ISO TC42 development of ISO TS 22028-5 Colour encodings for HDR still images

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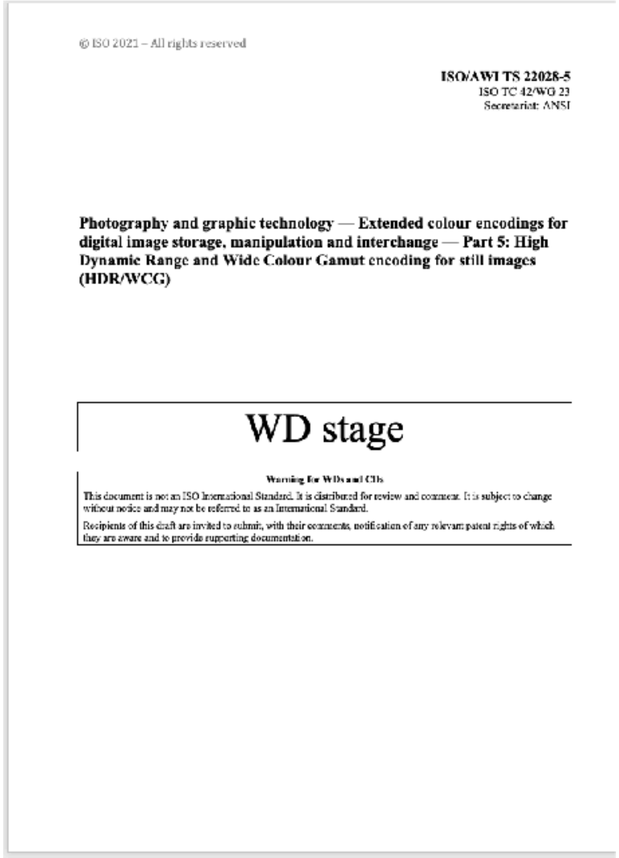
Outline

- Motivation
- ITU HDR workflows
- TS-22028-5 key specifications
- TS-22028-5 metadata
- Current status

HDR file format standardization

ISO/TC 42 Photography

- **New Technical Specification:** *TS 22028-5 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).*
  - Work conducted within the HDR Ad-Hoc Group of the ISO Technical Committee 42, Photography
- **Project Leaders:** Nicolas Bonnier & Paul Hubel (Apple)
- Goals
  - Provide requirements and guidelines for HDR/WCG colour encoding of still images.
  - Meet the industry need for a complete, fully documented, publicly available definition of a high dynamic range (HDR) and wide colour gamut (WCG) image encoding for digital still images.



Motivation

- There is a growing number of HDR/WCG displays (Smartphones, TVs, computer displays) that consumers use in their daily life
- Digital cameras improve over time and capture more and more dynamic range
- Several attempts to use PQ/HLG and BT.2020 for still photography are surfacing
- But so far, the digital still imaging industry has not settled on a reference HDR/WCG image encoding for consumers
- The purpose of TS 22028-5 is to provide requirements and guidelines for HDR/WCG colour encoding of still images
- This colour encoding can be leveraged separately in the specification of HDR/WCG file formats

