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Information technology — Coding-independent code points —

Part 4: Usage of video signal type code points

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information* in collaboration with ITU-T. The technically identical text is published as ITU-T Series H Supplement 19 (10/2019).

This second edition cancels and replaces the first edition (ISO/IEC TR 23091-4:2019), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Tables are added to describe the carriage of these combinations in baseband transmission formats.

— For high dynamic range and wide colour gamut usage, an additional combination describing usage of the IC_TC_P colour representation of Rec. ITU-R BT.2100 and content mastering with a mastering display having 4000 cd/m^2 peak brightness is described.

— Two new informative annexes are added. Annex A describes commonly used video property combinations that are not specified in industry standards. Annex B indicates the relevance of the system identifier tags in consumer distribution specifications.

— Additional general refinements are also included to improve readability and clarity and improve the use of terminology.

A list of all parts in the ISO/IEC 23091 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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 Rec. ITU-R BT.2100 would be combined with the colour primaries specified in Rec. 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.

Information technology — Coding-independent code points —

Part 4:
Usage of video signal type code points

1 Scope

This document 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 Normative 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.

Rec. ITU-T H.264 | ISO/IEC 14496-10, *Information technology — Coding of audio-visual objects — Part 10: Advanced video coding*

Rec. ITU-T H.265 | ISO/IEC 23008-2, *Information technology — High efficiency coding and media delivery in heterogeneous environments — High efficiency video coding*

Rec. ITU-T H.273 | ISO/IEC 23091-2, *Information technology — Coding-independent code points — Part 2: Video*

3 Terms and definitions

For the purposes of this document, the terms and definitions in Rec. ITU-T H.265 | ISO/IEC 23008-2, Rec. ITU-T H.264 | ISO/IEC 14496-10 and Rec. ITU-T H.273 | ISO/IEC 23091-2 and the following apply.

ISO ad IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org

3.1
3G-SDI
serial digital interface with a transport capacity of 2.970 Gbit/s and 2.970/1.001 Gbit/s for transporting uncompressed digital video signals

3.2
6G-SDI
serial digital interface with a transport capacity of 5.94 Gbit/s and 5.94/1.001 Gbit/s for transporting uncompressed digital video signals

3.3
10G-SDI
serial digital interface with a transport capacity of 10.692 Gbit/s for transporting uncompressed digital video signals

3.4
12G-SDI
serial digital interface with a transport capacity of 11.88 Gbit/s and 11.88/1.001 Gbit/s for transporting uncompressed digital video signals

3.5
colour coding characteristics
combination of colour gamut, colour primaries, dynamic range, transfer function, colour representation, video range, and chroma sample location

3.6
colour volume
space of all colours and intensities that a device or signal can reproduce or convey

3.7
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

3.8
dual-link SDI
two parallel serial digital interfaces for transporting uncompressed video signals

3.9
electro-optical transfer function
EOTF
function to map a non-linear video signal to display linear light

3.10
full range
range in a fixed-point (integer) representation that spans the full range of values that could be expressed with that bit depth

3.11
HD-SDI
serial digital interface for transporting uncompressed digital HD video signals

3.12
inverse electro-optical transfer function
inverse EOTF
function that is the inverse of an *EOTF* (3.9)

3.13
inverse opto-electrical transfer function
inverse OETF
function that is the inverse of an *OETF* (3.15)

3.14
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 1 to entry: Narrow range is, in some applications, referred to by synonyms such as: “limited range”, “video range”, “legal range”, “SMPTE range” or “standard range”.

3.15
opto-electrical transfer function
OETF
function to map relative scene linear light to a non-linear video signal

3.16
opto-optical transfer function
OOTF
function to map relative scene linear light to display linear light

3.17
quad-link SDI
four parallel serial digital interfaces for transporting uncompressed video signals

3.18
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 it in the bitstream

3.19
SDI
serial digital interface for transporting uncompressed video signals

3.20
SD-SDI
signal digital interface for transporting uncompressed digital SD video signals

3.21
transfer function
function among any of the following: *EOTF* (3.9), *inverse EOTF* (3.12), *OETF* (3.15), inverse *OETF* (3.13), *OOTF* (3.16), or inverse OOTF

