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Foreword

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Introduction

Linear TV services can be made available on 3GPP services based on MBMS and PSS user services (over RTP or 3GP-DASH).

- 3GP-DASH aims at offering the best quality of experience as possible by adapting to the UE capabilities and dynamically to the network conditions. Linear TV and on-demand services are already identified as major use cases for 3GP-DASH delivery format.
- (e)MBMS user services offer the possibility to offload the network when the same content is consumed simultaneously by many UEs. This typically happens when a large audience accesses the same content concurrently, such as a popular football match, the Olympic Games, a political debate, breaking news, etc. For this reason, the access to live broadcast TV services is a major use case for eMBMS.

For traditional linear TV distribution, TV services accessed through Satellite, Digital Terrestrial TV (DTT), cable or IPTV obey to requirements on the video profiles to ensure a consistent quality of experience while accessing different channels within a TV bouquet.

On-demand video services, via streaming or downloading, generally obey to the same requirements.

In previous releases, 3GPP specifications were missing detailed definitions of consistent video distribution formats (such as spatial and temporal resolutions, aspect ratios, random access points, etc.) for which operators can provide such guarantees in terms of quality of experience. The purpose of the present document is to specify those distribution formats.

1 Scope

The present document specifies requirements and guidelines on video source formats (frame rate, resolution, aspect ratio, colorimetry, bit depth...) and encoding parameters (codec format, random access point period, SEI messages...) for different types of TV services, including linear TV, catch-up TV or on-demand services. A limited set of Operation Points (e.g. SDTV, HDTV...) are defined to provide confidence to content providers/broadcasters on the quality of experience offered by 3GPP services when used for TV-like distribution. Operation Points define format and encoding restrictions, but may also be viewed as compatibility points for UEs.

In particular, the Operation Points defined in the present document may serve as the primary tested configurations for TV centric video distribution. The Operation Points are defined based on the analysis and findings in the technical report TR 26.949 [2].

In addition, in the context of DASH operations, not only the main distribution formats are defined, but also a subset of spatial and temporal resolutions. In order to minimize testing for seamless switching experience, suitable lower resolutions of distribution formats are defined. Furthermore, to compensate congestion situations, a minimum service quality is defined in order to provide service continuity.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
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- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TR 26.949: "Video formats for 3GPP services".
- [3] Recommendation ITU-R BT.709-6 (06/2015): "Parameter values for the HDTV standards for production and international programme exchange".
- [4] Recommendation ITU-R BT.2020-2 (10/2015): "Parameter values for ultra-high definition television systems for production and international programme exchange".
- [5] Recommendation ITU-T H.264 (04/2017): "Advanced video coding for generic audiovisual services" | ISO/IEC 14496-10:2014: "Information technology – Coding of audio-visual objects – Part 10: Advanced Video Coding".
- [6] Recommendation ITU-T H.265 (12/2016): "High efficiency video coding" | ISO/IEC 23008-2:2015: "High Efficiency Coding and Media Delivery in Heterogeneous Environments – Part 2: High Efficiency Video Coding".
- [7] 3GPP TS 26.244: "Transparent end-to-end packet switched streaming service (PSS); 3GPP file format (3GP)".
- [8] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".
- [9] ISO/IEC 14496-15: 2017: "Information technology - Coding of audio-visual objects - Part 15: Carriage of network abstraction layer (NAL) unit structured video in ISO base media file format".
- [10] ISO/IEC 23001-8:2016, "Information technology -- MPEG systems technologies -- Part 8: Coding-independent code points".

- [11] Recommendation ITU-R BT.2100-1 (06/2017): "Image parameter values for high dynamic range television for use in production and international programme exchange".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

Bitstream: A media bitstream that conforms to a video encoding format and certain Operation Point.

Operation Point: A collection of discrete combinations of different content formats including spatial and temporal resolutions, colour mapping, transfer functions, etc. and the encoding format.

Pillarbox: The pillarbox effect occurs in widescreen video displays when black bars (mattes or masking) are placed on the sides of the image. It becomes necessary when film or video that was not originally designed for widescreen is shown on a widescreen display, or a narrower widescreen image is displayed within a wider aspect ratio.

Receiver: A receiver that can decode and render any bitstream that is conforming to a certain Operation Point.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

AVC	Advanced Video Coding
CVS	Coded Video Sequence
DASH	Dynamic Adaptive Streaming over HTTP
EOTF	Electro-Optical Transfer Function
FFS	For Further Study
HD	High Definition
HDR	High Dynamic Range
HRD	Hypothetical Reference Decoder
HEVC	High Efficiency Video Coding
MBMS	Multicast Broadcast Multimedia Service
MPD	Media Presentation Description
NAL	Network Abstraction Layer
PPS	Picture Parameter Set
PQ	Perceptual Quantization
PSS	Packet Switch Streaming
RAP	Random Access Point
SDR	Standard Dynamic Range
SEI	Supplemental Enhancement Information
SPS	Sequence Parameter Set
TV	Television
UHD	Ultra High Definition
VCL	Video Coding Layer
VUI	Video Usability Information

4 Video profiles Operation Points

4.1 Introduction

The video profile Operation Points defined in this clause are primarily defined in order to apply to the content format being delivered to 3GPP UE PSS/DASH and MBMS clients over the 3GPP system. Parameters for video encoder/decoder, content format and transport are defined.

The following Operation Points are defined in the present document: H.264/AVC 720p HD, H.264/AVC Full HD, H.265/HEVC 720p HD, H.265/HEVC Full HD, H.265/HEVC UHD, H.265/HEVC Full HD HDR and H.265/HEVC UHD HDR.

Clause 4.2 specifies general requirements applicable to all Operation Points. Clause 4.3 specifies general requirements applicable to the video codecs. Then for each Operation Point, Bitstream and Receiver requirements are detailed in clause 4.4 for H.264/AVC and clause 4.5 for H.265/HEVC.

4.2 General requirements on video profile Operation Points

The following requirements apply to video profile Operation Points:

- 16:9 picture aspect ratio shall be used. 3GPP UEs with display aspect ratio different from 16:9 and supporting the TV services over 3GPP are, by default, assumed to display the video in letter-box or pillarbox modes, depending on the screen size and orientation.
- Y'CbCr (non-constant luminance) as the Chroma Format should be used.
- 4:2:0 chroma sub-sampling shall be used.
- The following spatial resolutions should be used for:
 - Operation Points (for video intended to be viewed in full-screen mode): 3840×2160 , 1920×1080 and 1280×720 .
 - Distribution formats: 3840×2160 , 3200×1800 , 2560×1440 , 1920×1080 , 1600×900 , 1280×720 , 960×540 , 854×480 , 640×360 , 426×240 .

NOTE 1: Distribution formats within an Operation Point do not exceed the native resolution of the Operation Point, but they may be subsampled in order to optimize distribution or adapt to the viewing conditions.

- The following frame rates should be used depending on the Operation Point: 24; 25; 30; 50 and 60Hz. The following fractional frame rates may be used: 24/1.001, 30/1.001, 60/1.001 (Hz). Frame rates are not associated to any particular spatial resolution.
- The following colour space formats may be used depending on the Operation Point: ITU-R BT.709 [3] and ITU-R BT.2020 [4]. If no signal is provided for the colour space, BT.709 [3] should be assumed as default colour space. Receiving devices should support BT.2020 [4] signaling and provide an appropriate mapping of the signal to the supported colour space of the device. Colour spaces are not associated to any particular spatial resolution.
- The following transfer characteristics may be used depending on the Operation Point: BT.709 [3] and BT.2020 [4] non-constant luminance transfer characteristics or the electro-optical transfer function as defined in Recommendation ITU-R BT.2100 [11] for the Perceptual Quantization (PQ) system.

NOTE 2: Although ITU-R BT.2020 is originally only recommended for 2160p/4320p resolution, this 3GPP specification recommends that BT.2020 be supported irrespective of the resolution to keep the colour space consistent across resolutions.

- The Random Access Point period shall be less than or equal to 5 seconds, should be less than or equal to 2 seconds and may be less than or equal to 0.5 second for H.264/AVC [5] and 1 second for H.265/HEVC [6] for specific service requirements such as fast channel change or fast access to the bitstream.
- Bit depth: Either 8 or 10 bits shall be used depending on the Operation Point.

Table 4.1 provides an overview of the Operation Points defined in the present document.

