EBU Technical Information I39-2004
Maximising the quality of conventional quality broadcasting in the flat panel environment

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SUMMARY

The broadcasting environment is changing because of digital technology. Further changes will be needed soon if flat panel displays become widely used in home receivers. The quality demands of large screen flat panel receivers will call for new care and attention from broadcasters in providing 'conventional' quality television. This report is intended to help broadcasters understand the factors which affect quality in this new world, and offer suggestions for ways of maximising the finally received quality.

Section 1 is an introduction to the new environment. Section 2 is a list of some of the key action points broadcasters need to consider. The Appendix gives more background on what can be done.

1. Introduction

The changing environment

1.1 As screen sizes become larger in the home, defects in television picture quality become more noticeable - and more annoying - for the viewer. Display technology is changing from the CRT to LCD or AC-PDP flat panel displays. These types of displays, particularly AC-PDP, mask picture impairments to a lesser extent than CRTs, and thus, compared to CRT displays, are apparent magnifiers of impairments. Television broadcasting is moving to an age where high picture quality will be more important.

1.2 EBU Members have broadcast in PAL/SECAM for the last 40 years; and, in recent years, digital broadcasts have used the MPEG2 digital compression system. The picture quality of an MPEG2 delivered channel depends on many factors, but a limiting factor is the channel bit rate. Most European broadcasters use bit-rates of 2.5 – 5.0 Mbit/s. For a number of reasons, there are circumstances where the programme’s picture quality cannot be delivered well to the viewers of flat panel displays[1]. EBU Members need to review the way they make and deliver television in the light of the new age of displays, and at some stage they will need to improve the picture quality available for viewers with flat panel displays.

[1] See EBU Technical Texts, I34 and I35.

1.3 In responding to the new age of large displays, broadcasters may decide to introduce high definition broadcasting. This scenario may be the most far-sighted. However, it is not the subject of this document. The issues associated with a change to HD delivery are considered in another EBU document, I40. This document, I39, is concerned with steps that broadcasters may take for services which remain with what is considered 'conventional quality television'. *The purpose of this report is to outline options open to public service broadcasters, and to suggest elements of operating practice, that will help to achieve the highest quality possible from existing digital broadcasting infrastructures.*

1.4 Studies conducted within the EBU over the past two years[1] have suggested that, as a first approximation, more critical kinds of scene content will need to be delivered in an MPEG2 conventional channel (with currently available encoders and decoders) with a bit rate of 8-10 Mbit/s, to appear good 'conventional'[2] quality on large screen flat panels. This is a rule of thumb for ensuring high quality for all types of content for digital delivery in the flat panel age, though it is not needed for all types of picture-content found in average programmes.

1.5 If bit-rates adequately higher than used today are possible for conventional quality television broadcasting, a major part of the potential limitation on flat panel quality is removed. This is the step that will have most effect on critical content impairments. But whether it can be raised or not, there are steps that can be taken to make the best of the situation. There are 'good practice' steps, worth taking, whatever the bit-rate limit available. These are the subject of this document. The first remedy for flat panel impairments is higher broadcast bit rates. However, whether to ensure there are no other quality bottlenecks before the encoder, or to make the best of a less than ideal lower broadcast bit rate, the steps in this document should be considered.

1.6 In time, practical experience will be available from Members on bit rates needed and measures needed, which can be shared. In the meantime, broadcasters should evaluate the extent to which they can adopt the measures suggested in this report. **Furthermore, they should consider setting organisational broadcast picture quality targets for digital television**. Having a benchmark will make it possible to evaluate the costs of improvement, and allow broadcasters to plan the appropriate measures needed to achieve improvements

2. Recommendations for best practice

2.1 Thorough research on relative performance should be done before buying MPEG2 encoders. It will be good investment. The state of the art needs to be reviewed frequently.

[1] EBU Technical Texts I34, I35.

[2] Good high definition quality, using MPEG-2 compression, needs 15-22 Mbit/s depending on scanning format and acceptable level of degradation from uncompressed high definition quality.

