Recommendation ITU-R BT.2123-1

(02/2025)

BT Series: Broadcasting service (television)

Video parameter values for advanced immersive audio-visual systems for production and international programme exchange in broadcasting

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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| Series of ITU-R Recommendations  (Also available online at <https://www.itu.int/publ/R-REC/en>) | |
| **Series** | Title |
| **BO** | Satellite delivery |
| **BR** | Recording for production, archival and play-out; film for television |
| **BS** | Broadcasting service (sound) |
| **BT** | Broadcasting service (television) |
| **F** | Fixed service |
| **M** | Mobile, radiodetermination, amateur and related satellite services |
| **P** | Radiowave propagation |
| **RA** | Radio astronomy |
| **RS** | Remote sensing systems |
| **S** | Fixed-satellite service |
| **SA** | Space applications and meteorology |
| **SF** | Frequency sharing and coordination between fixed-satellite and fixed service systems |
| **SM** | Spectrum management |
| **SNG** | Satellite news gathering |
| **TF** | Time signals and frequency standards emissions |
| **V** | Vocabulary and related subjects |

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| ***Note***: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.* |

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Video parameter values for advanced immersive audio-visual systems for production and international programme exchange in broadcasting

(2019-2025)

Scope

Advanced immersive audio-visual (AIAV) systems will provide viewers with immersive experiences with an unprecedented degree of presence by enabling a wide field of view of their desired direction. In order to produce high-quality comfortable images, AIAV systems require video system parameters that go beyond the levels of UHDTV as well as additional system parameters to support omnidirectional image representation. This Recommendation specifies AIAV system parameters for production and international programme exchange.

Keywords

Immersive media, virtual reality, 360o video, system parameters, projection mapping

The ITU Radiocommunication Assembly,

considering

*a)* that virtual reality, 360o video, and other immersive media technologies have caught the attention of the content providers, audiences, and the associated consumer technology vendors;

*b)* that television and radio programme makers and others are exploring advanced immersive systems to enhance the audiences’ experience of their content;

*c)* that currently immersive media content is usually acquired and produced to the requirements of specific delivery or distribution technologies;

*d)* that currently no worldwide standards or recommended practices exist for production, mastering, and exchange of virtual reality, 360o video, and other immersive programmes in broadcast;

*e)* that broadcasters are distributing a wide variety of content to audiences via an increasing number of interactive delivery platforms;

*f)* that making virtual reality 360o images high quality and comfortable requires having a significantly high spatial resolution;

*g)* that specifying parameter values of audio-visual components for advanced immersive audio-visual (AIAV) systems for production of professional linear content facilitates producing a variety of AIAV content,

recommends

that for production and international exchange of AIAV content, the specifications described in this Recommendation should be used.

# 1 Picture characteristics for 360oimages in three degrees of freedom (3DoF) applications[[1]](#footnote-2)

Picture characteristics are shown in Tables 1 through 3 for 360o images in 3DoF applications.

TABLE 1

Image spatial and temporal characteristics

|  |  |
| --- | --- |
| Parameter | Values |
| Projection method of a sphere to a rectangular image | Equirectangular projection (see details in Annex 1) |
| Pixel count of mapped images  Horizontal × vertical | 30 720 × 15 360 (1), (2)  (30K × 15K) |
| Pixel aspect ratio | 1:1 (square pixels) |
| Frame frequency (Hz) | 120, 120/1.001, 100, 60, 60/1.001, 50 |
| Image format | Progressive |
| (1) These values are based on typical human spatial angular acuity for viewers not to perceive a pixel structure when viewing part of a 360° image. A pixel count of 30K × 15K is required for a full 360° image. Other pixel counts may be used when actual system design is undertaken.  (2) A hemisphere or a part of a 360° image may be represented by taking a part of 30K × 15K pixels. | |

TABLE 2

System colorimetry

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | | Values | | |
| Optical spectrum (informative) | Chromaticity coordinates  (CIE, 1931) | |
| *x* | *y* |
| Primary colours | Red primary (R) | monochromatic 630 nm | 0.708 | 0.292 |
| Green primary (G) | monochromatic 532 nm | 0.170 | 0.797 |
| Blue primary (B) | monochromatic 467 nm | 0.131 | 0.046 |
| Reference white | | D65 per  ISO 11664-2:2007 | 0.3127 | 0.3290 |
| Colour Matching Functions | | CIE 1931 | | |

