TECHNICAL SPECIFICATION

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Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange —

Part 5: High dynamic range and wide colour gamut encoding for still images (HDR/WCG)

Photographie et technologie graphique — Codages par couleurs étendues pour stockage, manipulation et échange d'image numérique —

Partie 5: Plage dynamique élevée et codage large de la gamme de couleurs pour les images fixes (HDR/WCG)

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Contents

Page

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 ISO documents 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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 42, *Photography*.

A list of all parts in the ISO 22028 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 has been developed to meet the industry need for a complete, fully documented, publicly available specification of high dynamic range (HDR) and wide colour gamut (WCG) image encodings for digital still images.

High dynamic range images, that have been produced to look correct on high dynamic range displays, can provide a better user experience than standard dynamic range images. High dynamic range images allow a greater range of shadow and highlight detail to be conveyed, with sufficient precision and acceptable artifacts, including sufficient separation of diffuse white and specular highlights.

Wide colour gamut images, in addition, can represent a wider range of colours and allow for better colour reproduction. These two features are commonly bundled together. In this document, for simplicity, we will refer to both such features using the HDR/WCG acronym.

ITU-R has published requirements and guidelines for HDR/WCG television production and exchange, the foundation of the blooming HDR/WCG video and movie ecosystems. There are now a growing number of HDR/WCG displays (Smartphones, TVs, computer displays) that consumers use in their daily life, but a limited amount of HDR/WCG still image content is available.

In parallel, digital cameras improve over time and capture more and more dynamic range. To overcome the limitations of sensing technology, HDR images can be generated by fusing several images captured with different exposures. But so far, the digital still imaging industry has not settled on a reference HDR/WCG image encoding for consumers.

The purpose of this document is to provide requirements and guidelines for colour encoding of HDR/WCG still images. The digital still imaging industry will benefit from these requirements and guidelines. They will help establish a standard and open HDR/WCG ecosystem, to take better advantage of HDR cameras and displays. These colour encoding requirements and guidelines can be leveraged in the specification of HDR/WCG file formats.

The encoding and decoding methods specified in this document are from ITU-R BT.2100-2, to ensure full compatibility with existing HDR/WCG devices and the associated video and movie ecosystems. Metadata is specified in this document to support the communication of scene-referred and display-referred image states in accordance with ISO 22028-1.

The outline of this document is as follows. The scope is defined in Clause 1, the normative references are listed in Clause 2. Clause 3 lists the terms, definitions, and acronyms. Clause 4 covers the colour image encoding requirements.

Annex A (normative) specifies the extended HDR/WCG colour encoding.

Annex B (informative) lists a selection of highly relevant ITU-R Rec. BT.2100-2 tables.

Annex C (informative) lists relevant ISO/IEC 23000-22/Amd.2 tables, that are related to metadata recommended in this document.

Annex D (informative) presents different HDR workflows.

Annex E (informative) provides information about ISO 22028-1 image states and the linear light interpretations of HDR image signal values specified in ITU-R BT.2100-2.

Annex F (informative) presents tone mapping options.

Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange —

Part 5:
High dynamic range and wide colour gamut encoding for still images (HDR/WCG)

1 Scope

This document defines a set of colour image encodings for use in storage, transmission, and display of high dynamic range and wide colour gamut (HDR/WCG) digital still images. It defines the colour encodings, the mandatory and optional metadata, and the reference viewing conditions for HDR/WCG images.

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.

