ATSC Candidate Standard: A/341 Amendment – SL-HDR1

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Advanced Television Systems Committee
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The Advanced Television Systems Committee, Inc., is an international, non-profit organization developing voluntary standards for digital television. The ATSC member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

Specifically, ATSC is working to coordinate television standards among different communications media focusing on digital television, interactive systems, and broadband multimedia communications. ATSC is also developing digital television implementation strategies and presenting educational seminars on the ATSC standards.

ATSC was formed in 1982 by the member organizations of the Joint Committee on InterSociety Coordination (JCIC): the Electronic Industries Association (EIA), the Institute of Electrical and Electronic Engineers (IEEE), the National Association of Broadcasters (NAB), the National Cable Telecommunications Association (NCTA), and the Society of Motion Picture and Television Engineers (SMPTE). Currently, there are approximately 150 members representing the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

ATSC Digital TV Standards include digital high definition television (HDTV), standard definition television (SDTV), data broadcasting, multichannel surround-sound audio, and satellite direct-to-home broadcasting.

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This specification is being put forth as a Candidate Standard by the TG3/S34 Specialist Group. This document is an editorial revision of the Working Draft S34-268r0 dated 10 February 2017. All ATSC members and non-members are encouraged to review and implement this specification and return comments to cs-editor@atsc.org. ATSC Members can also send comments directly to the TG3/S34 Specialist Group. This specification is expected to progress to Proposed Standard after its Candidate Standard period.

Revision History

Version	Date
Candidate Standard approved	21 August 2017
Revision 1 approved	Insert date here

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ATSC Candidate Standard:
A/341 Amendment – SL-HDR1

1. OVERVIEW

This document describes constraints and usage of ETSI TS 103 433 (SL-HDR1) SEI messages for enabling delivery of SDR-to-HDR dynamic SEI messages along with an SDR stream in ATSC 3.0 video services. If approved by the ATSC, A/341:2017, "Video–HEVC," would be amended according to the edits described herein.

2. CHANGES TO A/341

In this document, "[ref]" indicates that a cross reference to a cited reference document that is listed in A/341 would be inserted. Actual cross references indicate that the reference is to a document that would be added to the A/341 references section as described below.

Change instructions are given below in italics. Unless otherwise noted, inserted text, tables, and drawings are shown in blue; deletions are shown in ~~red strikeout~~.

2.1 Add the following Normative Reference to A/341

[1] ETSI: "High-Performance Single Layer Directly Standard Dynamic Range (SDR) Compatible High Dynamic Range (HDR) System for use in Consumer Electronics devices (SL-HDR1)," Doc. ETSI TS 103 433 V1.1.1 (2016-08), European Telecommunications Standards Institute, Sophia Antipolis Cedex – FRANCE.

2.2 Add the following acronym to A/341 Section 3.3 "Acronyms and Abbreviations

SL-HDR1 – Single Layer High Dynamic Range version 1

2.3 Add the following text to Section 6.3.2.1"SDR Transfer Characteristics"

Video with SDR transfer characteristics may contain Single Layer High Dynamic Range (SL-HDR1) SEI messages as described in Section 6.3.2.1.x.

2.4 Add a new subsection under Section 6.3.2.1 titled "SDR Transfer Characteristics"

(The following inserted text is not shown in markup to preserve readability.)

Section 6.3.2.1.x SL-HDR1 SEI Messages

The SL-HDR1 SEI messages allow reconstructing HDR video from the SDR video. As a result, a video stream containing SL-HDR1 SEI messages provides both an SDR picture and an HDR picture. The reconstructed HDR video can be represented as linear light or using any of the available HDR transfer functions listed in these specifications.

> Note (informative): typical usage of SL-HDR1 goes as follows. First, at the distribution encoder, HDR video is broken down into SDR video plus SL-HDR1 SEI messages; then, the SDR video is compressed and the SL-HDR1 SEI messages are embedded in the video stream using SEI messages. At the receiver end, an SDR-only receiver decodes the stream, ignoring the SL-HDR1 SEI messages, and therefore outputs SDR video; an HDR receiver with SL-HDR1

decodes the same SDR stream, then uses the SL-HDR1 SEI messages to reconstruct the HDR video.

