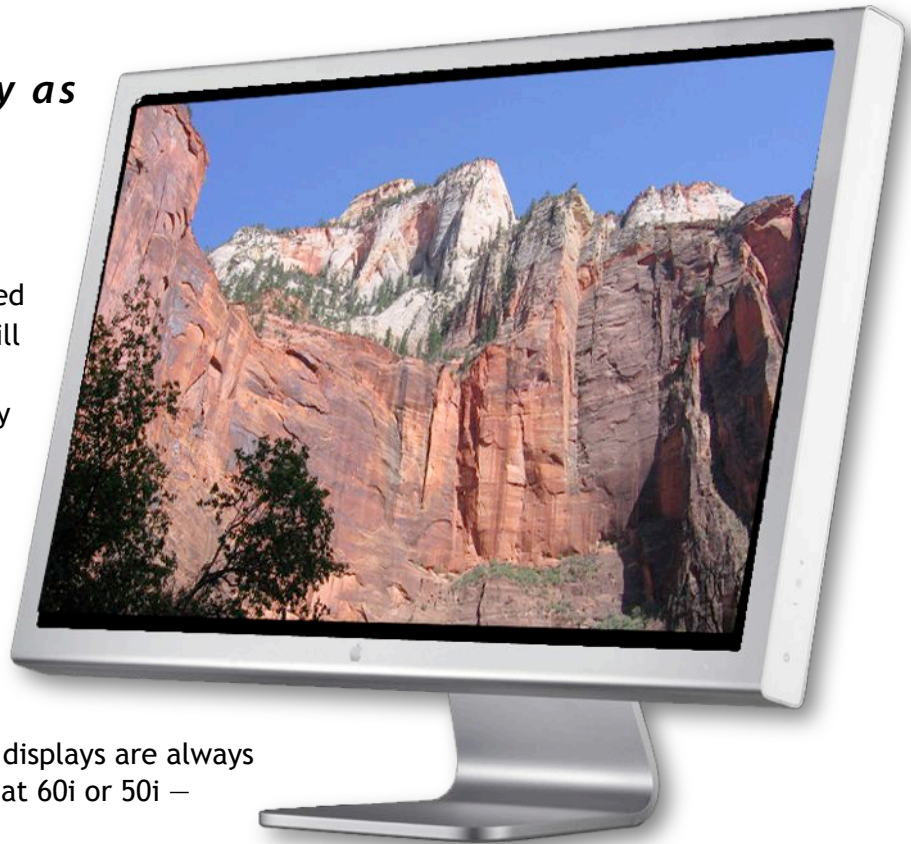
HD studio video monitors have two issues themselves:

- They are expensive.
- They are LCD so have the same issues as computer displays: changes in viewing angle affect color, and a true black is hard to create.

## *Using a computer display as an HD Monitor*

There's no doubt that using a computer monitor as an HD display makes sense economically. With even an Apple branded 23" Cinema Display (the smallest that will display 1080 HD at native size) the investment is still under \$900. But simply connecting a computer monitor to the DVI port and, say, using Final Cut Pro's Digital Cinema Desktop display, or Media Composer's Full Screen Playback function for that monitor won't give you a useful HD video monitor because of the colorspace and gamma issues.

Further muddying the waters: computer displays are always progressive scan, while HD video can be at 60i or 50i – interlaced formats.





## Use a HD-SDI to DVI adapter

Blackmagic Design makes the [HD-Link](#) and [HD-Link Pro](#) and AJA has the similar [HDP converter](#) to take an HD SDI output from a hardware card or adapter and convert it to an HD video signal that will display on a computer monitor with HD colorspace and gamma. With the adapters costing around \$5-600 and a Cinema Display (or other supported monitor) an HD monitor good enough for routine edit tasks becomes available.



You can use an LCD computer monitor with a converter like the Blackmagic Design HD-link or the AJA's HDP converter. These adapters de-interlace and convert the HD-SDI signal (with embedded audio) to progressive DVI to use with a computer monitor. Importantly, they also convert the colorspace and gamma so the display on the computer monitor is simulating the display on a video monitor. They are not a perfect solution but they go close. They work with a range of LCD displays, particularly the Apple 23" model that displays 1920 × 1080 for unscaled 1080.

However the Cinema Display-as-HD-monitor route still has issues with black level not being truly black and the "off-axis" viewing issues. It is most certainly not considered sufficient for critical color grading. It also requires an output card/device with support for HD-SDI output: an additional US\$1000.

Because of the need for an HD-SDI output, this type of monitoring setup is not suitable for laptops.

## Matrox MXO

The [Matrox MXO](#) similarly converts a DVI output to work with a Cinema Display or other DVI monitor putting the output, de-interlace, colorspace and gamma conversion in one device that does not need an HD-SDI output. Instead of connecting via HD-SDI the MXO uses a DVI port for the video signal. This reduces the total number of displays that can be used as most Macintosh computers come with only two DVI display ports: one for the computer monitor, one for the MXO. (Using an HD-SDI configuration as in the last section allows two computer monitors to be used, with a third display as the HD video monitor.)



However, the MXO, at around US\$1000 will save the cost of the HD-SDI output required for the

AJA and Blackmagic Design converters, while providing an HD-SDI output for recording to tape from the computer, making it an excellent choice for routine monitoring. Real-time downscaling is included for monitoring on SD Monitors.



## Monitoring on SD monitors

Let's be honest, most people are going to monitor most of their HD work on SD monitors for the near future. While there is a slight difference between the 601 (SD) and 709 (HD) standard color space, for general monitoring purposes they are quite close. Since almost all monitoring hardware, and the built-in features of Final Cut Pro monitoring, provide an SD output from an HD sequence or clip, a good quality SD video monitor (preferably broadcast quality – at a minimum with SMPTE C phosphors) will prove adequate for editing purposes. All final output adjustments should be made referring to an HD monitor.

### Consumer grade LCD and Plasma

These monitors can look great, and are certainly great eye-candy for client monitors, but they are not a good choice for final image approval or color grading.

Consumer grade LCD and Plasma screens are also rarely full raster – check the specifications to be sure you're getting a full 1280 × 720 or 1920 × 1080 display.



### Native Final Cut Pro Monitor outputs — HD via DV devices

Final Cut Pro 6 and later can convert an HD output to SD and output that as DV through a FireWire cable, as long as the processor is fast enough. This provides another route for budget monitoring of HDV via an existing DV/Analog converter (or DV camcorder/deck). Work in HDV or other HD format, but select the preset for a DV Device for monitoring. The signal will be scaled and output via that device and then to an (existing) SD monitor. (See comments on monitoring SD for HD above.)

The frame rate must be within frame-rate families: 59.94, 29.97 or 23.976 will work to an NTSC DV



output; 25 and 50 to a 25 fps PAL DV output. Of course, with that much processing going on, you can't expect great performance so render any sections of the sequence that have multiple layers, filters or motion effects, before attempting to output.

You will still need a device to convert the DV output to analog signals for monitoring on a CRT.



## Monitoring with video projectors

Few projectors are designed with HD video in mind. Most are for computer display and therefore, all the comments about colorspace, gamma and interlace above are valid. Few projectors are full raster even for  $1280 \times 720$ , frequently being  $1024 \times 768$  or  $800 \times 600$ . They can also be slow to refresh, smearing a fast moving video image.

To find a suitable projector, choose one that has  $1920 \times 1080$  (minimum) pixels and a video input: analog component, HDMI or HD SDI. The analog component and HDMI options will probably be more often available on video-capable projectors. These video inputs will process and display the signal correctly in the right colorspace and gamma. Projectors without a video input will probably smear.



## *Real HD Monitors*

True studio-quality HD monitors, suitable for color grading are available from Sony eCinema, Front Niche, Teranex, DIT, TVLogic, JVC and Panasonic. There are new companies entering the market trying to make a true broadcast reference monitor based on LCD technology (and a lot of active processing).

The main contenders, with comments, are below. The comments are based on the observations of more critical eyes than mine at the Alpha Dogs' Editor's Lounge in July 2007, where a shootout was held between these 23-26 inch "reference" monitors:

- TVLogic LVM 240D
- Front Niche
- JVC DTV 24L1D
- Teranex ClearVue
- DIT DTS-OR23.NS4
- DIT DTS-OR23.NS3
- eCinema DPX
- Panasonic BTLH2600W
- Sony LMD-2450WHD



TVLogic LVM 240D

Of all the monitors in the shootout only the eCinema DPX was considered to produce a true black in a darkened room with proper front and back lighting for studio conditions. It was the only monitor in the shootout to produce a true black. Pricing is around US\$38,000.

While the Panasonic was judged "best" by many in the audience, it was displaying an oversaturated image with a bias toward red.

The Teranex ClearVue was not judged highly as it displayed washed-out black, light leaks and a four-frame delay. Not surprising since it appeared to be a standard Gateway computer monitor with a Teranex badge.

All monitors except a TVLogic 42" model (being displayed independently of the comparison shootout), but including the eCinema DPX shows some off-axis shift if the viewer moved significantly off-axis. While a problem in some situations, this generation of LCD displays are acceptable for fixed location viewing. The size of the larger 42" model was given as the reason it did not display the same off-axis change as do consumer displays.

It should be noted that Sony did not provide any of their BVM series for comparison and CineTal declined the invitation as they "don't do shootouts".

## And the Winner is?

For budget and performance reasons the [JVC DT-V24L1DU](#) is a great choice for a display suitable for color grading (in a suitable environment). This monitor sells for approximately US\$5,000 and is my recommendation if you want to go for a “true” broadcast reference monitor without breaking the bank.



## HP DreamColor LP2480xz

A new entrant in the “highly accurate” color monitor race that’s been getting some very positive reviews and user comments is HP’s new [DreamColor LP2480xz](#). HP claim 10 bits-per-channel and the ability to display “billions of colors”<sup>17</sup>.

It has a variety of video inputs but no support for SDI. Although the monitor sells for US\$2000 you’ll need to spend extra on the calibration software, shadow hood and SDI conversion. Further the monitor only supports progressive RGB displays, so if you have interlaced or YUV video source you’ll need a Gefen HD-SDI to HDMI Scaler Box selling for around US \$1500, making the JVC DT\_V24L overall better value.

HP, however, seem to be serious about getting into this market so look for future models in the DreamColor range to be more pro-video friendly.



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<sup>17</sup> For a reality check, keep in mind that the human visual system (eyes and brain interpreting) is capable of resolving about 300,000 individual colors.



## Monitoring HD Signals

While the scopes inside Final Cut Pro and Color are accurate, they are completely within the digital domain – within the computer. They do not tell you what is happening to your signal as it goes out to tape or other output. In order to confirm that the signal is maintaining correct video levels, we need external scopes that can monitor the output of the system, and the output of any external tape or disc recorder.

How essential this monitoring is, depends on where you feel you fit within the production ecosystem. If you are delivering to a major cable or broadcast network with tight technical specifications to follow, you will absolutely need to have scopes for output. You could rent the scopes if you're in a major market but otherwise owning may be the only way to have access.

One potential solution to the high cost of HD Waveform monitor and Vectorscopes is to have someone set up your facility using the scopes and then never varying from that correct setup. That's practical if you finish the programs in house. Another solution for those who only occasionally need to output for a “major” with less stringent delivery requirements, would be to use some type of output bureau, such as the [Digital Service Station](#) service, which will confirm technical accuracy of the signals they output.



### *Can you do without external scopes?*

Well, the technical purist, the engineers among us, would say no, but the reality of the HD era is that, by and large, if the signal is right in the computer it will be correct when output to tape or disc, because most output is a digital file transfer. In the days of NTSC analog video there was considerable room for error because (in North America only) NTSC video in the analog domain had 7.5 IRE setup for black, so there was always the possibility when moving from analog to digital and back to analog, that the setup would not be handled correctly. (Remove setup from analog video for zero IRE in the digital domain **always**, and then add setup when going back from digital to analog.)

Fortunately with HD video there is never any setup or level change so the chances are very good that the signal output will be the signal recorded. It is always true for file transfer output, using FireWire or USB, of HDV (back to tape); XDCAM HD/EX (back to disc) or DVCPRO HD back to tape or P2 media.



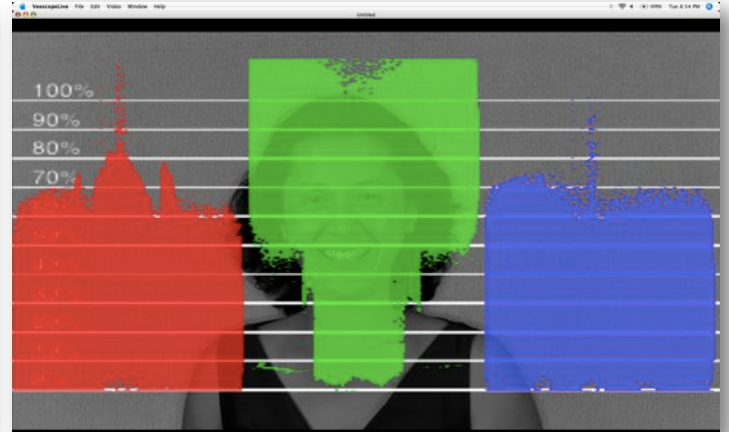
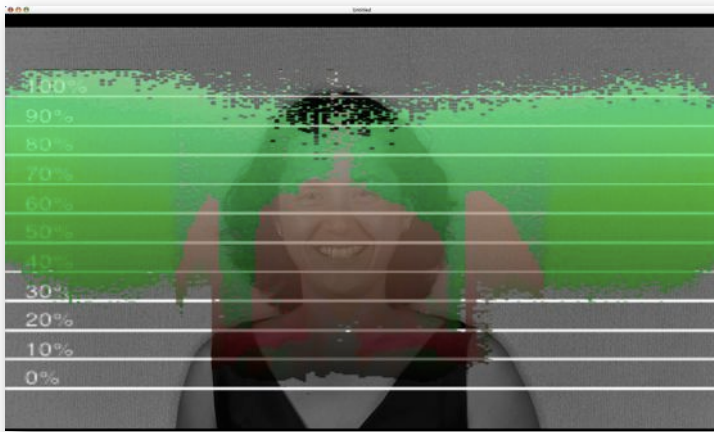
Output via HD SDI should also be transparent — whatever is in the computer is accurately reproduced on the tape or disc — as long as all settings on the output card or interface and deck are set to “unity”, i.e. no change.

So yes, you can manage without HD Scopes, but for the most critical output, they are essential.

## ***HD Scope Options and recommendation***

HO Scopes (Waveform Monitor, Vectorscope, etc) have been very expensive. Most people have managed with software solutions like [ScopeBox](#) and [Veescopes Live](#) on Mac OS X, and Adobe’s [OnLocation](#) (formerly DVRRack) on both platforms (as of CS4) and Hamlet [VidScope-vx](#) on Windows. They require a computer, interface card and display, which drives the cost of the “software scope” up considerably.

Further, because they work with the signal off a capture card, they do not accurately display issues with blanking. Others do not always update in real time.



Veescopes Live displays Waveform, Vectorscope and RGB Parade directly over the image to make interpreting the display much easier.

Images courtesy of Brad Wright, Veescopes Live

## **Blackmagic Design’s UltraScope**

At NAB 2009 Blackmagic Design announced the [Ultrascope](#): a package of a Decklink Optical Fiber card with their UltraScope software to create the first Optical Fiber/HD/SD-SDI comprehensive scope solution. The UltraScope uses a commodity PC (Windows) as a host to provide power supply, interface and output to a 24” computer monitor for display.<sup>18</sup>

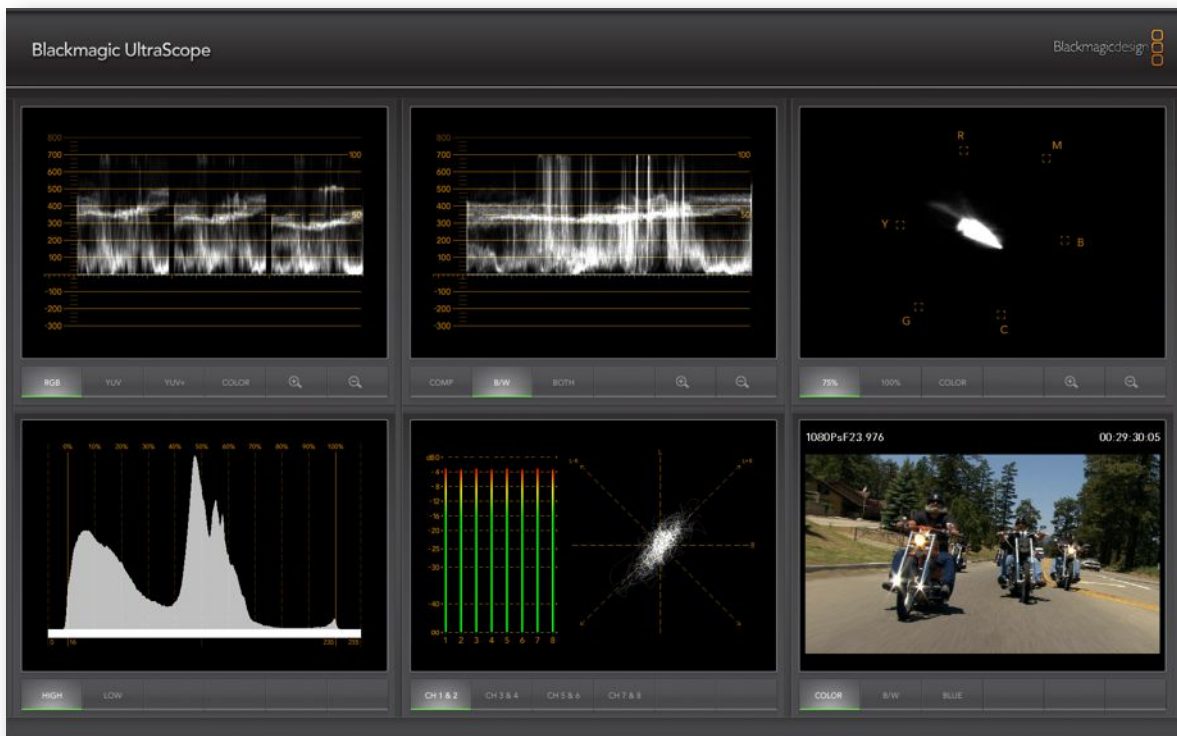
Blackmagic UltraScope will display 6 live scope views simultaneously! UltraScope is engineering accurate and includes 3 Gb/s SDI plus 3 Gb/s optical fiber SDI. UltraScope auto detects SD, HD and 3 Gb/s SDI inputs.

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<sup>18</sup> Mac lovers just get over it. It’s a scope, you’ll only ever see the Ultrascope interface. Just pretend it’s a dedicated hardware box, which is what you need to do anyway. Why would you waste a perfectly good Mac for that utility task?

The UltraScope accepts SD and HD-SDI signals, including 3 Gbits/sec (switchable) as well as Fiber optic signals. Available scope displays (use any combination on the 24" screen) are:

- RGB Parade for Colorists
- Waveform
- Component Vectorscope
- Histogram
- Audio level monitoring (on all eight channels simultaneously)
- Picture view with VITC



I am not an expert on video scopes, and generally defer to those who are in my recommendations. In this case, engineer Bob Zelin highly recommends the Ultrascopes. Prior to that he recommended the (more expensive) [Tektronix WVR-5000](#) HD rasterizer scope, which also uses a computer display. This is a real scope at “rock bottom” prices (around US\$6000) – which prior to the UltraScope was considered “rock bottom” pricing for an HD Scope. It’s pretty clear to see that the UltraScope is an important breakthrough in monitoring HD signals.



Another suggested alternative would be the [Leader LV7700](#) scopes.

# HD Workflows

## *Test, test, test and test some more*

With so many formats, frame rates and codec options, it's ***absolutely crucial*** that you test every workflow completely before committing to a format for any given production. You can reuse workflows you've tested and proven on previous projects, but if there are any variations, test again.

By testing the workflow I mean that you **must**:

Test the shooting environment and workflow, particularly if using solid state media: who's responsible for transferring media from the cards so they can be recycled, and what backup strategy will be used? — that data is your “camera original” and having a single copy is foolish. At a minimum capture to one drive and clone to another drive on a daily basis. If the workflow permits, do simultaneous copies.

Shoot footage with the camera, or cameras you propose to use and in the general types of locations or settings you will be using. Use this test to make sure the camera is set up correctly for your project. This is particularly important if you are planning to work at “24P” because there are so many variations and only a few of them are correct. See the section later on “[24P pitfalls](#).”

Capture footage into Final Cut Pro or Media Composer using the deck or method you plan to use for the project. If you're going to capture over HD-SDI, test that; if you're going to capture using FireWire, XDCAM HD/EX transfer, Log and Transfer, or Avid AME, then that's what you will test.

If you're working in “24P” you'll test capture while removing Advanced pulldown (where you can).

If you're working in “24P” from a camera that does not support Advanced Pulldown (Canon's HV20 and HV30, for example) then test the pulldown removal process through Cinema Tools (or Compressor) for Final Cut Pro or use Media Composer's native tools for pulldown removal for FireWire capture.

Do a test edit using all the pieces you've shot.

If you're working in 24P, which is really 23.976 or 23.98 in shorthand, then edit in a sequence with those settings.

If you're going to use Color for color correction or grading then take your test sequence to Color, apply some preset looks to selected clips, but leave some clips

untouched so you can compare with the source footage. Sometimes gamma shifts or level shifts happen even if the clip has not been processed in Color.

If you're going to be taking a Media Composer edit to Symphony for color correction, take your test piece to the Symphony facility and test grade the piece.

Make sure that the color-timed-sequence (and media) imports back to Final Cut Pro/ Media Composer.

Prepare each type of output you plan to make — tape, disc, DVD, Blu-ray — and create an example. If you're going out to film, do a film-out test. Most facilities will allow a test output of up to one minute of film at nominal charge, if you plan to use their facility for the final output.

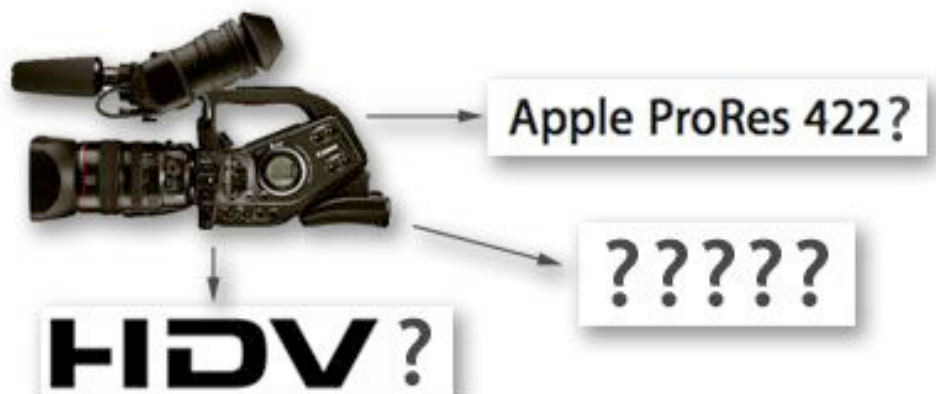
Only when you've performed a full and comprehensive test, and worked out the pain points you will no doubt discover — particularly if using Color/Symphony or working with one of the newer formats — then you're ready to begin production. Do not vary from the tested workflow without additional testing.

I know you won't follow this advice. I also know there will come a time when you wish you had! There are a lot of workflows for HD — to decide on one without testing would just be foolish. Remember, there are four different methods of doing "24P" in HDV alone; three frame sizes that all claim to be "1080" and two that both claim to be "720"; four affordable acquisition formats; and eight frame rates. Add in support for PAL and NTSC and a camera like the Sony EX1 or Panasonic's HVX200 are capable of 30-80 formats between tape and solid state media. You might "luck into" the right combination the first production... or you might not and won't deliver on time.

**Testing pays for itself, every single time.**

## Staying Native or Converting Formats?

Ask ten workflow experts about whether you should stay in the native acquisition codec, or convert to something else, like an intermediate codec or the output format, and you'll likely get 11 answers! There are no hard and fast rules, but with the proliferation of formats and the difficulty of supporting all of them natively, both Avid and Apple have offered a high quality, post-production oriented codec: DNxHD from Avid and ProRes 422 from Apple.



**Note:** This section is based on an article I wrote originally published at [KenStone.net](http://KenStone.net). for Final Cut Pro. For the full detail I recommend reading that.

With so many source codecs and output formats there isn't a single good answer to the questions "When do I stay native and when do I convert to another codec?" and "If I convert codecs what codec should I use?"

Sometimes the choice is easy: with HDCAM, HDCAM SR or D5 there is no native codec, so the only real choice is to capture via HD-SDI (with third-party hardware) to either uncompressed or to ProRes 422 in Final Cut Pro, or DNxHD in Avid. If you decide that working with ProRes 422/

DNxHD, is acceptable and you're working with Final Cut Pro then the Io HD from AJA makes sense.



With DVCPRO HD, being a well supported in both hosts, all-I-frame 4:2:2 codec, there's little point converting if the output is to be in DVCPRO HD. (Note: Media Composer uses the native MXF files while Final Cut Pro rewraps losslessly to QT files.)

Both Media Composer and Final Cut Pro can work with XDCAM HD/EX codec files natively (or with a simple rewrap to QuickTime). If your output is to be a flavor of XDCAM this is the best option, otherwise transcode to DNxHD or ProRes 422 on capture and output via HD-SDI to your master format.



