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# Abstract

This document contains a draft of a technical report on prominent video property description points combinations that are widely used in the production and video distribution industry. This output document is to be used for a discussion on a planned Technical Report (ITU-T H.Sup.UVSTP | ISO/IEC 23009-4), which is a non-normative document of industry widely used practices on describing existing combinations of video properties, some of which are coding points and their representations in different carriage systems. The combinations of properties and the permutations of all possible values being considered can reach hundreds of choices to describe a stream and some of these combinations are not expected to be used in practice (such as using the ITU-R BT.2100 perceptual quantization (PQ) transfer characteristics with ITU-R BT.601 colour primaries). Only a small subset of these combinations (such as BT.2100 colour primaries with BT.2100 PQ and hybrid log-gamma transfer characteristics) is used in practice. This document aims to avoid mistaken assumptions on video property combinations made by vendors of various content processing tools that may be part of a production/video distribution equipment chain. With the increased usage of high-dynamic range and the increased use of look-up tables in television systems, these content processing mistakes could increasingly become magnified to become noticeable degradations in quality. Lastly, this Technical Report aims to help its readers, especially toolset developers, in avoiding unnecessary, complicated tailoring of their content processing tools to specific areas of the workflow, and thus improve the repurposing of their tools to different parts of the workflow.

# Scope

This document describes non-normative industry widely used practices on the usage of existing combinations of video properties and their representations in different carriage systems for video content production.

# References

1. Rec. ITU-T H.273 | ISO/IEC 23091-2 Coding-independent code points – Part 2: Video.
2. SMPTE 2067-20:2016 Interoperable Master Format- Application #2.
3. SMPTE 2067-21:2016 Interoperable Master Format- Application #2E.
4. SMPTE ST 2086:2014:Mastering Display Color Volume Metadata Supporting High Luminance and Wide Color Gamut Images.
5. SMPTE 377-1:2011 Am1:2012 Am2:2012: Material Exchange Format (MXF)- File Format Specification.
6. Rec. ITU-T H.264 | ISO/IEC 14496-10, Information technology – Coding of audio-visual objects Part 10: Advanced Video Coding.
7. Rec. ITU-T H.265 | ISO/IEC 23008-2, Information Technology – High efficiency coding and media delivery in heterogeneous environments Part 2: High efficiency video coding.
8. ITU-R BT.2100-1:2017 Image parameter values for high dynamic range television for use in production and international programme exchange.
9. ST 2113 (PD365) definition
10. SMPTE ST 2022-6:2012 Transport of High Bit Rate Media Signals over IP Networks (HBRMT)
11. SMPTE ST 2110-20:2017 Professional Media Over Managed IP Networks: Uncompressed Active Video
12. SMPTE 298:2009 Universal Labels for Unique identification of Digital Data
13. SMPTE ST 336:2017 Data Encoding Protocol using Key-Length-Value
14. SMPTE ST 335:2012 Metadata Element Dictionary Structure
15. SMPTE ST 395:2014 Metadata Groups Register
16. SMPTE ST 2003:2012 Types Dictionary Structure

[Ed. Add MPEG-2, H.Sup15, H.Sup18]

# Definitions

This document defines the following terms. The definitions used in the AVC (Rec. ITU-T H.264 | ISO/IEC 14496-10) and HEVC (Rec. ITU-T H.265 | ISO/IEC 23008-2) standards also apply.

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| * 1. **a** | **electro-optical transfer function (EOTF):** The function used in the post-decoding process to convert from a non-linear representation to a linear representation. |
|  | **full range:** A range in a fixed-point (integer) representation that spans the full range of values that could be expressed with that bit depth, such that, for 10-bit signals, black corresponds to code value 0 and peak white corresponds to code value 1023 for Y′, as per the full range definition from Rec. ITU-R BT.2100. |
|  | **inverse electro-optical transfer function (inverse EOTF**): A function used in the pre-encoding process to convert from a linear representation to a non-linear representation, computed as the inverse of the EOTF.  NOTE to entry – In this document the pre-encoding process is assumed to operate on HDR/WCG video content that has been prepared for a hypothetical reference viewing environment as shown in **Error! Reference source not found.**. The content preparation step may contain processing such as applying an opt-optical transfer function (OOTF), in which the HDR/WCG video is converted from one linear representation (corresponding to the scene) to another linear representation (corresponding to the display). The OOTF has the role of applying a “rendering intent”. In systems where no such OOTF is applied in the content preparation step, the process of converting from a linear representation (corresponding to the scene) to a non-linear representation is typically called the opt-electrical transfer function (OETF). |
|  | **narrow range:** A range in a fixed-point (integer) representation that does not span the full range of values that could be expressed with that bit depth such that, for 10 bit representations, the range from 64 (black) to 940 (peak white) is used for Y′ and the range from 64 to 960 is used for Cb and Cr, as per the narrow range definition from Rec. ITU-R BT.2100.  NOTE to entry –  Narrow range is, in some applications, called by synonyms such as: “limited range”, “video range”, “legal range”, “SMPTE range” or “standard range”. |
|  | **opto-electrical transfer function (OETF):** The function that converts linear scene light into the video signal, typically applied within a camera. |
|  | **opto-optical transfer function (OOTF):** A function that maps relative scene linear light (typically the camera output signal) to display linear light (typically, the signal driving a mastering monitor). |
|  | **random access point access unit (RAPAU):** An access unit in the 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. |
|  | **transfer function:** In this document, a transfer function refers to any of the following; EOTF, inverse EOTF, OETF, inverse OETF, OOTF, or inverse OOTF. |
|  | **colour volume:** |

