Migrating to HD

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Preamble

Although there have been a number of technologies referred to as "High Definition" (dating back to the 1930s-40s British 405-line black-and-white system), it was not until the early 2000s that technology had progressed enough to deliver sufficient storage capacity and processing power to support compression algorithms powerful enough to make HDTV affordable for consumers, as well as being profitable for broadcasters and other programme makers. The main enabling factor was the transition from analog to digital TV standards. Digital compression methods such as MPEG-2 and MPEG-4 allow the bandwidth of a single analogue TV channel (6 MHz in the US) to carry up to 5 standard-definition or up to 2 high-definition digital TV channels instead. Most developed nations have plans in place for a transition to digital television, but not necessarily or exclusively HDTV; for example, on 17th February 2009, the US intends to terminate all full-power terrestrial analogue broadcasting (although some smaller local stations have later deadlines), with both standard definition TV (SDTV) and HDTV being allowed.

Current HDTV broadcast standards include ATSC (US and Canada) and DVB (Europe, and most of the rest of the world). HDTV can also provide 5.1-channel surround sound audio using for example the Dolby Digital (AC-3) format.

Since Snell & Wilcox' first broadcast high-definition television product was introduced in 1988, the company has been designing and planning for this revolution in broadcasting. For that reason, we have some of the world's top engineers working in many facets of HD signal processing.

Our products and services are used by the largest and most diverse broadcasters in the world. In this document, we examine some of the issues involved with the migration to HD for the television broadcaster.

Choose Your Standard

Background

Against the backdrop of the existing SD television standards (e.g. USA 525 lines 59.94 pictures per second and 625 lines 50 pictures per second) a large number of HD formats and standards were proposed by wide variety of interest groups from Television, Computer, Telecommunications, Consumer Electronics and Government organisations. The two common formats that have emerged for Television use, and particularly for Transmission are 1080i (1920 pixels horizontal x 1080 lines vertical – Interlace scan) and 720p (1280 pixels horizontal x 720 lines vertical – Progressive scan). Organisations initially aligned themselves to one of these formats due primarily to their following either the Interlace (with more lines and pixels) or the Progressive religion. More recently, with widespread adoption of the 1080i format, the 720p format seems to be dropping by the wayside. "Progressive" believers have not lost though, as the newly emerging 1080p format promises to deliver the benefits of both Progressive scanning and high spatial (horizontal and vertical) resolution.

Why Progressive?

The attraction of standards that utilise progressive scanning is that they bring with them an inherent match to current flat screen display technologies (flat screens are fundamentally progressive), ease of conversion (Up, Down, Cross), and they compress far more efficiently.

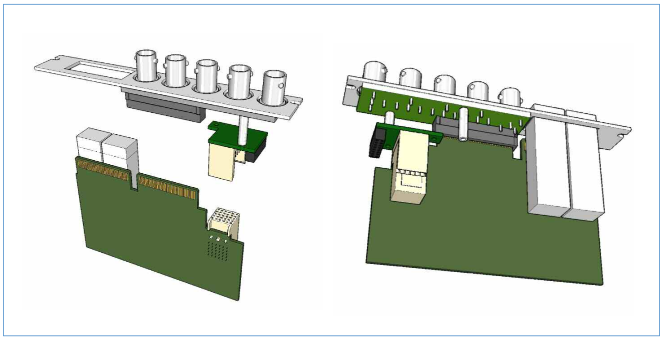
At What Cost?

AThe associated penalty is that being Progressive, the bandwidth is double the Interlace counterpart for the same picture rate and motion portrayal. Therefore, any infrastructure needs to be capable of handling twice the data rate, in the SDI form factor, this being 3.0 Gb/s (Giga bits per second) as opposed to the 1.5Gb/s associated with 1080i & 720p signals.

A further consideration is that in general, 3.0Gb/s signals travel only half the distance, or less, than a 1.5Gb/s. Typical distances achievable may be as little as 50 to 70 metres. This is far from the SD days of 300 to 400 metres down a coax cable and clearly needs to be taken account of during any system design and layout phase. Some SDI plants may go 1.5Gb/s just on the distance issues alone.

