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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Usage of video signal type code points

ITU-T H-series Recommendations – Supplement 19

International Telecommunication Union

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Supplement 19 to ITU-T H-series Recommendations

Usage of video signal type code points

Summary

Supplement 19 to ITU-T H-series Recommendations provides information on video signal property description code points and their combinations that are widely used in production and video content workflows.

This H-series supplement was developed collaboratively with ISO/IEC JTC 1/SC 29 and corresponds with ISO/IEC TR 23091-4 as a technically aligned twin text.

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Introduction

This document discusses video signal property description code points and their combinations that are widely used in production and video content workflows. Video properties and values are usually expressed in "metadata" that can exist across production and distribution workflows. Knowledge of these properties and their combinations has value as content is processed in the end-to-end production-to-distribution workflow chain.

The combinations of all possible expressible video properties as code point values could hypothetically result in hundreds or thousands of permutations; but many of those combinations are rarely or never used in practice. For example, it is highly unlikely that perceptual quantization (PQ) transfer characteristics function specified in Recommendation ITU-R BT.2100 would be combined with the colour primaries specified in Recommendation ITU-R BT.601. Only a small subset of the possible combinations is used in practice.

This document is written to provide information to help the producers of various content processing tools to avoid processing mistakes that can cause video quality degradation due to having incorrect assumptions made about video property combinations. There are only a few limited sets of video property combinations that are widely used in present-day video production and distribution equipment chains. This document describes these limited sets of combinations that are currently widely used and describes how the associated signal type metadata is carried to aid in the automation of content workflows across various domains of capture, production and distribution. Lastly, this document aims to help its readers, especially toolset developers, to repurpose tools to work properly across several domains (e.g., capture, production, production distribution and service distribution) where similar video conversion functions (e.g., chroma subsampling or colour space conversions) may be performed.

Supplement 19 to ITU-T H-series Recommendations

Usage of video signal type code points

1 Scope

This Supplement describes common industry representation practices for the usage of video signal type code points, as these properties are conveyed across video content production and distribution carriage systems.

2 References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.1 Identical Recommendations | International Standards

- Recommendation ITU-T H.222.0 | ISO/IEC 13818-1 *Information technology – Generic coding of moving pictures and associated audio information – Part 1: Systems*.
- Recommendation ITU-T H.262 | ISO/IEC 13818-2 *Information technology – Generic coding of moving pictures and associated audio information – Part 2: Video*.

2.2 Paired Recommendations | International Standards equivalent in technical content

- Recommendation ITU-T H.264, *Advanced video coding for generic audiovisual services*.

  ISO/IEC 14496-10, *Information technology – Coding of audio-visual objects – Part 10: Advanced Video Coding Advanced Video Coding*.
- Recommendation ITU-T H.265, *High efficiency video coding*.

  ISO/IEC 23008-2, *Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 2: High efficiency video coding*.
- Recommendation ITU-T H.273, *Coding-independent code points for video signal type identification*.
- ISO/IEC 23091-2, *Information technology – Coding-independent code points – Part 2: Video*.

2.3 Additional references

- ITU-T H-Suppl. 15, *Conversion and coding practices for HDR/WCG Y'CbCr 4:2:0 video with PQ transfer characteristics*.

  ISO/IEC TR 23008-14, *Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 14: Conversion and coding practices for HDR/WCG Y'CbCr 4:2:0 video with PQ transfer characteristics*.
- ITU-T H-Suppl. 18, *Signalling, backward compatibility and display adaptation for HDR/WCG video coding*.

  ISO/IEC TR 23008-15, *Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 15: Signalling, backward compatibility and display adaptation for HDR/WCG video*.
- ARIB STD-B32 Version 3.9 *Video Coding, Audio Coding, and Multiplexing Specifications for Digital Broadcasting*.
- ATSC A/341 ATSC Standard: Video – HEVC.
- Blu-ray Disc White Paper (Ultra HD Blu-ray) *Audio Visual Application Format Specifications for BD-ROM Version 3.2*.
- ETSI TS 101 154 *Digital Video Broadcasting (DVB): Specification for the use of Video and Audio Coding in Broadcast and Broadband Applications*.
- ISO/IEC 14496-12, *Information technology – Coding of audio-visual objects – Part 12: ISO base media file format.*
- ISO/IEC 14496-14, *Information technology – Coding of audio- visual objects – Part 14: MP4 file format*.

