

Production & Exchange Formats for 3DTV Programmes

**Recommendation for the production, archive
and international exchange of 3DTV programmes**

Source: FTV - 3DTV

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The purpose of this recommendation is to give technical aid to broadcasters who intend to use current (or future) 2D HDTV infrastructures to produce 3DTV programmes.

Another EBU document on 3DTV Production Guidelines that deals with issues such as the grammar of 3DTV scene production (depth range, permissible parallax, convergence etc.) will be published.

Conformance Notation

This document contains both normative text and informative text.

All text is normative except for that in the Introduction, any section explicitly labelled as 'Informative' or individual paragraphs which start with 'Note:'.

Normative text describes indispensable or mandatory elements. It contains the conformance keywords 'shall', 'should' or 'may', defined as follows:

- 'Shall' and 'shall not': Indicate requirements to be followed strictly and from which no deviation is permitted in order to conform to the document.
- 'Should' and 'should not': Indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others.
OR indicate that a certain course of action is preferred but not necessarily required.
OR indicate that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.
- 'May' and 'need not': Indicate a course of action permissible within the limits of the document.

Default identifies mandatory (in phrases containing "shall") or recommended (in phrases containing "should") presets that can, optionally, be overwritten by user action or supplemented with other options in advanced applications. Mandatory defaults must be supported. The support of recommended defaults is preferred, but not necessarily required.

Informative text is potentially helpful to the user, but it is not indispensable and it does not affect the normative text. Informative text does not contain any conformance keywords.

A conformant implementation is one which includes all mandatory provisions ('shall') and, if implemented, all recommended provisions ('should') as described. A conformant implementation need not implement optional provisions ('may') and need not implement them as described.

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Recommendation

The EBU, considering that:

1. Members that produce, archive and distribute Plano-Stereoscopic television (3DTV) have a responsibility to ensure their 3D quality meets a standard that satisfies their audiences and that they are able to exchange these programmes internationally whilst maintaining the 3D quality and the long term viability of their archives.
2. Stereoscopic 3DTV presently requires two separate views of the same subject (Left and Right Eye) that, once captured, must be processed, carried and stored in such a way that no errors are introduced that might affect one signal more than, or differently from the other, including the relative timing of the two signals.
3. Some Members may be required to distribute content for public viewings or to cinemas equipped with digital projection systems ('theatrical distribution of 3DTV').

Recommends that:

1. Both images (Left and Right eye) have the full resolution of the HDTV system being employed¹.
2. Although System 4 (1080p/50) is the target for 3DTV production and exchange, Systems 1, 2 and 3 are acceptable for current 3DTV production.
3. No emission style sub-sampling shall be applied to the signals for production and exchange of 3DTV programme.
4. The left eye image signal shall be designated as the *A-Signal* and the right eye image signal shall be designated as the *B-Signal*.
5. The timing difference between the *A-Signal* and *B-Signal* SDI streams shall not exceed $\pm 330ps^2$.

¹ HDTV Systems are described in EBU Tech 3299

² EBU Technical Report 002 "Advice on the use of 3 Gbit/s HD-SDI interfaces" Table 2 "Jitter Specifications" for the alignment of twin 1.5 Gbit/s links.

6. The *A-Signal* may be used for an alternative 2D transmission.
7. Where required, twin (dual link) 3 Gbit/s HD-SDI links according to SMPTE ST 424 (2006) and SMPTE ST 425-1 (2011) are used to carry both images at full resolution.
8. The international sound is carried as discrete PCM audio signals embedded in the *A-Signal*.
9. 3D programming is accompanied by multi-channel audio (5.1 surround sound).

1. General Guidance for the Production of 3D programmes

1.1 Acquisition

- The two *Signals* (A & B) should be kept at the native resolution of the EBU Tech 3299 standard that the broadcaster has chosen for production of HD programmes.
- Acquisition camera recording codecs for mainstream programmes using system 4, should be:
 - A minimum of 2x 100 Mbit/s 4:2:2 10bit inter-frame coding, or
 - A minimum of 2x 185 Mbit/s 4:2:2 10bit intra-frame coding
- Acquisition camera recording codecs for mainstream programmes using system 1, 2 or 3 should comply with the requirements of EBU R 132 for each signal, i.e.
 - A minimum of 2x 50 Mbit/s 4:2:2 MPEG-2 based inter-frame coding, or
 - A minimum of 2x 100 Mbit/s 4:2:2 intra-frame coding.
- The A & B Signals should have no horizontal or vertical timing displacement relative to each other.
- Tape formats and file-based codecs used for acquisition and post processing should be capable of recording the two individual (A- & B-Signal) channels. Any compression should preserve the image quality such that it should be virtually transparent to the original, at normal 3h viewing distance, after 7 generations (encode-decode processes) with a pixel shift after each generation.
- Intermediate³ codecs used for post processing should be at least:
 - A minimum of 2x 185 Mbit/s 4:2:2 10bit for system 1, 2 or 3 or
 - A minimum of 2x 360 Mbit/s 4:2:2 10bit for system 4.

