THE MISSING LINK IN FILE-BASED VIDEO: AUTOMATED QC

Thomas Dove
Tektronix
Bristol, United Kingdom

I. ABSTRACT

The broadcast world is going digital, and the digital domain is expanding enormously for broadcasters. In the past, 'digital' meant taking video from analog tape, encoding it to MPEG-2 and then transmitting it. However, the entire broadcasting landscape is getting more complex with distribution via terrestrial, satellite, cable, 'podcasts', HD-DVD, internet and mobile; not just standard definition but also HD (High Definition) and many other resolutions to suit the new distribution media. Content is being re-purposed at these different resolutions and frame rates, using new codecs and at different bit-rates, with different system requirements for each.

II. THE GOOD OLD DAYS

Well, not actually the 'old days' - more like the here and now for most broadcasters.

Most video assets are still on analog tape, but likewise most broadcasters have started down the digital path. Figure 1 shows a common set-up for this part of the ingest process.

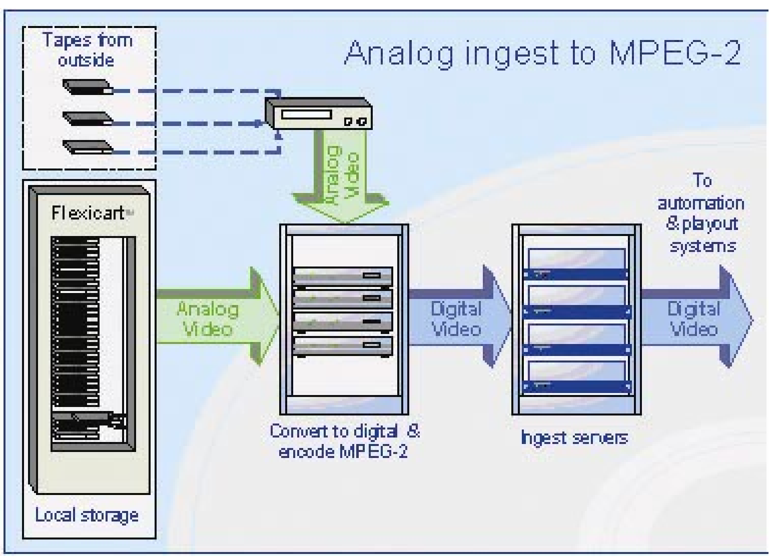

Figure 1: A common set-up for part of the broadcast ingest process

After ingest, the video is usually transported around a broadcast center as SDI, ASI, or increasingly as files on a Gigabit Ethernet network.

Gone Digital

In fact, most US broadcasters have already "gone digital" - as at December 2005 there were 1537 TV stations markets serving 99.99% of US TV households which had made the transition to broadcasting a digital signal (source: National Association of Broadcasters www.nab.org).

There are also many broadcasters around the world who have already made or are making the same transition right now, and many countries have dates set in the next 5 - 10 years for switching off analog signal transmission.

As a result, the process of ingest to digital is already understood to a greater or lesser extent by most broadcasters. Following ingest, and in many cases to control parts of the ingest, broadcasters have an automation system with facilities such as scanning of bar-coded tapes which automatically note receipt and put the tape in the queue for appropriate ingest quality control ("QC").

File-based Video

Most broadcasters of course appreciate that digital is different to analog, but there is another step: *file-based* video. File-based video is the way the broadcast world is going for a whole host of good reasons but there is yet to be a real appreciation by some that file-based video is fundamentally different.

In particular, although the automation/control in the playout center can be easier - after all, it is just moving files around - the QC requirements have an extra layer of complexity.

III. QUALITY CONTROL OF DIGITAL VIDEO

QC From An Analog Perspective

Most broadcasters are familiar with monitoring video. In the past this has comprised monitoring the analog signals at the "baseband" level, i.e. items such as:

- video gamut and signal legality
- audio levels
- presence and level of synchronisation signals
- line and frame timings

There is a video signal with 525-lines, 29.97 Hz frame rate, and setting up hardware with alarms to monitor these is pretty straightforward; equipment to do this has been available for some time.

There are many well-known techniques for displaying the data: waveform displays; vector displays; 'diamond' (RGB gamut) displays and 'arrow-head' displays (composite violation); with alarm logs.

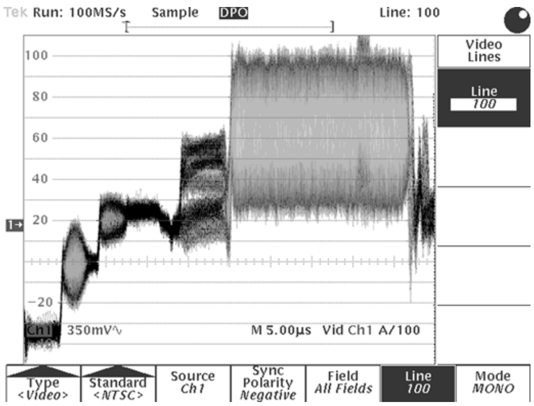

Figure 2: Waveform monitor display, showing an intensity-graded display on a digital phosphor oscilloscope

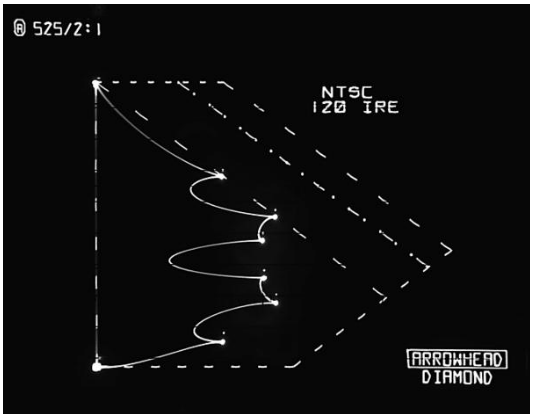

Figure 3: Arrowhead display showing legality of composite video

There are many other sorts of errors that can occur as a result of the video being stored on a tape, e.g.:

- drop-out of video and/or synchronisation and/or color burst signals due to partial loss of magnetisation of a part of the tape
- 'ghost images' where the parts of the (magnetic) video tape on the reel touch, can cause 'print-through' of video and audio data from one part of the tape to another
- loss of video/audio/synchronisation signal due to oxide errors/drop off or contamination on the tape
- timing inaccuracy due to tape stretching
- noise (visual and audio)

All of these types of errors evidence themselves in the visual or audio quality.