- ISO/IEC 14496-15, *Information technology – Coding of audio-visual objects – Part 15: Carriage of network abstraction layer (NAL) unit structured video in ISO base media file format*.
- Recommendation ITU-R BT.601-7, *Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios*.
- Recommendation ITU-R BT.709-6, *Parameter values for the HDTV standards for production and international programme exchange*.
- Recommendation ITU-R BT.1886-0, *Reference electro-optical transfer function for flat panel displays used in HDTV studio production*.
- Recommendation ITU-R BT.2020-2, *Parameter values for ultra-high definition television systems for production and international programme exchange*.
- Recommendation ITU-R BT.2100-2, *Image parameter values for high dynamic range television for use in production and international programme exchange*.
- SMPTE ST 298, *Universal Labels for Unique identification of Digital Data*.
- SMPTE ST 335, *Metadata Element Dictionary Structure*.
- SMPTE ST 336, *Data Encoding Protocol using Key-Length-Value*.
- SMPTE ST 377-1, *Material Exchange Format (MXF) – File Format Specification*.
- SMPTE ST 395, *Television – Metadata Groups Register Structure*.
- SMPTE ST 2003, *Types Dictionary Structure*.
- SMPTE ST 2067-20, *Interoperable Master Format- Application #2*.
- SMPTE ST 2067-21, *Interoperable Master Format- Application #2 Extended – Includes Access to Additional Content*.
- SMPTE ST 2086, *Mastering Display Color Volume Metadata Supporting High Luminance and Wide Color Gamut Images*.
- SMPTE ST 2113:2019, *Colorimetry of P3 Color Spaces*.

3 Definitions

For the purposes of this Supplement, the following definitions and the definitions in the high efficiency video coding (HEVC) specifications (Rec. ITU-T H.265 | ISO/IEC 23008-2), advanced video coding (AVC) specifications (Rec. ITU-T H.264 | ISO/IEC 14496-10), and coding-independent code points (CICP) specifications (Rec. ITU-T H.273 | ISO/IEC 23091-2) apply.

3.1 colour volume: Space of all colours and intensities that a device or signal can reproduce or convey.

3.2 creative intent: Desired vision of the content creator (e.g., a director, cinematographer, videographer, editor, or colourist) who adjusts and approves the appearance of rendered content in the production process.

3.3 electro-optical transfer function (EOTF): Function to map a non-linear video signal to display linear light.

3.4 full range: Range in a fixed-point (integer) representation that spans the full range of values that could be expressed with that bit depth.

3.5 inverse electro-optical transfer function (inverse EOTF): Function that is the inverse of an EOTF.

3.6 narrow range: Range in a fixed-point (integer) representation that does not span the full range of values that could be expressed with that bit depth.

NOTE – Narrow range is, in some applications, referred to by synonyms such as: "limited range", "video range", "legal range", "SMPTE range" or "standard range".

3.7 opto-electrical transfer function (OETF): Function to map relative scene linear light to a non-linear video signal.

3.8 opto-optical transfer function (OOTF): Function to map relative scene linear light to display linear light.

3.9 random access point access unit (RAPAU): Access unit in a video bitstream containing an intra-coded picture with the property that all pictures following the intra-coded picture in output order can be correctly decoded without using any information preceding the random access point access unit in the bitstream.

3.10 transfer function: Function among any of the following: EOTF, inverse EOTF, OETF, inverse OETF, OOTF, or inverse OOTF.

4 Abbreviations

For the purposes of this Supplement, the following abbreviations apply:

2K Informally used to refer to an HD resolution (1920×1080 for television or 2048×1080 for film)

4K Informally used to refer a UHD resolution (3840×2160 for television or 4096×2160 for film)

8K Informally used to refer to a UHD resolution (7680×4320 or 8192×4320)

AVC Advanced Video Coding (Rec. ITU-T H.264 | ISO/IEC 14496-10)

CICP Coding-Independent Code Points (Rec. ITU-T H.273 | ISO/IEC 23091-2)

EOTF Electro-Optical Transfer Function

GBR Green, Blue, and Red component colour system in linear light domain. Same as RGB, although emphasizing that the Green component is handled as the primary colour component by some technical elements of the video coding technology

NOTE – The colour representation does not indicate the media component order in a coded representation. For example, GBR represents the same component colour system as RGB.

G′B′R′ Green, Blue, and Red component colour system in a non-linear domain associated with a transfer function which maps the linear light domain to a more perceptually uniform domain. Same as R′G′B′, although emphasizing that the Green component is handled as the primary colour component by some technical elements of the video coding technology

NOTE – The colour representation does not indicate the media component order in a coded representation. For example, G′B′R′ represents the same component colour system as R′G′B′.

HD High Definition

HDR High Dynamic Range

HEVC High Efficiency Video Coding (Rec. ITU-T H.265 | ISO/IEC 23008-2)

HLG Hybrid Log-Gamma (as defined in Rec. ITU-R BT.2100)

HVS Human Visual System

LCD Liquid Crystal Display

LED Light-Emitting Diode

LUT Look-up Table

MDCV Mastering Display Colour Volume

MXF Material eXchange Format (as defined in SMPTE ST 377-1)

N/A Not Applicable

N/R Not Required

NCG Narrow Colour Gamut (typically as per Rec. ITU-R BT.709)

NCL Non-Constant Luminance

OLED Organic Light-Emitting Diode

PQ Perceptual Quantizer (as defined in Rec. ITU-R BT.2100)

QP Quantization Parameter

RAPAU Random Access Point Access Unit

RGB Red, Green, and Blue component colour system in linear light domain

NOTE – The colour representation does not indicate the media component order in a coded representation. For example, RGB represents the same component colour system as GBR.

