HDTV production codec tests

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To address the need for more efficient HDTV studio compression systems, vendors have recently introduced new HDTV studio codecs. In 2007, an EBU project group investigated these codecs and this article describes the methodology used for the tests and summarizes the results obtained.

The introduction of HDTV in Europe requires that broadcasters renew their production equipment. Whilst HDTV equipment in the past has targeted tape-based solutions, the user requirements for modern HDTV production workflows are file-based, non-linear and non-real-time – with shared access via networks and servers – and, last but not least, they have to be cost-effective. These requirements put challenges on the video compression format applied in mainstream HDTV production equipment – particularly on the trade-off between the data rate and video-quality head-room.

To meet these requirements, the industry has offered several codec solutions for mainstream HDTV production and the EBU decided to test these codecs in its P/HDTP (High Definition Television Production) project group. New codecs were provided for these tests by:

- AVID (DNxHD);
- GVG/Thomson (Infinity J2K);
- Panasonic (AVC-I);
- Sony (XDCAM HD422).

Existing legacy systems were also included in the evaluations in order to gather an understanding of the improvements achieved by new technology over legacy systems.

All tests on the new codecs were performed with each of the vendor’s products individually (i.e. non-comparative tests) and the test plan and the results obtained were discussed between the EBU project group and the individual vendors.

The tests were carried out between spring and August 2007 and were conducted by several key EBU Members of the P/HDTP project. The AVID tests were performed by the IRT (Germany), the GVG/Thomson and Sony tests by the RAI (Italy), and the Panasonic tests by the EBU (Switzerland) with the assistance of RTVE (Spain). A representative of the vendor concerned was present at each test and at the subsequent expert viewing sessions.

1. Massimo Visca acted as project coordinator and team leader for the codec tests.

1. Scope of the tests

The EBU codec tests focused on the image quality which the individual compression algorithm would provide after multi-generation processing. This codec performance is certainly only a part of the overall equipment performance of a recorder/server or camcorder device, camera, etc. But, in particular for HDTV with its inherent demand for high quality images, it is a very important parameter. The multi-generation codec assessment – by means of introducing pixel shifts after each generation – simulates how the production chain affects the images as a result of multi-compression and decompression stages.

For SDTV, the agreed method of multi-generation testing was to visually compare the 1st, 4th and 7th generations (including pixel shifts after each generation) with the original image under defined conditions (reference video monitor, particular viewing environment settings, and expert viewers). The same method was adapted to the current HDTV codec tests. In addition, an objective measurement – the PSNR – was calculated to give some general trend indication of the multi-generation performance of the individual codecs.

2. Algorithms under test

The framework of the tests was aimed at investigating the performance of practically all the HDTV compression algorithms available on the market or under development in the manufacturers' laboratories. The test plan included both the so-called "Legacy" algorithms, applied in the most widely used systems since the start of HDTV production, and the "New" algorithms that were planned for market launch in the shorter term at the time of testing: some of these, at the time of writing this article, are now commercially available.

2.1. "Legacy" algorithms

The main features of the video compression algorithms employed in the "Legacy" equipment are summarized in *Table 1*.

Table 1
Video compression algorithms employed in the "Legacy" equipment

	Video Bitrate (Mbit/s)	Bit depth	Subsampling	Compression	Format	SMPTE standard
HDCAM	116.64	8	1440 Y 480 C_b/C_r	DCT based (Intra)	1080i/25 1080p/25	SMPTE 367M-368M
DVCPRO	100	8	1440 Y 480 C_b/C_r	DV based (Intra)	1080i/25 1080p/25	SMPTE 370M-371M
	100	8	960 Y 480 C_b/C_r	DV based	720p/50	
HDCAM-SR	≈440	10	NO	MPEG-4 SP (Intra)	1080i/25 1080p/25 720p/50	SMPTE 409-2005
XDCAM@35	35	8	1440 Y 720 C_b/C_r 4:2:0	MPEG-2 (GoP)	1080i/25 1080p/25	-

2.2. "New" algorithms

The new HDTV systems – AVID (DNxHD), GVG/Thomson (Infinity J2K), Panasonic (AVC-I) and Sony (XDCAM HD422) in alphabetical order – employ a wide range of compression algorithms, differing both in terms of bitrate and in the mathematical tools used to perform the compression itself.

It should be noted that this article provides only the information about these algorithms that is necessary for a general understanding of their functioning. The following Tables provide some basic information (bitrate, bit depth, etc.) but, for a complete understanding, the reader should refer to the bibliography and to any official information provided by the manufacturers. Moreover, it is worth underlining that whilst these parameters provide some objective information about the system resources (e.g. the bitrate vs. storage capacity and network bandwidth), their correlation with the available picture quality is much more difficult, if not impossible, to determine from them. This is the reason for the large effort expended by the P/HDTP group in testing real implementations of the algorithms.

2.2.1. AVID (DNxHD)

Table 2
AVID DNxHD video compression codec parameters

Name	Video Bitrate (Mbit/s)	Bit depth	Subsampling	Compression	Format	SMPTE standard
DNxHD	120	8	NO	DCT based (Intra)	1080i/25 1080p/25	SMPTE VC-3
	115	8	NO	DCT based (Intra)	720p/50	SMPTE VC-3
DNxHD	185	8	NO	DCT based (Intra)	1080i/25 1080p/25	SMPTE VC-3
	175	8	NO	DCT based (Intra)	720p/50	SMPTE VC-3
DNxHD	185	10	NO	DCT based (Intra)	1080i/25 1080p/25	SMPTE VC-3
	175	10	NO	DCT based (Intra)	720p/50	SMPTE VC-3

2.2.2. GVG/Thomson (Infinity J2K)

Table 3
GVG/Thomson video compression codec parameters

Name	Video bitrate (Mbit/s)	Bit depth	Subsampling	Compression	Format	Compression standard
Infinity	50	10	NO	Wavelet based (Intra)	1080i/25 1080p/25 720p/50	JPEG2000
Infinity	75	10	NO	Wavelet based (Intra)	1080i/25 1080p/25 720p/50	JPEG2000
Infinity	100	10	NO	Wavelet based (Intra)	1080i/25 1080p/25 720p/50	JPEG2000

2.2.3. Panasonic (AVC-I)

Table 4
Panasonic AVC-I video compression codec parameters

Name	Video bitrate (Mbit/s)	Bit depth	Subsampling	Compression	Format	Compression standard
AVC-I	54.272	10	1440 Y 720 C_b/C_r 4:2:0	AVC (Intra)	1080i/25 1080p/25	High 10 Intra Profile
	54.067	10	960 Y 480 C_b/C_r 4:2:0	AVC (Intra)	720p/50	High 10 Intra Profile
AVC-I	111.820	10	NO	AVC (Intra)	1080i/25 1080p/25	High 4:2:2 Intra Profile
	111.616	10	NO	AVC (Intra)	720p/50	High 4:2:2 Intra Profile

2.2.4. Sony (XDCAM HD422)

This algorithm employs a Long GoP (Group of Pictures) with L=12 and M=3, i.e. the GoP structure is IBBPBBPBBPBBI. This feature has some important implications on the testing of multi-generation performance, as described in detail in paragraph 3.2.3.