# Abbreviations and acronyms

This document uses the following abbreviations and acronyms:

|  |  |
| --- | --- |
| AVC | Advanced Video Coding (Rec. ITU-T H.264 | ISO/IEC 14496-10) |
| EOTF | Electro-Optical Transfer Function |
| HD | High Definition |
| HDR | High Dynamic Range |
| HEVC | High Efficiency Video Coding (Rec. ITU-T H.265 | ISO/IEC 23008-2) |
| HVS | Human Visual System |
| LUT | Look-up Table |
| NCL | Non-Constant Luminance |
| PQ | Perceptual Quantizer (as defined in SMPTE ST 2084 and Rec. ITU-R BT.2100) |
| QP | Quantization Parameter |
| RAPAU | Random Access Point Access Unit |
| RGB | Colour System using linear light Red, Green, and Blue components |
| R′G′B′ | Colour System using non-linear (mapped to approximately perceptually uniform steps) Red, Green, and Blue components. The mapping between linear RGB and non-linear R′G′B′ is indicated by the transfer function. |
| SDR | Standard Dynamic Range |
| SEI | Supplemental Enhancement Information |
| OETF | Opto-Electrical Transfer Function |
| OOTF | Opto-Optical Transfer Function |
| VUI | Video Usability Information. A sequence level sub-header in AVC and HEVC bitstreams. |
| WCG | Wide Colour Gamut |
| XYZ | The CIE 1931 colour space. Y corresponds to the luminance signal. |
| Y′CbCr | Colour space representation commonly used for video/image distribution as a way of encoding RGB information, also commonly expressed as YCbCr, Y′CBCR, or Y′C′BC′R. The relationship between Y′CbCr and RGB is dictated by certain signal parameters, such as colour primaries, transfer characteristics, and matrix coefficients. Unlike the (constant luminance) Y component in the linear light XYZ representation, the non-linear, approximately perceptual uniform Y′ in this representation might not be representing the same quantity, regardless of the transfer function. Y′ is commonly referred to as “luma”. Cb and Cr are commonly referred to as “chroma”. It could also be known as YUV in other domains. |

# Overview

Part 2 of the Coding-Independent Code Points (CICP) standard (ISO/IEC 23091-2) defines code points and fields that identify the video signal type, independent from its compressed representation in a coded video layer bitstream, such as an AVC or HEVC bitstream. The compressed representation is often considered to be a temporary, compact distribution delivery state of the video signal, while the reconstructed video signal output from the decoder should be interpreted as having the same meaning as the video signal immediately prior to compression, indicated by the signal type code points conveyed by metadata mechanisms of the compressed stream such as the VUI header. The combinations of properties and the permutations of all possible values being considered can reach hundreds of choices to describe a signal type, and some of these combinations are not expected to be used in practice (such as using the ITU-R BT.2100 perceptual quantization (PQ) transfer characteristics with ITU-R BT.601 colour primaries). Only a small subset of these combinations (such as BT.2100 colour primaries with BT.2100 PQ /HLG transfer characteristics, Y’CbCr with narrow range signaling) are expected to be used in the industry. These properties, usually expressed in "metadata", can exist across the production and distribution workflows and knowledge of these properties and combinations has value as content gets processed in the E2E [End-to-End] production to distribution workflow chain.

This text is a non-normative document of industry widely used practices on describing existing combinations of video properties and their representations in different carriage domain systems. This document aims to avoid mistaken assumptions on video property combinations made by vendors of various content processing tools that may be part of a production equipment chain. With the increased usage of high-dynamic range and the increased use of look-up tables in television systems, these content processing mistakes could increasingly become magnified. Lastly, this document aims to help its readers, especially toolset developers, avoiding unnecessary, complicated tailoring of their content processing tools to specific areas of the workflow, and thus improve the repurposing of their tools to different parts of the workflow.

This Technical Report will first talk about the types of common standard colour volumes and the properties associated to define them. Then for each common standard colour volume what different parameters of the associated properties are in use in industry. Lastly depending on domain (production, distribution) how each of these associated properties are carried.

# Domains- capture, production, production distribution, service distribution

The following diagram describes the different domains that video content may exist and can be edited or converted in a workflow. Similar conversions may be done in different domains and tools need to understand what conversions happened in the preceding domain.



Figure 1 Video workflows through different carriage domains

# Common combinatorial descriptions

Separately defining video properties with all of their possible enumerated values can fully describe all cases of the video property in isolation. Describing video content requires looking collectively at the groups of video properties. Some combination of values of the video properties may collectively not make sense (e.g. xxx) or are not being used by the industry. This section defines commonly associated video properties and those combinations of values in use for the content industry today. Additionally, it defines for each domain (Capture, Production, Production-Distribution, Service-Distribution) what methods of carriage are commonly used to convey these video properties.

In order to allow for proper operations, conversion tools will need to understand the location and values of stream properties and metadata associated with the stream in widely used formats. This will allow tools to properly understand source stream properties for better conversions of the stream as video content gets changed to one of the widely used formats in each domain. For many tables, there will be sub tables created that indicate the identification and locations for each set of values. One of these sub tables will be a SMPTE MXF format table indicating parameters and values through SMPTE UL structures[[1]](#footnote-1) and another one will be an HEVC/AVC format sub table indication parameters and values through VUI and SEI constructs.