The following SEI messages shall be embedded in an ATSC 3.0 HEVC stream:

- "user data registered by Recommendation ITU-T T.35" SEI message carrying the ts_103_433_info payload representing the "ETSI TS 103 433 Information" SEI message, as specified in clause A.2 of the ETSI TS 103 433 [1] specification.
- "user data registered by Recommendation ITU-T T.35" SEI message carrying the colour_volume_reconstruction_info payload representing the "Colour Volume Reconstruction Information" SEI message, as specified in clause A.4.2 of the ETSI TS 103 433 [1] specification.

The following SEI messages should be embedded in an ATSC 3.0 HEVC stream:

- Mastering Display Colour Volume SEI message [ref].[1]

In addition to the constraints in Section 6.3.2.1, streams with SL-HDR1 SEI messages shall comply with the following:

- The above three SEI messages shall be transmitted at least at each IRAP.
- When HEVC Spatial Scalable Coding is employed, the SL-HDR1 SEI messages NAL units shall have nuh_layer_id equal to 0.
- When Temporal Layering is applied, the SEI messages shall be inserted in the sub-layer representation with TemporalId equal to 0.
- Constraints specific to the "ETSI TS 103 433 Information" SEI message:
  - The syntax element ts_103_433_spec_version shall be set to 0.
  - The syntax element to ts_103_433_payload_mode shall be set to 0. This constrains to the parameter-based mode of ETSI TS 103 433.
- Constraints specific to the Mastering Display Colour Volume SEI message:
  - A valid number shall be set for the following syntax elements: display_primaries_x[c], display_primaries_y[c], white_point_x, white_point_y, and max_display_mastering_luminance.
  - It is recommended to set a valid number for min_display_mastering_luminance syntax element. If the proper value for this syntax element is unknown, it is recommended that min_display_mastering_luminance is set to 0.
- Constraints specific to the "Colour Volume Reconstruction Information" SEI message:
  - The syntax element cv_rec_target_info_flag shall be set to “1”. This indicates that cv_rec_primaries, cv_rec_matrix_coefficients are present.
  - cv_rec_primaries shall be set to 9. This indicates BT.2020 primaries.
  - cv_rec_matrix_coefficients shall be set to 9. This indicates Y’CbCr BT.2020 NCL system.

Note (informative): at the decoder, the presence of the "ETSI TS 103 433 Information" SEI message identifies the content as HDR compatible. Additional signalling may be required at the transport layer to indicate that the service if both HDR and SDR compatible.

HDR receivers receiving a video stream with SL-HDR1 SEI messages shall reconstruct the HDR picture following TS 103 433 [1]. As indicated in [ref] Section 5, when the SDR video and

[1] In the case that the MDCV SEI message is not present, the default peak luminance value of 1000 nit should be used, as recommended by the UHD Forum Guidelines.

the reconstructed HDR video do not have the same color space, an invertible gamut mapping may be used. Annex [ref] describes the gamut mapping and inverse gamut mapping methods that should be used.

2.5 Add a new annex at the end of the A/341 document

(The following inserted text is not shown in markup to preserve readability.)

Annex [X] Invertible Gamut Mapping

[X].1 OVERVIEW

This section describes the invertible gamut mapping that may be used in SL-HDR1 when the color gamut of the HDR video and the color gamut of the derived SDR video are not the same. The direct gamut mapping is used at the encoder for SDR derivation ([1] Annex C); the inverse gamut mapping is used at the decoder for HDR reconstruction ([1] Section 7.2).

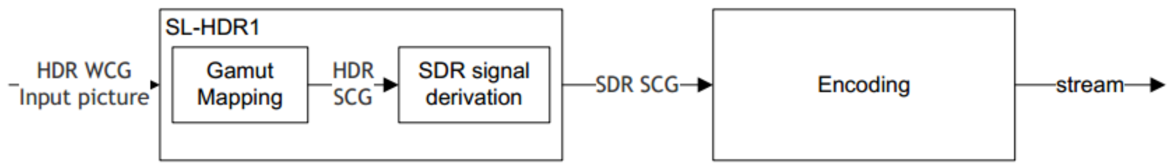

Figure [X].1 Encoder.