Table 4.1: TV over 3GPP services Video Profile Operation Points

Operation Point name	Resolution format	Picture aspect ratio	Scan	Max. frame rate	Chroma format	Chroma sub-sampling	Bit depth	Colour space format	Transfer Characteristics
H.264/AVC 720p HD	1280 x 720	16:9	Progressive	30	Y'CbCr	4:2:0	8	BT.709 [3]	BT.709 [3]
H.265/HEVC 720p HD	1280 x 720	16:9	Progressive	30	Y'CbCr	4:2:0	8	BT.709 [3]	BT.709 [3]
H.264/AVC Full HD	1920 x 1080	16:9	Progressive	60	Y'CbCr	4:2:0	8	BT.709 [3]	BT.709 [3]
H.265/HEVC Full HD	1920 x 1080	16:9	Progressive	60	Y'CbCr	4:2:0	8; 10	BT.709 [3]; BT.2020 [4]	BT.709 [3]; BT.2020 [4]
H.265/HEVC UHD	3840 x 2160	16:9	Progressive	60	Y'CbCr	4:2:0	10	BT.2020 [4]	BT.2020 [4]
H.265/HEVC Full HD HDR	1920 x 1080	16:9	Progressive	60	Y'CbCr	4:2:0	10	BT.2020 [4]	BT.2100 [11] PQ
H.265/HEVC UHD HDR	3840 x 2160	16:9	Progressive	60	Y'CbCr	4:2:0	10	BT.2020 [4]	BT.2100 [11] PQ

Operation Points are defined including the video codec format.

4.3 General Video codec requirements

The following video codecs and associated Profiles and Levels should be used:

- H.264/AVC Progressive High Profile Level 3.1 [5] for 720p HD services
- H.264/AVC Progressive High Profile Level 4.2 [5] for Full HD services
- H.265/HEVC Main Profile Main Tier Level 3.1 [6] for 720p HD services
- H.265/HEVC Main-10 Profile Main Tier Level 4.1 [6] for Full HD services
- H.265/HEVC Main-10 Profile Main Tier Profile Level 5.1 [6] for UHD services
- H.265/HEVC Main-10 Profile Main Tier Profile Level 4.1 [6] for Full HD HDR services
- H.265/HEVC Main-10 Profile Main Tier Profile Level 5.1 [6] for UHD HDR services

The Table 4.2 presents the mapping of the operation points with the codec type, profile and level.

Table 4.2: Video codec parameters

Operation Point name	Resolution Format	Codec type, profile and level
H.264/AVC 720p HD	1280 × 720	AVC/H.264 Progressive High Profile Level 3.1
HEVC/H.265 720p HD	1280 × 720	HEVC/H.265 Main Profile Main Tier Level 3.1
H.264/AVC Full HD	1920 × 1080	AVC/H.264 Progressive High Profile Level 4.2
HEVC/H.265 Full HD	1920 × 1080	HEVC/H.265 Main-10 Profile Main Tier Level 4.1
HEVC/H.265 UHD	3840 × 2160	HEVC/H.265 Main-10 Profile Main Tier Level 5.1
HEVC/H.265 Full HD HDR	1920 x 1080	HEVC/H.265 Main-10 Profile Main Tier Level 4.1
HEVC/H.265 UHD HDR	3840 x 2160	HEVC/H.265 Main-10 Profile Main Tier Level 5.1

4.4 H.264/AVC Operation Points

4.4.1 Common requirements and recommendations

4.4.1.1 General

The video Bitstream and Receiver shall conform to Recommendation ITU-T H.264 / ISO/IEC 14496-10 [5] with the restrictions described in this clause. H.264/AVC Bitstreams and Receivers shall support some parts of the "Video Usability Information (VUI)" syntax elements as specified in Recommendation ITU-T H.264 / ISO/IEC 14496-10 [5], annex E, which values are defined in this clause.

4.4.1.2 Random access point

4.4.1.2.1 Definition

An H.264/AVC random access point (RAP) is defined as an access unit in an H.264/AVC Bitstream at which a Receiver can begin decoding the video successfully. This access unit shall include an AU delimiter NAL unit, only one Sequence Parameter Set (that is active) including the VUI and the Picture Parameter Set (PPS) that is required for decoding the associated picture. The access unit shall contain an IDR picture or an I picture.

4.4.1.2.2 Random access point period

RAPs shall be present in the Bitstream at least once every 5 seconds. It is recommended that RAPs occur in the video Bitstream on average at least every 2 seconds. The time interval between successive RAPs is measured as the difference between their respective decoding time values.

4.4.1.3 Sequence parameter set

The following restrictions apply to the active Sequence Parameter Set (SPS):

- `gaps_in_frame_num_value_allowed_flag` value shall be set to 0.
- The Video Usability Information shall be present in the active Sequence Parameter Set. The `vui_parameter_present_flag` shall be set to 1.
- The source video format shall be progressive. `frame_mbs_only_flag` shall be set to 1 for every picture of the Bitstream.

4.4.1.4 Video usability information

The aspect ratio information shall be present, i.e.

- The `aspect_ratio_present_flag` value shall be set to 1.
- The `aspect_ratio_idc` value shall be set to 1 indicating a square pixel format.

The colour parameter information shall be present, i.e.

- `video_signal_type_present_flag` value and `colour_description_present_flag` value shall be set to 1.
- The values of `colour_primaries`, `transfer_characteristics` and `matrix_coefficients` are defined in clause 4.4.2.4 for H.264/AVC 720p HD and in clause 4.4.3.4 for H.264/AVC Full HD Operation Points.

The timing information may be present.

- If the timing information is present, i.e. the value of `timing_info_present_flag` is set to 1, then the values of `num_units_in_tick` and `time_scale` shall be set according to the frame rates allowed in clause 4.4.2.5 for H.264/AVC 720p HD and in clause 4.4.3.5 for H.264/AVC Full HD Operation Points. The timing information present in the video Bitstream should be consistent with the timing information signalled at the system level.

NOTE: In 3GPP PSS and MBMS User services, the Receiver observes the timing at the system level, and ignores the timing information in the video Bitstream.

- The frame rate shall not change between two RAPs. `fixed_frame_rate_flag` value shall be set to 1.

There are no requirements on output timing conformance for H.264/AVC decoding (Annex C of [5]). The Hypothetical Reference Decoder (HRD) parameters, if present, should be ignored by the Receiver.

4.4.2 H.264/AVC 720p HD Operation Point

4.4.2.1 Introduction

The following restrictions apply for the **H.264/AVC 720p HD** Operation Point. The general requirements and recommendations for Bitstreams and Receivers for H.264/AVC Operation Points in clause 4.4.1 shall apply.

NOTE: This format is within the capabilities of H.264/AVC video codecs of 3GPP video services up to Release 13.

4.4.2.2 Profile and level

A Bitstream conforming to the H.264/AVC 720p HD Operation Point shall comply with the following restrictions:

- The `profile_idc` shall be set to 100 indicating the High profile.
- The `constrain_set0_flag`, `constrain_set1_flag`, `constrain_set2_flag` and `constrain_set3_flag` shall all be set to 0.
- The value of `level_idc` shall not be greater than 31 (corresponding to the level 3.1) and should indicate the lowest level to which the Bitstream conforms.

4.4.2.3 Spatial resolutions

The spatial resolution of the distribution format shall be one of the following:

- 1280 × 720,
- 960 × 540,
- 854 × 480,
- 640 × 360,
- 426 × 240.

4.4.2.4 Colour information

A Bitstream conforming to the H.264/AVC 720p HD Operation Point shall use Recommendation ITU-R BT.709 [3] colorimetry.

The `colour primaries` value, the `transfer characteristics` value and the `matrix coefficients` value in the Video Usability Information shall all be set to 1.

A Receiver conforming to the H.264/AVC 720p HD Operation Point shall be capable of decoding Bitstreams that use Recommendation ITU-R BT.709 [3] colorimetry.

4.4.2.5 Frame rates

A Bitstream conforming to the H.264/AVC 720p HD Operation Point shall have one of the following frame rates: 24; 25; 30; 24/1.001; 30/1.001 Hz.

The frame rate may be indicated in the VUI by setting `time_scale` and `num_units_in_tick`.

4.4.2.6 Receiver compatibility

Receivers conforming to the **H.264/AVC 720p** Operation Point shall support decoding and displaying **H.264/AVC 720p HD** Bitstreams.

Receivers conforming to the **H.264/AVC 720p** Operation Point are only required to support Bitstreams with the maximum VCL Bit Rate constrained to be 14 Mbps with `cpbBrVclFactor` and `cpbBrNalFactor` being fixed to be 1000 and 1200, respectively.

4.4.3 H.264/AVC Full HD Operation Point

4.4.3.1 Introduction

The following restrictions apply for the **H.264/AVC Full HD** Operation Point. The general requirements and recommendations for Bitstreams and Receivers for H.264/AVC Operation Points in clause 4.4.1 shall apply.

4.4.3.2 Profile and level

A Bitstream conforming to the H.264/AVC Full HD Operation Point shall comply with the following restrictions:

- The `profile_idc` shall be set to 100 indicating the High profile.
- The `constrain_set0_flag`, `constrain_set1_flag`, `constrain_set2_flag` and `constrain_set3_flag` shall all be set to 0.
- The value of `level_idc` shall not be greater than 42 (corresponding to the level 4.2)) and should indicate the lowest level to which the Bitstream conforms.