For sure, there is likely to be a greater reliance on fibre circuits to handle difficult long runs. One should also remember that the distances quoted by most manufacturers refer to the distance achievable over a specific cable type – typically Belden 1694 – which is thicker, heavier and more expensive than regular cable types. Further, the insertion of connections, U-Links, and patch-panels will all serve to attenuate the distances achievable between any given equipments.

Delivery of both local and more distant signal requirements can be achieved by a modular solution that utilises a hybrid rear connection strategy, as presented below.



The BNC connectors pass the HD SDI signals while in parallel the fibre blocks are able to deliver the HD signals via mono-mode fibre circuits over distances of up to say 30km or more. This provides distribution of HD signals between buildings, OB trucks, location venues and even intra-city.

Snell & Wilcox' products are in general able to carry 1080p signals up to and over 100 metres as seen in the latest generation of IQ Modular interface and distribution products.

ARC – Aspect Ratio Conversion

For most of the world's broadcasters, the transition to HD means dealing with the transition from 4:3 to 16:9 picture aspect ratios too (many European countries have adopted 16:9 for SD programming for some years now). This brings with it both production and system issues. From a production standpoint, the display method chosen impacts on the choice of graphics, captions, logos, bug, and clock placements and the final result the viewer receives.

From an engineering standpoint, signalling information both incoming and that which will be passed to the viewers display equipment needs to be read and generated to ensure that the intended decisions are acted upon by the system and delivery processes. Such signalling practice has been standardised by the SMPTE in REC2016. This signalling will also be referred to by many as AFDs (Active Format Descriptors).

Snell & Wilcox gear is being rolled out with SMPTE 2016 support as standard where it makes sense for equipment types to include this functionality.

Format Conversion – Signal Processing

SD sources are defacto Interlace signals and fundamental to any conversion they may undergo (Upconversion, for example), is a process known as deinterlacing. Various techniques exist,

Good Deinterlacing Poor Deinterlacing

but only one, motion compensation, is able to produce near perfect. Converting 1080i signals also requires the use of motion compensation to achieve the best possible results.

For instance in the picture above, notice the jagged diagonal lines on the red and white strips on the right hand side of the example above. This is as a direct result of sub-standard deinterlacing.

Consider these signals will be ahead of perhaps many compression steps, including final transmission delivery. It is important that the conversion techniques deployed are "compression friendly". That is, they are aware of what an encoder can see in the vision path and how to avoid exacerbating the already difficult job a compression encoder has. Failure to consider this can result in excessive and extremely undesirable artefacts, like, visible Macro Blocks, and just plain wasted bandwidth (Money).

During the transition to Digital, the PAL or NTSC Decoder was often regarded as the single processing step having greatest impact on the final vision quality. One of the most cost effective methods of going HD is simply to Up Convert the SD programme. In the migration to HD, the Upconverter is the processing step having the biggest and most dramatic impact on your picture quality and the viewer's acceptance of your broadcast when compared to native HD programming.

Frame rate conversion between the world's 50Hz and 59.94Hz HD television systems is still required in the same way that the SD standards conversion market has existed for years. Again motion compensation is the only sure way to convert the images with transparency.

Snell & Wilcox pioneered the practical implementation of a motion compensation technique known as Phase Correlation (Ph.C), which has long been recognised internationally as the conversion quality benchmark.

Format Conversion – Production Switching

In today's emerging multi-format world, the production switcher is recipient of a variety of formats and standards – especially in live news and sports environments.

The switcher and its operator are expected to be able to handle all formats at a moment's notice. Most current switchers are able to switch between HD & SD, and most now have been crudely adapted to offer some form of up, down and cross conversion processes to handle sources different from the switcher's current operating standard. Some only offer conversion on dedicated Inputs.

It has been a golden rule in engineering for many years that all the sources to the switcher must arrive at "zero time". However, due to the addition of conversion functions to the front end of switchers, one finds the native sources arriving at zero time, while those video and key sources that require converting will arrive some number of frames later. These delays can be typically up to four frames (roughly 0.16 seconds, nearly that of a satellite hop!).

This delay is certainly more than enough to add significant lip-sync and shot matching errors, severely limiting production creativity and freedom. Not to mention adding the chance of major errors creeping in. No amount of audio delay and compensation can correct the problems! The only solution is a switcher architecture designed to solve the problem from the outset.

