EBU Technical Information I35-2003
Further considerations on the impact of Flat Panel home displays on the broadcasting chain

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1. Summary

1.1 The EBU continues its evaluation of the impact of flat panel displays on the broadcast chain by considering the performance of new compression schemes, and a range of other dimensions. These are licensing costs, the use of variable bit rate, the cascading of codecs, the relevance of the Australian model, the evolution of DVDs, the price acceptability thresholds and timescales of flat panels, and potential future developments in codec technology.

2. Introduction

2.1 There are many factors which influence a purchaser's choice of television receiver - its appearance as furniture, its price, and the impression the picture makes. The new generations of flat panel displays offer many attractions to viewers. They provide striking pictures, and take up less space for a given screen size. Their current prices, though falling relatively rapidly, are still too high for most European viewers. However, as the retail cost continues to fall, they are likely to become the preferred type of receiver for the public. Broadcasters need to recognise this, and make plans accordingly.

2.2 The EBU has studied the properties and evolution of flat panel displays over recent years. A previously published information document (EBU I34) explained the tests made, and the conclusions reached from them. In a simplified summary, the test showed that if digital television broadcasting uses the MPEG2@ML compression system for standard definition television, as it does today, European broadcasters will need to double the bit-rates they normally use, if they intend to serve the flat panel audience with pictures which are predominantly free of visible flaws.

2.3 The EBU also studied the delivery of high definition pictures to flat panel displays. Most (but not all) manufacturers say the 'WideXGA'[1] display will be the dominant HDTV home display in the years ahead. The information in I34 suggests that, in this case, the best match to an HDTV broadcast environment, that uses MPEG2@HL, would be to use a 720p/50 delivery channel.[2] In this case, the maximum quality picture is available to the viewer because no standards conversion is needed in the receiver. If conversion were needed, its structure (square cells and progressive scanning) helps to arrange simple and high quality conversion.

2.4 One manufacturer, Sony, points out to the EBU that they have an alternative display format, 1024 by 1024, the ALIS panel, and the same logic would not apply to these panels. This is clearly the case. A lack of standardisation by manufacturers in formats means it will not be possible to optimise the delivery channel for all receivers. Other manufacturers suggest that the WideVGA[3] and WideXGA formats will be the most widely available.

2.5 The work reported in I34 concerns tests made with MPEG2 video compression. This is used throughout the world today for broadcasting standard definition and high definition television. It is a technically stable and mature system. However, the potential "average"[4] performance of video compression systems in general continues to improve. Over the years a pattern has emerged, which is shown in a stylised way in Figure 1.

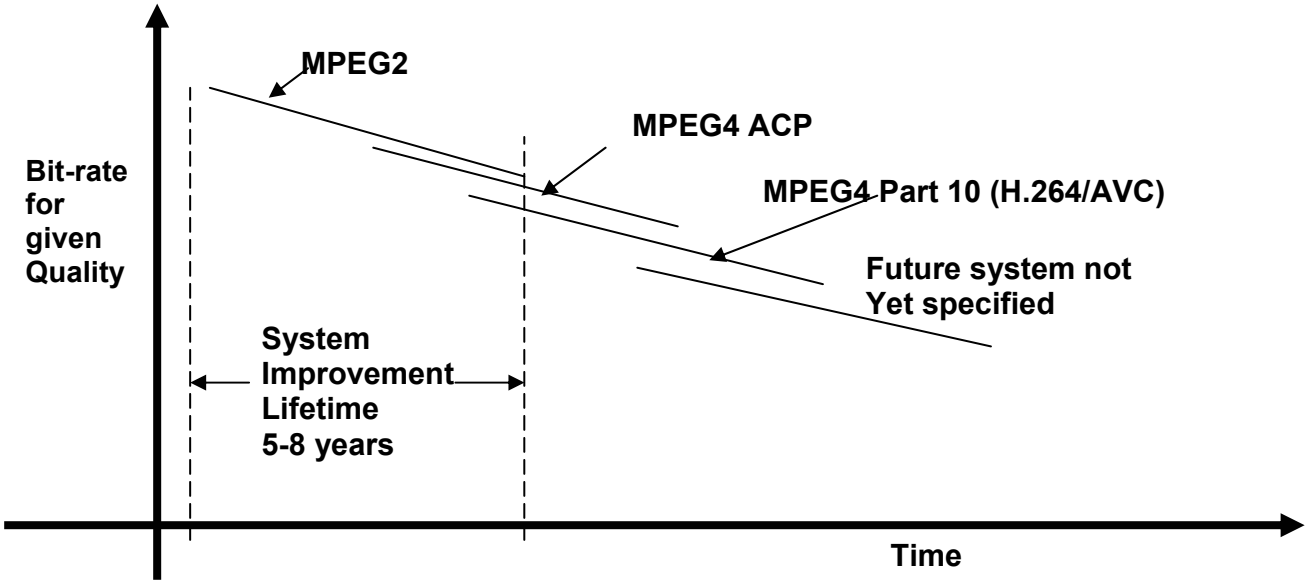
[1] WideXGA has 768 'lines' or vertical cells. The precise horizontal resolution may differ slightly, but "square cells" are common, giving the 16:9.raster 1365x768 cells

