



# ***JCTVC-Z0028***

## ***AHG 7: On Content Colour Volume***

### ***SEI message***

Jan. 2017

Dolby Laboratories

# Outline

- Background of content colour volume (CCV) SEI
  - JCTVC-Y1005: draft text includes a minimal set of CCV SEI message.
- Our proposal
  - Add one additional syntax: average luminance value
- Syntax and semantics
- Verification test
- Conclusion

# Background

- JCTVC-Y1005: draft text for Content Colour Volume (CCV) SEI message
  - Includes the minimal set of metadata:
    - Three colour primaries expressed in CIE1931 (x, y, Y) colour representation
    - Minimum and maximum luminance
  - Other metadata needs to be verified by their benefit.
- Our proposal:
  - Add one more syntax: average luminance value
  - Verification test is performed to illustrate its benefit for colour volume mapping.

# Syntax and Semantics

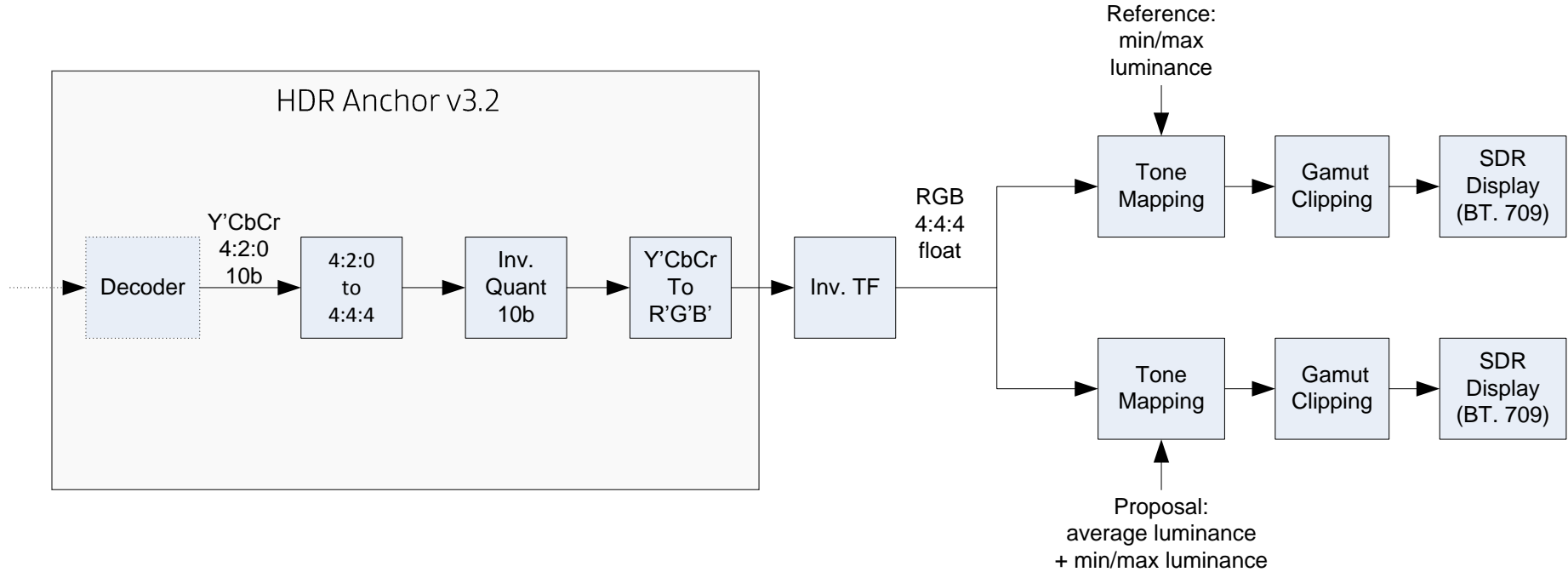
**ccv\_avg\_lum\_value** specifies the normalized average luminance value, according to CIE 1931, that is expected to be present in the content, where values are normalized to  $L_0$  or  $L_c$  as specified in Table E.4 and according to the transfer characteristics of the signal. The values of **ccv\_avg\_lum\_value** are in normalized increments of 0.00000001 in the linear representation.