[YS1-22: Text on system Identifier if used. Common ITU doc so make sure reference are HEVC/ AVC throughout document]

## Colourimetry and range scalability descriptions

Common colour volumes describes combinations of video properties that are needed to do conversions on colour volumes. These may be conversions to other colour volumes, changes in bit depth, changes in colour sampling, non-linear optimizations and may also include transformations based on carriage and bit rate restrictions. Tools performing these conversions need to know the values of these video properties to decode the video and consistently perform its operations.

Carriage formats for colour properties in each of the domains (capture, production, production distribution, 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 ST 2067-21[[2]](#footnote-2). Colour Volume Information in the distribution domain can be carried within the video stream as syntax information in the selected video format such as AVC, HEVC, MPEG-2 etc, through VUI headers according to ISO/IEC 29001-2. The full and narrow range scalability video property is not carried explicitly in all technologies and may need to be taken implicitly through the system identifier though common practice is the Y′CbCr colour representation uses narrow range scalability values and the R′G′B′ colour representation uses full range scalability values. .

### Defined properties

* ColourPrimaries [ref- coding points]
  + Table Parameters: colour\_primaries [AVC/HEVC], Colour Primaries [SMPTE-MXF]
  + Synonyms:
  + Widely used practices: SDR uses a BT.709 colour space, Digital Cinema restricts colours to P3 values (ST 2067-30) but in a 2020 colourspace container, HDR over time will use the complete 2020 values.
* TransferCharacteristics [ref- coding points]
  + Table Parameters: transfer\_characteristics [AVC/HEVC], Transfer Characteristic [SMPTE-MXF]
  + Synonyms:
  + Widely used practices: For HDR uses either PQ or HLG, for SDR uses transfer characteristic for BT.709 assuming a display characteristic corresponding to BT.1886
* MatrixCoefficients [ref- coding points]
  + Table Parameters: matrix\_coeffs [AVC/HEVC], Coding Equations[SMPTE-MXF]
  + Synonyms:
  + Widely used practices: Specifies the encoding equations to convert RGB image components to component colour difference image components. No matrix is used for R’G’B’
* VideoFullRangeFlag [ref-codingpoints]
  + Table Parameters: video\_full\_range\_flag[AVC/HEVC], Unknown [SMPTE-MXF]
  + Synonyms: “Full” can be known as QE.1; “Narrow” can be known a legal range, SMPTE range, QE.2
  + Widely used practices: Y’CbCr colour representation uses narrow range scalability values, R’G’B’ colour representations use full range scalability values

### Common descriptions and carriage: Standard Dynamic Range- Narrow Colour Gamut

This colour volume describes SDR video, which includes the majority of the production and distribution workflows used in the industry today. There are several combinations of values of these video properties that are used for this colour volume. Table 1 describes these combinations. Note 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 level range scale operations.

The following system identifier tags are described:

* BT.709 YCC
* BT.709 RGB
* BT.709 RGB IMF
* BT.601 525
* BT.601 625

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Standard dynamic range and narrow colour gamut** | | | | | |
| System Identifier | BT.709 YCC | BT.709 RGB | BT.709 RGB IMF | BT.601 525 | BT.601 625 |
| **Colour properties** |  |  |  |  |  |
| Colour primaries | BT.709-6 | BT.709-6 | BT.709-6 | BT.601 | BT.601 |
| Transfer characteristics | BT.709-6 | BT.709-6 | BT.709-6 | BT.709-6 | BT.709-6 |
| Colour representation | Y′CbCr | R′G′B′ | R′G′B′ | Y′CbCr | Y′CbCr |
| Full/narrow range | Narrow | Narrow | Full | Narrow | Narrow |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **AVC/HEVC VUI parameters** |  |  |  |  |  |
| colour primaries | 1 | 1 | 1 | 5 | 6 |
| transfer\_characteristics | 1 | 1 | 1 | 6 | 6 |
| matrix\_coeffs | 1 | 0 | 0 | 6 | 5 |
| VideoFullRangeFlag | 0 | 0 | 1 | 0 | 0 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SMPTE MXF parameters** |  |  |  |  |  |
| Colour primaries | 06.0E.2B.34.04.01.01.06.04.01.01.01.03.03.00.00 | 06.0E.2B.34.04.01.01.06.04.01.01.01.03.03.00.00 | 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 | 06.0E.2B.34.04.01.01.01.04.01.01.01.01.02.00.00 | 06.0E.2B.34.04.01.01.01.04.01.01.01.01.02.00.00 | 06.0E.2B.34.04.01.01.01.04.01.01.01.01.02.00.00 | 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 | 06.0E.2B.34.04.01.01.01.04.01.01.01.02.01.00.00 |
| Full/Narrow level range  indicated in black ref level, white ref level, colour range | Implicit | Implicit | Implicit | Implicit | Implicit |

### Common descriptions and carriage: standard dynamic range – wide colour gamut

This colour volume describes SDR with wide colour gamut video, which is keyed off the colour primary video property. 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 colour volume it is operating in to make sure the conversion is handled consistently.