3.22
U-SDI
multilink (up to 24 links) serial digital interface with a transport capacity of 10.692 Gbit/s per link for transporting uncompressed digital video signals

4 Abbreviated terms

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
IC_TC_P	constant intensity signal format (as defined in Rec. ITU-R BT.2100)
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
OETF	opto-electrical transfer function
OOTF	opto-optical transfer function
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
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 bit-streams)
WCG	wide colour gamut (a gamut substantially wider than the gamut conveyed by Rec. ITU-R BT.709, e.g., as per Rec. ITU-R BT.2020 or Rec. ITU-R BT.2100)
XYZ	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 Rec. ITU-R BT.601, Rec. ITU-R BT.709, Rec. ITU-R BT.2020 or Rec. ITU-R BT.2100. Unlike the CIE-Y component in the linear-light XYZ representation, the non-linear, approximately perceptual uniform Y′ 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.

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The coding-independent code points (CICP) specification for video (Rec. ITU-T H.273 | ISO/IEC 23091-2) defines code points and fields that identify properties of video signals. These code points 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 in the encoder.

Subclauses 7.2 and 7.3 define system identifier tags for combinations of the described commonly used values of such video signal property combinations that apply across signal domains. In addition, these subclauses also identify how the video property values are carried in the signal processing workflow. Subclause 7.3 defines system identifier tags for commonly used values for mastering display colour volume descriptions. Annex A defines system identifier tags used for additional combinations that are not specified as industry standards. Annex B defines system identifier tags that are used in some existing consumer distribution formats.

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 either theatrical/scripted (episodic) TV or live events. There are many similar video processing functions that can be performed in each domain and often these functions may be repeated in the next successive domain.