SDI Digital

Monitoring SDI is harder in some ways as there is no longer a direct correlation between the 525-line NTSC signal and the signals being monitored. For example, the synchronization 'signals' are actually synchronization code-words in the data stream, for both the frames and the lines.

As a result, monitoring systems that are going to check the video and audio first need to extract the relevant data from the stream and interpret the data correctly into the video, audio and synchronisation portions, before the analog-type checks can be done.

Certainly, SDI monitoring systems are getting more intelligent, providing not only all the 'analog' type displays, but also showing errors in the digital signals:

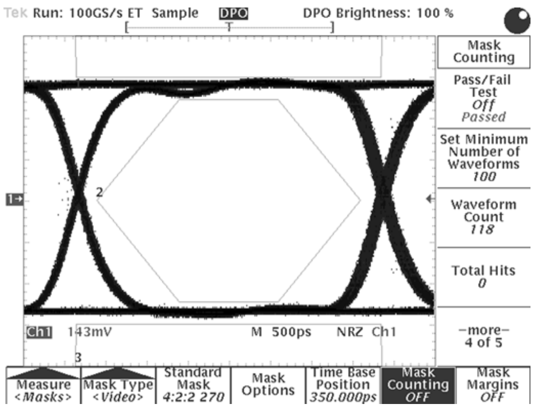

Figure 4: SDI jitter signal test

Transport Stream/MPEG

Although there are other transport stream formats than MPEG-2 TS, this is the most common format by far in the broadcast field. Some of the errors that can be generated in MPEG-2 ASI streams (in addition to the analog errors and SD errors) include:

- MPEG-2 video encoding errors - syntax errors introduced in the encoder or during the multiple multiplexing/de-multiplexing processes that go on
- likewise, audio syntax errors
- .. and errors in associated meta data
- errors in PIDs, PATs, PMTs (e.g. scrambling of the data tables for these, or where they appear too infrequently)
- PCR errors e.g. values in the multiplexer not correct or transmission impairments, both of which then cause problems in the PLL of a receiver

Current test equipment goes a long way to testing/monitoring these and many other errors, often showing for example, which areas of which frames are in violation of limits, or which program PID has the fault amongst the programs in a multi-program transport stream ("MPTS").

An MPEG-2 Transport Stream is interesting as it is both a 'container format' (i.e. it contains video, audio and meta-data for one or more streams) and also a transport mechanism (i.e. packetization, framing, CRC of the data).

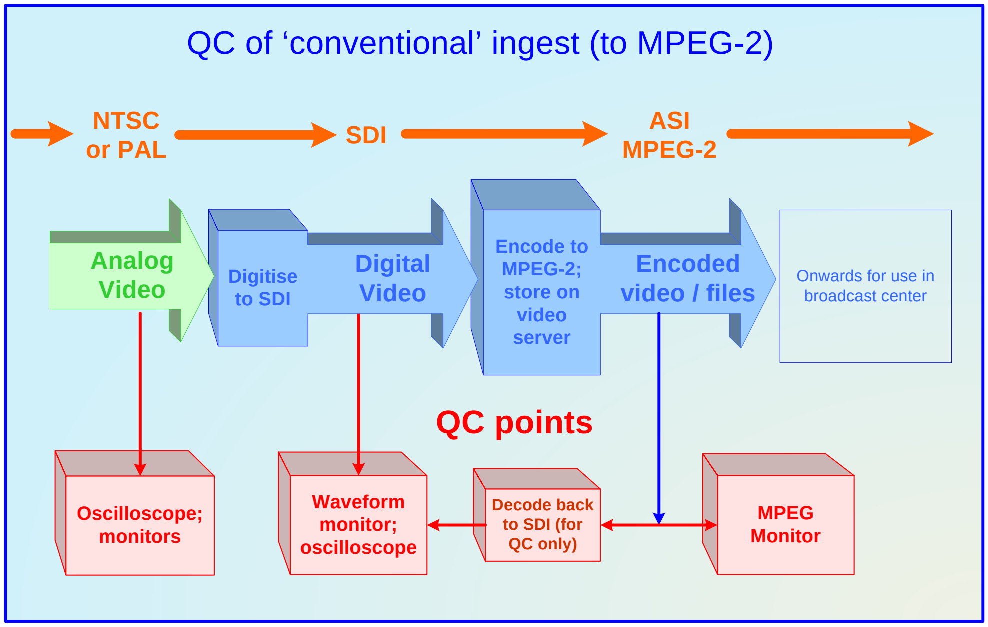

Figure 5: Common QC arrangement ingest to MPEG-2

Clearly, different file wrapper formats (such as ASF ™, QuickTime ™, Windows Media ®, 3GPP) and different transport mechanisms (such as IP/RTP), which are used to transmit these different file formats, require different analysis and monitoring software.

Worse, from a complexity viewpoint, each of these will have their own specific sets of common/likely problems to be found/monitored and diagnosed.

Elementary Stream

Encapsulated within the packetization and CRC data of an MPEG-2 Transport Stream there are three functional components: video, audio and meta-data, time-multiplexed each in their own logical data stream (or sometimes multiple sets of video, audio and meta-data).

The video and audio data streams are *Elementary Streams*, in which the video and audio has usually been compressed. Errors typically occur separately in the Elementary Streams as well as in the meta-data - that is, there could be a perfectly legal and correct Transport Stream, but the video or audio Elementary Stream or meta-data is incorrect.

The process of compressing the video and audio signals is complex and can itself generate many errors. The newer video compression schemes - H.264/AVC (a.k.a. MPEG-4 Part 10) and VC-1 are more complex than MEPG-2 and give much greater scope for errors.

