Technical Report 10

3D Briefing Document for Senior Broadcast Management

EBU TECHNOLOGY AND DEVELOPMENT

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3D TV - Its importance to EBU Members

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Contents

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3D TV Briefing Document
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3D TV Synopsis – What is important for EBU Members?

The value of 3D to the audience

The perception of the public towards 3D is predominately determined by cinema experiences. In spite of this, the consumer electronic manufacturers are promoting 3D as the next big desirable viewing experience in the home.

The EBU believes that public service broadcasters (PSBs) must take a pragmatic approach to 3D services and they should be aware of the value of an event or programme to its audience when making decisions about producing and broadcasting in 3D.

Programmes such as the Olympics and Eurovision Song Contests can be regarded as an "appointment to view" where an audience will be prepared to use glasses and watch 3D content instead of a 2D simulcast. This may not be the case with day to day viewing where the 2D version will just seem easier to watch.

Certain content genres such as wildlife documentary, especially macro and animation elements and some live events in smaller size areas can deliver a very immersive 3D viewing experience.

The display market

It is expected that all larger displays will be 3D capable in the future. For PSBs it is important to understand the potential number of households that are equipped with 3D capable displays.

GfK figures (Oct. 2010) suggest:

It is expected that by 2014 about 42% of all purchased display devices will be 3D capable.

The number of 3D devices in Europe is expected to be 600 000 by the end of 2010, and by the end of 2011, about 3 Million devices.

The primary question is whether consumers will accept 3D at all and whether they will invest in additional glasses (usually the displays are sold with one or two pairs of 3D glasses).

Content

Creating good 3D content requires special equipment and skills.

The current position of 3D rights is unclear, and public service broadcasters must pay close attention to developments in the discussions of 3D rights.

PSBs should grasp their responsibility to inform and educate the public about 3D for Television (in a way similar to that done for HDTV).

3D content is best produced with a particular range of screen sizes - home (30" to 70"), cinema or IMAX in mind.

Stereographers use different depth budgets for cinema and TV. Disparity (see glossary) that produces a good but large 3D effect on TV could cause extreme 'pain' as your eyes try to look in opposite directions in the cinema!

Making 3D that is OK on all screen sizes may be just that; OK but not stunning. This means that 3D content produced for the cinema requires post-processing to work adequately on consumer sized displays (and vice-versa). Not following this guideline will generally lead to unsatisfactory results.

3D and Health Issues

Poor stereoscopy *is* responsible for headaches, eye strain and nausea!

Estimates[1] of the number of people who suffer from 'stereo blindness' vary from 5% to as many as 15% of the population!

> *Note:* *Stereoscopic 3D-TV displays call on the eye-brain to work in a way they do not normally do by separating the functions of focussing and pointing. This can cause eye discomfort, and may cause eye fatigue or other symptoms. The ITU-R is considering these 'health-related' issues. There is generally a shortage of information about the potential short or longer term effects of viewing S3D. The ITU-R, prompted by the views of the Italian administration, also recognizes that for environments such as the 3D cinema there may be health related effects in the use of the same glasses by multiple viewers. The ITU-R is asking the World Health Organization for information on all these issues.*

What can the EBU do to help?

The EBU technology group will continue to monitor market developments and those in the production, distribution and consumer domains. In particular, the following areas will be covered:

- 3D content availability from the industry at large (Blu-ray, gaming, acquisitions);
- Production technology, training and operational guidelines;
- Distribution and consumer technologies;
- Recommendations to standards bodies;
- Representing PSBs' positions;
- Monitoring and disseminating information about the physiological effects of 3D viewing.

[1] See for example, http://www.telegraph.co.uk/science/steve-jones/7451130/When-watching-3D-can-fall-flat.html and http://www.settheory.com/stereo_blindness_test.html.

1. 3D history

What we currently think of as 3D is more accurately described as 'stereoscopy'. A true 3D image would allow you to see around objects in the picture. Also, as you moved, the image would look different viewed from different angles.

Stereo TV, on the other hand, follows 2D television rules i.e. the image follows you around the room and you can't look around objects. Stereo is more about providing additional depth rather than an additional dimension.

Stereoscopy experiments began in the 19th century, starting with still images but rapidly following the movies into the early cinema.

Stereo camera rigs were patented around 1900 and the earliest confirmed 3D film (*The Power of Love*) was shown in the Ambassador Hotel Theatre, Los Angeles, in September 1922!

Over the past 90 years, 3D has come and gone. After each decline there have been various attempts to revive the technology.

The 1950s were described as the golden age of 3D with the now-infamous '*House of Wax*' released in April 1953 with stereo sound!