[2] 720p/50 is specified in SMPTE 296M.

[3] WideVGA has 480 lines. The precise horizontal resolution may differ, but "square cells" are common giving the raster 853x480 in 16:9.

[4] This can be taken to mean uncritical and moderately critical scenes, but not necessarily very critical scenes.

Fig. 1: The evolution of open standard video compression systems. A pattern of development cycles occurs, which result in long-run continuous gains in efficiency



2.6 The pattern which has emerged in open standard video compression is one of long-run continuous gains in efficiency. A cycle occurs. A set of compression tools is assembled at a given point in time (e.g. about 1993 for MPEG2) and over the next 5-8 years manufacturers are able to produce ever more efficient systems by fine tuning elements within the tools. Then, when it becomes clear that new tools are available which would bring substantive advantages, a new set is assembled (e.g. 1998 for MPEG4 ACP), which is in turn subject to its own maturity period.

2.7 The new systems are more sophisticated than the last, and take advantages of the continuously increasing processing power available for consumer electronics. This cycle repeats itself. There is no evidence today that the cycle will stop, but clearly finite bit rates will always be needed for video signals.

2.8 Fig. 1 is a stylised simplification to help understanding. If the "average" performance generally continues to improve, the improvement for demanding or 'very critical' scenes is not necessarily so continuous. It may be that a new set of tools helps moderately critical content more than very critical content. Broadcasters must examine the relative impact on all types of material. Understanding fully the performance of a codec requires knowledge of the statistical distribution of critical content. The level of improvement will not necessarily be the same at all quality levels – LDTV, SDTV, and HDTV.

2.9 The ISO/IEC JTC is now in the process of standardising the MPEG4 Part 10 system (also called H.264, and H26L or most simply AVC for Advanced Video Codec). We can thus expect the improvement cycle to commence for AVC.

2.10 Microsoft announced in 2002 a proprietary compression system which is part of a suite of media tools. This is 'Windows Media Player 9' (WM9). Thus, the cutting edge of compression technology today is, arguably, the AVC open system and the WM9 proprietary system. We may expect a more advanced open set of tools to be assembled in, say, five-eight years' time, and cyclic improvements in WM9.

2.11 In drawing conclusions about the potential changes needed by broadcasters to accommodate a future flat panel receiver environment, the EBU needs to evaluate the extent to which the use of AVC or WM9, rather than MPEG2, would change the conclusions drawn based on MPEG2 compression. The results of first evaluations are reported in Section 3 and 4 below. Since both AVC and WM9 will evolve in efficiency over the coming years, the tests reported below are based on expert viewing assessments rather than subjective evaluations. Subjective evaluations are expensive, and may need to be reserved for the point where the commercial systems are available.

2.12 DVB-T channels, allocated in the VHF and in the UHF bands, make available, for rooftop reception conditions, a net bit-rate of up to respectively 21 and 24 Mbps for programmes and multimedia services. Digital broadcasts in the Germany and the UK now provide lower net bit rates of 14-18 Mbps to improve reception ruggedness.

2.13 The delivery of new multimedia services in multiplexes used for multi-channel broadcasting could be reasonably expected to require up to 1 - 4 Mbps per multiplex. Thus about 17 - 21 Mbps will be available for linear TV programmes, and this may fall to 11 - 15 Mbps where high ruggedness is needed. Digital audio and SI signals also need to be carried in the multiplex.

2.14 In the above conditions, and for services targeted to CRT home displays, a DVB-T service based on MPEG2 encoding algorithms can allocate 3-5 SDTV programs in each multiplex, assigning an average bit-rate of about 4 Mbps per programme. But, when plasma display panels (or equally demanding) displays significantly penetrate the home user market, at least 8 Mbps for a SDTV program will be necessary to provide predominantly artifact-free quality to standard definition viewers, as explained in I34.

