신장비 소개

Post Production in a Multi-format Environment

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ABSTRACT

The introduction of broadcast digital television (DTV) was, at one time, seen as an opportunity to rationalise video formats. The reality is quite different with a rapid divergence as the United States' ATSC offers 18 formats to cover both standard definition (SD) and high definition (HD), and yet more are supported by Europe's DVB. At the same time multi-media is expanding both as an area for source material and for finished work. Post production needs to move away from single-format facilities as requirements for multi-format operation is already increasing.

A 'format-independent' solution is described which allows efficient operation with any mix of input formats and able to output any format with high quality. Attention is given to retaining the speed, accuracy and immediacy which is a feature of today's professional facilities - even while handling the greater demands of HD. Another route, using 24 frames-per-second is also examined.

INTRODUCTION

Television has grown up with, or perhaps learned to live with, single-format operation. The use of ITU-R 601 helped to allow standard definition (SD) 525/60 and 625/50 switchable facilities for many but now there is a growing need for working with a variety of video formats - including high definition.

The rapid spread of digital television broadcasting (DTV), satellite, cable or terrestrial, indicates demands for multiple format operation in post production as transmission formats proliferate. Whilst individual television stations may output just one video format, those working outside, such as facilities and production houses, will need to serve a range of customers and so handle a variety of formats, both at SD and HD. This is not limited to countries now broadcasting HD - already European facilities are receiving requests to work at HD.

GOALS

Moving post production to a multi-format environment should in no way compromise performance. Television has thrived on the immediacy and flexibility - not least in editing and post production. In addition, to be of any long term value, equipment must have headroom to adapt or expand to handle the needs of DTV for the foreseeable future - including HD.

Mixed Formats

The introduction of DTV has spawned the opportunity to bring more video formats into use. With scans being interlaced or progressive, picture aspect ratios 4x3 or 16x9, active lines per picture from 480 to 1080, it becomes increasingly clear that there may never be a universal panacea, or even a national standard, for video formats as technology offers increasing choice. Choices for a particular programme will depend on production type, (eg sport or drama), target markets, preferences of the producers and, of course, budget.

Already many are familiar with the various different tape formats which are used to supply material. This situation is not likely to get any better as more formats are developed and adopted. But material may not just be delivered on tape or via video lines. It may well be supplied down a network for recording onto a local store. And certainly the Internet should be recognised as a source for material.

Post production should be able to cope efficiently and effectively with all of these. This does not mean simply switching the standard of the edit suite for a particular production, but accepting any mix of TV formats to be edited together into a single programme in any format, or in several formats. There needs to be complete freedom to mix formats, not only in cutting material together, but in layering and composition, to allow free use of all programme assets.

Flexibility and Speed

Speed of operation is the key to keeping costs low as well as encouraging trial and error to explore better results. Today the best television editing and post production uses fast non-linear working with ITU-R 601 video. This speed now needs to be realised at high definition, where pictures have up to five times the spatial resolution (six times compared to 480-line standards). At the same time the complete tool-set now available, including DVEs, colour correctors, keyers, multiple-layer working, painting, etc. must be available as immediately and extensively for all HD requirements.

Picture Quality

For a number of years the term broadcast quality suffered from somewhat loose interpretation. Far from implying the highest quality it was applied to material deemed 'good enough'. The introduction of DTV and DVD has changed the standard. Both use MPEG-2 compression and are capable of reliably delivering far better pictures to viewers than could be expected with analogue technologies. Now viewers can start to appreciate sharper, lower noise, component digital pictures, they can also better see any defects of the programme material. At the same time MPEG-2 coders are more efficient given high quality, low noise inputs which produce better looking compressed images while using less data.

Not surprisingly, some digital broadcasters are already looking for high technical quality from their programme suppliers. Clearly post production is a major factor in this, so format-independent operation must offer the best quality possible whatever the input and output formats.

Straightforward Operation

Post production is primarily a creative process and should not be cluttered with technical demands. The handling of different video formats should not impose on the operation so that it is as straightforward as single format working is today. In addition, if output is required in more than one format, there should be an easy path towards this involving the minimum of re-working and maintaining the maximum quality.

