HDV – The Alternative for PracticalHD™ Production

Introduction

It's not if – but when. It's not why -- but why not. Can there be any doubt that the momentum behind HD is gathering? In March of 2004, 82% of all US TV stations broadcast in the DTV format and reached 99% of all US households. The move to HD- DVD is well under way with next generation players on the shelf by December 04. US Prime Time TV is saturated with HD programming and there are several full time HD cable and satellite channels. An early adopter, Japan has 8 Networks offering full time HD over satellite since 2000. Europe has the pioneering effort of Euro1080 in all HD. Dare we dream that affordable HD technology will trickle down to the prosumer or even the home videographer? And if it did, how would that impact the TV broadcast business -- if at all?

> ***"The time has come to bring an HD camera to the masses in support of the accelerating transition to DTV. We believe that HDV is just the vehicle to do this"***
>
> ***-- Larry Thorpe, VP, Canon***

One of the big roadblocks to new technology acceptance is often price. HD cameras cost more than SD ones, right? HD infrastructure is more complex and costly than SD, right? Well that is about to change with the advent of the HDV camera. "Oh no, not another tape format", you may be thinking. Well, not exactly and that's one of the strengths of HDV. As the name implies, HDV is a combination of the DV tape cassette (Standard or Mini DV) but using HD compression in the form of MPEG2 (MP@H-14) at 25 Mb/s. In a nut shell, HDV leverages DV tape cassette and camera technology to create HD solutions. A DV camera (also 25 Mb/s rates) needs only some upgrade modifications to support HD since the helical recording mechanism and recording rate are the same as for DV.

Does HD encoded at 25 Mb/s rates sacrifice quality? Well consider that worldwide almost every digital TV distribution system uses rates less than 21 Mb/s so the HDV format offers respectable quality. Of course it's not meant to replace high end HD cameras like the Sony HDCam or the Panasonic DVCPro/100 cameras. Figure 1 shows HDV in relation to several other HD devices that are in everyday use to acquire, produce and distribute HD programming. HD camera recording bit rates range from 25 to about 440 Mb/s for compressed formats. Uncompressed formats range from 350 Mb/s for 720P/24 to about 7 Gb/s for digital cinema at 4K X 2K resolutions The vertical axis is the data rate of the HD video. Significantly, data rate is not necessarily a quality metric. As we will see, data rate is only loosely related to image quality.