The following system identifier tags are described:

* BT.2020 YCC
* BT.2020 RGB

Table 2 SDR w/ WCG Common colour volume descriptions[[3]](#footnote-3)

|  |  |  |
| --- | --- | --- |
| **Standard dynamic range and wide colour gamut** | | |
| System Identifier | BT.2020 YCC | BT.2020 RGB |
| **Colour properties** |  |  |
| Colour Primaries | BT.2020 | BT.2020 |
| Transfer Characteristics | BT.709 | BT.709 |
| Colour Representation | Y′CbCr | R′G′B′ |
| Full/Narrow Range | Narrow | Narrow |

|  |  |  |
| --- | --- | --- |
| **AVC/HEVC VUI parameters** |  |  |
| colour primaries | 9 | 9 |
| transfer\_characteristics | 1 | 1 |
| matrix\_coeffs | 9 | 0 |
| VideoFullRangeFlag | 0 | 1 |

|  |  |  |
| --- | --- | --- |
| **SMPTE MXF parameters** |  |  |
|  |  |  |
| Colour primaries | 06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.00 | 06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.00 |
| Transfer characteristic | 06.0E.2B.34.04.01.01.0E.04.01.01.01.01.09.00.00 (ITU-R 2020-2) | 06.0E.2B.34.04.01.01.0E.04.01.01.01.01.09.00.00 (ITU-R 2020-2) |
| Coding equations (GBR) | 06.0E.2B.34.04.01.01.0D.04.01.01.01.02.06.00.00 (2020 NCL) |  |
| Full/narrow level range  indicated in black ref level, white ref level, colour range | Implicit | Implicit |

### Common descriptions and carriage: High Dynamic Range- Wide Colour Gamut

This colour volume describes what is known as HDR video, which is used in current ultra high definition video technologies. Tools including static and dynamic LUTs, tone mapping, and bit rate compression need to understand these combination values to produce consistent conversions.

The following system identifier tags are described:

* BT.2100 PQ YCC
* BT.2100 HLG YCC
* BT.2100 PQ RGB
* BT.2100 HLG RGB

Table 3 HDR/WCG common colour volume descriptions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **HD/UHD/8K, high dynamic range and wide colour gamut** | | | | |
| System Identifier | BT.2100 PQ YCC | BT.2100 HLG YCC | BT.2100 PQ RGB | BT.2100 HLG RGB |
| **Colour properties** | | | | |
| Colour primaries | BT.2020 / BT.2100 | BT.2020 / BT.2100 | BT.2020 / BT.2100 | BT.2020 / BT.2100 |
| Transfer characteristics | PQ | HLG | PQ | HLG |
| Colour representation | Y′CbCr | Y′CbCr | R′G′B′ | R′G′B′ |
| **Full/narrow level range** | Narrow | Narrow | Narrow | Narrow |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **AVC/HEVC VUI parameters** |  |  |  |  |
| colour primaries | 9 | 9 | 9 | 9 |
| transfer\_characteristics | 16 | 18 | 16 | 18 |
| matrix\_coeffs | 9 | 9 | 0 | 0 |
| VideoFullRangeFlag | 0 | 0 | 0 | 0 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SMPTE MXF parameters** |  |  |  |  |
| Colour primaries | 06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.00 | 06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.00 | 06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.00 | 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 (2020 NCL) | 06.0E.2B.34.04.01.01.0D.04.01.01.01.02.06.00.00 (2020 NCL) | 06.0E.2B.34.04.01.01.0D.04.01.0101.02.05.00.00 (GBR) | 06.0E.2B.34.04.01.01.0D.04.01.0101.02.05.00.00 (GBR) |
| Full/narrow level range  indicated in black ref level, white ref level, colour range | Implicit | Implicit | Implicit | Implicit |

## Widely used video/image characteristics in workflow domains

Several video properties can be associated as video/image characteristics. These types of video properties can be converted as it moves through each domain (capture, production distribution, service distribution) in the workflow. For distribution domains, bit depth, colour sampling structure, colour form, and compression format can be discovered through the format profile definition and bitstream syntax. The remainder of video properties in this description is not carried in any wrapper but can be identified through the system identifier tags which may be sent as out of stream information

## Video/image characteristics for capture domain

In the capture domain content originates from camera capture from one or multiple cameras. The process in this domain are often in real-time and can include some real-time production processes (e.g. adding graphics, colour grading, static/dynamic LUTs for things like transfer curves changes (HLG to PQ), full/narrow range scalability conversion). A real-time delivery through all the domains in the workflow to the viewer is generally a live event workflow. If production or service distribution is non realtime, this may become a part of a theatrical or scripted type of workflow. In the capture domain, content needs to be kept at a high information rate so it is stored/transmitted generally as editable images in a lossless or uncompressed format.

AVC Class 100, or 100 Mb/s, is an example of a **common** lossy compression level used for professional 709 capture. Corresponding uncompressed bit rate for 709 is about 3 Gb/s.