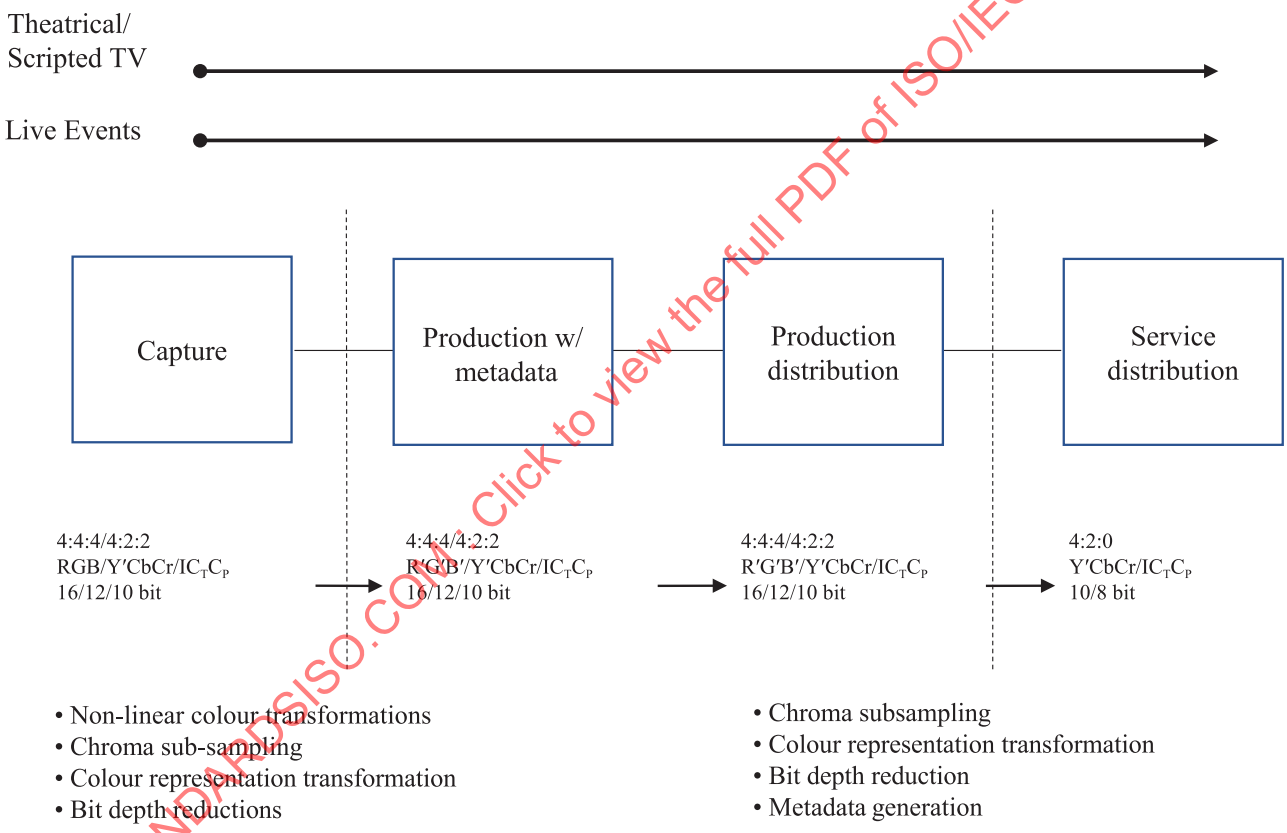

Figure 1 — Video workflows through different carriage domains

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 augmented with 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 the 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 compressed representation of 4:2:0 Y′CbCr 8 or 10 bit video using HEVC or AVC for the compression representation. Alternatively, MPEG-2 (Rec. ITU-T H.262 | ISO/IEC 13818-2) can be used as a compressed representation for 4:2:0 Y′CbCr 8 bit video content. This content workflow then finishes with 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 of 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 what can be expressed in a Rec. ITU-R BT.2020 or Rec. ITU-R 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, which may be smaller than the container 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 MXF headers. 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 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 Colour coding characteristics

7.2.1 General

Colour coding characteristics 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 colour coding characteristics 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 colour coding characteristics 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_ICTCP					IC_TC_P	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 (Rec. 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 coding characteristics information can be carried in an MXF wrapper

using a generic picture essence descriptor as specified by SMPTE ST 2067-21: 2016, Annex C. Colour coding characteristics 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.

In Table 2, the type of baseband carriage of video signals over serial digital interfaces are listed, dependent on data rate limitations of the interface which are specified by the resolution of the video signal.

Table 2 — Source format data (resolution) carriage over broadband SDI connections

Standard	Source format data (resolution)[a]							
	SD		HD			UHD		
	720 × 480	720 × 576	1280 × 720	1920 × 1080	2048 × 1080	3840 × 2160	4096 × 2160	7680 × 4320
ST 259M (SD-SDI)	√	√						
BT.656M (SD-SDI)	√	√						
ST 292-1 (HD-SDI)			√	√	√			
BT.1120-9 (HD-SDI)				√				
ST 372-1 (Dual link HD-SDI)				√	√			
ST 425-1 (3G-SDI)				√	√			
BT.1120-9 (Dual link HD-SDI/3G-SDI)				√				
ST 425-5 (Quad link 3G-SDI)						√	√	
ST 2081-10 (6G-SDI)				√	√	√	√	
ST 2082-10 (12G-SDI)						√	√	
ST 2082-12 (Quad link 12G-SDI)						√	√	√
ST 2036-3 (Single/multi-link 10G-SDI)						√		√
BT.2077-2 (U-SDI)						√		√

[a] Cells with check marks (√) indicate “used combinations”. Cells without check marks indicate “not used combinations”.

7.2.2 Colour properties

For colour coding characteristics, the video properties described in Table 2 ordinarily apply. Remarks on common usage are included in Table 3.

Table 3 — 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 characteristics for Rec. ITU-R BT.709, assuming the display characteristics corresponding to Rec. ITU-R BT.1886.

Table 3 *(continued)*

Carriage parameter names	Colloquial names	Common usage
MatrixCoefficients [CICP] matrix_coeffs [HEVC] matrix_coefficients [AVC] coding equations [MXF]	Colour representation, GBR, NCL, YCC, IC_TC_P, YUV, Y′UV, R′G′B′	Specifies the encoding equations to convert RGB image components to the corresponding representation format. 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.)
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, C_T, C_P) 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 4 indicates the code values for each property that are widely used for video content production and distribution systems.

Table 4 — Code point values widely used for colour coding characteristics 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)
	12	SMPTE ST 2113 and SMPTE EG 432-1 (P3D65)
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
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
	14	IC_TC_P for Rec. ITU-R BT.2100

Table 4 *(continued)*

HEVC property	Code point value	Meaning
ChromaLocType	0	Vertically interstitial, horizontally co-sited
	1	Vertically interstitial, horizontally interstitial
	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 5 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 5:

— BT709_YCC;

— BT709_RGB;

— BT601_525;

— BT601_625.