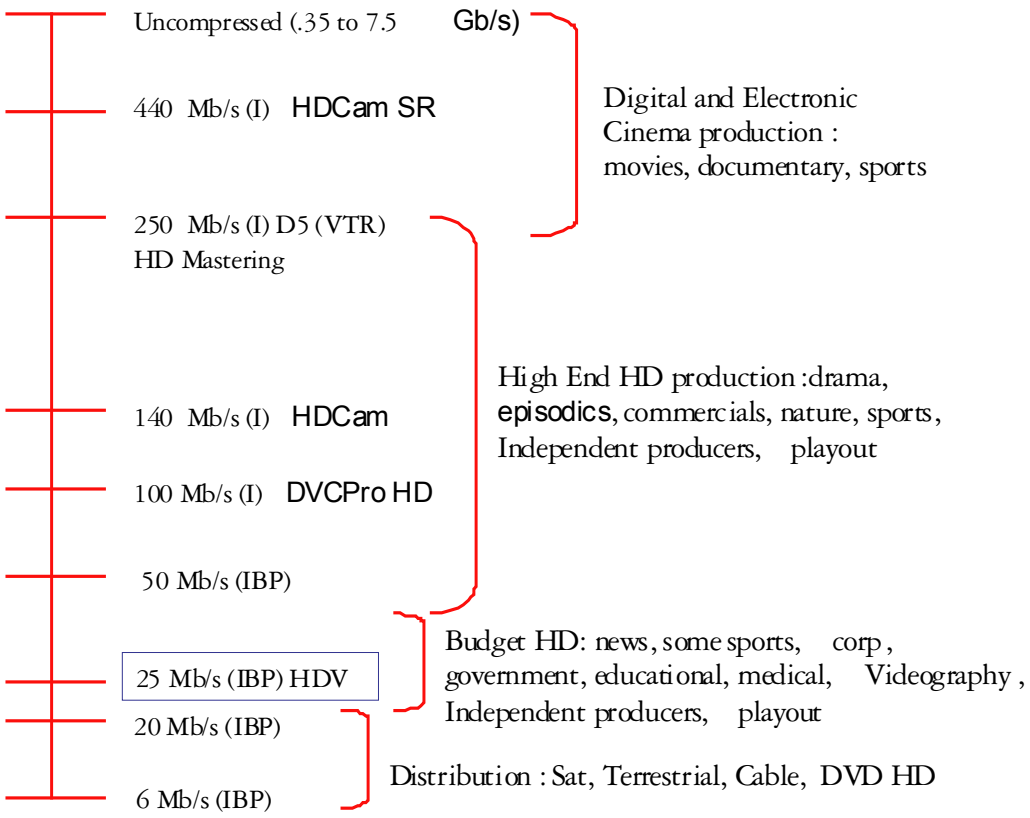

Figure 1 – The HD Spectrum of Rates

In the figure, the notations (IBP) and (I) are used. IBP refers to the most efficient form of MPEG also called Long-GOP MPEG. In this format, video frames are compressed in relation to the redundant image content of their nearest neighbor frames. This yields excellent compression metrics. So called I-frame compression is about 2.5 times less efficient than IBP but is easier to encode, decode and process. I-frame codecs don't factor in the image activity of nearest neighbor frames so the coding is less efficient than its IBP cousin. So an HDV image encoded at 25 Mb/s (IBP) is roughly equivalent to an I-frame image encoding of about 60 Mb/s. So, when comparing two compression schemes, remember that the higher bit rate version may not necessarily provide the better image quality.

The HDV Consortium

The HDV camera format was defined by Canon, JVC, Sharp and Sony in 2003. Noticeably absent are other camera vendors but more on that later. The HDV/MPEG format is an open spec for others to use (editors, servers, other) so Pinnacle Systems has signed on as a supporter. The main HDV contributors will offer cameras (and lenses) to the prosumer marketplace. JVC has announced a 720P format camera in the HDV format for delivery in 2004. Sony has announced a 1080i format camera for delivery likely in 2004 as well. The HDV specification does not support the 24P rate that is in vogue for some HD production. However , HDV[1] does support a range of useful frame rates and resolutions; for example, 720P/1280 (25, 29.97, 50, 59.94 frame rates) and 1080i/1440 (25, 29.97 frame rates) are supported all in a 16x9 aspect ratio. HDV also supports an audio stereo pair compressed as MPEG-1 Layer 2.

Although not all HDV camera prices have been announced, it is expected that most first generation gear will be in the (US) $4K range with the early entrant JVC JY-HD10U ringing in at $4K and under. Now this is certainly more expensive than most DV cameras in 2004. However, remember that the ever popular Canon XL1 DV professional camera (standard definition) sold in the $5K range just a few years ago. Furthermore, there is no prohibition to offering both DV and HDV in a switchable camera so expect to see this.

The HDV Sweet Spot

As Figure 1 shows, a 25 Mb/s compressed rate for HD is not for everyone but then again neither is DV. For news, some sports, Corp., government, educational, medical, videography, Independent producers and more, the HDV format should meet the needs of the users. Let's take the *way-back* machine to 1995 when DV was first introduced. Initially, the marketplace target was VHS deck replacement and digital consumer cameras. Over time the consumer DV camera became a huge success, but something unexpected happened. The professional community noticed the great price/performance of DV and creative people of all kinds flocked to it.

Today, the DV camera is a mainstay for news and event gathering worldwide. Videographers of all sorts depend on DV's acceptable quality compared to much more expensive alternatives. Could the same phenomenon happen to HDV? Could it start out as a prosumer camera and become the cornerstone of professionals worldwide? Could it sidestep other more expensive alternatives and find a sweet spot of acceptance for many professional endeavors? Of course, time will tell. Camera price/performance isn't the only magnet that will attract users. If we consider the A/V workflow of an HD production, other compelling advantages come to the surface. Let's see what these are.

[1] The HDV spec states that 720P has a raw encoded video rate of 19 Mb/s and the 1080i format requires 25 Mb/s both in the 4:2:0 sampling format. 720P cameras also support a 525P/60 and 625P/50 SD-plus format.