Table 4- Widely Used Video/Image Workflow Characteristics in the Capture Domain

|  |  |
| --- | --- |
| SDR/NCG | |
| Colour sampling structure | 4:4:4 [Y’CbCr, R’G’B’], 4:2:2 [Y’CbCr] |
| Frame structure | Interlaced, progressive |
| Bit depth | 10, 8 |
| Compression type | Lossless, uncompressed |
| Compression dimension | None |
| Compression format | None |
| Wrappers | None, MXF, SDI, HD-SDI, ST.2022 (IP/Mux), ST.2110 (IP/UnMux) |

|  |  |
| --- | --- |
| HDR/WCG, SDR/WCG | |
| Colour sampling structure | 4:4:4 [R’G’B’], 4:2:2 [Y’CbCr], 4:4:4 [Y’CbCr] |
| Frame structure | Progressive |
| Bit depth | 16, 12, 10 |
| Compression type | Lossless, uncompressed |
| Compression dimension | None |
| Compression format | None |
| Wrappers | None, MXF, SDI, HD-SDI, ST.2022 (IP/Mux), ST.2110 (IP/UnMux) |

## Video/image characteristics for production domain

In the production domain, the video/image content can be mixed with other sources such as CGI content. It can also undergo colour space, sampling structure, and bit-depth conversions as well as alterations of the content through colour grading processes to provide an intended “look” to the content to the viewer. Content conversions may lose come of the information from the capture domain, but the content is still of a high quality, and editable. Content is more in an uncompressed or lightly compressed format.

Table 5- Widely Used Video/Image Workflow Characteristics in the Production Domain

|  |  |
| --- | --- |
| SDR/NCG | |
| Colour sampling structure | 4:4:4 [Y’CbCr, R’G’B’], 4:2:2 [Y’CbCr] |
| Frame structure | Interlaced, progressive |
| Bit depth | 10, 8 |
| Compression type | Lossless, uncompressed |
| Compression dimension | None |
| Compression format | None |
| Wrappers | None, MXF, SDI, HD-SDI, ST.2022-6 (IP/Mux), ST.2110-10 (IP/UnMux), Others |

|  |  |
| --- | --- |
| HDR/WCG, SDR/WCG | |
| Colour sampling structure | 4:4:4 [R’G’B’], 4:2:2 [Y’CbCr] |
| Frame structure | Progressive |
| Bit depth | 12, 10 |
| Compression type | Lossless, uncompressed |
| Compression dimension | None, spatial |
| Compression format | None, J2K |
| Wrappers | None, MXF, SDI,SDI, ST.2022-6 (IP/Mux), ST.2110-20 (IP/UnMux), Others |

## Video/Image Characteristics for Production Distribution Domain

In the production distribution domain, is intended for distribution of content to other facilities or to act as a mezzanine or contribution feed (e.g. IMF, HEVC, J2K, AVC) to a service provider. Content is usually lightly compressed in a spatial dimension or both a spatial/temporal dimension.

Table 6- Widely Used Video/Image Workflow Characteristics in the Production Distribution Domain

|  |  |
| --- | --- |
| SDR/NCG | |
| Colour sampling structure | 4:2:2 [Y’CbCr], 4:2:0 [Y’CbCr] |
| Frame structure | Interlaced, progressive |
| Bit depth | 10, 8 |
| Compression type | Lossless, uncompressed |
| Compression dimension | None |
| Compression format | None, J2K, HEVC, AVC, MPEG-2 |
| Wrappers | MXF, SDI, HD-SDI, ST.2022-6 (IP/MUX), ST.2110-20 (IP/UnMux), MPEG2-TS, MP4, others |

|  |  |
| --- | --- |
| HDR/WCG, SDR/WCG | |
| Colour sampling structure | 4:2:2 [Y’CbCr], 4:2:2 [Y’CbCr] |
| Frame structure | Progressive |
| Bit depth | 16, 12, 10 |
| Compression type | Lossless, uncompressed |
| Compression dimension | None, spatial, spatial/temporal |
| Compression format | None, J2K, HEVC, AVC, MPEG-2 |
| Wrappers | MXF, SDI, HD-SDI, ST.2022 (IP/MUX), ST.2110-20 (IP/UnMux), MPEG2-TS, MP4, others |

## Video/image characteristics for service distribution domain

In the service distribution domain, the remaining conversion stage of the content is intended to be the final format that is consumed by the viewer’s player device. Video content may be reduced by further subsampling, bit depth, and traditional distribution video codec techniques.

Table 7- Widely Used Video/Image Workflow Characteristics in the Service Distribution Domain

|  |  |
| --- | --- |
| SDR/NCG | |
| Colour sampling structure | 4:2:0 [Y’CbCr] |
| Frame structure | Interlaced, progressive |
| Bit depth | 10, 8 |
| Compression type | Lossless, uncompressed |
| Compression dimension | None |
| Compression format | HEVC, AVC, MPEG-2, Others |
| Wrappers | MPEG2-TS, MP4 |

|  |  |
| --- | --- |
| HDR/WCG, SDR/WCG | |
| Colour sampling structure | 4:2:0 [Y’CbCr] |
| Frame structure | Progressive |
| Bit depth | 10 |
| Compression type | Lossless, uncompressed |
| Compression dimension | Spatial, spatial/temporal |
| Compression format | HEVC, AVC, MPEG-2, others |
| Wrappers | MPEG2-TS, MP4 |

## Mastering display colour volume descriptions

The mastering display information describes the colour volume of a display that was used for viewing during the authoring of the video content. It is the display where creative work is performed during the mastering process, and can be represented by a combination of video display properties. When the authored content is shown on other displays, this type of video display information can be used to more closely reproduce the creative intent originally achieved in the mastering suite. Again, only certain combinations of video display properties are used in the mastering display environment. Tools performing conversions of video content would be able to preserve more of the intended colour reproduction with knowledge of these combinations of in-use values for the video display property parameters.