SYSTEM DESIGN

The most effective way to provide a broad range of facilities and high technical quality is with an integrated design using non-compressed storage and non-linear operation. This offers the efficiency of providing most facilities from within one unit as well as the flexibility of non-linear working from its disk store. Non-compressed storage means there are no compression codec processes and so no generation losses within the system. At worst, compressed source material would be decompressed for input and compressed again, if required, at the output.

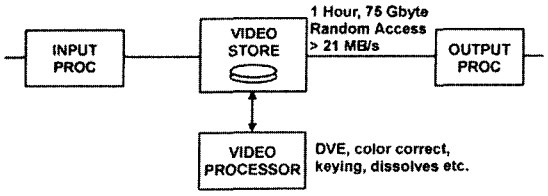

Figure 1 Single-format NLE

Working at standard definition, today's integrated, non-linear, single-format editing system can be described by a number of functional blocks (Figure 1). The video and audio source material is loaded onto the disk store in real-time from VTRs or live sources. Experience has shown that, even with the efficiency of free access to any frame in any order at video rate (true random access), the store needs to be at least one hour in length, requiring a capacity of 75 Gbytes for non-compressed video. Greater lengths offer some advantages in management and operation but these must be weighed against cost. Data rate must be at least a continuous 21 Mbytes/s to sustain the one channel of video essential for real-time recording and playback. Faster rates can lead to faster operation where access to

more than one video stream is needed (dissolves, DVEs etc). With true random access, store usage is very efficient as cuts require no copying as they are merely instructions for the order of replay. For all other operations, dissolves, wipes, mixes, DVEs, colour correction, keying etc., video is passed to the video processor and the results are stored back onto the disks as a series of new frames. These are cut into the programme as it is output as 601 video and made available on standard television interfaces, usually SDI.

The format-independent solution can be based on the same principals but with the major difference of being able to handle much larger pictures at the same speed as today's SD. A practical target is to handle the largest HD production standard, 1080 lines by 1920 pixels at up to 30 frames per second. This requires a continuous rate of 125 million YCrCb samples per second, or 156 Mbytes for 10-bit samples, per channel of uncompressed 4:2:2: video. At this data rate an hour of storage requires 560 Gbytes, - 7½ times that of SD.

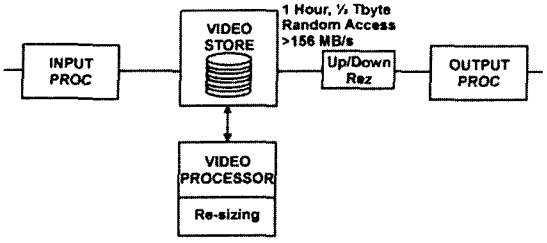

Figure 2. Format-independent solution

Although the machine is electronically far more powerful to cope with HD, the functional block diagram for the format-independent solution (Figure 2) is similar to that for the single-format version. Single-format HD requires a higher capacity store, faster busses, faster processing and 1.5 Gbps HD SDI input/output capability.

The additions for multi-format operation are re-sizing (including SD/HD colour correction) for 'artistic' (DVE, dissolves, etc) processing of dissimilar formats, and up/down rez (re-size with SD/HD colour correction) to render the output at the required picture format. Thus pictures may be re-sized as a part of picture manipulation for artistic effect or to change formats - or both. As re-size and colour correction are necessary functions of the Video Processor - itself a basic requirement of single-format post production - these additional facilities for multi-format operation may be mostly virtual, involving little, if any, additional hardware. This assumes real-time capability (see below - Mixed Format Editing). Finally, it may be required that the store operates with a mixture of video formats (see below).

Mixed-format Storage

A decision is needed as to where format changes should take place. Possibilities are:

1) Change all material to the required output standard as it is recorded
2) Convert everything to 1080x1920 on input, and re-convert on output
3) Keep everything at the input format and only re-format at the output
4) Initially store at input format, change to output format if 'creative' re-sizing is required, and make all other changes at the output during replay.

1) is perhaps the simplest solution, but may involve double re-sizing and use of more store space. 2) also risks an extra double re-sizing and, if any output other than 1080x1920 is required, it wastes store space and the full-sized pictures will always take longer to read/write and to process. 3) again risks double picture re-sizing, once for DVE/artistic requirements and again for output formatting.