	Descriptor
content_colour_volume( payloadSize ) {	
<b>ccv_cancel_flag</b>	u(1)
if( !ccv_cancel_flag ) {	
<b>ccv_persistence_flag</b>	u(1)
for( c = 0; c < 3; c++ ) {	
<b>ccv primaries_x</b> [ c ]	i(16)
<b>ccv primaries_y</b> [ c ]	i(16)
}	
<b>ccv_min_lum_value</b>	u(32)
<b>ccv_avg_lum_value</b>	u(32)
<b>ccv_max_lum_value</b>	u(32)
}	
}	

# Verification Test

- Colour volume mapping is used to show benefit of average luminance in addition of minimal set.
  - Importance of average luminance information for display mapping or colour volume mapping is known:
    - ST 2094 Applications #1, #2 and #4, which apply parametric mapping model, all use average luminance information in some variance.
  - Colour volume mapping can be roughly split into two parts: tone mapping and gamut mapping.
    - Tone mapping: luminance Transform Curve in Annex B.2 of ST 2094-10
    - Gamut mapping: colour/gamut clipping.

# Verification Test Diagram



# Tone Mapping Algorithm: Sigmoid Tone Curve in ST2094-10

$$L_m(L) = \left( \frac{c_1 + c_2 \times L}{1 + c_3 \times L} \right)$$

$L_m$  = mapped (transformed) luminance in units of cd/m<sup>2</sup>

$L$  = input luminance in units of cd/m<sup>2</sup>

$c_1, c_2, c_3$  = computed coefficients

$x_1$  = input image essence minimum luminance value in units of cd/m<sup>2</sup>

$x_2$  = input image essence average luminance value in units of cd/m<sup>2</sup>

$x_3$  = input image essence maximum luminance value in units of cd/m<sup>2</sup>

$y_1$  = targeted system display minimum luminance in units of cd/m<sup>2</sup>

$y_2$  = derived targeted system display adaptation point in units of cd/m<sup>2</sup>

$y_3$  = targeted system display maximum luminance in units of cd/m<sup>2</sup>

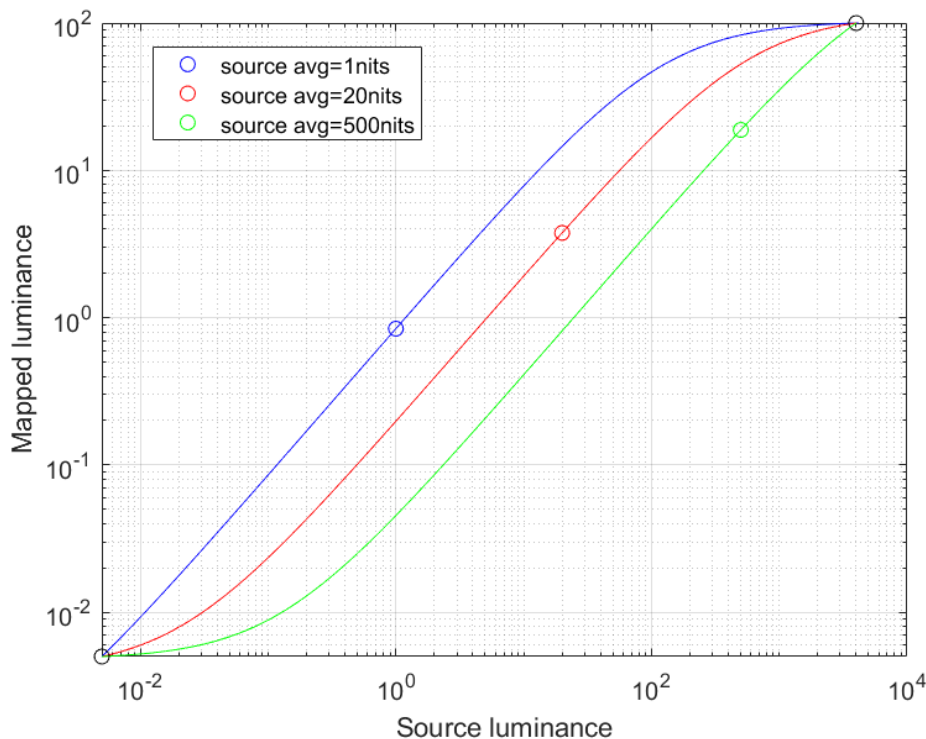
$$y_2 = \sqrt{x_2 \times \sqrt{y_3 \times y_1}}$$

$$\begin{pmatrix} c_1 \\ c_2 \\ c_3 \end{pmatrix} = \frac{1}{\alpha} \begin{pmatrix} x_2 x_3 (y_2 - y_3) & x_1 x_3 (y_3 - y_1) & x_1 x_2 (y_1 - y_2) \\ x_3 y_3 - x_2 y_2 & x_1 y_1 - x_3 y_3 & x_2 y_2 - x_1 y_1 \\ x_3 - x_2 & x_1 - x_3 & x_2 - x_1 \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix}$$

$$\alpha = x_3 y_3 (x_1 - x_2) + x_2 y_2 (x_3 - x_1) + x_1 y_1 (x_2 - x_3)$$

# Example Tone Mapping Curve:

(source max = 4000nits, source min = 0.005 nits, target max = 100 nits, target min = 0.005nits)