### Defined Properties

* Mastering display primaries [ref- ST 2086]
* Mastering display white point chromaticity [ref- ST 2086]
* Mastering display maximum luminance [ref- ST 2086]
* Mastering display minimum luminance [ref- ST 2086]

[Ed. Note (Alexis): These also exist in the HEVC and AVC specs. Ideally they should also be in CICP and we should be referencing those specs also. YS: Agreed

Also why reference each individual property of a group? YS: The identifiers differ with respect to different values of these parameters.]

### Common descriptions and carriage: MDCV descriptions (M42032)

The following system identifier tags are described:

* 709,D65,1000- represents display colour volume environments dealing with mastering of SDR/HDR content on LED/LCD displays capable of 1000 cd/m2 of peak brightness but restricted to BT.709 colourspace.
* 709,D65,4000- represents display colour volume environments dealing with mastering of SDR/HDR content on LED/LCD displays capable of 4000 cd/m2 of peak brightness but restricted to BT.709 colourspaces.
* 2020,D65,1000- represents display colour volume environments dealing with mastering of HDR content on OLED displays capable of 1000 cd/m2 of peak brightness and wider BT.2020 Colourspace.
* P3,D65,1000- represents display colour volume environments dealing with mastering of HDR content on OLED displays capable of 1000 cd/m2 of peak brightness, having overall a smaller gamut than BT.2020 (except for a slightly deeper red P3 primary), often used in mastering digital cinema content as described in Table 6-10 of [8]. Various white points (D60, D62, D65) are defined in Table G-1 of [9]

[Ed: Examples; table entry for content colour volumes at 1200 and and 4000 cd/m^2 for BT.2020/BT.2100 signals?.]

[Ed. TF needs to be understood for mastering displays input. Not relevant for ST 2086 however ]

[Ed. most of today’s video is 709-Gamma D65 with 200- 300 cd/m2 ]

[Ed. YS: This is one of those areas that we probably need to discuss]

Carriage formats for mastering display colour volume in each of the domains (Capture, Production, Production Distribution, 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 ST 2067-21[[4]](#footnote-4). In the distribution domain, the mastering display colour volume information is carried the mastering display colour volume SEI message (payload 137) that needs to be repeated at least every random access point access unit (RAPAU).

Table 8 Mastering display colour volume descriptions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mastering display colour volume description** | | | | |
| System identifier | 709-Gamma\_2.4,D65,1000 | 709-Gamma,D65,4000 | BT2020,D65,1000 | P3,D65,1000 |
| **Mastering display properties** |  |  |  |  |
| Primaries (x,y) for {R},{G},{B} | {32000,16500} {15000,30000} {7500,3000} | {32000,16500} {15000,30000} {7500,3000} | {35400,14600} {8500,39850} {6550,2300} | {34000,16000} {13250,34500} {7500,3000} |
| White point chromaticity {x,y} | {15635,16450} (D65) | {15635,16450} (D65) | {15635,16450} (D65) | {15635,16450} (D65) |
| Maximum luminance (1000\*cd/m2) | 10000000 (1000 cd/m2) | 40000000 (1000 cd/m2) | 10000000 (1000 cd/m2) | 10000000 (1000 cd/m2) |
| Minimum luminance (0.0001\*cd/m2) | 500 (0.05 cd/m2 for LCD/LED) | 500 (0.05 cd/m2 for LCD/LED) | 5 (0.0005 cd/m2 for OLED) | 5 (0.0005 cd/m2 for OLED) |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **AVC/HEVC SEI MDCV** |  |  |  |  |
| Display\_primaries\_x[0]/y[0] | {32000,16500} | {32000,16500} | {35400,14600} | {34000,16000} |
| Display\_primaries\_x[1]/y[1] | {15000,30000} | {15000,30000} | {8500,39850} | {13250,34500} |
| Display\_primaries\_x[2]/y[2] | {7500,3000} | {7500,3000} | {6550,2300} | {7500,3000} |
| white\_point\_x/y | {15635,16450} | {15635,16450} | {15635,16450} | {15635,16450} |
| max/min\_display\_mastering\_luminance | {10000000,500} | {40000000,500} | {10000000,5} | {10000000,5} |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SMPTE MXF parameters** |  |  |  |  |
| MasteringDisplayPrimaries | 060e2b34.0101010e.04200401.01010000 + [12 bytes] {32000,16500} {15000,30000} {7500,3000} | 060e2b34.0101010e.04200401.01010000 + [12 bytes] {32000,16500} {15000,30000} {7500,3000} | 060e2b34.0101010e.04200401.01010000 + [12 bytes] {35400,14600} {8500,39850} {6550,2300} | 060e2b34.0101010e.04200401.01010000 + [12 bytes] {34000,16000} {13250,34500} {7500,3000} |
| MasteringDisplayWhitePointChromaticity | 060e2b34.0101010e.04200401.01020000 + [4 bytes] {15635,16450} | 060e2b34.0101010e.04200401.01020000 + [4 bytes] {15635,16450} | 060e2b34.0101010e.04200401.01020000 + [4 bytes] {15635,16450} | 060e2b34.0101010e.04200401.01020000 + [4 bytes] {15635,16450} |
| MasteringDisplayMaximumLuminance | 060e2b34.0101010e.04200401.01030000 + [4 bytes] {10000000} | 060e2b34.0101010e.04200401.01030000 + [4 bytes] {40000000} | 060e2b34.0101010e.04200401.01030000 + [4 bytes] {10000000} | 060e2b34.0101010e.04200401.01030000 + [4 bytes] {10000000} |
| MasteringDisplayMinimumLuminance | 060e2b34.0101010e.04200401.01040000+ [4 bytes] {500} | 060e2b34.0101010e.04200401.01040000+ [4 bytes] {500} | 060e2b34.0101010e.04200401.01040000+ [4 bytes] {5} | 060e2b34.0101010e.04200401.01040000+ [4 bytes] {5} |