Recognising that the transition to HD was fraught with such obstacles, Snell & Wilcox pioneered a new switcher architecture, Kahuna. Uniquely, Kahuna is able to simultaneously handle any of today's broadcast formats and standards, with absolute "zero timing" on all inputs. There is no differential delay between sources. Kahuna keeps all production choices open while solving the engineering challenge at a stroke.

Latency

Latency, that is the time it takes a programme to travel though a broadcast system, has always been an issue. However, as one migrates to HD, there is ever greater reliance on Conversion and Interface products that can each introduce delay to the video channel, audio channel or both. Compression too is omnipresent in a busy HD facility and will also play its part in increasing the system latency. Compensating delays can ensure that video and audio services remain in synchronism with each other, but they cannot remove the overall delay that has been inserted by process intensive equipment.

As an example, the longer the processing delay between camera lens and the final transmission point, the harder it is for a commentator, watching the live event in front of him, to add commentary realistically to the final programme that happened sometime before. Similarly, the greater the overall delay, production talkback will be further from reality at any given point along the chain (for example, a Director speaking over talkback to a cameraman).

Video Monitoring

Since the inception of television, video signals have been monitored on CRT (Cathode Ray Tube) based video monitors. Recently, manufacture of TVs and video monitors alike have transferred to flat panel technology and CRTs are a thing of the past. The two most common flat panel technologies on t he market today are Plasma and LCD. Both with the capability to amaze and deceive in equal doses. Both exhibit limitations in various areas.

LCDs are notorious for poor motion portrayal, even on more expensive so called "broadcast" models from known and otherwise reputable brands. These flat panel screens are inherently progressive and so they must "deinterlace" any Interlace sources. Any sources not matching the native spatial resolution (horizontal & vertical number of pixels) of the flat panel must be scan converted by the screen's own internal processing. Be aware the most screens add around a video frame of delay between input spigot and light on the screen. If used in conjunction with a multi-viewer, you can easily see the delay increase to two or more video frames overall. This further impacts on the challenges of Latency detailed above.

Audio

For many, HD brings the advent of multi-channel sound delivery, including Dolby surround sound. HD equipment today generally supports the transportation of 16 audio channels (eight AES pairs). You may find older HD equipment examples that only handle 8 audio channels (4 AES pairs). The method of transporting surround sound within these capabilities is different in the broadcasting infrastructure to the consumer delivery.

A system developed by Dolby, known as Dolby E is most widely adopted today. Dolby E enables the high quality transportation of eight mildly compressed audio channels in a single AES pair. Eight channels enables the carrying of 5.1 surround sound (six channels), plus a stereo pair.

System integrators and broadcast engineers agree that integrating the video path itself is relatively straight forward and usually without incident. However, they report that the audio portion of a system is usually far from trivial and often fraught with problems, especially when Dolby E must be handled.

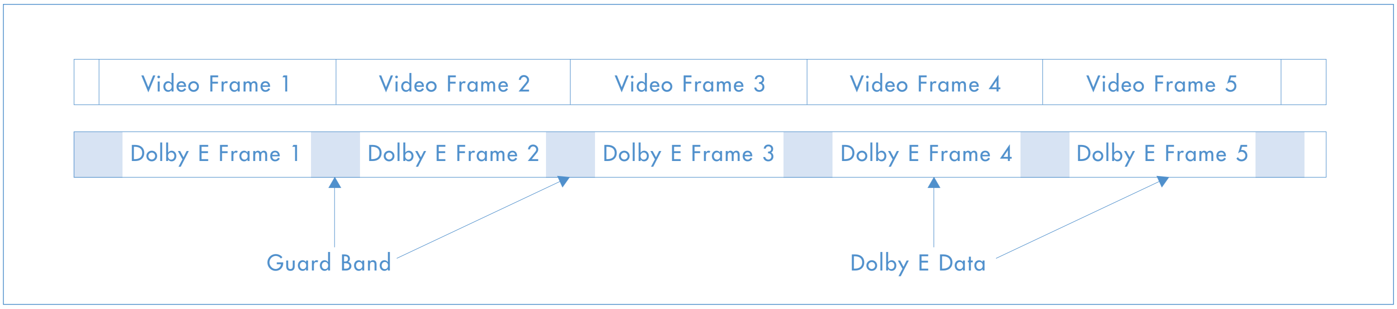


Figure 1: Aligned Video and Dolby E frames

Dolby E data packets are contained in audio frames. There is one Dolby E frame per video frame as can be seen in Figure 1. above. The Dolby E frames are shorter in duration than the video frames and are protected by guard bands which are intervals between each audio frame.

