EBU - Tech 3298

An EBU ‘route map’ to

high definition

(HD)

Geneva
October 2004

An EBU 'ROUTE MAP' TO HIGH DEFINITION (HD[1])

October 2004

PREPARING FOR HIGH DEFINITION

Photo DW/EBU off screen shot of Sony HD display.

[1] What exactly does 'High Definition' mean? It is an area of technical quality with noticeably sharper pictures than 'Standard Definition'. There are, however, alternative views about where the boundaries lie, and often definitions are ambiguous. The EBU Technical Committee uses the term in the same sense as the current pan European discussions on minimum requirements for HD-ready displays, founded on a minimum vertical resolution of 720 pixels, equivalent horizontal resolution, and a 16:9 aspect ratio.

SUMMARY

All EBU television broadcasters need to sensitize themselves to the current situation for High Definition Television (HD). Equipment is already being sold that will allow the public to experience HD[1]. HD digital satellite multi-channel services begin in earnest in 2005 or 2006 in Europe from Premiere, TF1, and BSkyB. When they do, the public may find current broadcast quality inadequate - though there is clearly much more to be considered when deciding on HD broadcasting. In this report we look at the background to the current situation, the choices and decisions that need to be made, and suggest a series of near term actions that EBU Members should take. More information is provided in Annexes.

1. Suggested Strategy for the near term for EBU Members

The following is a list of some of the steps EBU Members should consider. Background and more complete information are given in the following sections:

1.1 *Sensitize the organisation's management to the prospects for HD broadcasting. Be aware - inside and outside the technical community - what is happening.*

1.2 *Make a strategic analysis of which of the three options given in Section 5 is most appropriate for your national and organisational circumstances, and consider each of the points in 2.5 below. Make conscious decisions on HD policy.*

1.3 *Begin discussions with other broadcasters and regulatory departments in your country about the technology to be used for HD broadcasting when and if the time comes. Explain the reasons for the EBU proposals, and if useful invite fellow EBU Members, and the EBU Headquarters to help. It is better to act too early than too late.*

1.4 Collect knowledge and experience with HD technology tools in the next 12 months.

1.5 Start to produce programmes such as drama or documentaries in HD to give them greater longevity[2].

2. The HD situation today

2.1 High definition (HD) television is currently regarded with caution by many national broadcasters in Europe. There are a number of reasons for this, including the following:

- The HD-MAC broadcasting system, developed at considerable expense in the 1980s and the early 1990s, was never used.

[1] The EBU is cooperating with other European organisations in the development of a label for HD television displays which will help the public to understand the capabilities of the equipment they buy.

[2] An EBU Project Group P/HDTP is charged with preparing guidelines for HD production.

- The quality benefits of HD are not always readily apparent. Widescreen digital standard definition (SD) is already broadcast in some European countries. For conventional sized screens, for certain types of programme material, or for long screen-to-viewer distances, the perceived quality of SD is good.
- The means for national broadcasters to finance a transition to HD were/are not apparent.

2.2 However, home computer equipment can now display 'HD quality'. HD-capable television receivers, and other HD domestic equipment, including the HD DVD and camcorder, are soon to be available at consumer-affordable prices. Non-broadcasting factors may be creating an HD market around us, which broadcasters will be able to join if they wish, or if they are obliged to join by public demand. But we should always recognize that public demand in broadcasting is fundamentally driven by 'content' and not by 'technical quality', so decisions about HD broadcasting must take this into account. *There has to be HD content which is sufficiently compelling for HD services to succeed.*

2.3 Conventional quality (SD) television can appear good quality on a flat panel display, provided there are no artefacts to impair the pictures. But a key element effecting our judgement of technical quality is 'context'. If we can see HD pictures on the same screen as conventional television, the conventional television will look poor. Conventional broadcasting may become a latter-day 'am radio' compared to HD – good in isolation, but inevitably poor in an HD world. Once consumers have access to HD material and can view this on flat panel displays, they are likely to perceive conventional quality broadcasts as modest.

2.4 Many public service broadcasters recognise that HD is the natural evolution of television services. However, in the past, they have seen the timeframe for the introduction of HD to be beyond 2010. The current evidence suggests that these time frames may need to be reconsidered and advanced.

2.5 When deciding policy for HD broadcasting, there are - among others - seven major elements to consider. Broadcasters need a strategy for all these elements. They are as follows:

a) The economic basis for the service (how costs will be met).
b) The content arrangements (the programmes, and how they will be made).
c) The delivery platform (the choice of satellite[1], terrestrial[2], cable, broadband, package media).
d) The image delivery format (the choice of raster and scanning algorithm).
e) The delivery compression systems for video.
f) The format and compression system for accompanying audio (the kind of multi channel audio system).
g) The technology to be used for interactive broadcast applications.

[1] If the delivery platform is digital satellite then, inter alia, a technical decision needs to be made about the choice of modulation system, DVB-S or DVB-S2.

[2] If the delivery platform is terrestrial, then inter alia, the choice of an appropriate DVB-T mode needs to be made to provide adequate Net bit rate for HD.

In this document we consider d), e), and f). Point g) will be considered in future. The points a), b), and c) are equally or more important for the success of a new HD service, but they are not a matter for collective technical agreement. Nevertheless, the following two general comments are made below for the free-to-air television situation.