4.4.3.3 Spatial resolutions

The spatial resolution of the distribution format shall be one of the following:

- 1920 x 1080,
- 1600 x 900,
- 1280 x 720,
- 960 x 540,
- 854 x 480,
- 640 x 360,
- 426 x 240.

4.4.3.4 Colour information

A Bitstream conforming to the H.264/AVC Full HD Operation Point shall use Recommendation ITU-R BT.709 [3] colorimetry.

The `colour primaries` value, the `transfer characteristics` value and the `matrix coefficients` value in the Video Usability Information shall all be set to 1.

A Receiver conforming to the H.264/AVC Full HD Operation Point shall be capable of decoding Bitstreams that use Recommendation ITU-R BT.709 [3] colorimetry.

4.4.3.5 Frame rates

A Bitstream conforming to the H.264/AVC Full HD Operation Point shall have one of the following frame rates: 24; 25; 30; 50; 60; 24/1.001; 30/1.001; 60/1.001 Hz.

The frame rate may be indicated in the VUI by setting `time_scale` and `num_units_in_tick`.

4.4.3.6 Receiver compatibility

Receivers conforming to the **H.264/AVC Full HD** Operation Point shall support decoding and displaying **H.264/AVC 720p HD** and **H.264/AVC Full HD** Bitstreams.

4.5 H.265/HEVC Operation Points

4.5.1 Common requirements and recommendations

4.5.1.1 General

The video Bitstream and Receiver shall conform to Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6] with the restrictions described in this clause. H.265/HEVC Bitstreams and Receivers shall support some parts of the "Video usability information (VUI)" syntax elements as specified in Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6], annex E. which values are defined in this clause.

4.5.1.2 Random access point

4.5.1.2.1 Definition

An H.265/HEVC random access point (RAP) is defined as an access unit in an H.265/HEVC Bitstream at which a Receiver can begin decoding the video bitstream successfully. This access unit shall include an AU delimiter NAL unit, only one Video Parameter Set (that is active), only one Sequence Parameter Set (that is active) including the VUI and the Picture Parameter Set that is required for decoding the associated picture. The access unit shall contain an IRAP picture or an I picture, as defined in Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6].

4.5.1.2.2 Random access point period

RAPs shall be present in the Bitstream at least once every 5 seconds. It is recommended that RAPs occur in the video Bitstream on average at least every 2 seconds. The time interval between successive RAPs is measured as the difference between their respective decoding time values.

4.5.1.3 Video parameter set

H.265/HEVC Receivers should ignore the content of all Video Parameter Sets (VPS) NAL units as defined in Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6].

NOTE: The content of VPS may be used in future Operation Points.

4.5.1.4 Sequence parameter set

The following restrictions apply to the active Sequence Parameter Set (SPS):

- The Video Usability Information (VUI) shall be present in the active Sequence Parameter Set. The `vui_parameters_present_flag` shall be set to 1.

- The chroma sub-sampling shall be 4:2:0, `chroma_format_idc` value shall be set to 1.
- The source video format shall be progressive, i.e.
 - The `general_progressive_source_flag` shall be set to 1,
 - The `general_interlaced_source_flag` shall be set to 0,
 - The `general_frame_only_constraint_flag` shall be set to 1.
- Only 2D contents are required to be supported, i.e.
 - The `general_non_packed_constraint_flag` shall be set to 1.

Receivers conforming to any of the H.265/HEVC Operation Points shall only support Bitstreams with the restrictions on the SPS defined above.

4.5.1.5 Video usability information

The aspect ratio information shall be present, i.e.

- The `aspect_ratio_info_present_flag` value shall be set to 1.
- The `aspect_ratio_idc` value shall be set to 1 indicating a square pixel format.

The colour parameter information shall be present, i.e.

- `video_signal_type_present_flag` value and `colour_description_present_flag` value shall be set to 1.
- The values of `colour_primaries`, `transfer_characteristics` and `matrix_coeffs` are defined in clause 4.5.2.5 for H.265/HEVC 720p HD, in clause 4.5.3.5 for H.265/HEVC Full HD, in clause 4.5.4.5 for H.265/HEVC UHD, in clause 4.5.5.5 for H.265/HEVC Full HD HDR and in clause 4.5.6.5 for H.265/HEVC UHD HDR Operation Points.

The timing information may be present.

- If the timing information is present, i.e. the value of `vui_timing_info_present_flag` is set to 1, then the values of `vui_num_units_in_tick` and `vui_time_scale` shall be set according to the frame rates allowed in clause 4.5.2.6 for H.265/HEVC 720p HD, in clause 4.5.3.6 for H.265/HEVC Full HD, in clause 4.5.4.6 for H.265/HEVC UHD, in clause 4.5.5.6 for H.265/HEVC Full HD HDR and in clause 4.5.6.6 for H.265/HEVC UHD HDR Operation Points. The timing information present in the video Bitstream should be consistent with the timing information signalled at the system level.
- The frame rate shall not change between two RAPs. `fixed_frame_rate_flag` value, if present, shall be set to 1.

NOTE: In 3GPP PSS and MBMS User services, the Receiver observes the timing at the system level, and ignores the timing information in the video Bitstream.

There are no requirements on output timing conformance for H.265/HEVC decoding (Annex C of [6]). The Hypothetical Reference Decoder (HRD) parameters, if present, should be ignored by the Receiver.

4.5.2 H.265/HEVC 720p HD Operation Point

4.5.2.1 Introduction

The following restrictions apply for the **H.265/HEVC 720p HD** Operation Point. The general requirements and recommendations for Bitstreams and Receivers for H.265/HEVC Operation Points in clause 4.5.1 shall apply.

NOTE: This format is within the capabilities of H.265/HEVC video codecs as defined in 3GPP video services up to Release 13.

4.5.2.2 Profile, tier and level

A Bitstream conforming to the H.265/HEVC 720p HD Operation Point shall comply with the following restrictions:

- The `general_profile_idc` shall be set to 1 indicating the Main profile.
- The `general_tier_flag` shall be set to 0 indicating the Main tier.
- The value of `level_idc` shall not be greater than 93 (corresponding to the Level 3.1) and should indicate the lowest level to which the Bitstream conforms.

4.5.2.3 Bit depth

Bitstreams conforming to the H.265/HEVC 720p HD Operation Point shall be encoded with 8 bit precision.

- `bit_depth_luma_minus8 = 0`
- `bit_depth_chroma_minus8 = bit_depth_luma_minus8`

Receivers conforming to the H.265/HEVC 720p HD Operation Point shall support 8 bit precision.

4.5.2.4 Spatial resolutions

The spatial resolution of the distribution format shall be one of the following:

- 1280 × 720,
- 960 × 540,
- 854 × 480,
- 640 × 360,
- 426 × 240.

4.5.2.5 Colour information

A Bitstream conforming to the H.265/HEVC 720p HD Operation Point shall use Recommendation ITU-R BT.709 [3] colorimetry.

The `colour primaries` value, the `transfer_characteristics` value and the `matrix_coeffs` value in the Video Usability Information shall all be set to 1.

A Receiver conforming to the H.265/HEVC 720p HD Operation Point shall be capable of decoding Bitstreams that use Recommendation ITU-R BT.709 [3] colorimetry.

4.5.2.6 Frame rates

A Bitstream conforming to the H.265/HEVC 720p HD Operation Point shall have one of the following frame rates: 24; 25; 30; 24/1.001; 30/1.001 Hz.

The frame rate may be indicated in the VUI by setting `vui_time_scale` and `vui_num_units_in_tick`.

4.5.2.7 Receiver compatibility

Receivers conforming to the **H.265/HEVC 720p** Operation Point shall support decoding and displaying **H.265/HEVC 720p HD** Bitstreams.

4.5.3 H.265/HEVC Full HD Operation Point

4.5.3.1 Introduction

The following restrictions apply for the **H.265/HEVC Full HD** Operation Point. The general requirements and recommendations for Bitstreams and Receivers for H.265/HEVC Operation Points in clause 4.5.1 shall apply.

4.5.3.2 Profile, tier and level

A Bitstream conforming to the H.265/HEVC Full HD Operation Point shall comply with the following restrictions:

- The `general_profile_idc` shall be set to 2 indicating the Main10 profile.

- The `general_tier_flag` shall be set to 0 indicating the Main tier.
- The value of `level_idc` shall not be greater than 123 (corresponding to the Level 4.1) and should indicate the lowest level to which the Bitstream conforms.

4.5.3.3 Bit depth

Bitstreams conforming to the H.265/HEVC Full HD Operation Point shall be encoded with either 8 or 10 bit precision.