2.2 If the service is a 'green field' with no legacy receivers to serve, consider using codecs more modern than MPEG2. Make buying the encoder the last thing you do before the service starts.

2.3 Check if the picture quality limits due to the delivery mechanism match the quality limits possible in programme production. If the delivery mechanism is a significant constraint on quality transparency across the chain, programme makers may be wasting their investments in programme production. Our public service mission calls for technical quality which does justice to our high programme quality.

2.4 Take great care in the broadcasting chain to ensure end to end high quality 4:2:2 signals, and never allow the signal to be PAL coded or SECAM coded.

2.5 If possible, preserve 10 bit/sample values, rather than 8 bit/sample values, for the components in the 4:2:2 signals through the program production and broadcasting chain.

2.6 Explain to production staff what kind of production grammar (shot composition, framing and style) will lead to poor quality on large flat panels. Encourage and train them to avoid high entropy - unless you can use higher broadcast bit rates.

2.7 Encourage flat panel receiver manufacturers to develop high quality standards conversion and scaling electronics, and advise the viewing public about which are best flat panel receivers.

2.8 For mainstream television programme production, in compressed form, use no less than 50Mbit/s component signals.

2.9 Do not trans-code between different analogue or digital compression schemes, and use signal exchange technologies such as SDTI and File Transfer which handle compressed signals in their native form.

2.10 If noise reduction is required it should be introduced before encoding. However, noise reducers should be used with caution after a careful consideration of the following sections in the Appendix: A1.6, A2.5, A2.6, A2.19, A3.3 and A3.5.

2.11 Set clear organisational broadcast quality goals, and use the professional skills of your staff to keep to them.

APPENDIX A

MORE DETAILED EXAMINATION OF OPTIONS FOR OPTIMISING CONVENTIINAL QUALITY IN A FLAT PANEL ENVIRONMENT

The way compression systems work

A1.1 Before outlining the measures in more detail, it is useful to review the way digital compression systems work. While yesterday's analogue compression system - 'interlacing' - applied itself in exactly the same way to any kind of scene content, digital compression systems adapt themselves to the scene content. This makes them more efficient, but also it makes describing the way they perform more complex, and identifying ways to optimise quality more complex. But, worthwhile good-practice elements can be identified if care is taken.

A1.2 The key element of picture content that affects the way compression systems perform is the degree of detail and movement in the scene (sometimes called ‘entropy’). It is mainly this that determines how taxing the scene is for the compression system. Scenes with less detail and movement are 'easier' to compress, in the sense that the input is more closely reproduced at the output, and the reverse is true for scenes with much detail and movement. The detail is the total over the whole picture, rather than in parts. The point where 'easy to compress' become 'difficult to compress' is determined by the delivery bit rate limit. When the scene is difficult to compress, the compression system introduces impairments of its own in the picture ('compression artefacts').

A1.3 Programme makers need to understand the different types of scene content and they way they behave in compression.

A1.4 The most difficult or taxing scenes to compress are those containing high detail and movement over the whole scene. The most taxing or 'stressful' type of content is usually material shot originally with video cameras with scenes which have an elaborate 'canvas'. This usually means sports events or light entertainment. These are the kinds of programme that will look worse on the new displays at relatively low bit rates, because the compression process will introduce its own impairments into the picture unless the bit rate is high enough.

A1.5 The easiest or least taxing scenes to compress are usually, but not always, cartoons or those shot on celluloid film at 24 pictures per second. This usually means fiction/drama or documentary material. Movie material will usually look ‘good’ on new large screen displays at low bit rates because the compression process is least likely to introduce artefacts of its own - though film grain can make compression more difficult if it is present, as explained later. The higher the field or frame rate, the higher the entropy. For the same camera shot, 50Hz field rate interlaced television scenes are easier to compress than 60Hz field-rate interlaced television.