2.6 The transition to free-to-air colour television was financed by significant increases in grants, or licence fees, or advertising fees. Such measures may be impossible for a transition to high definition television. Savings in programme production that will accrue for broadcasters in future from the use of IT, and from other efficiency measures, may help, but financing the HD transition will require imaginative solutions and resourcefulness. However, over time the difference in programme production costs for SD and HD will disappear.

2.7 The HD quality improvement will have most impact for ‘events’ programming such as sport, for entertainment, and drama - produced on HD video. Equally, however, this kind of programming is the more expensive to produce, whatever the quality level. There has to be a significant difference in quality compared to SD to provide an incentive to buy HD by consumers. Mayor events such as football championship and the Olympic Games where the difference is clearly noticeable may speed acceptance of HD.

2.8 One of the factors to be considered is the relationship between 'widescreen' services and 'HD' services. An option may be to develop an evolutionary approach to HD, which has an intermediate step of widescreen conventional quality broadcasts. It may be that a 'top-up' will be a practical way to introduce HD broadcasting.

3. Key Factors that encourage HD

3.1 It is not yet certain whether the time has come for successful HD broadcasting in Europe, but there are several factors that could help HD broadcasting to be successful. The following are potentially the most important:

- The first and most significant is the growing market penetration of WideXGA flat panel displays. These are capable of displaying HD quality. The costs are falling, and most significantly, manufacturers claim that after 2005, WideXGA or higher resolution will be the only types of large flat panel made. Market penetration for flat panel displays are expected to account for 24% of global television sales by 2007[1], and to be continuing to grow rapidly.

- A second is the development of HD DVDs, which are said to be 'imminent' - though this has been the case for some years. If HD DVDs are available and successful in Europe, they will create expectations in the public for HD broadcasting.

- A third is the availability of professional and semi professional HD camcorders which can be edited on PCs, and which will allow low cost, and even consumer, HD production.

[1] Richard Salmon, Article in EBU Review, April 2004: 'The changing world of TV displays - CRTs challenged by flat-panel displays'.

- A fourth is a combination of the launch of the HD1[1] digital satellite services, the plans being made by Premiere (Germany), TF1 (France) and BSkyB (UK) for HD broadcasting, and the evaluations being made for the prospects of HD broadcasting to Europe by some US-based companies. The HD1 service was launched in January 2004. There are two MPEG2 1080/I/25[2] broadcast channels, one 19 Mbit/s designed for the public, and one at 38 Mbit/s designed for 'clubs'. Receivers capable of both 1080/I/25 and 720/P/50 are said to be available across Europe at about 500 Euros. In addition, the viewer needs a WideXGA or higher resolution display to do justice to the quality. At least two different vendors are understood to be providing set top boxes in Europe.

- A fifth factor is the development of integrated circuits for the more efficient compression systems (H.264/AVC, VC-1) which if used will allow better picture quality at lower bit rates. Manufacturers such as Broadcom and ST claim that ICs for H.264/AVC and VC1 will be available as early as 2005. If used, these will make delivery of HD broadcasts more quality/cost effective.

4. The options for HD systems elements

4.1 It may be convenient to classify the continuing evolution of 'tool sets' which may be used for HD broadcasting in terms of steps: first generation (HD/G1), second generation (HD/G2), and third generation (HD/G3). The most useful categorisation seems to be as given below:

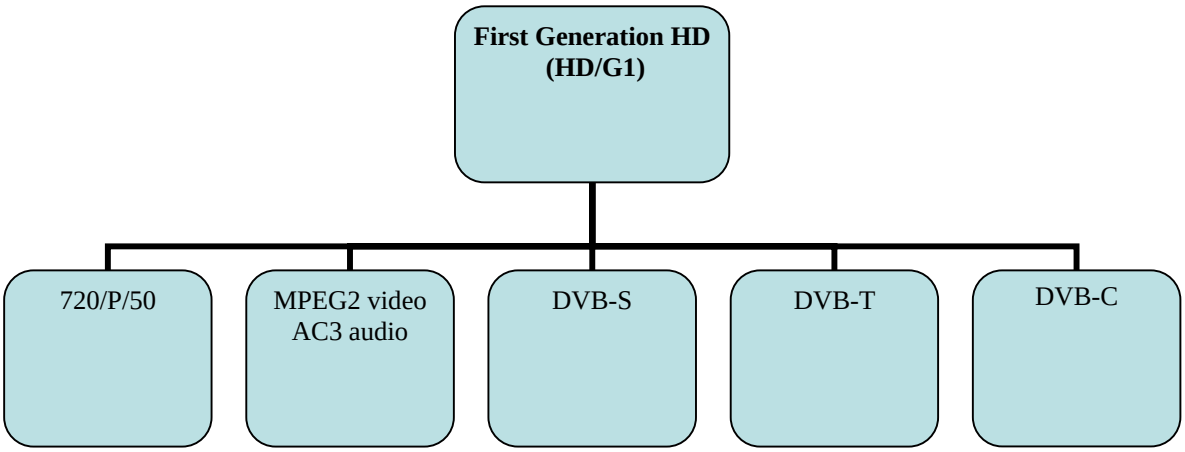

Fig.1: The HD/G1 set

[1] Formerly Euro1080.

[2] In this document we follow the naming convention: Active line number/Scanning Format/Frame rate. The Interlaced Scanning format is indicated with an I, and the progressive format with a P.