As the video and audio are compressed, the set-top box/mobile hand-set/ DVD player or other consumer device must correctly decode these compressed signals to re-construct the video picture and audio. In many of these compression schemes, large sections of subsequent data depend completely on the preceding data. Therefore if even a single bit of the earlier data is incorrect, all subsequent data is misinterpreted (or potentially illegal) until a re-synchronization point.

This can mean an error in a single bit can be critical enough to cause whole blocks of video or audio data to be incorrectly decoded, so that parts of a frame, whole frames, or multiple frames of video are not able to be displayed. This can also result in a crash in the decoder device software.

These errors are separate from all the other errors mentioned above, and the propensity for error is compounded by the fact that the encoding behind compressed video elementary streams is an order of magnitude more complex than the transport stream containing them.

A Nasty Elementary Stream Error

Figure 6 shows an example of a particularly difficult error to find. *In the red highlighted box there is some slippage of the video.*

Figure 6: Error in video frame

In this case, the broadcaster had done a “full” QC of the video, i.e. had manually watched the whole video, including the frame in question. The problem was that the error as shown in the picture is caused by a single bit error in the video elementary stream, which caused a number of subsequent ‘variable length codes’ to be incorrect in the encoded bitstream.

This was just one incorrect bit in one video frame (frame number 156; the red bounded frame in the middle of the filmstrip in Figure 7).

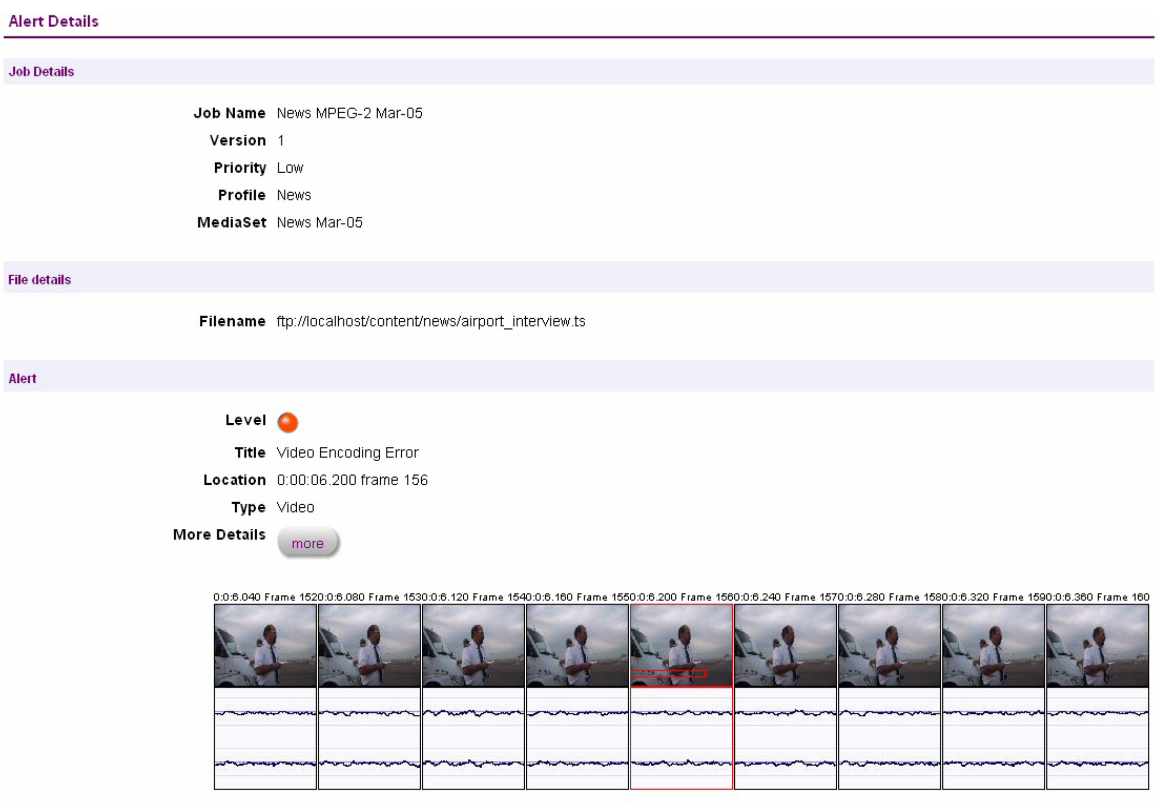

Figure 7: Error in a single video frame

This single bit error then caused a series of ‘cascade’ errors in the interpretation of the video, as shown in Figure 8:

Level

Title Video Encoding Error

Location 0:00:06.200 frame 156

Type Video

Level	Location	Title	Details	Thumbnail
	0:00:06.200 frame 156	DCT coefficient index out of bounds (alert ID 22199)	Inter-block DCT coefficient index out of bounds (65 >= 64) Stream position: 0x2ef763 (dec. 3077987), bit 3 Bitstream context: [VSQ|PCD|SLI|MBK|BLK]	
	0:00:06.200 frame 156	Bad slice order (alert ID 22210)	Restricted slice structure is in effect, yet the first macroblock of the current slice (x=0, y=31, slice=31) does not immediately follow the last macroblock of the preceding slice (x=32, y=30, slice=30). Stream position: 0x2ef807 (dec. 3078151), bit 7 Bitstream context: [VSQ|PCD|SLI|MBK]	
	0:00:06.200 frame 156	Bad VLC for macroblock_address_increment (alert ID 22100)	Invalid VLC for macroblock_address_increment: encountered bit pattern '00000010101'. This does not match any valid code value. Stream position: 0x2ef8f0 (dec. 3078384), start bit 1 Bitstream context: [VSQ|PCD|SLI|MBK]	
	0:00:06.200 frame 156	Bad slice order (alert ID 22210)	Restricted slice structure is in effect, yet the first macroblock of the current slice (x=0, y=32, slice=32) does not immediately follow the last macroblock of the preceding slice (x=13, y=31, slice=31). Stream position: 0x2efbdf (dec. 3079135), bit 7 Bitstream context: [VSQ|PCD|SLI|MBK]	

Figure 8: ‘cascade’ errors shown with full technical details selected for display

The software in the (expensive) video decoders in the broadcast center was robust enough to smooth over the error - *so it passed by in milliseconds and was never seen* by personnel doing the visual QC in the broadcast center.