2.15 Therefore, for reasonably artifact-free pictures in the flat panel environment, a maximum of 2 standard definition programmes could be included in each DVB-T multiplex.

2.16 Some years will be necessary for significant penetration of flat panel displays, though some predictions suggest substantial sales as early as 2005. If volume sales occur after the analogue switchover has occurred, further RF channels could be made available for digital broadcasting. At that point, it could be possible for the countries that have already started with DVB-T services, to respond to the quality demands of PDPs by allocating more RF channels for digital broadcasting, and increasing the MPEG2 bit-rate per standard definition program.

2.17 An alternative strategy, now discussed by SVT, would be to introduce a simulcast in high definition targeting WideXGA flat panels, possibly using a more advanced compression system. There are however complex issues in deciding the trade off between quality of service in the sense of picture quality, and in the coverage areas.

3. Observations on the performance of H264/AVC at 576i/25 and the consequences of it

3.1 Expert-viewing quality assessments have been made by the RAI on 42" plasma displays (WideVGA resolution) of 576i/25 images, coded with HHI reference H.264/AVC codec. The assessments used a set of standard EBU/ ITU-R Rec. 601 test sequences with moderate detail and movement, and which could be considered moderately critical. They indicated that on average its quality-efficiency gain of bit-rate over MPEG2 can be more than 50%. The quality efficiency gain does depend on the type of scene content, and does not follow exactly the same criticality parameters as MPEG2. Nevertheless, as a rule of thumb for standard definition television, on average a 2 to 1 saving rule applies.

3.2 Using AVC, the tests showed that each 576i/25 standard definition program could probably be compressed to 3 or 4 Mbps with a quality perceived on plasma displays higher than that available on CRT with MPEG2 at 4 or 5 Mbps. The DVB-T service 'normal robustness' multiplex could then include up to 5 or 6 TV programmes, delivering a multiplex richer than that available with MPEG2. Furthermore, by increasing the number of programmes per multiplex, statistical multiplexing would become more efficient, leading to even more gains.

3.3 However, because of MPEG2 receiver legacy, it may be necessary to simulcast both MPEG2 and AVC. In this case, as currently discussed by SVT, broadcasters might consider introducing high definition using AVC for WideXGA flat panels, and continue using MPEG2 for standard definition targeting CRTs only, as explained later in this report.

3.4 The adoption of a new compression system would require careful management of a difficult transition phase, which may well need to be different for different European countries – taking place at different speeds and taking somewhat different directions.

3.5 At present, MPEG2 is the only compression system included in the ETSI report on base band systems for the DVB-T standard. Today, DVB receivers sold in Europe are only able to decode SDTV MPEG2 video compressed signals, though the DVB standards can be used also for HDTV[1]. DVB is working towards the inclusion of H.264/AVC as an optional encoding algorithm, and it is defining maps of H.264/AVC on MPEG2 transport stream and on IP protocol.

3.6 Future DVB-T receivers could include either MPEG2 plus H.264/AVC decoder; or, in principle, software decoders that could be up-dated by down-loading the appropriate software. This would allow European broadcasters further strategies to adapt to the future penetration of PDPs on the consumer market. One of them could be to consider a transition period using simulcast broadcasting of programmes coded both in MPEG2 and in H.264/AVC, while another could be to wait for the introduction of a DVB-T service until receivers based on H.264/AVC decoders are available on the market. In this simulcast-scenario, broadcasters might consider simulcasting SDTV plus HDTV instead of SDTV plus SDTV.

[1] In Australia both DVB-T SD-STBs and HD-STBs based on MPEG2 have been introduced.

3.7 It is clear that the later the start of digital television broadcasting, the more efficient compression system that can be called upon. However, it is also true that, starting later, a range of other 'first-comer' advantages would be lost, and broadcasters may be out of phase with introductions via other media. Broadcasters face the difficult task of deciding on the optimum strategy.

4. Observations on the performance of H.264/AVC and Windows Media Player 9 at 720p/50

4.1 While the use of new compression systems could lead to improved conventional standard definition services on lower resolution WideVGA PDPs as explained above, it is also necessary to examine the future of HDTV broadcasting targeting flat panel displays. Most manufacturers tell us that in the next five years, higher resolution Flat Panel displays (WideXGA and above) for the general public will overtake WideVGA in production volume, and they estimate that the home demand for HDTV will be fuelled by home HD DVDs. It is therefore important to evaluate the use of the new compression systems in the 720p/50 environment. This is the subject of this section.