A1.6 Unfortunately 'noise' or ‘grain’ in a picture, which may be unintended and unwanted, can also be interpreted as entropy by an encoder, and can thus 'stress' the encoder and lead to impairments. The encoder has no way of knowing whether detail is desirable or undesirable, so noise or grain contributes to the overall entropy of the picture. Though impairments to noisy pictures which are themselves 'noise-like' may be masked by the noise itself, they can be the cause of impairments in desirable parts of the picture. 'Clean' pictures win twice **-** they are better to look at, and they are easier to compress.

A1.7 Apart from noise itself, creating a ‘PAL’ or ‘SECAM’ analogue picture leaves a certain technical ‘footprint’ on the picture. This footprint can pass unnoticed when a viewer first sees the picture, but it can also be interpreted by the digital compression as more entropy. For PAL, the footprint takes the form of fringes around objects. Thus, PAL pictures can be ‘stressful’ for compression. Note also that analogue PAL broadcasts can look poor on flat panel displays[1]

The notion of 'headroom'

A1.8 When deciding on the adequacy of a set of technical parameters of a television signal, it is important to remember that this is not just related to **the basic picture quality** as it is then seen. The adequacy is defined by the sum of the picture quality as it is there and then, and **'headroom**' which is included in the signal parameter values. These are technical elements which are, for the moment, not immediately visible, but which will become useful or visible later in the broadcast chain, after the programme has undergone further processes. They are a *safety factor against impairments*. Precautions mentioned below often amount to building in the highest safety factors practical to allow for the many stages of processing the signal has to go through.

The role of sound

A1.9 The perceived quality of a television programme is influenced by the presence or absence of sound, and by the sound quality. The presence of sound appears to have an effect rather like distraction on viewer's perception of picture quality. The goodness of the sound quality is carried over, in their mind, to the picture quality. Take care of the sound and, within the limits of home equipment, you help image perception too.

Quality and Impairment factors

A1.10 Picture quality is considered to be made up of a range of ‘quality factors’ which affect perception of the quality. These are elements like ‘colour fidelity', ‘motion portrayal’ (picture rate and scanning format), contrast range, and others. It is the combination of the affects of all of them which defines the picture quality.

A1.11 In addition, for convenience we consider there is a range of 'impairment factors' which also can contribute to picture quality. These are similar to quality factors, but the term is used for impairments added by compression systems or coding. These are elements like 'quantisation noise', 'static or dynamic ringing (mosquito noise)', 'temporal flicker', and 'blockiness'. Sometimes non technical analogies are used to describe these – for example, the 'heat haze' and the 'ice cube' effects. These are the impairments which

[1] see EBU I34/I35.

most arise when the bit rate is too low for the degree of detail and movement in the scene.

A1.12 The process of coding often involves balancing quality factors against impairment factors. Quality factors include those which increase potential entropy – definition and motion portrayal. At the same time, these are the elements which can induce impairment factors to 'kick in' because the compression system is over-stressed. The process of optimising the end-to-end broadcast chain can often be that of finding the best balance between these two forces which affect picture quality after a compression system.

The broadcaster's objectives

A1.13 Broadcasters will always want to broadcast their material at the lowest possible bit rates they can successfully use. Channel bit-rate is a precious resource which can be used for more multimedia or more programme channels. Broadcasters need to develop their end-to-end arrangements in the broadcast chain to use lowest bit rate delivery consistent with acceptable picture quality, or with other constraints.

A1.14 To achieve the objectives of individual broadcasters, optimising their broadcast chain for the flat panel environment in 576/50/i (conventional quality) delivery, need to be twofold.

a) To deliver, to the final MPEG2 encoder, pictures which have the minimum entropy possible, taking into account the programme maker's intention, and the impact the pictures have.

b) To use MPEG2 encoding arrangements that will result in the minimum coding artefacts being introduced into critical high entropy content.

Suggestions for a) above are considered in *Section A2* below.
Suggestions for b) are considered in *Section A3* below.
Section A4 below looks at ways receiver manufacturers can improve the perceived quality by features in the receiver.