ITU-R HDR Standardization

Key prior work

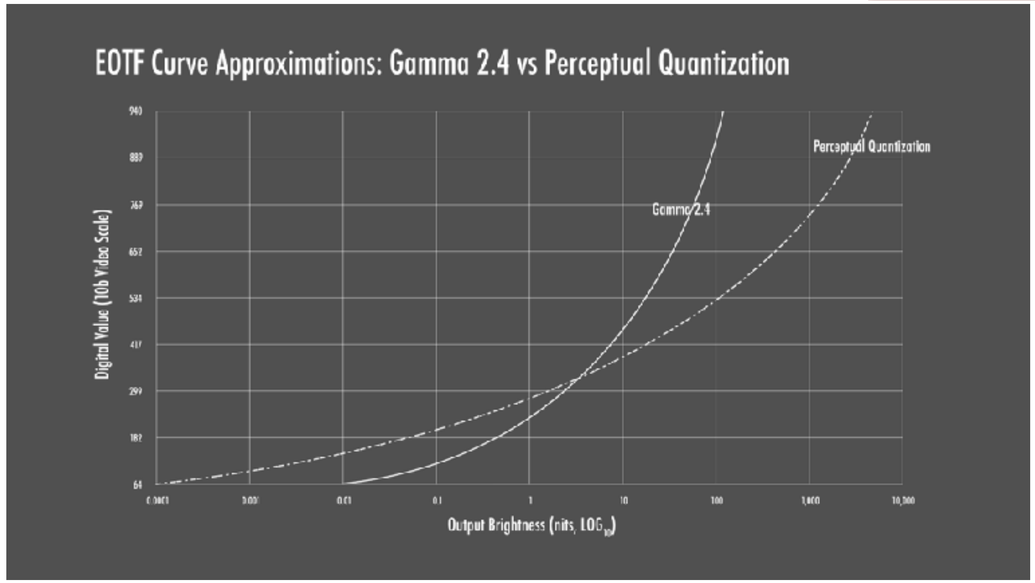
- **ITU-R has published requirements and guidelines for HDR/WCG television production and exchange, the foundation of the blooming HDR/WCG video and HDR/WCG movie ecosystem.**
  - Recommendation ITU-R BT.2020-2 (10/2015): Parameter values for ultra-high definition television systems for production and international programme exchange
  - Recommendation ITU-R BT.2100-2 (07/2018): Image parameter values for high dynamic range television for use in production and international programme exchange
  - Report ITU-R BT.2408-4, Guidance for operational practices in HDR television production
  - Report ITU-R BT.2390-10, High dynamic range television for production and international programme exchange
  - Report ITU-R BT.2446-1, Methods for conversion of high dynamic range content to standard dynamic range content and vice-versa

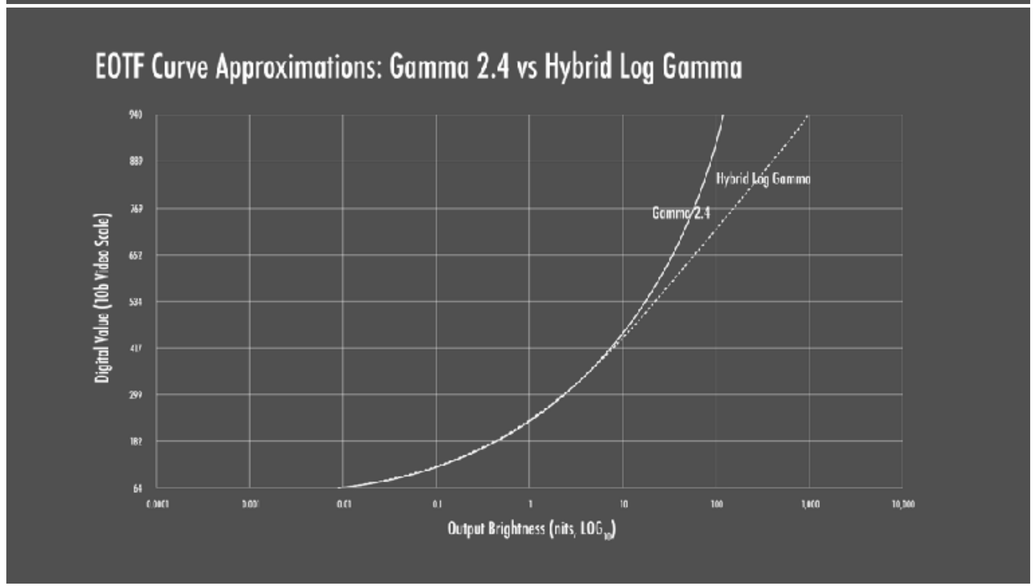
ITU HDR Electro-Optical Transfer Curves

HLG and PQ

- Two EOTF curves have been standardized in ITU-R BT.2100-2
  - Hybrid-Log Gamma (HLG), specified as a scene light signal encoding
  - Perceptual Quantizer (PQ), specified as an absolute colorimetric display-referred encoding

- Better suited for encoding HDR data, both are widely adopted by video HDR/WCG ecosystems



