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This specification is being put forth as a Candidate Standard by the TG3/S34 Specialist Group. This document is a revision of the Working Draft S34-262r0 dated 13 April 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

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ATSC Candidate Standard: A/341 Amendment: 2094-10

1. OVERVIEW

This document describes the **encoding and transport** in the ATSC emitted bitstream elements of ST 2094-10 “Dynamic Metadata for Color Volume Transform — Application #1” which is a technology for the use of dynamic metadata for HDR content. If approved by the ATSC, A/341:2017, “Video-HEVC,” (“A/341”) would be amended according to the edits described herein.

2. REFERENCES

The following references would be added to A/341.

2.1 Normative References

- [1] SMPTE: “Dynamic Metadata for Color Volume Transformation – Application #1,” Doc. ST 2094-10 (2016), Society of Motion Picture and Television Engineer, White Plains, NY.

2.2 Informative References

- [2] SMPTE: “Dynamic Metadata for Color Volume Transformation – Core Components,” Doc. ST 2094-1 (2016), Society of Motion Picture and Television Engineers, White Plains, NY.

3. DEFINITION OF TERMS

No new acronyms, abbreviations or terms would be added to A/341.

4. CHANGES TO A/341

In this section of this document, “[ref]” indicates that a cross reference to a cited referenced document that is listed in A/341 would be inserted (or as otherwise described within the square brackets). An actual cross reference to a referenced document listed in this document would be updated with the reference number of the newly added references that would be incorporated into A/341.

Add a Bullet to 6.3.2.2

Add the bullet item below to the bullet list found in 6.3.2.2 “PQ Transfer Characteristics”:

- [The bitstream may contain SEI messages with payloadType value equal to 4. This allows for the optional transmission of the ST 2094-10 metadata message described in \[ref to new subsection described below\].](#)

Add a new subsection under Section 6.3.2.2

Add the text below to A/341 as a new subsection under Section 6.3.2.2 “PQ Transfer Characteristics.” The new subsection is titled Section 6.3.2.2.x “Encoding and Transport of SMPTE ST 2094-10 Metadata Message.” (For readability, the following text is not shown in markup.)

Section 6.3.2.2.x “Encoding and Transport of SMPTE ST 2094-10 Metadata Message

The HEVC video bitstream may contain the 2094-10 metadata message in order to provide dynamic information about the HDR video signal. When a 2094-10 metadata message is present, this information can be employed by the display to adapt the delivered HDR imagery to the capability of the display device. Furthermore, this metadata can be used to derive an SDR (ITU-R BT.709 [ref]) picture by receiving devices such as an ATSC 3.0 receiver/converter. The information conveyed in the 2094-10 metadata message defined in [ref to new Annex described below] provides carriage for metadata elements defined in ST 2094-1 [2] and ST 2094-10 [1].

2094-10 metadata, when present, shall be encoded and transported as User data registered by a Recommendation ITU-T T.35 Supplemental Enhancement Information (SEI) message per the ATSC1_data() structure defined in Table 14 of ANSI/SCTE 128-1 [ref] and the assigned value for user_data_type_code is shown in [ref to Table x.x].

Table x.x user_data_type_code

| user_data_type_code | user_data_type_structure |
|---------------------|--------------------------|
| 0x09 | ST2094-10_data() |

The syntax and semantics for payload ST2094-10_data() shall be as specified in [ref to new Annex described below] clause [ref to new Annex, Section 1 described below]. Where present the corresponding NAL unit type shall be set equal to PREFIX_SEI_NUT.

If a 2094-10 metadata message is present, the following constraints shall apply:

- The 2094-10 metadata message shall be associated with every access unit of the bitstream. If this message is present, it shall only be present once per access unit.
- app_version shall be set equal to 0.
- Mastering Display Color Volume SEI messages (containing SMPTE ST 2086 [ref] static metadata) shall be present in the bitstream.
- The number of extension blocks with ext_block_level equal to 1 shall be constrained to be equal to 1.
- The number of extension blocks with ext_block_level equal to 2 shall be constrained to be less than or equal to 16.
- The number of extension blocks with ext_block_level equal to 5 shall be constrained to be equal to 0 or 1.

Add a new Annex to A/341

Add the text below as a new Annex to A/341. The Annex is titled “Metadata Based on SMPTE ST 2094-10_Data.” (For readability, the following text is not shown in markup.)