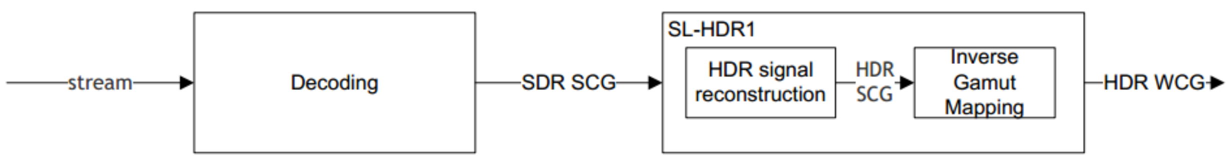

Figure [X].2 Decoder.

[X].2 DIRECT GAMUT MAPPING (GM)

At the input of the encoder, the aim of the GM process is to fit the BT.2020 gamut into the BT.709 gamut. The mapping process keeps the central part of the BT.2020 gamut unchanged (it is already within BT.709 boundaries), and shrinks the rest of the BT.2020 gamut to fit inside the BT.709 gamut.

The GM process is the reciprocal function of the IGM; refer to the next section describing the IGM to understand how the GM operates.

> Note (informative): The GM and the IGM act in pair thanks to metadata carried in the SL-HDR1 SEI messages. The metadata allows adjusting the size of the untouched part of the BT.709 gamut.

[X].3 INVERSE GAMUT MAPPING (IGM)

At the output of the decoder, the IGM process maps BT.709 back to BT.2020. The process is the inverse of the GM described in section X.2, using the BT.709 color as input and the BT.2020 color as output.

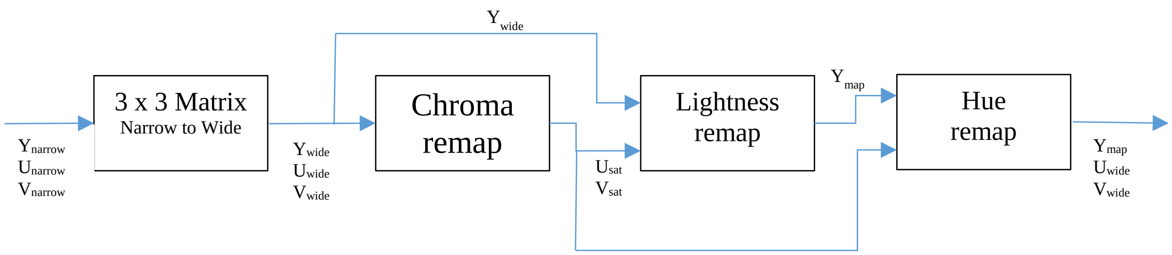

Figure [X].3 Block diagram of the inverse gamut mapping

The color reconstruction works on YUV 4:4:4 linear-light pixels and consist of several steps:

1) The input YUV pixels are first converted from narrow color space to wide color space by a simple matrix computation derived from SMPTE RP.177.

$$YUV_{wide} = Matrix_{narrow2wide} * YUV_{narrow}$$

2) Then, color saturation (chroma) is remapped as follows:

$$U_{sat} = k_{narrow2wide}\,(Y_{wide}, U_{wide}, V_{wide}) * U_{wide}$$

and

$$V_{sat} = k_{narrow2wide}\,(Y_{wide}, U_{wide}, V_{wide}) * V_{wide}$$

where $k_{narrow2wide}$ () is a non-linear function depending of the luminance and hue of the current pixel. This function is specific to the two gamuts. The expansion made by the $k_{narrow2wide}$ is implemented in such a way to preserve a part of the narrow gamut with lower saturation.