4) is the favoured solution as it is the most efficient in terms of re-sizing (processing) and store space as well as being the most flexible. Re-sizing would only have to be undertaken once and any re-working, either for artistic purposes or to generate a new format output, can always use the material in its original format. This requires the store to hold a mixture of video formats.

Mixed Format Compositing

The efficiency of the scheme is best illustrated with an example. For instance, a 720-line original is required as full-sized background and 576-line video is to be composed onto it at half height. The output is set to 1080 lines. First the background is re-sized by +50% to 1080 lines. Then the foreground and its key is re-sized -6.25% to 540 lines (1080/2) and keyed onto the background. The result is stored as a new 1080-line clip. In this way the re-sizing element shown in figure 2, becomes virtual - simply usage of existing DVE facilities coupled with intelligence of the

output standard. Note that if solutions 1 or 2 were used, the foreground clip would have been expanded by + 87.5% to 1080 lines using more storage, and then re-sized - 50% down to 540 lines - involving two sizing processes.

File Format

The chosen solution requires storing material in its original formats and the store able to handle mixed formats with the speed and agility required for post production. For this it must know the format of each clip - a situation allowed for by Quantel since introducing its VPB file format ten years ago (1). The VPB header includes information defining x and y picture size as well as pixel aspect ratio. Reading this allows the equipment to handle each clip according to its format. The header also includes other metadata such as title and time/date stamp.

Mixed Format Editing

The store has to replay in real-time and the system must output video in a chosen format. True random access ensures that the material can be real-time edited by playing any frame in any order. Any material already stored in the output standard (either as original input clips or new processed clips) bypasses the up/down rez section (see Figure 2) and goes straight to the output. Others, being original input frames not of the output standard, are up/down rez'd in real-time and passed to the output. File data identifying the video format is used to control the process. Thus stored clips of mixed formats are edited and replayed to any required format, in real-time.

Current non-linear editing equipment can be capable of allowing swift and easy adjustments of editing decisions. With the format-independent scheme able to cope with clip-by-clip changes in format as they occur in real-time, it offers the same flexibility - termed uncommitted editing. A cut edit still comprises only the original material and a list of instructions for the order of replay. Any alteration can be instantly played. This is useful for refinements and alterations, as well as creating different versions. Not all edits are cuts; altering those with any transitions such as dissolves and wipes, or using any effects (DVEs, colour correction, etc.) will require reprocessing and re-storage but there is no reason this cannot be made fast and fully automated, requiring no extra operator actions to complete the work.

Non-TV Formats

The format-independent system described can handle non-TV images. For this another type of I/O is required beyond the TV industry standards. A high-speed networking solution is indicated such as Quantel's Clipnet. Using Gigabit Ethernet and TCP/IP it allows a wide range of source-types to connect either with Targa(RGB) or VPB (YCrCb) file formats. Running as a background task this allows the primary operations of post production to continue while files are exchanged. Within the system, files are identified by their header. Although all TV formats should be recorded and replayed at real-time via their SDI connections, handling images larger than 1080 x 1920 may run slower.

FROM SD TO HD

As yet, format-independent systems are not available. Most existing equipment is for SD 601 operation only and for many, demand for HD editing is only beginning to grow. Under these conditions, a scheme to provide HD editing which utilises existing SD editing equipment (Editbox) supplemented by a basic HD edit element (Chaser), has its attractions.

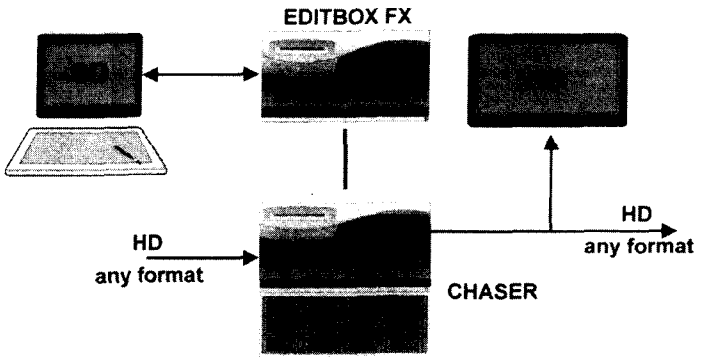

Figure 3. HD editing via SD Editbox FX

The Editbox provides a familiar user interface to control HD-native editing while its facilities are used for some more complex process-intensive functions (Figure 3). These are handled by down conversion to SD and subsequent up-conversion to the output HD standard - handled intelligently to minimise conversion processes. In addition to HD, this introduces mixed-format working where material from various sources are edited into one master. Given a sufficiently high quality result from the SD/HD conversions, this is a viable migration to HD.

