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| *Title:* | **Indication of SMPTE 2084 and 2085 and carriage of 2086 metadata in HEVC** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

The contribution proposes text changes in the HEVC specification to support metadata indicators for three SMPTE standards and the direct coding of XYZ. In Annex E, video usability information (VUI) changes are proposed for: (1) indication of SMPTE ST 428-1 (CIE XYZ in Digital Cinema) with a new colour\_primaries Table E-3 entry; (2) indication of SMPTE ST 2084 (Electro-Optical Transfer Function for High Dynamic Range Reference Displays) with a new transfer\_characteristcs Table E-4 entry; and (3) indication of direct XYZ (YZX in planar order) with a new matrix\_coeffs Table E-5 entry. In Annex D, a new SEI in is proposed for carriage of SMPTE ST 2086 (Mastering Display Color Volume Metadata for High Luminance and Wide Color Gamut Images) metadata. Support for all four metadata are independent of each other.

# Introduction

Following the additions of the recent proposal [1] to add Rec. 2020 [2] VUI indicators to HEVC, the proposed text included in section 2 of this proposal supports SMPTE ST 2084 [3], and SMPTE ST 2086 [4] in Annex E. Change text is made with respect to version 3 of the latest HEVC editor’s draft [5]. Testing of encoding configurations that would be indicated by various combinations of this metadata is provided in [6][7][8].

## Suggested use

An HEVC coded bitstream with an EOTF specified in SMPTE ST 2084 (signalled by the proposed transfer\_characteristcis=16) should have BitDepth >= 10 for all sample component planes.

Bitstreams encoding video in the XYZ would be expected to set color\_primaries = 10 (SMPTE 428-1 XYZ), with the matrix\_coeffs=11 for YZX (in planar order).

Similar to direct RGB (a.k.a. GBR in planar order), which can already be signalled by matrix\_coeffs=0, a directly coded XYZ bitstream (indicated by the combination of color\_primaries==10 and matrix\_coeffs=11) could utilize the cross-component residual prediction (CCP) RExt tool activated by PPS element luma\_chroma\_prediction\_enabled\_flag=1, as described in:

1. RExt test model [10] section 4.8
2. RExt draft [6] section 7.4.9.12 (Luma-chroma prediction semantics)
3. RExt draft [6] section 8.6.6 (Residual modification process for transform blocks using luma-chroma prediction)
4. “Experiment 2” from its original proposal [10].

# Proposed Text

Only the most relevant sections from Annex E [5] are copied herein for reader convenience.. A companion document to this proposal, located in the same .zip archive as this document, is provided (JCTVC-O1005\_v3\_AnnexE\_with\_SMPTE\_2084\_and\_2085\_r1.docx) that shows these proposed additions as tracked changes in the full context of annex E copied from the most recent editor’s HEVC draft specification.

The proposed Annex D SEI for carriage of SMPTE ST 2086 is provided in section 2.3 below. Since the text of the SEI is isolated, no companion document is necessary.

## SMPTE ST 2084 (EOTF)

Add the following entry (#16) to Table E-4 (Transfer Characteristics)

|  |  |  |
| --- | --- | --- |
| 16 | , where 0 ≤ C ≤ 10000  C is absolute luminance value, represented in candelas per square meter (cd/m2) | Society of Motion Picture and Television Engineers ST 2084 for 10, 12, 14, and 16-bit systems. |

## XYZ

The following entry (#10) to Table E-3 (Color primaries) indicates XYZ primaries:

|  |  |  |
| --- | --- | --- |
| 10 | primary x y  Y 0.0 1.0  Z 0.0 0.0  X 1.0 0.0  center white 0.333 0.333 | Society of Motion Picture and Television Engineers ST 428-1  (CIE 1931 XYZ , Digital Cinema) |

[ Equations E-43 through E-48 are added to support the Table E-5 matrix\_coeffs entries. ]

The variables EX, EY, and EZ are defined as "linear-domain" real-valued signals based on the indicated colour primaries before application of the transfer characteristics function. The application of the transfer characteristics function is denoted by ( x )′ for an argument x. The signals E′X, E′Y, and E′Z are determined by application of the transfer characteristics function as follows:

E′X = ( EX )′ (E‑43)

E′Y = ( EY )′ (E‑44)

E′Z = ( EZ )′ (E‑45)

E′X, E′Y, and E′Z are real numbers with values in the range of 0 to 1 inclusive.