However, the video decoder in the end-consumer set-top box was not so good, actually causing it to crash - generating many customer complaints. (This caused some dispute with the end-customers of the broadcaster; it was hard for the broadcaster to accept the complaints - after all, they had “done the full QC and the video was “fine”.)

This is a prime example where a broadcaster was set up with the correct production equipment to transmit the video, but having the production equipment was not enough.

(Figures 6, 7 and 8 are screenshots from the Tektronix Cerify product, which was the only means by which the broadcaster found the error.)

Good, But Still No Good

In addition, a stream can be *legal* (i.e. it complies with all the relevant standards in every way and is properly formed but is not as the broadcaster requires), e.g.:

- simple errors where the broadcaster wants 720x480 NTSC but the video has been supplied/encoded at 704x480 NTSC
- English audio is required to be on channels 1 & 2 (Spanish on 3 & 4) but these have been swapped
- the transport stream should be 188 bytes per packet but is actually 204 bytes per packet
- the peak bit-rate should be 4.5 MBits/sec, but is actually 4.6MBit/sec
- ingested video is expected to have color bars for the first 3 seconds and 400Hz tone for the first 2 seconds, but the times for each have been inadvertently swapped

There are *many* such constraints that the broadcaster will impose upon the video assets to be received. Effectively, there is a whole raft of limits and requirements specific to the playout center that represent a sub-set of the transmission and video standards concerned. If these additional limits are not adhered to, this can result in serious problems in the transmission chain.

Good, But Subjectively Really Bad

Even if all the above is correct and perfect, the video or audio may be of poor quality due to the encoding process, such as where the video looks ‘blocky’ (i.e. where the edges of the 16x16 pixel blocks in the video are visible).

These are the hardest problems to quantify, let alone check for - not only because the threshold of what is good or bad varies subjectively with the viewer/listener, but also because these thresholds will vary with the bit-rate, format and other parameters.

For example, easily visible blocks would be unacceptable in an HD movie that a consumer had paid to download, but some blockiness would be acceptable in a mobile real-time application.

File-based Video

This can be viewed as the next level of abstraction and therefore complexity.

In some ways it ought to be simple - file-based video is just that - files. We have all been used to handling digital files for many years; we know how to copy files, work out how big they are, move them around.

But the situation with video files is different: if we take for example a document file, a single manufacturer’s word processing program will do the creation and editing. If it is transmitted, it is usually encapsulated in a straightforward way, disassembled into packets, transmitted, re-assembled and un-encapsulated. The crucial point is that the document stays as a logical single file.

However, with digital video, this is supplied in a container format with video, audio and metadata - but then a key part of the transmission and/or ingest process is often to extract/re-order/re-combine these data elements. For example, for transmission of MPEG-2, multiple program streams are usually assembled into a single transport stream where the video, audio and meta-data from each program stream are time-multiplexed.

Where file-based video assets are transmitted, these are more often sent as single program transport streams, but at ingest, some video servers separate out the video, audio and meta-data, adding tags to each and putting each into new files.

With each of these types of operations there is considerable scope for errors to occur, in addition to all of the other errors that can occur in analog video and digital video.

(To continue with the document analogy, it would be like transmitting a document but re-formatting en-route using a raft of different suppliers’ products. And continuing the same example, there is a single major vendor supplying software for making a large proportion of the document files: whereas in the broadcast field there are many vendors providing different equipment for transmitting, assembling, disassembling and re-ordering the video assets: this gives scope for interoperability issues.)

Some examples of simple errors that can occur due to the fact that the video is file-based include:

- loss of video/audio sync (data)
- truncation of data in one or more files
- incorrect separation of video, audio and meta-data
- incorrect generation of other meta-data so that when re-assembled the relationships between incoming video, audio and meta-data is not correct

IV. BRAVE NEW DIGITAL WORLD

The situation as described above is complex enough and it is not surprising that errors occur on a daily basis in larger playout centers.

Unfortunately, the broadcast world is rapidly becoming yet more complex.

New Transmission Methods; New Business Threats

Going back just 25 years, 'conventional' free-to-air TV broadcasters had the field to themselves, relying on advertising revenue. Then along came the cable and satellite guys with new subscription business models. It was not too uncomfortable for the conventional broadcasters; everyone shuffled around a bit, but no-one lost out too much. Along came VOD - again, shift, but not too much disruption and change so far.

However, we are now at the start of a revolution where the technology has reached a stage such that wireless (mobile) and internet broadcasting are becoming feasible.

Figure 9

What will be the impact on 'conventional' broadcasters when the wireless network operators start transmitting video to a serious extent? Of course, there are valid arguments that no-one will watch a two hour movie on a 2" screen, nor on a PC screen: the 'lean-back relaxed' versus 'lean-forward' issue. However, given the levels of investment that are going on, it's clear that wireless network operators believe there is real money to be made from consumers - will there be a noticeable impact on current broadcasters (particularly as the network operators have the financial muscle to make the deals with content providers)?

I believe that we are only at the start of this process, as the current broadcasters have not really yet felt the pain - none of them have gone out of business and consolidation has not really happened.

In the future, those with the (best) content and best distribution will have the best chance of success. The content will follow those with the deepest pockets and guess who has those - not the conventional broadcasters, for sure - and who has the most customers, where the customer is most tied in - again, not the conventional broadcasters.

So what will it mean - how big will the new broadcasting pie be? With many types of players - particularly the wireless behemoths - how will the broadcasters prevent themselves from being squeezed out - being outbid on all the great content and just becoming a contract transmission center for a wireless company?

I believe that the only way is for broadcasters to embrace the new landscape with a vengeance and be much better at it than the new kids on the block.

There are many business issues related to this: for example, the business model behind providing video to wireless companies in the formats they want, but that is not the subject of this paper.