4.2 In tests made with EBU specialists, the BBC had encoded three sequences at 720p/50 using the H.264 reference codec version JM4.2, and the Beta release of the Windows Media 9 codec (WM9)[1]. The sequences were *waterfall, pan-slow and swim-reflection*, each of which had been used in the BBC's previous formal subjective tests on MPEG2 [1].

4.3 Interpreting the results of such comparisons is not simple. Firstly, WM9 is commercial software, operating under many additional constraints, whereas the other codecs are not. Secondly, the MPEG2 sequences used constant bit-rate encoding, whereas the other coders used variable bit rate (VBR). H.264 was used with constant quantiser settings, as rate control was not available at the time of encoding. WM9 was used with the single-pass VBR encoding.

4.4 The sequences were viewed at what had been found to be very challenging (low) bit rates for HDTV MPEG2 - the rates where 720p/50 started to perform better in overall quality than 576i/25, the cross over points: 10Mb/s for MPEG2 for *swim-reflection* and 6.4Mb/s for MPEG2 for the other sequences and similar and lower bit rates for the other codecs.

4.5 Despite these caveats, it was possible to draw some broad conclusions on the improvements that H.264 could offer, at least potentially, and the state of WM9 with respect to a known reference MPEG2 point.

[1] WM9 output is normally only available though the WM9 Player by live decoding on a PC screen, but thanks to the assistance of Michael Bohlin of Microsoft UK, the BBC and SVT were supplied with a tool which allowed uncompressed output to be obtained. Hence it was possible to compare the three codecs directly on a plasma screen using HD-SDI digital interfaces.

Comparisons

4.6 Over the three sequences, H.264 seemed to provide 30% - 50% reduction in bit rate for the same quality, but depending on the type of scene content. However, H.264 was marked down for artefacts that it should be possible to eliminate in future implementations. The performance of WM9 was, however, less good, and provided smaller subjective gains over MPEG2 for the bit rates and sequences viewed.

4.7 H.264 had quite different artefacts from MPEG2, tending to remove texture and maintain edges at low bit rates. There was no blockiness or mosquito noise, but the heavily compressed pictures had a plastic quality. Subjectively, improvements were visible on *swim-reflection*, with the movement of the water well represented, yet with edges and detail still sharp: H.264 was better at 7.3Mb/s than MPEG2 at 10Mb/s. On *waterfall*, by contrast, MPEG2 noise and blockiness was well masked by the random textures of trees and rocks, and so even though H.264 was still sharp at 3.8 Mb/s, the complete loss of texture made the picture very artificial. H.264 seemed to suffer from temporal artefacts correlated with the GOP structure, so at low bit rates pictures had a definite pulse as detail jumped about. This may be possible to eliminate by optimising the choice of prediction modes in the coder at very low bit rates. This needs to be solved as it significantly affected the overall quality.

4.8 WM9, at least with the encoder settings that were chosen, was judged to have a more MPEG2-like quality in its artefacts. Whilst blockiness and noise was generally reduced compared to MPEG2, this was matched by regular noise pulsing of a similar sort to H264, perhaps caused by adopting similar block prediction strategies, especially spatial prediction in intra frames. Since the overall gains in terms of edge preservation and blockiness removal were less than H.264, the resulting improvements over all pictures was reduced.

4.9 WM9 will have also many encoder settings - set by Microsoft or an authorised codec implementer rather than the user - and the best ones may not have been selected for the version supplied by Microsoft. However, SVT also reported to the EBU that they have, together with Teracom, obtained similar results by encoding using constant bit rate settings on their own material.

5. Observations on Price Acceptability Thresholds and Timescales for Flat Panels

5.1 The EBU has requested manufacturers of flat panel displays to outline their projections for markets, costs, and supply for flat panel receivers. Such projections are complex because many of the factors influencing the result are outside manufacturer's control – the availability of desirable content and the economic climate. One EBU member SVT has commissioned a study by management consultants in this area, and is sharing relevant and non confidential results with other Members,

5.2 Consumer products of the kind which are successful often follow a particular sales pattern which is defined by a logistic or 'S' curve. Sales follow three phases – modest or low sales until prices fall to a particular threshold, then rapid sales until a saturation point is reached, followed by a slow saturation phase. A critical point is the first 'knee', where rapid sales take over from slow sales. If we can deduce at what price the knee occurs, and when it is likely to occur, we may have some measure of

the likely roll-out of flat panel displays, and of the consequent timescale for action needed by broadcasters to respond to them.