– If matrix\_coeffs is equal to 11, the following equations apply:

Y = Round( ) (E‑46)

Cb = Round( ) (E‑47)

Cr = Round( ) (E‑48)

YZX (planar order) indication entry for Table E-5 (Matrix coefficients):

|  |  |  |
| --- | --- | --- |
| 11 | YZX | CIE 1931 See Equations E-43 to E-45 |

## SMPTE 2086 (Mastering Display Color Volume)

D.2.29 Mastering display color volume SEI message syntax

|  |  |
| --- | --- |
| mastering\_display\_color\_volume( payloadSize ) { | Descriptor |
| for( c = 0; c< 3; c++) { |  |
| **display\_primaries\_x** [ c ] | u(16) |
| **display\_primaries\_y** [ c ] | u(16) |
| } |  |
| **white\_point\_x** | u(16) |
| **white\_point\_y** | u(16) |
| **max\_display\_mastering\_luminance** | u(32) |
| **min\_display\_mastering\_luminance** | u(32) |
| } |  |

D.3.29 Mastering display color volume SEI message semantics

This SEI message provides metadata for specifying the color volume (the color primaries, white point, and luminance range) of the display that was used in mastering video content of the output picture colour samples. The metadata is specified as a set of values independent of any specific digital representation, and is applicable to three-color additive display systems. The mastering display is a three-color additive display and projection system that has been configured to the mastering color volume.

This metadata does not specify the measurement methodologies and procedures for capturing the parameters of the metadata as well as any description of the mastering environment. Additionally, this metadata does not specify any information on the color transformations that would be necessary to preserve the creative intent on displays with color volumes different from the mastering display color volume.

The mastering\_display\_color\_volume metdata persists in output order until any of the following conditions are true:

– A new CVS begins.

– A picture in an access unit containing a tone mapping information SEI message with the same value of tone\_map\_id is output having PicOrderCntVal greater than PicOrderCnt( CurrPic ).

The following elements given in CIE xy-coordinates (display\_primaries\_x[c], display\_primaries\_y[c], white\_point\_x, white\_point\_y), are derived by scaling and quantizing the traditional fractional unsigned values between 1.0 and 0 to a 16-bit unsigned integer (u(16)) signalled in the mastering\_display\_color\_volume SEI:

quantized\_CE\_xy\_coordinate = Round(( CIE\_fractional\_xy\_coordinate \* 216 ) -1 )

**display\_primaries\_x[c]** specifies the quantized CIE x-coordinate of the mastering display target primary color c.

**display\_primaries\_y**[c] specifies the quantized CIE y-coordinate of the mastering display target primary color c.

The combined xy display primaries coordinate represents the ratio of each CIE Y (c=0), Z (c=1), and X (c=2) tristimulus value to the sum of the tristimulus values as specified in CIE 15:2004 “Calculation of chromaticity coordinates”.

**white\_point\_x** specifies the quantized CIE chromatictiy x-coordinate of the mastering display target white point.

**white\_point\_y** specifies the quantized CIE chromatictiy y-coordinate of the mastering display target white point.

**max\_display\_mastering\_luminance** specifies the target maximum luminance of the mastering display in units of candela per square metre.

**min\_display\_mastering\_luminance** specifies the target minimum luminance of the mastering display in units of candela per square metre.

When present, max\_display\_mastering\_luminance shall be greater than or equal to min\_display\_mastering\_luminance.

# References

[1] T. Suzuki, “Proposal to support UHDTV colorimetory”, [JCTVC-J0577](http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=6457), 10th meeting of JCTVC, Stockholm, Sweden, 11-20 July 2012.

[2] ITU-R [BT.2020](http://www.itu.int/rec/R-REC-BT.2020/en) (2012), *Parameter Values for ultra-high definition television systems for production and internal programme exchange*

[3] Society of Motion Picture and Television Engineers ST 2085 (2014), *Electro-Optical Transfer Function for High Dynamic Range Reference Display*.

[4] Society of Motion Picture and Television Engineers ST 2086 (2014), *Mastering Display Color Volume Metadata for High Luminance and Wide Color Gamut Images*.

[5] D. Flynn, J. Sole, G.J. Sullivan, T. Suzuki, “HEVC Range Extension Draft 5”, [JCTVC-O1005](http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=8525), 17 December 2013.

[6] B. Mandel, C. Fogg, J. Helman, “High dynamic range video coding results,” [JCTVC-O0101](http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=8213), 15th Meeting: Geneva, CH, 23 Oct. – 1 Nov. 2013.

[7] P. Yin, T. Lu, “Cross-check Report for JCTVC-O0101 on High Dynamic Range Video Coding Results,” [JCTVC-O0366](http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=8509).

[8] B. Mandel, C. Fogg, J. Helman, “HDR simulation results for FruitStall and Oblivion test sequences”, JCTVC-Pxxxx., 16th Meeting: San José, US, 9–17 Jan. 2014.

[9] N. Naccari, C. Rosewarne, G. Sullivan, “HEVC Range extensions test model 1 encoder description”, [JCTVC-O1013](http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=8520), 15th Meeting: Geneva, CH, 23 Oct. – 1 Nov. 2013.

[10] W. Pu, W-S. Kim, J. Chen, J. Sole, M. Karczewicz, “RCE1: Descriptions and Results for Experiments 1, 2, 3, and 4”, [JCTVC-O0202](http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=8320), 15th Meeting: Geneva, CH, 23 Oct. – 1 Nov. 2013

# Patent rights declaration(s)

**Movielabs, and Harmonic do not have any current or pending patent rights relating to the technology described in this contribution.**