V. TECHNICAL CHALLENGES OF THE NEW LANDSCAPE

From a technical viewpoint, the problem is that the 'new landscape' demands video in different formats, different codecs, different sizes, different bit rates, delivered when and how the customer wants and tailored to their interests, at the right quality.

New Video and Audio Codecs

One of the large changes occurring now is the emergence of new video and audio codecs:

Although these new codecs can be used for the transmission of 'standard' NTSC/PAL video, more often than not they have been developed and are used more for specific application areas, as indicated in Table 2, depending upon their particular strengths (such as compression efficiency, complexity, and processing power required):

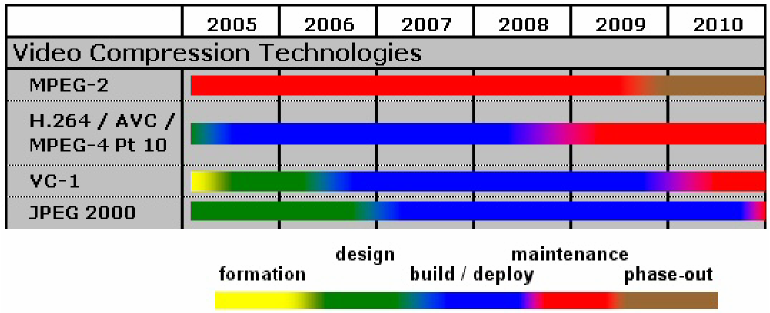

Table 1: timeline for broadcast video codecs

Video Codec	*Typical applications (new)*
MPEG-2	Broadcast, cable, VOD, DVD
H.264 / AVC / MPEG-4 Pt 10	Broadcast, cable, VOD, HD, Internet, HD video discs*
VC-1	Broadcast, HD, Internet, HD video discs*
JPEG 2000	D-Cinema, broadcast internal use
MPEG-4 Pt 2	Mobile

* HD-DVD or Blu-ray

Table 2: typical applications of different video codecs

There are of course a number of other proprietary formats (Real, Windows Media®, Divx to name a few) but the video standards mentioned in Table 2 currently appear to be those that are of most interest to broadcasters. Of these, certainly the video codec known variously as H.264 or AVC or MPEG-4 (Part 10) is generating most interest at the moment.

Each of these new codecs and formats introduces new issues for a 'conventional' broadcaster:

- new encoders and decoders are required
- updates to the automation system
- additions to the QC equipment.

Clearly this implies substantial capital cost outlay, but perhaps more difficult than the issue of direct capital cost, is the fact that broadcasters are not familiar with these codecs, which raises such questions as:

- what sorts of errors occur commonly; what should be tested for; where in the broadcast chain?
- when an error occurs, does a broadcaster have any idea where to start looking for the error source
- what does 'good' quality (or acceptable quality) look like and sound like?

Multiple Media Types In and Out

From an ingest and outgest viewpoint, there are also many more media types and formats to deal with, which also raises questions of equipment provision and staffing:

- VHS tape, analog beta tape, digi-beta, DVCAM, HDV, mini-DV, HDCAM, etc.
- DVD, HD video discs, hard disc media
- file-based: internet, wireless in a multitude of formats - including 'final' digital form

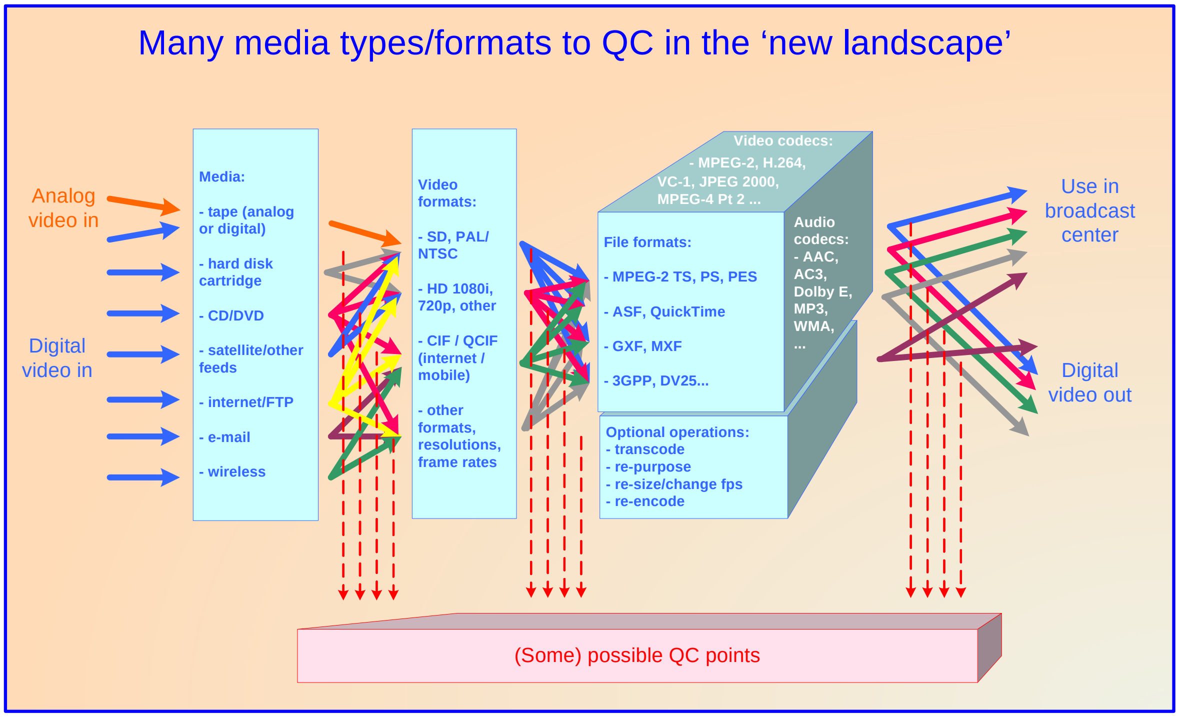

Figure 10: Complexity of QC in the 'new landscape'

Multi-way QC

Plus, content will not only be *transmitted* [by the broadcaster] in these different formats. To be cost-effective, a broadcaster is going to have to be able to receive all these different formats and handle them correctly, in a cost-effective manner, for re-transmission and perhaps re-encoding/re-purposing.