ISO 22028-1:2016, *Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange — Part 1: Architecture and requirements*

ISO/IEC 23091-2:2021/ITU-T H.273, *Information technology — Coding-independent code points — Part 2: Video*

ISO/IEC/TR 23091-4:2021/ITU-T H.SUPPLEMENT 19, *Information technology — Coding-independent code points — Part 4: Usage of video signal type code points*

RECOMMENDATION ITU-R BT 2100-2 (07/2018): *Image parameter values for high dynamic range television for use in production and international programme exchange*

SMPTE ST 2113, *SMPTE Standard — Colorimetry of P3 Color Spaces*

3 Terms, definitions and acronyms

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
coding-independent code points for video signal type identification
CICP
metadata that describes the colour image characteristics of the associated picture

3.2
colour image encoding
digital encoding of the colour values for a digital image, including the specification of a colour space encoding, together with any information necessary to properly interpret the colour values such as the image state, the intended image viewing environment, and the reference medium

[SOURCE: ISO 22028-1:2016, 3.9, modified — Notes to entry were deleted.]

3.3
colour volume
space of all colours and intensities that a device or signal can reproduce or convey

[SOURCE: ISO/IEC TR 23091-4:2021, 3.6/ITU-T H.SUPPLEMENT 19]

3.4
content colour volume
CCV
metadata that describes the colour volume (colour primaries, white point, and luminance range) characteristics of the associated picture

3.5
content light level
CLL
metadata that describes the light level characteristics (maximum and average) of the associated picture

3.6
diffuse white
stimulus that an observer adapted to the displayed content in the viewing environment would judge to be neutral and to have a luminance factor of unity

3.7
display light
image values that result from applying the reference EOTF to the encoded image signal values

3.8
display viewing colorimetry
colorimetry appropriate for a targeted display with specified viewing conditions

Note 1 to entry: The display viewing colorimetry typically depends on the creative intent for the content.

3.9
display referred
image state associated with image data that represents the colour-space coordinates of the elements of an image that has undergone colour-rendering appropriate for a specified display and viewing conditions

3.10
electrical-electrical transfer function
EETF
transfer function that adjusts the electronic signal, e.g. to tone map it to a lower display range

3.11
electro-optical transfer function
EOTF
transfer function which converts the non-linear signal into display light

3.12
high dynamic range and wide colour gamut encoding
HDR/WCG encoding
Colour image encoding that can contain wider variations in brightness, with a dynamic range significantly higher than that of a standard dynamic range encoding, and a wider range of colours with more saturated colours than standard colour gamut encodings

3.13
high dynamic range image
HDR image
image that contains wider variations in brightness, with a dynamic range significantly higher than that of a standard dynamic range image

3.14
highlights
image pixels with colorimetric values higher than those of the reference diffuse white

3.15
image
data structure that contains pixels and image-related data

[SOURCE: ISO/IEC 12087-1:1995, 3.1.3]

3.16
mastering display
a display that is used or targeted for viewing while authoring the content

3.17
mastering display colour volume
MDCV
metadata that identifies the colour volume (the colour primaries, white point chromaticity, and luminance range) of a mastering display

[SOURCE: SMPTE ST 2086:2018]

3.18
nominal peak luminance
luminance resulting on a display from the specified encoding peak white signal level

Note 1 to entry: The peak white signal level is specified to be lower than the peak signal level for narrow range encodings.

3.19
nominal diffuse white luminance
display luminance a viewer would consider, on average, correspond to a perfectly reflecting diffuser in the scene when viewing the mastering display

3.20
opto-electronic transfer function
OETF
transfer function that converts scene light into non-linear signal values

3.21
opto-optical transfer function
OOTF
transfer function that converts scene light to display light

3.22
nominal diffuse white
diffuse white value typical for the content encoding that is assumed for general purposes, independent of specified content or other information about the actual diffuse white

3.23
scene light
image values that result from applying the inverse reference OETF to the encoded image signal values

3.24
transfer function
single variable, monotonic mathematical function applied individually to one or more colour channels

3.25
wide colour gamut
WCG
gamut that has saturated colour primaries and includes a broad range of saturated colours

Note 1 to entry: It is wider than a standard colour gamut such as sRGB.

Note 2 to entry: WCG encodings provide a means to encode images with more saturated colours than standard colour gamut encodings, to represent a wider range of colours and allow for better colour reproduction.