- `bit_depth_luma_minus8` = 0 or 2 (8 or 10 bits respectively)
- `bit_depth_chroma_minus8` = `bit_depth_luma_minus8`

Receivers conforming to the H.265/HEVC Full HD Operation Point shall support 8 bit and 10 bit precision.

4.5.3.4 Spatial resolution

The spatial resolution of the distribution format shall be one of the following:

- 1920 × 1080,
- 1600 × 900,
- 1280 × 720,
- 960 × 540,
- 854 × 480,
- 640 × 360,
- 426 × 240.

4.5.3.5 Colour information

A Bitstream conforming to the H.265/HEVC Full HD Operation Point shall use either Recommendation ITU-R BT.709 [3] colorimetry or Recommendation ITU-R BT.2020 [4] colorimetry in non-constant luminance.

- BT.709 [3] shall be signalled by setting `colour primaries` to the value 1, `transfer characteristics` to the value 1 and `matrix coeffs` to the value 1.
- BT.2020 [4] shall be signalled by setting `colour primaries` to the value 9, `transfer characteristics` to the value 14 and `matrix coeffs` to the value 9.

A Receiver conforming to the H.265/HEVC Full HD Operation Point shall be capable of decoding Bitstreams that use Recommendation ITU-R BT.709 [3] and ITU-R BT.2020 [4] colorimetry. Such a Receiver should support ITU-R BT.2020 [4] signalling and provide an appropriate mapping of the signal to the supported colour space of the device.

NOTE: Colour spaces are not associated to any particular spatial resolution.

4.5.3.6 Frame rates

A Bitstream conforming to the H.265/HEVC Full HD Operation Point shall have one of the following frame rates: 24; 25; 30; 50; 60; 24/1.001; 30/1.001; 60/1.001 Hz.

The frame rate may be indicated in the VUI by setting `vui_time_scale` and `vui_num_units_in_tick`.

4.5.3.7 Receiver compatibility

Receivers conforming to the **H.265/HEVC Full HD** Operation Point shall support decoding and displaying **H.265/HEVC 720p HD** and **H.265/HEVC Full HD** Bitstreams.

NOTE: The requirement infers that the Receivers conforming to the **H.265/HEVC Full HD** support Main and Main10 Profile.

4.5.4 H.265/HEVC UHD Operation Point

4.5.4.1 Introduction

The following restrictions apply for the **H.265/HEVC UHD** Operation Point. The general requirements and recommendations for Bitstreams and Receivers for H.265/HEVC Operation Points in clause 4.5.1 shall apply.

4.5.4.2 Profile, tier and level

A Bitstream conforming to the H.265/HEVC UHD Operation Point shall comply with the following restrictions:

- The `general_profile_idc` shall be set to 2 indicating the Main-10 profile.
- The `general_tier_flag` shall be set to 0 indicating the Main tier.
- The value of `level_idc` shall not be greater than 153 (corresponding to the Level 5.1) and should indicate the lowest level to which the Bitstream conforms.

4.5.4.3 Bit depth

A Bitstream conforming to the H.265/HEVC UHD Operation Point shall be encoded with 10 bits precision.

- `bit_depth_luma_minus8 = 2`
- `bit_depth_chroma_minus8 = bit_depth_luma_minus8`

Receivers conforming to the H.265/HEVC UHD Operation Point shall support 10 bits precision.

4.5.4.4 Spatial resolution

The spatial resolution of the distribution format shall be one of the following:

- 3840 × 2160,
- 3200 × 1800,
- 2560 × 1440,
- 1920 × 1080,
- 1600 × 900,
- 1280 × 720,
- 960 × 540,
- 854 × 480,
- 640 × 360,
- 426 × 240.

4.5.4.5 Colour information

A Bitstream conforming to the H.265/HEVC UHD Operation Point shall use Recommendation ITU-R BT.2020 [4] colorimetry in non-constant luminance.

- BT.2020 [4] shall be signalled by setting `colour primaries` to the value 9, `transfer_characteristics` to the value 14 and `matrix_coeffs` to the value 9.

A Receiver conforming to the H.265/HEVC UHD Operation Point shall be capable of decoding Bitstreams that use ITU-R BT.2020 [4] colorimetry. Such a Receiver should support ITU-R BT.2020 [4] signalling and provide an appropriate mapping of the signal to the supported colour space of the device.

4.5.4.6 Frame rates

A Bitstream conforming to the H.265/HEVC UHD Operation Point shall have one of the following frame rates: 24; 25; 30; 50; 60; 24/1.001; 30/1.001; 60/1.001 Hz.

The frame rate may be indicated in the VUI by setting `vui_time_scale` and `vui_num_units_in_tick`.

4.5.4.7 Receiver compatibility

Receivers conforming to the **H.265/HEVC UHD** Operation Point shall support decoding and displaying **H.265/HEVC 720p HD**, **H.265/HEVC Full HD** and **H.265/HEVC UHD** Bitstreams.

NOTE: The requirement infers that the Receivers conforming to the **H.265/HEVC UHD** support Main and Main-10 Profile.

4.5.5 H.265/HEVC Full HD HDR Operation Point

4.5.5.1 Introduction

The following restrictions apply for the **H.265/HEVC Full HD HDR** Operation Point. The general requirements and recommendations for Bitstreams and Receivers for H.265/HEVC Operation Points in clause 4.5.1 shall apply.

4.5.5.2 Profile, tier and level

A Bitstream conforming to the H.265/HEVC Full HD HDR Operation Point shall comply with the following restrictions:

- The `general_profile_idc` shall be set to 2 indicating the Main-10 profile.
- The `general_tier_flag` shall be set to 0 indicating the Main tier.
- The value of `level_idc` shall not be greater than 123 (corresponding to the Level 4.1) and should indicate the lowest level to which the Bitstream conforms.

4.5.5.3 Bit depth

A Bitstream conforming to the H.265/HEVC Full HD HDR Operation Point shall be encoded with 10 bits precision.

- `bit_depth_luma_minus8 = 2`
- `bit_depth_chroma_minus8 = bit_depth_luma_minus8`

Receivers conforming to the H.265/HEVC Full HD HDR Operation Point shall support 10 bits precision.

4.5.5.4 Spatial resolution

The spatial resolution of the distribution format shall be one of the following:

- 1920 × 1080,
- 1600 × 900,
- 1280 × 720,
- 960 × 540,
- 854 × 480,
- 640 × 360,
- 426 × 240.

4.5.5.5 Colour information and HDR transfer characteristics

A Bitstream conforming to the H.265/HEVC Full HD HDR Operation Point shall comply with the following restrictions in the VUI:

- `colour primaries` shall be set to the value 9,
- `transfer characteristics` shall be set to the value 16,
- `matrix coeffs` shall be set to the value 9.

This signalling implies that BT.2020 [4] colorimetry in non-constant luminance and Perceptual Quantization (PQ) electro-optical transfer function (EOTF) as defined in Recommendation ITU-R BT.2100 [11] are in use.

4.5.5.6 Frame rates

A Bitstream conforming to the H.265/HEVC Full HD HDR Operation Point shall have one of the following frame rates: 24; 25; 30; 50; 60; 24/1.001; 30/1.001; 60/1.001 Hz.

The frame rate may be indicated in the VUI by setting `vui_time_scale` and `vui_num_units_in_tick`.

4.5.5.7 SEI messages for HDR metadata signalling

4.5.5.7.1 Introduction

In order to help the display device to adapt the rendering of an HDR content, the Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6] defines SEI messages for this purpose. These HDR SEI messages provide indication on the mastering environment and the brightness limitations characteristics of an HDR content.

NOTE: As per the Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6], SEI messages are optional and may be ignored by the decoder.

The following clauses describe the restrictions on Mastering display colour volume and Content light level SEI messages, if present in a bitstream conforming to H.265/HEVC Full HD HDR Operation point.

4.5.5.7.2 Mastering display colour volume

A Bitstream conforming to the H.265/HEVC Full HD HDR Operation point may indicate the colour volume of the display used when mastering the video content. This mastering display colour volume is described by its colour primaries, white point and luminance range and is signalled in a Mastering display colour volume SEI message as specified in Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6] clause D.3.28.

If the Mastering display colour volume SEI message is present, `display primaries_x[c]`, `display primaries_y[c]`, `white_point_x`, `white_point_y`, `max_display_mastering_luminance`, and `min_display_mastering_luminance` should be set to a value that is not 0. If a value is set to 0, it means that the value of this field is unknown.

NOTE 1: The lowest value for a known `min_display_mastering_luminance` that can be signalled is 1 (which is equivalent to 0.0001 candelas per square metre).

NOTE 2: In accordance to the HEVC specification, if `max_display_mastering_luminance` is set to 0, then `min_display_mastering_luminance` is set to 0 as well.