Table 5
Sony MPEG-2 Video Compression codec parameters

Name	Video bitrate (Mbit/s)	Bit depth	Subsampling	Compression	Format	SMPTE standard
XDCAM HD50	50	8	NO	MPEG-2 GoP L=12 M=3	1080i/25 1080p/25 720p/50	-

3. Methodology

In order to evaluate the performance of the different HDTV algorithms in a production environment, the very classical approach of the multi-generation (cascading) test was used. This method has been extensively used in all EBU tests since the introduction of compression algorithms in the SDTV production environment, starting from Digital Betacam up to the more recent IMX and DVCPRO systems. It is considered by the broadcast community to be a reliable methodology which is able to provide repeatable and stable results for easy interpretation.

The method is simply based on the performance of different compression-decompression steps using the algorithm under test, in order to simulate the cumulative effect of the artefacts introduced by the compression algorithm on the picture quality.

This method was originally devised to stress traditional tape-based equipment, where each copy implied a decompression and compression step. It could perhaps be considered as not fully reflecting the workflow of a future IT production-based infrastructure, where the necessity to perform a cascading of compression could be reduced. Nevertheless, considering that in the present production scenario, cascading is still a common process, the method allows the evaluation of the so-called “quality headroom” in the system. There is a good knowledge base in the evaluation of results using this method of assessment and it was agreed to continue to use it for analysis of the performance of compression algorithms implemented in the HDTV equipment under test.

3.1. Selection and shooting of test sequences

The selection of the test sequences to be used in any test is always a very critical issue; even ITU-R Rec. BT.500 – the most important reference document, containing all the procedures for picture quality evaluation based on subjective assessment – provides only a simple guideline, stating that the sequences have to be “critical, but not unduly so”. Obviously, a “biased” selection of test sequences can be used to “drive” the test. The only way to solve this problem is to select a very large amount of material, in order to include sequences that cover all the possible features in terms of:

- high-frequency content (details), motion portrayal, colorimetric, contrast, etc.;
- indoor and outdoor shooting;
- different kinds of content, i.e. natural and artificial objects, texture, skin tones, etc.

Moreover, it is better if at least a subset of the test material is brand new, in order to avoid any kind of “optimization” of the new compression algorithm using familiar sequences.

As such a library was not available at the time of testing, it was necessary to shoot brand new sequences. The shooting was performed using state-of-the-art technology (Canon FJS Series prime lens, Sony HDC 1500 camera and uncompressed storage on a DVS server via HD-SDI). The result was a large portfolio of test sequences, each of 10s duration, satisfying the above-mentioned criteria.

All the sequences were shot in different formats – i.e. 1080p/50, 1080i/25, 1080p/25 (with and without shutter) and 720p/50 – making the best effort in order to guarantee the same conditions of lighting and exposure.

Note: The 1080p/50 sequences were down-converted to obtain 1080i/25 or 720p/50 versions; they were therefore not directly used in these tests but they will provide a library that is available for future needs, such as the comparative test of the present 1.5 Gbit/s scenario with the future 3 Gbit/s.

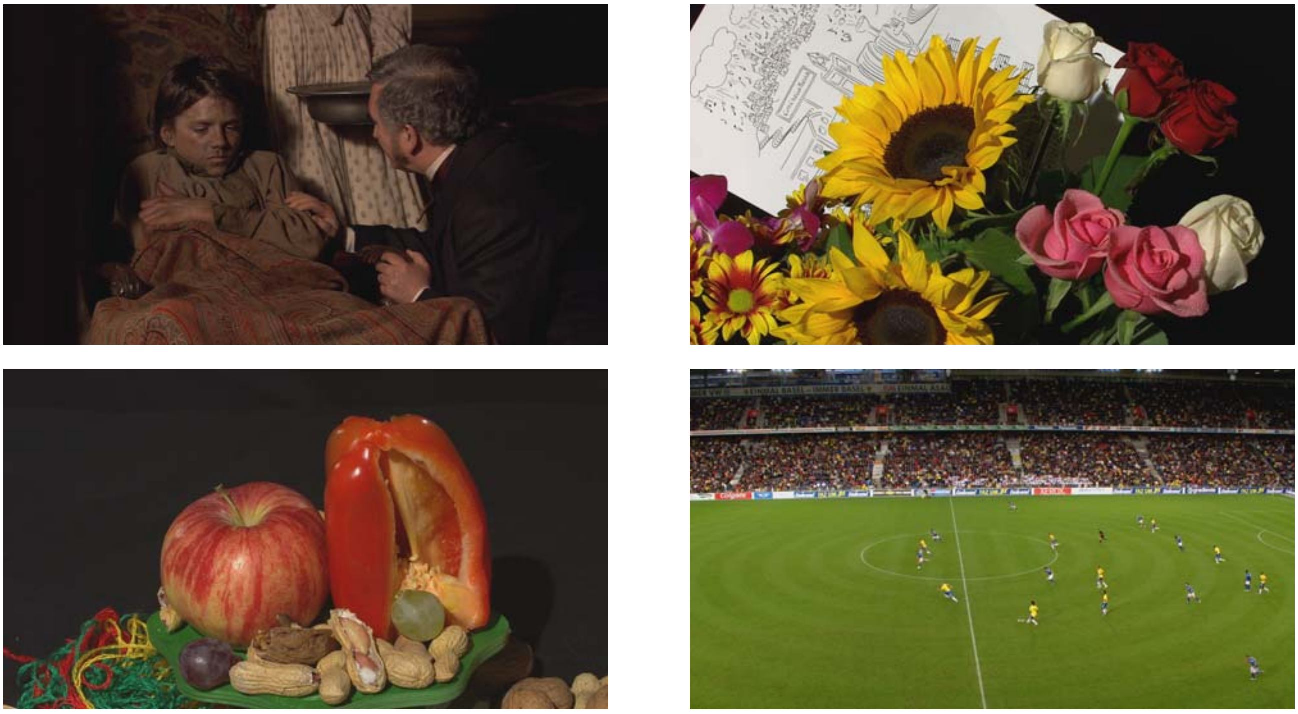

Figure 1
Still shots captured from four of the test sequences used

Some sequences were singled out from material originally shot in one single HDTV format only. Other sequences were converted from film, or from rendered graphics or even taken from the archive in PAL format. All these sequences were converted into the three HDTV formats included in the tests to obtain an even larger portfolio of 10s-long test sequences.