Table 5 — SDR NCG colour coding characteristics descriptions

	System identifier	BT709_YCC	BT709_RGB	BT601_525	BT601_625
Colour properties	Colour primaries	BT.709	BT.709	BT.601	BT.601
	Transfer characteristics	BT.709	BT.709	BT.709	BT.709
	Colour representation	Y′CbCr	R′G′B′	Y′CbCr	Y′CbCr
Other	Full/narrow range	Narrow	Narrow	Narrow	Narrow
	4:2:0 chroma sample location alignment	Interstitial	N/A	Interstitial	Interstitial
CICP parameters Rec. ITU-T H.273 ISO/IEC 23091-2	ColourPrimaries	1	1	6	5
	TransferCharacteristics	1	1	6	6
	MatrixCoefficients	1	0	6	5
	VideoFullRangeFlag	0	0	0	0
SMPTE MXF parameters SMPTE ST 2067-21	Colour primaries	urn:smpte:ul:06.0E.2B.34.04.01.01.06.04.01.01.01.03.03.00.00		urn:smpte:ul:06.0E.2B.34.04.01.01.06.04.01.01.03.01.00.00	urn:smpte:ul:06.0E.2B.34.04.01.01.06.04.01.01.03.02.00.00
	Transfer characteristic	urn:smpte:ul:06.0E.2B.34.04.01.01.01.04.01.01.01.01.02.00.00			
	Coding equations	urn:smpte:ul:06.0E.2B.34.04.01.01.01.04.01.01.01.01.02.02.00.00	N/R	urn:smpte:ul: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 (ChromaLocType = 0)	N/A	Inferred (ChromaLocType = 0)	Inferred (ChromaLocType = 0)

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

— Rec. 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 (Rec. ITU-R BT.2020) video. ATSC specifications list the use of the transfer characteristics value of 1 for SDR NCG (Rec. ITU-R BT.709) 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 3, indicates the 4:2:0 chroma sample position alignment. The ITU-R program signal exchange series Recommendations (Rec. ITU-R BT.601, Rec. ITU-R BT.709, Rec. ITU-R BT.2020, Rec. ITU-R BT.2100) specify 4:2:2 and 4:4:4 chroma samples to be co-sited with luma.

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

This colour coding characteristics information 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 ensure that the conversion is consistent.

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

— BT2020_YCC_NCL;

— BT2020_RGB.

Table 6 — SDR WCG common colour coding characteristics descriptions

	System identifier	BT2020_YCC_NCL[a]	BT2020_RGB
Colour properties	Colour primaries	BT.2020	BT.2020
	Transfer characteristics	BT.2020	BT.2020
	Colour representation	Y′CbCr	R′G′B′
Other	Full/narrow range	Narrow	Narrow
	4:2:0 chroma sample location alignment	Co-sited	N/A
CICP parameters Rec. ITU-T H.273 | ISO/IEC 23091-2	ColourPrimaries	9	9
	TransferCharacteristics	14	14
	MatrixCoefficients	9	0
	VideoFullRangeFlag	0	0

[a] Most Y′CbCr colour formats are of the type known as NCL, so this is not mentioned in the tag names for most formats. However, Rec. ITU-R BT.2020 has both an NCL format and an alternative Y′CbCr format, so NCL is mentioned explicitly in this tag name to distinguish between the two.

Table 6 *(continued)*

	System identifier	BT2020_YCC_NCL[a]	BT2020_RGB
SMPTE MXF parameters SMPTE ST 2067-21	Colour primaries	urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.00	
	Transfer characteristic	urn:smpte:ul:06.0E.2B.34.04.01.01.0E.04.01.01.01.01.09.00.00	
	Coding equations	urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.02.06.00.00	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

[a] Most Y′CbCr colour formats are of the type known as NCL, so this is not mentioned in the tag names for most formats. However, Rec. ITU-R BT.2020 has both an NCL format and an alternative Y′CbCr format, so NCL is mentioned explicitly in this tag name to distinguish between the two.