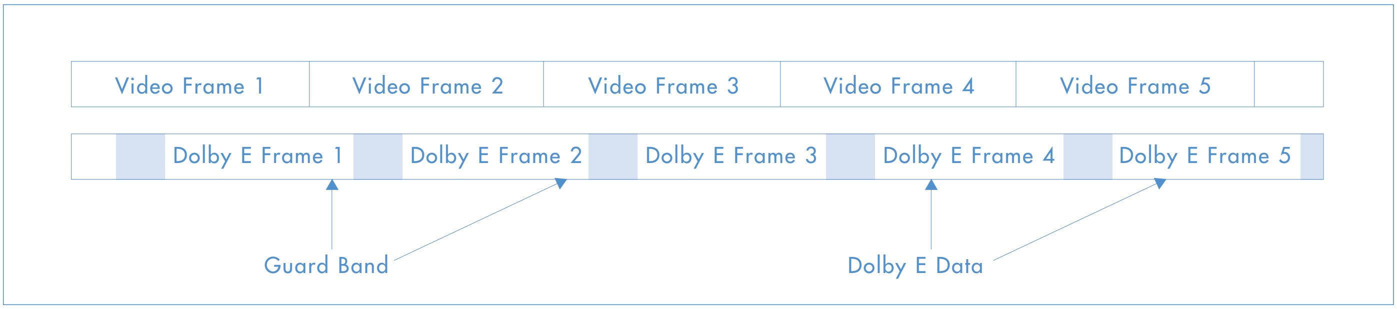


Figure 2: Misaligned Video and Dolby E frames

Misalignment of the audio frames with respect to the video frames as seen in Figure 2. above, can cause significant problems, resulting in pops, clicks or even complete corruption and failure of the audio service.