Note: All the technical details (equipment, software, etc.) relevant to the conversion process are available from the authors, upon request.

For the 1080i/25 and 720p/50 formats, fourteen 10s-long test sequences were concatenated one after the other (no gray or black frames included) to form a single clip.

For the 1080p/25 (shutter on) formats, only eight 10s long test sequences were then concatenated to form a single clip.

The total amount of test material employed, its different origins and the criteria of selection, guaranteed the completeness and formal correctness of the tests. Some frames extracted from the sequences are shown in *Fig. 1*.

3.2. Standalone chain

The "standalone chain" comprised a cascading of several compression and decompression processes of the same algorithm; each pair of compression and decompression processes is usually referred to as a single "generation". In order to simulate different production scenarios and to investigate different features of the algorithm under test, the chain may or may not include processing between each generation, as explained below. As already mentioned, each algorithm under test was subjected to a multi-generation process up to the seventh generation.

3.2.1. Standalone chain without processing

The standalone chain without processing simply consisted of several cascaded generations of the codec under test, without any other modifications to the picture content apart from those applied by the codec under test, as summarized in *Fig. 2*.

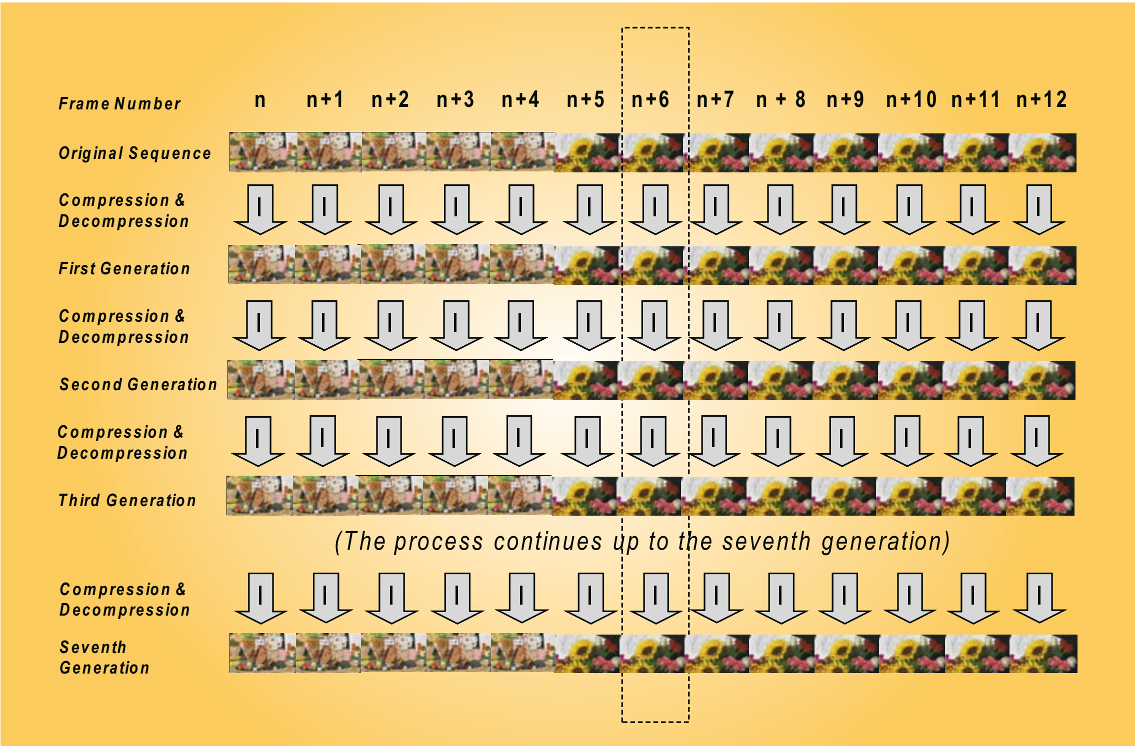

Figure 2
Standalone chain (without spatial shift) for INTRA codec

This process accurately simulates the effect of a simple dubbing of the sequence and is usually not very challenging for the compression algorithm. In fact, the most important impact on the picture quality should be incurred at the first generation, when the encoder has to eliminate some information, but the effect of the subsequent generations should be minimal as the encoder should basically eliminate the same information already deleted in the first compression step. Nevertheless, this simple chain can provide useful information about the performance of the sub-sampling filtering that is applied, or about the precision of the mathematical implementation of the code.

3.2.2. Standalone chain with processing

In a real production chain, several manipulations are applied to the picture to produce the master, such as editing, zoom, NLE and colour correction. Therefore, a realistic simulation has to take into account this issue. As all these processes are currently feasible only in the uncompressed domain, the effect of the processing is simulated by spatially shifting the image horizontally (pixel) or vertically (lines) in between each compression step, as summarized in *Fig. 3*.