While both Final Cut Pro and Media Composer will work natively with HDV files (without transcode) this is not the best choice if you need to composite or color correct the footage. If you plan to color correct or expect heavy compositing, it is best to transcode the HDV to DNxHD or ProRes 422 on capture or ingest. Output to the mastering format via HD-SDI or component analog.<sup>19</sup>

There is an argument to be made (for space saving reasons) to do the basic edit in HDV native and then, prior to compositing or color correction, recompress to ProRes 422 or DNxHD.

If your output format is different from your capture format, then converting to the output format, or a Sequence that supports that output format, as early as possible is a good idea. In other words, if you're going to master to HDCAM, HDCAM SR or D5, then work in an uncompressed sequence (or more realistically ProRes 422 or DNxHD) and output via HD-SDI to the deck either directly by hiring the deck or via a service bureau like the [Digital Service Station](http://DigitalServiceStation.com).

If you have a mix of formats for a Sequence – quite common with documentaries – either choose the dominant format, or convert all source material to ProRes 422 or uncompressed on capture (Log and Capture) or import (Log and Transfer/XDCAM Transfer). A common format is easier to deal with and will play more smoothly, even from Final Cut Pro's Open Format Timeline.

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<sup>19</sup> Certain long GOP formats require conversion to ProRes 422 (or other all-I-frame format, before reverse telecine in Cinema Tools is possible.



## Some good rules of thumb:

Do as few conversions as possible — each conversion costs a little quality.

Stay in the source format only if the output is the same, otherwise convert to your output format at capture, or immediately thereafter — always before starting editing.

Only ever convert to a higher quality format: it won't improve the quality but it will minimize loss.



## *ProRes 422/DNxHD or Uncompressed?*

You'll have noticed in the section above I refer to ProRes 422/DNxHD and uncompressed as being somewhat interchangeable. While it's true that ProRes 422/DNxHD are officially lossy codecs, that loss is miniscule. In fact there's no way to determine, after output, whether a program has been edited in ProRes 422/DNxHD or uncompressed. It's reasonable to say that ProRes 422/DNxHD is 99.5% of the quality of uncompressed, at a fraction of the bandwidth.

ProRes 422/DNxHD have [data rates](#) at (nominally) 140 Mbits/sec or 220 Mbits/sec compared with uncompressed 8-bit 29.97 at 7952 Mbits/sec or uncompressed 10-bit 29.97 at 9944 Mbits/sec. Both ProRes 422 and ProRes 422 (HQ) support 10-bit video if the source is 10-bit video. In the DNxHD family there are specific 10 bit and 8 bit codecs to choose. All versions of ProRes 422 and DNxHD are full raster, meaning that "1080" video is truly 1920 × 1080 and "720" video is 1280 × 720, unlike many acquisition formats that sample fewer pixels across the image than the format should have. By stretching the pixels out to fill the full raster, DVCPRO HD, XDCAM HD/EX (at some data rates) and HDV at 1080 all reduce the raster to reduce file sizes.



Given that the quality is so close, while only 2 or 3% of the storage size and throughput requirements, it makes sense to use ProRes 422 or DNxHD instead of uncompressed unless you have a contractual obligation to edit with uncompressed video. (Not that you'd ever "cheat" but there is no way to tell, after output, whether ProRes 422/DNxHD or uncompressed were used for the edit.)

My strong recommendation is to use ProRes 422/DNxHD unless specifically required to use uncompressed. If there is significant color correction, titling or compositing to be done on source from HDV, XDCAM HD or XDCAM EX, I would convert on capture to ProRes 422 or DNxHD (depending on editing platform) and work from there in ProRes 422 or DNxHD.

Certainly if Apple Color is to be used for color grading you will have to convert from the Long GOP XDCAM/HDV source to an all-I-frame format as Color 1.x does not deal with Long GOP source at all. Color 1.5, part of Final Cut Studio 3, deals with XDCAM HD 422 (50 Mbit/sec) natively.

Likewise, if you are shooting with a format that imposes 23.98 on 29.97 by adding 3:2 pulldown (such as the Canon HV20/HV30 does) then you will need to convert to ProRes 422 on capture, as Cinema Tools does not support Long GOP source for reverse telecine.

## *Handling mixed frame rates*

Although Final Cut Pro's Open Format Timeline supports mixed frame rates, the output from this frame rate conversion is of poor quality. Media Composer does not handle mixed frame rates in a single timeline at all.

Far better results can be obtained by external conversion, either in hardware ([Teranex](#), [Snell & Wilcox](#)) or in software ([Compressor](#)). However, the problem is that conversion is expensive. It's expensive in dollars to use the hardware route and it's expensive in time to use Compressor for high quality frame rate conversions.

This is a problem when you don't really know how much of the "off" (minority) frame rate material will be used in the edit. To convert all source footage would be wasteful (of time or money) but easier as you never have to deal with the off-frame-rate material during editing.

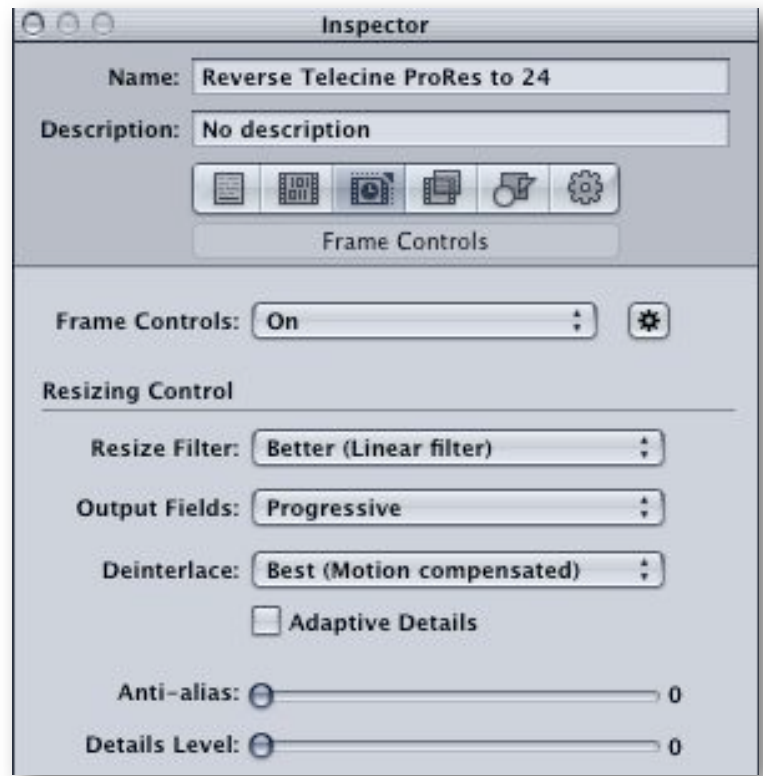
Alternatively, you can edit with the off-frame-rate clips in a Sequence with frame rate set to match the majority of the footage and then, after the edit reaches picture lock, or close to it, do a batch export of the off-frame-rate clips only (by reference, not self contained to save space) and process those clips in Compressor to convert to the frame rate of the sequence.

Compressor comes with a wide range of settings in the Format and High Definition folders. These do not have control over Frame Controls, so you will get better quality if you create a setting that matches the majority of clips in your Sequence and set the Frame Controls as above. If you can take the time hit, use Best for Resize. Set Output Fields to match the result you want – Interlaced or Progressive.

Compressor can work with the Avid DNxHD QuickTime codecs if installed on the same machine as Media Composer.

**Note:** Frame rate conversion in Compressor at Best quality is very time consuming.

Expect it to take at least an hour for every finished minute converting frame rates.



## Mixing in SD Source

The move to HD has left us with one problem: the use of SD archive footage in an HD program. This is a problem that's not going to go away any time soon so we have to learn to deal with it.

The worst approach to including SD in an HD Sequence is to scale the footage up in the NLE. Even at the highest render quality for scaling (which is set in Sequence Settings, Video Processing Tab by the Motion Filtering Quality pop-up menu in Final Cut Pro) Final Cut Pro does a very poor job of scaling that much larger. (Media Composer does not fare any better when upscaling.) Scaling in Final Cut Pro has one advantage: it's fast. My test piece (for comparison) took 3 minutes to render to HD size in Final Cut Pro compared with nearly 30 minutes for the same render in Compressor.

Scaling can also be done in Compressor with maximum quality set in the Frame Controls, but it takes about 10x longer than rendering in Final Cut Pro or Media Composer. The quality is higher, but not ten times better.

There are other solutions such as [Instant HD](#) from Red Giant Software or [Topaz Enhance](#) from Topaz Labs<sup>20</sup> that are designed specifically to convert SD material to HD. Uprez in the [Boris Continuum Complete](#) filter set is used for the same purpose. This filter was introduced to Continuum Complete at version 5.

These tools are definitely better than scaling in Final Cut Pro or Media Composer, but often it's better to scale the SD material only a little and then do something creative to fill the HD frame.

Creatively filling the frame with multiple SD images composited together, or over a background, is particularly useful when dealing with SD 4:3 material in 16:9 HD productions. Even when scaled up to fill the height, the edges are still empty. Scaling up to fill the full width of the HD frame requires scaling the SD material even larger, with further reduced quality.



This example from the [Digital Anarchy website](#) shows how much better the results are with Digital Anarchy Resizer, compared with Adobe After Effects, which is considered to be "pretty good". The frame at the top shows the area being scaled. Both are actual size before and after.

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<sup>20</sup> Digital Anarchy's ReSizer technology is being rolled into Red Giant's Instant HD after Red Giant purchased the technology from Digital Anarchy.

## Mixing 4:3 and 16:9

While there are no really good techniques for showing 4:3 footage in a 16:9 Timeline, one solution is to use a modified version of the 4:3 image behind the 16:9 footage. The copy behind is scaled across (or simply larger) to fill the blank space, dropped in opacity with a color treatment and/or blur.

There are no really good solutions:

- Blowing up the shot drops the quality and totally destroys the original composition;
- Stretching the width is just plain ugly; and
- Leaving 4:3 as 4:3 leaves unattractive pillar boxes to the sides.

One of the more effective solutions is to fill the pillars at the side with something relevant. This can be used quite creatively, but the problem with creativity, is that it takes time! A quicker solution is to put the same Clip behind and treat it so it fills the screen. This approach is relevant to the image, but not hard to work with.

- Duplicate the Clip.
- Scale the lower (background) layer to fill the screen. Depending on the footage you can just scale it horizontally or scale it in proportion.
- This example was scaled horizontally without changing vertical scale by holding down the Shift key while dragging a corner, to over-ride the proportion scaling.
- Drop the Opacity of this layer to give some “depth” between layers
- 60-65% is a good starting point but the amount will vary with the footage.
- Apply a Blur Filter to soften the detail and make the background more abstract.



This example uses a Gaussian blur at 12; usually 8 to 14 will be a suitable range where the background image is still recognizable, without having distracting detail that conflicts with the foreground.

This 1080i50 frame has been “faked” from two Standard Definition frames — the interview and the background. The background was flopped to fill the remaining area of the screen and provide a better framing for the interview subject.

The blurring also helps hide the loss of resolution caused by scaling the image. If you get banding add a small amount of Gaussian noise.



# Final Cut Pro HD Workflows

Once upon a time, in an all-SD world, there was Log and Capture. It didn't matter if it was a FireWire transfer or through third party hardware cards, all tape-based content was captured through the Log and Capture window. Then came HD and we got a special Log and Capture Window for HDV that cannot be selected *except* by using one of the Easy Setups for HDV.

To accommodate IT-based workflows, such as with DVCPRO HD, AVCHD/AVCCAM, AVC-I, RED Digital Cinema and Sony Video Disk Units<sup>21</sup>, we have the Log and Transfer window (named P2 Import in Final Cut Pro 5). Of course, this isn't confusing enough, so for Sony's XDCAM, we have to use yet another interface, the Sony XDCAM Import Utility, although its use is now optional.

Apple are clearly moving toward standardizing on the Log and Transfer window for file-based formats like XDCAM HD/EX, AVCHD/AVCCAM, AVC-Intra, P2 Media natively and additional formats with plug-ins. The use of the XDCAM Import Utility has now become optional since the release of the XDCAM plug-in for Log and Transfer, included in Final Cut Pro 7 and available for download for earlier versions: check the latest versions of the [Final Cut Pro release notes](#) and [Sony's software site](#) for a plug-in that adds XDCAM HD/EX import into the standard Log and Transfer window.

## Log and Capture

The Log and Capture window is designed for capture, or digitize, from tape-based media. In SD the Log and Capture window was used for digital transfer off DV/DVCAM/DVCPRO tape as well as use with third-party hardware.



Final Cut Pro's long-term Log and Capture window.



The HDV Log and Capture window shows up when you select an HDV Easy Setup before opening the Log and Capture window

<sup>21</sup> The mysterious "VDU" in the Import menu of Final Cut Pro 5.



In HD, the traditional Log and Capture window is still used for capture from tape, using component analog or HD-SDI input only.<sup>22</sup> These formats require additional [hardware](#) so in practice the traditional Log and Capture window in HD is only used with third-party hardware. The only tape format that's captured as a data transfer is HDV and there is a special Log and Capture Window for HDV that you cannot select *except* by using one of the Easy Setups for HDV. See screen shots on the previous page.

## Choosing a Capture Codec

The best approach to capturing HD material is to use one of the Easy Setups supplied with your capture hardware. You do, however, have to choose a setting with the codec for the footage to be captured to, as there are no native codecs for HD-SDI or component analog HD. Remember, None and Apple Uncompressed (8- or 10-bit) are codecs as well. Just because the word literally means “compress/decompress” does not mean that every codec is compressed, nor that all compressed codecs are equal, as you would have learnt from our discussion of ProRes 422.

With HD you have three codec choices with two variations within two of them:

- Uncompressed 8-bit, or Uncompressed 10-bit.
- DVCPRO HD
- ProRes 422 in standard or (HQ) versions.

Codec	Data rate	Full Raster
8 bit Uncompressed	354 – 994 Mbits/sec	Yes
10 bit Uncompressed	442 – 1243 Mbits/sec	Yes
ProRes 422	59 – 147 Mbits/sec	Yes
ProRes 422 (HQ)	88 – 220 Mbits/sec	Yes
DVCPRO HD	65 – 100 Mbits/sec	No

In our previous discussion, I recommended against DVCPRO HD because it is not a full raster codec and will lose resolution compared with almost all HD sources (particularly in 60 Hz countries). It does have the advantage of being usable on older, slower (single or dual G5) Macintosh computers (for Final Cut Pro 6 and earlier) and the quality is definitely acceptable for broadcast HD. On computers that can handle it, ProRes 422 is a better choice because it is full raster, less compressed and supports 8- or 10-bit sample depth in both versions.

Uncompressed 10-bit is certainly going to provide the highest possible quality, but at the expense of the highest performing (and highest cost) drive arrays. Working with Uncompressed 10-bit is going to be expensive and a huge amount of storage will be required. Most productions finishing in 10-bit Uncompressed will do an offline in a lower quality format, often DVCPRO HD. This approach requires an off-line/on-line workflow with its complications. I would only recommend 10-bit uncompressed, or even 8-bit uncompressed, where contractual requirements require it.

<sup>22</sup> OK, technically an lo HD or V4HD use the Log and Capture window and connect via FireWire, but that's simply because they “tether” the converter hardware to the computer with FireWire. It's still a hardware capture device.

For most purposes, ProRes 422 (or the Avid equivalent, DNxHD) is the perfect choice. It is a near-lossless (and completely visually lossless) codec that provides quality comparable with 10-bit uncompressed at a fraction of the data rate, meaning that the speed of the hard drives can be slower than required for 10-bit uncompressed, and at only 1/10<sup>th</sup> the data rate the amount of storage will be reduced accordingly.

So, unless contractually obligated to finish in Uncompressed HD, work in ProRes 422 or DNxHD when capturing with hardware. ProRes 422 is the only format supported by the Io HD<sup>23</sup> and is also supported on the V4HD. It is a good choice with other AJA or Blackmagic Design hardware, which use the CPU to encode after capture.

## *The HDV Log and Capture Window*

As mentioned above the Log and Capture window for HDV is actually a completely different interface. Unlike the bulk of Final Cut Pro it is written in native Cocoa code using the same interface look as the other Pro Apps (other than Final Cut Pro).

You can identify the difference in two ways:

- The look is the same as DVD Studio Pro, LiveType and Motion – the Pro Apps look – instead of the regular Final Cut Pro Log and Capture window; and
- When capturing, the image window can be moved around the screen by dragging on the top bar (a.k.a ‘the drag bar’) – the traditional Log and Capture window has no drag bar and cannot be moved during capture.

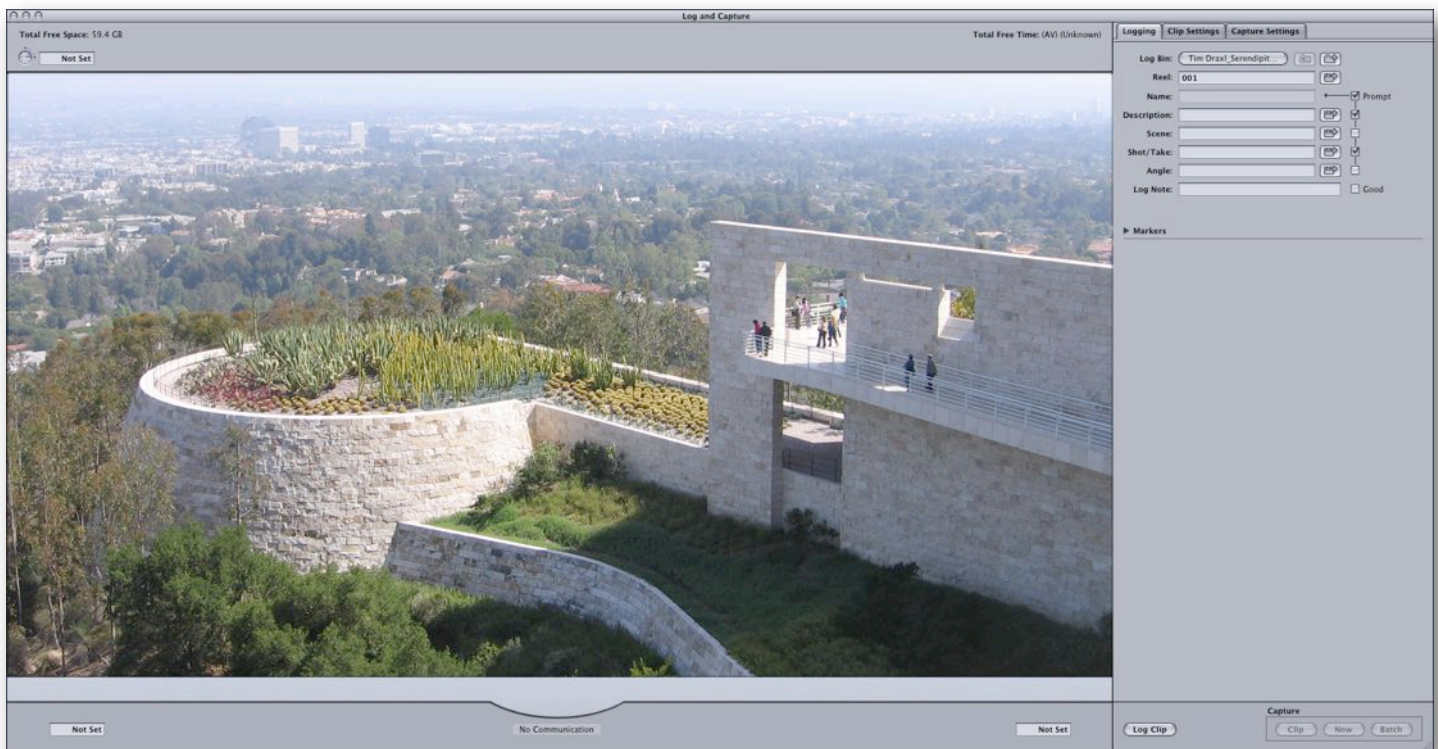
The **only** way to access the HDV Log and Capture window is to choose an HDV Easy Setup. This is one of two places where an Easy Setup does more than simply select a combination of Capture Setting, Device Control Setting, Sequence Setting and Output/Monitor setting. (The other is capturing HDV to ProRes 422 directly without additional [hardware](#).)

The HDV Log and Capture Window is used only for capturing HDV footage natively to HDV QuickTime movies. It can be used to reverse telecine Advanced Pulldown during capture, similar to removing Advanced Pulldown in DV, but it cannot be used to reverse standard 3:2 pulldown. See the section on “[Capturing 24P](#)” later in this book.

**Note:** The HDV Log and Capture Window displays significantly later than the display at the camcorder or deck. For this reason you need to monitor out points at the deck.

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<sup>23</sup> It is possible, on a suitably powerful computer, to capture with the Io HD using its hardware ProRes 422 codec and then, in the host computer, decompress the ProRes 422 in order to compress to another format. This means that two codecs will be used and that’s not a good thing. It’s a theoretical capability that no-one will ever use.



The HDV Log and Capture window can be recognized by the look that matches DVD Studio Pro, Motion, Compressor, Soundtrack Pro and Cinema Tools

## HDV to ProRes 422

While native HDV is perfect for many applications, a lot of the time we need to convert to ProRes 422 because the project will have significant compositing and/or titling, or will need color correction in Color. If the project is going to be color corrected in Apple's Color application it has to be available in an all-I-Frame format like ProRes 422. Color will not work with native HDV (or XDCAM HD/EX) files.

## Convert to ProRes 422 after editorial completes

It is possible to work natively in HDV through the editorial phase and then convert to ProRes 422 before final render or color correction. At the end of the editorial process, when picture is locked, use Media Manager to Recompress to ProRes 422. Be sure to uncheck "Include master clips outside selection." Alternatively you could create an Offline project and recapture your final clips via HD-SDI and compress directly to ProRes 422.

Whether you want to work with ProRes 422 throughout the process, saving the time to render from HDV to ProRes 422 or recapture, or just wait until picture lock will depend on how "locked" picture lock is, and how much storage space you have. ProRes 422 is either roughly 5x or 9x larger than native HDV. My recommendation is that, if you plan on color correcting, in Final Cut Pro or Color, is to work in ProRes 422 from capture to output.

Having made the decision to work in ProRes 422 there are three options:

- Capture from HDV via HD Component Analog, HD-SDI or HDMI and compress to ProRes 422 on capture using third party hardware and decks/camcorders that support the appropriate output format. In an ideal work we'd all be using Sony's HVR 1500 out HD-SDI to ProRes 422;
- Capture Native HDV and Batch Export to ProRes 422 before editing starts;
- Have Final Cut Pro capture from HDV to ProRes 422 directly in software, which is a feature that was added to Final Cut Pro 6.0.2.

## Capture to ProRes 422 with hardware

Use the standard Log and Capture window. Choose an Easy Setup for the input type, hardware and using the ProRes 422 codec as the compressor for capture.

We use the standard Log and Capture window because the input is HD-SDI, HDMI or Component Analog and they are all captured with the standard Log and Capture window.



AJA's new io HD is a perfect choice because it has the ProRes 422 codecs in hardware. That means the computer can be a little less powerful, making the io HD workable with a MacBook Pro Quad G5.

Without an io HD we could use any Decklink or Kona card, or Blackmagic's Multibridge or Intensity series or V4HD or Matrox MXO2 to bring in the HD-SDI, HDMI or Component Analog and compress it, during capture, to

ProRes 422 using the computer's own resources. This is the same as coming in HD-SDI and compressing to any other codec (or uncompressed), except ProRes 422 requires more processor power to encode than most other codecs. Great results require great resources.

## Capture to ProRes 422 from HDV Direct (not necessarily real time)

With the 6.0.2 release of Final Cut Pro, Apple added the ability to capture directly from HDV to ProRes 422 for dual G5, or faster, computers. This process captures the HDV and converts to ProRes 422 without additional hardware. Like iMovie capture, this is not necessarily a real-time function.

This function takes an entire reel, or until you manually press stop, and creates ProRes 422 clips for every "shot" on the tape. Each shot is captured to a separate file (as is common for HDV), sequentially numbered but based on the same file name — that is the only control we have. On slower computers, like a dual G5, the process falls behind real time and takes longer.



For this process, monitor at the camera or deck and stop that when the content runs out. The computer could be displaying the capture much later. A 30-40% lag behind real time is not uncommon on slower machines. On a Quad G5 (PCIe) the capture to ProRes 422 of 1080i60 is approximately real time.

There are actually three Easy Setups for this, depending on the camera you want to use.

**HDV-Apple ProRes 422 1080p24** is used to transcode HDV 1080p24 footage from the Sony HVR-V1 camcorder to the Apple ProRes 422 codec during capture.