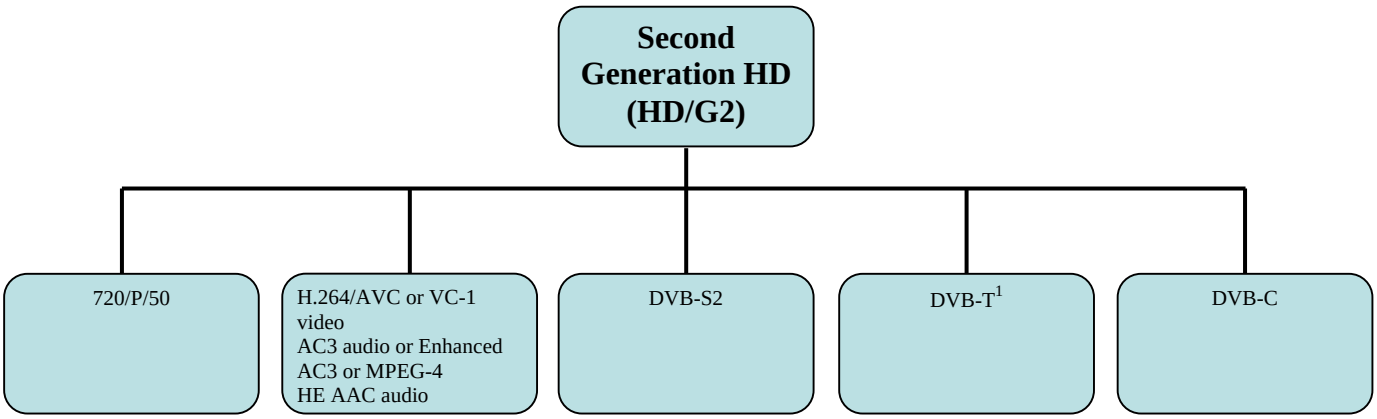

Fig. 2: The HD/G2 set

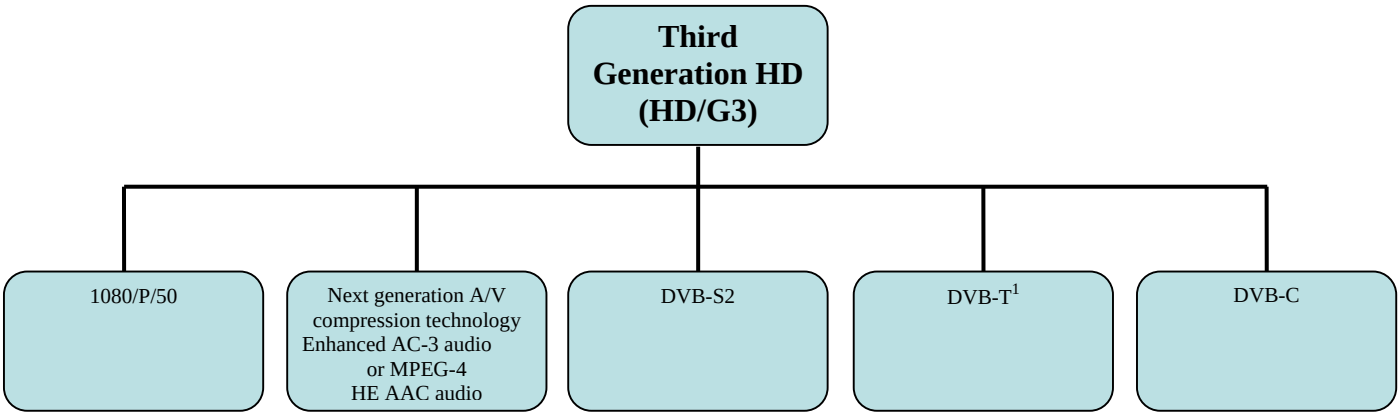

Fig. 3: The HD/G3 set

[1] Possibly also DVB-H at SD available for appropriate receiving environment as part of a package of new service elements.

5. What are the delivery options for HD?

5.1 There are, arguably, three major scenarios to be considered

A. Start HD broadcasting in the **next year or so using HD/G1**, probably by satellite. This is the technology used today by digital HD satellite broadcasters around the world, and by HD1 in Europe.

B. Start in **two to five year's time using HD/G2**, when more advanced compression tools become available in receivers. This is being considered (as far as the EBU is able to observe) currently by TF1, BSkyB, Premiere, and other US-based organisations.

C. Start in **five to fifteen year's time**, only when relevant technologies become mature, when obliged by significant consumer demand, and following the widespread use of commercial HD Pay-TV services, HD DVDs and HDV domestic camcorders. In principle the option of HD/G3 may be available, but it is likely that in some countries there will be a legacy of HD/G1 and/or HD/G2 which will inhibit this.

5.2 A start in the next year or so (Scenario A)

5.2.1 This would need to be based on existing compression technology, and on 'real time' broadcasting only. Such services would probably be aimed at peak-time viewing for maximum cost-effectiveness.

5.2.2 MPEG-2 coding would need to be used, with two HD channels in a DVB-S multiplex of 38 Mbit/s, or one HD channel and a statistical multiplex of standard definition (SD) channel. A DVB-C multiplex over cable may be an alternative for some countries.

5.2.3 If terrestrial spectrum is available (and that is not the case in many countries), virtually an entire DTT multiplex would be occupied by the HD channel, possibly with space for an SD channel alongside, depending on the chosen DVB-T mode.