4 Requirements

4.1 General introduction

The colour image encodings specified in this document conform to the requirements defined in ISO 22028-1:2016, Clause 5, and include a colour space representation, associated metadata, a reference viewing environment, and a reference medium.

Colour image encoding and transfer functions are specified in 4.2 and 4.3 respectively. The reference viewing environment and the reference display are defined in 4.4 and in 4.5 respectively. These subclauses provide context for interpreting the intended colour appearance of the encoded image colorimetry. The associated metadata are specified in 4.6. The most relevant ITU-R BT.2100-2 properties are referred to in Annex B of this document.

4.2 Colour image encoding

4.2.1 General

Two sets of colour encodings are defined, baseline and extended. Images shall conform either to the baseline colour encoding defined in 4.2.3, or to the extended colour encoding defined in Annex A. Image readers shall support the baseline colour encoding, and may support the extended colour encoding.

The baseline colour encoding is recommended for cameras, TVs, and image readers on other consumer devices. It is fully compatible with ITU-R BT.2100-2 and recommended for image exchanges with wider viewing compatibility. The extended colour encoding is intended for applications where dedicated hardware and/or software are used.

4.2.2 Colour primaries and white point

Images shall use the colour primaries and white point, as defined in Table 2, System colorimetry, of ITU-R BT.2100-2.

Table 1 reproduces the chromaticity coordinates of the RGB primaries and white point of the colour encoding space specified in ITU-R BT.2100-2.

Table 1 — Chromaticity coordinates of the RGB primaries and white point of the colour encoding space

Parameter		Values		
		Optical spectrum (informative)	Chromaticity coordinates (CIE, 1931)	
			x	*y*
Primary colours	Red primary (R)	monochromatic 630 nm	0,708	0,292
	Green primary (G)	monochromatic 532 nm	0,170	0,797
	Blue primary (B)	monochromatic 467 nm	0,131	0,046
Reference white		D65 per ISO 11664-2:2007	0,312 7	0,329 0
Colour matching functions		CIE 1931		

4.2.3 Baseline colour encoding

Images conforming to the baseline colour encoding shall comply with the specifications defined in Table 9 in ITU-R BT.2100-2. Images shall use the non-constant luminance Y', C'_B, C'_R signal format defined in Table 6 in ITU-R BT.2100-2.

Table 2 partially reproduces the Table 9 of ITU-R BT.2100-2.

Table 2 — Baseline colour encoding specification

Parameter	Value			
Coded signal	Y', C'_B, C'_R			
Coding format	n = 10, 12 bits per component			
Quantization of Y'	Narrow range		Full range	
(resulting values that exceed the video data range should be clipped to the video data range)	D = Round [(219 × E' + 16) × 2^{n-8}]		D = Round [(2^n-1) × E']	
Quantization of C'_B, C'_R, (resulting values that exceed the video data range should be clipped to the video data range)	D = Round [(224 × E' + 128) × 2^{n-8}]		D = Round [(2^n-1) × E' + 2^{n-1}]	
Quantization levels	10-bit coding	12-bit coding	10-bit coding	12-bit coding
Black (Y' = 0) DY'	64	256	0	0
Nominal Peak (Y' = 1) DY'	940	3 760	1 023	4 095
Achromatic (C'_B = C'_R = 0) DC'_B, DC'_R	512	2 048	512	2 048
Nominal Peak (C'_B = C'_R = +0,5) DC'_B, DC'_R	960	3 840	1 023	4 095
Nominal Peak (C'_B = C'_R = -0,5) DC'_B, DC'_R	64	256	1	1
Video data range	4 through 1 019	16 through 4 079	0 through 1 023	0 through 4 095

Where:

Round(x) = Sign(x) * Floor(| x | + 0,5)

Floor(x) the largest integer less than or equal to x

$$\text{Sign}(x) = \begin{cases} 1 & ; \quad x > 0 \\ 0 & ; \quad x = 0 \\ -1 & ; \quad x < 0 \end{cases}$$

NOTE The narrow range representation is in widespread use in the video and broadcasting industries. The full range representation is commonly used in the photographic industry.