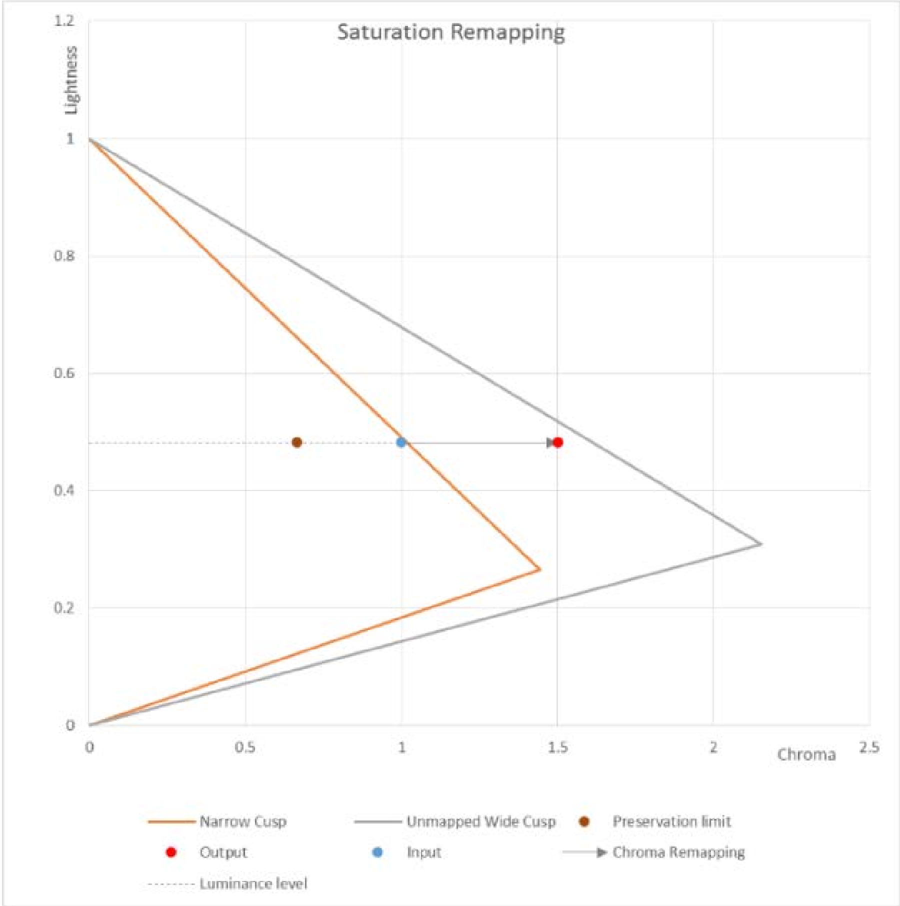

Figure [X].4 Color saturation remapping.

3) Then, lightness (luma) is remapped as follows:

$$Y_{map} = g_{narrow2wide}(Y_{wide}, U_{sat}, V_{sat})$$

where $g_{narrow2wide}$ is a non-linear function depending on the luminance, the chroma and the hue of the current pixel. Again this function is specific to the two gamuts.

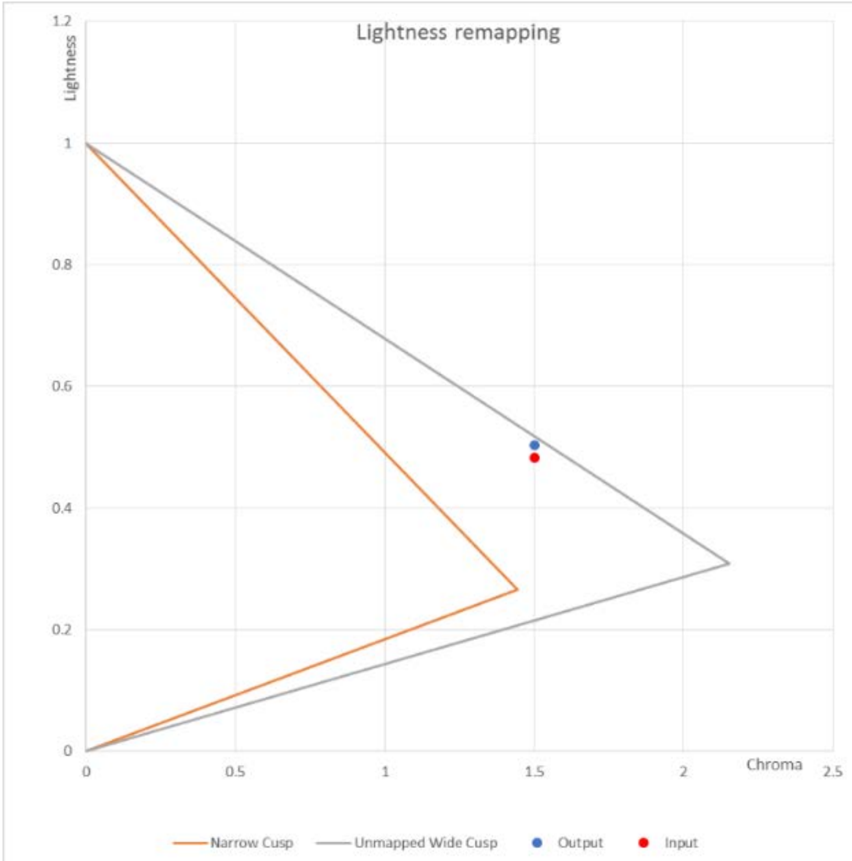

Figure [X].5 Lightness remapping.