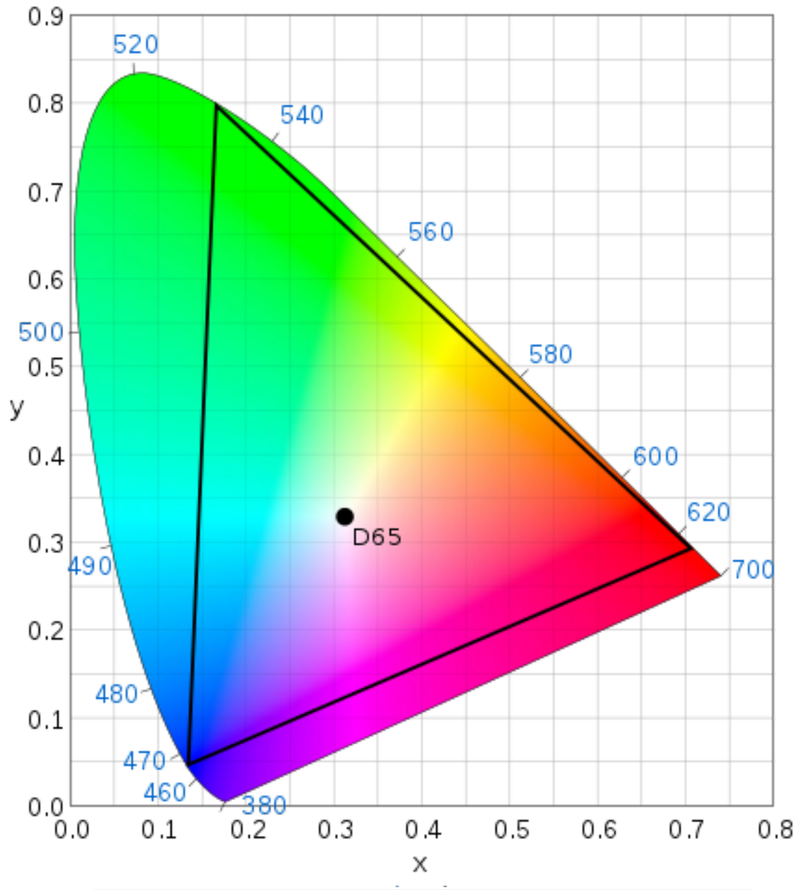


https://www.mysterybox.us/blog/2016/10/19/hdr-video-part-3-hdr-video-terms-explained

ITU Wide Color Gamut

ITU-R BT.2020-2

- A wide color gamut was specified in ITU-R BT.2020-2
- Wider than current displays
- Better suited for data archiving and exchange



Color space	White point		Primaries					
	x_W	y_W	x_R	y_R	x_G	y_G	x_B	y_B
ITU-R BT.2020	0.3127	0.3290	0.708	0.292	0.17	0.797	0.131	0.046

https://en.wikipedia.org/wiki/Rec._2020

ISO TS 22028-5 Key specifications

- The image signal will have properties that follow or conform to the ITU-R BT2100-2 recommendations for interchange considerations

Transfer functions	Shall use either the HLG transfer function or the PQ transfer function
Color encoding	Shall use ITU-R BT.2020/2100-2 colour primaries, RGB or YCbCr non constant luminance representations
Signal range	Narrow range and full range representations might be used