These can be discussed separately for convenience, but the broadcast chain as a whole needs to be considered. Measures taken in production and delivery need to be proportional. There is no reason to take special care with production if poor arrangements are used for encoding, and vice versa.

A2. Production and contribution arrangements to maximise quality

Quality is more than technical parameter values alone.

A2.1 The perceived technical quality of a television picture is not just a matter of the technical fidelity of the picture, and the lack of impairments in it. Our impression of picture quality is also determined by our interest in the scene. This means that picture quality is influenced by the professional skills in shot framing and scene composition of the cameraman and editor in the production process.

A2.2 The ‘quality factors’ (see Section A1 above) of the scene are also influenced by the professional skills of the cameraman and editor. These are responsible for elements such as colour balance, colorimetry, lighting and the effects on contrast and noise. Control and care not only reflect on the impact of the pictures but also upon the entropy of the pictures.

Capture

A2.3 Production staffs need to have the final delivered quality in mind. There are two main areas to consider. The first is the impact that shot composition, framing and style (sometimes called ‘production grammar’) and lighting and camera settings may have on picture entropy. The second is the influence they may have on noise or grain levels in the picture.

A2.4 Production ‘grammar’ influences, among other things, how much visible detail and movement there is in the picture. Camera pans and zooms over detailed areas should be avoided to the extent acceptable in the production's context. Camera tracking is (for our technical purposes) better than panning. Shooting with lens settings that lead to short depths of field, and thus low detail in background, and hence lower entropy, may reduce encoding artefacts in the received picture.

A2.5 Production lighting, camera settings, and types of equipment can influence the noise level in the picture. Low lighting with high gain settings should be avoided. Although it may not be noticeable to the naked eye, the signal-to-noise ratio is deteriorated - there is less 'headroom' in the signal.

A2.6 To improve picture sharpness the camera processing introduces 'aperture correction' and/or ‘contour/detail’correction which amounts to boosting the high frequency end of the spectrum. By improving picture sharpness it also makes the signal-to-noise ratio worse. In addition, the ‘thickness’ of the ‘contours’ is magnified and hence more unnatural when viewed on a large flat panel, at a shorter viewing distance at home. Aperture/contouring correction should be used with caution in any camera. In low cost cameras (i.e. DV camcorders) the correction circuits are often not as well designed as they could be (to lower costs), and their use should be avoided. In these cases it is better to apply any indispensable ‘peaking/sharpening’ using subsequent high quality processing equipment.

Since aperture- and detail correction also corrects for (lack of) ‘lens sharpness’ the best possible lenses should be used to minimise the need for these corrections.

Processing

A2.7 Pure ITU-R BT.601 production with no compression will produce the best quality to be delivered to the encoder. This may well be impractical.

A2.8 4:2:2 sampling structures should nevertheless be used throughout the production process.

A2.9 The use of helper signals such as the 'MOLE'[1] which carry information on the first application of compression 'coding decisions' along the production chain could in principle be useful for maintaining quality in production. In practice, we have not been able to identify an organisation which has been able to successfully apply them. These technologies are arguably most useful when very high levels of compression are used, rather than the low levels usually used for production. Furthermore, it is difficult to pass the MOLE signal entirely error free through the production process.

A2.10 In the production chain, multiple decoding and recoding of compressed signals must be avoided. Compressed video should be carried throughout production in its 'native' compressed form (i.e. as it first emerged from the camcorder).

A2.11 For real time transfer via the existing SDI infrastructure, the Serial Data Transport Interface (SDTI, SMPTE 305) should be used.

A2.12 For file transfer, the MXF file format should be used as it provides standardised methods of mapping native compressed (and uncompressed) Video and Audio 'essence' (e.g. DV/DV-based, MPEG-2 Long GOP, D10 etc).

A2.13 Compression in mainstream television production to not less than 50Mbit/s, as explained in EBU Technical Text D-8-1999 (use of 50Mbit/s compression in television programme production), should be used.