According to ITU-T H.265 / ISO/IEC 23008-2 [6] clause D.3.28, when a Mastering display colour volume SEI message is present for any picture of a coded video sequence (CVS), a Mastering display colour volume SEI message is present for the first picture of the CVS. The Mastering display colour volume SEI message persists from the current picture until the end of the CVS. All Mastering display colour volume SEI messages that apply to the same CVS have the same content.

4.5.5.7.3 Content light level information

A Bitstream conforming to the H.265/HEVC Full HD HDR Operation point may indicate the upper bound on the maximum light level among all individual pictures and the upper bound on the maximum average light level for any individual picture of a video content that are signalled in a Content light level SEI message as specified in Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6] clause D.3.35.

If the Content light level SEI message is present, `max_content_light_level` and `max_pic_average_light_level` should be set to values that are not 0. If a value is set to 0 it means that the value of this field is unknown.

When a Content light level information SEI message is present for any picture of a CVS, a content light level information SEI message shall be present for the first picture of the CVS. The content light level information SEI message persists from the current picture until the end of the CVS. All content light level information SEI messages that apply to the same CVS shall have the same content.

4.5.5.8 Receiver compatibility

Receivers conforming to the **H.265/HEVC Full HD HDR** Operation Point shall support decoding and processing **H.265/HEVC 720p HD**, **H.265/HEVC Full HD** and **H.265/HEVC Full HD HDR** Bitstreams.

Receivers conforming to the **H.265/HEVC Full HD HDR** Operation Point should support processing the SEI messages defined in clause 4.5.5.7.

4.5.5.9 HD HDR Operating Modes

HD HDR services may be defined with lower spatial and temporal resolutions than full HD at 60fps. The following operating modes are defined accordingly:

- **HEVC/H.265 HDR 720p HD30** mode: Spatial resolutions do not exceed (1280x720) and frame rate does not exceed 30fps.
- **HEVC/H.265 HDR 720p HD60** mode: Spatial resolutions do not exceed (1280x720), frame rate exceeds 30fps.
- **HEVC/H.265 HDR Full HD30** mode: Spatial resolutions exceed the HEVC/H.265 HDR 720p HD mode, but do not exceed (1920x1080). Frame rate does not exceed 30fps.
- **HEVC/H.265 HDR Full HD60** mode: Spatial resolutions exceed the HEVC/H.265 HDR 720p HD mode, but do not exceed (1920x1080). Frame rate exceeds 30fps.

4.5.6 H.265/HEVC UHD HDR Operation Point

4.5.6.1 Introduction

The following restrictions apply for the **H.265/HEVC UHD HDR** Operation Point. The general requirements and recommendations for Bitstreams and Receivers for H.265/HEVC Operation Points in clause 4.5.1 shall apply.

4.5.6.2 Profile, tier and level

A Bitstream conforming to the H.265/HEVC UHD HDR Operation Point shall comply with the following restrictions:

- The `general_profile_idc` shall be set to 2 indicating the Main-10 profile.
- The `general_tier_flag` shall be set to 0 indicating the Main tier.
- The value of `level_idc` shall not be greater than 153 (corresponding to the Level 5.1) and should indicate the lowest level to which the Bitstream conforms.

4.5.6.3 Bit depth

A Bitstream conforming to the H.265/HEVC UHD HDR Operation Point shall be encoded with 10 bits precision.

- `bit_depth_luma_minus8` = 2
- `bit_depth_chroma_minus8` = `bit_depth_luma_minus8`

Receivers conforming to the H.265/HEVC UHD HDR Operation Point shall support 10 bits precision.

4.5.6.4 Spatial resolution

The spatial resolution of the distribution format shall be one of the following:

- 3840 × 2160,
- 3200 × 1800,
- 2560 × 1440,
- 1920 × 1080,
- 1600 × 900,
- 1280 × 720,
- 960 × 540,
- 854 × 480,
- 640 × 360,
- 426 × 240.

4.5.6.5 Colour information and HDR transfer characteristics

A Bitstream conforming to the H.265/HEVC UHD HDR Operation Point shall comply with the following restrictions in the VUI:

- `colour primaries` shall be set to the value 9,
- `transfer characteristics` shall be set to the value 16,
- `matrix coeffs` shall be set to the value 9.

This signalling implies that Recommendation BT.2020 [4] colorimetry in non-constant luminance and Perceptual Quantization (PQ) electro-optical transfer function (EOTF) as defined in Recommendation ITU-R BT.2100 [11] are in use.

4.5.6.6 Frame rates

A Bitstream conforming to the H.265/HEVC UHD HDR Operation Point shall have one of the following frame rates: 24; 25; 30; 50; 60; 24/1.001; 30/1.001; 60/1.001 Hz.

The frame rate may be indicated in the VUI by setting `vui_time_scale` and `vui_num_units_in_tick`.

4.5.6.7 SEI messages for HDR metadata signalling

4.5.6.7.1 Introduction

In order to help the display device to adapt the rendering of an HDR content, the Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6] defines SEI messages for this purpose. These HDR SEI messages provide indication on the mastering environment and the brightness limitations characteristics of an HDR content.

NOTE: As per the Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6], SEI messages are optional and may be ignored by the decoder.

The following clauses describe the restrictions on Mastering display colour volume and Content light level SEI messages, if present in a bitstream conforming to H.265/HEVC Full HD HDR Operation point.

4.5.6.7.2 Mastering display colour volume

A Bitstream conforming to the H.265/HEVC UHD HDR Operation point may indicate the colour volume of the display used when mastering the video content. This mastering display colour volume is described by its colour primaries, white point and luminance range and is signalled in a Mastering display colour volume SEI message as specified in Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6] clause D.3.28.

If the Mastering display colour volume SEI message is present, `display primaries_x[c]`, `display primaries_y[c]`, `white_point_x`, `white_point_y`, `max_display_mastering_luminance`, and `min_display_mastering_luminance` should be set to a value that is not 0. If a value is set to 0, it means that the value of this field is unknown.

NOTE 1: The lowest value for a known `min_display_mastering_luminance` that can be signalled is 1 (which is equivalent to 0.0001 candelas per square metre).

NOTE 2: In accordance to the HEVC specification, if `max_display_mastering_luminance` is set to 0, then `min_display_mastering_luminance` is set to 0 as well.

According to ITU-T H.265 / ISO/IEC 23008-2 [6] clause D.3.28, when a Mastering display colour volume SEI message is present for any picture of a coded video sequence (CVS), a Mastering display colour volume SEI message is present for the first picture of the CVS. The Mastering display colour volume SEI message persists from the current picture until the end of the CVS. All Mastering display colour volume SEI messages that apply to the same CVS have the same content.

4.5.6.7.3 Content light level information

A Bitstream conforming to the H.265/HEVC UHD HDR Operation point may indicate the upper bound on the maximum light level among all individual pictures and the upper bound on the maximum average light level for any individual picture of a video content that are signalled in a Content light level SEI message as specified in Recommendation ITU-T H.265 / ISO/IEC 23008-2 [6] clause D.3.35.

If the Content light level SEI message is present, `max_content_light_level` and `max_pic_average_light_level` should be set to values that are not 0.

If a value is set to 0 it means that the value of this field is unknown.

When a content light level information SEI message is present for any picture of a CVS, a content light level information SEI message shall be present for the first picture of the CVS. The content light level information SEI message message persists from the current picture until the end of the CVS. All content light level information SEI messages that apply to the same CVS shall have the same content.

4.5.6.8 Receiver compatibility

Receivers conforming to the **H.265/HEVC UHD HDR** Operation Point shall support decoding and processing **H.265/HEVC 720p HD**, **H.265/HEVC Full HD**, **H.265/HEVC UHD**, **H.265/HEVC Full HD HDR** and **H.265/HEVC UHD HDR** Bitstreams.

Receivers conforming to the **H.265/HEVC UHD HDR** Operation Point should support processing the optional SEI messages defined in clause 4.5.6.7.

4.5.6.9 UHD HDR operating modes

UHD HDR services may be defined with a lower temporal resolution than 60fps. The following additional operating modes beyond those defined for HEVC Full HD HDR Operation point in clause 4.5.5.9 are defined accordingly:

- **HEVC/H.265 HDR UHD30** mode: Spatial resolutions exceed the HEVC/H.265 HDR Full HD mode, but do not exceed (3840x2160). Frame rate does not exceed 30fps.
- **HEVC/H.265 HDR UHD60** mode: Spatial resolutions exceed the HEVC/H.265 HDR Full HD mode, but do not exceed (3840x2160). Frame rate exceeds 30fps.

5 Mapping to 3GP-DASH delivery

5.1 General

5.1.1 MPD and 3GP-DASH format

The MPD shall conform to the 3GP-DASH format [8] with the constraints defined in clause 5.1.3. The MPD may signal the appropriate profiles parameter as defined below in the `MPD@profiles` attribute.