4.3 Transfer functions

4.3.1 General

Two HDR/WCG colour encodings specified in ITU-R BT.2100-2 are widely adopted by video HDR/WCG ecosystems: the hybrid log-gamma (HLG) encoding and perceptual quantization (PQ) encoding.

These encodings use the same colour primaries and white point but different transfer functions. Images conforming to this document shall be encoded using an HLG transfer function (see 4.3.2), or a PQ transfer function (see 4.3.3). Diagrams of the workflows using the different transfer functions are provided in Annex D.

The HLG and PQ systems are designed to encode images for viewing on HDR/WCG displays. Scene light captured by the camera may be adjusted to produce a desired image appearance when viewed on a display.

However, in some cases, imaging systems communicate estimated scene-referred colorimetry. This scene-referred colorimetry should be indicated by using scene-referred metadata (Annex E provides details).

NOTE Scene-referred colorimetry images can be used in applications such as digital archiving, virtual scenes, photorealistic compositing, some types of medical imaging, and machine vision.

4.3.2 Hybrid Log-Gamma (HLG) system

When scene light values are mapped into HLG signal values, this mapping shall be as specified by the HLG Reference OETF defined in ITU-R BT.2100-2. When values are mapped in the inverse direction, this mapping shall be according to the inverse of the HLG Reference OETF defined in ITU-R BT.2100-2.

When HLG signal values are mapped into display light values, this mapping shall be as specified by the HLG Reference EOTF defined in ITU-R BT.2100-2.

When values are mapped in the inverse direction, this mapping shall be according to the inverse of the HLG Reference EOTF defined in ITU-R BT.2100-2.

If the MDCV metadata is present, as defined in 4.6.4.2, its minimum and maximum luminance parameters should be used for the derivation of the EOTF. When the MDCV metadata is not present, the minimum and maximum luminance parameters of the reference display, as defined in 4.5, should be used for the derivation of the EOTF.

If the HLG signal values represent estimated scene colorimetry, this should be indicated using scene-referred metadata. The inverse of the reference HLG opto-electronic transfer function (OETF) can be applied to the encoded scene colorimetry to revert to linear light colorimetry (D.2, D.3, and Annex E provide details).

NOTE While the HLG encoding as defined in ITU-R BT.2100-2 is by default scene-referred, with a fixed OETF and a variable OOTF/EOTF that adapts to different display dynamic ranges, in practice the OETF might be adjusted by the content creator based on viewing the resulting image on a display. Alternatively, the OETF might be adjusted by automatic image tuning algorithms in the camera image processing pipeline or in the post processing software. Consequently, HLG images encoded as defined by ITU-R BT.2100.2 do not necessarily represent the colorimetry of the actual scene.

4.3.3 Perceptual quantizer (PQ) system

When PQ signal values are mapped into display light values, this mapping shall be as specified by the Reference PQ EOTF defined in ITU-R BT.2100-2. When values are mapped in the inverse direction, this mapping shall be according to the inverse of the Reference PQ EOTF defined in ITU-R BT.2100-2.

When scene light values are mapped into PQ signal values, this mapping shall be as specified by the Reference PQ OETF defined in ITU-R BT.2100-2. When values are mapped in the inverse direction, this mapping shall be according to the inverse of the Reference PQ OETF defined in ITU-R BT.2100-2.

If the PQ signal values represent estimated scene colorimetry, this should be indicated by using scene-referred metadata. When decoding the signal, the inverse of the reference PQ OETF can be applied to the encoded scene colorimetry to revert to linear light colorimetry (D.4, Annex D.5 and Annex E provide details).

NOTE The PQ encoding as defined in ITU-R BT.2100-2 is by default display-referred.