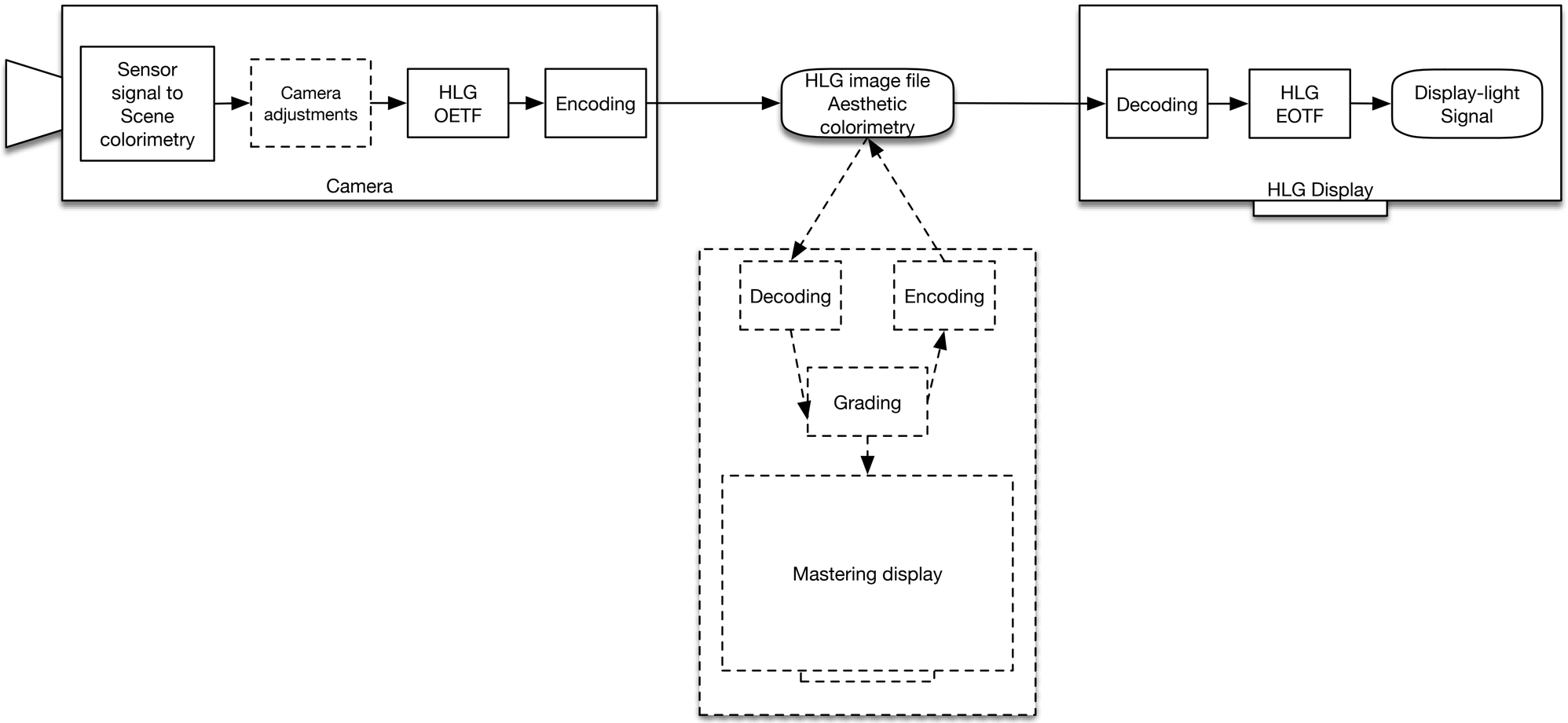
TS 22028-5 | Hybrid Log-Gamma (HLG) workflow

- Artistic intent
  - The HLG transfer functions are designed to produce pleasing images on HDR/WCG displays (the default artistic intent).
  - Scene linear light captured by the camera is adjusted to produce a desired image appearance when viewed on a display.
  - The resulting linear light colorimetry is encoded using the reference HLG opto-electronic transfer function (OETF).
  - The HLG electro-optical transfer function (EOTF) is recommended to map the HLG signal into display light.

- Scene colorimetry intent
  - In cases where the intent is to communicate the scene colorimetry.
  - The reference HLG opto-electronic transfer function (OETF) shall be used to directly map the scene linear light to non-linear HLG signal values, without adjustments.
  - 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.
  - The scene colorimetry intent should be indicated by using scene-colorimetry metadata.

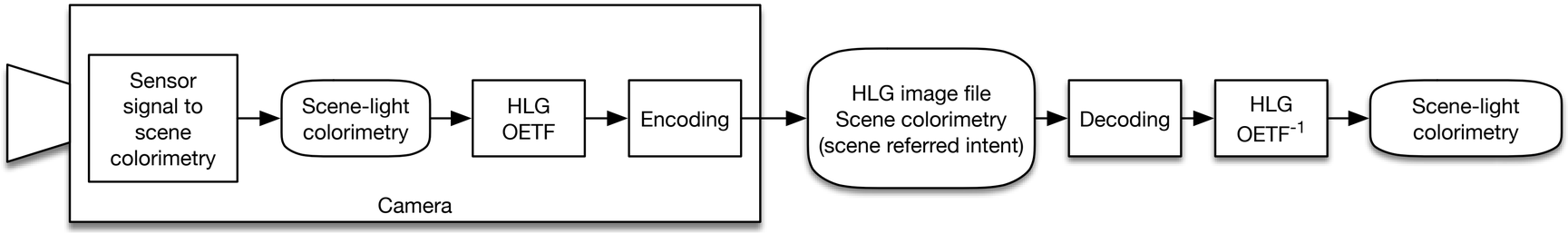
TS 22028-5 | Artistic Colorimetry Hybrid Log-Gamma (HLG) workflow