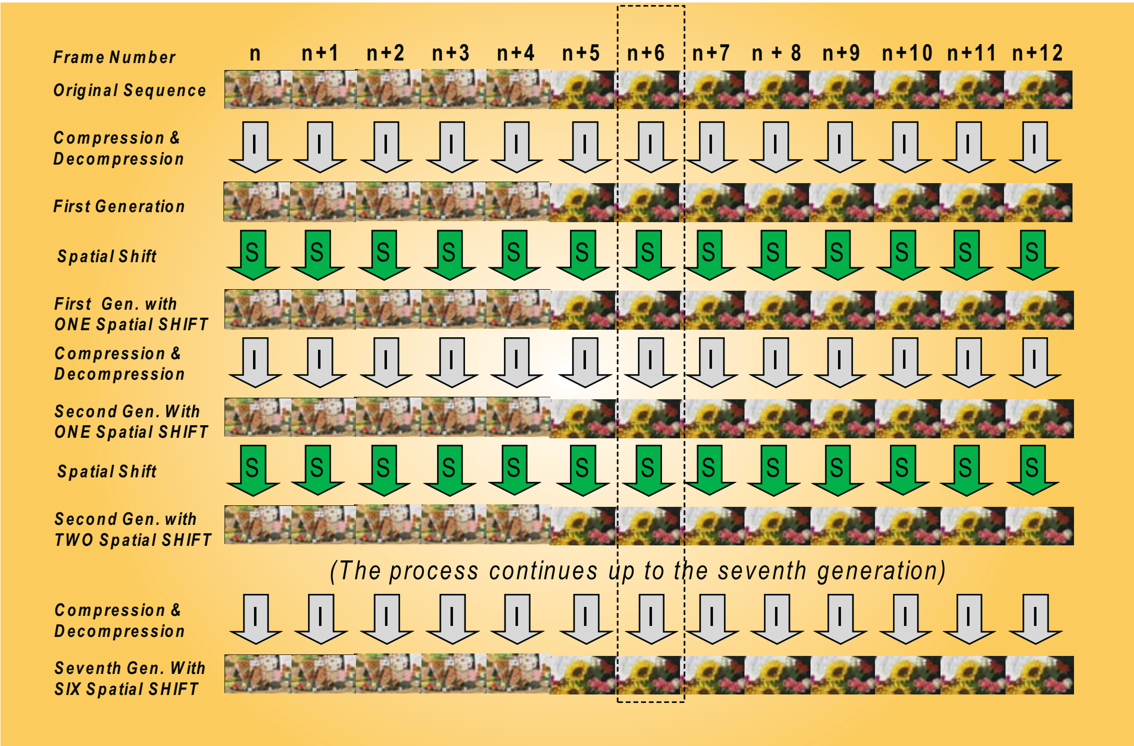

Figure 3
Standalone chain (with spatial shift) for INTRA codec

Obviously, this shift makes the task of the coder more challenging, especially for those algorithms based on a division of the picture into blocks (e.g. NxN DCT block), as in any later generation the content of each block is different to that in the previous generation.

The shifts were applied variously using software or hardware, but the method used was exactly the same for all the algorithms under test. The shifts are summarized in *Table 6* and the process is summarized in *Fig. 4*.

For the horizontal shift (H), a “positive” shift means a shift towards the right, “negative” towards the left. Only even shifts are performed to take into account the chroma subsampling of the 4:2:2 format.

For the vertical shift (V), a “positive” shift means a down shift, “negative” an up shift. The shift is applied on a frame basis and is always an even value. For progressive formats, the whole frame is shifted by a number of lines corresponding to the vertical shift applied, while for interlaced formats

Table 6
Spatial (vertical and horizontal) applied between each generation

Shift between	Spatial Shift
First and second generation	+4H and +4V
Second and third generation	+2V
Third and fourth generation	–2H
Fourth and fifth generation	–2H
Fifth and sixth generation	–2V
Sixth and seventh generation	–4V

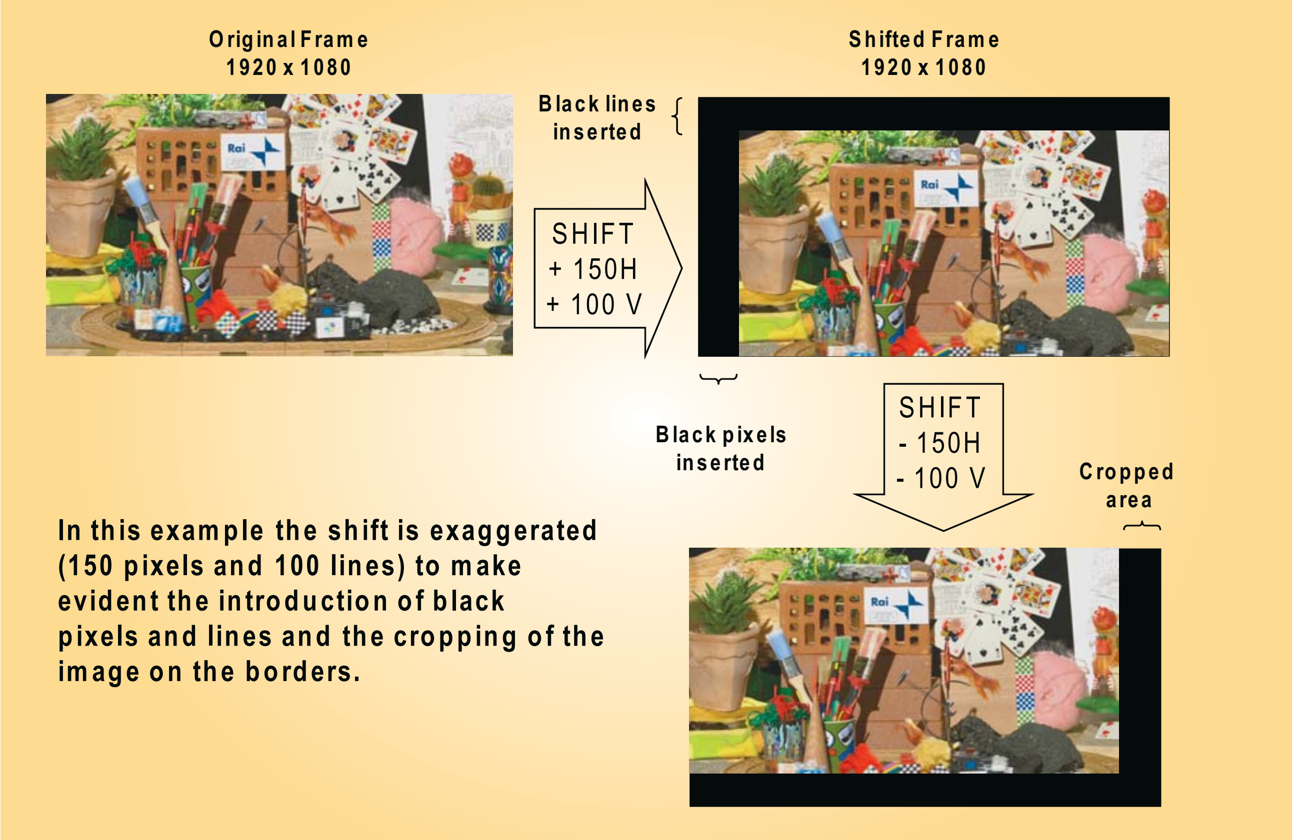

Figure 4
The shift process in the standalone chain

each field is shifted by a number of lines corresponding to half the shift applied. For example, a shift equal to +2V means two lines down for progressive formats and 1 line down for each field of an interlaced format.

The shift process introduces black pixels on the edges of the frame if/when necessary.

3.2.3. Standalone chain for GoP-based algorithms

As shown in *Table 5* (on *page 4*), the XDCAM HD50 system exploits the MPEG-2 motion compensation tools and, in particular, Long GoP coding with L=12 and M=3 (i.e. IBBPBBPBBPBBI); even if each MPEG-2 encoder applies a rather sophisticated strategy to allocate its bitrate resources on the different kinds of pictures, all the MPEG-2 algorithms usually guarantee the best quality for the Intra picture (I), a reduced quality for the Predicted picture (P) and, in the same manner, an even lower quality for the Bidirectional picture (B).