[Ed. Note (Alexis) : For MXF, instead of numbers, should the actual byte values be written?

[Ed. For BT.2020, the red primary has an x coordinate of 0.708 \* 50000 = 35400. Please verify all points

YS: Yes needs to be double checked. ]

[Ed. Maximum luminance seems to be scaled by 10000, not 1000 as reported on the first column, row 6.]

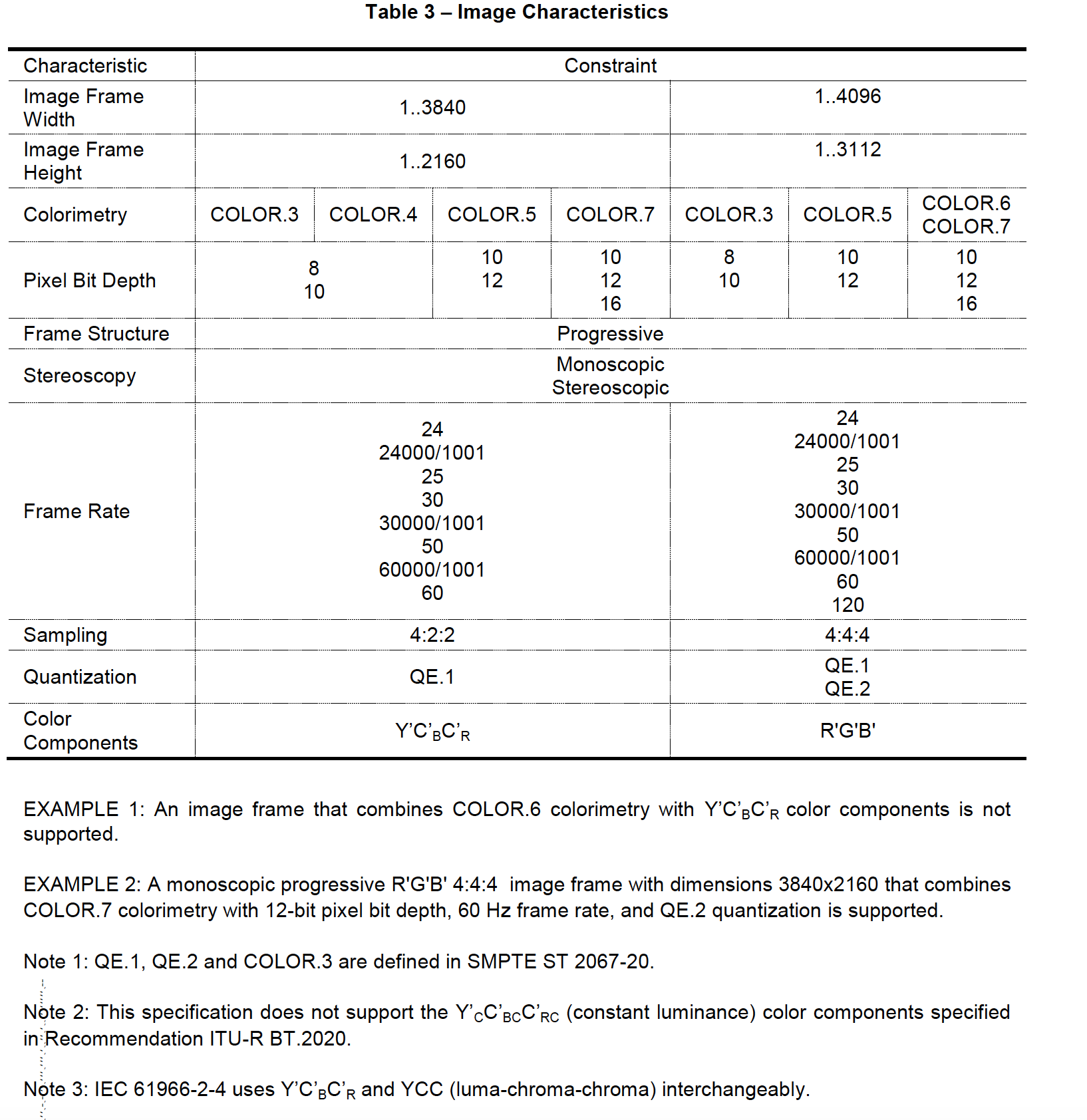
[Ed. There is nothing that mentions that the values in this table are scaled by 50000 ].