5.2.4 720/P/50 is the best choice for delivery format to progressively scanned displays for the reasons given in Section 5.5 of this document (though HD1 started with 1080/I/25, their receivers are capable of both 1080i and 720p). Commercial reasons and equipment availability may cause some operators to additionally adopt other 50 Hz based formats.

5.2.5 The scope for choice of compression system is less clear in the immediate future, but certainty of availability of set top boxes could probably only be assured in this time frame by using MPEG2 compression. Only MPEG2 can be received on existing digital receivers.

5.2.6 The current AC-3 system (Dolby Digital) system is likely to be used.

5.2.7 The appropriate interactive TV system remains to be considered.

5.2.8 Any HD services launched at present will be constrained in programme material, since there is limited HD production experience, and little archive material available apart from celluloid. However, European launch is possible as the services HD1 have shown.

5.3 A start in two to five years when improved compression technology is commercially available in receivers (Scenario B)

5.3.1 In this timescale the broadcaster might still be introducing services somewhat ahead of DVD-driven public demand, but at the period when sales of large flat-screen displays are still expanding and are starting to saturate the market. However, a legacy will still exist as the normal lifetime of the domestic television is 7-10 years.

5.3.2 720/P/50 format best meets the requirements for HDTV delivery in Europe in this scenario. Commercial reasons and equipment availability may cause some operators to additionally adopt other 50Hz based formats.

5.3.3 The compression options at this point in time would extend to H.264/AVC and VC1 (Windows Media 9), which would offer the prospect of HD coding at data rates that no longer require (as MPEG-2 does) an entire terrestrial multiplex for each channel of HD.

5.3.4 New generations of set-top boxes and receivers would have to be specified[1], and these might be specified to include a PVR, a technology which is beginning to make an impact across Europe.

5.3.5 Single chip solutions to decode and display these formats might be available in 2005, or either at the launch of the service, or soon after.

5.3.6 HD transmission over satellite would be relatively easy. New generations of decoding chips are expected to compatibly decode MPEG-2 in addition to the new systems, and so a new generation of satellite set top boxes should be available in this time frame.

5.3.7 New decoders will also inevitably find their way into cable set top boxes, and so there will be the opportunity to carry HD over cable.

5.3.8 For terrestrial broadcasting, with spectrum still tight in many countries, even the reduced bandwidths of the advanced coding systems might still not be enough to include two channels per multiplex coping with the more critical types of programme material (sports, etc.). Even if bandwidth were available, the new system, incompatible with existing set-top boxes (in those countries which have already launched DTT) would require new hardware.

5.3.9 One conceivable option could be for the HD programming on DTT to be broadcast as a non-real-time download, sent the previous night or morning, but only available for first viewing simultaneous with the same programme broadcast at SD on a conventional channel. This enables an extra layer of robustness, and also the opportunity to save further bandwidth. If there is a gap in the recording, due to power failure or transmission errors overnight, the receiver would revert to the standard definition live reception.

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[1] EBU Project Group B/TQE plans to prepare an analytic report on receivers as its next deliverable in March 2005. DVB TS 101 154 is under major revision, to be finalized in 2004.

5.3.10 A ‘smarter’ option, for a documentary or other such programme, would be to enable mixed HD/SD transmission, with the HD components (the material which would benefit greatly from extra resolution) sent in advance, and the remaining SD sequences ('talking heads' for example) patched in by the receiver at viewing time. These SD patches would also need to be stored in the PVR if it were wished to view the programme at a later time. Philips has developed such a 'top up' technology, but this has not yet been evaluated. The 'top up' signal might even be delivered by another bearer such as broadband, and might carry a premium charge.

5.3.11 Manufacturers have told us that it will not be possible to have mass produced 1080p/50 decoders in this timescale.

5.4 A start in five to fifteen years, in reaction to market pressure for HD (Scenario C)

5.4.1 In this scenario the broadcaster has waited to see how HD takes off commercially, and then tries to catch up if it has been successful.

5.4.2 In some countries, it is of little value planning technical elements for this at present, since the technical solutions will largely have been dictated by the HD services introduced earlier by others.

5.4.3 It could then be difficult for the broadcasters to specify a technically advanced system such as HD/G3, if this is not already in use, due to the need for backwards compatibility with the installed base of conventional quality receivers.

5.4.4 On the other hand, if the timescale were such that it followed on from the switch-off of analogue services, and the consequent increased availability of spectrum, real-time HD terrestrial broadcasting using the more efficient new coding systems could be cheaper and more feasible.

5.5 Background on suggested format for delivery

The EBU Technical Committee agreed in April 2004 to recommend to EBU Members the use of a progressively scanned delivery (or ‘transmission’) format for higher quality digital television broadcasting by members. The main arguments for the use of progressive scanning[1] for the delivery channel are as follows:

- It avoids the need for a de-interlacer in the display.
- De-interlacing, when needed, can be done with professional equipment in the studio.
- The transmission channel achieves the best efficiency because of the progressive scanning coding gain[2].
- Improved motion portrayal is possible, given a progressively scanned source signal is used.

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[1] See article of David Wood et al: 'HD in Europe, A Progressive Approach', EBU Review, September 2004.

[2] Though quantifying this is difficult because of the evolution of encoders and compressions systems, and the variability of encoders between manufacturers. However, manufacturers have pointed out to us that it must be fundamentally true whatever the coding scheme or manufacturer, since a content adaptive compression scheme must be more quality efficient than a non content adaptive scheme.