The 1980s saw a run of 'Part III' films with the addition of a "-D" at the end of the title (e.g. '*Jaws Part IIID*'). Each revival was usually the result of a technical advance or a technique that seemed to make 3D better or more compelling, but it was never enough to catch a mass sustainable market.

2. Current situation

The latest revival of 3D is slightly different. It is being driven by a combination of factors:

- a run of very good 3D animations in the cinema that has whetted the public's appetite;
- the availability of affordable domestic flat screens capable of displaying several different 3D formats (prices starting from around 1400 €);
- in the near future, all HD Ready displays will be 3D capable;
- 3D content (feature films, gaming, US series) will be available direct to home via 3D Blu-ray disks and high speed internet (HBBTV, VoD, etc.);
- consumer cameras (stills and video cameras) are available that interface directly with the 3D displays.

3. Stereoscopy for Television

3.1 Acquisition

Traditional 2D camera positions for an event may not be good enough for 3D. If the cameras are too far away from the action, for example, the 3D depth effect is lost.

Mini Camera
Side by Side Rig

2 eyes = 2 cameras. But it's not quite as simple as strapping two cameras side-by-side.

The theory suggests the centres of the lenses should be about the same distance apart as human eyes. It's this distance that makes the depth 'seem' about right. Cameras are placed on a rig in different ways.

Only mini-cameras with small lenses are narrow enough for **side-by-side** rigs.

Studio cameras and field camcorders with high quality lenses are usually too large for side-by-side mounting (the lenses would be too far apart). Larger cameras therefore use 3D **mirror** rigs.

Full Size
Mirror Rig

The most common mirror rigs mount the cameras at 90° to each other with one looking through a 45° mirror.

Good mirror rigs can cost over 30 k€ and they are big!

Notes:

- *Lenses are matched as closely as possible for left eye and right eye cameras.*
- *Cameras are aligned and tracked as closely as possible.*
- *Zooms do not necessarily work well and some camera moves destroy the 3D illusion.*

Camera Positions for 2D and 3D coverage of football

Figure 1a: Camera positions for 2D production

Figure 1b: Additional cameras required for 3D production
(courtesy of HBS [http://www.hbs.tv/orientation])

The additional cost of producing 3D content is difficult to calculate accurately.

Until there is a lot more experience of 3D acquisition, using one (typically the left eye) view of a 3D production for 2D HDTV is normally not advisable. In consequence of this, events for 2D HD and 3D will require two production crews.

Studio infrastructures based on 3G-SDI are being developed and can be used both for 3D and for next generation HDTV (1080p/50).

3D single camera productions usually need a longer time to set up and light and they may in fact need separate 2D and 3D cameras on the same shots if they are to be used for 2D and 3D services.

Each programme type will need to be assessed for 3D suitability against cost and value to the audience. Estimates vary from 20 - 50% increase over 2D HD.

Is has been observed that there is now a trend for integrated 3D cameras (combining left and right image capture in one camera housing; various technologies are employed).

Several manufactures are developing production tools to make set-up and alignment for 3D productions easier.