5.3 SVT and others have conducted market research about the relationship between viewer's actions and HDTV flat panel prices, with certain assumptions about content availability. These may provide clues to necessary timetables for broadcasters.

5.4 In Focus Groups totalling 900 individuals, the relationship between price and attractiveness was assessed for WideXGA displays supplied with movie content at a technical quality likely to be achieved with HD-DVD (MPEG2, 1080i/30, 28Mbps). Such HD-DVDs may be the 'driver' for flat panel sales. At a price of 3700 Euros, 10% of the individuals would buy the panel. At 2200 Euros, 50% would buy the panel. Individuals have different price acceptance points depending on their interests and income, but in market research conducted in Sweden, "phase two" of the S curve, when rapid sales start to occur, was at about 3000 Euros

5.5 The projections of the SVT consultants are that the 3700 Euro price for WideXGA will be reached in 2005 and the 2200 Euro in 2007[1]. Prices for WideVGA displays will be lower than for WideXGA, but they may be less of a 'must buy' because the quality available will be closer to the viewers current receiver. Overall, we could estimate that, though many factors and unknowns will influence the situation, flat panel displays could 'take off' (in Sweden at least) in about five year's time.

5.6 The Focus Groups also examined the perception of the flat panel receiver as 'furniture' in the home. 81% found the flat panel more attractive than the CRT as furniture.

5.7 Viewer's perception of quality is partly determined by the context of what they are used to, and what they can mentally or physically refer to. For example, viewers might rate a given quality as excellent if it is the best they have ever seen, but rate it much less excellent if they have just seen something considerably better. Thus, the acceptability of standard definition television broadcasting and the need to broadcast HDTV is determined partly by what else is available from media delivery. The Focus Groups found that where viewers were sensitized to the existence of HDTV quality, their perception of standard definition quality was the equivalent of about two ITU-R grades lower[2].

6. Licensing costs issues

6.1 In choosing new digital compression systems quality efficiency gain has to be weighed against the licensing costs of using it. Broadcasters and manufacturers expect to pay a fair and reasonable licence for technologies used for coding or compression. All technical standards bodies ask those submitting proposals for standards to offer

[1] The prices here refer to ASP (average selling price) to consumers globally. Differences between markets like the US, Eastern Asia and Europe are not shown here. The company that forecast these ASPs claim that the intention is *not* to present any best-case scenario, but a usable forecast based on primary research.

[2] The film "U-571" released to consumers on pre-recorded high definition packaged media (D-VHS/D-Theatre) where it was rated to be in the *excellent-range*. *T*he same content, released on standard definition DVD Video (European Region 2), where rated to be in the *fair-range by viewers who saw both*.

assurances that licences will be available on fair, reasonable, and non discriminatory (FRND) terms. However, there is no precise legal definition of what constitutes 'reasonable' in the concept of FRND.

6.2 MPEG2 licences amounted to 2.5 USD per decoder and 3 cents per disc for DVDs. With MPEG4part4 ACP a new regime was agreed by the consortium of licence holders, the MPEG LA. Their objective was to charge services that make revenue with their codec for time used. Thus in the case of Pay TV and DVDs, there would be a charge of 4 cents each two hours of use for using MPEGPart4, in addition to a decoder charge (though now smaller than for MPEG2). This 'per use' charge may not apply to free to air television, but the EBU Legal Department tells us this is not certain, because digital broadcasts are available for mobile use, which may fall into the 'per-use' category.

6.3 The licence fees for MPEG4 part 10 are still to be decided. There are signs that the 'per use' charge is constraining use of MPEG4Part4. For example, Japanese broadcasters are said to be considering ruling out its use for mobile digital terrestrial television. The licence holders may thus decide for MPEG4Part10 to return to the regime 'per codec' used for MPEG2, which has been very successful.

6.4 Microsoft has announced that they will undercut the MPEG4Part4 and the MPEG4Part10 licences, whatever they are, with their Windows Media Player 9 codec. They have so far announced that terms until 2012. There will be no 'per use' licence, and the charge for each decoder will be 10 cents. Thus Microsoft licence costs are likely to undercut all others. This element would have to be taken into account in decisions about which system to use.