**HDV-Apple ProRes 422** is used to transcode HDV footage to the Apple ProRes 422 codec during capture.

**HDV-Apple ProRes 422 (HQ)** is used to transcode HDV footage to the Apple ProRes 422 (HQ) codec during capture.

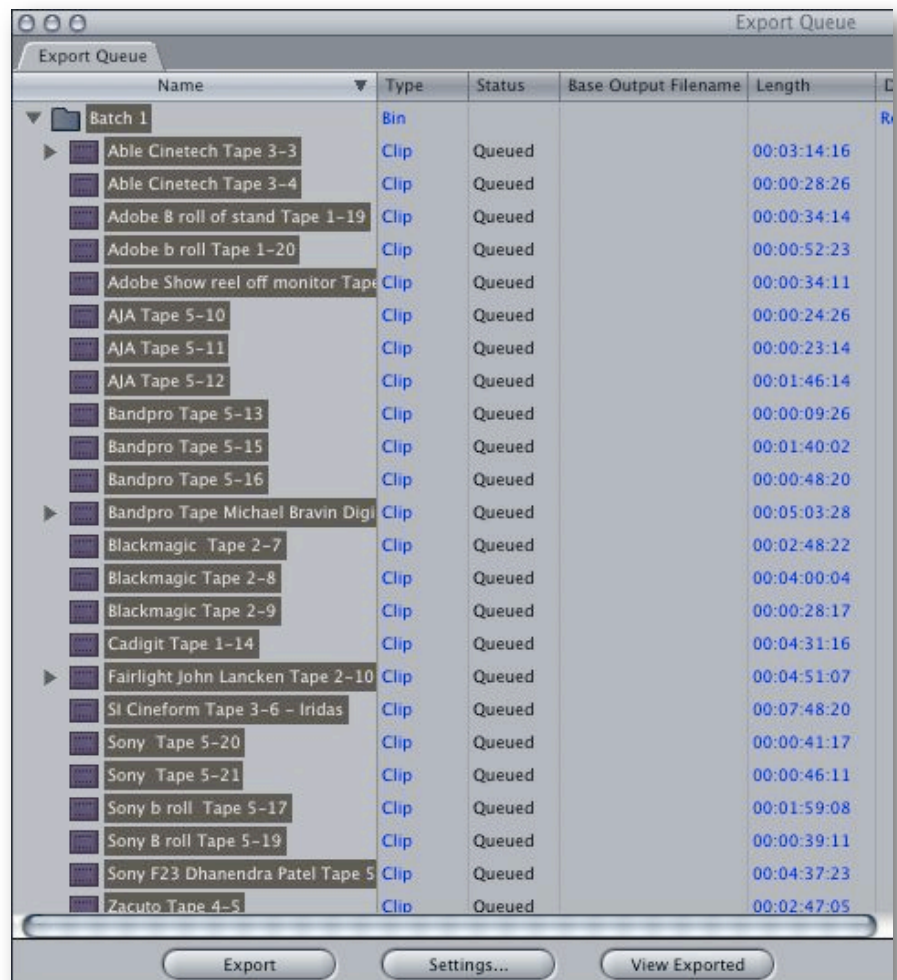
## Capture Native HDV and Batch Export

If you want to work with ProRes 422 and you capture HDV over FireWire, then the first step is to capture native HDV.

Once captured onto disk, do a Batch Export of your captured clips to the appropriate ProRes 422 codec, or use Media Manager to convert. Alternatively use Compressor 3 to do a batch conversion.

Compressor would be a good choice if you had captured Canon “24P” because it comes with regular 3:2 pulldown and a Reverse Telecine needs to be performed on these clips. Compressor can do that during the batch convert to ProRes 422.

This is a good choice if you have older hardware that can’t use the non-realtime capture technique above, or if you want more control over file names.





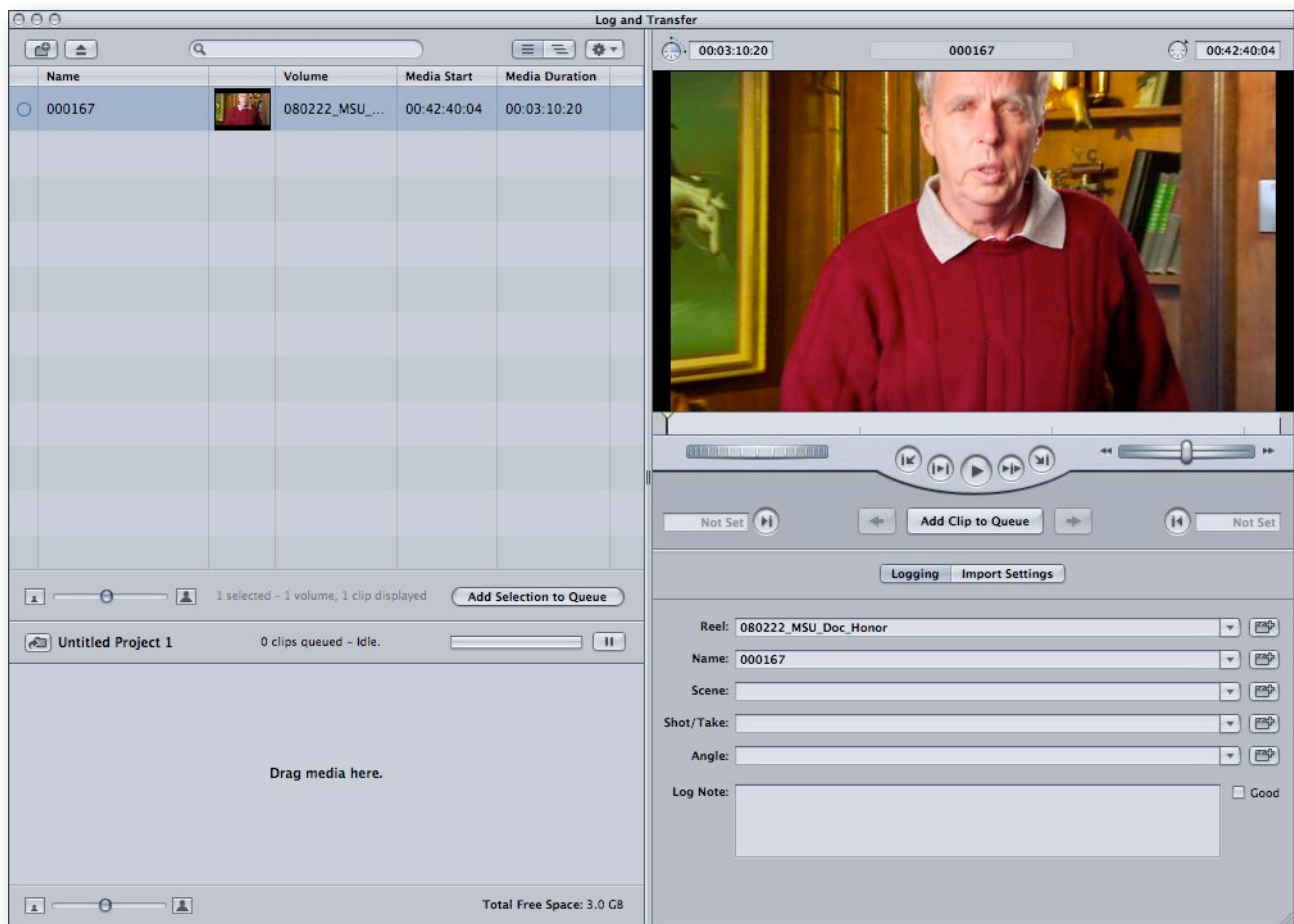
## Log and Transfer

If the Log and Capture window is for tape-based capture, then the Log and Transfer window is the equivalent for File-based formats like those from a P2 card, XDCAM HD disc, XDCAM EX SxS media, AVCHD and other formats. The Log and Transfer window has a plug-in architecture, so third parties can build plug-ins to add their format to the Log and Transfer window as new file-based formats are developed. Among plug-in support known of at the time of writing are those from:

- [RED Digital Cinema](#) (Intel Macs only);
- Sony XDCAM (Intel Macs only) and
- [Sony HVR-DR60](#) hard drive unit and the CF Card of the Memory recording unit.

Final Cut Pro 7 ships with support for P2 Media, XDCAM HD/EX, Sony VDU hard drive media, AVCHD<sup>24</sup> and AVC-Intra. These plug-ins also work to match metadata from the acquisition format(s) to Final Cut Pro's Logging nearest equivalent logging columns. Metadata that can't be mapped to Final Cut Pro's visible columns is stored as QuickTime Metadata in the Project file. This metadata can be viewed and sent to Final Cut Pro visible fields using the [miniME](#) from Intelligent Assistance, that I helped co-develop.

Unlike the Log and Capture window, the Log and Transfer window is resizable.



<sup>24</sup> As of Final Cut Pro 6.0.3 or later.

## The Log and Transfer Window

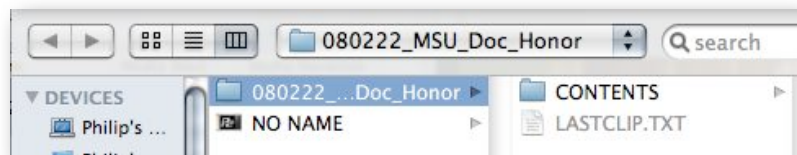
Using the Log and Transfer window is simple:

- Open the Media device or folder containing clips and metadata;
- Trim the Clip to the section you want to import;
- Add logging data (metadata/log notes); and
- Decide whether to import Audio, Video or both (if available).
- Import.

### 1 Opening the Media device or Choose a Folder

Add a folder (or card) of media by clicking the “Add Folder” button at the top left of the Log and Capture Window.

This is probably the most important part of the process. Unlike what you’d expect, you don’t select the media file. Instead you select the enclosing folder. It does depend a little on the media format you’re importing as to which folder you’ll choose. For example, for P2 Media, the folder you need to choose is the one that **encloses** (is above) the “CONTENTS” folder for this clip. You need the “CONTENTS” folder (and all it contains) and the “LASTCLIP.TXT” file. Without these files you cannot import P2 Media.



**Note:** If you have lost this structure you may still be able to rescue the P2 Media with the (not inexpensive) P2 Log from Imagine Software. (See [later in this section](#))

### 2 Select and Trim the Clip

Like with the Log and Capture window, we can trim clips in the Log and Transfer window. We do not have to import all that was shot for any individual clip.

Select the Clip from the list of available clips in the clip area at the upper right of the window. It’s also possible to jump to the Next or Previous Clip using the ‘Previous Clip’ and ‘Next Clip’ buttons under the viewer area, either side of the ‘Add Clip to Queue’ button.

The selected clip will appear in the viewer area of the window. Optionally set In and Out points for the import.



**Note:** We can create multiple Final Cut Pro clips from a single media file by setting In and Out points and adding the Clip to the queue. As only the selected segment will be added to Final Cut Pro the rest of the source clip can have In and Out points set and be independently imported.

This section of the Log and Transfer window works almost identically with scrub tools and play around current, etc.

### 3 Add Logging Notes (Metadata)

For anyone who's used the Log and Capture window the Logging section of the Log and Transfer window will be very familiar: the entry fields are identical. The only difference is that fields do not automatically increment number or suffix when a new clip is created. The button to the right of each Logging field increments the Clip count suffix, despite looking like a folder icon.

### 4 Decide on Import Settings

In the 'Import Settings' Tab you can choose whether or not to include Video, choose Audio channels to be imported, and set Stereo pairs for selected channels. (The default is to import as multiple mono channels.) The number of audio channels available will depend on the format of the imported media and the settings on the camera.

### 5 Import

When trimming and log note entry is complete, click the 'Add Clip to Queue' button below the viewer to add the Clip to the Transfer Queue.

The media will go to the Project selected with the 'Reveal Logging Bin' button at the top of the Transfer Queue area. To change this, click the button and set the Logging Bin inside Final Cut Pro that you want to send this media to.

When Clips are added to the Transfer Queue, they immediately begin processing. This involves unwrapping the media from the original file structure and format, and rewrapping it as a QuickTime file that Final Cut Pro can use.

Untitled Project 1 1 clip queued - Transferring 000167...						
	Status	Name	In	Out	Duration	
		000167	00:43:34:08	00:44:13:23	00:00:39:16	

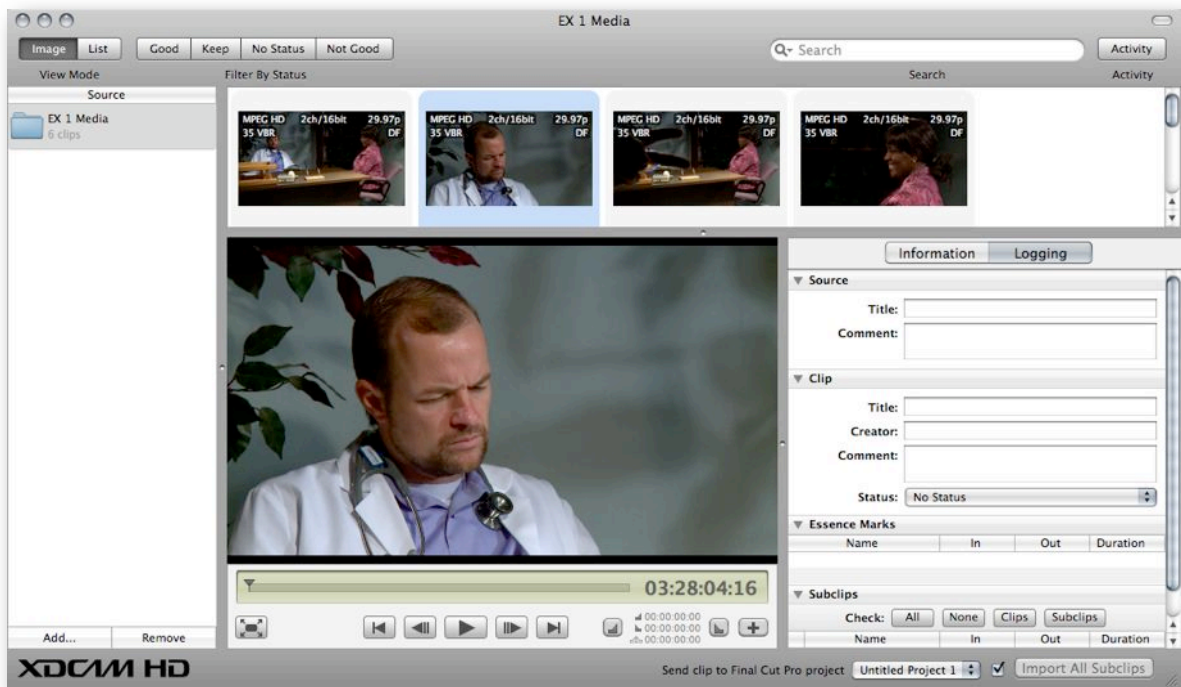
The Media is imported with the native codec, if supported in Final Cut Pro, or converts to ProRes 422 on import if there is no native codec support for the format in Final Cut Pro. P2 media is imported with the native DVCPRO HD codec from the source, while AVCHD, for example, is converted to ProRes 422 on import.

**Tip:** You can also drag clips directly from the Browse Area to the Transfer Queue. The entire length of the media file on the source will be imported to Final Cut Pro.

## XDCAM Transfer Utility

See note at the start of this section regarding a possible change to XDCAM import to Final Cut Pro, using the Log and Transfer window instead of the XDCAM Transfer Utility.

The utility is used to import by XDCAM HD off disc and XDCAM EX off SxS solid state media cards: the same software is used for both sources. You can also use the XDCAM Transfer Utility to organize clips by copying, moving, and deleting them. You can also perform format conversions, preview the clips, and view their metadata.



### Advantages of the XDCAM Transfer vs Log and Transfer

- Support both XDCAM EX & XDCAM Disc
- Handles XDCAM EX and XDCAM Disc clips
- Mounting SxS & PD media at the same time
- MXF export capability
- Can write edited material back to Professional Disc in MXF files
- Standalone browser/viewer
- Browsing/viewing are possible without running Final Cut Pro

## Installing the Software

The Sony XDCAM Transfer Utility requires Mac OS X 10.4.10 or higher and an Intel Core 2 Duo 1 GHz or higher (although it also works on my earlier series Core Duo MacBook Pro).

Download the XDCAM Transfer Utility – [XDCAM Transfer for Mac FCP Version 2.51](#) – and install it. It's a standard Mac OS X installer, simply follow the instructions from an Administrator's account on the computer.

**NOTE:** If you want to read (at the Finder Level) the SxS cards on a MacBook Pro, or other ExpressCard34 card slot, without the XDCAM Transfer Software you'll also need the SxS Pro Memory Card drivers for OS X: [SxS\\_Device\\_Driver.dmg](#) (available at the bottom of the page). These drivers are not necessary for the XDCAM Transfer Utility but will probably still be required to read media from the cards when the functionality of the XDCAM Transfer Software is incorporated into a Log and Transfer window plug-in some time in "Summer" 2008.

When launched for the first time you'll have to set some locations for the software's cache, the Scratch Disk location where you want the full resolution imported media files to be located – Sony call this "Import Location" – and the Export Scratch Location for exporting back to XDCAM.

## Using the XDCAM Transfer Utility

After installing XDCAM Transfer Utility on your computer, you can use its intuitive graphical user interface to organize your clips by copying, moving, and deleting them. You can also perform format conversions, preview the clips, and view their metadata.

Importing through the XDCAM Transfer Utility is very similar to using the Log and Transfer window. To get started choose the File menu and from the Import submenu select Sony XDCAM.

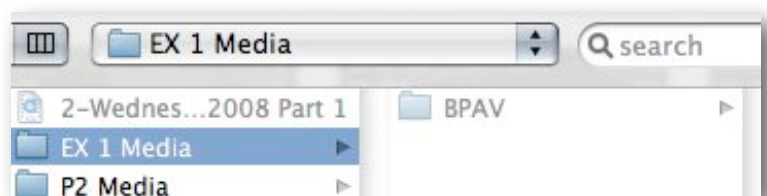
**Tip:** Open (or create and save) the Project that you're going to import the XDCAM material into, before launching the XDCAM Transfer Utility. Since the Utility is not part of Final Cut Pro it needs to be manually told which project to send the media to. It cannot do this if the Project is not open in Final Cut Pro.

The XDCAM Transfer Utility will launch. This software is independent of Final Cut Pro.

**Note:** You cannot select the folder with the footage inside, but instead you must select the folder enclosing the folder with the media. When selecting the enclosing folder, the XDCAM Transfer Utility will discover all relevant files within folders within the enclosing folder.

Add a source by clicking on the Add clip button at the bottom left of the window. (Remove a source from the Source list by clicking the remove button.)

**IMPORTANT NOTE:** You must keep





the entire folder structure, including text and XML files, for the import to be successful. So, when transferring media off the solid state card, be sure to move all the files and their folder structure and keep it strictly in the same structure. The files include the “essence” (actual media) plus a lot of metadata (data about the file) that is useful in post-production.

When media is discovered, the XDCAM Transfer Utility will load previews of each file from the proxies filed on disk across the top window of the interface.

For each clip that you want to import you can:

- Capture the entire clip as it is on the disc/card; and
- Set and In and/or Out Point(s) and import a selection from the clip.

From within the XDCAM Transfer Utility you can also:

- Send Clips to Final Cut Pro;
- Move Clips;
- Copy Clips;
- Rename the Clip;
- Group Split Clips; and
- Change the Index Picture.



### Importing XDCAM

- Select the Clip from the top of the window.
- Preview in the XDCAM Transfer Utility.
- Trim the clip, if necessary, by setting in and out points.
- Under the Logging Tab you have access to all the metadata stored with the clip, however the Logging Tab is where you’ll want to do some work.
- Enter the Source and Clip information in the Logging Tab. This information will appear in Final Cut Pro.
- When you’re done entering the metadata, choose which of the open projects in Final Cut Pro you want to send this Clip to.
- Click the ‘Import’ Button to send the clip and its information to Final Cut Pro.

Repeat until Clip transfer is complete for this session.

## XDCAM Essence Markers

If, like me, you don't know what an "Essence Mark" is — in the XDCAM Transfer Utility's Logging Tab, they are non-editable markers set by the camcorder. These are automatically set when particular events occur during recording. These can be configured in the camera, but include events like:

- audio level overshoots, and
- when there is an abrupt change in video luminance levels.

Multiple types of Essence Markers can be set, so Sony's tools allow searching by type.



## Other Logging and Transfer Tools

Imagine Products have tools for both P2 logging and media management and for XDCAM Media Management. [P2Log Pro](#) can be used to manage, name, search and repair P2 media files and their folder/metadata structure.



For XDCAM footage, [ShotPut Express](#) does much the same, adding the ability to make up to three simultaneous copies and secure copy. ShotPut Express is also available for Windows.

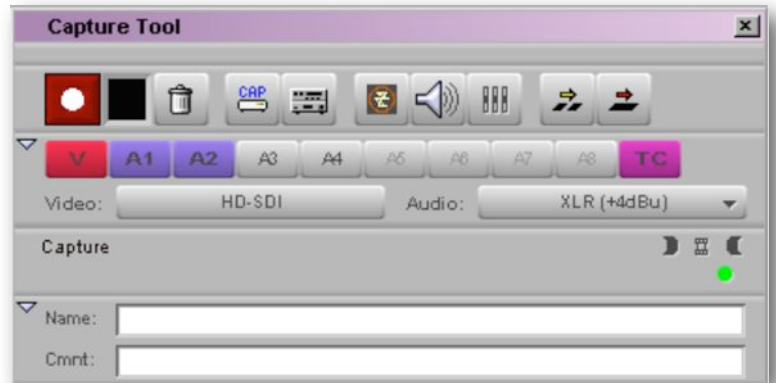
Both tools offload the task of managing the solid-state media from Final Cut Pro to these applications, freeing an edit station from the tasks of file copy and backup.



# Media Composer HD Workflows

Media Composer captures tape-based HD the same way that it captures tape-based SD: with the Capture Tool.

- Enter a name for the tape;
- Set Media Composer project settings;
- Set Capture location settings;
- Set audio and video tracks required; and
- Capture.
- 

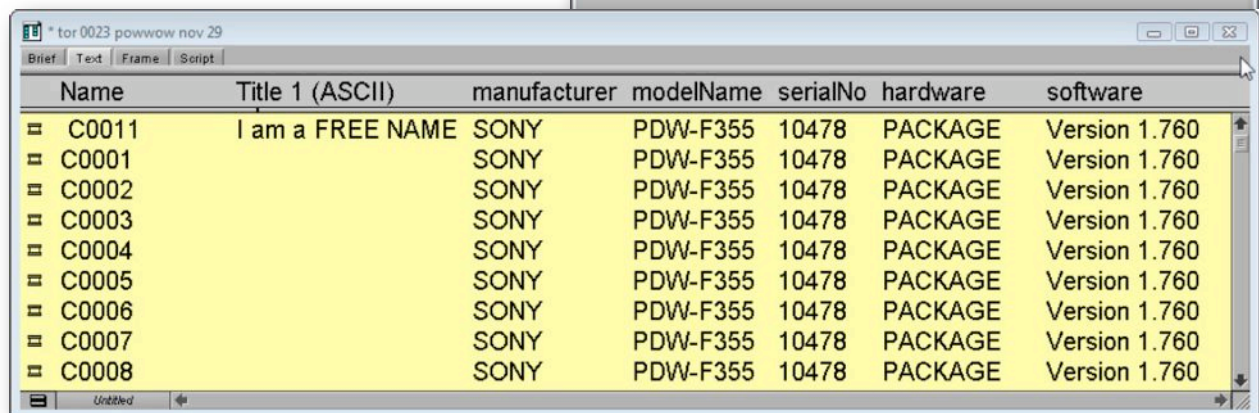
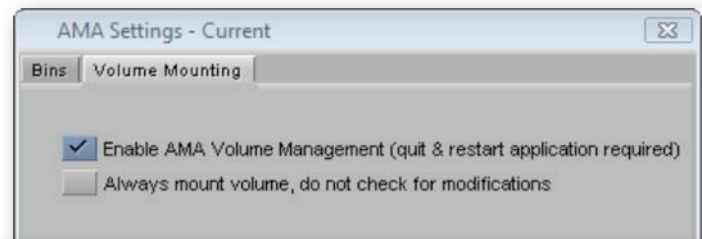


## AMA (Avid Media Access Architecture)

At NAB 2009 Avid announced a new plug-in architecture for dealing with non-tape media in native format and on native media (or consolidated media). Media does not have to be transferred to hard drive, although consolidating to local media from solid-state media is definitely recommended. Volumes link and clips relink intelligently.

Currently AMA supports Panasonic P2 media (DVCPRO HD and AVC-I) and Sony XDCAM HD/EX devices. Support for future devices can come from Avid or the manufacturer as the SDK for developing plug-ins is available.

Scott Simmons gives a [great introduction to AMA](#) over at ProVideoCoalition.com and goes into a lot more depth than I can here.



AMA is on by default. Imported media from an AMA volume shows highlighted in yellow. Consolidate to another volume before working.

# 24P

As an escapee from a “25Hz” country, I’ve never understood the fascination with the 24P “film look” that is prevalent in the US. I guess it’s so ingrained in the public conscience that 3:2 pulldown and too low a frame rate equal “film” that now it’s a given. (Trust me, if you’re not used to it, it’s a really ugly artifact that drives me nuts, but you didn’t buy this for my pet peeves!).

If you are going to shoot in 24P then you have to commit to doing it right. I’ve seen enough recent examples to suspect that the majority of work done in 24P is done wrongly or badly.

**IMPORTANT:** Through this section I’m going to write “24P” for convenience and shorthand, but in reality you will very, very rarely work in true 24P. All video-based 24P is, in reality, 23.976 frames per second. This odd number is a result of NTSC video working at 29.97 fps, instead of a true 30 fps. True 24 or 30 fps material will not play out to monitors using any standard hardware.