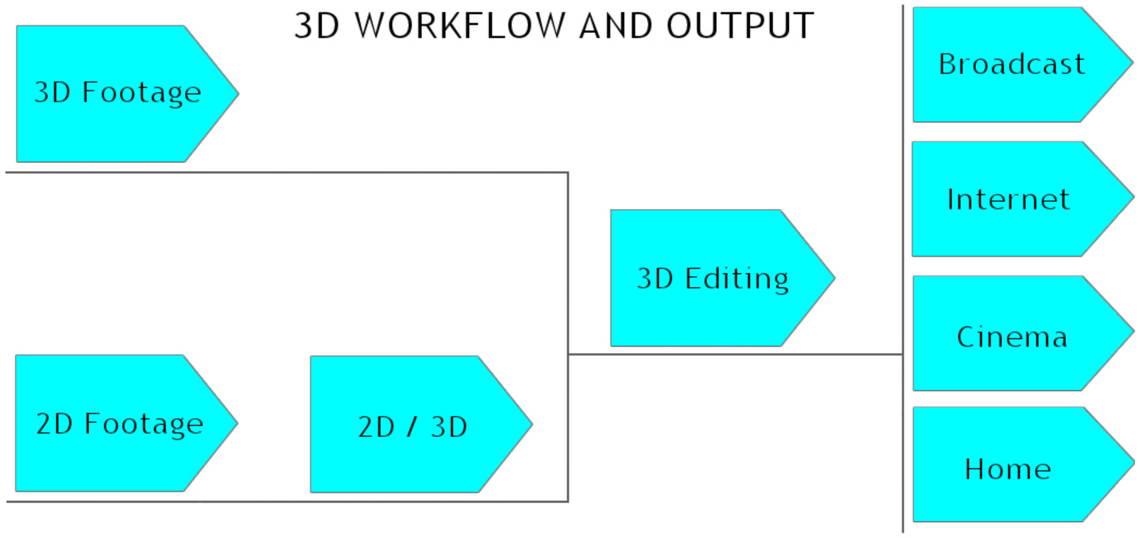


Figure 2: Simplified production route

3.2 *Postproduction and Processing*

If the cameras are set up properly, live and as-live programmes with simple cut editing are relatively straightforward. If the 3D depth of a programme needs to be adjusted in postproduction (with special 3D capable equipment and trained staff), this can take longer than editing the programme itself!

All major manufactures for postproduction equipment such as AVID, DVS, EVS, GV, Quantel and Sony are providing or updating their products to become 3D capable.

Getting things right in postproduction is a very time consuming and expensive thing to do. The shortage of skilled 3D editors will only add to the time and expense.

Storage requirements for 3D are double that of 2D and two images have to be moved around existing infrastructure and also archived.

All this will add to the cost and time taken to postproduce a 3D programme. Current thinking indicates that costs will increase by 25 - 30% over 2D programme costs.

3D postproduction costs will nevertheless fall as 3D options become standard in equipment.

Computer animation is ideal for 3D - hence the recent glut of 3D animated feature films. The rendering and postproduction computing power already required for (2D) animation is quite capable of handling the 3D element.

Animation has one other advantage as far as 3D is concerned; as everything in a computer animation is synthesised, if anything looks wrong, it can be changed to look right! The perspective or horizon or any part of the image can be adjusted until the 3D works properly.

3.3 *2D to 3D conversion*

It is technical possible to generate low quality 3D images from 2D images.

This process can be used where 3D cameras were not available for acquisition or for archived content to be included in 3D programmes.

<u>Extreme caution should be used for converting 2D to 3D.</u>

3.4 Displays and glasses

How can 3D work when it's displayed on a 2D screen? There are currently four primary technologies:

3.4.1 Colour separation

Anaglyph and Colorcode (and other colour variants) work by showing both left and right images at the same time on screen, the left eye image in one colour and the right eye image in another. This was the 'original' 3D technology used in cinemas in the past ('*House of Wax*' etc.).

Anaglyph Glasses

Colorcode Glasses

The viewer uses coloured glasses to make sure that the images go to the appropriate eye.

Figure 4: Red/Cyan anaglyph image as it is transmitted and appears on all TVs

Whilst this is an inexpensive technology that works on any available display, the resulting 3D image quality is very unsatisfactory. It is no longer competitive in face of newer technologies and it is possibly the reason why 3D was never accepted in the past.

Consequently, EBU Members are advised not to use this technology.

3.4.2 Polarised / Passive

This technology demands a new 3D TV display with a polarised screen. The left and right eye images are lined up behind the polarising screen and each image is given a different polarisation.

To see the 3D image, polarised glasses are needed. These are similar to polarised sun glasses but the lens of each eye has a different polarisation to make sure the correct image goes to each eye.

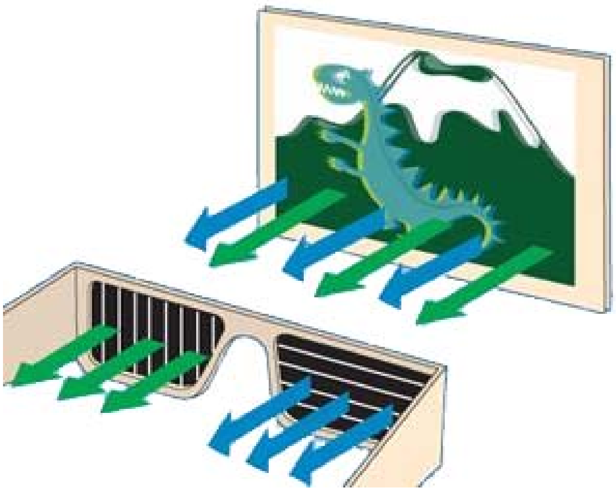
The glasses include no active electronic elements and are therefore termed 'passive'.

Advantages

- Good 3D;
- No colour or picture distortion as with colour separation;
- Glasses are very cheap;
- Used in displays for the professional market.

Disadvantages

- Requires a new 3D TV display;
- Both images are reduced resolution (no longer HD resolution);
- Technology in the display is more complex than for displays with shutter glasses (see below), thus they are not very common in the consumer display market;
- Variants of polarisation technology (e.g. linear orthogonal, circular) mean that glasses may not be compatible between different displays.