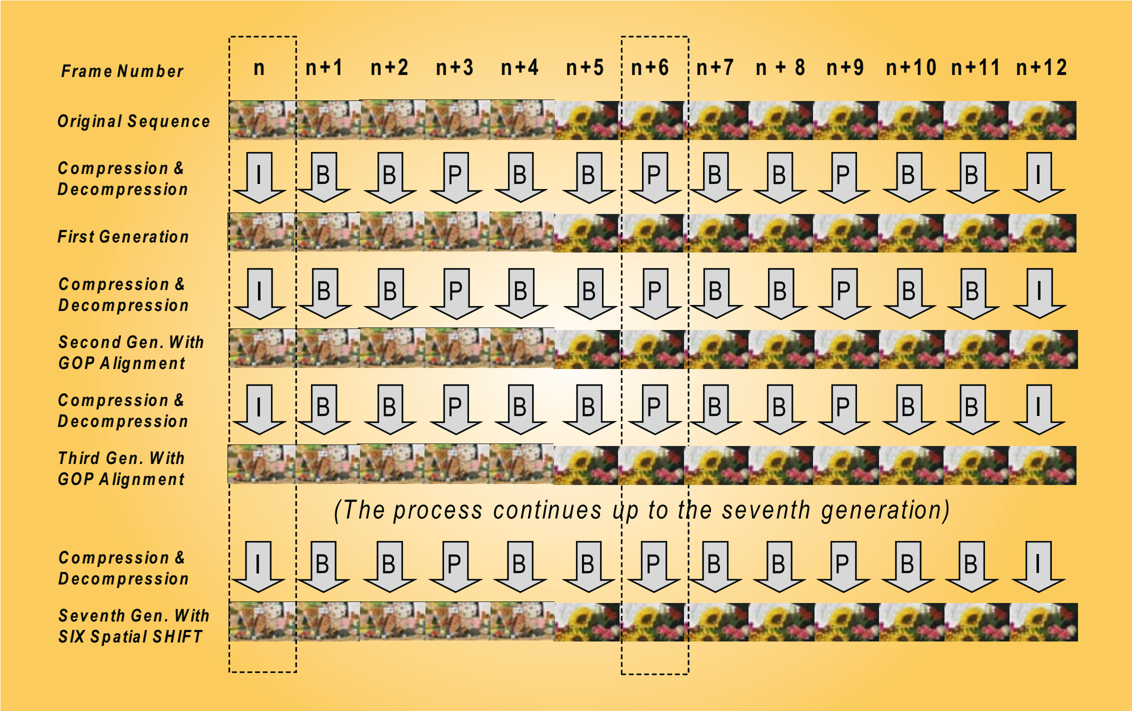

Figure 5
Standalone chain with GoP alignment (without spatial shift) for INTER codec

Therefore, the GoP structure has some important implications on the way the standalone chain has to be realized, and introduces a further variable in the way the multi-generation can be performed – depending on whether the GoP alignment is guaranteed between each generation (GoP aligned) or not (GoP mis-aligned).

As explained in *Fig. 5*, the GoP is considered to be *aligned* if one frame of the original picture that is encoded at the first generation using one of the three possible kinds of frame – Intra, Predicted or Bidirectional – is again encoded using that same kind of frame in all the following generations: for

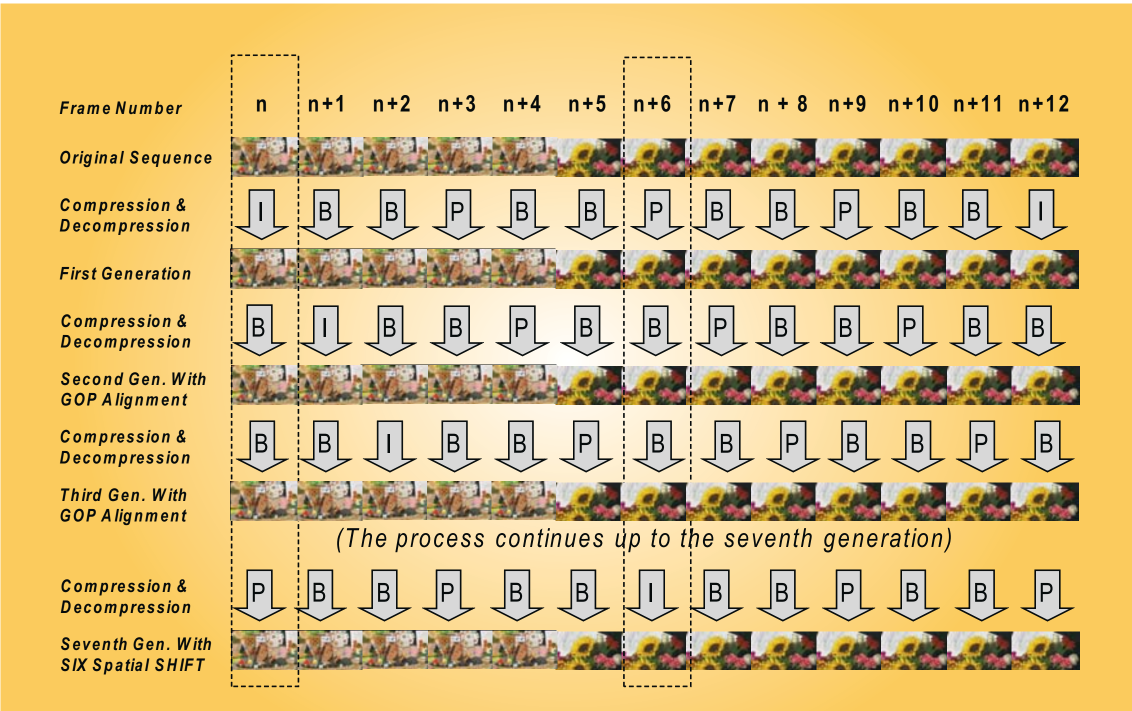

Figure 6
Standalone chain without GOP alignment (without spatial shift) for INTER codec

example, if frame *n* of the original sequence is <u>always</u> encoded as Intra and frame *n*+6 as Predicted. It is therefore possible to have only one multi-generation chain with "GoP alignment".

On the contrary, if this condition is not guaranteed, several conditions of GoP mis-alignment are possible; considering the GoP length L=12, for the second generation 11 different GoP mis-alignments are possible, then for the third generation 11 by 11 and so on, making the testing of all the possible conditions unrealistic. It was therefore agreed to apply one "temporal shift" equal to one frame between each generation, as explained in *Fig. 6*, so that the frame that is encoded in Intra mode in the first generation is encoded in Bidirectional mode in the second generation and, in general, in a different mode for each following generation. It is interesting to underline that the alignment of the GoP in the different generations was under control (not random) and that this was considered the likely worst case as far as the mis-alignment effect is concerned, and was referred to in the documents as "chain without GoP alignment".