The Technical Committee noted that there are two candidate progressively scanned formats included in SMPTE specifications. These are 720/P/50 and 1080p/50.

Evidence before the EBU Project Group B/TQE leads to the conclusion that viewers' needs for overall picture quality can best be met by the use of the 720/P/50 broadcast format in Europe.

A short summary of the main elements which have lead to this conclusion are given below.

5.5.1 The standard chosen must be a balance which allows both an improvement in resolution, and the ability to deliver the largest number of HD services virtually artefact-free. In choosing a standard we need to consider both the resolution available and the risk of compression artefacts. For likely available bit rates, the 720p format should present a better balance than 1080p which will inevitably require a higher bit rate whatever compression scheme is used.

5.5.2 The information given to us by display manufacturers is that 480p raster flat panel displays will be phased out. The majority of flat panel receiver displays will use a 768p raster. There is little purpose in broadcasting 1080p signals to 768p displays. Displays with greater performance that the delivery signal are beneficial, rather than the reverse.

5.5.3 Future 1080p displays will still be well served by 720p delivery. Content delivered at 720p will be seen at closer to its absolute potential because there will be less spatial aliasing.

5.5.4 Broadcasters have a national responsibility, and an economic need, to manage spectrum efficiently. Broadcasting 1080p rather than 720p would significantly reduce the number of programme services available to viewers[1]. In Europe, there is limited channel capacity for terrestrial and satellite services, because the many individual countries need their own multichannel broadcast services.

5.5.5 At flat panel screen sizes above 28", standard definition images are probably not adequate for European homes. The preferred viewing screen size in the flat panel matrix display environment (as 'furniture') will be between 32" and 50". Tests have shown that 720p satisfies the vast majority of resolution needs with this size screen[2]. As an example, the chart below shows, for a range of screen sizes, what proportion of the observers require which progressive standard:

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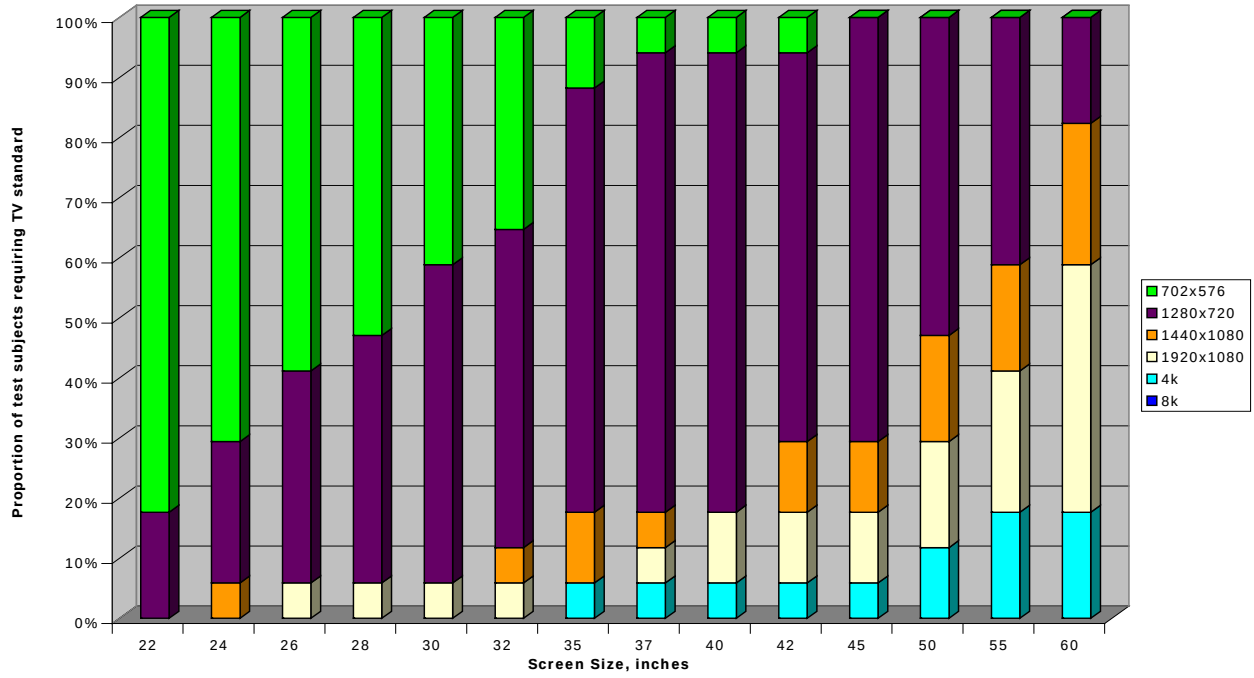
[1] The gain would depend of the type of content, and thus would depend on the 'quality of service' required. A typically cited figure is however a saving of 20%.

[2] See for example: "Tests of visual acuity to determine the resolution required of a television transmission system" from Drewery and Salmon, BBC Research and Development White Paper WHP 092, http://www.bbc.co.uk/rd/pubs/whp/.



Resolution required from the television standard to provide adequate horizontal resolution for 2.7 m viewing distance. 2.7 m comes from previous evaluations of the most preferred viewing distance for large screen viewing in the European environment.

Note that this chart describes the TV broadcast standard, and not the resolution required in the matrix display. To get the best from the broadcast signals, the matrix display requires more pixels in each direction than the transmission channel resolution[1], so a 720-line standard viewed on a 1080-line display will give a better picture than if it is displayed on a 720-line or 768-line display.