<u>One</u> can gear up with the necessary hardware to do some or all of this - as some broadcasters are <u>doing</u>- but how <u>can one be sure to</u> get it right (i.e. send the right video to the right device with all the parameters correct)?

Essentially, the QC technical challenge has gone from a linear, largely one-to-one problem of a single video format (MPEG-2), resolution (e.g. NTSC) and frame rate (e.g. 29.97), to a multi-dimensional many-to-many problem, as indicated in Figure 10.

Personnel Pressures

There is constant pressure to further automate a broadcast center, but these new, more complex requirements suggest a demand for more staff or personnel with much broader skills.

Staff who have some years' experience of MPEG-2 broadcasting will have a pretty good idea of what looks and sounds right; however, even those seasoned professionals may not necessarily know what is right for HD/mobile/ internet/H.264/MPEG-4/VC-1. Plus, can a broadcaster actually get the staff with the skills for these new areas, even if willing to pay for them?

Adding more staff is generally not an option, although for some new higher value services - such as HD transmission - the end-customer has paid for and expects premium quality.

Automation Solutions

Automation vendors clearly recognise these problems, and although it is highly demanding, these systems are being upgraded to deal with the myriad of inputs and outputs, integrating [as far as possible] the diverse equipment required. The upgrading/integration process is on-going and will continue for a long time to come, but once the delivery is automated, what about the QC?

The fact is that with current automation systems, even in the 'simple' one-to-one MPEG-2 situation, there are often errors that occur, from all stages from ingest right through to live transmission. The scope for errors is multiplied many-fold in the 'new landscape.' It is not realistic to expect any automation system to deal with this flawlessly.

In addition, automation vendors have their job really cut out just getting it all to work together at all - and generally have not had and do not have the time / expertise to fully look at QC, let alone automation of the QC.

VI. WHERE TO TEST IN THE BROADCAST CHAIN

So what are the options to test in this new, more complex environment? Among these layers of complexity, where to start?

Testing at different stages of the broadcast chain requires many different sorts of equipment: Figure 11 shows a broadcast chain all the way from generation to consumer:

As this paper focuses on ingest checking the later parts of the broadcast chain are not discussed. (Ingest is the start of the process for the broadcaster - and if the files are not right here, there is not much point in the broadcaster proceeding any further with them.)

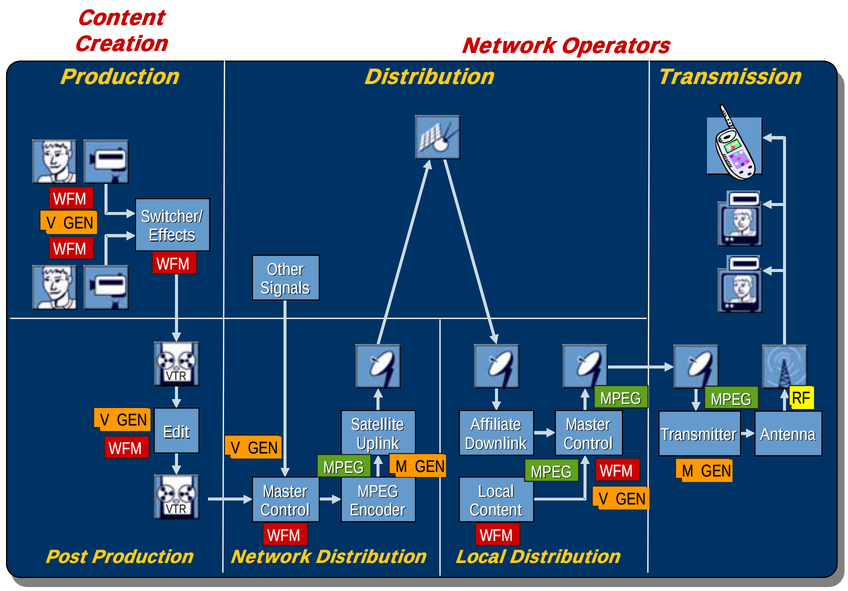

Figure 11: From generation to delivery

WFM = Waveform Monitor; V Gen = Video Generator; MPEG = MPEG Monitor; M Gen = MPEG Generator; RF = RF Monitor

Rather than 'test', continuous checking is typically referred to by equipment vendors as 'monitoring' - as the equipment concerned is continually monitoring signals, and often includes alarms for error conditions.

VII. OPTIONS FOR INGEST MONITORING

Obviously, the optimal approach is to test for the errors that are most likely to occur at each layer of complexity: clearly this will vary from one broadcaster to another and depends upon many factors such as:

- the source of the files - are they mainly generated in-house, encoded from analog tape, or do they mainly come from outside suppliers?
- how fixed is the internal encoding set-up / how extensive the equipment / how experienced the personnel?
- how good are the external asset suppliers?
- are there many formats to deal with or just a few?
- are the video assets being edited in-house by the broadcaster, and if so, in what ways?
- There is not sufficient space in this paper to look in detail at all the test options at each level: the purpose here is to provide pointers on areas to look at, and some examples of common test equipment that is used.

Baseband Testing (Analog and Digital)

Starting at the 'lowest' level, the analog signals can be monitored, from a camera or tape deck.
The analog signals can be composite (single line with color burst) or component (separate RGB or Y Pr Pb) or the digital equivalents.

These signals can be displayed in a variety of ways, to show up common errors, using equipment such as oscilloscopes or video signal monitors or waveform monitors from a number of suppliers.

Such types of test equipment work well for monitoring and in particular diagnosing problems with analog and digital signals.

However a major drawback with this form of testing is that experienced and knowledgeable personnel are required to run the equipment and interpret the displays.

A different approach is to decode the compressed video and audio data back to their baseband components, then do the measuring.

Transport Stream Monitoring

There are a small number of vendors of real-time MPEG-2 TS monitoring systems, which provide checking of many error conditions.