A2.14 When higher compression rates and low bit rates are necessary for high content value news contributions, a long GOP should be used. Compression systems more efficient than MPEG2 for news feeds could be considered.

A2.15 If, in the overall chain, multiple codecs cascading cannot be avoided, then at least similar encoding and decoding devices should be used to minimize quality loss.

A2.16 For file transfer of programme material in non real time, the original or native compression system should be used at 50 Mbit/s or higher, I-frame only .

A2.17 Broadcasters are converting to file/server based systems, and though ever larger storage is possible, these do not have infinite data capacity, so today some form of compression will be needed. The bit rate of the compressed signal should not be below 50 Mbit/s. Do not use editing/storage equipment that has its own internal compression scheme different from the 'native' one used in the capture camcorder.

A2.18 It may be absolutely necessary to use noise reduction. If so, this should be performed before the first compression process. Noise reduction should not be introduced in the middle of a series of concatenated compression systems.

HD production for conventional quality television

A2.19 HD production which is down converted to 576/50/i gives very good quality, particularly if the HD is progressively scanned (e.g. 720p), but also if the HD is

[1] See doc. SMPTE 327.

interlaced (e.g. 1080i). This is a very effective way to prepare high quality 576/50/i material. There are additional benefits because the material can be archived at HD and used in future years when there are HD broadcast services. Material captured using cameras operating on an interlaced standard includes spatio-temporal aliasing virtually 'burnt in' to the picture. If 1080i material is down converted to 576i much of the burnt-in alias is lost, consequently the signal is a cleaner and easier to compress in the 576i signal domain. If the production is 720p originated, the alias is absent, so the 576i signal produced can be even cleaner than that sourced from 1080i.

Broadcasters that make HD productions are advised to achieve the produced material in the same format as the production format. Although it might not be practical to archive a 720p or 1080i signal in base-band uncompressed form, a compressed bit rate at 720p or 1080i should be chosen that will still provide sufficient quality headroom for future repurposing and post productions. Further studies on this subject are required.

Wide aspect ratio

A2.20 The use of aspect ratio should ideally be controlled in such a way that the best quality result is obtained, though the scope for using different aspect rations will depend on the organisation’s broadcast policy. However, whatever arrangements are used for shoot and protect areas, 16:9 productions should be shot in the 16:9 production format (‘anamorphic 16:9’) and not as a letter-box inside the 4:3 production format.

A2.21 Semi professional (consumer) cameras normally provide only 4:3 aspect ratio sensors but some of them utilise in-built signal manipulation to give 16/9 aspect ratio. Experience has shown that these camera-internal manipulations should not be used. If needed for wider aspect ratios in post-production, a high quality professional converter should be used, extracting the area of interest.

PAL/SECAM signals

A2.22 Do not use video signals that have been at some point analogue composite coded. The quality headroom is already lost, and nothing can be done to retrieve it. Furthermore, PAL coding adds unwanted artefacts to the picture (sub-carrier fringing effects, and luminance/chrominance cross effects) which can consume compressed bit rate because they are interpreted as valuable picture entropy.

Primary distribution

A2.23 The input to primary distribution should use MPEG2 MP@ML encoding for transmission. It is important that encoders of a very high quality perform this encoding process, and that the highest possible bit rate is used. Statistical multiplexing should be used if more than two programmes are being distributed in the same stream.

The final quality check

A2.24 Production or technical staff should always check during production a version of their programme which is compressed to the level used for broadcasting, on a large screen display. This is the only way to be sure about the picture quality. This care will pay off in the long term. This check is probably not needed if broadcast bit rates of 8-10 Mbit/s are being used for broadcasting.

A3. Delivery channel arrangements to maximise quality

Choosing an MPEG encoder

A3.1 The MPEG compression family is arranged specifically to allow encoders to evolve and improve. Only the form of the MPEG2 decoder signal is specified, and as long as the signal received conforms to that, the encoder can be as simple or sophisticated as it needs. The system is also intended to be ‘asymmetric’, in the sense that the decoder system is simple, and complexity is loaded into the encoder.