5.1.2 File Format Signalling

Representations used in the context of the specification shall conform to the 3GP File Format [7] and the 3GP-DASH Segment format [8] with the following further requirements:

- The '3gtv' ISO brand shall be set as a `compatible_brand` in the File Type Box ('`ftyp`').
- The value of the `duration` field in the Movie Header Box ('`mvhd`') shall be set to a value of '0'
- The Track Header Box ('`tkhd`') shall obey the following constraints:
 - The value of the `duration` field shall be set to '0'.
 - The `width` and `height` fields for a visual track shall specify the track's visual presentation size as fixed-point 16.16 values expressed in on a uniformly sampled grid (commonly called square pixels)
- The Media Header Box ('`mdhd`') shall obey the following constraints:
 - The value of the `duration` field shall be set to '0'.
- The Video Media Header ('`vmhd`') shall obey the following constraints:
 - The value of the `version` field shall be set to '0'.
 - The value of the `graphicsmode` field shall be set to '0'.
 - The value of the `opcolor` field shall be set to {'0', '0', '0'}.
- The Sample Description Box ('`stsd`') shall obey the following constraints:
 - A visual sample entry shall be used.
 - The box shall include a NAL Structured Video Parameter Set.
 - the maximum width and height values shall correspond to the maximum cropped horizontal and vertical sample counts indicated in any Sequence Parameter Set in the track.
 - It shall contain a Decoder Configuration Record which signals the Profile, Level, and other parameters in the video track.
- The `entry_count` field of the Sample-to-Chunk Box ('`stsc`') shall be set to '0'.
- Both the `sample_size` and `sample_count` fields of the Sample Size Box ('`stsz`') box shall be set to zero ('0'). The `sample_count` field of the Sample Size Box ('`stz2`') box shall be set to zero ('0'). The actual sample size information can be found in the Track Fragment Run Box ('`trun`') for the track.

NOTE: This is because the Movie Box ('`moov`') contains no media samples.

- The `entry_count` field of the Chunk Offset Box ('`stco`') shall be set to '0'.
- Movie Fragment Header Boxes ('`mfhd`') shall contain `sequence_number` values that are sequentially numbered starting with the number 1 and incrementing by +1, sequenced by movie fragment storage and presentation order.

- Any Segment Index Box ('sidx'), if present, shall obey the additional constraints:
 - the `timescale` field shall have the same value as the `timescale` field in the Media Header Box ('mdhd') within the same track; and
 - the `reference_ID` field shall be set to the `track_ID` of the ISO Media track as defined in the Track Header Box ('tkhd').
- For AVCSampleEntry ('avc3') and HEVCSampleEntry ('hev1') NAL Structured Video tracks, the 'first_sample_flags' shall signal the picture type of the first sample in each movie fragment as specified below.
 - `sample_is_non_sync_sample=0`: If the first sample is a sync sample.
 - `sample_is_non_sync_sample=1`: If the first sample is not a sync sample.
 - `sample_depends_on=2`: If the first sample is an I frame.
- The Colour Information Box ('colr') should be present. If present, it shall signal the `colour_primaries`, `transfer_characteristics` and `matrix_coeffs` applicable to all the bitstreams associated with this sample entry.
- The sample timing shall obey the frame rate requirements for each Operation Point.

5.1.3 Adaptation Set Constraints

For a video Adaptation Set, the following constraints apply:

- The `@codecs` parameter shall be present on Adaptation Set level and shall signal the maximum required capability to decode any Representation in the Adaptation Set. The `@codecs` parameter should be signalled on the representation level if different from the one on Adaptation Set level.
- The `@profiles` parameter may be present to signal the constraints for the Adaptation Set.
- The attributes `@maxWidth` and `@maxHeight` shall be present. They are expected to be used to signal the original source content format. This means that they may exceed the actual largest size of any coded Representation in one Adaptation Set. More details for each Operation Point are provided.
- The `@width` and `@height` shall be signalled for each Representation (possibly defaulted on Adaptation Set level) and shall match the values of the maximum width and height in the Sample Description box of the contained Representation.
- The Chroma Format may be signalled. If signalled:
 - An Essential or Supplemental Descriptor shall be used to signal the value by setting the `@schemeIdURI` attribute to `urn:mpeg:mpegB:cicp:MatrixCoefficients` as defined ISO/IEC 23001-8 [10] and the `@value` attribute according to Table 4 of ISO/IEC 23001-8 [10]. The values shall match the values set in the VUI.
 - The signalling shall be on Adaptation Set level.
- The Color Primaries and Transfer Function shall be signalled unless ITU-R BT.709 is used. If signalled:
 - An Essential or Supplemental Descriptor shall be used to signal the value by setting the `@schemeIdURI` attribute to `urn:mpeg:mpegB:cicp:ColourPrimaries` and `urn:mpeg:mpegB:cicp:TransferCharacteristics` as defined ISO/IEC 23001-8 [10] and the `@value` attribute according to Table 4 of ISO/IEC 23001-8 [10]. The values shall match the values set in the VUI.
 - The signalling shall be on Adaptation Set level only, i.e. the value shall not be different for different Representations in one Adaptation Set.
- The maximum frame rate may be signalled on Adaptation Set using the `@maxFrameRate` attribute.

- The @frameRate shall be signalled for each Representation (possibly defaulted on Adaptation Set level). In one Adaptation Set, only frame rates shall be present from one of the following subsets:
 - 24 Hz with proposed signalling @frameRate="24"
 - 25 Hz, 50 Hz with proposed signalling @frameRate="25" or @frameRate="50",
 - 30 Hz, 60 Hz with proposed signalling @frameRate="30" or @frameRate="60",
 - 24/1.001 Hz with proposed signalling @frameRate="24000/1001",
 - 30/1.001 Hz, 60/1.001 Hz with proposed signalling @frameRate="30000/1001" or @frameRate="60000/1001".
- Random Access Points shall be signalled by @startsWithSAP set to 1, 2 or 3.

5.2 H.264/AVC 720p HD Operation Point

5.2.1 Operation Point Identifier

If all Representations in an Adaptation Set conforms to the elementary stream constraints for the **H.264/AVC 720p HD** Operation Point as defined in clause 4.4.2 and the Adaptation Set conforms to the MPD signalling according to clause 5.2.2 and 5.2.4, and the Representations conform to the file format constraints in clause 5.2.3, then the @profiles parameter in the Adaptation Set may signal conformance to this Operation Point by using "urn:3GPP:video:op:h264-720p-HD".

5.2.2 MPD Signalling

The requirements as defined in clause 5.1.2 shall apply. In addition, the conditions in 5.2.3 shall apply.

5.2.3 File Format Signalling

The requirements as defined in clause 5.1.3 shall apply. In addition, the following shall apply.

The syntax and values for visual sample entry shall be set as follows:

- It shall conform to AVCSampleEntry ('avc1') or AVCSampleEntry ('avc3') as defined in ISO/IEC 14496-15 [9].
- If AVCSampleEntry ('avc3') is used the following requirements apply:
 - If the sample is a Sync Sample, all parameter sets needed for decoding that sample SHALL be included in the sample itself.
 - If the sample is at the start of a Segment or a Subsegment, (i.e. a random access point position) that is not a Sync Sample, all parameter sets needed for decoding that sample shall occur in one of the samples between the starting point and that sample inclusive.
- The video track shall be encoded using the requirements and recommendations for H.264/AVC 720p HD Operation Point as defined in clause 4.4.2.

5.2.4 Adaptation Set Constraints

The requirements as defined in clause 5.1.3 shall apply. In addition, the following shall apply:

- @maxWidth shall be set to 1280 and @maxHeight shall be set to 720.
- The @codecs parameter shall be set to avc1.64Y01F or avc3.64Y01F,
- @width and @height for Representations shall be set to one of the following pairs: (1280, 720), (960, 540), (854, 480), (640, 360), or (426, 240).
- @frameRate shall be set to one of the following values: "24", "25", "30", "24000/1001", or "30000/1001".

5.3 H.264/AVC Full HD Operation Point

5.3.1 Operation Point Identifier

If all Representations in an Adaptation Set conforms to the elementary stream constraints for the **H.264/AVC Full HD** Operation Point as defined in clause 4.4.3 and the Adaptation Set conforms to the MPD signalling according to clause 5.3.2 and 5.3.4, and the Representations conform to the file format constraints in clause 5.3.3, then the @profiles parameter in the Adaptation Set may signal conformance to this Operation Point by using "urn:3GPP:video:op:h264-Full-HD".

5.3.2 MPD Signalling

The requirements as defined in clause 5.1.2 shall apply. In addition, the conditions in 5.3.3 shall apply.

5.3.3 File Format Signalling

The requirements as defined in clause 5.2.3 shall apply. In addition, the video track shall be encoded using the requirements and recommendations for H.264/AVC Full HD Operation Point as defined in clause 4.4.3.