TABLE 3

Signal format

|  |  |
| --- | --- |
| Parameter | Values |
| Signal format | *R’G’B’*, *Y'C'BC'R* (non-constant luminance), *ICTCP* |
| Derivation of *R'G'B'*, *Y'C'BC'R,* and *ICTCP (HDR only)* | Standard dynamic range (SDR): As per Rec. ITU-R BT.2020  High dynamic range (HDR): As per Rec. ITU-R BT.2100 |
| Bit depths | 10 or 12 bits per component |
| Colour sub-sampling | As per Table 8 of Rec. ITU-R BT.2100 |
| Digital integer representation | As per Table 9 of Rec. ITU-R BT.2100  (SDR: narrow range, HDR: narrow or full range) |
| *Note to Table 3:* Constant Intensity *ICTCP signal* format was initially introduced in 2016 in Recommendation ITU‑R BT.2100. This signal format should not be used for programme exchange unless all parties agree. | |

# 2 Presentation characteristics for 360o images

Informative presentation characteristics for 360o images are shown in Annex 2.

Annex 1   
(normative)  
  
Omnidirectional video projection[[2]](#footnote-3)

# 1 Projection structure and coordinate system

The projection structure is a unit sphere.

The coordinate system specified in this section should be used to indicate the orientation of the projection structure or the spherical location of a point. In the latter case, the roll angle may be absent or ignored.

NOTE 1 – It is assumed that the coordinate systems for different media types were aligned during content production.

NOTE 2 – The specified coordinate system is the same as the reference coordinate system for actuators specified in ISO/IEC 23005-5.

Figure 1 specifies the coordinate axes used for defining yaw (φ), pitch (θ), and roll angles. Yaw rotates around the Y (vertical, up) axis, pitch around the X (lateral, side-to-side) axis, and roll around the Z (back-to-front) axis. Rotations are extrinsic, i.e. around the X, Y, and Z fixed reference axes. The angles increase clockwise when looking from the origin towards the positive end of an axis.

Figure 1

Principal axes for yaw, pitch, roll angles  
Yaw rotates around Y (vertical, up) axis, pitch around X (lateral, side-to-side) axis, roll around Z (back-to-front)

A diagram of a face with arrows and lines

Description automatically generated

**Yaw angle** (φ) indicates the rotation angle around the Y axis in degrees.

Type: floating point decimal values

Range: in the range of −180, inclusive, to 180, exclusive

**Pitch angle** (θ)indicates the rotation angle around the X axis in degrees.

Type: floating point decimal values

Range: in the range of −90, inclusive, to 90, inclusive

**Roll angle** indicates the rotation angle around the Z axis in degrees.

Type: floating point decimal values

Range: in the range of −180, inclusive, to 180, exclusive

# 2 Omnidirectional projection formats

Inputs to this clause are:

**– Picture width** (*w*) and **Picture height** (*h*), which are the width and height, respectively, of the equirectangular panorama picture in samples, and

– the centre point of a sample location (*i*, *j*) along horizontal and vertical axes, respectively.

Outputs of this clause are:

– angular coordinates (φ, θ) for the sample in degrees relative to the coordinate axes specified in § 1.

The angular coordinates (φ, θ) for the luma sample location, in degrees, are given by the following equirectangular mapping equations, as shown in Fig. 2.

φ = ( *i* ÷ *w* − 0.5 ) \* 360

θ = ( 0.5 − *j* ÷ *h* ) \* 180

Figure 2

Sampling coordinate definition

A white rectangular box with black text

Description automatically generated

Annex 2   
(informative)

Presentation characteristics for 360o images

Presentation of 360o images on a head-mounted display (HMD) requires the spatial characteristics as shown in Table 4.

TABLE 4

Spatial characteristics requirements for an HMD when presenting 360o images

|  |  |  |
| --- | --- | --- |
| Spatial characteristics | | Requirements |
| Field of view (FV) | Horizontal (FVH) | FVH ≥ 240o |
| Vertical (FVV) | FVV ≥ 160 o |
| Spatial resolution (SR) | FVH ≤ 100o, FVV ≤ 90o | SR ≥ 30 cpd |
| 100o < FVH ≤ 160o, 90o < FVV ≤ 110o | SR ≥ 8 cpd |
| 160o < FVH, 110o < FVV | SR ≥ 1 cpd |
| *Note to Table 4:* The requirements are based on Report ITU-R BT.2506-1. | | |

1. Programme material in which a user can freely look around in any direction having three degrees of freedom (3DoF) (yaw, pitch, and roll). A typical use case is a user sitting in a chair looking at 3D VR/360° content presented on a head-mounted display (HMD). Figure 1 provides further detail. [↑](#footnote-ref-2)
2. This Annex is based on the specifications in ISO/IEC 23090-2 Omnidirectional Media Format. [↑](#footnote-ref-3)