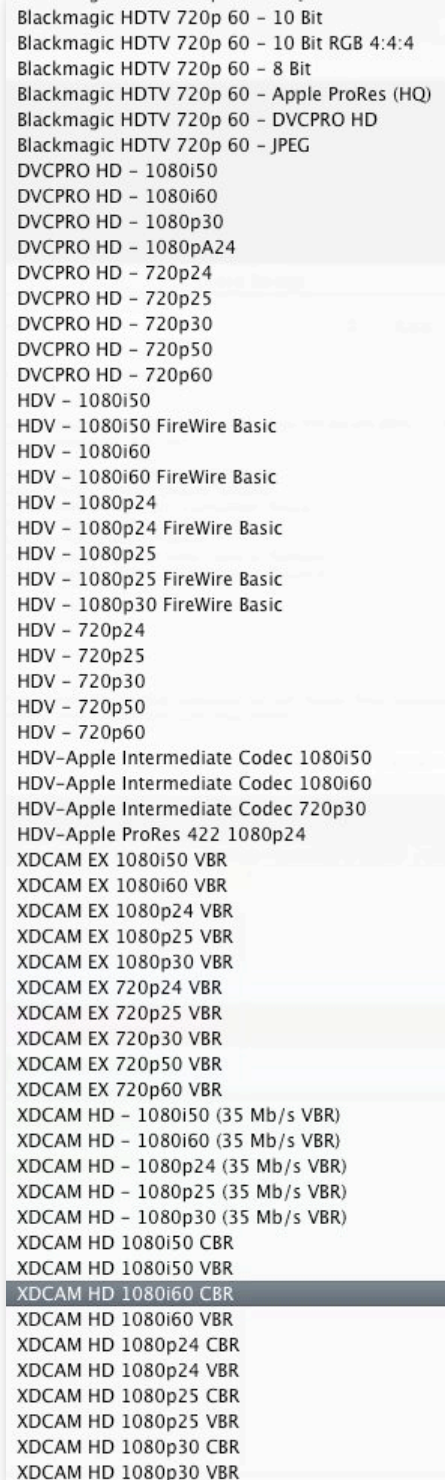
## 25P, 30P, 60P, 50P

Various HD formats and/or cameras offer 25P, 30P, 50P and 60P (in reality 25, 29.97, 50 and 59.94 fps). There are no special tricks to dealing with these frame rates as they correlate to native video frame rates. Simply choose the Easy Setup that matches the equipment you’re using.

If there is no Easy Setup, choose the closest setting and set the Sequence settings to “None” for Field Dominance in the Sequence settings. Unless the Field Dominance is set to “None” anything rendered in Final Cut Pro will be rendered with fields, something we do not want for progressive video.

## 24P done Right

If we could work natively with 24P footage throughout the process there would be a whole lot fewer problems. With the sole exception of Panasonic’s 24PN (on P2 Media) all other formats add some form of pulldown to the 24P frames to make them “fit” within a 29.97 fps interlaced transport. There are two types of pulldown in common use: Regular 3:2 (a.k.a. 2:3) pulldown and Advanced Pulldown.



Blackmagic HDTV 720p 60 – 10 Bit  
Blackmagic HDTV 720p 60 – 10 Bit RGB 4:4:4  
Blackmagic HDTV 720p 60 – 8 Bit  
Blackmagic HDTV 720p 60 – Apple ProRes (HQ)  
Blackmagic HDTV 720p 60 – DVCPRO HD  
Blackmagic HDTV 720p 60 – JPEG  
DVCPRO HD – 1080i50  
DVCPRO HD – 1080i60  
DVCPRO HD – 1080p30  
DVCPRO HD – 1080pA24  
DVCPRO HD – 720p24  
DVCPRO HD – 720p25  
DVCPRO HD – 720p30  
DVCPRO HD – 720p50  
DVCPRO HD – 720p60  
HDV – 1080i50  
HDV – 1080i50 FireWire Basic  
HDV – 1080i60  
HDV – 1080i60 FireWire Basic  
HDV – 1080p24  
HDV – 1080p24 FireWire Basic  
HDV – 1080p25  
HDV – 1080p25 FireWire Basic  
HDV – 1080p30 FireWire Basic  
HDV – 720p24  
HDV – 720p25  
HDV – 720p30  
HDV – 720p50  
HDV – 720p60  
HDV-Apple Intermediate Codec 1080i50  
HDV-Apple Intermediate Codec 1080i60  
HDV-Apple Intermediate Codec 720p30  
HDV-Apple ProRes 422 1080p24  
XDCAM EX 1080i50 VBR  
XDCAM EX 1080i60 VBR  
XDCAM EX 1080p24 VBR  
XDCAM EX 1080p25 VBR  
XDCAM EX 1080p30 VBR  
XDCAM EX 720p24 VBR  
XDCAM EX 720p25 VBR  
XDCAM EX 720p30 VBR  
XDCAM EX 720p50 VBR  
XDCAM EX 720p60 VBR  
XDCAM HD – 1080i50 (35 Mb/s VBR)  
XDCAM HD – 1080i60 (35 Mb/s VBR)  
XDCAM HD – 1080p24 (35 Mb/s VBR)  
XDCAM HD – 1080p25 (35 Mb/s VBR)  
XDCAM HD – 1080p30 (35 Mb/s VBR)  
XDCAM HD 1080i50 CBR  
XDCAM HD 1080i50 VBR  
**XDCAM HD 1080i60 CBR**  
XDCAM HD 1080i60 VBR  
XDCAM HD 1080p24 CBR  
XDCAM HD 1080p24 VBR  
XDCAM HD 1080p25 CBR  
XDCAM HD 1080p25 VBR  
XDCAM HD 1080p30 CBR  
XDCAM HD 1080p30 VBR

## Types of Pulldown

The use of pulldown in “60Hz” countries dates from the first need to transmit 24 fps film on a 30 fps interlaced video system. This problem was solved by adding “2:3 Pulldown”, which creates a pattern where each progressive source frame is played for some additional fields. The *pattern is obvious in the image* below:

Source Frame 1 (yellow) displays for two fields. Because this is a progressively acquired image, both fields are from the same moment in time and the frame appears to be progressive. We refer to frames like this as Whole Frames because the frame comes from the same moment in time.

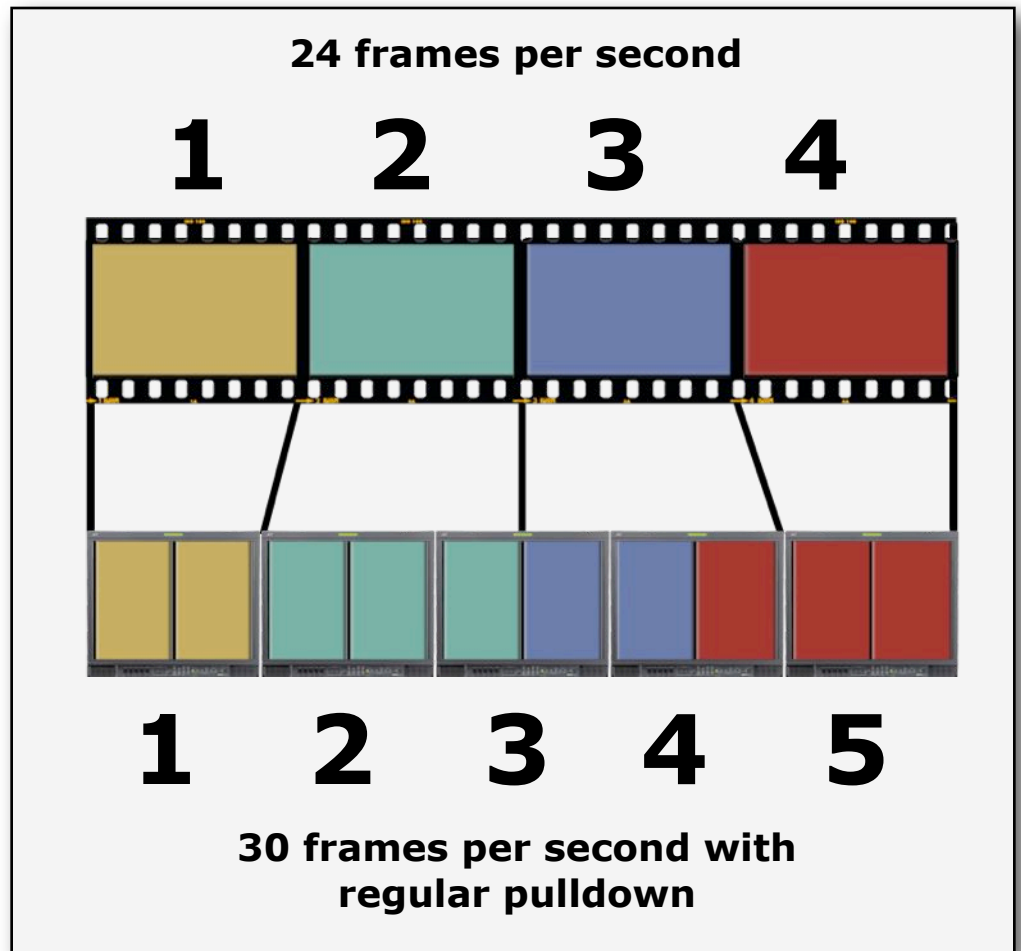
Source Frame 2 (green) is displayed for three fields. This creates “a frame and a half”. The first two fields, like in Frame 1, create a progressive Whole frame. The leftover field is carried forward to make the first half of output frame 3.

Source Frame 3 (blue) contributes two fields but we’ve already got a half field from Source Frame 2, so the two fields from Source Frame 3 contribute a second field to Output frame 3, with the second field from Source Frame 3 passing forward to Output Frame 4. Output Frame 3 has one field from Source Frame 2 and one Field from Source

Frame 3. You can see how this looks in image number 3 in the sequence of frame grabs above. Frames like this are referred to as Split Frames in a pulldown sequence, because the image is split with a field from one frame and a field from another frame.

Source Frame 4 (red) contributes three fields. One completes Output Frame 4, which is another Split frame, and the final two fields from Source Frame 4 complete Output frame 5 and the pulldown sequence.

3:2 pulldown was routinely added to film when it was Telecined to Video in one continuous pass. It’s also reasonable to add 3:2 pulldown to an edited 23.98P master after completing the edit in a 23.98P sequence if, and only if, the show was going to tape for eventual NTSC analog distribution. And then it needs to be applied to the whole master tape in one pass, not shot by shot.





## The Problems with 3:2 Pulldown

The problem is that adding 3:2 pulldown in the camera is problematic to remove and yet it must be removed before we edit or output for the web. (See [Broken Cadence cannot be removed.](#))

To remove 3:2 pulldown, Output Frames 3 and 4 have to be decoded, the third field from Source Frame 2 removed; the third field from Source Frame 4 removed, and the remaining fields from Source Frame 3 joined together into a new Frame 3 for the progressive output. Needless to say this can't be done in real time during capture to the Non Linear Editor. It requires separate processing after capture to remove 3:2 pulldown. Apple supplies Final Cut Studio's Cinema Tools for this purpose. Compressor is also able to remove pulldown. Media Composer can remove pulldown on capture.

**If you shoot progressive you MUST edit progressive.**

**Pulldown added in the camera must be removed from each clip before editing starts**

## Editing 3:2 Pulldown clips at 29.97

It would seem that many people mistakenly think that they can edit footage shot at 24P with regular 3:2 pulldown applied, as 29.97 clips in a regular 29.97 Sequence.

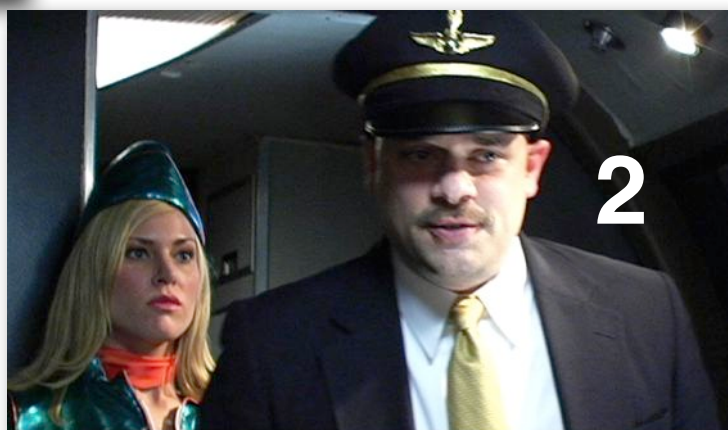
The best way to explain the problem with this is to consider the following sequence of frames from



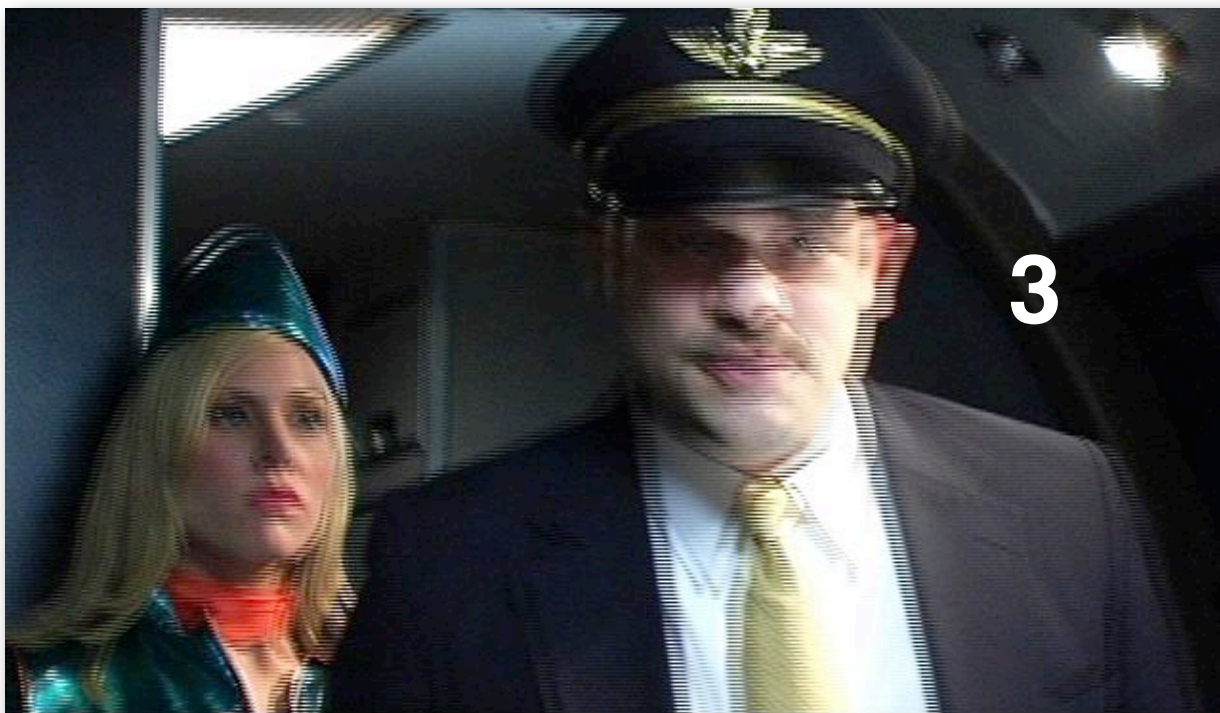
**W W S S W**

The first two fields are progressive (Whole) as they should be.

**W W S S W**

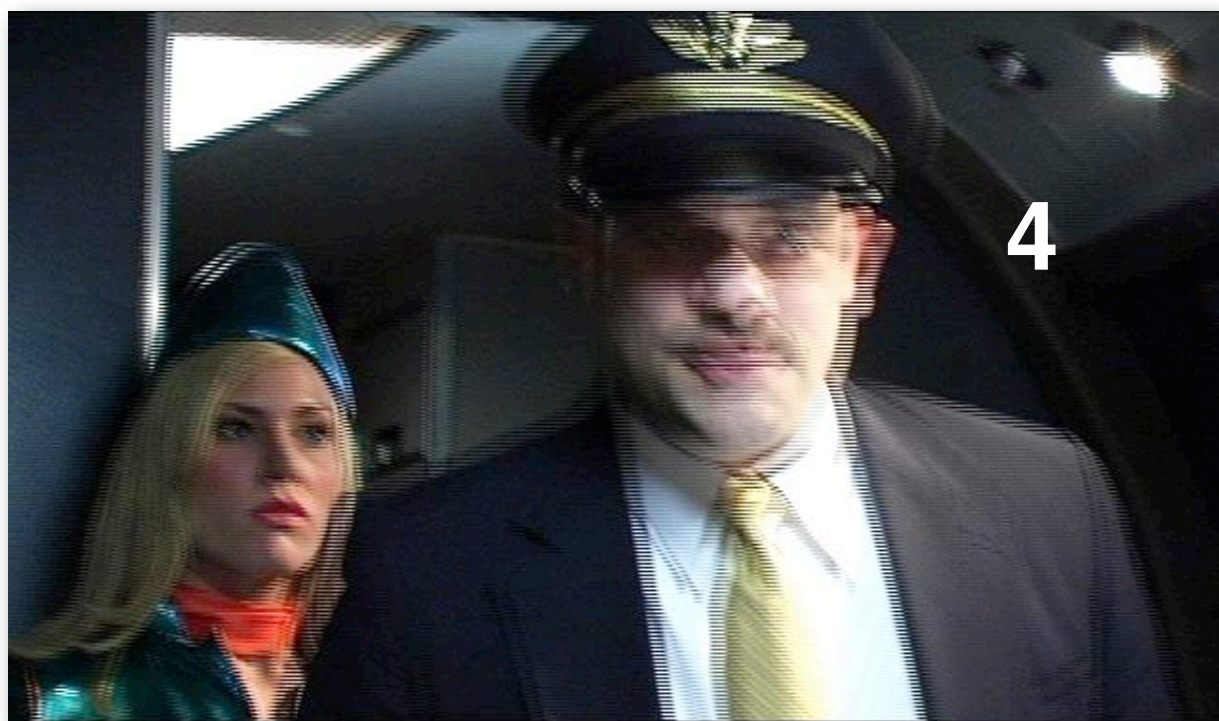


a video edited at 29.97 but shot at 24P with 3:2 pulldown.



The third frame is Split as it should be.

**WWSSW**



**WWSSW**

The fourth frame is Split as it is in the normal sequence of 2:3 pulldown.





The sequence finishes with a Whole progressive frame at frame five, before starting over.

**WWSSW**

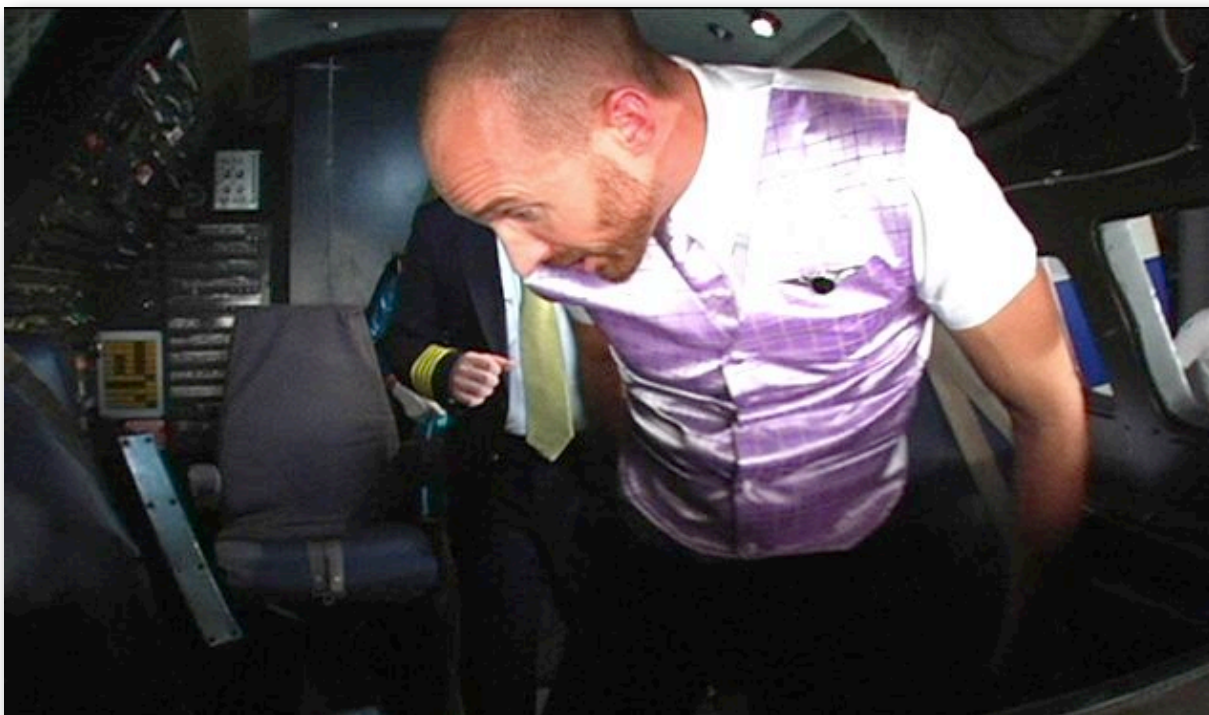
While the shot is continuous the sequence will continue correctly. Problems arise when shots are edited together.

**WWSSW**



The cadence is broken across the edit!

**WWSSW**



This should be a split frame, but it's progressive because the pulldown was applied to each shot, individually, not continuously across the edit!

**WWSSW**

## Broken Cadence

If the clips have 3:2 pulldown baked into them in the camera and editing is done at 29.97 fps then the pulldown cadence – the pattern of whole (W) and split (S) frames – potentially changes (or “breaks”) at every edit in the 29.97 fps sequence, as indeed it has in this program. This is a bad thing for three reasons:

- Broken cadence will get a program rejected by Quality Assurance at any network or distributor;
- Broken cadence cannot be easily reversed to 24P for distribution on DVD meaning that you have to include 20% redundant frames, reducing the efficiency of your encode; and
- For web distribution we need progressive frames and broken cadence makes it nearly impossible to do a clean, interlace-free encode for digital distribution.

The editor could examine every edit for correct cadence, but the chances are that any given edit would have to move up to four frames earlier or later just to match cadence. This is not good for editing so the best solution is to revert to true 24P before editing starts. How you get there will depend on the way your camera encodes 24P. (See later section on “[24P Workflows](#)”.)

## Why not just drop the 29.97P (23.98+ 3:2 pulldown) footage in a 23.98 fps Sequence?

The problem is that Final Cut Pro and Media Composer, will try to map the (now) 29.97 fps into 23.98 fps, and will do a very, very bad job of it. The result will have split frames where whole frames were expected. Although Final Cut Pro 6 will allow mixed frame rates in a Sequence, you cannot get good results using source footage with 3:2 pulldown added by the camera, while editing in a 23.98 fps Sequence. The cadence will (potentially) break at every edit.

## Choose your pulldown wisely

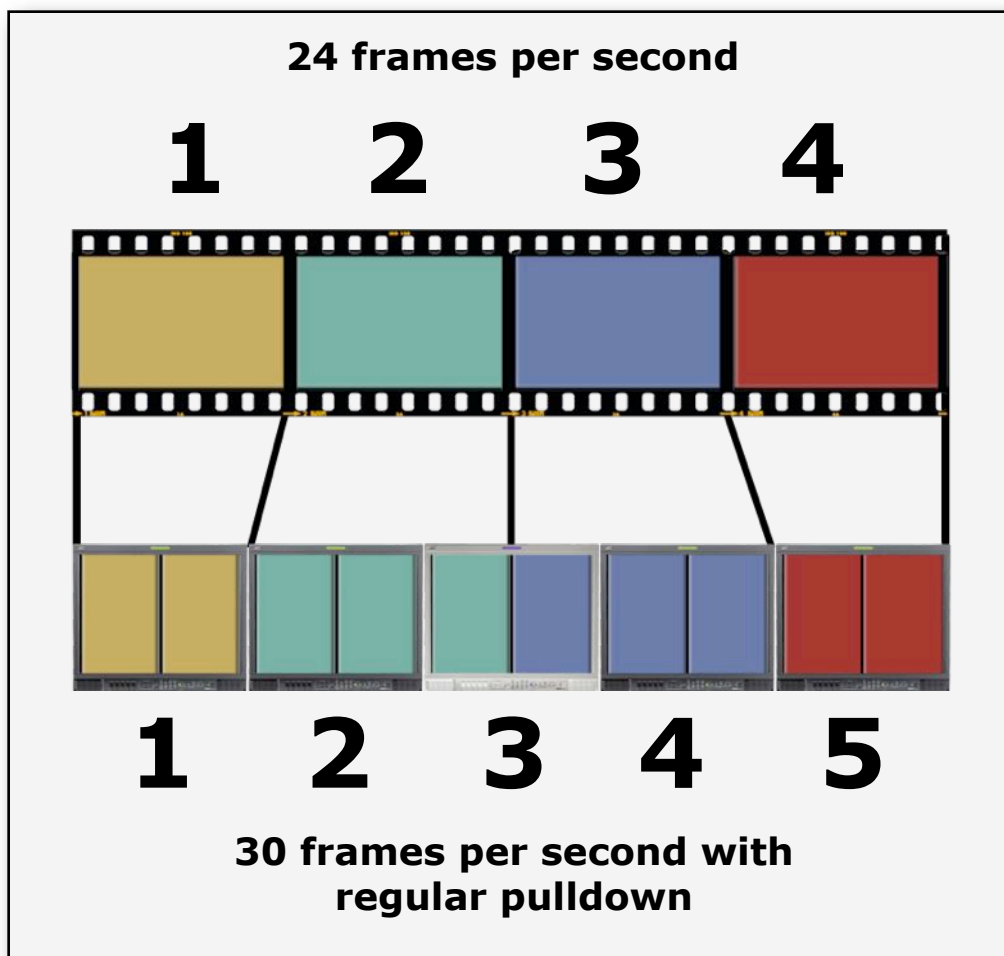
As we've seen, regular 3:2 pulldown is **completely the wrong choice for production**. If you have this type of source footage for Final Cut Pro, you must use Cinema Tools or Compressor to decode the footage and remove the pulldown. With Media Composer you must remove pulldown for each clip on Capture. Removing pulldown is called Reverse Telecine, a name that stuck from the early days of encoding for the Internet, when film source needed to have pulldown removed before it was encoded for the Internet.