- Three content, which have the same content min/max luminance value but different average luminance value, result significant different tone mapping curves.
- It shows average luminance value is crucial to tone mapping.



# Test Set-Up

- Colour volume mapping: map 4000 nits P3D65 content to SDR 100nits BT. 709
- **Two references:** using min/max luminance value for tone mapping
  - Reference 1: linear tone mapping

$$L_m(L) = c_1 \times (L - x_1) + c_2$$

$$c_1 = (y_3 - y_1) / (x_3 - x_1)$$

$$c_2 = y_1$$

- Reference 2: ST 2094-10 sigmoid tone mapping
    - Average luminance is derived as:  $x_2 = (x_1 + x_3) / 2$ .
- **Proposed test:** using min/max + average luminance value for tone mapping
  - ST 2094-10 sigmoid tone mapping

# Test Set-Up

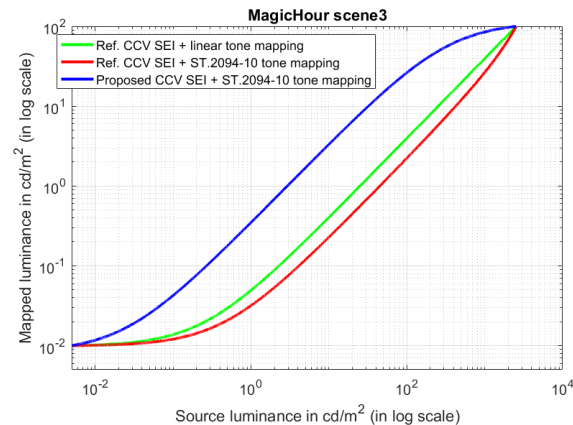
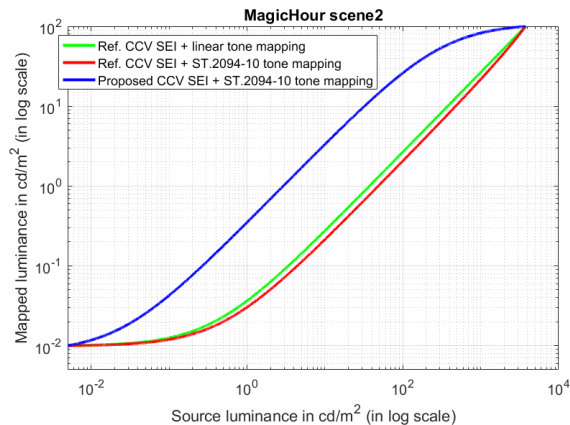
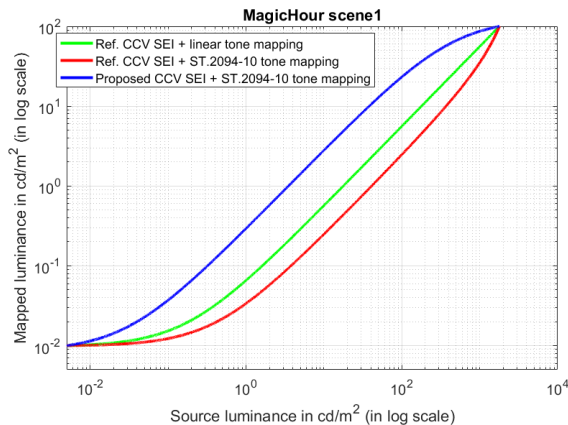
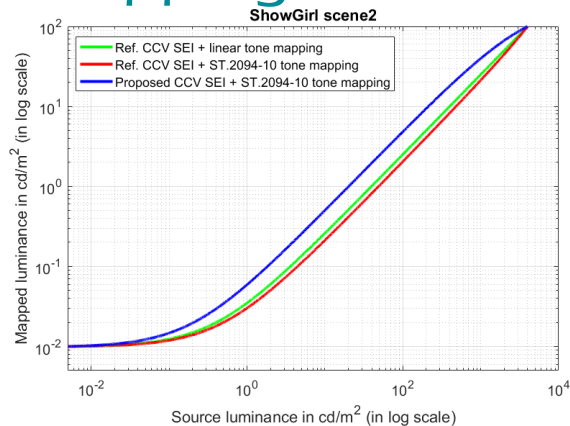
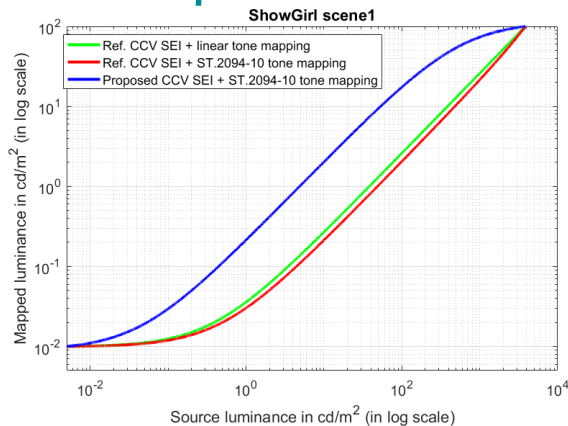
- Anchor 3.2 compression results are used as input to perform colour volume mapping.
- Tone mapping is performed at per-scene basis to avoid temporal fluctuation.
- Two clips: “ShowGirl” and “StEM\_MagicHour” in JCTVC HDR CTC
  - Contain multiple scene changes and have very dark and bright scenes.
  - Can represent very realistic content to test colour volume mapping.