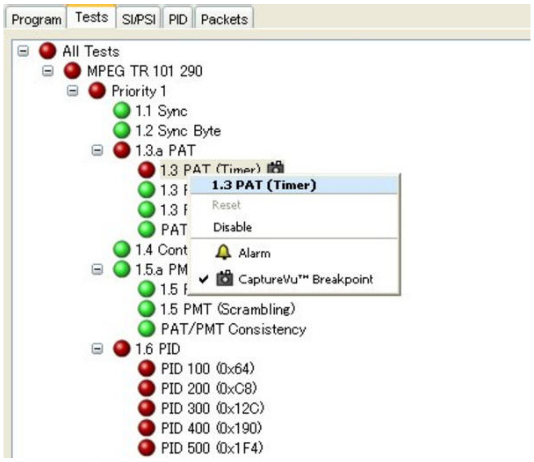

Figure 12: MPEG real time monitor summary

Elementary Stream Monitoring

There are no systems known of currently on the market that specifically monitor only elementary streams; the only system which monitors the elementary video and audio streams is the Tektronix Cerify product.

Monitoring Compliance With System Requirements

[These are the requirements over and above those of signal legality / format correctness, e.g. for limited bit-rate.] Various equipment is available for monitoring some parts of a broadcaster's system compliance requirement: these tend to focus on areas of compliance of:

- Transport Stream parameters
- bit-rates
- audio presence / levels on specific channels

Monitoring of Subjective Quality

There is a Tektronix Picture Quality Analyzer (PQA) which does measurement of encoded picture quality related to the human visual system ('HVS') and human perception, but this requires the un-encoded video also and is not real-time.

Tektronix' Cerify takes a different approach with a quantified measurement of picture quality, but works in real-time.

Other systems are being developed by other vendors which focus on correlation with HVS, although in each case known of, these only look at the picture quality, not all the other QC aspects.

File-Based Checks

Automation systems will make some rudimentary checks to ensure files are correct once split out within an ingest server (assuming this is done).

This typically includes: presence of files, dates/times, file sizes etc. However, in many cases, the list of items to be checked is also provided directly by the automation system, so the check is tautological in nature, and the check by the automation system does not include confirmation by checking the actual integrity of the data within each file.

Sometimes this check is done by decoding the compressed MPEG-2 video back to baseband then using standard monitoring equipment for gamut and legality checks: this is fine as far as it goes, but:

- this only covers a limited range of checks
- it would need re-configuration or multiple configurations for different video standards/ resolutions etc.
- and generally would not detect elementary stream errors such as the 'nasty' error described above.

The Human Option

One option is to visually check all video at ingest (and at further stages through the broadcast chain). Not only is this prohibitively expensive, there are many drawbacks regarding the quality of testing done:

- visual/audio errors are easily missed with human play-out - just by blinking or losing concentration for a second
- subjectivity - different skill level/experience/ training of testers mean there will be considerable differences between the errors found by different people
- simple errors – a human may not get constraints correct, particularly if they vary from one asset or asset type to another
- consistency – it is impossible for a person to repeat exactly the same test with the same threshold levels - particularly on visual quality, day after day, week after week
- a person cannot easily look inside the file at the details e.g.: standard used for compression for video, audio; bit-rates of video, audio and overall

Sampling can be used, but this does not do the job required (as shown in the 'nasty' example above) - in actuality, 100% QC is not only desirable, in time it will be required.

VIII. OTHER CONSIDERATIONS FOR AUTOMATED QC

Simplified Test Results But Also Detail

The day-to-day staff in a broadcast center may not be experts in the aspects of video signaling and compression, but instead they may know about program scheduling or editing or setting up the Edit-Decision List ('EDL'). For these personnel, straightforward go/no-go test results are required (e.g. traffic lights, where red is bad, green is good; amber is in between).

However, once a problem is found, there is a requirement to be able to delve deeper, to different levels:

- firstly, for the day-to-day staff to be able to see the video frames / audio waveforms which has the errors
- with some simple diagnosis information
- but with more detailed data available to the more expert staff whose job it is to fix the problem.

The person of the appropriate skill/knowledge level can then take a decision as to whether the error found is a serious problem or not.

Consistency in a Changing Environment

In the 'new landscape' described, broadcasters will often have to deal with new file formats, resolutions, bit-rates etc. - and will need to:

- test these in the same way each time, i.e. with assured consistency
- be able to easily compare the test results now with past results
- and do all this fully automatically

For example, was the same error found last time a news clip came in from a particular provider as this time? If so, what was the outcome - was it OK to continue and go to air anyway?

Ingest Video Server Formats

There are a number of vendors of video servers, e.g.: Omneon, Avid/Pinnacle, Grass Valley, Leitch, SeaChange, MassTech, Sony.

These servers store video in a variety of wrapper formats which encapsulate or provide the connection between the video, audio and meta-data. For example Grass Valley servers use GXF; Omneon uses QuickTime but separates the video and audio elementary streams out into separate files in a sub-directory.

MXF seems to be a format that is becoming more popular in many broadcasters; other broadcasters are using standard servers from the likes of Dell, IBM, Intel or HP and running Windows or Linux to store standard MPEG-2 single program Transport Streams (where the video, audio and meta-data are stored together in a single file).

Go With the New Workflow

A typical file-based workflow will include the automation system listing files expected at ingest, checking their receipt, then moving the files onwards for play-out.

The problem with this is that it can give little or no time for ingest QC. Effectively there is a list of files to test, but some of them are moved from the ingest server before they are actually tested.

In this situation the workflow needs to be modified to included the QC step before files are moved off the ingest server.

Proof of the Pudding

Increasingly, files will be used not only from internally encoded sources, but also come in from outside sources and be supplied onwards to outside recipients in different formats.

Coupled with this will be SLAs (Service Level Agreements, i.e. agreements concerning the quality of service provided).

Without automated full QC, a broadcaster is effectively flying blind and taking the “quick check, hope, and beg” approach i.e. do a quick check, hope that this is sufficient - then beg forgiveness when it goes wrong.

If there is a problem with content received, there will be an increased need to prove where the fault is (and what the fault is) - with the broadcaster perhaps getting money back from a content provider.