R′G′B′ Red, Green, and Blue component colour system in a non-linear domain associated with a transfer function which maps the linear light domain to a more perceptually uniform domain

NOTE – The colour representation does not indicate the media component order in a coded representation. For example, R′G′B′ represents the same component colour system as G′B′R′.

SD Standard Definition

SDR Standard Dynamic Range

SEI Supplemental Enhancement Information

OETF Opto-Electrical Transfer Function

OOTF Opto-Optical Transfer Function

UHD Ultra High Definition

UL Universal Label (as defined in SMPTE ST 377-1)

VUI Video Usability Information (a sequence-level syntax structure in HEVC and AVC bitstreams)

WCG Wide Colour Gamut (a gamut substantially wider than the gamut conveyed by Recommendation ITU-R BT.709, e.g., as per Recommendation ITU-R BT.2020 or Recommendation ITU-R BT.2100)

XYZ The CIE 1931 colour space (wherein Y corresponds to the luminance signal)

Y′CbCr Luma (Y′), chroma blue (Cb) and chroma red (Cr) colour representation defined by a matrix transformation relationship to an R′G′B′ colour system

NOTE – A Y′CbCr representation is commonly used for video/image distribution as a way of encoding RGB information. Such a representation is also commonly expressed as YCbCr, $Y'C_BC_R$, or $Y'C'_BC'_R$, and can also be known as YUV in some documents. The relationship between Y′CbCr and R′G′B′ considered in this document is defined by matrix coefficients specified in Recommendation ITU-R BT.601, Recommendation ITU-R BT.709, Recommendation ITU-R BT.2020 or Recommendation ITU-R BT.2100. Unlike the CIE-Y component in the linear-light XYZ representation, the non-linear, the approximately perceptual uniform Y′ in this representation might not be representing true luminance, regardless of the transfer function.

5 Overview

This document discusses video signal property description code points and their combinations that are widely used in production and video content workflows. Video properties and values are usually expressed in "metadata" that can exist across production and distribution workflows. Knowledge of these properties and their combinations has value as content is processed in the end-to-end production-to-distribution workflow chain.

The combinations of all possible expressible video properties as code point values could hypothetically result in hundreds or thousands of permutations; but many of those combinations are rarely or never used in practice. For example, it is highly unlikely that the perceptual quantization (PQ) transfer characteristics function specified in Recommendation ITU-R BT.2100 would be combined with the colour primaries specified in Recommendation ITU-R BT.601. Only a small subset of the possible combinations is used in practice.

This document is written to provide information to help the producers of various content processing tools to avoid processing mistakes that can cause video quality degradation due to having incorrect assumptions made about video property combinations. There are only a few limited sets of video property combinations that are widely used in present-day video production and distribution equipment chains. This document describes these limited sets of combinations that are currently widely used and describes how the associated signal type metadata is carried to aid in the automation of content workflows across various domains of capture, production and distribution. Lastly, this document aims to help its readers, especially toolset developers, to repurpose tools to work properly across several domains (e.g., capture, production, production distribution, and service distribution) where similar video conversion functions (e.g., chroma subsampling or colour space conversions) may be performed.

The coding-independent code points (CICP) specification for video (Recommendation ITU-T H.273 | ISO/IEC 23091-2) defines code points and fields that identify some properties of video signals. These are defined independently from how these properties are carried in a coded video-layer bitstream such as an HEVC or AVC bitstream, which could differ depending on bitstream format. The compressed representation is sometimes considered to be a temporary, compacted state for distribution or delivery of the video signal, while the reconstructed video signal output from a video decoder may be interpreted as having the same meaning as a video signal immediately prior to compression by a compression encoder.

Clauses 7.2 and 7.3 define system identifier tags combinations of the described commonly used values of such video signal property combinations that apply across domains. In addition, these clauses also identify how the video property values are carried in the signal processing workflow.

6 Workflow domains

Figure 1 illustrates workflow domains (capture, production, production distribution and service distribution) in which video content may exist, be edited, or be converted. Typical content workflows across these domains are theatrical/scripted TV or live events. There are many similar video processing functions that can be performed in each domain and often these may be repeated in the next successive domain.