1.2 Contribution Links

- **MPEG-4/H.264 based contribution links (recommended):** Programmes should use two synchronous (MPEG-4/H.264) links as recommended in EBU R 132. Links should be at least:
 - 42 Mbit/s (for each signal) for a single hop, and 60 Mbit/s (for each signal) for multiple hops for Systems 1,2 or 3,
 - 60 Mbit/s (for each signal) for a single hop, for System 4. Still being investigated are MPEG-4 multiple hop links, but it is unlikely they will exceed 90 Mbit/s.
 - Quality loss should always be less than 6% with the most critical content⁴ ('high entropy content').
- **MPEG-2 based contribution links:** For Systems 1, 2 or 3. (System 4 should not use MPEG-2 links) Programmes should use two synchronous links as recommended in EBU R 132. Links

³ An intermediate codec is one used to ingest material into a production workflow, where the material was originally acquired or compressed using a different, lower bit-rate codec.

⁴ EBU R 132, § 2.6

should be at least:

- 60 Mbit/s (each eye) for a single hop and 90 Mbit/s (each eye) for multiple hops.
- Quality loss should always be less than 6% with the most critical content ('high entropy content').
- **Pre-Processing:** It is acceptable, where no further processing is required, that a 3DTV programme may be pre-processed into the emission standard (e.g. Side-by-Side) before the contribution link. This is advisable only if the broadcaster is uncertain whether the contribution path can maintain the timing and quality of two independent links and there is no requirement for further postproduction processing or archival recording. It is assumed that archival recordings will be undertaken at the source.

Note: The SMPTE is currently working on full resolution 3D contribution links and this recommendation will be updated to include any appropriate standards.

1.3 Standards Conversion

In the case that a Member is required to use standards conversion for the 3D stereoscopic signal, it should be considered, that:

- Two converters of the same make, model and firmware version shall be used with identical settings.
- Motion vector standards conversion shall be used.
- Both converters shall be locked to a common reference.
- Some conversion processors offer the option of synchronising the decisions made during the conversion process. Although not proven to be a requirement for all types of material, there is a possible benefit when converting fast motion (e.g. sports).

1.4 Distribution formats

Where emission pre-processing is required:

- Side-by-Side horizontal samples should be generated from a linear sub-sampling of the YCrCb alternate horizontal pixels (e.g. 0, 2, 4, 6...1918).
- Top-and-Bottom vertical samples should be generated from a quality optimised interpolation (down-conversion) of the original vertical samples.
- If content is distributed to theatres equipped with digital projection systems, particular consideration has to be given to the image format capabilities of the projector. It is known that some digital cinema projection systems have difficulties in operating with HDTV formats such as 1080i/25, 720p/50 and 1080p/50. Many legacy systems only operate successfully with 720p/60 signals. It is vital that this conversion is carried out at the highest possible quality.

2. Recommendations based on EBU Tech 3299

2.1 System 4

System 4 (S4), 16:9 aspect ratio with 1920 horizontal samples and 1080 active lines in progressive scan at a frame rate of 50 Hz, abbreviated as 1080p/50⁵. This is the preferred format for 3DTV production, as it is able to deliver the highest quality to the viewer whatever emission format is used, and it ensures the longest life for the content.

⁵ See EBU R 115 (2005) for more information about the recommendations for the use of 1080p/50.

2.1.1 3G HD-SDI

A pair of System 4 signals (Left/Right Eye) can be carried via

- Twin (Dual Link) 3 Gbit/s HD-SDI links as either Level A or Level B-DL as defined by SMPTE ST 425-1 (2011)⁶.

Note: this does not guarantee synchronisation of the Left/Right Eye signals at clock frequencies.