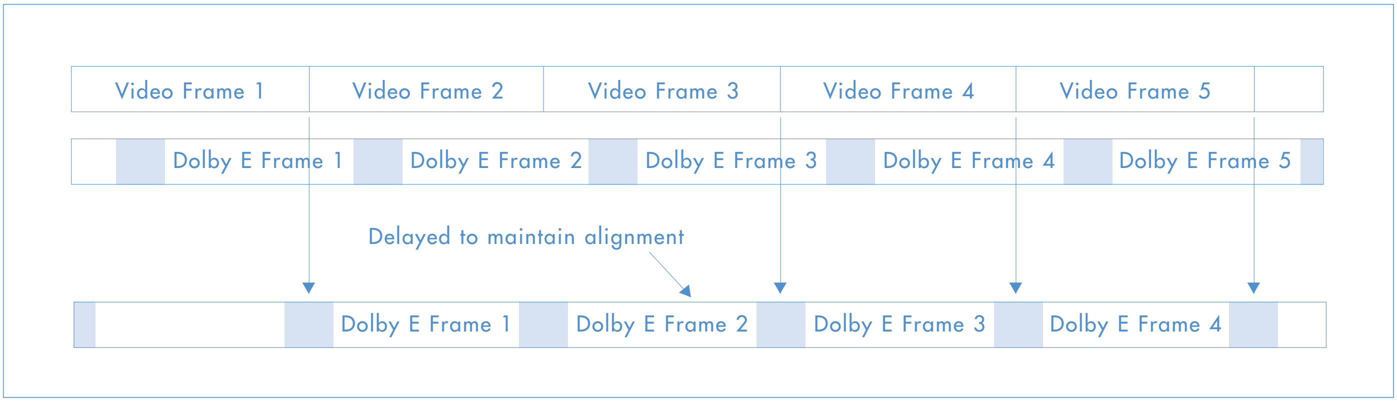


Figure 3: Aligned Video and Dolby E frames

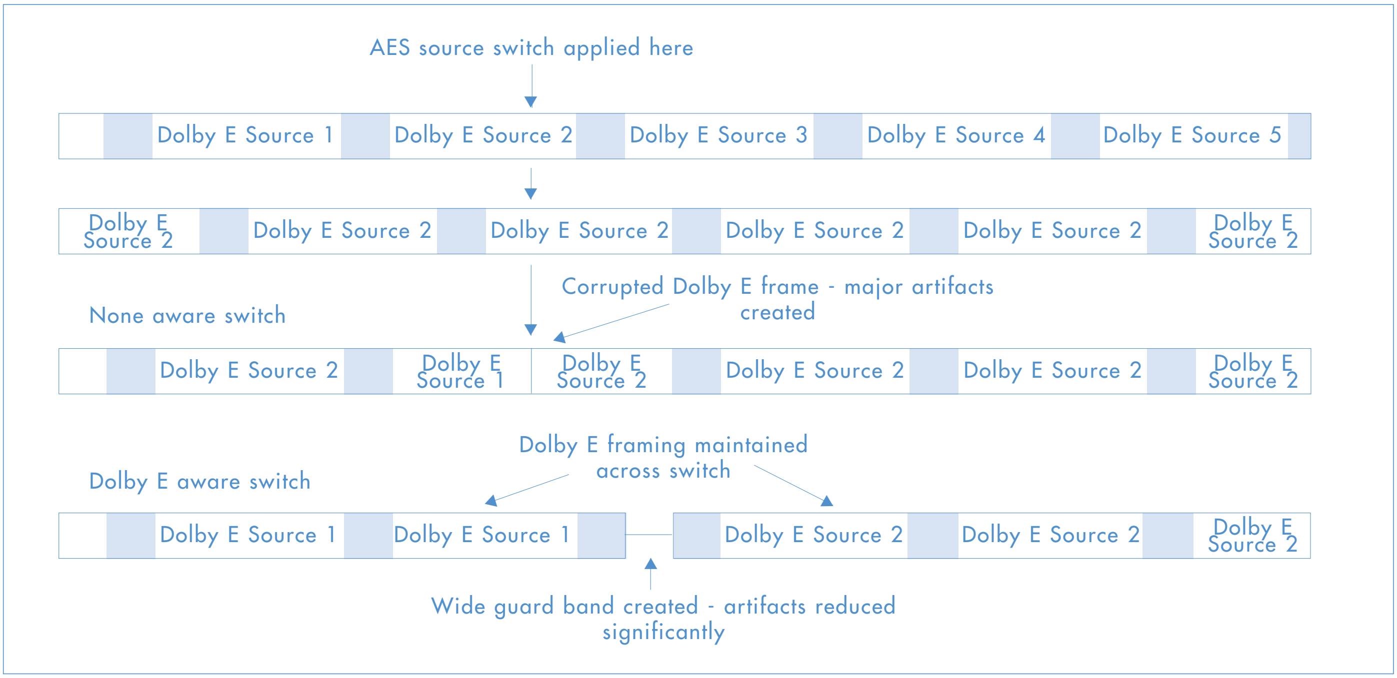


Figure 4

Similar issues can occur when audio sources with misaligned Dolby E frames are switched (cut) Figure 4. below shows an example of this.

These commonly experienced audio issues have led Snell & Wilcox to develop a range of dedicated solutions.

The company's unique, automatic processing seeks to eliminate such issues, simplifying the Integration and system commissioning processes and ensuring clean, corruption free audio services.

Often migration from SD to HD means the transition from stereo to surround sound. Some customer's systems require processes referred to as upmixing, a technique for creating pseudo surround sound from a stereo source which is capable of filling the 5.1 sound field. The reverse process is known as downmixing.