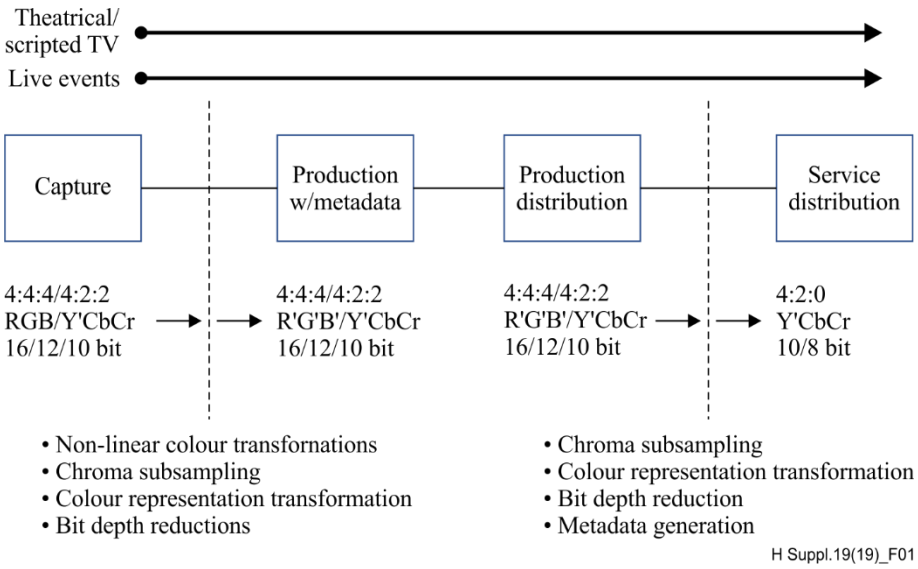

Figure 1 – Video workflows through different carriage domains

In the capture domain, content is created through sensors on cameras converting optical signals into a digital format. Content is retained at its highest informational format, although some conversions may be performed to reduce transport bandwidth demands.

In the interface to the production domain, content undergoes further processing transformations such as non-linear transformations, chroma subsampling (e.g., 4:4:4 to 4:2:2), colour representation changes (e.g., RGB to Y′CbCr NCL) and bit depth reduction (e.g., 16 bits per sample to 10 bits per sample). For theatrical/scripted TV workflows entering in the production domain, content can be added to by computer-generated imagery sources, overlaid with graphics, and colour graded using a mastering display. For live event workflows, there is always a real-time constraint, which limits content processing to real-time operations. After the colour grading, both static and dynamic metadata may be generated that are to be attached to the content workflow. However, for live events, the generation of highly customized metadata may not be practical and metadata may need to be generated further downstream by automated content analysis approaches.

In the production distribution domain, some additional processing is done to the content to further reduce transport bandwidth demands. This may include some sample-wise processing transformations (chroma subsampling and bit depth) and compression (e.g., using HEVC or AVC) but mostly employing spatial compression techniques.

For 4:2:0 chroma subsampling operations, it is important to make known the relative location alignment of the initial subsampling location processing of the content to avoid unnecessary quality degradation upon further content processing. For purposes of this document, this property is described in terms of the ChromaLocType variable as defined in HEVC, which further corresponds with the value of the syntax elements chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field in HEVC and AVC. For NCG material, the usual alignment corresponds to ChromaLocType equal to 0 (vertically interstitial). For wide colour gamut (WCG) material, the usual alignment corresponds to ChromaLocType equal to 2 (co-sited).

At the service distribution domain, the content version in the workflow is in final form, though the presentation of it may have some additional overlay graphics. Content processing at this interface continues to reduce signal information to address transport bandwidth distribution demands while still maximizing perceptual optimizations to retain content video quality. Operations reduce the content to a 4:2:0 Y′CbCr 8 or 10 bit compressed stream using HEVC, AVC, or even MPEG-2 (Rec. ITU-T H.262 | ISO/IEC 13818-2) for the compression representation. This content workflow then finishes by the content being distributed to the customer through broadcast, multicast, or unicast approaches and then being presented for viewing.

Many of the content processing operations may employ multiple third-party content processing tools. Currently most such tools are designed and operate within a specific domain with general assumptions of how content was handled in the preceding domain. Tools may also have further constraints depending on the content resolutions (e.g., HD or UHD). Some applications restrict the utilized colour volume to be smaller than that of a full Recommendation ITU-T BT.2020 and Recommendation ITU-T BT.2100 container, such as the smaller P3D65 colour gamut (as specified in SMPTE ST 2113) and intensity range of common mastering or reference displays used in content production and delivery presentations. The approved colour volume is often indicated with SMPTE ST 2086 metadata. Over time, it is expected that WCG and/or high dynamic range (HDR) applications will evolve to use more of the available container colour volume.

7 Common video signal type combinations

7.1 General

This clause enumerates common combinations of video properties and values that are currently used within the content industry. Common methods of conveying video property information are also described for the capture, production, production distribution and service distribution carriage domains.

System identifier tags are provided in this document to succinctly identify each commonly used combination. Such system identifier tags may be used as out of band metadata for conversion tools, and by production/distribution teams, to identify the workflow path needed to process and distribute content.

Content conversion tools need the locations and values of stream properties and metadata values associated with the corresponding system identifier. In some cases, the information to identify and locate video properties of the stream information are described in a specific coded video stream specification.

For example, SMPTE MXF structured streams indicate parameters and values through universal label (UL) structures located in material exchange format (MXF) headers. Such ULs are a set of registered labels maintained by SMPTE (at registry.smpte-ra.org). An MXF UL structure is a 16-byte structure comprised of a UL header [4 bytes-"0"] (per SMPTE ST 298), a UL designator [4 bytes-"0"] (per SMPTE ST 336), and an item designator [8 bytes-"000"] (per SMPTE ST 335, SMPTE ST 395, and SMPTE ST 2003). SMPTE MXF sub-tables provide these 16-byte labels in addition to any values associated with the label.