A.1 METADATA BASED ON ST 2094-10_DATA (NORMATIVE)

This clause specifies the syntax and semantics of ST2094-10_data().

The syntax for ST2094-10_data() is shown in Table Y.Y, Table Z.Z, and Table M.M.

The parsing process of each syntax element by the descriptors f(n), i(n), ue(v) and u(n) is described in HEVC[ref].

Note: The metadata elements are defined according to the SMPTE standards ST 2086[ref], ST 2094-1[2], or ST 2094-10 [1]. Conversion between luminance values and 12-bit PQ values can be found in ST 2084 Annex A.

Table Y.Y ST2094-10_data()

| ST2094-10_data () { | Descriptor |
|--|-------------------|
| app_identifier | ue(v) |
| app_version | ue(v) |
| metadata_refresh_flag | u(1) |
| if(metadata_refresh_flag) { | |
| num_ext_blocks | ue(v) |
| if(num_ext_blocks) { | |
| while(!byte_aligned()) | |
| dm_alignment_zero_bit | f(1) |
| for(i = 0; i < num_ext_blocks; i ++) { | |
| ext_dm_data_block(i) | |
| } | |
| } | |
| } | |
| while(!byte_aligned()) | |
| dm_alignment_zero_bit | |
| } | |

Table Z.Z ext_dm_data_block()

| ext_dm_metadata_block(i) { | Descriptor |
|---|-------------------|
| ext_block_length[i] | ue(v) |
| ext_block_level [i] | u(8) |
| ext_dm_data_block_payload(ext_block_length[i], ext_block_level [i]) | |
| } | |

Table N.N ext_dm_data_block_payload()

| ext_dm_data_block_payload(ext_block_length, ext_block_level) { | Descriptor |
|--|------------|
| ext_block_len_bits = 8 * ext_block_length | |
| ext_block_use_bits = 0 | |
| if(ext_block_level == 1) { | |
| min_PQ | u(12) |
| max_PQ | u(12) |
| avg_PQ | u(12) |
| ext_block_use_bits += 36 | |
| } | |
| if(ext_block_level == 2) { | |
| target_max_PQ | u(12) |
| trim_slope | u(12) |
| trim_offset | u(12) |
| trim_power | u(12) |
| trim_chroma_weight | u(12) |
| trim_saturation_gain | u(12) |
| ms_weight | i(13) |
| ext_block_use_bits += 85 | |
| } | |
| if(ext_block_level == 5) { | |
| active_area_left_offset | u(13) |
| active_area_right_offset | u(13) |
| active_area_top_offset | u(13) |
| active_area_bottom_offset | u(13) |
| ext_block_use_bits += 52 | |
| } | |
| while(ext_block_use_bits++ < ext_block_len_bits) | |
| ext_dm_alignment_zero_bit | f(1) |
| } | |

This clause defines the semantics for ST2094-10_data().

For the purposes of the present clause, the following mathematical functions apply:

$$\text{Abs}(x) = \begin{cases} x & ; x \geq 0 \\ -x & ; x < 0 \end{cases}$$

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

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

$$\text{Clip3}(x, y, z) = \begin{cases} x & ; z < x \\ y & ; z > y \\ z & ; \textit{otherwise} \end{cases}$$

$$\text{Round}(x) = \text{Sign}(x) * \text{Floor}(\text{Abs}(x) + 0.5)$$

/ = Integer division with truncation of the result toward zero. For example, $7/4$ and $-7/-4$ are truncated to 1 and $-7/4$ and $7/-4$ are truncated to -1 .

The precision of the information conveyed in this SEI message is intended to be adequate for purposes corresponding to the use of SMPTE ST 2094-10 [1].

app_identifier identifies an application and is set equal to 1 according to constraints of the section 5 of ST 2094-10 [1].

app_version specifies the application version in the application and is set equal to 0 .

metadata_refresh_flag when set equal to 1 cancels the persistence of any previous extended display mapping metadata in output order and indicates that extended display mapping metadata follows. The extended display mapping metadata persists from the coded picture to which the SEI message containing ST2094-10_data() is associated (inclusive) to the coded picture to which the next SEI message containing ST2094-10_data() and with **metadata_refresh_flag** set equal to 1 in output order is associated (exclusive) or (otherwise) to the last picture in the CVS (inclusive). When set equal to 0 this flag indicates that the extended display mapping metadata does not follow.