Particular aspects of the usage described in Table 6 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 (Rec. ITU-R BT.2020) video. ATSC specifications list the use of the transfer characteristics value of 1 for SDR (Rec. ITU-R BT.709) video. ARIB STD B32 lists use of the transfer characteristics value 1 for HD SDR (Rec. ITU-R BT.709) and 14 for UHD SDR WCG (Rec. ITU-R BT.2020) 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 3, indicates the 4:2:0 chroma sample position alignment. The ITU-R program signal exchange series Recommendations (Rec. ITU-R BT.601, Rec. ITU-R BT.709, Rec. ITU-R BT.2020, Rec. ITU-R BT.2100) specify 4:2:2 and 4:4:4 chroma samples to be co-sited with luma.

7.2.5 Colour coding characteristics and carriage – high dynamic range video with wide colour gamut

This colour coding characteristics information 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 7:

— BT2100_PQ_YCC;

— BT2100_HLG_YCC;

— BT2100_PQ_ICTCP;

— BT2100_PQ_RGB;

— BT2100_HLG_RGB.

Table 7 — HDR WCG colour coding characteristics descriptions

	System identifier	BT2100_PQ_YCC	BT2100_HLG_YCC	BT2100_PQ_ICTCP	BT2100_PQ_RGB	BT2100_HLG_RGB
Colour properties	Colour primaries	BT.2020 / BT.2100	BT.2020 / BT.2100	BT.2100	BT.2020 / BT.2100	BT.2020 / BT.2100
	Transfer characteristics	BT.2100 PQ	BT.2100 HLG	BT.2100 PQ	BT.2100 PQ	BT.2100 HLG
	Colour representation	Y′CbCr	Y′CbCr	IC_TC_P	R′G′B′	R′G′B′
Other	Full/narrow range	Narrow	Narrow	Narrow	Narrow	Narrow
	4:2:0 chroma sample location alignment	Co-sited	Co-sited	Co-sited	N/A	N/A
CICP parameters Rec. ITU-T H.273 | ISO/IEC 23091-2	ColourPrimaries	9	9	9	9	9
	TransferCharacteristics	16	18[a]	16	16	18
	MatrixCoefficients	9	9	14	0	0
	VideoFullRangeFlag	0	0	0	0	0
SMPTE MXF parameters SMPTE ST 2067-21	Colour primaries	urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.00				
	Transfer characteristic	urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0A.00.00	urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0B.00.00	urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0A.00.00	urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0A.00.00	urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0B.00.00
	Coding equations	urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.02.06.00.00		urn:smpte:ul:06.0E.2B.34.04.01.01.0D.04.01.01.01.02.07.00.00	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)	Inferred (ChromaLocType = 2)	N/A	N/A

[a] For purposes of backward compatibility for an HEVC or AVC encoded Rec. ITU-R BT.2100 HLG bitstream to be interpreted as Rec. ITU-R BT.2020 (SDR WCG) video, the bitstream may be marked in the VUI with the transfer_characteristics syntax element value 14 as using Rec. ITU-R BT.2020 transfer characteristics while also sending an alternative transfer characteristics SEI message with the preferred_transfer_characteristics syntax element of the SEI message equal to 18 with each coded video sequence to identify the preferred interpretation as Rec. ITU-R BT.2100 HLG video. Such a usage is specified in ETSI 101 154.

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

— The colour primaries specified in Rec. ITU-R BT.2020 and Rec. 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 3, indicates the 4:2:0 chroma sample position alignment. The ITU-R program signal exchange series Recommendations (Rec. ITU-R BT.601, Rec. ITU-R BT.709, Rec. ITU-R BT.2020, Rec. ITU-R BT.2100) specify 4:2:2 and 4:4:4 chroma samples to be co-sited with luma.

7.2.6 Baseband carriage of colour coding characteristics descriptions

Uncompressed video signals carried over different SDI interfaces can carry colour volume descriptions according to Table 8 and Table 9.