As another example, HEVC or advanced video coding (AVC) bitstreams indicate parameters and values through video usability information (VUI) and supplemental enhancement information (SEI) constructs at the sequence parameter set level.

7.2 Colorimetry and colour range descriptions

7.2.1 General

Colour volume information can describe combinations of video properties that are needed to convert between colour volumes. Such conversions may include changes in bit depth, changes in colour subsampling, non-linear optimizations and may also include transformations based on carriage and bit rate restrictions. SD, HD, and UHD material are typically associated with certain colorimetry properties as indicated in Table 1, but this information can be carried in different places or may be inferred depending on the storage or streaming format.

Table 1 – SD, HD, and UHD video colorimetry properties

	Tag	Colour		Light		Container space properties		
		Gamut	Primaries	Dynamic range	Transfer function	Colour representation	Integer code level scaling	4:2:0 chroma sample location alignment (ChromaLocType)
HD or SD	BT601_525	NCG	BT.601	SDR	BT.709	Y′CbCr	Narrow	Vertically interstitial (ChromaLocType = 0)
	BT601_625					Y′CbCr	Narrow	Vertically interstitial (ChromaLocType = 0)
	BT709_YCC		BT.709			Y′CbCr	Narrow	Vertically interstitial (ChromaLocType = 0)
	BT709_RGB					R′G′B′	Narrow	N/A
	FR709_RGB					R′G′B′	Full	N/A
UHD	BT2020_YCC_NCL	WCG	BT.2020			Y′CbCr	Narrow	Co-sited (ChromaLocType = 2)
	BT2020_RGB					R′G′B′	Narrow	N/A
	FR2020_RGB					R′G′B′	Full	N/A
	BT2100_PQ_YCC		BT.2100	HDR	PQ	Y′CbCr	Narrow	Co-sited (ChromaLocType = 2)
	BT2100_PQ_RGB					R′G′B′	Narrow	N/A
	BT2100_HLG_YCC				HLG	Y′CbCr	Narrow	Co-sited (ChromaLocType = 2)
	BT2100_HLG_RGB					R′G′B′	Narrow	N/A

In this document, as in various industry groups such as UltraHD Forum, EBU and DVB, UHD applications are considered as those having at least one major property greater than HD (Recommendation ITU-R BT.709), such as colour gamut, resolution, dynamic range, or frame rate (e.g., 1080p60 HDR/WCG is considered UHD herein).

Carriage formats for colour properties in each domain (capture, production, production distribution, and service distribution) contain the same payload but in different wrappers. In the capture and production domains, the colour property information can be carried in an MXF wrapper using a generic picture essence descriptor as specified by Annex C of SMPTE ST 2067-21. Colour volume information in the distribution domain can be carried within the video stream as syntax information in the selected video format such as HEVC, AVC, or MPEG-2 through VUI or equivalent syntax. The full and narrow range scaling video property is not carried explicitly in all technologies and may need to be taken implicitly or through a system identifier. In common practice, Y′CbCr colour representation uses narrow range scaled levels.

7.2.2 Colour properties

For colorimetry and range scaling descriptions, the video properties described in Table 2 ordinarily apply. Remarks on common usage are included in the table.

Table 2 – Video colour description properties and their common usage

Carriage parameter names	Colloquial names	Common usage
ColourPrimaries [CICP] colour_primaries [HEVC or AVC] colour primaries [MXF]	Colour space, colour gamut	SDR video uses a Rec. ITU-R BT.709 colour representation. WCG video may restrict colour to the P3D65 gamut (SMPTE ST 2113) but in a Rec. ITU-R BT.2020 colour space container. HDR over time is expected to exhibit a more complete coverage of the Rec. ITU-R BT.2020 colour representation.
TransferCharacteristics [CICP] transfer_characteristics [HEVC or AVC] transfer characteristic [MXF]	Transfer curves, log curves, gamma curves	HDR video uses either PQ or HLG. SDR video typically uses the transfer characteristic for Rec. ITU-R BT.709, assuming a display characteristic corresponding to Rec. ITU-R BT.1886.
MatrixCoefficients [CICP] matrix_coeffs [HEVC] matrix_coefficients [AVC] coding equations [MXF]	Colour representation, GBR, NCL, YCC, YUV, Y′UV, R′G′B′	Specifies the encoding equations to convert RGB image components to component colour difference image components. For R′G′B′ representations, no matrix applies, which is typically indicated by the value 0. (The colour representation notation does not indicate the media component order in a coded representation.)