num_ext_blocks specifies the number of extended display mapping metadata blocks. The value shall be in the range of 1 to 254, inclusive.

dm_alignment_zero_bit shall be equal to 0.

ext_block_length[i] is used to derive the size of the i-th extended display mapping metadata block payload in bytes. The value shall be in the range of 0 to 1023, inclusive.

ext_block_level[i] specifies the level of payload contained in the i-th extended display mapping metadata block. The value shall be in the range of 0 to 255, inclusive. The corresponding extended display mapping metadata block types are defined in Table E.1.4. Values of **ext_block_level[i]** that are ATSC reserved shall not be present in the bitstreams conforming to this version of ATSC specification. Blocks using ATSC reserved values shall be ignored.

When the value of **ext_block_level[i]** is set equal to 1, the value of **ext_block_length[i]** shall be set equal to 5.

When the value of **ext_block_level[i]** is set equal to 2, the value of **ext_block_length[i]** shall be set equal to 11.

When the value of **ext_block_level[i]** is set equal to 5, the value of **ext_block_length[i]** shall be set equal to 7.

Table M.M Definition of Extended Display Mapping Metadata Block Type

| ext_block_level | extended display mapping metadata block type |
|------------------------|---|
| 0 | ATSC Reserved |
| 1 | Level 1 Metadata – Content Range |
| 2 | Level 2 Metadata – Trim Pass |
| 3 | ATSC Reserved |
| 4 | ATSC Reserved |
| 5 | Level 5 Metadata – Active Area |
| 6..255 | ATSC Reserved |

When an extended display mapping metadata block with **ext_block_level** equal to 5 is present, the following constraints shall apply:

- An extended display mapping metadata block with **ext_block_level** equal to 5 shall be preceded by at least one extended display mapping metadata block with **ext_block_level** equal to 1 or 2.

- Between any two extended display mapping metadata blocks with `ext_block_level` equal to 5, there shall be at least one extended display mapping metadata block with `ext_block_level` equal to 1 or 2.
- No extended display mapping metadata block with `ext_block_level` equal to 1 or 2 shall be present after the last extended display mapping metadata block with `ext_block_level` equal to 5
- The metadata of an extended display mapping metadata block with `ext_block_level` equal to 1 or 2 shall be applied to the active area specified by the first extended display mapping metadata block with `ext_block_level` equal to 5 following this block.
- When the active area defined by the current extended display mapping metadata block with `ext_block_level` equal to 5 overlaps with the active area defined by preceding extended display mapping metadata blocks with `ext_block_level` equal to 5, all metadata of the extended display mapping metadata blocks with `ext_block_level` equal to 1 or 2 associated with the current extended display mapping metadata block with `ext_block_level` equal to 5 shall be applied to the pixel values of the overlapping area.

min_PQ specifies the minimum luminance value of the current picture in 12-bit PQ encoding. The value shall be in the range of 0 to 4095, inclusive. Note that the 12-bit `min_PQ` value is calculated as follows:

$$\text{min_PQ} = \text{Clip3}(0, 4095, \text{Round}(\text{Min} * 4095))$$

where `Min` is `MinimumPqencodedMaxrgb` as defined in clause 6.1.3 of SMPTE ST 2094-10 [1]

max_PQ specifies the maximum luminance value of current picture in 12-bit PQ encoding. The value shall be in the range of 0 to 4095, inclusive. Note that the 12-bit `max_PQ` value is calculated as follows:

$$\text{max_PQ} = \text{Clip3}(0, 4095, \text{Round}(\text{Max} * 4095))$$

where `Max` is `MaximumPqencodedMaxrgb` as defined in clause 6.1.5 of SMPTE ST 2094-10 [1].

avg_PQ specifies the average PQ code value for the luminance of the picture in 12-bit PQ encoding. The value shall be in the range of 0 to 4095, inclusive. Note that the 12-bit `avg_PQ` value is calculated as follows:

$$\text{avg_PQ} = \text{Clip3}(0, 4095, \text{Round}(\text{Avg} * 4095))$$

where `Avg` is `AveragePqencodedMaxrgb` as defined in section 6.1.4 of SMPTE ST 2094-10 [1].

target_max_PQ specifies the maximum luminance value of a target display in 12-bit PQ encoding. The value shall be in the range of 0 to 4095, inclusive. The `target_max_PQ` is the PQ encoded value of `TargetedSystemDisplayMaximumLuminance` as defined in clause 10.4 of SMPTE ST 2094-1 [2].