Taking into account also the necessity to simulate the effect of manipulation by means of the spatial shift, it was agreed for the GoP-based system (XDCAM HD50) to consider and to realize four different possible standalone chains up to the seventh generation, as follows:

- Multigeneration chain with GoP alignment (without spatial shift) *(see Fig. 5)*
- Multigeneration chain without GoP alignment (without spatial shift) *(see Fig. 6)*
- Multigeneration chain with GoP alignment AND spatial shift *(see Fig. 7)*
- Multigeneration chain without GoP alignment AND spatial shift *(see Fig. 8)*

All the abovementioned chains were carried out on the "Legacy" systems and on the "New" systems. The resultant sequences were all stored in YUV 10-bit format.

Note: For the XDCAM @35 chain it was not possible to obtain the GoP alignment control and therefore this multi-generation has to be considered "random" in terms of GoP alignment)

The tests on the AVID DNxHD codec were performed by the IRT, the tests on the GVG/Thomson codec were performed by the RAI using an Infinity prototype camera, the tests on the Panasonic AVC-I codec were performed by the EBU using a prototype encoder, and the Sony XDCAM HD50 was tested by the RAI using a prototype encoder. Engineers from the respective manufacturers attended the tests for at least the first day to ensure the correct working of the equipment.

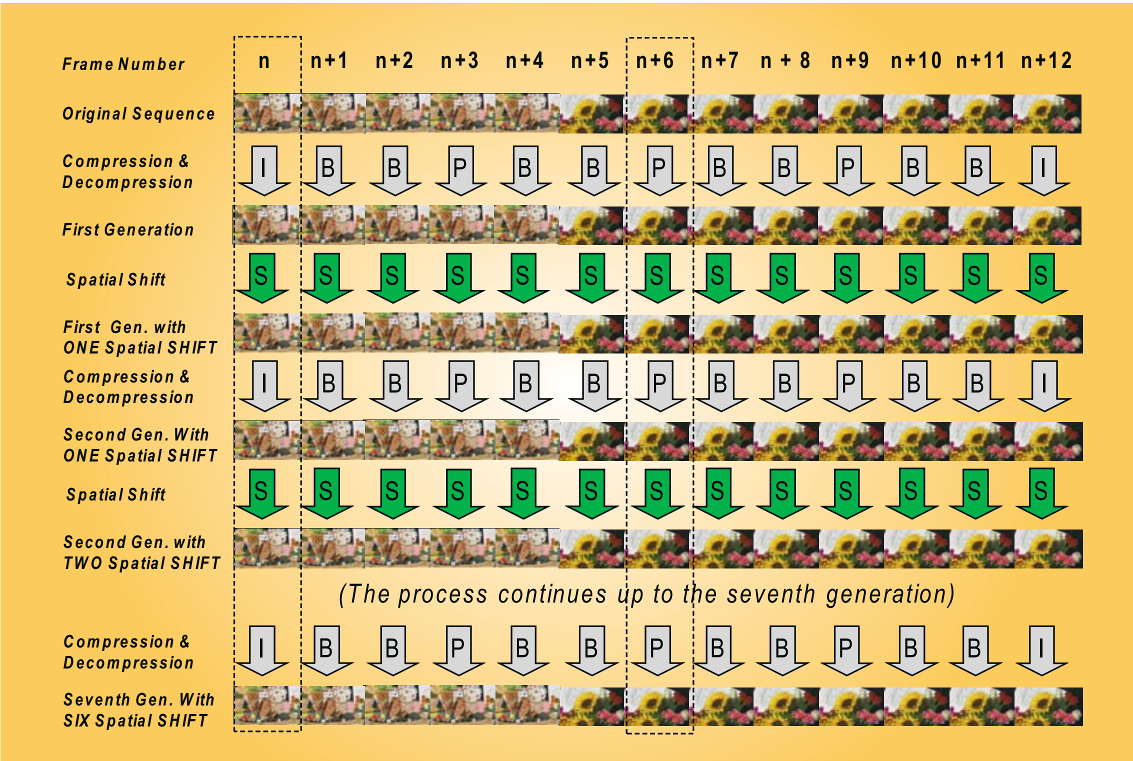

Figure 7
Standalone chain with GoP alignment AND with spatial shift for INTER codec

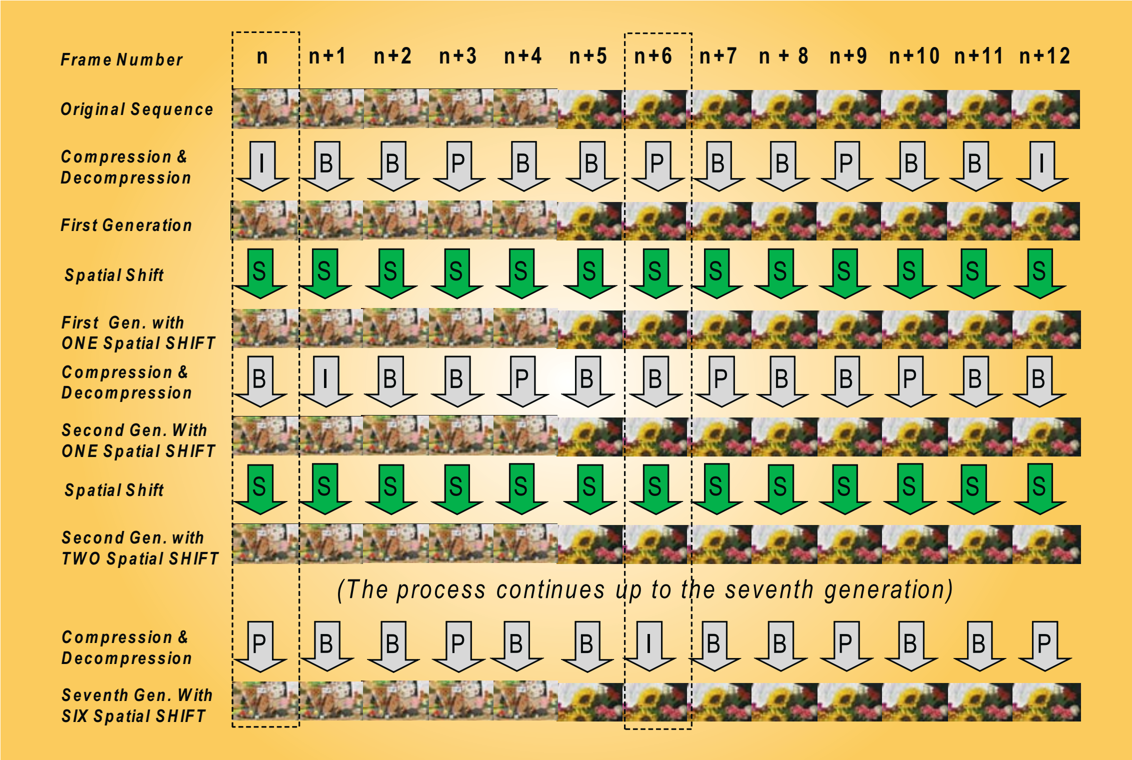

Figure 8
Standalone chain without GoP alignment AND with spatial shift for INTER codec

4. Analysis of the performance of the algorithms

The analyses of the performance of the algorithms was performed both using objective measurements (PSNR) and visual scrutiny of the picture (i.e. expert viewing), as described in the following sections. These two methods provide different kinds of information and they are considered to be complementary.