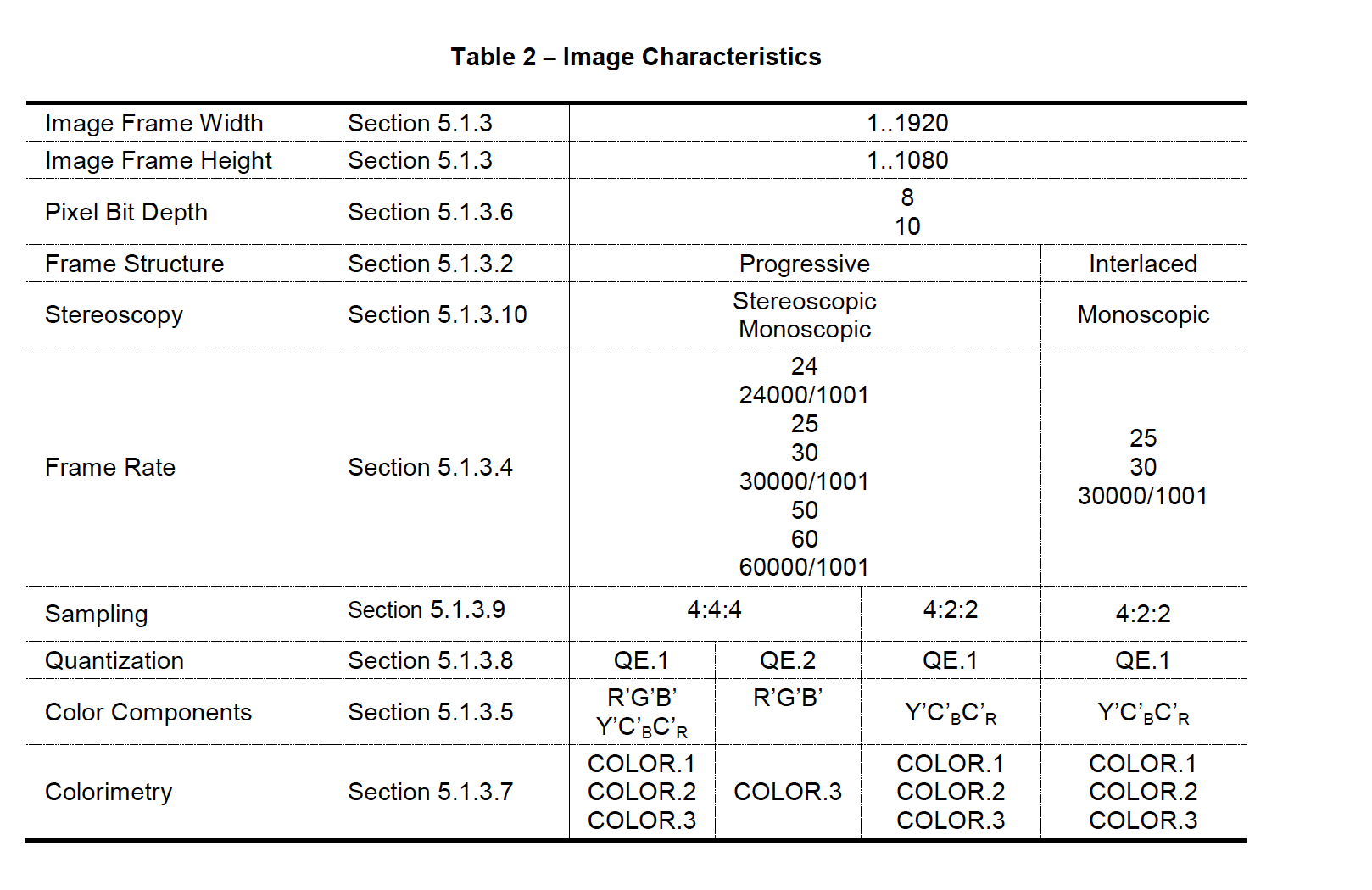
[Ed. In the SEI messages as well CICP spec, the order is green, blue, red. Not red, green, blue. So this seems maybe problematic. Please fix.]

[Ed. Notes (Chad): Check whether MXF and IMF values for ST 2086 carriage may be in R,G,B order. SMPTE 2067-21

ST 2067-21 states:  
"""  
Mastering Display Primaries [...] shall be a fixed-size sequence of 3  
instances of the ColourPrimary type, for a total of 12 bytes. The  
ColourPrimary instances should be ordered as follows: (i) instance with  
the largest x chromaticity coordinate, (ii) instance with the largest y chromaticity  
coordinate, and (iii) instance with neither the largest y nor the  
largest x chromaticity coordinate.  
  
Note 2: The recommended ordering of the ColourPrimary instances  
corresponds to RGB ordering in many common cases.  
"""  
Note it is only a recommendation, and implementations are expected to  
support any ordering.]

# [Document End]





1. SMPTE MXF structures make use of UL (Universal Labels) which are a set of registered labels maintained by SMPTE (registry.smpte-ra.org). This is a 16 byte structure comprised of SMPTE UL Header [4bytes] [12], SMPTE UL Designator [4bytes] [13], and an Item Designator [8 bytes] [14][15][16]. SMPTE MXF Sub tables will provide these 16 byte labels in addition to any values associated with the label. [↑](#footnote-ref-1)
2. In the capture, production, and distribution domains, the colorimetry property information can also be carried combined as single string of values (e.g. “9-1-9”) .

   **Table 1 SDR common colour volume descriptions** [↑](#footnote-ref-2)
3. [↑](#footnote-ref-3)
4. [↑](#footnote-ref-4)