The only way to remove 3:2 pulldown from the source clips is to capture each shot separately and remove the pulldown. Pulldown removal **must** be done before any editing starts.

## Advanced Pulldown — a better choice

There is another kind of pulldown, originally pioneered by Panasonic with their AG-DVX100 series of DV camcorders, called "Advanced Pulldown". Instead of a 3:2:3:2 sequence, Advanced pulldown uses a 2:3:3:2 cadence. This creates a sequence of frames like these.

Advanced pulldown is designed to be easily removed before editing. Traditional 3:2 pulldown can only be removed by decoding each frame, removing the redundant fields and then recreating





the original whole frames. Something that cannot be done in real time by any current software-based edit system.

Advanced pulldown can be easily removed by simply skipping the third frame in the sequence. Advanced Pulldown removal can be done by most modern software non-linear editors, like Final Cut Pro and Media Composer, during capture, without decoding the file at all.

Editing is then performed at 23.98 Progressive and delivery is 23.98 Progressive. No pulldown should be added unless outputting to tape. DVDs should be authored at 23.98, it's part of the spec!

## ***Never add pulldown***

A number of camcorders available today use solid state media, such as Panasonic's P2 system. Cameras based on P2 media have a mode called 24PN. This mode only writes the 23.98 progressive frames to the solid state media. There is no pulldown added, so pulldown does not need to be removed. This is definitely the preferred method with these cameras. It gives 20% longer record times too, because it doesn't have to add redundant (and useless) information to make the footage match a tape-based frame rate. There is also a 30PN mode that writes 30 true progressive frames per second.



## ***Summary***

If you shoot progressive, edit progressive.

If you shoot 23.98P to tape, use **ONLY** advanced pulldown so it can be removed during capture to Final Cut Pro or other NLE. If you only have the option of standard pulldown, remove it from every clip before editing starts, using Cinema Tools.

If you shoot P2, use a mode that records only progressive frames to the solid-state media. For Panasonic's P2 that's 23.98PN or 30PN.

If you shoot 23.98P, edit at 23.98P. Make sure the Field Dominance is set to None for the Sequence. This is set correctly in Final Cut Pro's 23.98P Sequence Presets

If you shoot at 29.97P, make sure the Field Dominance is set to None for the Sequence. There is **NO** Sequence Preset for this supplied with Final Cut Pro. You will need to duplicate a regular 29.97 fps Sequence and change the Field Dominance to None as above.

# 24P Workflows

There are four distinct ways of handling 24P within modern formats and sub-\$10,000 cameras:

- 2:3 Pulldown (HV20, V1U, Z7, Z270, EX-1, EX-3)
- 2:3:3:2 Advanced Pulldown (XL H1, A1, G1)
- Repeat Frame Flag (JVC HV 110, 200, 250)
- Whole frames only 24PN (HVX200, HPX-170)

The nice thing about standards is how many there are! Each of these approaches requires a different workflow to ensure that you work with **only** 24P Clips when you start editing in a 24P Sequence.

## *Reversing 2:3 (3:2) pulldown.*

Working with regular 3:2 pulldown with any of the HV20, V1U, Z7, Z270, EX-1, EX-3 cameras, requires first capturing the footage in its native format and then processing in Cinema Tools or Compressor.

**IMPORTANT NOTE:** On the Sony V1U, Z7, Z270, EX-1, EX-3 check that you are recording in 24A mode. This is not Advanced Pulldown but instead ensures that each new recording will start a new GOP with the correct Timecode sequence so that the 3:2 pulldown can be removed in a batch process. Without this we have to manually set the pulldown cadence for each captured clip, before running it through Media Composers' Capture Tool or Apple's Cinema Tools. Cinema Tools expects the A frame of the pulldown sequence to always start on a 0 or 5 frame Timecode. That is 00:00:12:00 and 00:00:12:05, 00:00:12:10, 00:00:12:15 etc.

## Media Composer:

Media Composer will remove 3:2 pulldown or Advanced Pulldown during capture.



DVCPRO HD - 1080i50 48 kHz  
DVCPRO HD - 1080i60 48 kHz  
DVCPRO HD - 1080p30 48 kHz  
DVCPRO HD - 1080pA24 48 kHz  
DVCPRO HD - 720p24 48 kHz  
DVCPRO HD - 720p25 48 kHz  
DVCPRO HD - 720p30 48 kHz  
DVCPRO HD - 720p50 48 kHz  
DVCPRO HD - 720p60 48 kHz  
Generic Capture Template  
HDV  
HDV-Apple Intermediate Codec  
HDV-Apple ProRes 422  
HDV-Apple ProRes 422 (HQ)

## For Final Cut Pro

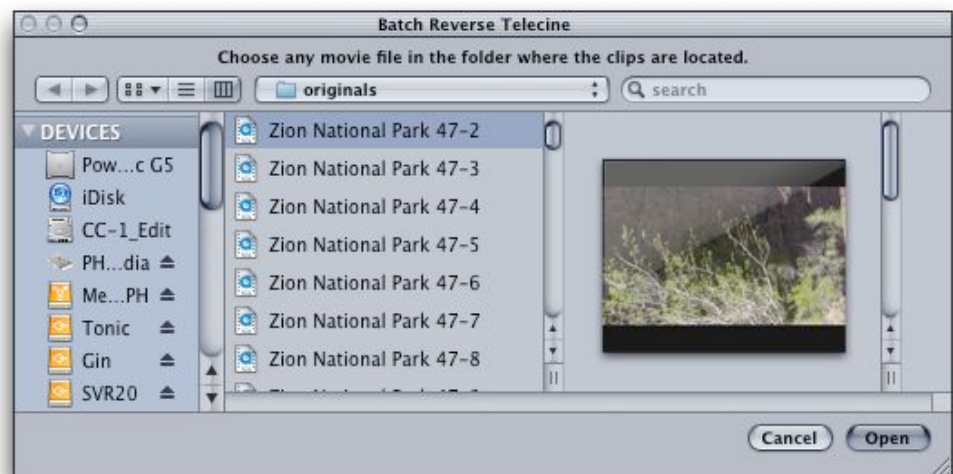
When capturing, Apple presents the choice to capture to the native codec or to convert to ProRes 422 on capture. Because Cinema Tools requires an all I-frame codec to work, meaning HDV and XDCAM HD won't work in native format, converting to ProRes 422 on capture is definitely recommended. Compressor can Reverse Telecine HDV and XDCAM HD but it will take a much longer time than from all-I-frame footage, as each frame needs to be constructed from 15 frames, before it can be determined which frames need pulldown removed and which do not. This is very computationally intensive. It is much more efficient to convert on capture.

- Capture using the **1080i60 Easy Setup**
- After Capture open the captured clips in either Cinema Tools or Compressor to Reverse Telecine.

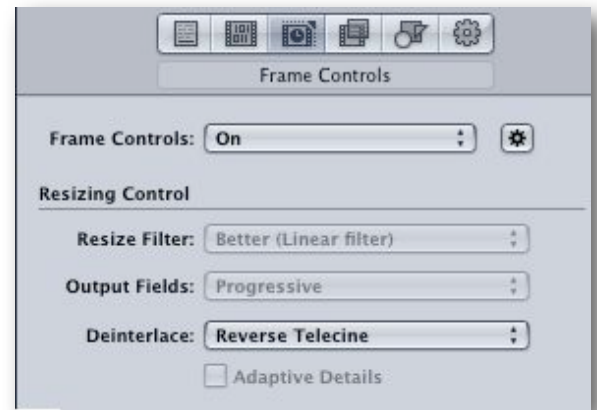
## Reverse Telecine in Cinema Tools

- Run Cinema Tools
- In the Welcome to Cinema Tools window choose "Open Existing Database" and click Continue.
- When the Open dialog displays, click "Cancel". All windows close.
- Choose the File menu and select "Batch Reverse Telecine..." An Open dialog will appear.
- Open the folder containing the clips to be Reverse Telecined.
- Select one clip in the folder. It doesn't much matter which Clip you select, as the whole folder will be processed.
- Click "Open" to continue.
- Most of the time you will simply accept the default settings in the Batch Reverse Telecine dialog. Click "OK" to start processing.
- After processing there will be a folder of Original Clips, Reversed Clips and, sometimes, a folder of skipped Clips if they cannot be successfully reversed.

Import the new 24P Clips to Final Cut Pro. I recommend using a new Project for the 24P clips, keeping the original capture Project with a link to the source media.



**Note:** If the Clips are not locked to an A frame at “0” and “5” frame Timecodes, Batch Reverse Telecine will not work successfully. In that case I recommend using Reverse Telecine in Compressor, as processing each clip manually through Cinema Tools is very time consuming. For each clip you manually process you have to determine the actual cadence on the clip (from the first frame) and then choose the reversal patten that matches. Not fun.



## Reverse Telecine in Compressor

- Run Compressor.
- You will need to create a new setting. (You may need to apply the Apple preset to a clip to modify the settings.)
- Start with either of these Apple-supplied presets:
- Apple ProRes 422 for Progressive Material; or
- Apple ProRes 422 for Progressive Material (High Quality).
- Leaving all other settings the same, select the Frame Controls tab in the Inspector, and turn on Frame Controls
- From the Deinterlace pop-up menu select ‘Reverse Telecine’.
- Save this setting.
- Set the new setting as the default in Compressor Preferences: Default Setting.
- You should also create a new Destination for the resulting media files and make that the default.
- Making the setting and destination the defaults means that they will automatically be applied to any imported Clips, saving a lot of time for multiple clips.
- Import your captured files from the media location. Although there is no import folder function in Compressor, you can select multiple files in the Open dialog that comes up after clicking “Add File”, or you can drag and drop a group of clips from their capture folder to the Compressor interface.
- Submit the batch to Batch Processor.



When the Clips are processed, import the new 24P Clips to Final Cut Pro. I recommend using a new Project for the 24P clips, keeping the original capture Project with a link to the source media.

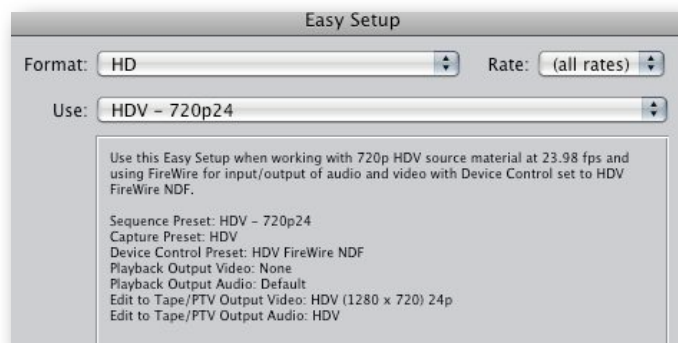
## Reversing Advanced Pulldown

In Media Composer, set the Capture Tool to reverse advance pulldown and proceed.

In Final Cut Pro, Advanced 2:3:3:2 pulldown is as easy to remove in HD as it is in SD. Choose the **HDV – 1080p24 FireWire Basic** for any of the Canon family of HDV camcorders.

Capture using this preset and Final Cut Pro will skip the redundant frame in Advanced Pulldown footage during capture. No additional post-processing is required.

**Note:** The clock must be set in the camcorder for Advanced Pulldown removal to work. This only needs be set once when the camera is new if it's not set correctly at the factory.



## Working with Repeat Flag footage

Media Composer detects and compensates for repeat flag MPEG 2.

The JVC series of HDV camcorders does not add pulldown to the HDV 1 footage. Instead, it simply flags every fifth frame as being redundant and not required. This is a simple “switch” in the file to repeat a frame already encoded and not encode any additional frames. Since there are no duplicate frames or added pulldown, it's very easy for Final Cut Pro to simply ignore the duplicate on capture, producing true 24P footage.

Choose the **HDV – 720p24 Easy Setup** for the JVC family of HDV camcorders that support 720p24.

Capture using this preset and Final Cut Pro will capture the 24 real frames per second and ignore the “duplicate frame flag”. No additional post-processing is required.

## Working with Native 24P

Only formats recording to solid-state media can capture native 24P. Why Sony chose not to take that route for the EX-1 is unclear, possibly to maintain full compatibility with their disc-based XDCAM HD files (although changing the container format didn't seem to phase them!)

For footage that has been taken with an HVX-200 or the HPX-170 in 24PN mode can be captured via the Log and Transfer window as native 24P for Final Cut Pro or mounted directly using Avid's AMA in Media Composer. These are 24P files on the card and are transferred as they are to native 24P ready for editing in Final Cut Pro or Media Composer.

## Test the workflow

Regardless of these instructions, you should test the entire workflow – from shooting, to capture, editing and output – before committing to a format. This applies doubly before working on any project that is to be shot at “24P”.



# Storing and Archiving Tapeless Media

Bunim Murray, producers of *The Real World* can go back to the vault to the tapes shot on the first season 14 years ago. In some ways it's an archive of obsolete formats (starting with ¾" on that first season). Regardless, they can find any tape from any season in the vault. With tapeless workflows there are no source tapes. For XDCAM and XDCAM HD on Blu-ray disc the discs function as tape: they can be archived or reused as needed.

However solid state media like Panasonic's P2 and Sony SxS formats (and captures direct to hard drive without tape), are much more problematic as it is not financially viable to keep the footage stored on solid state media. So the question is "how to archive the content", or more succinctly:

"How will you know where to find a file from today's shoot, in five years time?"

There is no single magic bullet as of June 2009, nor any in the immediate pipeline. Best solutions to date include RAID 5 or RAID 6 storage and data tape archives.

At the Creative Storage Conference in 2007, 100-year life storage for film assets was quoted at around \$400 a minute of archived material. For "lesser" assets the storage may not be so crucial but it still needs to be considered before a tapeless format is adopted.

## ***RAID 5 or 6***

When considering storage for archive purposes the most important factor is reliability and cost. RAID 5, which is tolerant of one drive failure at a time, is probably the most common solution. It still leaves vulnerability because, even if the drive is replaced immediately it fails (unlikely) there will be 24-48 hours before the media has propagated across all drives. During that period, the RAID is vulnerable to drive failure. One more failure in that RAID during the rebuild period would be fatal to all the data. Consider that most people do not have a spare drive at hand, and that it may take a day or so to notice the failure, then a system could be vulnerable to a second failure for 3-5 days.

RAID 6 tolerates two failure and prudent producers will opt for that, even though it further reduces storage by 20%. In the 3-5 day scenario, a second drive could fail without losing data.



[www.caldigit.com](http://www.caldigit.com)

## ***Data Tape Backup***

The way that other industries have evolved backup for the irreplaceable digital data is to use a data tape backup system, usually automated.

Quantum would recommend their SDLT 600A, which can hold 300 GB of data on a single SuperDLTape II. Echo Entertainment found that footage from a day's shoot with three cameras can be stored on a single 300 GB tape, with an expected shelf life of 30 years. (That life expectancy is likely to be longer than the drives are likely to be available to read it).



Drobo Robotic Storage

## ***Blu-ray Disc***



At 25 GB and (roughly) \$15 a disc, Blu-ray is much more expensive storage than hard drive arrays. It is also totally unproven for long-term storage.

One interesting idea, though, is that XDCAM EX can be output to XDCAM Blu-ray without transcoding or losing quality. The resulting disc is a fully compatible XDCAM HD disc. Multiple copies could be made for redundant backup.

**Note:** An XDCAM HD Blu-ray disc is not the same as a regular recordable Blu-ray disc. The XDCAM HD disc comes in a protective cover and has had nearly a decade of reliable performance to draw on.

## ***Bottom Line***

The only truly reliable way for long-term archiving is to output to film. To be precise: to output to Technicolor separations for Red, Blue and Green. Monochrome film is much more stable than color film, which tends to fade after 20-30 years. Technicolor separations, stored in the appropriate vault with stable, cool temperature and low moisture, will last particularly well.

Due to cost considerations (that's painfully expensive) most people will never do Technicolor separations, and realistically, it's overkill for almost all production (despite how the producer, director or client may feel at the time).

The reality is that we can archive solid-state media back to tape, or to hard drives in RAID arrays, but we are really going to be transferring from old format to newer format every 15-20 years. That should determine whether the content is still valuable enough to pay for the cost of new archive masters every 20 years.

# Distributing High Definition

*Having explored the exciting new alternatives sub-\$10,000 HD camcorders offer and considered the complications of post-production workflow, it's time to consider what happens after that HD master is complete. How do we get the project to the viewer in HD?*

Blu-ray distribution has become significantly more practical this year, in a big move forward from just a year ago. The AACCS licensing fees have been significantly reduced; Final Cut Pro 7 adds a simple Blu-ray disc facility; and there are workflows using Encore DVD (Adobe) and third party software to make the Encore output replicatable.

The other options — data on a regular DVD, Hard Disk, or Digital Distribution — all have their own problems, meaning that HD distribution is nowhere near as mature as production and post-production.

Internet distribution has also advanced over the intervening year since the last edition, with the cost of distribution dropping and modern codecs like H.264 - now supported in more places than ever - are reducing the bandwidth required for a high quality image.

# Blu-ray Disc

In early 2008 Sony's Blu-ray HD disc format won out over the rival HD DVD format. While it is great to finally have a single standard, Blu-ray isn't anywhere near as friendly to independent producers as HD DVD was. HD DVD was an extension of the very-well-established SD DVD but using advanced codecs and a blue laser instead of a ruby (red) laser in standard DVD. HD DVD could be produced on standard DVD production lines with only minor modification, so replication pricing was close to SD DVD. Most importantly for our purposes, AACS – the HD content protection system – is mandatory on all replicated discs in Blu-ray but was optional with HD DVD.



## AACS and Blu-ray replication

The [Advanced Access Content System](#) (AACS) is an attempt by the big studios to reestablish the content protection that was so easily broken on SD DVD – the CSS or Content Scramble System. AACS was supposed to be “unbreakable” for “at least 10 years” but most parts of it have already been circumvented, for at least some titles, and it is inevitable that it will no more protect HD discs than CSS did SD discs. The studios survived (and thrived) on DVD sales despite the effective lack of content protection.

Regardless, AACS is mandatory on every replicated (pressed) Blu-ray disc. It is not mandatory on duplicated (or burnt) Blu-ray discs, but many early players would simply not play duplicated Blu-ray discs at all. Regardless of whether or not you want AACS copy protection you have to have it on every replicated disc.

This is expensive.

## AACS fees

In order to replicate a Blu-ray disc the content owner/rights holder must become a member of the AACS group. Fortunately this is a lot less expensive than it was a year ago, thanks to the good work from Bruce Nazarian, the [IDMA](#) and others. There is now an annual payment of \$500 per content owner.

From then, every title you release requires a US\$500 fee per title and 4c per disc replicated. This makes the minimum fees for a 1000-unit run (assuming you can find a replicator who will do a run that small), for a new content owner, US\$1000, far less than last year's US\$4340! That is still without the actual replication fees, but the IDMA have set up a [website to help](#).

**Note:** The AACS fees are for each content owner. It appears that a production company cannot be the “content owner” on behalf of their clients and share the sign-up fee of \$3000 between customers, unless the ownership of the content is assigned to the production company.

Continues on page 200...

## **SIDEBAR: *Blu-ray Disc Java (BD-J)***

Blu-ray Disc Java is the technology chosen by the Blu-ray consortium to drive advanced interactivity on Blu-ray discs, including fairly sophisticated web interactivity, picture-in-picture features, and access to local storage. It is therefore (theoretically) possible to have a Blu-ray disc with no actual video included where the most recent version of the video is continually downloaded and updated from the Internet.

BD-J support came after the initial release of Blu-ray players so many early players did not support it. Currently the best support for BD-J is on Sony's PlayStation 3 as long as it has the Profile 1.1 firmware upgrade released in January 2008. Since the end of October 2007, all new players are supposed to have support for the "Bonus View" features, but that does not guarantee that all features are supported. For example, "BD Live" — the web connectivity part of the spec — is always optional for a player. That is, while it's "standard" there's no guarantee that any given player will support it. That appears to be unlikely to change, meaning that we cannot rely on an important feature like that, to be available on any given player.

If early DVD compatibility issues were a problem for us all, then Blu-ray is going to be a double nightmare: some players will not play duplicated (burnt) discs, others won't support any of the BD Live features while firmware versions will mean that it will be uncertain as to what features any specific model may, or may not, support. What a nightmare!

What features are supported on which players is defined within the Blu-ray specification by "profiles". Players that support only video playback were allowed during the "grace period" before the final BD-J specifications were finalized.

<b>Feature</b>	<b>BD-Video</b>	<b>Bonus View</b>	<b>BD-Live</b>
	Profile 1 (Grace)	Final Standard 1.1	Profile 2.0
<b>Persistent Memory</b>	64 KB	64 KB	64 KB
<b>Local Storage</b>	-	256 MB	1 GB
<b>2nd PIP Video Decoder</b>	Optional	Mandatory	Mandatory
<b>2nd Audio Decoder</b>	Optional	Mandatory	Mandatory
<b>Virtual File System</b>	Optional	Mandatory	Mandatory
<b>Internet Connection</b>	No	No	Mandatory



As of October 2007 all players must support the 1.1 profile, known as Bonus View with Profile 2.0 (not yet finalized) supporting the BD-Live features. But remember, players can be moved between profiles with firmware updates, making the targeting of BD-J features a sharpshooter's game.

According to Wikipedia:

Excepting the LG-BH100, the [PlayStation 3](#), and the Samsung BD-UP5000, Profile 1.0 players can not be upgraded to be Bonus View or BD-Live compliant.[\[55\]](#)[\[56\]](#)[\[57\]](#) On December 17, 2007, the PlayStation 3 became Bonus View 1.1 compliant through PlayStation 3 System Software version 2.10.[\[58\]](#) On March 24, 2008 Sony released the 2.20 firmware update for the PlayStation 3, which is compliant with Blu-ray Disc Profile 2.0, making it the first in the market to have it.[\[59\]](#) The first BD Live titles ([War](#) and [Saw IV](#)) were released by Lionsgate in January 2008.[\[60\]](#)

To author the advanced features of BD-J you'll need either Blu-print or Scenarist 4 HDMV.

### AACS Fees continued...

Of course, as you produce multiple titles, the initial sign-up fee is spread over the additional titles, but there is still US\$500 to be paid per title, along with 4c per disc replicated.

Compared with the current deals for SD DVD replication, which can give 1000 retail ready (barcode, printing and shrink-wrap packaging) DVDs for US\$1200, the first Blu-ray title you replicate is going to cost a lot more for 1000 discs.

## Compatibility

Duplicated, or burnt, Blu-ray discs do not have universal compatibility. If you thought the bad old days of DVD compatibility of 85% was bad, wait for the coming storm of Blu-ray incompatibility. As of this writing, Samsung Blu-ray players do not support duplicated discs at all. Other released players need a post-shipping firmware update to be downloaded and installed in order for them to play duplicated discs. LG combo and Sharp players do not support BD-R/-RE recorded discs unless you record using AVC (H.264).



## Creating a Blu-ray disc

With Final Cut Pro 7/Final Cut Studio 3 Apple have provided a simple path for a very basic Blu-ray disc (on Blu-ray media or standard DVD media, for short programs). Avid ship Avid DVD by Sonic as part of their Windows-only Studio Collection. However, Apple's new output functions duplicate the ability Toast 10 has been able to provide for the last year.

Final Cut Pro's new Blu-ray feature does not support menus or interactivity; just a simple push-in-and-play disc, which is fine for many event videographer's needs or for client review. Of course Adobe's Encore DVD remains the best tool for authoring Blu-ray discs with features comparable to SD DVD's menus and interactivity. On Windows you might also consider Ulead's DVD Movie Factory or Roxio's MyDVD.



For those wanting access to the full range of interactivity available using Blu-ray Java, there are the Windows-based Sony Blu-print and Sonic Scenarist 4 HDMV for prices in the range of US\$40,000 a seat.

The others (Encore DVD, Avid DVD, Roxio MyDVD and DVD Movie Factory) author Blu-ray discs with similar interactivity as SD DVD. This is probably quite acceptable for most authoring purposes.

### *Encore DVD*

Encore DVD is part of Adobe's Creative Suite 3 [Production Premium](#) or [Master Collection](#) and unfortunately is not available by itself. Still the Production Premium or Master Collection include Adobe After Effects (almost essential in a modern production toolbox), Flash authoring, Photoshop and Illustrator among other applications that you'll want anyway. You'll also get Premiere Pro as a bonus.

The key feature in this context is that an Encore DVD project can be authored once and distributed to DVD, Blu-ray and a Flash website without needing to re-author for each format. The ability to automatically do a Flash version of the content for a website with a single button click opens new markets for the average video professional without needing Flash authoring knowledge. The web version has the entire DVD interactivity and menus, without any additional applications or work. Media is recompressed for each version.

Encore DVD comes with strong integration with Photoshop and After Effects. However, note that it only supports standard DVD interactivity, not the advanced interactivity supported by Blu-ray Java.