Table 2 – Video colour description properties and their common usage

Carriage parameter names	Colloquial names	Common usage
VideoFullRangeFlag [CICP] video_full_range_flag [HEVC or AVC] N/A [MXF]	Full range, narrow range, headroom, footroom, legal range, SMPTE range, QE.1, QE.2	Y′CbCr colour representations ordinarily use narrow range scaling for video.
ChromaLocType [HEVC] chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field [AVC or HEVC] N/A [CICP or MXF]	4:2:0 subsampled chroma location type	Indicates the horizontal and vertical positions of chroma samples (Cb, Cr) with respect to luma samples with subsample position accuracy. The alignment is typically horizontally co-sited with even-numbered columns of luma samples (indexed starting from 0). For SD and HD video, the alignment is typically vertically interstitial between rows of luma samples (ChromaLocType = 0). For UHD video, the alignment is typically vertically co-sited with even-numbered rows of luma samples (ChromaLocType = 0).

Table 3 indicates the code values for each property that are widely used for video content production and distribution systems.

Table 3 – Code point values widely used for colorimetry properties

HEVC property	Code point value	Meaning
colour_primaries	1	Rec. ITU-R BT.709 primaries
	5	Rec. ITU-R BT.601 625-line systems primaries
	6	Rec. ITU-R BT.601 525-line systems primaries
	9	Rec. ITU-R BT.2020 and Rec. ITU-R BT.2100 primaries (share the same code point since their values are identical)
transfer_characteristics	1, 6, 14, 15	Rec. ITU-R BT.709, Rec. ITU-R BT.601, Rec. ITU-R BT.2020, and Rec. ITU-R BT.2100 transfer characteristics (functionally equivalent values)
	16	Rec. ITU-R BT.2100 PQ
	18	Rec. ITU-R BT.2100 HLG (Hybrid Log-Gamma)
matrix_coeffs	0	R′G′B′ (identity matrix applied to primaries after transfer function)
	1	Y′CbCr for Rec. ITU-R BT.709 primaries
	5	Y′CbCr for Rec. ITU-R BT.601 625-line primaries
	6	Y′CbCr for Rec. ITU-R BT.601 525-line primaries
	9	Y′CbCr for Rec. ITU-R BT.2020 and Rec. ITU-R BT.2100 primaries
ChromaLocType	0	Vertically interstitial, horizontally co-sited
	2	Vertically co-sited, horizontally co-sited

7.2.3 Common descriptions and carriage – standard dynamic range video with narrow colour gamut

This colour volume describes standard dynamic range (SDR) video with narrow colour gamut (NCG), which includes the majority of the production and distribution workflows currently used in the industry. There are several combinations of values of video properties that are used for this colour volume. Table 4 describes these combinations. There are several one-way operations that can be performed for this colour volume including bit depth reductions, colour sampling reductions and full-to-narrow range scaling operations.

The following system identifier tags are described herein, as defined in Table 4:

- BT709_YCC
- BT709_RGB
- FR709_RGB
- BT601_525
- BT601_625

Table 4 – SDR NCG common colour volume descriptions

	System identifier	BT709_YCC	BT709_RGB	FR709_RGB	BT601_525	BT601_625
Colour properties	Colour primaries	BT.709	BT.709	BT.709	BT.601	BT.601
	Transfer characteristics	BT.709	BT.709	BT.709	BT.709	BT.709
	Colour representation	Y′CbCr	R′G′B′	R′G′B′	Y′CbCr	Y′CbCr
Other	Full/narrow range	Narrow	Narrow	Full	Narrow	Narrow
	4:2:0 chroma sample location alignment	Interstitial	N/A	N/A	Interstitial	Interstitial
CICP parameters Rec. ITU-T H.273 | ISO/IEC 23091-2	ColourPrimaries	1	1	1	6	5
	TransferCharacteristics	1	1	1	6	6
	MatrixCoefficients	1	0	0	6	5
	VideoFullRangeFlag	0	0	1	0	0
SMPTE MXF parameters SMPTE ST 2067-21	Colour primaries	06.0E.2B.34.04.01.01.06.04.01.01.01.03.03.00.00			06.0E.2B.34.04.01.01.06.04.01.01.01.03.01.00.00	06.0E.2B.34.04.01.01.06.04.01.01.01.03.02.00.00
	Transfer characteristic	06.0E.2B.34.04.01.01.01.04.01.01.01.01.02.00.00				
	Coding equations	06.0E.2B.34.04.01.01.01.04.01.01.01.02.02.00.00	N/R	N/R	06.0E.2B.34.04.01.01.01.04.01.01.01.02.01.00.00	
	Full/narrow level range	Inferred (indicated in black reference level, white reference level, colour range)				
	4:2:0 chroma sample location alignment	Inferred (ChromaLoc Type = 0)	N/A	N/A	Inferred (ChromaLoc Type = 0)	Inferred (ChromaLoc Type = 0)

Particular aspects of the usage described in Table 4 are clarified as follows:

- Recommendation ITU-R BT.601 colour volumes are used for SD material only.
- The transfer characteristics indicator values of 1, 6, 14 and 15 are functionally the same. Blu-ray BD-ROM 3.1 ("4K") and the DVB UHD specifications list use of the transfer characteristics value of 14 for SDR/WCG (Recommendation ITU-R BT.2020) video. ATSC specifications list use of the transfer characteristics value of 1 for SDR NCG video.
- Matrix coefficients indicator values of 5 and 6 are functionally the same.
- The indicated chroma sample location alignment is only applicable for 4:2:0 chroma sampling. ChromaLocType (the generic label used in this document for the HEVC and AVC bitstream syntax elements: chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field), listed in Tables 1 and 2 of this document, indicates the 4:2:0 chroma sample position alignment.