A3.2 There are a range of technologies available for pre-processing and post processing in MPEG2 (and other) encoders. Pre-processing algorithms essentially filter the image before or during compression. This improves the performance by simplifying the image content. Post processing algorithms identify and attenuate artefacts that were introduced into the encoder.

A3.3 Noise and other high entropy elements 'stress' the encoder and generate impairments, but over-application of pre-processing, de-noising and filtering will blur the picture. The best quality will be obtained by the best balance between the two.

A3.4 More effective pre-processors and noise reducers are obtained by 'loop filters' and de-blocking processors, within the encoder and the decoder. Indeed these techniques are included in more recent codecs such as H.264. They are not included in the MPEG2 system which is used today for digital broadcasting at conventional quality.

A3.5 Noise reducers and pre-processors can be used in MPEG2 systems before the encoder. They can be separate from the encoder or controlled by it. In the first case, the user him or herself can adjust the weight of the pre-processor and noise reducer to obtain the best picture quality in a set up stage, even changing them scene by scene. This cannot usually be done 'live' in real time. In the second case the encoder selects their weight of the pre-processor and noise reducer by measures such as 'buffer fullness' (which is related to entropy). The second approach could be more effective than the first because changes can automatically be made at small time intervals, but this may cause resolution pumping as an unwanted side effect.

A3.6 The performance of MPEG2 commercial encoders has improved dramatically since MPEG2 was standardised in the mid 1990s. As a generalisation, and on average, the performance has improved by 5-10% a year over the past six years, and overall the performance has improved by about 40%. Thus, the MPEG2 encoder should be the last item of equipment to buy when starting digital broadcasting. The very latest models should be used, and the encoder should be periodically replaced to take advantage of improved performance.

A3.7 The performance of MPEG2 encoders also varies significantly from manufacturer to manufacturer. Variations in performance of equipment available at any given time can be as much as 30%. Users should evaluate all available encoders, either with their own tests or based on reports of the experience of others. As a rule of thumb, across the broadcast chain, the same type of MPEG2 encoders provides better overall quality than a mixture of types.

A3.8 'Two pass' MPEG2 encoders offer higher encoding efficiency than 'single pass' encoders, but they suffer higher encoding delay. They can be up to 20% more quality efficient than single pass encoders, and should be used where the delay is not important.

A3.9 Statistical multiplexing increases effective encoding performance[1]. The gain is higher in multiplexes of many programmes, but it is still useful in multiplexes of only 3 or 4 programme channels. The unchecked application of statistical multiplexing can lead to impairments when particular combinations of content entropies occur. To reduce the effects on premium content, different priority levels can be applied to different programme channels. In this case, a request for bit rate from a high priority channel will be satisfied before requests from low priority channels.

The new NHK MPEG2 encoder

A3.10 EBU Project Group B/TQE has recently tested a new MPEG2 encoder developed by NHK, the Japanese Broadcasting Corporation, principally to improve the quality efficiency of compression of 1080/60/i HD signals. The system uses adaptive selection of picture structure to optimise the encoding and reduce the amount of signalling needed for motion compensation. This leaves more data free for coefficient data. Thus a given data rate can deliver a higher quality. Tests made by NHK show major benefits for 1080/60/i compression. The bit-rate needed for impairment-free delivery falls from about 22Mbit/s (an NHK measured bit rate which agrees with EBU tests) to about 15Mbit/s – an improvement of 25-30%.

A3.11 In principle, the same techniques can be applied to any other scanning format, interlace or progressive. NHK kindly helped the EBU group to evaluate the new technique working with 576/50/i material. The technique brings less saving at conventional quality, because less of the overall bit rate is taken up with motion compensation signalling than for 1080/60/i. The results suggested that on most (but not all) critical material, the techniques saved about 12% bit rate. This is definitely worth gaining, and thus EBU Members are encouraged to look for encoders which use this technique[2].