7. Observations on multiplex structure and the exploitation of VBR in HDTV delivery

7.1 The process of re-planning the television broadcast bands in Europe is currently underway to the extent that the requirements for future television broadcasting services are being examined. The re-planning is being made on the basis of allocations of whole digital multiplexes as containers, so the precise nature of the service does not arise directly in the re-planning. Nevertheless, the nature of the service will need to be decided, so that the number of independent programmes can be established and the overall reasonableness of the new plan can be judged.

7.2 EBU Member SVT has been establishing how the multiplex capacity could be optimised if services were to include those targeted to WideXGA (or higher resolution) receivers. SVT used a multiplex with the total capacity of 22Mbps. This is available as the service is intended for fixed receivers with rooftop aerials, rather than to portables.

7.3 SVT used a 720p/50 signal with a peak bit rate of about 15Mbps. The HDTV signal instantaneous bit rate varies with programme content, and there is considerable scope for opportunistic data in the multiplex which can be used for multimedia. The space for MHP multimedia was arranged to be never less than 1.8Mbps, but usually bit rates several times as large were available via the opportunistic data.

7.4 The multiplex also included a SDTV version of the same service to serve legacy MPEG2 SDTV CRT receivers. It was found best to give this a constant bit rate of 4.5Mbit/s.

7.5 The multiplex also included DD surround sound (AC3),an MPEG1Layer II stereo signal (to serve legacy SDTV - receivers) and an audio service for visually impaired, an audio set which it is envisaged would serve *both* the HDTV and SDTV viewers at the same time. This will require synchronisation measures.

7.6 This multiplex has been demonstrated to opinion formers in Sweden.

8. Potential quality deterioration in cascaded HDTV codecs and DVTRs

8.1 While the performance of individual codecs can readily be evaluated, it is more difficult to see what may happen in circumstances where codecs are cascaded. This is a normal and necessary element of the broadcast chain, so it is important to build in 'headroom' in the choice of codec parameter values, to allow for the cumulative effects of impairments that may occur with cascading of the same or different types of codec.

8.2 Different types of compression and channel introduce different types of impairments, and these cumulate in complex ways. Nevertheless, some assessments have to be made of the degree of headroom needed to allow for cascading. Such headroom should take account of the needs of final viewing on flat panel displays.

8.3 For a broadcast chain which culminates in standard definition television broadcasting, using Rec. 601, studio compression at 50Mbps seems to give adequate headroom, and experience is that it is a cost effective choice for Rec. 601 in the standard definition environment.

8.4 Evidence to date suggests that a 'scaled up' compressed bit rate will be needed for the HDTV production environment, and this might be expected to be about 200Mbps. Current digital HDTV camcorders use much lower bit rates. These may produce adequate 'one pass' picture quality, but will probably be inadequate when extensive post production is performed with multiple generations.

8.5 Studies at SVT have also suggested that conversion between 1080i and 720p can be performed well with professional standards converters. The finally seen quality is affected when producing critical material in an interlaced format for later delivery in a progressive format, but for less critical material, the final pictures can be transparent compared to both production and delivery in 720p/50.

8.6 Further studies at SVT have shown that SDTV to HDTV up-conversion with professional equipment prior to transmission in an HDTV channel produces clear gains in quality compared to delivery in an SDTV channel of the same material. The professional up-converter can reduce the difference between HDTV originated source material and originated SDTV source material, by about one quality grade. In other words it can, in a best case, and depending on the delivery bit-rates, close the gap between normal SDTV quality and HDTV by nearly half.

8.7. However, none of the existing standard definition VTR-formats (from 50 Mbps and above) when professionally up converted to high definition, nor uncompressed Rec.601 itself, matched [1] natively produced high definition. SVT suggests that standard definition archives, except 35mm film and native HD-productions, could be acceptable for rerun programming, but will not be optimum if targeting WideXGA (or better) panels with 720p/50 delivery.

9. Observations on the Australian model for digital terrestrial broadcasting for Europe

9.1 In Australia, digital terrestrial broadcasting had its official launch in 2001. The intention of the Australian government, based on the wishes of the incumbent broadcasters, was to provide HDTV services. A delegation of EBU Members recently undertook a study mission to Australia to see if lessons could be learned for Europe.

9.2 The approach adopted by the Australians has, thus far, brought only a relatively slow take-up of digital receivers domestically. Encouragingly, the majority[2] of digital receivers sold are HDTV-receivers, although HDTV programme production can only be called modest. Mandatory HDTV quotas of 1040 hours annually, planned since the start of services, will finally be introduced in July 2003.