6. Indicators which may be useful signals to public service broadcasters of the need for HD broadcasting.

6.1 Individual broadcasters will decide under which circumstances they may introduce HD broadcasting. Public service broadcasters cannot spend money without a clear and justifiable case in the public interest. There is no case for broadcasting HD if there is no demand for it. There is every case for broadcasting HD if the demand is high. Somewhere between these two, the public service broadcaster has to decide on the justifiably appropriate moment to begin HD. A first discussion in B/TQE has suggested one or more of the following as potentially reasonable thresholds to consider. These are simply guidelines for the justification for reasonable spending, not laws of economics.

[1] This is because the rectangular pixels acts as a very poor (box-car) optical output filter. In addition, the RGB colour elements of a display are not in exactly the same physical locations, and thus the addition of the colour elements will not occur exactly as it did when the scene was shot. This will cause some degree of spatial aliasing. To move this aliasing away from the wanted spectrum, the display needs a higher resolution than the source.

1. The penetration of HD-DVD players in the home reaches 10%.
2. There are 20 channels available HD by satellite over Europe.
3. The HD share of general household viewing hours exceeds 2%.
4. The penetration of widescreen receivers reaches 70% and the rate of widescreen programmes reaches 50% of all programmes.

6.2 Factors which might delay the introduction of HD by public broadcasters in Europe, and which need to be monitored.

A. *Copy protection*
If copy protection measures hamper reasonable use of content in the homes, or fail to prevent large scale piracy of premium content, it will be a discouragement to broadcasters and the public to move to HD.

B. *Multiple standards for HD-DVD*
If none of the standards is a clear winner, it will lead to market confusion.

C. *Availability of terrestrial frequencies*
If governments “take back” analogue frequencies for auction in the current cycle of Planning Conferences, RRC 04/05 this will limit options for HD DTT.

D. *Consumer disposable income and take up*
If consumers do not have the disposable income to buy flat panels or find them unattractive, this will slow the roll out of HD.

7. The SES/Astra initiative for 'badging' HD displays and receivers

In Europe[1] there are widespread sales of flat panel receivers in stores without sales staff or the purchasers having any idea about the quality capability of the display. It can be quite difficult to find out whether the purchase is a WideVGA, which is not HD capable, or a WideXGA which is HD capable, and exactly what connectors are available.

Being aware of this, SES/Astra have launched an initiative to encourage the receiver industry to 'label' displays as 'HD ready' when they are so, in terms of quality potential and connectors. This will be very beneficial for the public and potential HD broadcasters, but it remains to be seen if display manufactures will agree to do so.

This initiative is welcomed by EBU Members. The implication of an "HD-ready" label to protect the public is that the display meets a number of criteria, such as allowing at minimum 720 lines progressive scanning and a standardised colorimetry (ITU-R Rec. 709-5). The EBU is offering to support this initiative, and encourage Eutelsat and EICTA to do so.

As future steps, Astra will consider 'labelling' for set-top boxes.

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[1] In Japan, the JEITA has defined a term « digital Hi Vision Television » which is used to label equipment.

8. Conclusions

Launching new technology brings many risks and challenges. Public service broadcasters must spend public money, or money earned because of their public service franchise, with great care.

It is inevitable that High Definition television will eventually be broadcast. The difficult question is to assess the right time to begin. There are growing signs that we are approaching that time, largely because of events outside the control of broadcasters – the advent of low cost HD progressively scanned flat panel displays. It is important also not to be overconfident about the speed of HD's arrival. Broadcasters have a systematic tendency to overestimate the speed at which new technology arrives, but equally a tendency to underestimate its eventual impact. The right balance needs to be found.

In this report we have made a first examination at the issues to be considered by public service broadcasters, and we suggest that HD delivery technology can be seen in three sets of tools – first, second, and third generation HD. The broadcaster needs to decide which generation to use and when to use it.

These are complex questions which will need study - but they cannot be ignored.