5.3.4 Adaptation Set Constraints

The requirements as defined in clause 5.1.3 shall apply. In addition, the following shall apply:

- @maxWidth and @maxHeight shall be set to one of the following pairs: (1920, 1080), (1280, 720)
- The @codecs parameter shall be set to avc1.64Y030 or avc3.64Y030,
- @width and @height for Representations shall be set to one of the following pairs: (1920, 1080), (1600, 900), (1280, 720), (960, 540), (854, 480), (640, 360), or (426, 240).
- If ITU-R BT.2020 is used, then the Colour Primaries, Transfer Characteristics and Matrix Coefficients shall be signalled as defined in clause 5.1.3.

5.4 H.265/HEVC 720p HD Operation Point

5.4.1 Operation Point Identifier

If all Representations in an Adaptation Set conforms to the elementary stream constraints for the **H.265/HEVC 720p HD** Operation Point as defined in clause 4.5.2 and the Adaptation Set conforms to the MPD signalling according to clause 5.4.2 and 5.4.4, and the Representations conform to the file format constraints in clause 5.4.3, then the @profiles parameter in the Adaptation Set may signal conformance to this Operation Point by using "urn:3GPP:video:op:h265-720p-HD".

5.4.2 MPD Signalling

The requirements as defined in clause 5.1.2 shall apply. In addition, the conditions in 5.4.3 shall apply.

5.4.3 File Format Signalling

The requirements as defined in clause 5.1.3 shall apply. In addition, the following shall apply:

- It shall conform to HEVCSampleEntry ('hvc1') or HEVCSampleEntry ('hev1') as defined in ISO/IEC 14496-15 [9];
- If HEVCSampleEntry ('hev1') is used the following requirements apply:

If the sample is a Sync Sample, all parameter sets needed for decoding that sample shall be included in the sample itself.

- If the sample is at the start of a Segment or a Subsegment, (i.e. a random access point position) that is not a Sync Sample, all parameter sets needed for decoding that sample occur in one of the samples between the starting point and that sample inclusive.

- The video track shall be encoded using the requirements and recommendations for H.265/HEVC 720p HD Operation Point as defined in clause 4.5.2.

5.4.4 Adaptation Set Constraints

The requirements as defined in clause 5.1.3 shall apply. In addition, the following shall apply:

- @maxWidth shall be set to 1280 and @maxHeight shall be set to 720.
- The @codecs parameter shall be set to hev1.1.2.L93.B0 or hvc1.1.2.L93.B0,
- @width and @height for Representations shall be set to one of the following pairs: (1280, 720), (960, 540), (854, 480), (640, 360), or (426, 240).
- @frameRate shall be set to one of the following values: "24", "25", "30", "24000/1001", or "30000/1001".

5.5 H.265/HEVC Full HD Operation Point

5.5.1 Operation Point Identifier

If all Representations in an Adaptation Set conforms to the elementary stream constraints for the **H.265/HEVC Full HD** Operation Point as defined in clause 4.5.3 and the Adaptation Set conforms to the MPD signalling according to clause 5.5.2 and 5.5.4, and the Representations conform to the file format constraints in clause 5.5.3, then the @profiles parameter in the Adaptation Set may signal conformance to this Operation Point by using "urn:3GPP:video:op:h265-Full-HD".

5.5.2 MPD Signalling

The requirements as defined in clause 5.1.2 shall apply. In addition, the conditions in 5.5.3 shall apply.

5.5.3 File Format Signalling

The requirements as defined in clause 5.4.3 shall apply. In addition, the video track shall be encoded using the requirements and recommendations for H.265/HEVC Full HD Operation Point as defined in clause 4.5.3.

5.5.4 Adaptation Set Constraints

The requirements as defined in clause 5.1.3 shall apply. In addition, the following shall apply:

- @maxWidth and @maxHeight shall be set to one of the following pairs: (1920, 1080), (1280, 720).
- The @codecs parameter shall be set to hev1.2.4.L123.B0 or hvc1.2.4.L123.B0,
- @width and @height for Representations shall be set to one of the following pairs: (1920, 1080), (1600, 900), (1280, 720), (960, 540), (854, 480), (640, 360), or (426, 240).
- If ITU-R BT.2020 is used, then the Colour Primaries, Transfer Characteristics and Matrix Coefficients shall be signalled as defined in clause 5.1.3.
- @frameRate shall be set to one of the following values: "24", "25", "30", "50", "60", "24000/1001", "30000/1001" or "60000/1001".

5.6 H.265/HEVC UHD Operation Point

5.6.1 Operation Point Identifier

If all Representations in an Adaptation Set conforms to the elementary stream constraints for the **H.265/HEVC UHD** Operation Point as defined in clause 4.5.4 and the Adaptation Set conforms to the MPD signalling according to clause 5.6.2 and 5.6.4, and the Representations conform to the file format constraints in clause 5.6.3, then the @profiles parameter in the Adaptation Set may signal conformance to this Operation Point by using "urn:3GPP:video:op:h265-UHD".

5.6.2 MPD Signalling

The requirements as defined in clause 5.1.2 shall apply. In addition, the conditions in 5.6.3 shall apply.

5.6.3 File Format Signalling

The requirements as defined in clause 5.4.3 shall apply. The video track shall be encoded using the requirements and recommendations for H.265/HEVC UHD Operation Point as defined in clause 4.5.4.

5.6.4 Adaptation Set Constraint

The requirements as defined in clause 5.1.3 shall apply. In addition, the following shall apply:

- @maxWidth and @maxHeight shall be set to one of the following pairs: (3840, 2160), (1920, 1080), (1280, 720).
- The @codecs parameter shall be set to hev1.2.4.L153.B0 or hvc1.2.4.L153.B0.
- @width and @height for Representations shall be set to one of the following pairs: (3840, 2160), (3200, 1800), (2560, 1440), (1920, 1080), (1600, 900), (1280, 720), (960, 540), (854, 480), (640, 360), or (426, 240). @width and @height shall not be greater than @MaxWidth and @MaxHeight respectively.
- @frameRate shall be set to one of the following values: "24", "25", "30", "50", "60", "24000/1001", "30000/1001" or "60000/1001".
- The Colour Primaries, Transfer Characteristics and Matrix Coefficients shall be signalled to indicate ITU-R BT.2020 as defined in clause 5.1.3.

5.7 H.265/HEVC Full HD HDR Operation Point

5.7.1 Operation Point Identifier

If all Representations in an Adaptation Set conforms to the elementary stream constraints for the **H.265/HEVC Full HD HDR** Operation Point as defined in clause 4.5.5 and the Adaptation Set conforms to the MPD signalling according to clause 5.7.2 and 5.7.4, and the Representations conform to the file format constraints in clause 5.7.3, then the @profiles parameter in the Adaptation Set may signal conformance to this Operation Point by using "urn:3GPP:video:op:h265-Full-HD-HDR".

5.7.2 MPD Signalling

The requirements as defined in clause 5.1.2 shall apply. In addition, the conditions in 5.7.3 shall apply.

5.7.3 File Format Signalling

The requirements as defined in clause 5.4.3 shall apply. The video track shall be encoded using the requirements and recommendations for H.265/HEVC Full HD HDR Operation Point as defined in clause 4.5.5.

If sample entry hvc1 is in use, then any possibly present Mastering display colour volume SEI message or any possibly present Content light level information SEI message shall be provided in the decoder configuration record and shall be constant for the entire file.

5.7.4 Adaptation Set Constraint

The requirements as defined in clause 5.1.3 shall apply. In addition, the following shall apply:

- @maxWidth and @maxHeight shall be set to one of the following pairs: (1920, 1080), (1280, 720).
- The @codecs parameter shall be set to one of the values defined in Table 5.1, depending on the operating mode as defined in clause 4.5.5.9, except that the level indication may indicate a lower level to which all the applicable Bitstreams conform.