9.3 One feature of the Australian landscape is that commercial digital terrestrial broadcasters are required to 'tripplecast'. They must broadcast the same programme in analogue conventional form and in the same digital multiplex both an HDTV version and a standard definition version of the programme. Squeezing both HDTV and conventional quality into the same multiplex using MPEG2 compression with good quality (non film) pictures is a challenge, as Australia uses 7 MHz channelling in both the VHF- and UHF-spectrum.

9.4 A number of HDTV formats are allowed, but the two actually in use are 1080i/25 and 576p/50. 720p/50 is allowed but not used. 576p/50 is the easier to compress than 108i/25, and can fit well in a multiplex. 1080i/25 suffers from the lower compression quality efficiency, and loss of detail in movement, though it has higher horizontal and vertical resolution[3]. To reduce the delivery artefacts, when broadcasting 1080i/25, the horizontal resolution before encoding is reduced from 1920 to 1440. There are few basic models of HD-monitors on the market except expensive flat panels, but a roll out of less expensive CRTs is planned for spring of 2003 - CRT's that will convert the incoming 1080i/25, 720p/50, 576p/50 or 576i/25 to a common[4] horizontal scan rate of 31.250 kHz and 25 Hz interlaced vertically.

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[1] An expert group at SVT estimated, in an informal subjective study that professionally up converted uncompressed Rec. 601 for delivery as 720p/50 retained a difference of at least *one grade* in average as compared to natively uncompressed originated 720p/50 delivered in the same way.

[2] Only 35 000 Set Top Boxes were sold by the end of 2002, of them where 18 000 "HD-STBs" that can receive and convert both HD- and SD-services. Ref, Mr. Tim O'Keef, Digital Broadcasting Australia www.dba.org.au

[3] 1080i/25 is an interlaced format with 1920x1080 square pixels. 576p/50 is a progressive format with 720x576 *non square* pixels. Both formats have a 16:9 aspect ratio only.

[4] This "Consumer HD CRT Display Mode" for a common 31.250 kHz / 25 Hz interlaced is described in the Draft Revision of Australian Standard AS 4933-1 200x. The intention is that the (CRT) user-enabled conversion should occur in the digital domain inside the HD-STBs before their analogue "CRT-friendly (31.250kHz) outputs". The mode is not intended for flat panels.

9.5 It is possible to observe that Australia is not in a favourable position to exploit WideXGA flat panel displays because of the restricted bit-rate and thus modest broadcast quality possible on critical 1080i/25 content. There is, in principle, no legacy-problem with HD-STBs with a change to 720p/50-delivery, as HD-STBs already cope with all four formats (1080i/25, 720p/50, 576p/50 and 576i/25). Alternatively the situation might be improved by ceasing digital transmission at standard definition and allocating the entire available bandwidth to the 1080i broadcast, or by allocating more transmission spectrum. Unfortunately, they are unable to use one of the new more efficient compression systems for HDTV, because of the legacy of MPEG2 receivers. By being the first into HDTV in the 50Hz world, they might have had first comer advantages, but possibly at the cost of drawbacks in years to come – though this would have been unpredictable when services were planned. Developments in China in the next few years, as well as the situation in Europe, will determine whether Australia remains the only country in the world using 50 Hz high definition interlace broadcast standards based on MPEG2 compression.

10. The evolution of the packaged media landscape

10.1 The evolution of packaged media will influence public demand and expectations for picture quality and displays. Although broadcasters are not directly involved with this part of the media industry, they need to be aware of what is happening in setting their own strategy.

10.2 There are a range of initiatives from different companies to release DVD systems which provide higher quality than today's conventional DVDs – even though these conventional DVDs in themselves can deliver picture quality higher than today's standard definition digital broadcasts, and adequately match the quality potential of the WideVGA display.

10.3 One system, proposed by one of the Hollywood studios, is termed HD9. This uses the existing red laser dual layer DVD disc technology (DVD9), together with more advanced compression and a higher bit rate. There are hopes to launch discs for Christmas 2003, but at this time we have not yet heard of plans for HD9-players to be produced in volume.

10.4 A second system is the 'Blue-Ray Disc' which is a similar size but new physical form leading to over 20GB per layer. This provides up to 36Mbps for video, using MPEG2. The disc is contained in a protective cartridge. A large grouping of manufacturers supports this format, including LG, Panasonic, Philips, Pioneer, Hitachi, Samsung, Sharp, Sony, and Thomson. It is initially intended for home recording and time shifting. First model is set for release in Japan in April 2003. The system includes DRM features, and the first model also plays CDs and conventional DVDs.