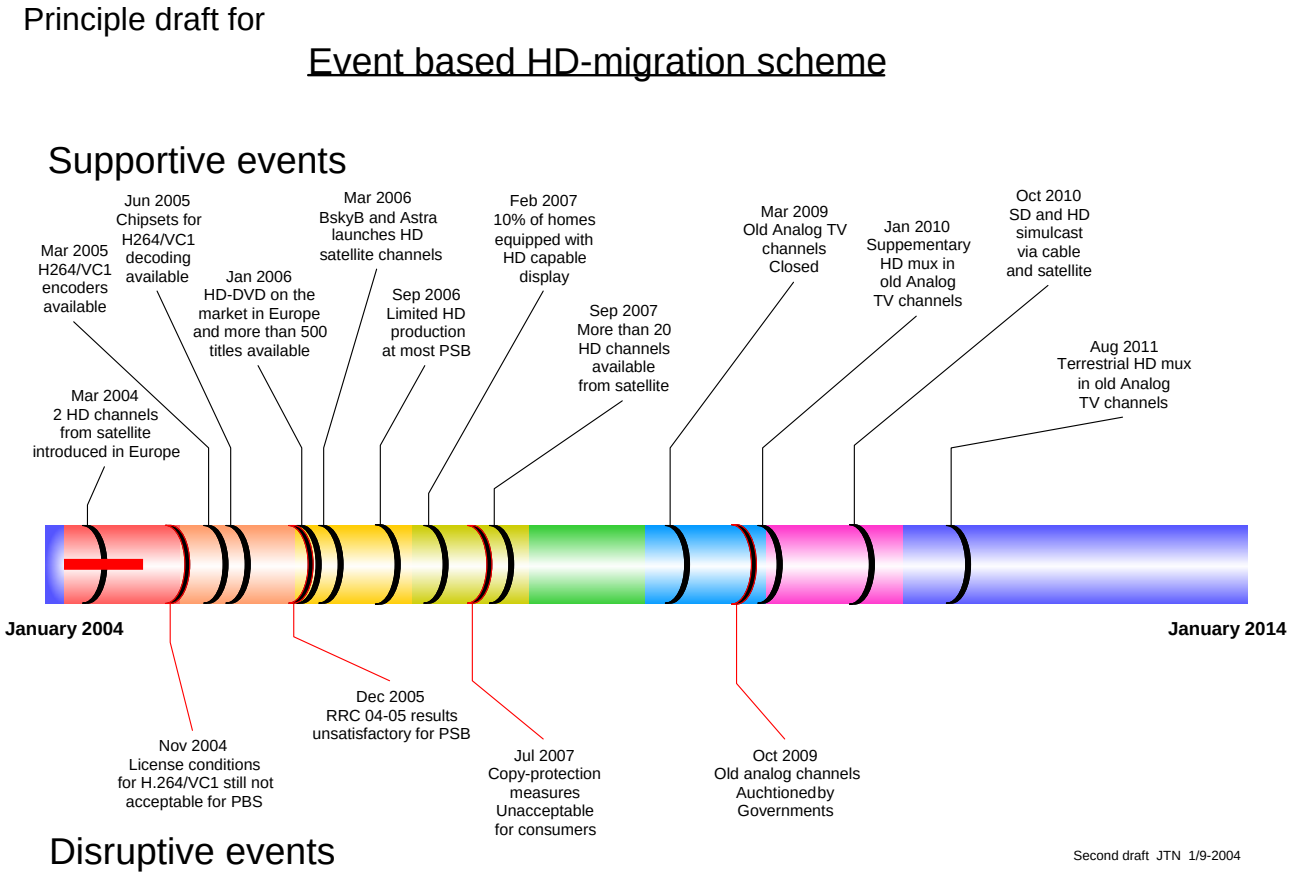
However if a commitment is made now to seek a common progressively scanned and thus future proof delivery standard (720p), accepting that commercial reasons and equipment availability may cause some operators to additionally adopt other 50 Hz based formats, this will make the launch of HD, whenever it comes, more manageable and less expensive for everyone.

One of the responsibilities of public service broadcasters is to help increase the quality of life by the use of new technology. Broadcasting rests on content and technology. Providing a better viewing experience where this can be done within the limits of resources can be seen as part of the mission of public service broadcasters.

ANNEX 1

Event based HD migration schematic

The roll out of HD will be conditioned by a wide range of factors, some of which will be supportive, and some disruptive. In the attached timeline we have attempted to delineate major positive and negative factors and their timescales. This device may be of value in deciding national strategy and organisational strategy. The dates cannot be definitive because the events have not yet happened, and some will vary from country to country. However, the timetable is as informed as we can make it.



ANNEX 2

Elements of HD development

1. HD analogue broadcasting by satellite began in Japan in the 1980s. Digital HD terrestrial broadcasting began in the United States in the mid 1990s and in Australia in the late 1990s. In all of these cases, receiver growth has been slower than predicted. In Japan, HD digital satellite broadcasting began in 2000 and digital terrestrial broadcasting in 2003.

2. The penetration of HD receivers in Japan, the United States, and Australia is more healthy today, but there has been the familiar 'chicken and egg' problem for horizontal markets for new services (few new programmes because there are few new receivers to use them, and vice versa).

3. The slow growth of HD in the 1990s in Japan and the US seemed to confirm the fears of those who considered that the time for HD had not yet come for Europe. In the early 1990s, market research in Europe showed a large gap between what the public would be willing to pay for an HD receiver, and the likely retail costs of HD ‘CRT’ receivers. HD receiver costs would be perceived by the public as disproportionate to the benefits of the higher picture quality. Furthermore, European national broadcasters could see no additional income available for HD production and transmission costs. These factors contributed to the scepticism about HD broadcasting in Europe. Current estimates are that flat panel HD receivers will be available for 2-3K Euros in the next 5 years.

4. In the 1980s, the world was divided about the 'best' HD format. The United States proposed to the ITU that there should be a single analogue HD format used throughout the world, 1035/I/30, originally developed in Japan in the 1970s, and based on 60 Hz ‘interlace scanning’.

5. The EBU was split about whether to accept this or not; but, in the world as a whole (the ITU discussions), the balance of opinion was that the use of 60 Hz would be unfair on the 50 Hz world - which is 75% of the world’s population - and the US proposal was not accepted.

6. In the early 1990s, the ITU-R WP 11A agreed on an HD 'common image/common data rate format' which used one active line number (1080) with a range of different field rates and scanning algorithms, interlace and progressive. The SMPTE, but not the ITU-R, also specifies a family of HD standards based on 720 lines and progressive scanning. The ITU-R currently only specifies a 720/P/60 format.