Officially, Encore DVD does not support third-party developer Rivergate Software have developed the [BluStreak Premaster](#) software for Mac OS X.

"BluStreak Premaster allows the correct formatting of Blu-ray output from any authoring application for large-scale manufacturing or replication of Blu-ray discs, including full AACs copy protection support."

## Other Authoring Options

If you want to go outside the Mac platform, there are other choices: Avid DVD by Sonic (part of the Studio Collection), Roxio's MyDVD and Ulead's DVD Movie Factory at the (relatively) inexpensive end; Sony Blu-print and Sonic Scenarist 4 HDMV at the high end. Only the two high-end options are capable of authoring all the capabilities of Blu-ray discs, BD Live and Bonus View. These high-end options are expensive: expect to pay \$40-50,000 a seat.

### Relatively inexpensive options

Avid DVD is only available as part of the [Avid Studio Toolkit](#) on Windows and not available separately. Avid DVD is capable of doing Blu-ray discs with interactivity similar to regular SD DVD.

Like Encore DVD, Roxio's [MyDVD](#) can be used to create basic Blu-ray DVDs with interactivity similar to SD DVD and no support for BD Live or Bonus View. Ulead's [DVD Movie Factory](#) is only US\$70-80. DVD Movie Factory does the most basic discs: no menus and no navigation.

I have not tested DVD Movie Factory nor MyDVD under Apple's Bootcamp, but it is certainly reasonable to expect them to work on an Intel Mac, although drivers for the specific burner would need to be the Windows versions in Bootcamp with separate Mac drivers for the OS X side.

### Sony Blu-print

From the originator of Blu-ray, Sony's [Blu-print](#) is designed as a full-function authoring tool for professional Blu-ray content for studios and major movie releases. Blu-print was, in fact, developed by the Sony Pictures Entertainment division of the company.

According to Sony:

“Blu-print™ is the optimal solution for Blu-ray Disc authoring. It is designed for professional high volume production. This application provides the flexibility to achieve complex authoring scenarios with great intuition for both the novice and the expert user. You can use Blu-print to efficiently create titles in HD Movie Mode or using Java technology.”



Blu-print is an abstraction-layer tool, like DVD Studio Pro. This means that you do not have to know the arcane details of the specification. Much of the detail is hidden behind a Graphical User Interface that makes it easier for the author.

In addition to the Blu-print software you will need an encoding tool. Blu-print does no encoding. The current recommended tool is the [Cinema Craft HD Encoder](#). The Cinema Craft HD encoder is “an innovative H.264/AVC tool for high-end Compressionists...”

**Note:** See section ahead on [Encoding for Blu-ray](#)

## Sonic Scenarist 4 HDMV

The other contender for “fully featured”<sup>25</sup> is from Sonic Solutions. [Scenarist 4 HDMV](#) is more designer-friendly, rather than technician-oriented, like Blu-print. This is largely because the design functions are split out to another application as is encoding, leaving Scenarist to connect the two together.

Sonic says:

“In terms of menu design and authoring, the Scenarist author only has to author in- and out-effects, program the button routing and author the navigation/commands, but maybe this will change in the future depending on what our users ask for.”



## Encoding for Blu-ray

For SD DVD there was only one format and codec choice: MPEG-2. For Blu-ray (and also the now-obsolete HD DVD format) video can be encoded as MPEG-2 HD, VC-1 or H.264 MPEG-4. VC-1 is the SMPTE-ratified variant of Windows Media Video. All players are mandated to support all three codecs. In fact, some titles have been released with their main feature encoded with H.264 while their bonus material has been in HD MPEG-2.



**Note:** For SD DVD MPEG-2 Main Profile, Main Level is used, allowing up to 720 × 576 images. For Blu-ray, MPEG-2 Main Profile, High Level is used, allowing images up to 1920 × 1080 pixels.

The choice of codec used will affect the licensing costs of the codec (often disguised in the cost of an encoding tool) and the duration of video that can be carried on a disc. MPEG-2 encoding limits content producers to about two hours of HD on a 25GB Blu-ray disc. The newer, and therefore more advanced codecs — VC-1 and H.264 — have greater encoding efficiency so that, at the same quality, more video can be included on the disc — up to twice the run time of MPEG-2.

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<sup>25</sup> In reality, neither Blu-print nor Scenarist 4 HDMV expose every feature of the BD-J at this time, but each release gets closer to full specification support. Don't be too hard on these companies: the specifications themselves were only finalized in Q3, 2007.

Apple provides encoding templates for Blu-ray disc using the AVC/H.264 codec. This is the format the Final Cut Pro 7 burn Blu-ray feature uses. The Cinema Craft HD Encoder will create appropriate H.264 (MPEG-4) files for Blu-ray but it's expensive.

On the audio side, encoding can be done to Dolby AC-3 (same as SD DVD), DTS and linear PCM. Players may optionally support Dolby Digital Plus and lossless formats like Dolby TrueHD and DTS-HD Master Audio. You would need to know your target audience well to include only these formats.

**Note:** There is a BD-Audio profile as well but it is not yet released and likely to be as successful as SACD or DVD-A. (Never heard of them? Not surprising, as most people have never heard of these advanced audio formats.)

## ***Blu-ray Burners***

No Mac has shipped with built-in support for Blu-ray (or HD DVD) yet, so anyone who wants to burn a Blu-ray disc will need to buy a third party burner. These manufacturers package drives from Sony (usually) or other suppliers into a case and include drivers for Mac OS X to use the Blu-ray drive.

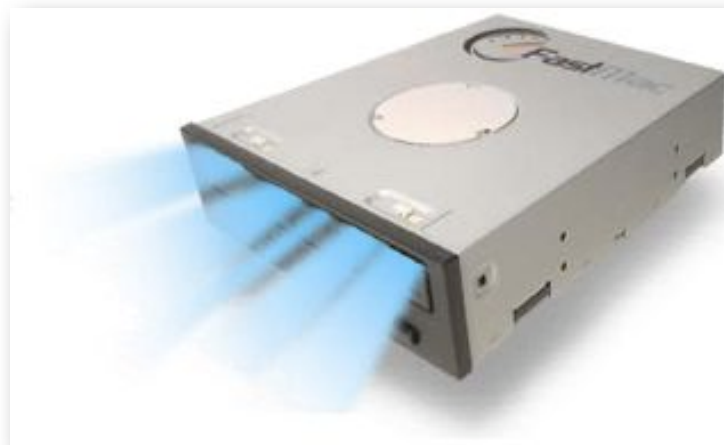
**Note:** None of these drivers allow Macs to play Blu-ray discs as Mac OS X does not yet have support for the DRM measures within the OS that the compulsory AACs content protection requires.

LaCie has the [d2 Blu-ray drive](#), which ships with Roxio's [Toast Titanium](#) software. Toast Titanium can be used to burn data to a Blu-ray disc, or a simple Blu-ray movie disc. The d2 Blu-ray drive has FireWire 400 and USB 2.0 interfaces and is compatible with Mac and Windows. (On Windows it ships with Easy Media Creator for Windows as well). The burn speed was doubled in May 2008. The Toast software can burn all variations of CD and DVD.

FastMac's [Blu-ray Drive](#) ships with [Toast Titanium](#) and one 25GB Blu-ray disc. It supports Toast's "Dynamic Writing" feature, which allows a Blu-ray disc to be mounted like a hard disk drive. Files can be dragged and dropped directly on the icon to add files, or dragged out of the disc to remove files.

Logitech shipped the first Blu-ray drive for Mac OS X — the LBD-A2FU2/WM but it does not appear among their current product offerings, nor do they seem to have a replacement.

OWC have [External Blu-ray drives](#) for Mac OS X available.





# HD Data files

Computers can play HD video files with ease – well computers from the last few years (2006 on) can play HD video across platforms. Apple TV plays HD video up to 720p24, and Flash files can go to even higher resolutions with Flash Player 9 release 3 onward (including Flash Player 10) and Adobe Media Player from its final release onward. Both Apple TV and Flash Player can now use H.264 MPEG-4 files, so it kind of makes sense to settle on that as a common format.

## Choosing a Format

Before we get to the specifics of encoding, let's talk briefly about what formats are suitable for which purposes. The main contenders are:

- Flash 7
- Flash 8 or 9r1 or 9r2
- Flash 9r3 onward
- Real Video and audio
- Windows Media 9
- MPEG-1
- MPEG-2
- MPEG-4 Simple Profile
- MPEG-4 H.264 and
- DivX.

Summarizing ahead of the explanation, in practice the two formats to consider are MPEG-4 and Windows Media. More specifically for HD, MPEG-4 H.264 (for QuickTime Player and Flash Player) or Windows Media for other purposes. Why not recommend QuickTime for distribution? In fact, why is it missing from the list completely?



## QuickTime's evolution

QuickTime is missing from the list for a reason: for distribution QuickTime is “obsolete.” Apple decided, around 2000, that they should move support for distribution codecs and formats to the ISO standard MPEG-4 format. MPEG-4 is not proprietary and now has extremely widespread support, proving the long-term wisdom of the decision. I’m sure it was also heavily influenced by the fact that the MPEG-4 container format is very heavily based on the QuickTime container format.



They are not identical – you cannot convert from one to the other by changing the file suffix – but the MPEG-4 container is a more modern version of the QuickTime container. Separate from the container format are the codecs, and it’s certainly possible to use the modern H.264 and AAC codecs, more commonly associated with MPEG-4, in a .mov container, but in general it’s better to choose MPEG-4 instead of QuickTime for widespread distribution. Therefore QuickTime *as a distribution container* is not included in this discussion. Without the modern MPEG-4 codecs (MPEG-4, H.264 etc.) QuickTime has no modern distribution codecs. The Sorenson Video 3 codec is ancient (and very inefficient) in codec terms. Even the older MPEG-4 (technically MPEG-4 Simple Profile) has higher video quality than Sorenson Video 3 (especially if you don’t have the expensive professional encoder for Sorenson Video 3).



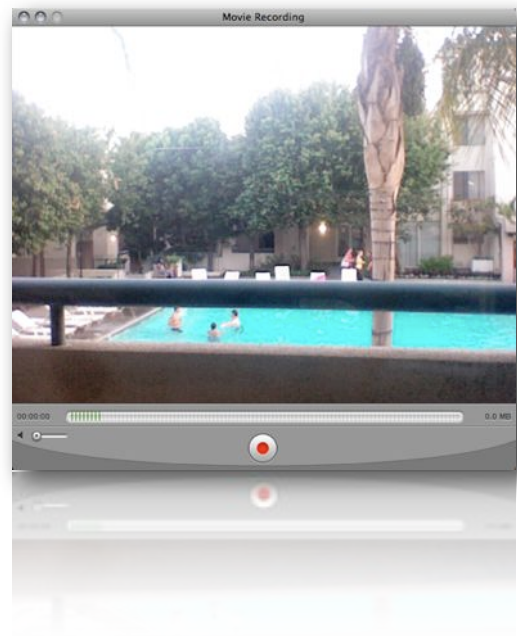
MPEG-4 Simple Profile, which Apple just identifies as MPEG-4,

has been well supported in QuickTime and the QuickTime Player since QuickTime 6.0.2 was released. MPEG-4 with the Advanced Video Codec H.264 has been supported in QuickTime since the release of version 7.

QuickTime is still essential for production and for building media applications on Macintosh and Windows, but for all intents and purposes Apple have decided that it makes more sense to build great support for the ISO standards instead of competing. So Apple have built support for .mp4 in their QuickTime Player, iTunes, iPods and iPhone, and made QuickTime/iTunes the most common .mp4 player software.

If you’re encoding for really, really old computers and feel you must use .mov then go for it, but you’ll absolutely need the professional version of the Sorenson Video 3 encoder and that’s going to cost you a couple of hundred dollars. Frankly I don’t think it’s worth it because MPEG-4 video is about the same quality and, while you could put it in a .mov container, I can’t think why you’d want to use a proprietary format over an open ISO standard format.

So, back to the formats we might use.





## Flash 8 or 9

Flash 8/9 up to Flash 9 release 3, use the VP6 codec from [On2 Technologies](#) and is a viable contender. In fact it's the choice of Google Video and most video sharing sites through 2006 and 2007. Flash is installed on most computers used for the Internet and, even if they need an update, it's a small one.

Flash 8/9 using On2 VP6 is a good choice for general distribution if you're targeting older Flash installations. The game changed considerably when Adobe announced in mid 2007 that the next release of Flash Player and Adobe Media Player would support the ISO industry standard H.264 video and AAC audio in a standard MPEG-4 container. That remains my recommendation for Flash Video.



That release (code-named "Moviestar") was finalized in November 2007 and released to the public. Given the usual uptake time for a new version of Flash, particularly now that Flash 10 is available, suggests that the time has come when it's safe to assume that most Flash installations will be equally capable of playing H.264 MPEG-4 as On2 VP6.

Since we don't have to buy additional encoders for H.264 MPEG-4 (it's already built into QuickTime on Mac and PC) it makes sense to use the Industry standard format for all distribution.

## MPEG-4 H.264



MPEG-4 Part 10 introduced the Advanced Video Codec (AVC) to MPEG-4. The AVC is also (and more commonly) known as H.264. It ended up with two names because two standards bodies developed it.

The MPEG-4 group were developing Part 10 at the same time as the European ITU was looking for a more modern codec for Television broadcasts, cable and satellite distribution. The groups co-operated so in MPEG-4 Part 10, it's the AVC; in the ITU world it's the H.264 codec, following the numbering of older codecs. (H.263 was a teleconferencing codec ratified by the ITU, for example.)

**Tip:** Apple and most people simply refer to "H.264" as shorthand for an MPEG-4 container file with H.264 video and AAC audio, and use "MPEG-4" to mean an MPEG-4 container file with MPEG-4 Simple Profile video and AAC audio.

H.264 scales really well so you can use the same codec from cell phones to digital cinema, which is unusual because most codecs are optimized for a small range of sizes, but H.264 is a great all-round codec.

MPEG-4 H.264 is what Apple expects you'll use. There is now great support for H.264 within Compressor. The starting points are in the "Apple Devices" preset group.

MPEG-4 with H.264 video and AAC audio would be my choice for almost all purposes. It can be embedded in a web page using the QuickTime plug-in; it can be called<sup>26</sup> by a Flash Player, or played in the Adobe Media Player. The same HD file is suitable for download to iTunes or an Apple TV.



**Note:** Only H.264 MPEG-4 files are compatible with a standard Apple TV. MPEG-4 Simple Profile and SD MPEG-4 files are compatible with iPods that support video. The two MPEG-4 variants are the only files an iPod or iPhone can play.



## *Windows Media 9*

Windows Media 9 and 10 (or the SMPTE VC-1) are another great choice for delivering HD video via the Windows Media Player or via Microsoft's Silverlight web browser plug-in.

Windows Media has one disadvantage — it does not play on iPods or Apple TV — and one big advantage. If you want to use Digital Rights Management (DRM) Windows Media was once the only choice, making the decision easy:

if you want DRM you have to use Windows Media. Now that Flash Media Server supports Adobe's own DRM format, those producers who (unwisely in my opinion) insist on DRM have a choice. In my opinion it makes more sense to use industry standard, widely compatible H.264 MPEG-4 for all purposes, adding Flash Media DRM if deemed desirable and affordable.

**Opinion:** As an aside, I have no idea why you would want to use DRM since it does not work and only devalues the content, but if you have some insane desire to make your project hard to work with then use DRM. Otherwise, price your offering fairly and make it easier for people to pay than pirate. If your client is demanding it, then you have no choice but to assist them.

Without DRM, WMV is still a great format but a proprietary one with little quality or "reach" advantage. Flash is as ubiquitous in corporate America as Windows Media Player, giving it no advantage. MPEG-4 with H.264 video into Flash Player, QuickTime Player or iTunes has much wider playability.

You'll also need to buy proprietary tools for encoding on a Mac. You should at least have the free player-only version of [Flip4Mac](#) installed for playing Windows Media on your Mac.

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<sup>26</sup> Traditionally Flash video — .flv — files were embedded within the swf player. H.264 MPEG-4 video must be called by the player, not embedded in the player.



## The Rest

The other formats listed below are all unsuitable for distributing HD video on the Internet.



### MPEG-4 Simple Profile for Standard Definition

The MPEG-4 specification is divided into “Parts” and “Profiles”. In practical terms the only two Parts we care about are Part 2 and Part 10. For detailed information on MPEG-4 see the [Wikipedia article](#) on the subject.

**MPEG-4 Part 2** introduced the original MPEG-4 specification. Apple adopted this version for “MPEG-4” support in QuickTime 6.0.2. Within the MPEG-4 Part 2 specification, Apple decided to support the “Simple Profile”, which has the widest compatibility. Simple Profile supports data rates up to 2 Mb/s. Sorenson Media created an Advanced Simple Profile encoder that offered higher quality within the MPEG-4 container but required a third-party codec to be downloaded for QuickTime compatible playback. (There are many free third party codecs, but these days I would recommend installing the [Perian](#) codec pack, which includes support for MPEG-4 Part 10 Advanced Simple Profile. The Advanced Simple Profile was also adopted by DivX, although in a somewhat incompatible way, as we’ll see shortly.

**Note:** Because MPEG-4 Part 2 does not support HD video, it is of no value in distributing HD. It is included for background and information purposes only. Many Advanced Simple codecs, like Xvid and 3ivX are capable of HD sizes but require third party codec installs, like Perian, for playback.



### Flash 7

Flash 7 video support is bad, but it was better than the pseudo support in earlier versions of Flash. Flash 7 uses the Sorenson Spark codec, which is really a slight rehash of the decades old H.263 codec and, while it was an improvement on the video quality of earlier versions of Flash – because video support was non-existent before Flash 7 – that’s damning with faint praise. Before Flash 7, Flash only supported still image sequences.

Even though YouTube uses Flash 7, it requires a lot of bandwidth for mediocre quality and needs a proprietary encoder from Sorenson. Not a good choice for any modern purpose. YouTube only continues to use it because of licensing costs for newer formats, given their vast throughput.

### MPEG-1

Until the dominance of Flash, MPEG-1 had a life as a legacy codec for a long time because it had universal playback capability. Every player plays MPEG-1. But it is an old codec and not particularly efficient for bandwidth and officially does not support HD resolution







## MPEG-2

MPEG-2 is the format for DVD, Digital Television and, for now, Digital Cable and Satellite, but it's not a web format. It is used for HD in Blu-ray but the file sizes are too large for efficient web distribution and the encoding technology is less efficient (quality for bandwidth) than more modern codecs like H.264 and Windows Media.

## DivX

DivX is an odd case: an MPEG-4 (Advanced Simple Profile) compliant video track with an MP3 audio track in an AVI container. DivX got its popularity with the "pirate video" community and that's probably where it's still the strongest. QuickTime Player will play most DivX files although, if they have VBR MP3 audio, it will be silent!<sup>27</sup>



DivX is capable of very good results but is not really mainstream and I'd avoid it for client review or regular web video where it's not commonly seen. If you want to send out your project on Pirate Bay or other peer-to-peer network then DivX might be a good choice.

DivX announced in 2007 that it had purchased German codec company Main Concept to incorporate into DivX's ecosystem. Adobe licensed its MPEG-4 H.264 support from Main Concept but the licensing deal remains in place despite the change in ownership of Main Concept.



## Real Video

their content.

Once king of Internet video, Real doesn't have much of a place any more. Real Networks are more of a content company and their codecs and container format are mostly just for distributing

Real is the only format where you have to pay for a server to deliver it, another reason that makes it unsuitable. Unless specifically requested, I don't see a role for Real anymore.

## *Analyze the audience*

Before you decide on the format for your HD delivery, it's really important to know the audience and target accordingly. If you want your video seen by people at work in corporate environments, then Windows Media 9 or Flash (with H.264 video) would be the best choice. For older company "Internet images" (supported formats) Flash 9 with On2 VP6 would work for HD.

Otherwise I'd tend to encode to MPEG-4 with H.264. If you must use QuickTime features like a chapter track then a .mov with H.264 is appropriate.

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<sup>27</sup> With the Perian codecs installed all variations of DivX can be played by QuickTime Player.

# Practical Encoding for HD Distribution

Good HD encodes start a long way before we get to the actual encoder. In an ideal world the material will have been shot with encoding in mind, but even where the finished master is the source for the encode there's a lot we can do to improve the result and/or lower the required bandwidth for any given quality.

**Note:** It's incredibly easy to get great looking HD video for digital distribution: just throw a lot of bandwidth at it! This, however, makes for longer download times, frustrated viewers and higher bandwidth bills for you or your client. None of these things are desirable so our goal is always to get the highest image quality for the lowest bandwidth. This usually requires testing, testing and testing some more.

## *Start with the right source*

The worst kind of footage to try to encode is fast moving, hand-held, shaky and badly lit. The Flash 7 video is not the only reason YouTube's encodes look so bad!

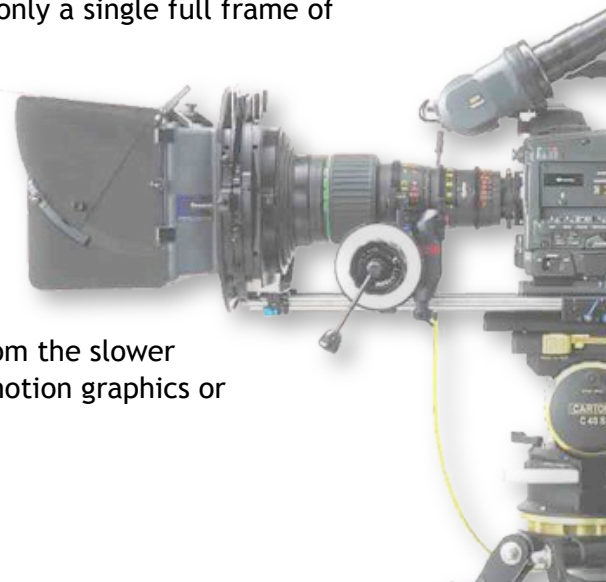
What we're looking for as "good source" for digital delivery is:

- Steady camera
- Well lit – good tonal range
- Avoid dissolves – wipes are more encoder friendly
- Avoid fine detail or allocate more bits

While the other criteria for good source are fairly self-evident, the avoidance of dissolves and preference for wipes (or even a cut) has to do with the way video gets encoded. Most modern codecs send keyframes with all the information and then, in between keyframes which may be hundreds of frames apart, they only send the difference to the next frame. Dissolves present a completely new image on every frame, effectively 30 keyframes in a second, demanding a huge data rate spike at that time. A cut requires only a single full frame of

information to be transmitted after the cut. Codecs will insert a keyframe at a cut automatically. A wipe or Digital Video Motion Effect only changes part of the image on each frame and is more bandwidth friendly.

The variation on demand for bandwidth at dissolves, wipes and effect shots, particularly motion graphic openings, is a very good reason for encoding with Variable Bit Rate (VBR) instead of a Constant Bit Rate (CBR). VBR encoding allows bits to be moved from the slower paced, steady shots to where they are needed for faster action, motion graphics or dissolves.



## Work from the Master or Source

Always work from the Master – encoding already encoded and compressed video is not going to deliver good results because the encoding artifacts from the first encoder are going to be preserved by the second encoder while it introduces its own artifacts. So, always work from the source, preferably uncompressed video or at least the native format of the edit.

Never use a video that has been encoded to Sorenson Video, Cinepak or other distribution codec. DV and HDV are acceptable if they are the native format. Also acceptable, if no real master is available, is a “rip” from a DVD using [MPEG Streamclip](#), [DVDxDV](#) or [Cinematize](#).



## Image Size

HD Video tends to be distributed at three sizes: 960 × 540 (half height and half width of 1920 × 1080); 1280 × 720 (720P size) or 1920 × 1080 (1080i size).

Full raster 1080 material will create much large file sizes and take longer for viewers to download and increase bandwidth bills for your client or yourself.

***The recommended sizes are 1280 × 720 or 960 × 540.***

Because the scaling tools in HD televisions, Apple TV, and most modern computers are so good, these smaller sizes do not show much degradation over full 1080. In fact, [unless you're sitting very close to a large television](#) you [won't be able to see any difference](#). You will get a much nicer looking image on a big screen by working with 1280 × 720 or 960 × 540 size movies and compressing them less heavily but scaling on playback, than with larger images that are more heavily compressed but have full raster images.

Working with 960 × 540 immediately reduces the bandwidth requirement to ¼ of 1920 × 1080 ( $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ ).

### The sweet spot for HD file distribution

The definite sweet spot is 1280 × 720 progressive. It's full HD (although not the largest HD size) and scales well on larger sets. It's the largest size currently supported on Apple TV (up to 24 fps).

**Simple Rule:** Always make sure both dimensions of your encoded video are divisible by 8.

## Smaller Sizes

Frequently we'll need to deliver our HD programming to smaller sizes for faster Internet download. This is fine: HD makes an excellent master for SD work, as we'll see in the next section.

There is one small complication that can arise when making reductions in size: detail scales down and becomes even finer, often making the smaller image look excessively “busy”. The solution is, ironically, to reduce the resolution slightly, to avoid the small detail becoming distracting. (For older video folk, the resulting look is somewhat like the “ringing” effect you get when a video signal is excessively sharpened, which is exactly what is happening.)

The solution is to:

- Add a small amount of blur to the image during the downsize;
- Use Best quality in the Frame Controls' Resize Filter in Compressor; or
- Check the “Lowpass source for large downscales” checkbox ‘on’ in Episode or Episode Pro.