Using new compression systems

A3.12 If it is a 'green field' service, new services could be launched using one of the new more efficient compression systems. These are MPEG4 Part10, and the Microsoft VC-9. Both are significantly more quality efficient that MPEG2 at conventional quality levels. Tests made by the RAI suggest that savings of 50% could be made at

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[1] See EBU Technical Text BPN 037.

[2] Adaptive field/frame picture structure, motion vector detection scheme which minimises transmission data.

conventional (SDTV) quality, even with the early implementations of MPEG4 Part10. Full tests have not yet been made with VC-9, but the savings are likely to be somewhat less though still significant. There is no guarantee that they will be included in commercial set top boxes, and if broadcasters wish to use the new algorithms they will need to convince manufactures to make receivers using them.

A3.13 The license costs of using these two systems are not yet entirely certain and this needs to be checked by potential users.

A4. Receiver arrangements to maximise quality

Flat Panel Technologies

A4.1 A major design problem for Plasma Display Panels (PDPs) has been arranging for good motion portrayal. Colour fringing can become visible because of the pulse-width-modulated greyscale used, which is typically limited to an 8-bit linear depth. In fact, 12-bit depth would be needed for transparency near black. There is also a difficult trade-off to be made between panel life-time, and settings for brightness and contrast. High brightness reduces lifetime but makes the display attractive at the point of sale. Improved contrast can also only be achieved at the cost of reducing brightness.

A4.2 The advantage of PDPs over LCDs has been the ease of making physically large size panels. High resolution was more difficult to achieve in PDPs, and this was reflected in the wide initial availability of 480-line panels of around 40-42 inch diagonal, and subsequently 768-line panels, usually around 50 inches in size. Only now are 1080-line HD-resolution PDPs being demonstrated in prototype form, and only at sizes over 50 inches.

A4.3 LCD technology has the ability to provide, more readily, displays of higher resolution. LCD technology is likely to dominate the flat panel market in terms of volume, with prices falling rapidly, following a vast ramp-up of production volumes in different parts of the world.

A4.4 LCD may not seem to be the ideal technology for television. Indeed, many of the LCD TVs seen in shops today are far from ideal in picture quality. Until very recently, LCD was not seen as a serious contender for the large-screen television market. This was not just due to the yield problems of making the larger sizes, but also to motion blur caused by slow response speeds, poor colorimetry and viewing angle, as well as higher costs. However, these drawbacks are being overcome.

A4.5 Colorimetry improvements have proved relatively simple to implement. LCD picture quality can now surpass Plasma for the first time. Motion blur is greatly improved by a variety of proprietary techniques which aim to speed the transitions between grey levels by modifying drive voltages during the transition. LCDs with 170° angles of view are becoming increasingly common, and cheaper backlights, now a significant part of the cost of a large display, are under development. The key to solving the remaining questions of cost and panel size lie in the new fabrication plants (FABs) now under construction. For example, one new FAB due next year will make 6 panels in 46” size at a time.

Display pre-processing

A4.6 The pre-processing of video signals for display on these new panels is a major challenge. Traditional television manufacturers have never needed to de-interlace interlace broadcasts, as a CRT can display an interlace signal directly. Similarly, image scaling/resolution changes are accommodated by adjusting the scan size with a CRT. With the new displays, with fixed rasters, addressed sequentially, the TV manufacturers need to incorporate de-interlacing and scaling technologies. These technologies are well understood in the professional broadcast environment, but less so by the domestic equipment industry or the PC industry.

A4.7 There are several integrated circuit sets available that claim to do everything necessary. Experience suggests that many of the scaling chips are characterised by poor de-interlacing, and insufficient taps on their scaling filters. They have features to partially mask these shortcomings, but are used with inadequate additional memory. The best way of mapping a picture to such a display is to transmit the signal in a progressive format, pixel mapped to the display. This is one of the reasons for the suggestion that progressive scanning should be used for new HD services in EBU Technical Text I34/I35. For legacy 576/50/i broadcasting we are obliged to use interlace scanning, and do the best we can with it.