7. When digital HD broadcasting began in the mid 1990s in North America, the academic community[1] and part of the US broadcasting community supported 'progressive scanning'. They argued that it is a more efficient way to deliver television via digital compression. CBS and NBC maintained the interlaced approach for HD. US broadcasters are allowed to use any one of a large number of different formats. In practice ABC, Fox, and ESPN - broadcasters who say that sports content is critical for them - use 720/P/59.94, and CBS and NBC and DTH operators use 1080/I/29.97.

8. In Australia, three standards are allowed, 576/P/50, 720/P/50, and 1080/I/25. In practice, Channel 9 uses 1080/I/25, and Channel 7 uses 576/P/50. ABC broadcasts some HD at 1080/I/25.

9. In Japan, all HD services (NHK, TBS and all others) are broadcast exclusively in the 1080/I/29.97 format. The 720/P/59.94 format is also specified and allowed in their broadcasting standards, but is not used.

10. All HD broadcasts to-date use the AC-3 system (Dolby Digital) or, in Japan, the MPEG-2 AAC multi-channel audio system.

11. All HD broadcasts to-date use the MPEG2 video compression system. EBU tests in 2003 suggested that about 22 Mbit/s is needed for adequate 1080/I/25 delivery and 18 Mbit/s is needed for adequate 720/P/50 delivery to achieve an appropriate balance between production quality and delivery quality reduction. However in practice, 1080/I/29.97 and 1080/I/25 bit rates which are 20-40% lower than 22 Mbit/s are being used for DTT broadcasting in North America and Australia. All 1080/I/29.97 broadcasts in Japan use 20 Mbit/s or below in satellite digital broadcasting and 14 Mbit/s in terrestrial digital broadcasting using MPEG2[2].

12. The elements of all the currently broadcast HD systems are not ‘new’. Interlacing is an analogue video compression system devised in the 1930s, and the MPEG2 compression system and the AC-3 Audio (Dolby Digital) audio were developed in the early 1990s. This does not mean they are necessarily inadequate - but it would be, to an extent, surprising if, in a world of Moore' law[3], there were not better technical solutions after such periods of time.

13. For a range of reasons, however, we maximise the quality efficiency delivered to the 'matrix display' (flat panel or projection display) to the home if the delivery channel uses a progressive format. This policy was recommended by the EBU Technical Committee in April 2004. There are two candidates for Europe that are SMPTE standardised progressive scanning formats; 720/P/50 and 1080/P/50.

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[1] For example, see http://www-wfschreiber-org/pageone.htlml.

[2] A new MPEG2 encoder developed by NHK will provide the same quality at lower bit rates.

[3] The processing capacity of integrated circuits of a given size doubles every 18 months.

14. The B/TQE group has reviewed these two options and believes the balance of advantages is in favour of 720/P/50, accepting that for commercial or equipment availability reasons some broadcasters may use, in addition, other 50 Hz based formats.

15. Since MPEG2 compression was developed in the early 1990s there have been two further generations of more efficient compression 'tool sets' agreed in the ISO/IEC JTC1 MPEG group. The more recent of the two is termed MPEG4/AVC (H.264/AVC). Several MPEG 'rules' have emerged over the past decade:

- The time to assemble a new and significantly better set of tools in the MPEG series appears to be about five years, and codec improvement 'life' about ten years.
- Tool sets which arrive too quickly or do not offer sufficient improvement such as the MPEG4 part4, can find themselves overtaken by technology.
- More efficient compression tool sets than MPEG4/AVC (H.264/AVC) will inevitably be developed, and the next in the MPEG series is likely to use 'wavelet' or other technology.

16. The AC-3 digital audio compression system with multi-channel possibility, dialogue normalisation, and dynamic range control features has become the de-facto standard for multichannel audio for television in Europe, and offers two modes running at either about 380 kbit/s or about 480 kbit/s. Tests done in the EBU suggest that the 480 kbit/s version is indistinguishable for the source signal for all material. Another compression standard for multi-channel audio used in Japan is MPEG AAC (Advanced Audio Coding).[1]

17. There is another video compression tool set, Windows Media Player 9 (VC1), which may become a candidate for digital broadcasting. It is not yet an 'open' standard, but its developers, Microsoft, intend to standardise the system. VC1 is more efficient that MPEG2, but may not be as quality efficient as MPEG4/AVC[2] (H.264/AVC). Associated with the use of either system are 'licensing terms'. At the current time the licensing terms for either system are not entirely known, but once known, if there are significant differences, or if they are unreasonable, this may influence the take up of one or other.

18. The DVB Technical Module has a sub-group (the TM-AVC group) responsible for revisions of the ETSI report (TR 101 154) on baseband signals for DVB containers. This report defines types of content formats and compression systems for DVB systems. It will become a part of the DVB standard as TS 101 154. The TM-AVC group is now preparing parts of its specification which will include provision for HD and new compression technologies. We believe the inclusions will encompass the proposals made in this document for 720/P/50 delivery.

19. Flat panel displays are replacing CRTs displays. Currently the majority of FPDs being made are 768p WXGA, but 1080p displays (WUXGA) have appeared on the market by several manufacturers (Sharp, LG) though at much higher costs. Other manufacturers (Pioneer) say they have no plans to make WUXGA display.

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[1] MPEG-4 HE AAC is a more recent audio format which roughly is matched in quality efficiency by Enhanced AC-3 (Dolby Digital plus).

[2] However, one European encoder manufacturer who has studied both systems in depth tells us they consider them roughly equivalent in performance potential.