Artistic intent: use cases where the image rendering goal is to produce pleasing images on an HDR display, using an OOTF and including any creative intent.



TS 22028-5 | Scene Colorimetry Hybrid Log-Gamma (HLG) workflow

Scene colorimetric intent: use cases where the image is intended to represent estimated scene colorimetry.

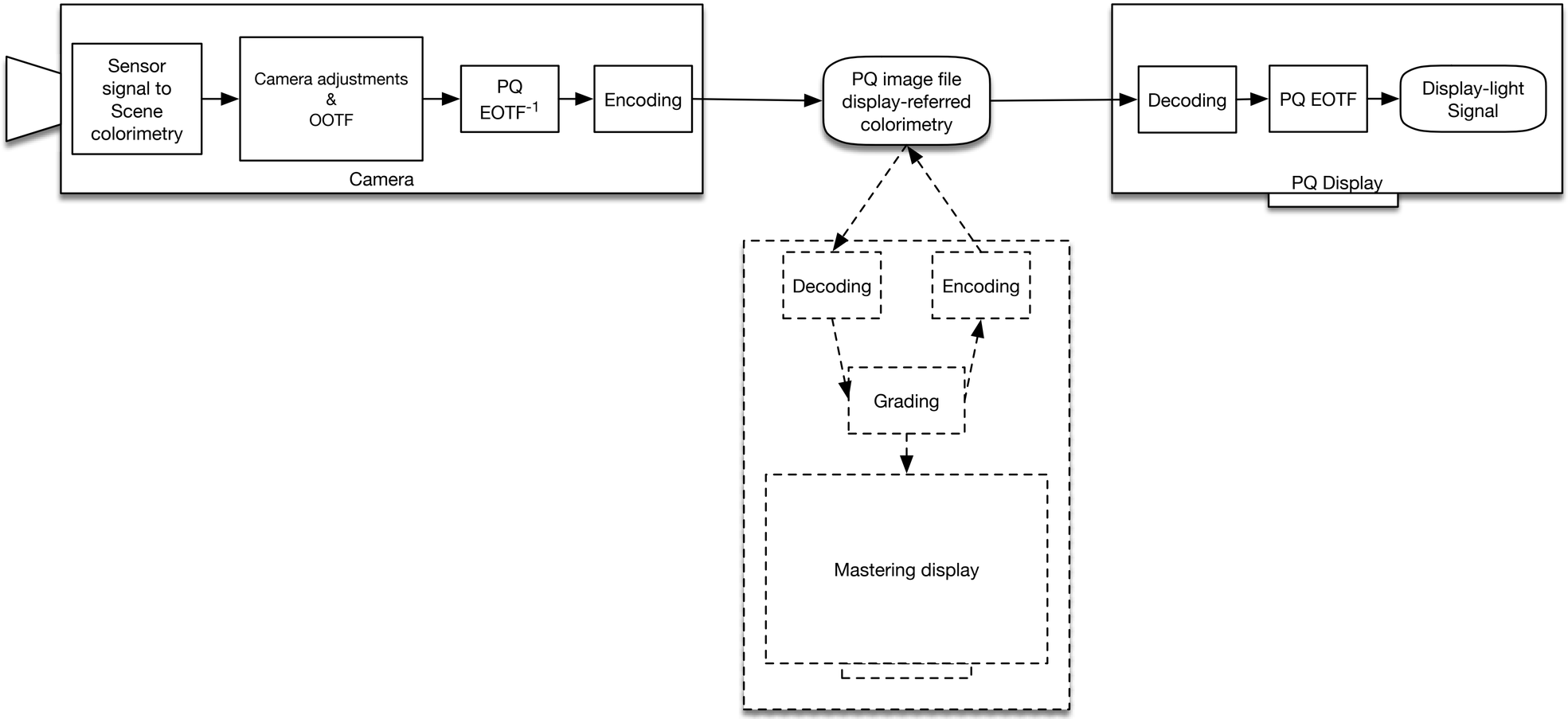


For use in applications where unadjusted scene colorimetry is needed, such as:

- digital archiving
- compositing
- some types of medical imaging
- machine vision

TS 22028-5 | Perceptual Quantizer (PQ) workflow

The image rendering goal is to produce pleasing images on an HDR display



TS 22028-5 | Reference environment

- This table specifies parameters to establish a reference viewing environment in which images conforming to this document are intended to be viewed.
- This reference viewing environment is identical to the environment specified in ITU-R BT.2100-2.

Parameter	Values
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.

TS 22028-5 | Reference display

- A default reference display is specified.
- It provides a default context for interpreting the intended colour appearance of the encoded image colorimetry.

Parameter	Values
Default nominal peak luminance	1 000 cd/m2
Default black point	0.0005 cd/m^2
Default nominal diffuse white luminance	203 cd/m^2
Default reference color volume	ITU-R BT.2020-2 RGB

TS 22028-5 | Metadata

- Required metadata to maximize compatibility
- Optional metadata to convey the intended interpretation of the images

Required	• Coding-independent code points for video signal type identification (CICP), or ICC profile

Optional	• Mastering Display Colour Volume (MDCV)
	• Content Colour Volume (CCV) metadata and Colour Light Level (CLL)
	• HLG intent:
	  • Artistic intent: use cases where the image rendering goal is to produce a desired colour appearance
	  • Scene colorimetric intent: use cases where the image is intended to represent estimated scene colorimetry

TS 22028-5 | CICP: Coding-independent code points

- ISO/IEC TR 23091-2:2019, ITU-T H.273, Information technology — Coding-independent code points — Part 2: Video

- **ColourPrimaries**: the encoding of colour primaries,
- **TransferCharacteristics**: the reference opto-electronic transfer characteristic function,
- **MatrixCoefficients**: the matrix coefficient used in deriving luma and chroma signal,
- **FullRangeFlag**: the video range.

TS 22028-5 | Mastering Display Colour Volume (MDCV)

- Optional 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 might 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 MDCV description of P3D65x1000n0005 is the recommended MDCV description.
  - When using an MDCV description of P3D65x1000n0005, the minimum and peak luminance of the reference display should be 0.0005 cd/m2 and 1 000 cd/m2, respectively, and the colour primaries of the reference display should correspond to those of the P3-D65 colour volume.

TS 22028-5 | Content Colour Volume and Colour Light Level

- Optional metadata

  - 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 Colour Light level (CLL) metadata may also be used to 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.

TS 22028-5 | Metadata and Gamut Mapping

- 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.
- The preferred metadata is the one associated with the MDCV description of P3D65x1000n0005.
- If an HDR/WCG image is tagged with an MDCV description of P3D65x1000n0005, such information indicates that the image data is expected to be constrained within the P3-D65 colour volume.
- Then, a display system with P3-D65 capability can safely 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.
- Alternatively, 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.

TS 22028-5 | Metadata for specific file formats

- When the image file is saved in accordance with the ISO/IEC 23000-22:2019 MIAF file format, the metadata defined in this document should be implemented in accordance with ISO/IEC 23000-22 AMD2 Advanced HDR profile.
- Metadata for other file formats is still to be determined at this stage.

TS 22028-5 | Current status and brief history of this effort

Fall 2019	• Initial proposal submitted at the Koln ISO TC 42 meeting
Fall 2020	• Ballot for new ISO project passed, project approved as a Working Draft stage. Expected completion within 36 months
Fall 2021	• Project leaders reach out to other key standardization bodies, to inform them and seek feedback
Winter 2021	• ISO and ITU converging on naming conventions and metadata, to maximize compatibility between HDR photos and HDR videos
Spring 2022	**• Getting ready to initiate a Committee Internal Ballot, to seek feedback from experts and liaison standardization bodies**

Thank you!

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