Note: This SEI message does not support signaling of `TargetedSystemDisplayPrimaries`, `TargetedSystemDisplayWhitePointChromaticity`, and `TargetedSystemDisplayMinimumLuminance` that are specified as mandatory in ST 2094-10 [1].

If there is more than one extended display mapping metadata block with `ext_block_level` equal to 2, those blocks shall have no duplicated `target_max_PQ`.

trim_slope specifies the slope metadata. The value shall be in the range of 0 to 4095, inclusive. If `trim_slope` is not present, it shall be inferred to be 2048. Note that the 12-bit slope value is calculated as follows:

$$\text{trim_slope} = \text{Clip3}(0, 4095, \text{Round}((S-0.5) * 4096))$$

where S is the `ToneMappingGain` as defined in clause 6.2.3 of SMPTE ST 2094-10 [1].

trim_offset specifies the offset metadata. The value shall be in the range of 0 to 4095, inclusive. If `trim_offset` is not present, it shall be inferred to be 2048. Note that the 12-bit offset value is calculated as follows:

$$\text{trim_offset} = \text{Clip3}(0, 4095, \text{Round}((O+0.5) * 4096))$$

where O is the `ToneMappingOffset` as defined in clause 6.2.2 of SMPTE ST 2094-10 1.

trim_power specifies the power metadata. The value shall be in the range of 0 to 4095, inclusive. If `trim_power` is not present, it shall be inferred to be 2048. Note that the 12-bit power value is calculated as follows:

$$\text{trim_power} = \text{Clip3}(0, 4095, \text{Round}((P-0.5) * 4096))$$

where P is the `ToneMappingGamma` as defined in clause 6.2.4 of SMPTE ST 2094-10 [1].

trim_chroma_weight specifies the chroma weight metadata. The value shall be in the range of 0 to 4095, inclusive. If `trim_chroma_weight` is not present, it shall be inferred to be 2048. Note that the 12-bit chroma weight value is calculated as follows:

$$\text{trim_chroma_weight} = \text{Clip3}(0, 4095, \text{Round}((CW+0.5) * 4096))$$

where CW is the `ChromaCompensationWeight` as defined in clause 6.3.1 of SMPTE ST 2094-10 [1].

trim_saturation_gain specifies the saturation gain metadata. The value shall be in the range of 0 to 4095, inclusive. If `trim_saturation_gain` is not present, it shall be inferred to be 2048. Note that the 12-bit saturation gain value is calculated as follows:

$$\text{trim_saturation_gain} = \text{Clip3}(0, 4095, \text{Round}((SG+0.5) * 4096))$$

where SG is the `SaturationGain` as defined in clause 6.3.2 of SMPTE ST 2094-10 [1].

ms_weight this field is reserved for future specification. This 13-bit signed integer shall be 0x1fff (-1).

active_area_left_offset, **active_area_right_offset**, **active_area_top_offset**, **active_area_bottom_offset** specify the selected pixels of the current picture, in terms of a

rectangular region specified in picture coordinates for the active area. The values shall be in the range of 0 to 8191, inclusive. See also ProcessingWindow of ST 2094-10 [1].

active_area_left_offset, active_area_right_offset, active_area_top_offset, active_area_bottom_offset represent the coordinates of UpperLeftCorner and LowerRightCorner constrained in clause 7.1 of ST 2094-10 [1] as follows:

$$\begin{aligned} \text{UpperLeftCorner} &= (\text{active_area_left_offset}, \text{active_area_top_offset}) \\ \text{LowerRightCorner} &= (\text{XSize} - 1 - \text{active_area_right_offset}, \text{YSize} - 1 - \\ &\quad \text{active_area_bottom_offset}) \end{aligned}$$

where Xsize is the horizontal resolution of the current picture and Ysize is the vertical resolution of the current picture.

ext_dm_alignment_zero_bit shall be equal to 0.

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