The Combined SD + HD Workflow

Figure 2 shows a simplified AV workflow (ingest, edit, output) for a medium size edit suite. Imagine this is a DV/25 based system with several Liquid editors all accessing PAMS storage. All Clients have instant access (over Ethernet) to storage and projects for efficient collaborative editing. Enter HDV. Since HDV's compressed data rate is the same as DV, it's a snap to upgrade an edit station to work in HD. With only a software upgrade, the Liquid editor can now work in SD or HD. No need to upgrade the infrastructure or storage. The legacy SD system is ready and willing to switch to HD at will.

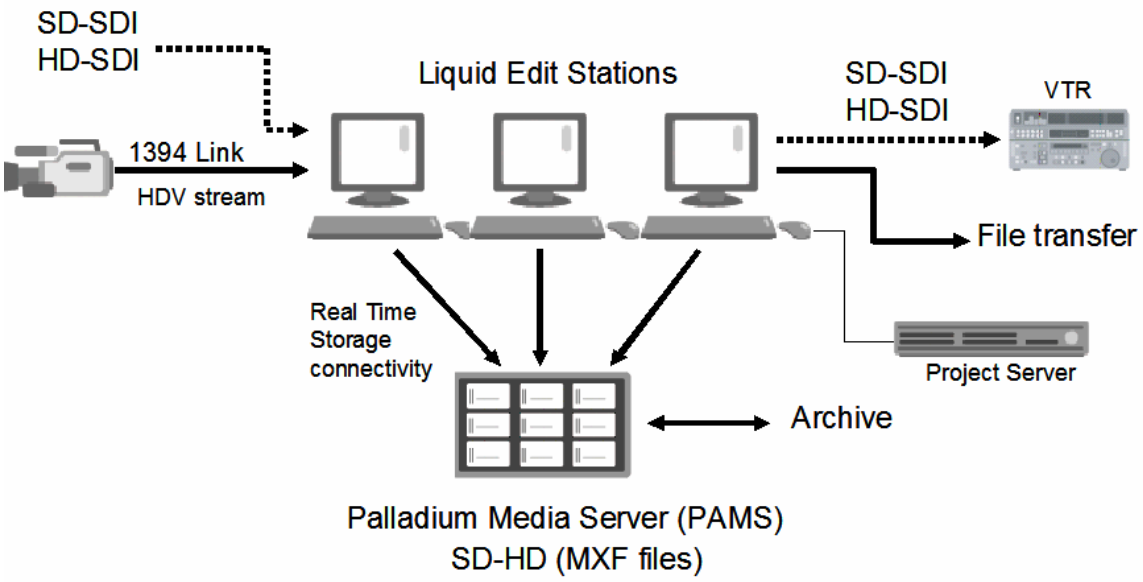

Figure 2 – SD/HD Edit Suite

HDV cameras have an IEEE-1394 port for off-loading the HD content. For this example the Liquid editor only needs to support the 1394 port at 25 Mb/s transfer rates. Optionally, the Liquid editor will offer HD-SDI (SMPTE 292M) ports for raw uncompressed I/O. If desired, the edited HD piece can now be played out from a Pinnacle MediaStream client (not shown). This product offers FreeHD™ – purchase a SD playout port and get HD output for free[2].

So the bottom line is obvious – HD production at SD rates and infrastructure costs. HDV leverages this efficiency to create compelling workflows from acquisition to store to edit to playout. Pinnacle's Liquid and MediaStream products will offer HDV's MPEG format compliancy. Although the native tape format is not MXF, as soon as the 1394 stream hits the Liquid editor, we convert the stream to an MXF wrapped HD/MPEG file. Why is MXF of value?

MXF will become the lingua franca of file formats for the professional. Pinnacle has a strategic imperative to natively support MXF across all our professional products. Selecting one format for all A/V operations allows for a remarkable degree of interoperability across all our products. Plus, we can share our MXF

[2] With MediaStream, every output port may be SD or HD on user choice. Users may need to purchase an external HD encoder for some applications, but not for the case of Figure 2.

files with others without the need for costly conversions in many cases. MXF coupled with HDV – a powerful combination for resource efficient HD workflows.

Editing Magic

Let's assume that an editor wants to create a single HD MPEG output file as the result of an edit session. Editing standard MPEG I-only (or DV) clips is straightforward. If a basic cut between two clips is made during an edit, then the resultant file is composed by simply joining the two clips as Figure 3 shows. Notice that the clips have a compressed video frame notation of F1, F2, F3,… for the first clip and f1, f2, f3,… for the second clip. If the editor chooses a transition rather than a cut then only the frames of the transition need to be MPEG re-encoded and the new piece is joined into the output stream. This too is relatively simple for I-Only material. There is no or little loss at the transition point.