4.4 Reference viewing environment

Table 3 specifies parameters to establish a reference viewing environment in which images with display viewing colorimetry and conforming to this document are intended to be viewed, as required in ISO 22028-1:2016, 5.4.4.

Table 3 — Reference viewing environment specification

Parameter	Value
Colour temperature of surround and periphery	Neutral grey at D65
Luminance of surround	5 cd/m^2
Luminance of periphery	≤ 5 cd/m^2
Spatial distribution of ambient lighting	No direct specular light sources shall be incident upon the eyes of the observer or the display.

NOTE 1 This reference viewing environment applies to display-viewing colorimetry, not to scene-referred colorimetry.

NOTE 2 "surround" is the area surrounding a display that can affect the adaptation of the eye, typically the wall or curtain behind the display; "periphery" is the remaining environment outside of the surround.

4.5 Reference display

4.5.1 General

Different high dynamic range and wide colour gamut displays can serve as reference media for HDR/WCG images. While ITU-R BT.2100-2 defines minimal requirements for HDR reference displays, ISO/IEC TR 23091-4 provides several HDR mastering display colour volume, i.e. MDCV, (see SMPTE ST 2086 and ISO/IEC 23000-22) descriptions for HDR reference displays, which represent displays widely used in production and video content workflows. When such metadata is present, its information should be used for the determination of the reference display's parameters, such as its colour primaries, white point chromaticity, and luminance range (maximum and minimum).

In the following clauses, a default reference display is specified. It provides a default context for interpreting the intended colour appearance of the encoded image colorimetry. 4.5.2 defines the default reference display colour volume, 4.5.4 the default nominal peak luminance, and 4.5.5 the default black point. Then, 4.5.5 defines the default nominal diffuse white luminance.

NOTE This default reference display does not necessarily apply to scene-referred images.

4.5.2 Default reference display colour primaries

The default display colour primaries shall be the P3-D65 colour primaries in accordance with SMPTE ST 2113.

If a different display is used as a mastering display, the colour primaries of that display should be indicated using metadata, as defined in 4.6.4.2.

4.5.3 Default nominal peak luminance

The nominal peak luminance of the default reference display shall be 1 000 cd/m^2.

If a different display is used as a mastering display, the nominal peak luminance of that display should be indicated using metadata, as defined in 4.6.4.2

4.5.4 Default black point

The minimum luminance of the default reference display shall be 0,000 5 cd/m^2.

If a different display is used as a mastering display, the minimum luminance of that display should be indicated using metadata, as defined in 4.6.4.2

4.5.5 Default nominal diffuse white luminance

The default nominal diffuse white luminance shall be 203 cd/m^2.

NOTE This nominal luminance value is defined in ITU-R BT.2408-4 as the HDR Reference White.

If the reference nominal diffuse white for specific content has a different displayed luminance, the reference nominal diffuse white for that content should be indicated using metadata, as defined in 4.6.5.

4.6 Metadata

4.6.1 General

This sub clause covers mandatory and optional metadata. The metadata provides information regarding the state and the colorimetry of the image. If different conditions from default settings are used, these conditions should be indicated by corresponding metadata.

When the scene-referred image state is indicated, the scene light conversion will produce scene colorimetry estimates. When colour volume metadata is present, it specifies the reference display for the display light conversion. In the latter case there should be no encoding values outside the indicated colour volume. Both scene-referred and colour volume metadata, or one or the other, or neither may be present.

ISO/IEC 23000-22/Amd.2, Advanced HDR profile provides an example implementation for images stored as MIAF files (Annex C provide details). When the image file is saved in accordance with the ISO/IEC 23000-22 MIAF file format, the metadata defined in this document should be implemented in accordance with ISO/IEC 23000-22/Amd.2 Advanced HDR profile. Specific implementations might differ for other file formats.

4.6.2 Coding-independent code points for video signal type identification: CICP metadata

Image metadata shall include either the coding-independent code points for video signal type identification in accordance with ISO/IEC 23091-2/ITU-T H.273, with the information in Table 4, or an ICC Profile containing a cicpTag.