7.2.4 Common descriptions and carriage – standard dynamic range video with wide colour gamut

This colour volume describes SDR video with WCG, which is typically identified by the combination of the colour primary video property with the identified matrix coefficients. In some cases, the same colour property may be described with two different values depending on the colour primary container used. It is important for tools to process video according to the colour volume it is operating in to make sure the conversion is consistent.

The following system identifier tags are described, as defined in Table 5:

- BT2020_YCC_NCL
- BT2020_RGB
- FR2020_RGB

Table 5 – SDR WCG common colour volume descriptions

	System identifier	BT2020_YCC_NCL	BT2020_RGB	FR2020_RGB
Colour properties	Colour primaries	BT.2020	BT.2020	BT.2020
	Transfer characteristics	BT.2020	BT.2020	BT.2020
	Colour representation	Y′CbCr	R′G′B′	R′G′B′
Other	Full/narrow range	Narrow	Narrow	Full
	4:2:0 chroma sample location alignment	Co-sited	N/A	N/A
CICP parameters Rec. ITU-T H.273 | ISO/IEC 23091-2	ColourPrimaries	9	9	9
	TransferCharacteristics	14	14	14
	MatrixCoefficients	9	0	0
	VideoFullRangeFlag	0	0	1
SMPTE MXF parameters SMPTE ST 2067-21	Colour primaries	06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.0		
	Transfer characteristic	06.0E.2B.34.04.01.01.0E.04.01.01.01.01.09.00.00		
	Coding equations	06.0E.2B.34.04.01.01.0D.04.01.01.01.02.06.00.00	N/R	N/R
	Full/narrow level range	Inferred (indicated in black reference level, white reference level, colour range)		
	4:2:0 chroma sample location alignment	Inferred (ChromaLocType = 2)	N/A	N/A

Particular aspects of the usage described in Table 5 are clarified as follows:

- The transfer characteristics indicator values of 1, 6, 14, and 15 are functionally the same. Blu-ray BD-ROM 3.1 ("4K") and the DVB UHD specifications list use of the transfer characteristics value of 14 for SDR/WCG (Recommendation ITU-R BT.2020) video. ATSC specifications list use of the transfer characteristics value of 1 for SDR video. ARIB STD B32 lists use of the transfer characteristics value 1 for HD and 14 for UHD for SDR WCG video.
- The indicated chroma sample location alignment is only applicable for 4:2:0 chroma sampling. ChromaLocType (the generic label used in this document for the HEVC and AVC bitstream syntax elements: chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field), listed in Tables 1 and 2 of this document, indicates the 4:2:0 chroma sample position alignment.

7.2.5 Common descriptions and carriage – high dynamic range video with wide colour gamut

This colour volume describes HDR video with WCG, which is typically associated with ultra high definition video.

The following system identifier tags are described, as defined in Table 6:

- BT2100_PQ_YCC
- BT2100_HLG_YCC
- BT2100_PQ_RGB
- BT2100_HLG_RGB

Table 6 – HDR WCG common colour volume descriptions

	System identifier	BT2100_PQ_YCC	BT2100_HLG_YCC	BT2100_PQ_RGB	BT2100_HLG_RGB
Colour properties	Colour primaries	BT.2020 / BT.2100	BT.2020 / BT.2100	BT.2020 / BT.2100	BT.2020 / BT.2100
	Transfer characteristics	BT.2100 PQ	BT.2100 HLG	BT.2100 PQ	BT.2100 HLG
	Colour representation	Y′CbCr	Y′CbCr	R′G′B′	R′G′B′
Other	Full/narrow range	Narrow	Narrow	Narrow	Narrow
	4:2:0 chroma sample location alignment	Co-sited	Co-sited	N/A	N/A
CICP parameters Rec. ITU-T H.273 | ISO/IEC 23091-2	ColourPrimaries	9	9	9	9
	TransferCharacteristics	16	18	16	18
	MatrixCoefficients	9	9	0	0
	VideoFullRangeFlag	0	0	0	0
SMPTE MXF parameters SMPTE ST 2067-21	Colour primaries	06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.00			
	Transfer characteristic	06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0A.00.00	06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0B.00.00	06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0A.00.00	06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0B.00.00
	Coding equations	06.0E.2B.34.04.01.01.0D.04.01.01.01.02.06.00.00		N/R	N/R
	Full/narrow level range	Inferred (indicated in black reference level, white reference level, colour range)			
	4:2:0 chroma sample location alignment	Inferred (ChromaLocType = 2)	Inferred (ChromaLocType = 2)	N/A	N/A

Particular aspects of the usage described in Table 6 are clarified as follows:

- The colour primaries specified in Recommendation ITU-R BT.2020 and Recommendation ITU-R BT.2100 are the same.
- The indicated chroma sample location alignment is only applicable for 4:2:0 chroma sampling. ChromaLocType (the generic label used in this document for the HEVC and AVC bitstream syntax elements: chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field), listed in Tables 1 and 2 of this document, indicates the 4:2:0 chroma sample position alignment.