4.1. Objective measurements

The PSNR has been computed via software and obviously applied a procedure to re-establish the spatial alignment between the original and the de-compressed version of the test sequence. Moreover, it skipped 16 pixels on the edges of the picture to avoid taking measurements on the black pixels introduced during the shift.

The formula used to evaluate the PSNR via software was:

$$PSNR = 10Log_{10}\left(\frac{Vpeak^2}{\frac{\sum_{i=1}^{Ncol}\sum_{j=1}^{Nlin}\left(ori(i,j)-cod(i,j)\right)^2}{Ncol * Nlin}}\right)$$

where: *ori (i,j)* = original frame, *cod(i,j)* = manipulated frame, *Ncol* = horizontal resolution in pixels, *Nlin* = vertical resolution in pixel and Vpeak = $2^{10} - 1 = 1023$.

The results are expressed in dB.

It is well known that PSNR does not correlate accurately with the picture quality and thus it would be misleading to directly compare PSNR from very different algorithms. On the other hand, this parameter can provide information about the behaviour of the compression algorithm through the multi-generation process.

4.2. Expert viewing

Analysis of the algorithm performance (from the point of view of picture quality) was carried out using so-called “expert viewing”. Even if this method is not formally included in any ITU Recommendation, it is very often used as it provides fast and consistent results. Under the generic name of “expert viewing” are included several kinds of analysis of the picture quality evaluation.

For the purposes of these P/HDTP tests, it was agreed in advance with manufacturers to use the following interpretation of what “expert viewing” would entail.

> All the sequences (original and those subjected to compression) were stored in uncompressed form (YUV10 format) on two video servers that were able to be run in parallel. The sequences were displayed simultaneously in a vertical split-screen condition (original on one side, those subjected to compression on the other side). During the expert viewing, the T bar of the mixer that provided the split-screen effect (a Panasonic type AV-HS300) was moved to compare the same areas of different versions of the same sequences, as was found necessary. The position of the split was made more evident by applying a just-noticeable vertical white bar at the transition between the two images; a real example is shown in *Fig. 9*.
>
> The viewing distance was marked on the floor and was set to 3H, where H defines the vertical dimension of the display, and the observers were asked to respect this viewing

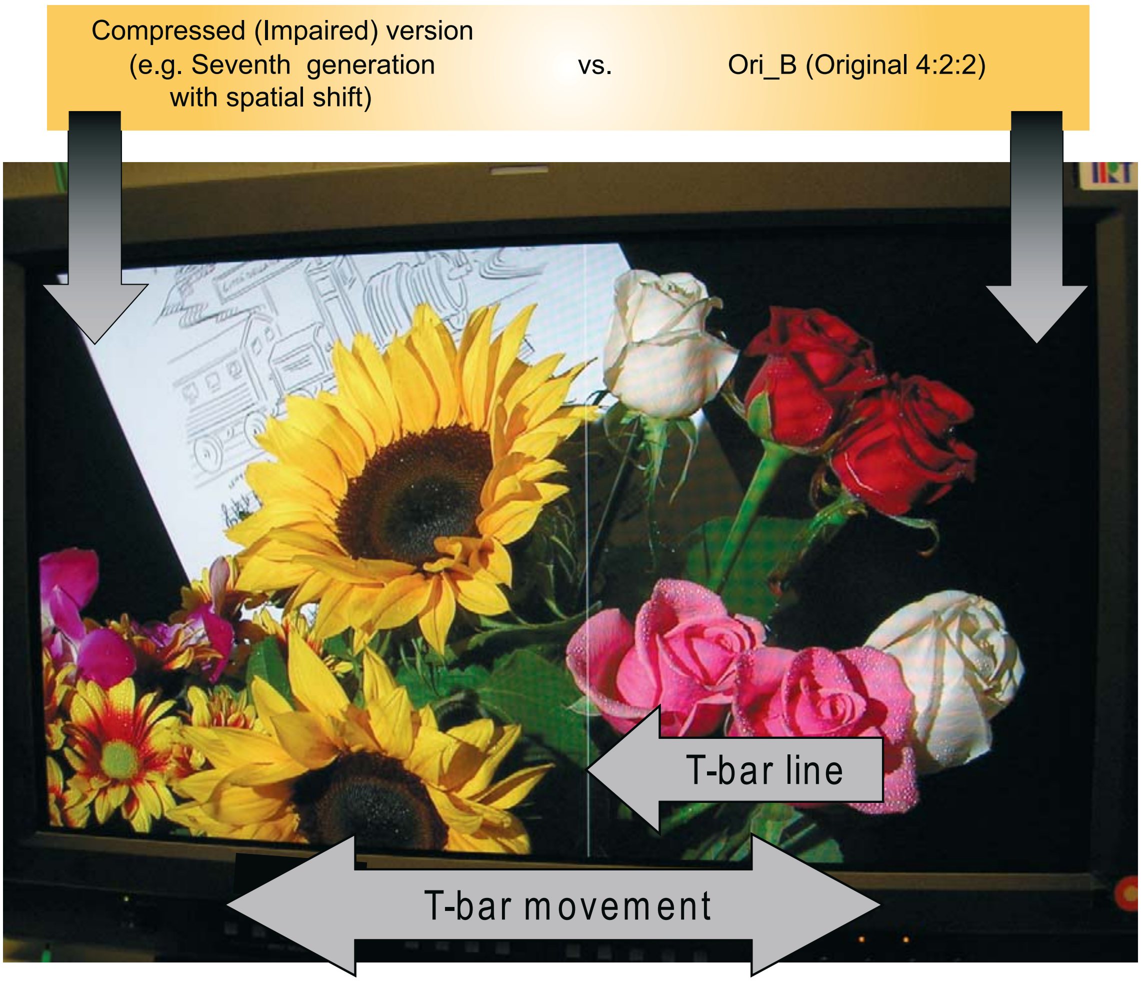

Figure 9
Split-screen analysis

distance. Sometimes a closer viewing distance, e.g. 1H, was used to closely observe small details and artefacts and, when used, this condition was clearly noted in the report.