3.4.3 Shuttered / Active

Shuttered technology requires two active components – the screen and the glasses.

Shuttered LCD glasses are controlled by an infra-red signal sent from the TV. The left and right images are displayed alternately on the screen at a high frame rate (100 or more frames per second). When the left eye image is on screen the right eye lens of the glasses is made opaque and vice-versa.

Advantages

- Good 3D;
- Full resolution images;
- This is the primary format chosen by display manufactures for the new consumer 3D TVs.

Disadvantages

- Glasses are expensive e.g. from 80 € a pair;
- The Infra Red signal has not been standardised (e.g. glasses of one display will not work on another manufacture's display);
- Interference of the infra red signal can cause flickering.

3.4.4 3D TV with no glasses

The screen is covered with tiny lenses, arranged to send viewing zones of left/right images to the viewer.

The lenses direct the left/right images out of the screen in zones. If you sit in a zone at the correct distance and angle you see 3D – if you move out of a zone you lose the 3D image.

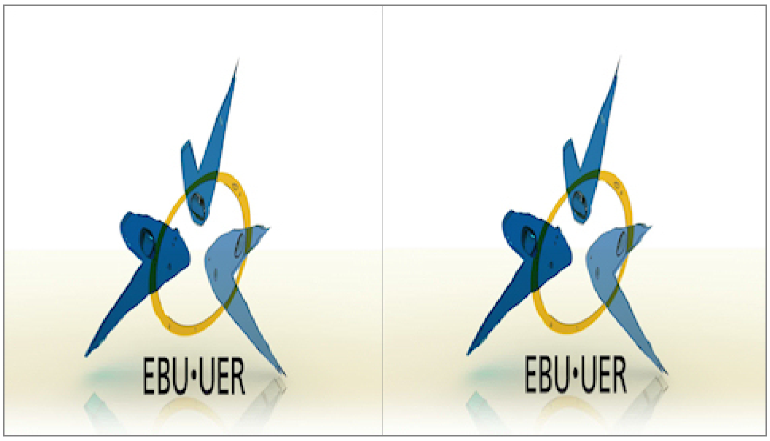
Lenticular screen technology is still very new. Displays for the consumer market are expected from about 2014 onwards.

4. Distribution and receiver

4.1 Current options

This involves using current HDTV distribution technologies and current set top boxes (STBs) in the home, but a new display is required.

The left and right signals are combined in a HDTV frame with the consequence that both images are reduced in resolution. This is called *Frame Compatible* 3D. Various ways of combining the signals are possible, the most prominent are:



Side-by-Side

Top and Bottom

The STBs pass these images through and it is the new 3D displays that stretch the reduced resolution left and right eye images to full frame to create the 3D image.

> *Note: Current 2D HDTV displays (not new, 3D displays) would show a side-by-side (or top-bottom) image as illustrated in the above figure, which is of course unusable for the viewer.*

4.2 Future technologies in distribution and production

The limitations in 3D image quality inherent with Frame Compatible technology have triggered several working initiatives in the standards organisations such as DVB (for distribution) and the SMPTE (for production). Some of the aims of these activities are:

- Improved 3D image quality;
- More features such as depth control on the receiver or display (consumer side);

- 2D HD backwards compatibility to avoid the need for simulcasting, called *Service Compatible* 3D;
- 3D subtitling;
- Contribution links;
- Broadcast equipment interoperability standards.

5. Glossary of important terms

These are some of the more common terms used in 3D production; many more are used by experts.

Convergence: Is where an object within a frame appears as a single image (both left and right images sit perfectly on top of each other). It is the position or plane of the TV screen and objects in front will appear to be out of the screen and objects behind will appear to be into the screen.

Depth budget: This is the amount of 3D that is established for the 3D production. Typically it is referred to as a percentage. For some 3D productions of live events, depth budgets of less than 4% are used, e.g. 2.5% into the screen 0.5% out of the screen have been used.

Disparity: Distance of the same object between the left and right eye view.

Inter Ocular / Inter Axial: Commonly termed IO this refers to the physical distance between the centre of 2 frames, or loosely how far the cameras are apart. Note: it is the relationship between the Convergence and Inter Axial that determines the amount of 3D.

Positive & Negative Parallax: ("Inies" and "Outies") Positive parallax means the object appears behind the screen, hence the term "Inies".

Negative parallax means the object appears in front of the screen, hence the term "outies".

Zero parallax means the object appears on the screen and the left and right eye images are exactly overlaid (exactly like a 2D image)

S3D: Stereoscopic 3D

Stereographer: New role in a 3D production team. He or She takes responsibility for the quality of the 3D.

Z-axis: The axis from front to back of a 3D image, i.e. into and out of the screen.