PUBLISHING AND ARCHIVE

Today, with the proliferation of television channels, programmes are more widely distributed and may well be required in several different formats and versions. Ideally the versions would be created at the time of the original edit but this is not always possible. The format-independent solution offers the possibility of comprehensive archiving. The editing process can be described by decisions so storing these and re-loading the original material allows the necessary re-working while avoiding a total re-edit. Quantel has already developed a number of archiving schemes for SD that can equally well be applied here (2). Different methods can be used to suit the nature of the edit, from just cuts to involving many processed frames, and the archive medium.

Multiple Output Standards

For wide distribution to include HD markets, the choice of 1080-line progressive as a master format is gaining ground. The large picture means that down conversion to SD can produce high quality results. The format-independent approach allows the production of other TV formats by re-setting the output standard and re-conforming from the original material. This should produce the highest quality as it repeats the favoured method (solution 4). It is assumed that any frame-rate conversions will be executed by established specialist equipment.

24 fps

Film has long been promoted as the universal television standard. Certainly motion pictures mastered at 24 frames per second are shown world-wide on TV. So why not use 24 fps as part of a master format and take advantage of the well trodden paths available to convert this into all major TV formats?

One plan is to use 1080/24P in production and to create masters in this format. DTV standards allow for direct 1080/24P transmission while down conversion coupled with well established frame rate translations to 60 fields per second, via 3/2 pulldown, and to 25 fps via +4% speed change, are practical and promise high-quality results.

The 24 fps principle can be applied at SD with minimal change - using standard VTRs and software allowing 24 fps in an integrated editing system (Editbox). Operating at 625/24P (preferred over 525/24P as the pictures are larger) can give good results at 625/25 as well as 525/60. HD is produced by frame-rate translation and up-conversion.

TECHNOLOGY BACKGROUND

Today's technology makes format-independent post production a practical proposition as many of the required system elements have already been proved from other applications and other media. Working with Quantel's Domino film effects system has proved real-time operation with 3k x 2k digital film images requiring storage, handling and processing, while compositing mixed format images from a multitude of sources is used in print-resolution graphics assembled by Graphic Paintbox. Experience with mixed-format video storage has been gained with the Clipbox video server handling both SD and compressed HD channels simultaneously.

Another key technology is up/down conversion. Up-converting from SD to HD is most critical and it may be thought over-optimistic to expect acceptable results. However, experience gained up-converting 625-line TV to 35mm film which, when projected, stood up well to pure-film products, validated the process. Keys to success are starting with well shot material, the best is 35mm film, and keeping to non-compressed 601 throughout post production. The full capability of 601 is rarely seen as, too often, cameras or recorders limit quality. The 16-point bi-cubic interpolation used in the tape-to-film up-conversion process has been widely applied to all picture size conversions in the format-independent designs, including the down/up conversions required in some Chaser operations.

Non-linear editing of HD has not previously been practical due to its vast storage and high data rate requirements. As expected, the seemingly inexorable march of disk drive development, increasing year-on-year capacity by as much as 80%, is now supplying product suitable for adaptation to this task. Likewise, Moore's Law has placed sufficient RAM and more powerful processing within easier reach.

Dylan HD has been developed as the major building-block of edit length (ie approximately one hour) non-compressed, HD storage. The continuous data rate >156 Mbytes/s, allows real-time operation and true random access offers flexibility. Derived from the widely used Dylan disk, the new store provides RAID-3 protection from a 12-disk array and the design should accept appropriate new drives when available.

CONCLUSIONS

Radical changes need radical solutions. The format-independent design offers an across-the-board answer for post production in the multi-format DTV age. Most of the required technology is proven so the design is a logical progression - not a step-change. The scheme depends on high quality results from up and down conversions, now proven, as well as large storage for HD editing - practical thanks to disk drive development. Given the growing need for non-linear editing for HD, the format-independent solution is a logical next step to offer wider usage. It requires little additional hardware and there may be interesting spin-offs such as work with formats beyond TV as well as enhanced performance of SD editing.

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