Table 8 — Baseband carriage of colour coding characteristics descriptions for SDR NCG and SDR WCG

Colour coding characteristics description		SDR NCG[b]				SDR WCG[b]	
System identifier		BT709_YCC	BT709_RGB	BT601_525	BT601_625	BT2020_YCC_NCL	BT2020_RGB
Rec. ITU-R	SMPTE						
BT.656-5 SDI	ST 259M (SD-SDI)			√	√		
BT.1120-9	ST 292-1 1.5 Gb/s	√	√				
	ST 372-1 Dual 1.5 Gb/s	√	√				
	ST 425-1 3G	√	√				
N/A	ST 425-5 Quad 3G	√	√			√	√
BT.2077-2	ST 2081-10 6G	√	√			√	√
	ST 2082-10 12G	√	√			√	√
	ST 2082-12 Quad 12G	√	√			√	√
	ST 2036-3 (Single/ Multi-link 10G SDI)	√	√			√	√
N/A	ST 2036-4 (U-SDI)	√[a]	√[a]			√	√
N/A	ST 2110-20 Uncompressed Video/IP	√	√			√	√
CTA 861.4/HDMI Uncompressed HSDI		√	√	√	√	√	√

[a] In SMPTE ST.2036-4, only 3840×2160 up to 60Hz is permitted. For Rec. ITU-R BT.2077-2, no combinations are permitted.

[b] Cells with check marks (√) indicate "used combinations". Cells without check marks indicate "not used combinations". Baseband video properties may be used with camera log video properties.

Table 9 — Baseband carriage of colour coding characteristics descriptions for HDR WCG

Colour coding characteristics description		HDR WCG[a]				
System identifier		BT2100_PQ_ YCC	BT2100_HLG_YCC	BT2100_PQ_ ICTCP	BT2100_PQ_ RGB	BT2100_HLG_ RGB
Rec. ITU-R	SMPTE					
BT.656-5 SDI	ST 259M (SD-SDI)					
BT.1120-9	ST 292-1 1.5 Gb/s	√	√	√		
	ST 372-1 Dual 1.5 Gb/s	√	√	√	√	√
	ST 425-1 3G	√	√	√	√	√

[a] Cells with check marks (√) indicate "used combinations". Cells without check marks indicate "not used combinations". Before 2017, HDR and full range identifiers were not contained in many specifications. Baseband video properties may be used with camera log video properties.

Table 9 *(continued)*

Colour coding characteristics description		HDR WCG[a]				
System identifier		BT2100_PQ_YCC	BT2100_HLG_YCC	BT2100_PQ_ICTCP	BT2100_PQ_RGB	BT2100_HLG_RGB
Rec. ITU-R	SMPTE					
N/A	ST 425-5 Quad 3G	√	√	√	√	√
BT.2077-2	ST 2081-10 6G	√	√	√	√	√
	ST 2082-10 12G	√	√	√	√	√
	ST 2082-12 Quad 12G	√	√	√	√	√
	ST 2036-3 (Single/Multi-link 10G SDI)	√	√	√	√	√
	ST 2036-4 (U-SDI)	√	√	√	√	√
ST 2110-20 Uncompressed Video/IP		√	√	√	√	√
CTA 861.4/HDMI Uncompressed HSDI		√	√	√	√	√

[a] Cells with check marks (√) indicate "used combinations". Cells without check marks indicate "not used combinations". Before 2017, HDR and full range identifiers were not contained in many specifications. Baseband video properties may be used with camera log video properties.

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:

— 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 10 for HDR and Table 11 for SDR, 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/m^2 of peak brightness, 0.05 minimum brightness, and a D65 white point setting within a Rec. ITU-R BT.709 colour representation.

— P3D65x1000n0005 – representing a mastering display OLED environment for mastering of HDR content with displays having 1000 cd/m^2 of peak brightness, 0.0005 minimum brightness, and a D65 white point setting within a Rec. ITU-R BT.2100 colour representation constrained to P3 colour gamut values.

— P3D65x4000n005 – representing a mastering display LED LCD environment for mastering of HDR content with displays having 4000 cd/m^2 of peak brightness, 0.005 minimum brightness, and a D65 white point setting within a Rec. 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/m^2 of peak brightness, 0.0005 minimum brightness, and a D65 white point setting.