7.3 Mastering display colour volume descriptions

7.3.1 Mastering display colour volume properties

A display colour volume can be defined as a solid in colorimetric space containing all possible colours that a display can produce. Mastering display colour volume (MDCV) information describes the colour volume through specification of the colour primaries, white point and luminance range parameters of the display that was used for authoring/grading video content; i.e., it is the display where creative work performed during the mastering process achieved the creative intent of the content author. When the authored content is shown on other displays, MDCV information can be used to more closely reproduce the original creative intent than may otherwise be feasible.

For the MDCV descriptions, the following mastering display properties are included, with values in specific combinations that represent widely used mastering display setups used to grade content. This document discusses MDCV properties as described in SMPTE ST 2086 and in the corresponding SEI messages of HEVC and AVC, as listed below:

- Mastering display primaries
- Mastering display white point chromaticity
- Mastering display maximum luminance
- Mastering display minimum luminance

7.3.2 Common descriptions and carriage – mastering display colour volume descriptions

The following system identifier tags, as defined in Table 7, are used to describe properties of commonly used mastering displays. (All commonly used mastering display systems have a D65 white point.)

- BT709x100n05 – representing a mastering display LCD or LED environment for mastering of SDR content with displays having 100 cd/m2 of peak brightness, 0.05 minimum brightness, and a D65 white point setting within a Recommendation ITU-R BT.709 colour representation.
- P3D65x1000n0005 – representing a mastering display OLED environment for mastering of HDR content with displays having 1000 cd/m2 of peak brightness, 0.0005 minimum brightness, and a D65 white point setting within a Recommendation ITU-R BT.2100 colour representation constrained to P3 colour gamut values.
- BT2100x108n0005 – representing a mastering display laser projector environment for mastering of HDR content for cinema presentations with displays having 108 cd/m2 of peak brightness, 0.0005 minimum brightness, and a D65 white point setting.

Carriage formats for a MDCV descriptions in each of the domains (capture, production, production distribution, and service distribution) contain the same payload but in different wrappers. In the capture and production domains, the MDCV information can be carried in an MXF wrapper using Generic Picture Essence descriptor as described by Annex C of SMPTE ST 2067-21. In the distribution domain using HEVC or AVC, the MDCV information is carried an MDCV SEI message (SEI message payload type 137) that needs to be repeated at least in every random-access point access unit (RAPAU).

Table 7 – Mastering display colour volume descriptions

	System identifier		BT709x100n05	P3D65x1000n0005	BT2100x108n0005
Mastering display properties defined according to SMPTE ST 2086	Colour primaries (x,y)		{0.6400, 0.3300} {0.3000, 0.6000} {0.1500, 0.0600}	{0.6800, 0.3200} {0.2650, 0.6900} {0.1500, 0.0600}	{0.7080, 0.2920} {0.1700, 0.7970} {0.1310, 0.0460}
	White point chromaticity (x,y)		{0.3127, 0.3290} (D65)		
	Maximum luminance [cd/m2]		100	1000	108
	Minimum luminance [cd/m2]		0.05 for LCD/LED	0.0005 for OLED	0.0005 for laser
HEVC or AVC MDCV SEI message Rec. ITU-T H.265 | ISO/IEC 23008-2	Display_primaries_x[0]/y[0]		{32000, 16500}	{35400, 14600}	{34000, 16000}
	Display_primaries_x[1]/y[1]		{15000, 30000}	{8500, 39850}	{13250, 34500}
	Display_primaries_x[2]/y[2]		{7500, 3000}	{6550, 2300}	{7500, 3000}
	White_point_x/y		{15635, 16450}		
	Max/min_display_mastering_luminance		{1000000, 500}	{10000000, 5}	{10000000, 5}
SMPTE MXF parameters SMPTE ST 2067-21	MasteringDisplayPrimaries	Registration identifier	060e2b34.0101010e.04200401.01010000		
		Coded decimal	{32000, 16500} {15000, 30000} {7500, 3000}	{35400, 14600} {8500, 39850} {6550, 2300}	{34000, 16000} {13250, 34500} {7500, 3000}
	MasteringDisplayWhitePoint Chromaticity	Registration identifier	060e2b34.0101010e.04200401.01020000		
		Coded decimal	{15635, 16450}		
	MasteringDisplayMaximum Luminance	Registration identifier	060e2b34.0101010e.04200401.01030000		
		Coded decimal	1000000	10000000	10000000
	MasteringDisplayMinimum Luminance	Registration identifier	060e2b34.0101010e.04200401.01030000		
		Coded decimal	500	5	5

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