Table 4 — CICP parameters

Parameter	Informative description
ColourPrimaries	the encoding of colour primaries
TransferCharacteristics	the reference opto-electronic transfer characteristic function,
MatrixCoefficients	the matrix coefficient used for conversion of RGB to other colour representations (i.e. YCbCr, ICtCp)
VideoFullRangeFlag	identifies nominal video signal range quantization (i.e. Narrow Range vs Full Range).

4.6.3 Reference environment metadata

This metadata stores the characteristics of the viewing environment.

If the viewing environment differs from be the reference viewing environment defined in 4.4, it should indicated using metadata.

4.6.4 Colour volume metadata

4.6.4.1 General

When the image has been created for display-viewing, the Mastering Display Colour Volume, as defined in SMPTE ST 2086, should be stored as metadata. The Content Colour Volume and the Content Light Level, as defined in ISO/IEC 23008-2, may also be stored. They provide additional colour gamut information. Alternatively, an equivalent set of metadata could be attached to HDR/WCG still images.

4.6.4.2 Mastering display colour volume (MDCV) metadata

The mastering display colour volume (MDCV) metadata comprises the colour primaries, white point chromaticity, and luminance range (maximum and minimum) of the mastering display.

The MDCV defines the display targeted by the content creator, e.g. camera operator or colourist, based on viewing the resulting image on such a display. MDCV can be leveraged to define the display targeted by automatic image tuning algorithms in the camera image processing pipeline or in post processing software.

ISO/IEC TR 23091-4 specifies a set of commonly used MDCV metadata, also referred to as MDCV descriptions, which are given a system identifier tag.

The default MDCV description shall be P3D65x1000n0005, as defined in ISO/IEC TR 23091-4.

NOTE When using the MDCV description of P3D65x1000n0005, the minimum and peak luminance of the reference display are 0,000 5 cd/m^2 and 1 000 cd/m^2, respectively, and the colour primaries of the reference display correspond to the P3-D65 colour primaries.

4.6.4.3 Content colour volume (CCV) metadata and content light level (CLL)

The content colour volume (CCV) metadata describes the colour volume characteristics of the associated picture.

It comprises the colour primaries, white point chromaticity, and luminance range (maximum, average, and minimum) of the content. Content colour volume metadata could be provided using a mechanism such as the supplemental enhancement information (SEI) message scheme available in several video coding specifications.

CCV indicates the colour volume that the content of the associated image should not exceed, while MDCV indicates the colour volume of the mastering display. CCV is dynamic, and could change for each

frame, while MDCV is static and, in the context of video applications, commonly remains the same for an entire sequence. This information can be leveraged when applying colour conversions or display tone mapping.

The content light level (CLL) metadata may also provide information about the light level of the associated picture.

NOTE An HDR/WCG image might have the MDCV description of P3D65x1000n0005, with no colour outside of the sRGB colour gamut. The CCV metadata of this image could then be the colour volume of sRGB. The CCV metadata can be used during rendering of the content on displays supporting a limited colour gamut, for example an sRGB display.

4.6.5 Diffuse white luminance metadata

The diffuse white luminance metadata stores the luminance value of the reference nominal diffuse white, in cd/m^2.

If the luminance of the diffuse white differs from the default reference display nominal diffuse white luminance defined in 4.5.5, it should be indicated using metadata.

4.6.6 Scene-referred metadata

The scene-referred metadata indicates that image is scene-referred (Annex E provides details). When the scene-referred image state is indicated, scene light conversion will produce scene colorimetry estimates.

In the absence of the scene-referred metadata, all images conforming to this document are created for display viewing.

5 Colour mapping

5.1 General

Displays with various characteristics and in various viewing environments can be used to view HDR/WCG images encoded according to this document. This clause covers colour conversion algorithms recommended to render HDR/WCG images for these displays. Tone mapping algorithms strategies are covered in Annex F.