## Format without Letterbox

Unless you are uploading to YouTube, which does not currently support 16:9, do not encode 16:9 material with letterbox black bars. Digital Distribution is not restricted to the size of a CRT that it must always fill, so any size or shape is possible.

If your source is letterboxed, which it should not be for HD, crop off the black bands. If your source is letterboxed you probably do not have the Master or Source footage and should request that instead.

Otherwise, format without letterbox. See examples on next page.



Format 16:9 as native 16:9  
unless you're uploading to  
YouTube

Formatting to 4:3 with letter-  
boxing is unnecessary and  
wasteful of bandwidth.



## ***Preprocessing***

A very large part of what a professional encoding specialist will do is in the pre-processing of the video before it's encoded to make it easier for the encoding software to get the best possible image.

While there is a lot you can learn about pre-processing for encoding, it's a subject that's book-sized in itself, so it's beyond the scope of this basic overview of encoding for HD. However, the contribution of pre-processing to the quality of HD encodes cannot be under-estimated.

The most bang-for-buck pre-processing is to:

- De-interlace or Reverse Telecine;
- Crush the blacks in the image; and
- Correct Gamma.

For SD distribution I advocate cropping the image when going to smaller than  $640 \times 480$ , but for HD cropping is not useful because HD distribution sizes are generally at full size. At full size, cropping means that the remaining image has to scale larger and that is not desirable, as it will soften the image.



## De-interlace

While all 720P material is Progressive, at 1080 the majority is shot at 50i or 60i and requires de-interlacing. All interlaced source should be de-interlaced for web video because all computer screens are progressive. Therefore video for the web must be de-interlaced.

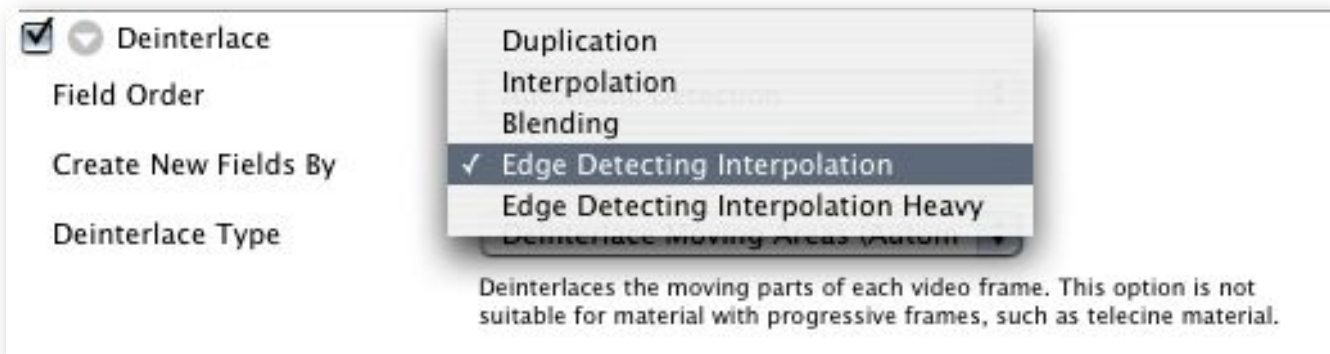
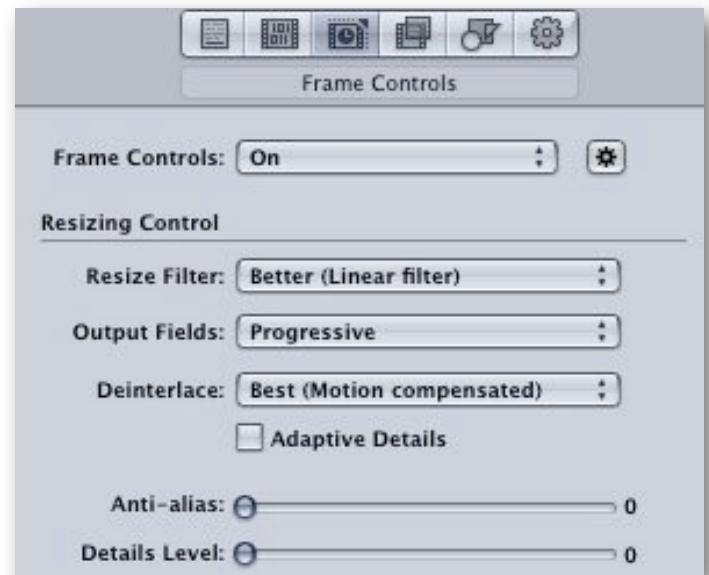
However, for HD video we (generally) are not reducing the size so we cannot simply drop one field. The exception is if we're going from 1080i50 or 1080i60 to 960 × 540: half height and half width.

Most encoding tools have a de-interlace control. In Compressor 2.x or 3.x the controls are in the Frame Controls area. In Episode Pro they're in the Video settings area, under their own heading.

For HD video make sure that the settings carefully match those shown for Compressor and Episode Pro. We're looking for a high quality de-interlace of 1080i60 or 1080i50 material so that the output is progressive.

In Compressor, the settings to the right will work well. For most encoding, use "Better". For the absolute best quality use "Best" but be prepared for a long, slow encode because Compressor is tracking where pixels are moving between the fields and interpolating new pixels.

Episode Pro, using the settings below, will detect which parts of the image are moving and then de-interlace those parts of the image and interpolate (create new pixels between the values either side) only in the moving parts. This retains maximum quality but is much slower to encode.

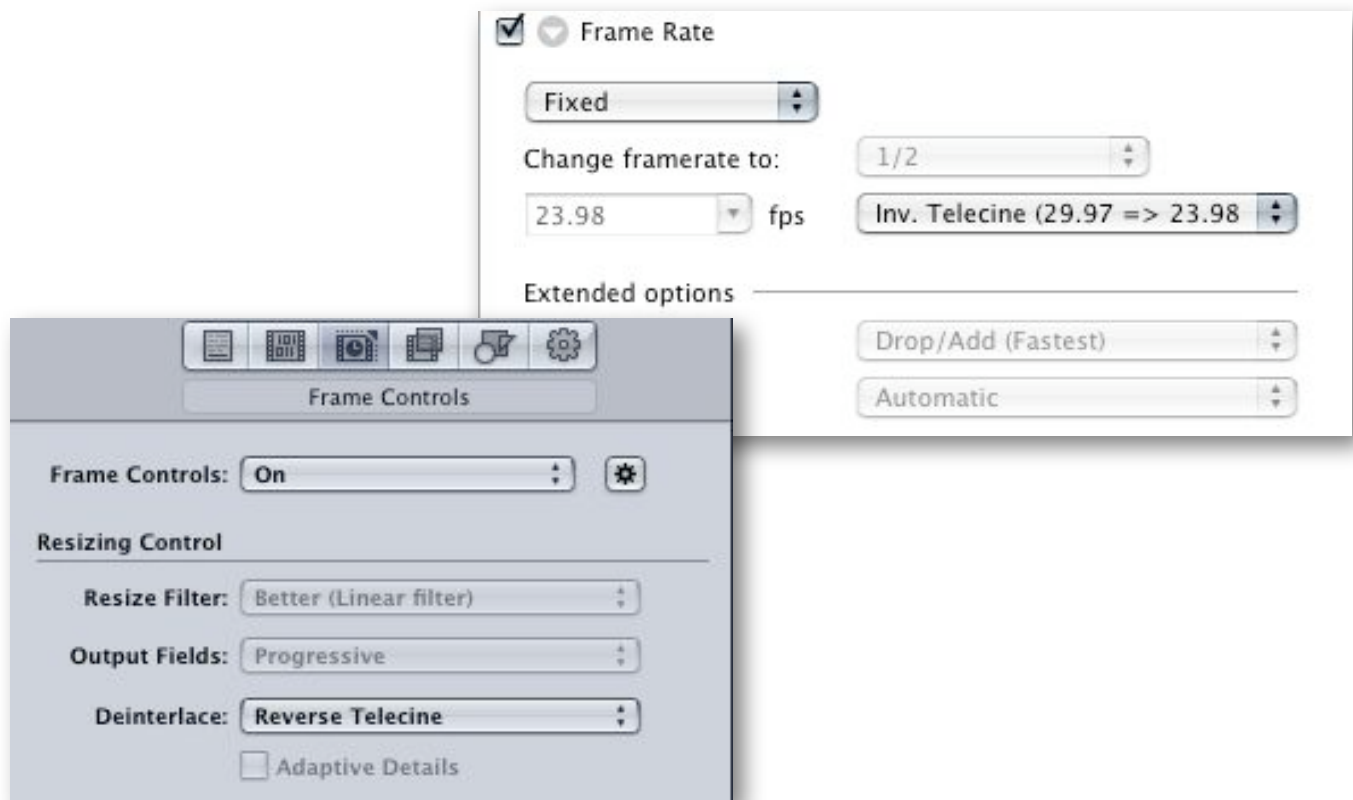


If you decide, instead, to simply use one field of the 1080i material — an entirely reasonable decision — then you can ignore the need to de-interlace, because one field is de-interlaced by definition.

## Reverse Telecine

If your source includes 3:2 pulldown with *clean* (i.e. continuous) cadence then remove the pulldown. Refer to the section on [24P in the Post-Production](#) section to make sure you have continuous cadence, or better yet, do not ever add pulldown to your master file. Even if you print back to tape (which requires pulldown to be added), keep a 24P digital copy for mastering for digital distribution.

The best choices for reverse telecine in Compressor and Episode are shown in the screen shots.

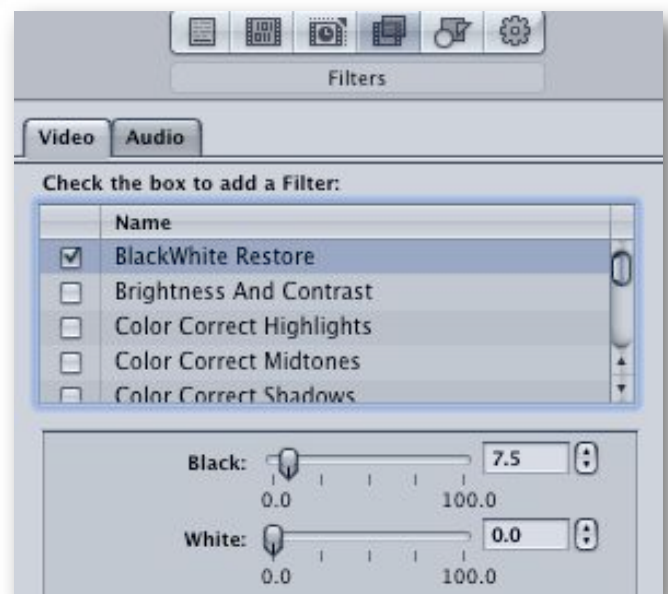


## Crush (Restore) the Blacks

Black is complicated in video. As the signal gets closer to black, it becomes noisy. Noise – a random dancing pattern – is a problem for encoding software because it does not know that noise is unimportant. To an encoder, noise is detail so it devotes large amounts of the available data rate to preserve the noise. This is exactly what we do not want!

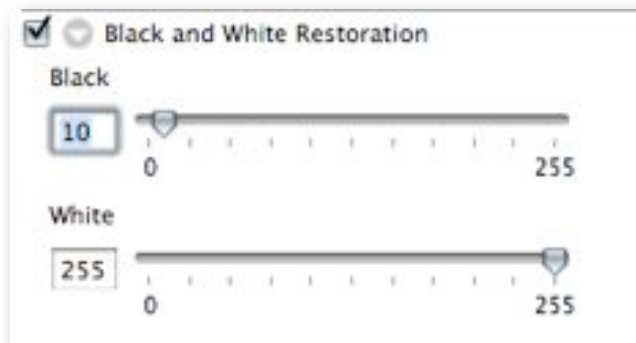
We want to make all the near-black values into real black. To do this we use a tool that's called Black Restore in most encoding software.

In Compressor apply a BlackWhite Restore Filter and set it so the black is crushed down to one value, or as far as you can go without compromising the image.



In Episode Pro it's simpler: set the Black level to its value from 0-255. Usually something in the 20-30 range will kill the noise in the very darkest parts of the image.

This simple technique probably brings the greatest benefit to images that are dark or have dark areas, and still need to be encoded.



**Before Black Restore:** blacks are filled with noise and become harder to compress.

**After Black Restore:** blacks and near blacks, are uniformly black and easier to encode.



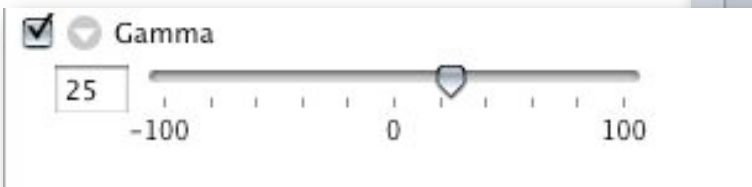
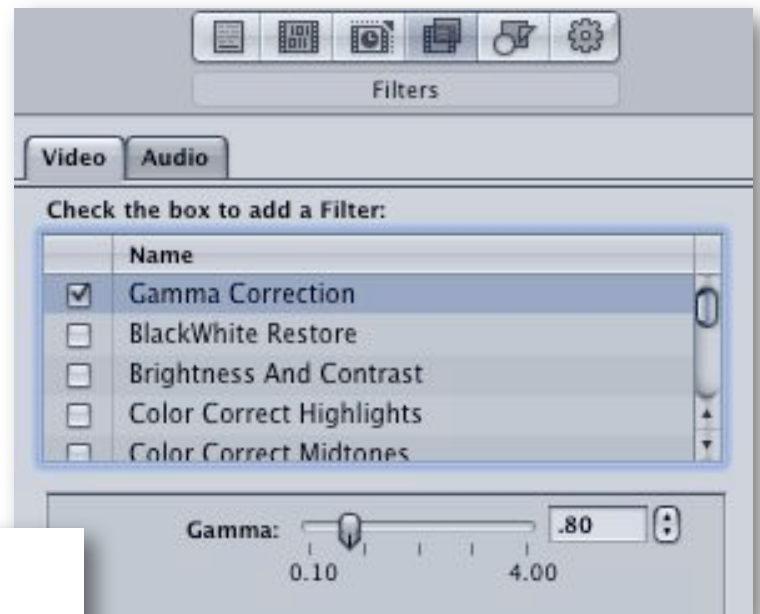
## Gamma Correction

Gamma controls how the intensity of the displayed images increases with higher values. A gamma curve describes how graphics hardware interprets luminance values to display brightness. Gamma issues occur when you're trading image files among platforms with different gammas.

Among the differences between platforms is the difference between a computer monitor and video monitor, which we covered in the [Post-Production module](#). We need to correct gamma so that the video plays back on a computer monitor with the same apparent brightness as it would on a video monitor.

Our decision-making process becomes more difficult if we are targeting both computer monitors for web playback and Apple TV, iPod (etc.) connected to an HD Television. In that situation we always have to compromise a little, selecting gamma settings that are between the two ideals.

For video monitor playback through an Apple TV or similar device to an HD Television we need no gamma correction. For playback to a computer we should apply gamma correction as shown here:



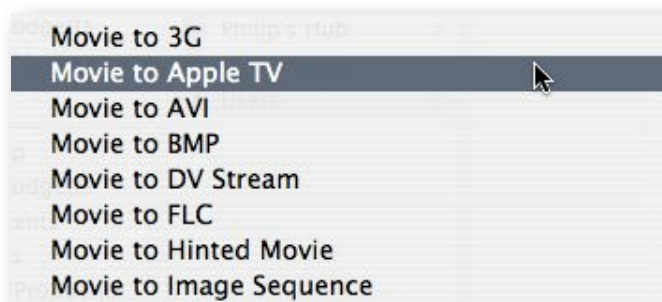
Before Gamma Correction the image appears dark on a computer monitor



After Gamma Correction the image appears more like the original video

## Encoding H.264

If you want to deliver video for other purposes, then you should use the “Movie to Apple TV” export setting in QuickTime Player or from Final Cut Pro’s Export with QuickTime Conversion. In Compressor 3 choose the Apple Devices group and select Apple TV (QuickTime 7.1.5 or later required.) Using this setting as a starting point ensures compatibility with Apple TV. Simply matching the settings to what Apple suggest in their Tech Specs does not make a file that synchronizes to Apple TV — there is some “secret sauce” being used. So starting with an Apple TV compatible setting in Compressor or Episode Pro ensures that the resulting file will play there.



**Note:** Anything encoded for Apple TV will be suitable for web browser playback using the QuickTime Plug-in and can be called into a Flash Player or the Adobe Media Player.

### “Export for Apple TV”

Up to 1280 × 720 —  
native size

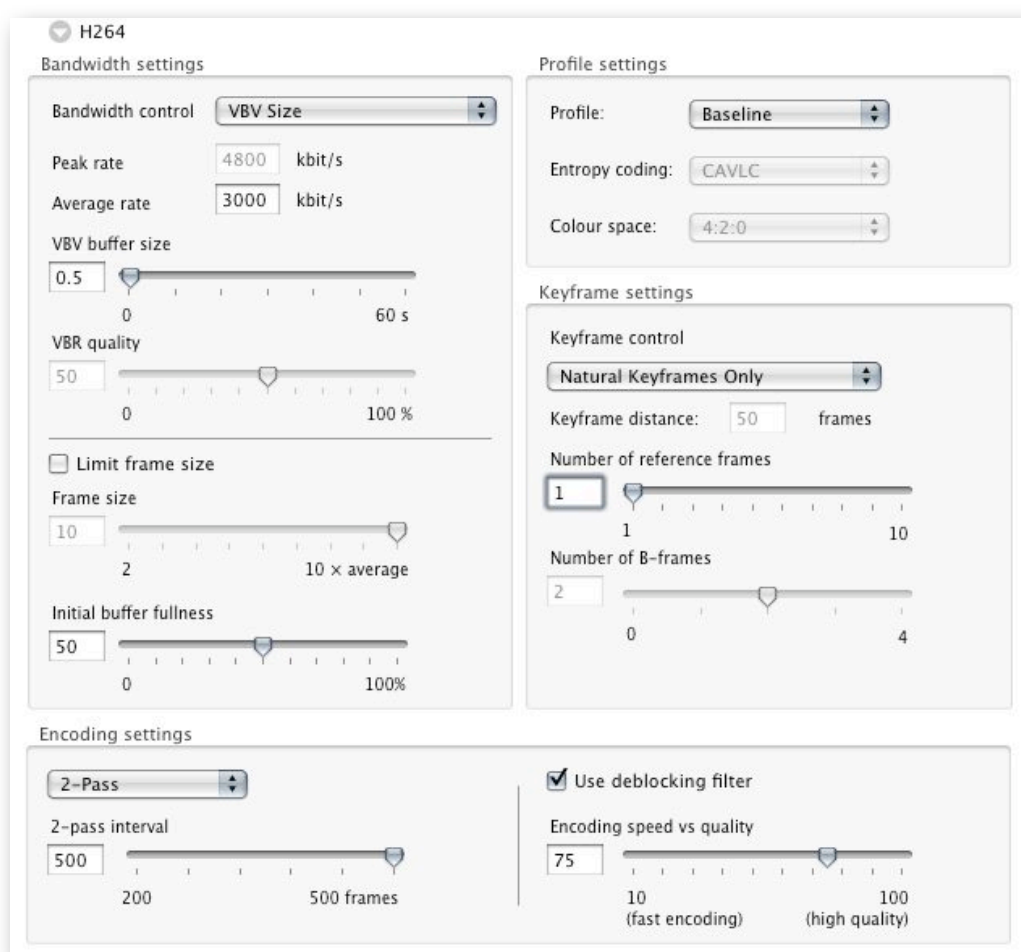
Over 1280 × 720 —  
940 × 540

Frame rate to 24 fps —  
maintained

Data rate —  
automatic up to  
5 Mbits/sec

If you want to encode to  
sizes larger than 720P,  
create your own settings in  
Compressor or Episode Pro.

These are the default  
settings for 720P I use in  
Episode Pro.





Target Data Rates		
Size	Frame Rate	Data Rate (Mbits/sec)
960 × 540	30	2 – 3
960 × 540	25	2 – 3
1280 × 720	24	2.5 – 3.5
1280 × 720	25	2.5 – 3.5
1280 × 720	30	3 – 3.5
1280 × 720	50	4 – 4.5 (Not recommended, use 25 fps)
1280 × 720	60	4.5 – 6 (Not recommended, use 30 fps)
1920 × 1080	24	3.5 – 5
1920 × 1080	25	3.5 – 5
1920 × 1080	30	4 – 4.5
All rates are Progressive		

These data rates will give good results for typical video footage. Carefully encoded low action material, like “talking heads” can be encoded into lower data rates; high action hand-held or rapidly changing footage may require higher bandwidth.

**Note:** It is important to test, test and test some more to get the best results.

## Getting H.264 to Play in Flash Players or the Adobe Media Player

The only downside to using Flash for browser playback is that there is no standard player. You have to encode the video to a compatible format, then build, borrow or buy a player and embed the player in the web page.

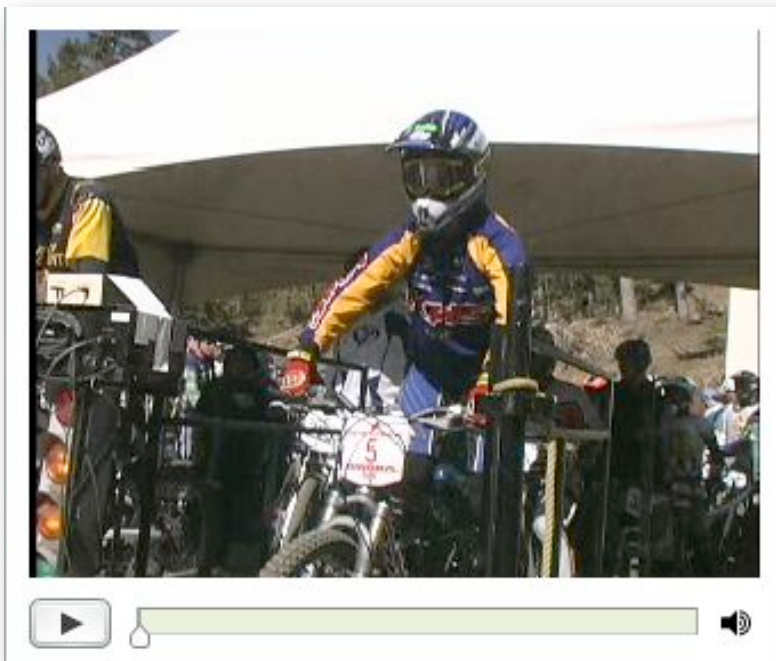
Any standard Flash Player will play an H.264 MPEG-4 movie by “cheating” and changing the suffix of the MPEG-4 file to .flv. This is a hack and not recommended. Although it does work it does not allow the file to be compatible with the QuickTime plug-in, QuickTime Player or iTunes.

The better solution is to properly call the H.264 MPEG-4 file into the Flash Player. Complete instructions, which will make more sense for experienced Flash programmers, can be found at [Adobe's web site](#).

## Player elegance

By default, Windows Media will play back in Windows Media Player on Windows or the QuickTime Player on Mac<sup>28</sup>. H.264 MPEG-4 files will usually play in the QuickTime Player or iTunes on both platforms. If you prefer a more elegant solution, create a custom player in Flash or use one of the many free, or licensable, players available.

**IMPORTANT:** For incorporation into a Flash Player you must use either the On2 VP6 codec, which will require a separately licensed encoder, or H.264 MPEG-4, which can be exported from QuickTime Player Pro, Compressor, Final Cut Pro or other QuickTime application on Mac and Windows. Since the release of Flash Player 9 release 3, Flash has been able to play H.264 MPEG-4 as “Flash video”. (See [earlier discussion on distribution formats](#).)



Many styles and designs of embedded player are available, often free. Or work with a Flash specialist and create your own.

Wimpy FLV Player



The Wimpy FLV Player, or Adobe Media Player will play Flash files on Mac OS X, as will QuickTime Player with the Perian codecs.

<sup>28</sup> Windows Media Playback on Mac OS X requires the FREE QuickTime components from [Flip4Mac](#). It is highly recommended that these be part of a standard production machine install. They are well tested and present no conflicts.

# Getting the files out

It's quite easy to create HD, but as we've already seen, distribution has not yet caught up. In this digital age, though, creating compressed versions of our masters is relatively easily done. What we do with those files from there is the conundrum.

Well, for computer playback, as we have seen, we can encode to H.264 MPEG-4 and play it almost everywhere once we get it there. Getting the files "there" is the challenge. At this point our options (other than Blu-ray) are:

- Data files on a DVD for direct playback;
- Data files on CD, DVD, hard drive or memory stick for loading to computers for playback; or
- Deliver directly over the Internet.

These options do not take into account the reality that we have the files on a computer, not on a Television screen.

## Data Files on standard DVD

One of the major benefits of the HD DVD standard was the files could be recorded on a standard DVD and the HD DVD player would still play in the HD format. Of course, the total file size is limited to the 4.2GB<sup>29</sup> but with the higher efficiency of H.264 or VC-1 a lot of corporate, education and event content could be distributed this way.



Unfortunately we lost that asset when Blu-ray "won" the format war and Toshiba withdrew HD DVD from the market. We can still use a standard DVD for HD distribution if we can control the player as well. These solutions are not suitable for widespread consumer distribution. They won't help if you're distributing wedding videos, for example, but will be useful for trade shows, installations and limited training series.