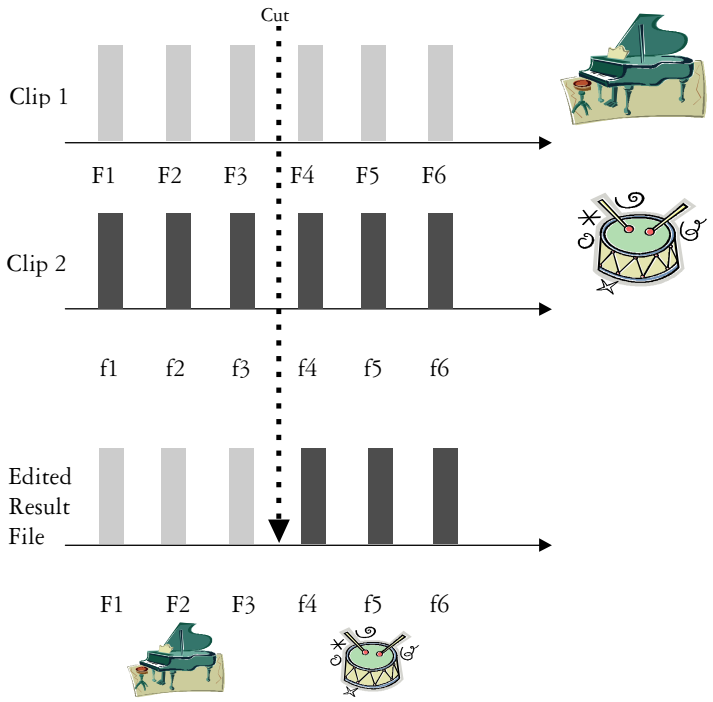

Figure 3 -- Editing Compressed Clips

Now, let's imagine that Clip 1 and Clip 2 in Figure 3 are IBP encoded instead of I-only. This is the HDV MPEG format case. For this case[3] individual B and P frames are encoded using the information from the surrounding frames. Now the operation of performing a frame accurate cut or transition is not as easy. A simple minded IBP clip/join operation (as with the I-only case) will create a format-illegal resultant MPEG file. In fact, achieving a near loss-free cut is a sophisticated piece of engineering because

[3]In MPEG speak, a B frame is a Bi-directionally predicted frame and a P frame is a forward Predicted frame. The I-frame term in IBP refers to a standalone frame that provides the anchor to encode the nearest B and P dependent frames.

of the need to account for the association of nearby frames. Pinnacle has perfected IBP editing so you don't have to worry about it. Liquid will edit HDV content (IBP encoded) as effortlessly as it edits DV.

HD Editing at Pinnacle

In addition to HDV support, our Liquid editing family will also offer 720P/1080i uncompressed and high rate (100 Mb/s and higher, in future) I-only MPEG for more demanding applications. Of course, one size doesn't fit all that's why we will offer a range of HD formats to meet your creative needs. Each of these formats will have a sweet spot and users will select one versus the other based on quality, needed bandwidth, storage costs and archive considerations. It is planned for Liquid to support a mix and match of all three HD compression formats in the same time line. That's PracticalHD editing from Pinnacle.

Beyond HDV

The overall HDV advantages discussed in this paper will be compelling for many users. But HDV cameras are still tape based. Sony has recently introduced a new line of cameras based on Optical media (XDCam) and Panasonic has introduced a camera line based on solid state memory (P2 Camera family) – no tape for either case. These cameras (and others) can theoretically support the same MPEG format as HDV. Looking at the crystal ball, these vendors and others may choose to raise the ante and encode somewhere between 25-50 Mb/s (IBP) for even better HD quality than HDV supports today. In any case, we are ready to meet the challenge. Pinnacle is committed to building HD ingest, edit and playout products that meet a wide range of user quality expectations.

Conclusion

When it comes to HD production, HDV will turn many heads. What other format gives you the power to upgrade an edit system from SD to SD/HD with a simple software upgrade? No forklift upgrades here. Truly, *HD production values at DV prices* is a persuasive value proposition. We believe that HDV will become an inflexion point in history of HD production. We look forward to its acceptance by a large sector of the creative community. When you think HDV, think Pinnacle and our commitment to PracticalHD across our product lines.

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