While ITU-R BT.2100-2 specifies a colour volume based on the ITU-R BT.2020-2 RGB primaries, current HDR displays often have less saturated colour primaries, such as those of P3-D65 (ST 2113).

When images fully utilize the ITU-R BT.2100-2 colour volume, HDR displays might perform a gamut mapping to the display colour volume (Clause 11 of Report ITU-R BT.2390-10 provides details).

Images values can be within a more limited subset, for example if they are optimized for a mastering display.

The information about the subset utilized by the data, can be indicated by metadata such as the Mastering Display Colour Volume (MDCV), the Content Colour Volume Information (ISO/IEC 23008-2), or equivalent metadata. This information can be leveraged by colour management.

5.2 Colour conversions

As described in 4.5.5, while HDR/WCG images are encoded in the ITU-R BT.2100-2 colour space, colour primaries of current HDR displays are often less saturated. Report ITU-R BT.2408-4, A.7.2 describes a colour conversion process from linear and normalized ITU-R BT.2100-2 RGB primaries to the RGB primaries of an arbitrary display system.

Different colour mapping strategies exist to handle colours outside the gamut of the display system. CCV and MDCV metadata might be leveraged to select a mapping strategy.

If an HDR/WCG image is tagged with an MDCV description of P3D65x1000n0005, such information indicates that the image data is expected to be contained within the P3-D65 colour volume.

Then, a display system with P3-D65 capability can sometimes clip to the P3-D65 gamut instead of using other methods of colour gamut mapping that might alter colours within the P3 D65 colour volume.

When showing that same image on a display system with sRGB capability, one might leverage other methods of colour gamut mapping, such as a gamut compression algorithm, to avoid clipping artifacts.

Annex A
(normative)

Extended HDR/WCG colour encoding

A.1 General

In addition to the baseline colour encoding in 4.2.3, the extended colour encoding provide more options. These additional options might be preferred in some editing workflows or some imaging devices.

A.2 Extended colour encoding

Conforming images shall use the following specifications:

Parameter	Value	
Coded signal'	R', G', B' or Y', C'_B, C'_R, or I, C_T, C_P	
Coding format	n = 10, 12, or 16 bits per component	
Quantization of R', G', B', Y', I	Narrow range	Full range
(resulting values that exceed the video data range should be clipped to the video data range)	D = Round [(219 × E' + 16) × 2^{n-8}]	D = Round [(2^n-1) × E']
Quantization of C'_B, C'_R, C_T, C_P (resulting values that exceed the video data range should be clipped to the video data range)	D = Round [(224 × E' + 128) × 2^{n-8}]	D = Round [(2^n-1) × E' + 2^{n-1}]

Images using the Y', C'_B, C'_R signal encoding shall comply with Table 6 in ITU-R BT.2100-2.

NOTE The coding format 16 bits per component, specified in the extended colour encoding, is not specified by ITU-R BT.2100-2.

Annex B
(informative)

ITU-R transfer functions

B.1 General

Properties such as the transfer functions for the hybrid log-gamma (HLG) system and the perceptual quantizer (PQ) system, signal formats, colour sub-sampling, and bit depth information are published in ITU-R BT.2100-2 (07/2018).

In particular, the following tables are highly relevant:

— ITU-R BT.2100-2, Table 4 PQ system reference non-linear transfer functions covers the reference PQ electro-optical transfer function (EOTF), the PQ opto-optical transfer function (OOTF), and the PQ opto-electronic transfer function (OETF).

— ITU-R BT.2100-2, Table 5 Hybrid log-gamma (HLG) system reference non-linear transfer functions covers the reference HLG opto-electronic transfer function (OETF), the HLG opto-optical transfer function (OOTF), and the HLG electro-optical transfer function (EOTF).

— ITU-R BT.2100-2, Table 6 Non-constant luminance Y', C'_B, C'_R signal format covers the derivation of R', G', B', the derivation of Y' and the derivation of colour difference signals.