**Note:** Files can also be distributed on DVD even when playback is intended to come from a hard drive. In this case the DVD is merely a convenient way to distribute data for a kiosk or trade show display out of a standard computer.

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<sup>29</sup> A standard DVD holds 4.2GB of data, but by the magic of counting 1024 as 1000, the size is often expressed as 4.7GB: both are accurate because they measure differently. When it comes to pure data, use 4.2GB as the limit.

## JVX SRDVD-100U for standalone playback

The basic principle is to encode the HD file to Windows Media/VC-1<sup>30</sup> or HD MPEG-2 and play them back with the [JVX SRDVD-100U](#): a unique player from JVC Professional that understands a variety of HD file formats and will play them from DVD-R.

This player will play these file formats: HDV, MPEG-2 TS/PS (HD 720P, 1080i), WMV9, DivX® HD using standard DVD media. It sells for US \$399 in one-off sales.



## Hard Drive and Flash media Distribution

Instead of placing the encoded files on some form of optical media, they can be distributed via hard disk, usually with USB 2.0 or FireWire interface for easy connection at the other end. The files will generally be copied to local media for playback, or played directly from the drive. Encoding for Hard Drive Distribution is the same as encoding for any other form of distribution and is explained above.

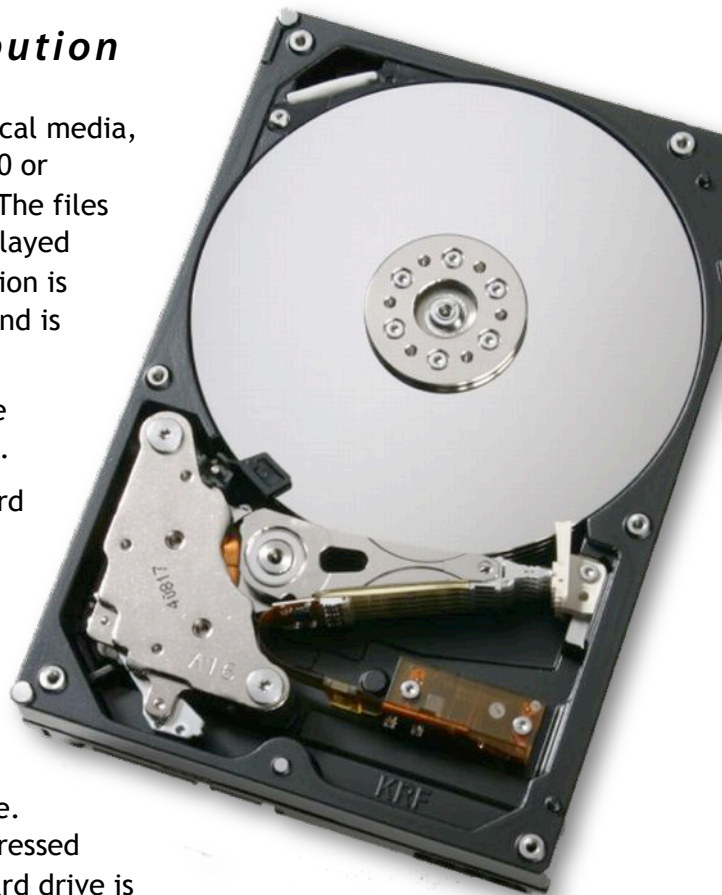
The best drives for this purpose, being most portable, are built on 1.8" hard drives (the same as in the iPod Classic).

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.

Flash media like memory sticks are not fast enough to play HD in real time, but as a small and light transport device it works if the files are small enough and the memory stick large enough.

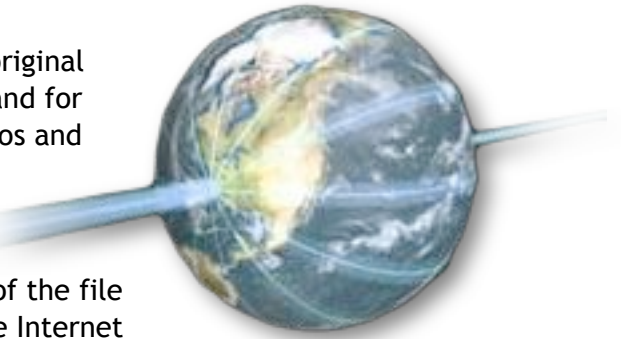


<sup>30</sup> VC-1 is the SMPTE-sanctioned version of the Windows Media 9 codec.



## *Internet Distribution*

Most Internet distribution is by progressive download, the original form of web video delivery. It is used by Apple for Trailers and for Movie sales and rentals; it's used by YouTube for all its videos and for most non-network websites. It is used by all podcasts and similar downloads. Progressive download is also known as "Fast Start" video, because the video will start playing before it's all downloaded, usually within a minute or two of the file being requested for HD files, depending on the speed of the Internet connection.



Progressive download is sometimes incorrectly referred to as "streaming" or "http streaming". Streaming should be kept to describe the Real-Time Streaming Protocol (RTSP). RTSP servers are very complex and expensive to set up and manage. Bandwidth costs are also dramatically higher.

Unlike RTSP, progressive download transfers the file using the same protocols as web pages and graphics. 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. They will not have a poor experience with buffering video though.

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.

Best of all, Progressive Download works on standard (and cheap) web servers from virtual hosts (that's what most people have), to fully dedicated servers.



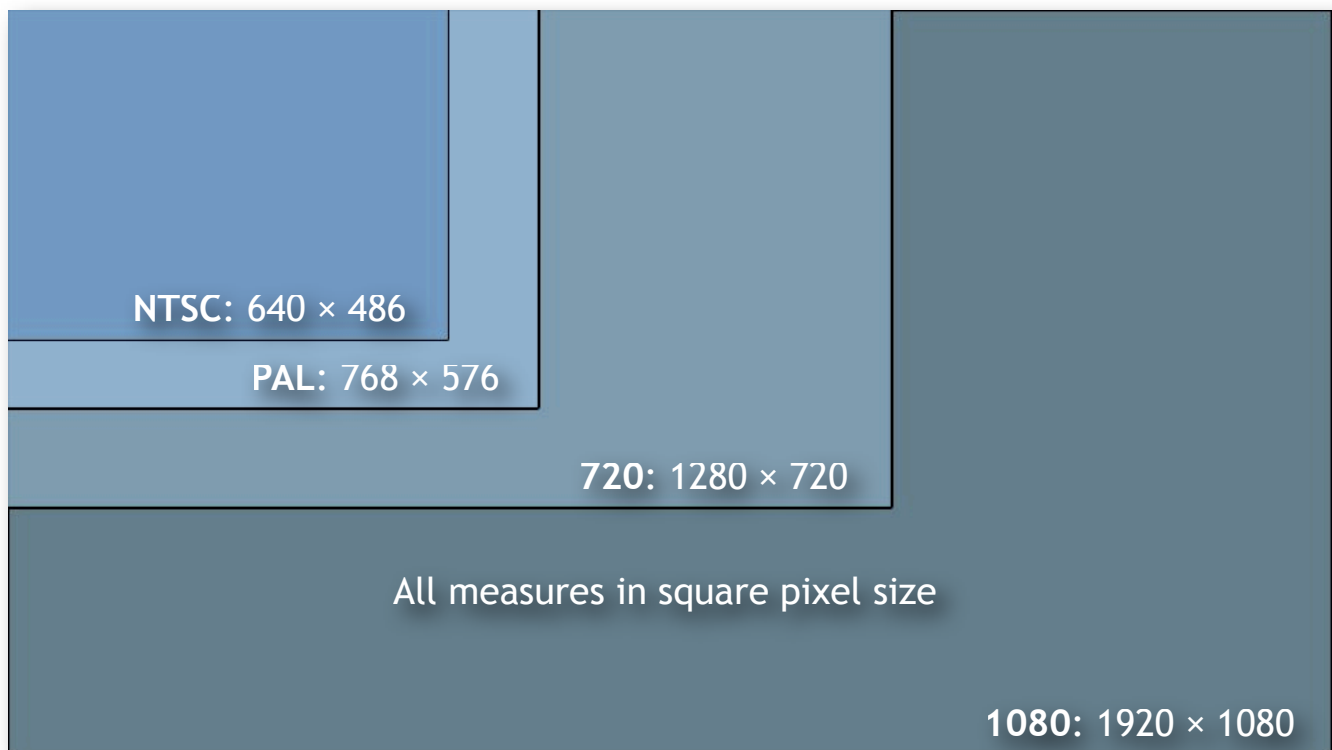


# Standard Definition Distribution from HD Masters

While the move is definitely toward High Definition for the future, and it's wise to produce in HD if the program has any life expectancy, the majority of delivery in 2008 will continue to be SD.

Therefore the dilemma is, should we edit in HD or edit in SD? There are three primary workflows:

1. Edit in HD and downsize the finished result;
2. Work entirely in SD from source footage downconverted from the HD camera source; or
3. Do something creatively different.



Because there is such a difference between HD sizes and SD sizes, down-converting is not trivial

## Edit HD, Downsize later

The path I would strongly recommend is to capture and edit in HD throughout the post-production process to produce an HD Master. We can create an SD version using software conversion, or via hardware conversion on output.

This is the recommended path. Even if there is no HD distribution planned at this time, and Independent production, training or even corporate message may have an HD opportunity come up in the future, as these types of programs tend to have multi-year life spans.

Even event videography that is being shot in HD should be mastered in HD. Right now you may only be able to provide your client with an SD DVD version, but we know that, eventually, the issues with Blu-ray playback compatibility for burnt discs will be resolved, and the price of blanks will come down when volumes increase. Think of the opportunity for additional business a couple of years after the wedding when, on their anniversary, you can go back to the couple and ask if they'd like an HD version for a little extra cost.

When planning to produce in HD and distribute initially in SD, the production and editing uses the standard HD workflows we discussed in the Post-Production module.



**HD Master**


Footage courtesy Shiva Entertainment from "The Enlightened Cook" series. Used with permission.

Proportionally sized NTSC downconvert from 1080i.

## Downconverting in Software

There are a number of ways to convert from HD to SD in software:

- Nest the HD Sequence(s) into an SD Sequence and render;
- Use Media Manager to produce an SD Sequence and recompress media;
- Output an HD Master (a wise move anyway) and use Compressor (or other encoding tool) to scale to the SD size and codec of choice.

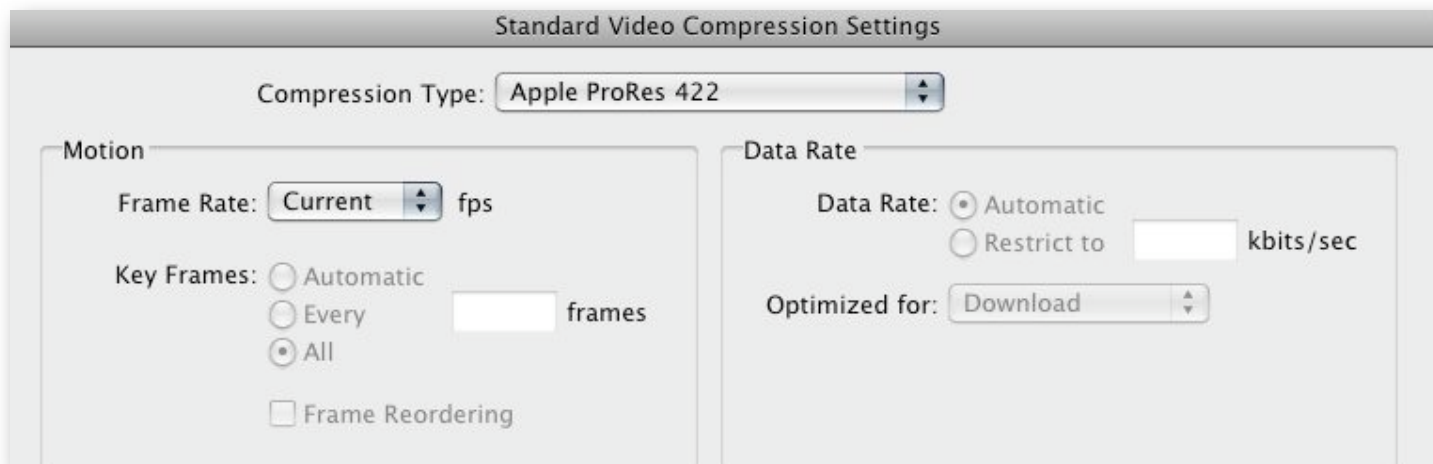
 DVCPRO50 NTSC Anamorphic  
DVCPRO50 NTSC Anamorphic with 48kHz stereo audio

Start with this setting in the "Other Workflows" group in Compressor.



Set the Frame Controls for best quality conversion. If you have time set Resize and Deinterlace to "Best", but it will be much slower to encode.

For HD the SD setting should always be a 16:9 anamorphic to retain the image aspect ratio.



Choose whatever SD codec best suits your workflow but ProRes 422 or DVCPRO 50 would be my recommendation.

## Nest HD Sequence(s) to SD Sequence and render

This simplest approach should be familiar to anyone who's used Final Cut Pro for more than a few hours.

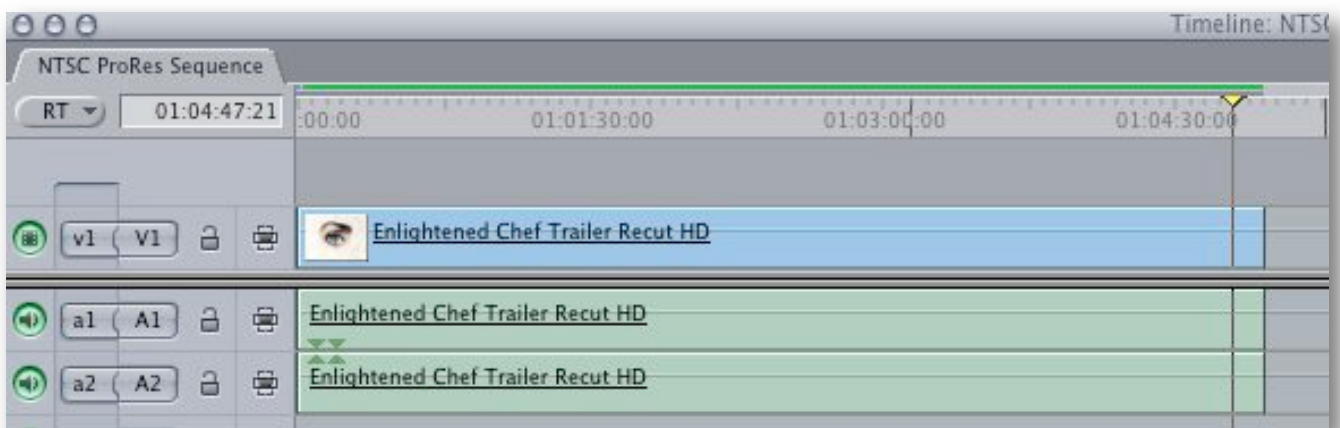
- Create an SD sequence with your desired codec and frame rate. Create an Anamorphic SD sequence to retain the image aspect ratio of the HD source. Create a 4:3 SD sequence if you want to do a "center cut" of the HD, and perhaps Pan and Scan the HD source using Motion Tab keyframes on Center.
- The frame rate should match the HD Master unless it's 720p60, in which case you'll have to convert to 30/29.97fps since there is no 60P available in SD. Likewise 720p50 will have to be converted to PAL 25fps video.
- Take the HD Sequence(s) and edit them into the SD sequence. If you're nesting Widescreen HD into 4:3 SD, you will have to restore the nested Clip or sequence to full height in the Motion Tab, Distort settings and Scale settings as Final Cut Pro will default to nesting as letterboxed.

**Tip:** Final Cut Pro 6.x will ask if you want to change the Sequence settings to match the nested Sequence or clip. You do NOT want to do that, so click on 'No'.

Final Cut Pro will automatically add a Shift Line filter if necessary to retain field order correctly.

**Note:** In doing one downconversion this way I discovered an issue with HD slo-mo. While the HDV was fine in the uncompressed SD sequence (before ProRes 422 was available) the clips that had some severe (1-2% speed) slow motion applied had field order problems that I could not resolve. These problems only affected the slow motion clips. My resolution, since we were going to less than half the vertical resolution anyway, was to simply de-interlace those clips.

Render and output the new SD Sequence.

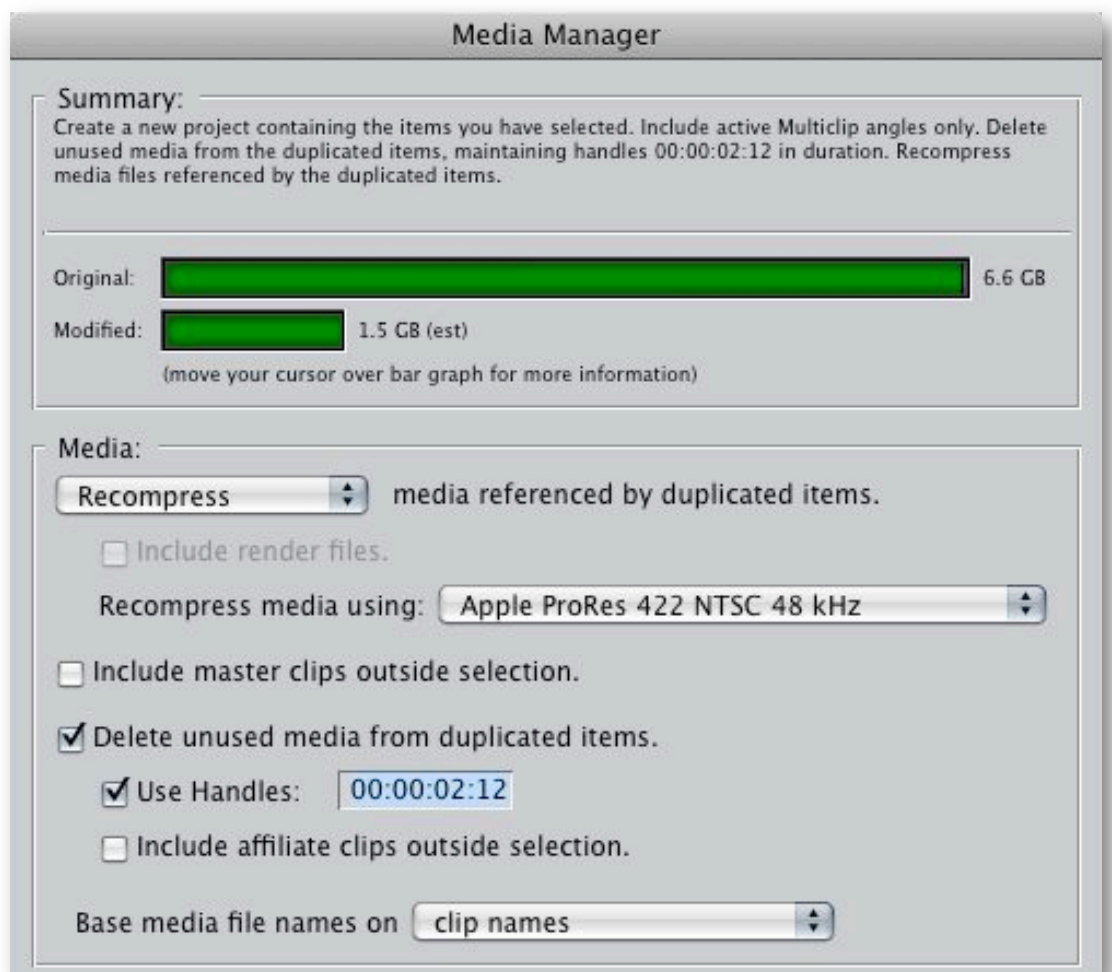


## Use the Media Manager to produce an SD Sequence and recompress media

Using Media Manager to control the downconvert process is another approach.

- Choose the HD Sequence(s) and open Media Manager.
- In Media Manager choose the settings in the example:
  - Recompress
  - To the setting you want to use for your downconvert (ProRes 422 is good, or uncompressed)
  - Don't include Master Clips outside the selection;
  - Delete unused media and use an appropriate handle size.
  - Do not include affiliate Clips outside selection;
  - Base Media files on Clip names (or current name – your call)
- Create a New Project but exclude multiclip angles unless this is a multiclip project.
- Choose a media destination and export.

If you do not plan to make any changes in the SD version do not use handles, but I recommend some handles as you may want to check the edit after downconverting, particularly if you have center cut the image.





## Producing SD DVDs from HDV Source

Direct HDV-to-SD-DVD does not produce the best results in Final Cut Pro and Compressor. Ken Stone, of KenStone.net has a great article on a better conversion that exports the HDV to a HD intermediate in ProRes 422. This produces great results and I have used it recently myself and been happier with the results. Rather than reproduce a summary here, you can read the article [“Exporting HDV Video from the Timeline to Standard Definition DVD”](#) online.

## Downconverting in Hardware

If you were paying close attention in the post-production module, you will have noticed that all the HD capture cards or external boxes have the ability to produce an SD output from an HD Sequence, downconverting via the AJA, Blackmagic Design or Matrox hardware.

The settings will vary slightly from output device to output device, but the general principle is that the output size from Final Cut Pro is the full size of the sequence. The downconvert settings are in the AJA Control Panel Software or the Decklink Preferences Pane. (Multibridge Pro and Multibridge Extreme both use the Decklink Preferences Pane.)

**Tip:** If you're working at 24P, add pulldown with the hardware (where available) rather than in Final Cut Pro. Hardware pulldown is more reliable and consistent than software pulldown in Final Cut Pro.



Modern hardware will downconvert HD to SD in real time.

# Convert source footage to SD and edit SD

All HDV camcorders will output DV as an alternative to HDV, and many of the other cameras also have an option for a standard definition output. We can use those, or capture via a Blackmagic Design, AJA or Matrox hardware device and take the HD SDI or HD component analog source and convert on capture to SD.

From that point on the edit and distribution would be as you would work with any SD project. It is best to retain the 16:9 aspect ratio from the HD and edit the SD at anamorphic 16:9. Crop or letterbox the 16:9 master to 4:3 where necessary.

## *An all-SD edit isn't such a good idea*

There are few situations where I recommend down-converting all source to SD before editing. Down-convert all source and edit in SD *if*:

- This is timely news with a limited life and the only distribution is SD video or the Internet; and
- You're absolutely sure that there is no possibility, no matter how remote, of there being an HD release in the future.

## Format by Format downconversion

### HDV

Set the camcorder or deck to give SD DV output and capture as SD DV in the appropriate format.

### HDCAM, HDCAM SR, D5

Capture over HD SDI and use the capture hardware to downconvert to SD and compress to your codec of choice. (ProRes 422 recommended unless uncompressed is contractually obligated or otherwise necessary.)

This would also be suitable for any other format captured over HD SDI. For example we could capture-and-downconvert XDCAM HD, XDCAM EX or even HDV using this method.

### DVCPRO HD or XDCAM EX

DVCPRO HD or XDCAM EX can be sent via HD SDI and downconverted with third-party hardware. Alternatively capture natively to DVCPRO HD or XDCAM EX and then Batch Export the Clips to SD before starting editing. Once converted to SD, the HD capture can be deleted.

### AVCHD

AVCHD is converted to ProRes 422 when imported via the Log and Transfer window. Like other formats, it can be converted to SD before editing by Batch Exporting the Clips. The HD ProRes 422 files can be deleted after converting to SD.

## Be creative with the Frame

A project I worked on a year or so ago points to another approach: consider the downconvert as an opportunity to be creative. The project was *Yoga for Couch Potatoes* – a DVD to help large-bodied people ease their way into Yoga in a way that is size appropriate and not excessively stressful.

The producer, Shiva Entertainment, has had many successful DVD titles and knows that their programs tend to be relevant for many years. The program was shot in HDV, which was very appropriate for the budget and low action involved. It was always known that the initial release would be on SD DVD because that's where the current market it. (It has also been released for digital download through klickTab, in segments.)

The producer and I worked together to come up with a creative approach to fitting the 16:9 frame from the HD edit into the SD 4:3 sequence that would form the basis of the edit.

What we have done is to create a 4:3 SD Sequence (uncompressed at the time, but I would use ProRes 422 today for the smaller file sizes).

In that Sequence we nested the HD master.

The 16:9 letterboxed video was moved up in the frame, so the top of the 16:9 frame was just inside the Action Safe – so that the black at the top of the frame was going to be missed on most televisions.



In the background we put some slowly evolving background footage. This was shot with the main video for this purpose and where various pieces of organically moving footage like reflections off water, or slowly waving foliage. This footage was slowed down to, typically, 1-3% of full speed. It evolved slowly using field blending<sup>31</sup> and filled in the space below the 16:9 video instead of leaving it black. A drop shadow on the 16:9 footage gave separation.

We left the lower third titles — used largely for Sanskrit words used in Yoga — off the HD version. They will need to be added for a future HD release. Instead we added the Lower Third titles so they overlapped into the otherwise useless space below the 16:9, utilizing the whole screen instead of leaving black, unused space around the letterboxed 16:9.<sup>32</sup>



This is just one way that the space can be used when downconverting HD to 4:3 SD. If you retain the 16:9 aspect ratio, by using Anamorphic 16:9 in SD, then you don't strike this issue, but few people (particularly in the U.S.) have SD 16:9 televisions so we felt, and I recommend you consider, converting to 4:3 using a creative use of the frame.

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<sup>31</sup> This was the footage where these extreme slow motion pieces showed field order problems until they were temporarily de-interlaced in the HDV Master while the downconvert was done.

<sup>32</sup> I feel the need to note that the color choice was not mine!