Table 5.1: Codecs parameters for different HD HDR Operating modes

Operation Modes name	Codecs Parameter for hvc1	Codecs Parameter for hev1
HEVC/H.265 HDR 720p HD30	hvc1.2.4.L83.B0	hev1.2.4.L83.B0
HEVC/H.265 HDR 720p HD60	hvc1.2.4.L93.B0	hev1.2.4.L93.B0
HEVC/H.265 HDR Full HD30	hvc1.2.4.L113.B0	hev1.2.4.L113.B0
HEVC/H.265 HDR Full HD60	hvc1.2.4.L123.B0	hev1.2.4.L123.B0

- @width and @height for Representations shall be set to one of the following pairs: (1920, 1080), (1600, 900), (1280, 720), (960, 540), (854, 480), (640, 360), or (426, 240). @width and @height shall not be greater than @MaxWidth and @MaxHeight respectively.
- @frameRate shall be set to one of the following values: "24", "25", "30", "50", "60", "24000/1001", "30000/1001" or "60000/1001".
- The Colour Primaries, Transfer Characteristics and Matrix Coefficients shall be signalled to indicate ITU-R BT.2020 and BT.2100 PQ as defined in clause 5.1.3. In particular, the Essential Descriptors shall be present to signal BT.2020 and BT.2100 PQ as follows:
 - an Essential Descriptor shall be used to signal the value by setting the @schemeIdUri attribute to urn:mpeg:mpegB:cicp:MatrixCoefficients as defined ISO/IEC 23001-8 [10] and the @value attribute according to Table 4 of ISO/IEC 23001-8 [10]. The values shall match the values set in the VUI, i.e. the value is set to 9.
 - Essential Descriptors shall be used to signal the value by setting the @schemeIdUri attribute to urn:mpeg:mpegB:cicp:ColourPrimaries and urn:mpeg:mpegB:cicp:TransferCharacteristics, respectively, as defined ISO/IEC 23001-8 [10] and the @value attribute according to the "Colour primaries" Table and the "Transfer characteristics" Table of ISO/IEC 23001-8 [10], respectively. The values shall match the values set in the VUI, i.e.
 - urn:mpeg:mpegB:cicp:ColourPrimaries with value set to 9
 - urn:mpeg:mpegB:cicp:TransferCharacteristics with value set to 16
 - The Essential Descriptors shall be on Adaptation Set level only, i.e. all Representations in one Adaptation Set are required to have the same Matrix Coefficients, Color Primaries and Transfer Function.
 - If any Representation contains a mastering display colour volume SEI message or a content light level information SEI message, the same SEI message shall be present in all Representations in the Adaptation Set.
 - For hvc1 this implies that the SEI messages shall be provided in the decoder configuration record of every Representation.
 - For hev1, if any of such SEI message is carried inband within a segment/subsegment of any Representation of the Adaptation Set, it shall be carried with the first picture of that segment/subsegment in decode order in all Representations of this Adaptation Set.

5.8 H.265/HEVC UHD HDR Operation Point

5.8.1 Operation Point Identifier

If all Representations in an Adaptation Set conforms to the elementary stream constraints for the **H.265/HEVC UHD HDR** Operation Point as defined in clause 4.5.6 and the Adaptation Set conforms to the MPD signalling according to clause 5.8.2 and 5.8.4, and the Representations conform to the file format constraints in clause 5.8.3, then the @profiles parameter in the Adaptation Set may signal conformance to this Operation Point by using "urn:3GPP:video:op:h265-UHD-HDR".

5.8.2 MPD Signalling

The requirements as defined in clause 5.1.2 shall apply. In addition, the conditions in 5.8.3 shall apply.

5.8.3 File Format Signalling

The requirements as defined in clause 5.4.3 shall apply. The video track shall be encoded using the requirements and recommendations for H.265/HEVC UHD HDR Operation Point as defined in clause 4.5.6.

If sample entry `hvc1` is in use, then any possibly present Mastering display colour volume SEI message or any possibly present Content light level information SEI message shall be provided in the decoder configuration record and shall be constant for the entire file.

5.8.4 Adaptation Set Constraint

The requirements as defined in clause 5.1.3 shall apply. In addition, the following shall apply:

- `@maxWidth` shall be set to 3840 and `@maxHeight` shall be set to 2160.
- The `@codecs` parameter shall be set to one of the values defined in Table 5.2, depending on the operating mode as defined in clause 4.5.6.9,

Table 5.2: Codecs parameters for different UHD HDR Operating modes

Operation Modes name	Codecs Parameter for hvc1	Codecs Parameter for hev1
HEVC/H.265 HDR Full UHD30	<code>hvc1.2.4.L143.B0</code>	<code>hev1.2.4.L143.B0</code>
HEVC/H.265 HDR Full UHD60	<code>hvc1.2.4.L153.B0</code>	<code>hev1.2.4.L153.B0</code>

- `@width` and `@height` for Representations shall be set to one of the following pairs: (3840, 2160), (3200, 1800), (2560, 1440), (1920, 1080), (1600, 900), (1280, 720), (960, 540), (854, 480), (640, 360), or (426, 240).
- `@frameRate` shall be set to one of the following values: "24", "25", "30", "50", "60", "24000/1001", "30000/1001" or "60000/1001".
- The Colour Primaries, Transfer Characteristics and Matrix Coefficients shall be signalled to indicate ITU-R BT.2020 and BT.2100 PQ as defined in clause 5.1.3. In particular, the Essential Descriptors shall be present to signal BT.2020 and BT.2100 PQ as follows:
 - an Essential Descriptor shall be used to signal the value by setting the `@schemeIdUri` attribute to `urn:mpeg:mpegB:cicp:MatrixCoefficients` as defined ISO/IEC 23001-8 [10] and the `@value` attribute according to Table 4 of ISO/IEC 23001-8 [10]. The values shall match the values set in the VUI, i.e. the value is set to 9.
 - Essential Descriptors shall be used to signal the value by setting the `@schemeIdUri` attribute to `urn:mpeg:mpegB:cicp:ColourPrimaries` and `urn:mpeg:mpegB:cicp:TransferCharacteristics`, respectively, as defined ISO/IEC 23001-8 [10] and the `@value` attribute according to the "Colour primaries" Table and the "Transfer characteristics" Table of ISO/IEC 23001-8 [10], respectively. The values shall match the values set in the VUI, i.e.
 - `urn:mpeg:mpegB:cicp:ColourPrimaries` with value set to 9
 - `urn:mpeg:mpegB:cicp:TransferCharacteristics` with value set to 16
 - The Essential Descriptors shall be on Adaptation Set level only, i.e. all Representations in one Adaptation Set are required to have the same Matrix Coefficients, Color Primaries and Transfer Function.
 - If any Representation contains a mastering display colour volume SEI message or a content light level information SEI message, the same SEI message shall be present in all Representations in the Adaptation Set.
 - For `hvc1` this implies that the SEI messages shall be provided in the decoder configuration record of every Representation.

- For hev1, if any of such SEI message is carried inband within a segment/subsegment of any Representation of the Adaptation Set, it shall be carried with the first picture of that segment/subsegment in decode order in all Representations of this Adaptation Set.

Annex A (informative): Registration Information

A.1 3GPP Registered URIs

The clause documents the registered URIs in this specification following the process in <http://www.3gpp.org/specifications-groups/34-uniform-resource-name-urn-list>

Table A-1 lists all registered URN values as well as

- a brief description of its functionality;
- a reference to the specification or other publicly available document (if any) containing the definition;
- the name and email address of the person making the application; and
- any supplementary information considered necessary to support the application.

Table A-1: 3GPP Registered URNs

URN	Description	Reference	Contact	Remarks
urn:3GPP:video:op:h264-720p-HD	DASH profile identifier for H.264/AVC 720p HD Operation Point	TS 26.116, clause 5.2.1	Thomas Stockhammer tsto@qti.qualcomm.com	none
urn:3GPP:video:op:h264-Full-HD	DASH profile identifier for H.264/AVC Full HD Operation Point	TS 26.116, clause 5.3.1	Thomas Stockhammer tsto@qti.qualcomm.com	none
urn:3GPP:video:op:h265-720p-HD	DASH profile identifier for H.265/HEVC 720p HD Operation Point	TS 26.116, clause 5.4.1	Thomas Stockhammer tsto@qti.qualcomm.com	none
urn:3GPP:video:op:h265-Full-HD	DASH profile identifier for H.265/HEVC Full HD Operation Point	TS 26.116, clause 5.5.1	Thomas Stockhammer tsto@qti.qualcomm.com	none
urn:3GPP:video:op:h265-UHD	DASH profile identifier for H.265/HEVC UHD Operation Point	TS 26.116, clause 5.6.1	Thomas Stockhammer tsto@qti.qualcomm.com	none
urn:3GPP:video:op:h265-Full-HD-HDR	DASH profile identifier for H.265/HEVC Full HD HDR Operation Point	TS 26.116, clause 5.7.1	Thomas Stockhammer tsto@qti.qualcomm.com	none
urn:3GPP:video:op:h265-UHD-HDR	DASH profile identifier for H.265/HEVC UHD HDR Operation Point	TS 26.116, clause 5.8.1	Thomas Stockhammer tsto@qti.qualcomm.com	none

Annex B (informative): Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2017-03	75					Version for Release 14	14.0.0
2017-12	78	SP-170821	0004	-	A	URN Registration for DASH profiles	14.1.0
2017-12	78	SP-170821	0006	-	A	Corrections to TV Video Profiles	14.1.0
2017-12	78	SP-170826	0007	1	B	HDR Support in TV Video Profiles	15.0.0
2017-12	78	SP-170826	0008	-	B	URN Registration for DASH profiles	15.0.0
2018-09	81	SP-180638	0012	-	F	Correction on AVC Colour Parameters	15.1.0

History

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