4) Finally, the last step remapps the hue as follows:

$$U_{map} = Hu_{narrow2wide}\,(U_{sat}, V_{sat})$$

and,

$$V_{map} = Hv_{narrow2wide}\,(U_{sat}, V_{sat})$$

where $Hu_{narrow2wide}$ and $Hv_{narrow2wide}$ are two non-linear functions depending the chroma and the hue of the current pixel that are nearly equivalent to a rotation in the UV plane but with a significant part of the narrow gamut being preserved (no remapping). These functions are specific to the two gamuts.

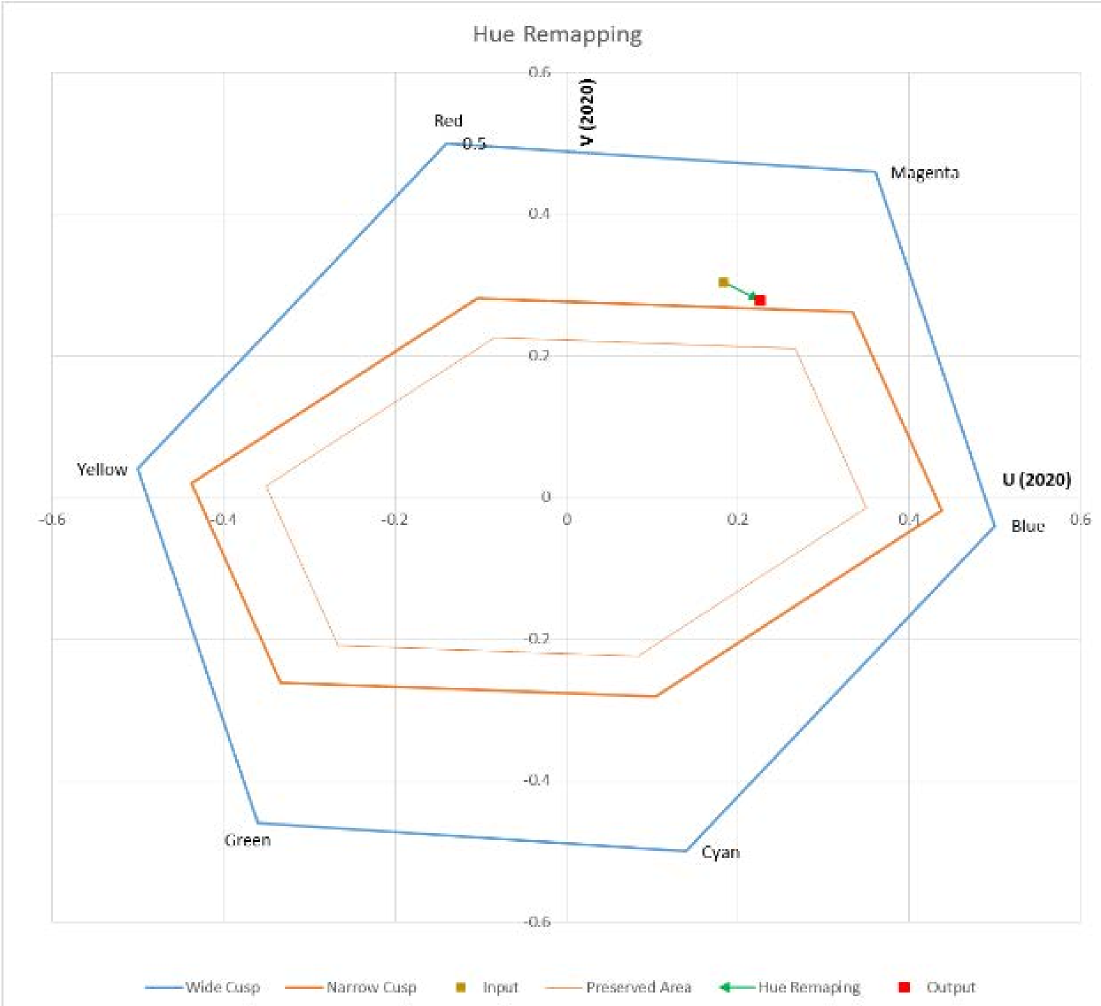

Figure [X].6 Hue remapping.

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