Likewise, if a broadcaster is supplying video assets to a 3rd party and that 3rd party says there are errors, the broadcaster will increasingly need to be able to show that they have done the required tests, and that the assets were error-free and as specified when supplied, that is with all the requisite system parameters such as bit-rates, audio levels correctly set.

By doing this, a broadcaster should be able to reduce disputes and save time and money.

Content Providers/Transmission Ready

The issues of SLAs and complexity, and shear number of different outputs required, applies even more so to content providers. Currently, content is typically provided to broadcasters at 50MBits/sec, I-frame only video, MPEG-2.

However, the broadcaster would ideally like to receive it “transmission ready” - and there will be increasing pressures to do this.

In this case, the content provider may end up supplying the same video assets to different broadcasters *but*:

- at different bit-rates and resolutions, e.g. MPEG-2 SD 3.8MBits/sec to a cable broadcaster; SD 4.5MBits/sec and HD at 14 MBits/sec to a satellite broadcaster; SD 1.5 MBits/sec for Internet transmission (H.264/AVC format)
- to a US broadcaster in SD NTSC/HD 1080i format and a European one in SD PAL/HD 720p format

This means that QC needs to be very flexible and immediately re-configurable: this situation would rapidly become unmanageable for the content provider without fully automated QC.

Dealing With It All, Automatically

All the input video will go through the ingest servers: therefore this is the obvious point at which to do the QC.

The ideal would be if the QC at this point could look at all the different sources of error and analyze for all of these, as shown in Figure 13 in the red box. (The only product known of that does this is Cerify.)

IT-trained Personnel (Compression Too)

Running a broadcast center will increasingly become an IT activity with a video element, rather than the other way round.

This implies that the new file-based video and the workflows that go with this will require personnel with a different skill set, i.e. those that understand about TCP/IP, network configurations, server set-ups and so on, and can diagnose and keep running such set-ups, with little knowledge about video.

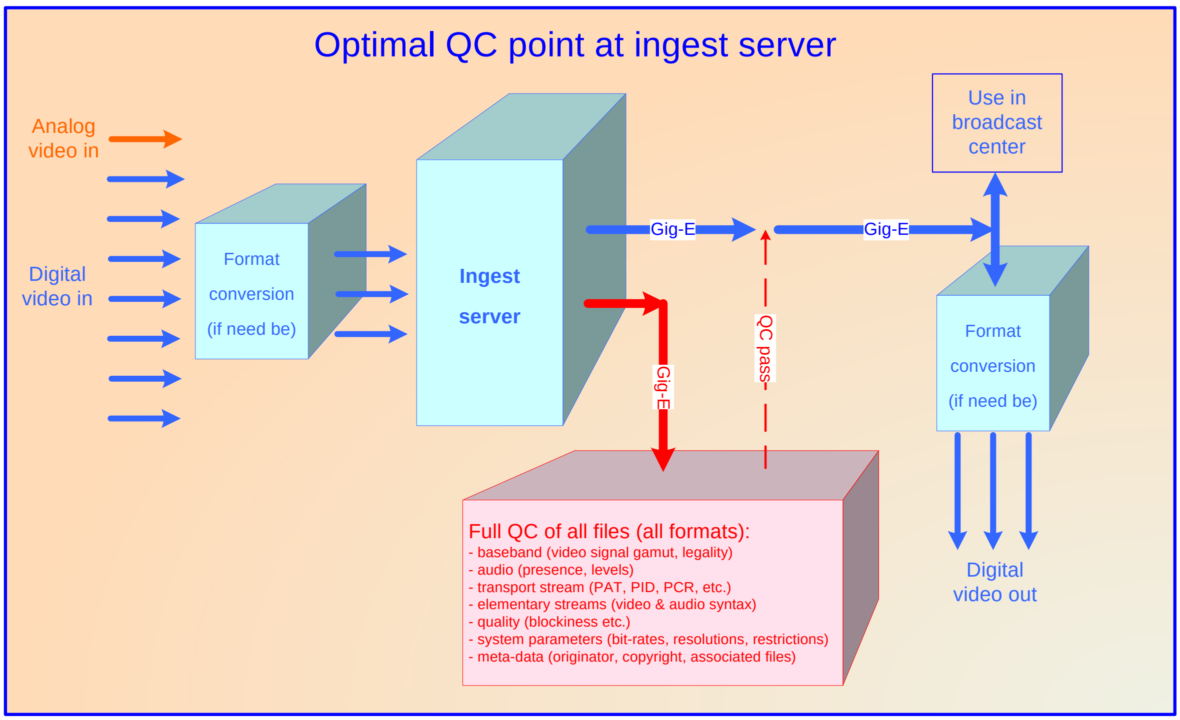

Figure 13: Full QC at ingest

There may also be a need for someone who understands a bit about video and audio compression - perhaps the baseband video experts should be trained for this role.

Beyond Ingest

This paper has mainly focused on ingest QC: clearly, the video goes a long way after that.

Within a broadcast center, video is often trimmed to suit play times for commercial breaks and network branding, involving editing the video / or cutting it into sections. Video is often moved around a broadcast center in a standard format (e.g. MPEG-2 intra-frame only at 50 MBps, to allow these operations to occur - so clearly there must be reliable transcoding from whatever the input format is to this, then from this to whatever the output format is.

If being transmitted - rather than being sent out as files - then the out-going video feed will need to be assembled using the EDL and then (usually) put into a multiple program transport stream.
All these operations will require to be QC'd also.

SUMMARY

Automation system vendors and server vendors appear to be picking up the baton regarding the many new formats: the element missing from the playout centers of broadcasters is automated QC.
In use now are a range of older technologies for QC including human visual QC, baseband and transport stream monitoring equipment. These are not sufficient to find the plethora of errors that can occur in file-based video and nor do they provide the flexibility and re-configurability required. Likewise, video personnel are generally insufficiently equipped to deal with a largely file-based environment and there will be requirements for IT training.

Automated QC will be key to broadcasters supplying these new formats and remaining cost-effective; and new SLAs and increasing user expectations are likely to demand this.