— ITU-R BT.2100-2, Table 8 Colour sub-sampling covers several colour sub-sampling strategies.

— ITU-R BT.2100-2, Table 9 Digital 10- and 12-bit integer representation covers key encoding parameters and values.

Annex C
(informative)

HDR signalling

C.1 General

HDR signaling properties such as the Recommended colour information for HDR signaling, the Recommended MDCV values for P3 primaries and the Recommended MDCV value for D65 white point are published by ISO in ISO/IEC 23000-22:2019/Amd.2.

In particular, the following tables are highly relevant:

— Table 2 — Recommended colour information for HDR signaling

— Table 3 — Recommended MDCV values for P3 primaries

— Table 4 — Recommended MDCV value for D65 white point

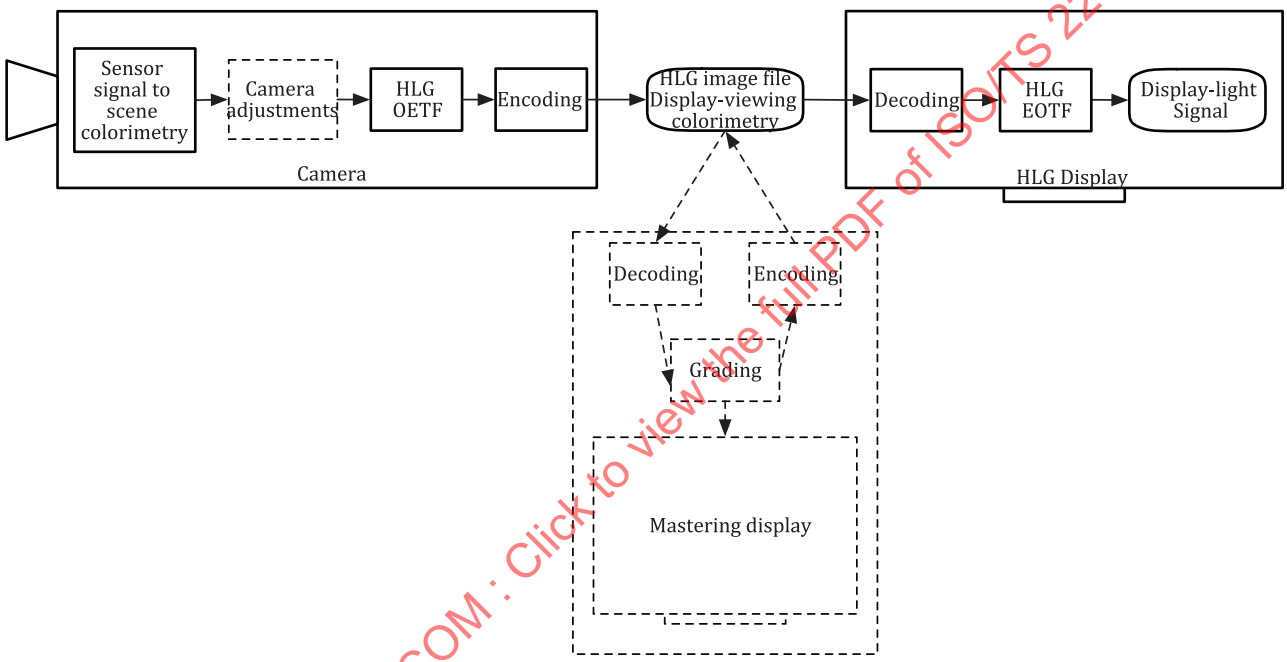
Annex D
(informative)

Workflows for the different transfer functions

D.1 General

The workflows corresponding to the different encoding options are represented in this annex.

D.2 Display-viewing colorimetry Hybrid Log-Gamma (HLG) workflow



D.3 Scene-referred colorimetry Hybrid Log-Gamma (HLG) workflow