It should be made clear that this method allows the evaluation of very small impairments, near to the visibility threshold, and it must be considered a very severe analysis of the picture quality.

As mentioned, the tests focused on the performance of the algorithms at the first, fourth and seventh generations, comparing the picture quality with the original (headroom evaluation) or with legacy system (improvement provided by the new system). A test list, which summarized in the form of tables all the different comparisons planned, was prepared and discussed in advance.

Each expert was provided with a paper copy of the test list, so she/he was always completely aware of what sequence was displayed in each part of the screen.

For example, in the case of a comparison between the "Original" sequence and the version subjected to seven generations of algorithm "A", including a spatial shift between each generation, the expert was provided with the following table:

Compressed (Impaired) version (e.g. Seventh generation with spatial shift)	**vs.**	**Ori_A (Original 4:2:2)**
Ratio: loss due to seven generations with post-processing		

The expert was aware that "A" meant a specific vendor and was given full details of each test condition (bitrate, GoP aligned or not, etc.). The table also included a short sentence describing the "rationale" of the test and, in order to avoid any misunderstanding, the position (right or left) of the sequences was the same on the paper table and on the display; c.f., the Original sequence on the right side and the processed sequence on the left side in the above table.

All the experts were formally requested to refrain from expressing their opinions during the sessions, in order to avoid biasing other people. Only after the complete analysis of the test sequence (for its full length) was a discussion started to summarize in a few sentences the opinions of the different experts. Sometimes it was not possible to get an agreement on the visual analysis of a sequence and in this case the sequence was repeated. If even in this case an agreement was not possible, the situation was noted in the report.

Best efforts were made to guarantee that the panel of experts was comprised of the same people during the different expert viewing sessions; this condition was readily met during each single day and almost perfectly so during different days. One day of expert viewing was dedicated to each manufacturer, and representatives of the individual vendor took part in the expert viewing as well.

The results of the expert viewings were collected in a series of EBU BPN documents; BPN 076 (results for Avid DNxHD), BPN 077 (results for GVG/Thomson JPEG2000), BPN 078 (results for Panasonic AVC-I) and BPN 079 (results for Sony XDCAM HD50). These documents are published by the EBU exclusively for its Members.

The reader should be aware that, due to the complexity and framework of the tests, only a deep analysis of these documents can provide a complete appreciation of the results.

4.2.1. Display

The following displays were used during the tests:

- CRT 32″ Sony — Type BVM-A32E1WM
- CRT 20″ Sony — Type BVM-A20F1M
- Plasma Full HD 50″ — Type TH50PK9EK Panasonic
- LCD 47″ — Type Focus

The displays were connected through HD-SDI interfaces. The displays were aligned according to the conditions described in ITU-R BT.500-11 and the room conditions were set accordingly.

The final assessment was always done while considering the quality perceived on the CRT displays.

Nevertheless, there was a general agreement that the flat-panel displays, both LCD and plasma, magnified the impairments.

5. Results

It was agreed between the EBU project group and the vendors to make the reports about the test details available to EBU Members only. In late 2007, the results of the test were published as BPN076 to BPN079, as noted above.

Note: Due to the importance of the subject, vendors and the EBU agreed to provide some preliminary results in a PowerPoint presentation given at the IBC-2007 conference, before the actual BPN reports became available to EBU Members. This PowerPoint presentation contained a short summary of the test results in tabular form. The published reports BPN076 to BPN079 contain a much larger framework of test conditions than shown in the IBC-2007 PowerPoint. Neither the test reports nor the PowerPoint tables are intended, or suited, for comparative studies. The tabular form of the PowerPoint presentation did not include information about whether the tests were conducted with or without pixel shift.

The EBU Production Management Committee then subsequently concluded in a recommendation (EBU R124-2008) [2] that:

> ***For acquisition applications an HDTV format with 4:2:2 sampling, no further horizontal or vertical sub-sampling should be applied. The 8-bit bit-depth is sufficient for mainstream programmes, but 10-bit bit-depth is preferred for high-end acquisition. For production applications of mainstream HD, the tests of the EBU has found no reason to relax the requirement placed on SDTV studio codecs that "Quasi-transparent quality" must be maintained after 7 cycles of encoding and recoding with horizontal and vertical pixel-shifts applied. All tested codecs have shown quasi-transparent quality up to at least 4 to 5 multi-generations, but have also shown few impairments such as noise or loss of resolution with critical images at the 7th generation. Thus EBU Members are required to carefully design the production workflow and to avoid 7 multi-generation steps.***

The EBU recommends in document R124-2008 that:

- If the production/archiving format is to be based on I-frames only, the bitrate should not be less than 100 Mbit/s.
- If the production/archiving format is to be based on long-GoP MPEG-2, the bitrate should not be less than 50 Mbit/s.

Furthermore, the expert viewing tests have revealed that:

- A 10-bit bit-depth in production is only significant for post-production with graphics and after transmission encoding and decoding at the consumer end, if the content (e.g. graphics or animation) has been generated using advanced colour grading, etc.
- For normal moving pictures, an 8-bit bit-depth in production will not significantly degrade the HD picture quality at the consumer's premises.

2. R124-2008: **http://tech.ebu.ch/docs/r/r124.pdf**

Abbreviations

720p/50	High-definition progressively-scanned TV format of 1280 x 720 pixels at 50 frames per second
1080i/25	High-definition interlaced TV format of 1920 x 1080 pixels at 25 frames per second, i.e. 50 fields (half frames) every second
1080p/25	High-definition progressively-scanned TV format of 1920 x 1080 pixels at 25 frames per second
1080p/50	High-definition progressively-scanned TV format of 1920 x 1080 pixels at 50 frames per second
AVC	(MPEG-4) Advanced Video Coding, part 10 (aka H.264)
DCT	Discrete Cosine Transform
GoP	Group of Pictures
ITU	International Telecommunication Union **http://www.itu.int**
ITU-R	ITU - Radiocommunication Sector **http://www.itu.int/publications/sector.aspx?lang=en&sector=1**
JPEG	Joint Photographic Experts Group **http://www.jpeg.org/**
MPEG	Moving Picture Experts Group **http://www.chiariglione.org/mpeg/**
NLE	Non-Linear Editing
PSNR	Peak Signal-to-Noise Ratio
SMPTE	Society of Motion Picture and Television Engineers (USA) **http://www.smpte.org/**
YUV	The luminance (Y) and colour difference (U and V) signals of the PAL colour television system

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