A4.8 On a digital panel, the overscan used systematically for CRT displays might be seen as redundant, since the edge of the picture is clearly defined. However, there may be a case for a few pixels overscan to allow easy scaling ratios, and a case for overscan to mask archive programme content which were not made with a totally 'clean aperture' (mikes in shot etc), and to cope with unwanted incursions into frame in live programming today.

A4.9 Another area where virtually all currently available panels are inadequate is in the presentation of film-mode material carried on an interlaced format (sometimes known as psf – progressive segmented frame). Virtually all current display pre-processing fails to treat film-mode material as such, and apply a de-interlacer to the signal, so degrading a signal which, by the progressive nature of flat panel devices, should in practice be easier to scale and display. The broadcast signal should signal 'film mode', when appropriate.

A4.10 Presentation of pictures with coding artefacts would be improved by adaptive pre-processing able to distinguish between picture features and coding block-edges. Better interlace to progressive conversion using two- or three-field spatio-temporal filtering would also improve picture quality of current broadcast pictures.

A4.11 To scale an image to a particular raster size, the scaling filters used need to be carefully chosen to obtain the best final image quality. Therefore the scaling chips should include pre-selected filters, with an adequate number of taps, for the common conversion ratios which they are likely to encounter. A 'one size fits all' filter design will not produce the best image quality when scaling from, for example, 720 to 768, if it is optimised for scaling from 1080 to 768.

Physical interfaces between equipment and display screen

A4.12 Digital interfaces, such as DVI and HDMI, offer the possibility of making the transfer of picture data to the display screen transparent. Experience of panels with digital inputs suggests that this will enable the panel to display a clean signal (though so much so that coding artefacts become more prominent). The mechanism for this is the lack of optical output-filter on the flat panel display, compared to the Gaussian spread, and hence filtering effect, of the CRT spot. This could be mitigated by having many more pixels on the screen than in the source, and appropriate up-conversion filters. This would smooth block boundaries, as well as providing, effectively, extra bit-depth in the display by means of spatial dithering, providing the processing were done to an adequate bit-depth.

A4.13 'HDMI' (the High-Definition Multimedia Interface)[1] specifies a means of conveying uncompressed digital video and multi-channel audio. It can support data rates up to 5 Gbit/s, and video from standard definition, through the enhanced progressive formats to HDTV at 720p, 1080i and even 1080p at 60 fps and lower, including 50 fps. This is an appropriate interface for digital connections to flat panel displays.

A4.14 Included in the HDMI is the HDCP (High-bandwidth Digital Content Protection)[2] to prevent piracy of the uncompressed digital signal. The system encrypts the signal before it leaves the 'source', e.g. the Set Top Box, and the 'sink', e.g. the display, then decrypts the signal to allow it to be watched. HDCP is a link encryption system. The first products incorporating HDMI interfaces are now available. However, some issues about the licensing and use of HDMI and HDCP remain to be resolved at the time this report is written.

A4.15 The DVI (Digital Visual Interface)[3] is the predecessor of HDMI. It is increasingly used on computers and display products, and uses very similar technology to HDMI, but lacks the audio capability. There is a measure of electrical compatibility between the two, enabling adaptors between the different connectors[4]. One advantage of HDMI over DVI will be cable length. Usually limited to about 2m for DVI, 15m (and beyond) should be possible over HDMI.

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[1] High-Definition Multimedia Interface; HDMI Licensing, LLC. www.hdmi.org.

[2] High-bandwidth Digital Content Protection; Digital Content Protection, LLC. www.digital-cp.com.

[3] Digital Visual Interface; Digital Display Working Group. www.ddwg.org/dvi.html.

[4] However, the connectivity will be lost once a DVI/HDMI-capable 'source' with HDCP enabled does not sense a HDCP enabled DVI/HDMI 'sink' in the other end. Hence most display manufacturers, targeting Home Entertainment and Television, now implement HDCP functionality to their DVI/HDMI interfaces to avoid complaints about unwatchable content.