10.5 A third system is the Advanced Optical Disc from Toshiba (and backed by NEC). This has the capacity to record up to 15GB per layer via a blue laser. Its advantage is that existing replication equipment can be used for the discs as it is not contained in any protecting cartridge.

10.6 A forth option is the D-VHS cassette. This provides fixed 28Mbps on backwards compatible cassettes using MPEG2. Though not a 'disc' format, D-VHS/D-Theatre has the immediate consumer advantage that pre-recorded Hollywood-titles in high definition, because of its DRM-feature, have been released continuously since summer 2002.

10.7 An option, for the D-VHS owner, is the JVC 720p/30 camcorder system, which is intended to allow home users the capacity to create content in HD. The output is edited via a bundled PC-software that converts the result to 720p/60 or 1080i/30 to finally be recorded on the D-VHS recorder.

11. Future tools for compression

11.1 Video compression is currently a moving field, with advances recently in both coding tools and in encoder optimisation. If High-Definition (HDTV) broadcast services are not needed in Europe for some years, new coding technologies and standards will be available to choose from.

11.2 While H.264 is a very powerful coding standard feature-wise, its gain over MPEG2 at HD does not match its gain at lower quality levels[1]. The performance of H.264/AVC codec's at higher resolutions will be improved, but over a timescale of 10 years, it is possible that standards exhibiting greater scalability, as well as even better performance, will be available.

11.3 In this context, there has been considerable work in academic coding circles on wavelet coding technology, which offers an intrinsically multi-resolution coding technology, and therefore the opportunity for fully scalable coding. The difficulty with creating a truly scalable codec lies in extending the multi-resolution features of the wavelet transform to representing motion vectors in a multi-resolution way. In 2001, sufficient advances had been made in developing systems to justify MPEG initiating work groups first on Interframe Wavelets, and then Scalable Video Coding (SVC). Recently, the group has issued a Call for Evidence for scalable video coding systems, and has been developing a test methodology.

11.4 The development of compression technology is fuelled by internet streaming, in which video is decoded in software; this allows codecs to be upgraded as technology improves without the legacy bottleneck of hardware decoders. The current generation of digital television services do not have this advantage, but future PC platforms could certainly be capable of real-time decoding of SDTV and HDTV pictures, even for very sophisticated compression algorithms.

11.5 The scope for involvement in digital TV delivery of software vendors and telecommunications providers will only increase over time. HD services may not be delivered in the way SD services are now delivered, with standardised codecs over traditional broadcast media, decoded by a specialised piece of hardware and delivered to a specialised TV display. There probably may no longer be a fixed relation between

[1] CIF or QCIF quality.

the amount of lines/resolution sent - and the lines/resolution viewed in the receiving end.

11.6 The evolution of compression should be seen in the same light as that of programme production is today - as a two stage transition. The first being from 'analogue to digital', and the second being from 'digital to software'. Broadcasters need to recognise this in their long term strategy.

12. Conclusions

12.1 Preliminary tests have shown that H.264 compression will produce higher quality efficiency than MPEG2 compression, at all quality levels, and needs to be seriously considered for any new digital broadcast services. However these are early days in the maturity of the system, and more time is needed to quantify the potential gains and understand the potential of the system. The WM9 compression system has been examined at HDTV level and was found to offer important gains but be less efficient that H.264 in the form tested, though better than MPEG2.

12.2. A range of additional dimensions have been examined, including the price threshold for volume sales of WideXGA displays, and the time before such prices are reached. The information available at this time, based on studies in Sweden, is that the critical price threshold of 3000 Euros may be reached between 2005 and 2007. The report also summarises the situation on codec licensing costs, and makes observations on possible multiplex structures, and cascading of codecs intended to eventually serve flat panel displays. The report also examines the Australia model of digital terrestrial broadcasting, and concludes that it may not be well placed for the flat panel environment. Finally, the report averts us to the potential for further improvements in codec efficiency in the years ahead through the use of wavelet technology.

12.3. This second report, following I34, provides more information for EBU Members that should be helpful in responding to the emerging flat panel environment. However, the work needs to continue on a range of issues. These include seeking more information about roll outs for flat panel displays, and the arrangements that need to be made by broadcasters for maximising viewed picture quality with programme production using Rec. 601 and HDTV.

References

[1] EBU Technical Report I.34, ‘The impact of flat panel displays on broadcast delivery of television’, June 2002.