2.1.2 Recording and archive

Tape: Twin timecode locked tapes, each capable of recording 1080p/50 signals.

File: This is a very new area for file processing. Currently it is advisable to store the files in separate wrappers. Broadcasters are advised to keep 1080p/50 3D files in a form that is easy to extract and reprocess as and when necessary, as more information becomes known.

2.1.3 Cameras and Camera codecs

Cameras should normally meet the Tier 1 criteria described in EBU R 118 and camera codecs should be able to provide and maintain the quality required for a 1080p/50 signal per eye. The EBU tests on 1080p/50 HD acquisition codecs provide guidance on the required image quality⁷.

2.2 Systems 2 & 3

For the purposes of this document, Systems 2 and 3 will be considered together.

System 2 (S2), 16:9 aspect ratio with 1920 horizontal samples and 1080 active lines in interlaced scan with a frame rate of 25 Hz, abbreviated as 1080i/25.

Or,

System 3 (S3), 16:9 aspect ratio with 1920 horizontal samples and 1080 active lines in progressive scan with a frame rate of 25 Hz, abbreviated as 1080p/25.

System 4 should be used wherever possible and practical in preference to Systems 2 & 3.

2.2.1 HD-SDI

A pair of System 2 & 3 signals (Left/Right Eye) can be carried via

- Twin (Dual Link) 1.5 Gbit/s HD-SDI links as defined by SMPTE ST 292-1, or
- A single 3 Gbit/s Level B-DS link as defined by SMPTE ST 425-1 (2011).

Note: Neither option guarantees synchronisation of the Left/Right Eye signals at clock frequencies.

⁶ See EBU Tech Report 002 "Advice on the use of 3 Gbit/s HD-SDI interfaces" for an overview of the use of SMPTE ST 425.

⁷ See EBU R 115 (2005) for more information about the recommendations for the use of 1080p/50.

2.2.2 Recording and archive

Tape: Two timecode locked tapes of a format capable of recording 1920 x 1080 4:2:2 signals or a single tape capable of recording dual 1920 x 1080 4:2:2 signals.

File: Left/Right Eye files should be stored in separate wrappers until development of 3D file formats in the SMPTE is complete. Archive files should either be in the native acquisition codec or if transcoded, the archive codec should be at least 160 Mbit/s (R 132, § 2.3), in order to preserve the quality of the image.

2.2.3 Cameras and Camera Codecs

Cameras should have a minimum of 3x ½" 1920 x 1080 sensors with a minimum recording codec of 50 Mbit/s MPEG-2 Long GOP or 100 Mbit/s i-frame, as described in EBU R 118 Tier 2L or better.

2.3 System 1

System 1 (S1), 16:9 aspect ratio with 1280 horizontal samples and 720 active lines in progressive scan with a frame rate of 50 Hz, abbreviated as 720p/50. System 4 should be used wherever possible and practical in preference to System 1.

2.3.1 HD-SDI

A pair of System 1 signals (Left/Right Eye) can be carried via

- Twin (Dual Link) 1.5 Gbit/s HD-SDI links as defined by SMPTE ST 292-1, or
- A single 3 Gbit/s Level B-DS link as defined by SMPTE ST 425-1 (2011)⁸

Note: Neither option guarantees synchronisation of the Left/Right Eye signals at clock frequencies.

2.3.2 Recording and archive

Tape: Two timecode locked tapes of a format capable of recording 1280 x 720 4:2:2 signals or a single tape capable of recording dual 1280 x 720 4:2:2 signals.

File: Left/Right Eye files should be stored in separate wrappers until development of 3D file formats in the SMPTE is complete. Archive files should either be in the native acquisition codec or if transcoded, the archive codec should be at least 160 Mbit/s (R 132, § 2.3), in order to preserve the quality of the image.

2.3.3 Cameras and Camera Codecs

Cameras should have a minimum of 3x ½" 1920 x 1080 sensors with a minimum recording codec of 50 Mbit/s MPEG-2 Long GOP or 100 Mbit/s i-frame, as described in EBU R 118 Tier 2L or better.

2.3.4 Format conversion

Format conversion for international exchange from 720p/50 to 1080i/25 (or 1080p/25) will require the same care as conversion between frame rates.

⁸ See EBU Tech Report 002 "Advice on the use of 3 Gbit/s HD-SDI interfaces" for an overview of the use of SMPTE ST 425.

3. Bibliography

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