Carriage formats for 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 SMPTE ST 2067-21: 2016, Annex C. 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 10 — HDR mastering display colour volume descriptions

	System identifier	P3D65x1000n0005	P3D65x4000n005	BT2100x108n0005
Mastering display properties defined according to SMPTE ST 2086	Colour primaries (xR,yR) (red)	{0.6800, 0.3200}	{0.6800, 0.3200}	{0.7080, 0.2920}
	Colour primaries (xG,yG) (green)	{0.2650, 0.6900}	{0.2650, 0.6900}	{0.1700, 0.7970}
	Colour primaries (xB,yB) (blue)	{0.1500, 0.0600}	{0.1500, 0.0600}	{0.1310, 0.0460}
	White point chromaticity (x,y)	{0.3127, 0.3290} (D65)		
	Maximum luminance [cd/m^2]	1000	4000	108
	Minimum luminance [cd/m^2]	0.0005 for OLED	0.005 for LED LCD	0.0005 for laser
HEVC or AVC MDCV SEI message Rec. ITU-T H.265 | ISO/IEC 23008-2	Display_primaries_x[2]/y[2] (red)	{34000, 16000}	{34000, 16000}	{35400, 14600}
	Display_primaries_x[0]/y[0] (green)	{13250, 34500}	{13250, 34500}	{8500, 39850}
	Display_primaries_x[1]/y[1] (blue)	{7500, 3000}	{7500, 3000}	{6550, 2300}
	White_point_x/y	{15635, 16450}		
	Max/min_display_mastering_luminance	{10000000, 5}	{40000000, 50}	{1080000, 5}

Table 10 *(continued)*

	System identifier		P3D65x1000n0005	P3D65x4000n005	BT2100x108n0005
SMPTE MXF parameters SMPTE ST 2067-21	MasteringDisplayPrimaries	Registration identifier	urn:smpte:ul:060e2b34.0101010e.04200401.01010000		
		Coded decimal (red, green, blue)	{34000, 16000} {13250, 34500} {7500, 3000}	{34000, 16000} {13250, 34500} {7500, 3000}	{35400, 14600} {8500, 39850} {6550, 2300}
	MasteringDisplayWhitePoint Chromaticity	Registration identifier	urn:smpte:ul:060e2b34.0101010e.04200401.01020000		
		Coded decimal	{15635, 16450}		
	MasteringDisplayMaximum Luminance	Registration identifier	urn:smpte:ul:060e2b34.0101010e.04200401.01030000		
		Coded decimal	10000000	40000000	1080000
	MasteringDisplayMinimum Luminance	Registration identifier	urn:smpte:ul:060e2b34.0101010e.04200401.01040000		
		Coded decimal	5	50	5

Table 11 — SDR mastering display colour volume descriptions

	System identifier		BT709x100n05
Mastering display properties defined according to SMPTE ST 2086	Colour primaries (xR, yR) (red)		{0.6400, 0.3300}
	Colour primaries (xG, yG) (green)		{0.3000, 0.6000}
	Colour primaries (xB, yB) (blue)		{0.1500, 0.0600}
	White point chromaticity (x, y)		{0.3127, 0.3290} (D65)
	Maximum luminance [cd/m^2]		100
	Minimum luminance [cd/m^2]		0.05 for LCD/LED
HEVC or AVC MDCV SEI message Rec. ITU-T H.265 | ISO/IEC 23008-2	Display_primaries_x[2]/y[2] (red)		{32000, 16500}
	Display_primaries_x[0]/y[0] (green)		{15000, 30000}
	Display_primaries_x[1]/y[1] (blue)		{7500, 3000}
	White_point_x/y		{15635, 16450}
	Max/min_display_mastering_luminance		{1000000, 500}
SMPTE MXF parameters SMPTE ST 2067-21	MasteringDisplayPrimaries	Registration identifier	urn:smpte:ul:060e2b34.0101010e.04200401.01010000
		Coded decimal (red, green, blue)	{32000, 16500} {15000, 30000} {7500, 3000}
	MasteringDisplayWhitePoint Chromaticity	Registration identifier	urn:smpte:ul:060e2b34.0101010e.04200401.01020000
		Coded decimal	{15635, 16450}
	MasteringDisplayMaximum Luminance	Registration identifier	urn:smpte:ul:060e2b34.0101010e.04200401.01030000
		Coded decimal	1000000
	MasteringDisplayMinimum Luminance	Registration identifier	urn:smpte:ul:060e2b34.0101010e.04200401.01030000
		Coded decimal	500