QC & Confidence Monitoring

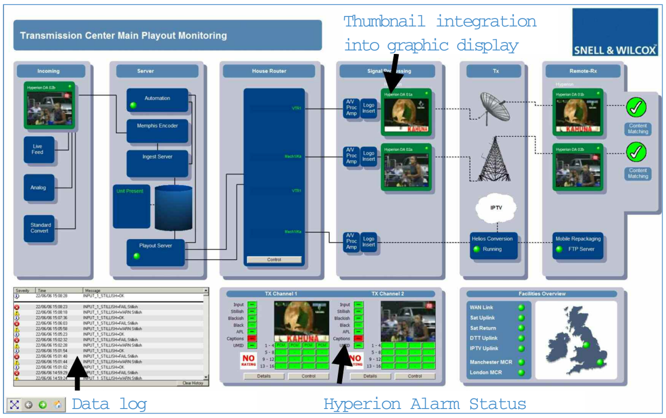
The requirement for QC (Quality Control) systems and processes are not unique to HD. However, whether building for your future from an analogue or SD-SDI plant, your migration to HD will give you a fresh opportunity to review your QC strategies. Today's video and audio signals are combined with a growing list of silent, invisible metadata.

Imagine the challenge of in addition to watching the video for defects, having to listen to an English stereo sound track, Clean FX, and the 5.1 surround sound track variant. Then, add the same again in a second language, hidden metadata, AFDs, and closed captions.

Additionally, such are the quality expectations placed on new HD services that broadcasters and content owners alike are looking to protect their brand interests as well as gaining buy-in from the viewing public.

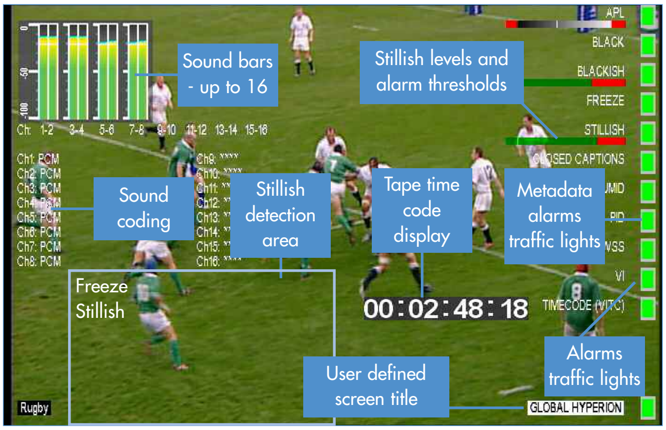
All this quickly adds up to a multi-person task, before you even consider the ramifications of a busy playout centre for example, with many simultaneous channels on-air. There are tools available for checking specific video parameters, or the presence of a particular data type. But, the optimum solution is to mimic human monitoring capabilities and make informed decisions about what is normal and what represents an alarm state.

Snell & Wilcox has rolled these together with some unique tools into a single, multi-format package. The suite of tools is referred to as Hyperion. It can report on each and every facet of your video, audio and metadata, frame accurately and is completely open to reporting to third party monitoring software such as Volicon.



The above example shows how status information and data relating to Snell & Wilcox and 3rd party software and hardware systems can be pulled together and presented in one simple to understand flow diagram. Notice how live monitoring of the content is also integrated showing what signals are flowing through the various paths represented.

A simpler method of integration is to use the conveniently provided video overlay output provided on the standalone QC Station tool. This is a standard HD or SD SDI port which superimposes all the monitoring data in graphical form on top of the associated video channel, requiring no specialist integration services, as can be seen in the following example below.



Each channel and genre will have its own requirement. The alarm threshold for all the detected and measured parameters may be individually customised on a per channel basis.

Conclusion

The business of television broadcasting is undergoing rapid change on multiple levels. Not only are engineers under a mandate to transition to digital transmission, but they now must cope with the rapidly expanding popularity of HDTV. Each broadcaster must determine how to remain competitive against a growing choice of HD programming available on a variety of delivery platforms. Indeed some broadcaster's policy is to be available for consumption on all platforms ranging from Antenna to the Internet.

Such rapid change is inevitable. However, when change is properly managed and intelligently controlled, it can offer extraordinary new business opportunities to those who embrace it. We at Snell & Wilcox think the best way to successfully ride the wave of change is through a well-planned, open and future-proofed infrastructure.

A great broadcast infrastructure is the core of a successful long-term broadcast business. It is the key to the digital, HDTV, IT transition and beyond.

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