# Scene Statistics

- Scene based content luminance statistics
  - Average luminance value is highly content dependent
  - Hard to derive average luminance value from min/max luminance value

Content	min lum	max lum	avg. lum	(min+max)/2
ShowGirl_scene1	0.00	3863.14	26.16	1931.57
ShowGirl_scene2	0.00	3995.94	521.74	1997.97
MagicHour_scene1	0.00	1791.30	12.56	895.65
MagicHour_scene2	0.00	3767.13	8.50	1883.57
MagicHour_scene3	0.00	2530.98	9.16	1265.49

# Comparison of Tone Mapping Curves



## Colour Volume Mapped Image (ShowGirl QP=19)

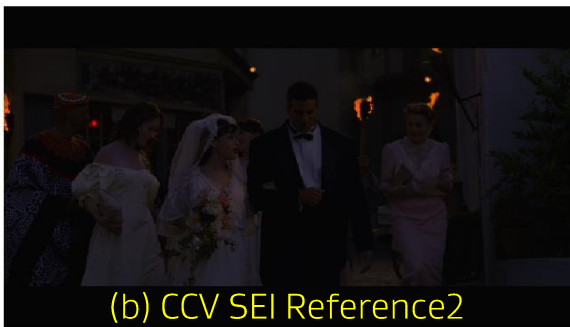
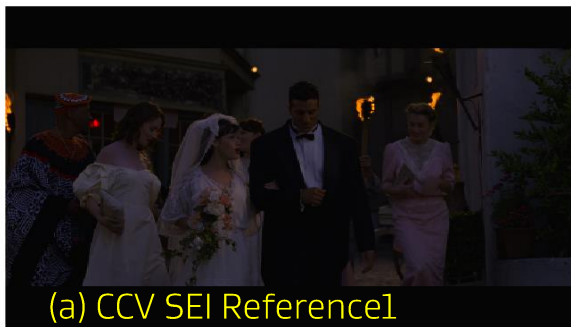


(a) CCV SEI Reference1

(b) CCV SEI Reference2

(c) CCV SEI Proposed

# Colour Volume Mapped Image (MagicHour QP=19)



(a) CCV SEI Reference1

(b) CCV SEI Reference2

(c) CCV SEI Proposed

# Conclusion

- The quality of mapped images are reasonable for all tested scenes with proposed CCV SEI including average luminance value.
  - Without real content average luminance, the mapped image quality can become unacceptable.
- The benefit of adding signalling of average luminance value is justified by colour volume mapping.
- Propose to adopt syntax of average luminance value in CCV SEI message.





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# LetterBox or CroppingWindow

- LetterBox can impact luminance statistics.
- Propose to add the following notes as in CLL SEI message:
  - NOTE – When the visually relevant region does not correspond to the entire cropped decoded picture, such as for "letterbox" encoding of video content with a wide picture aspect ratio within a taller cropped decoded picture, the indicated average should be performed only within the visually relevant region.