SCTE · ISBE

STANDARDS

Digital Video Subcommittee

AMERICAN NATIONAL STANDARD

ANSI/SCTE 215-1-1 2020b

HEVC Video Constraints for Cable Television
Part 1-1 HDR

NOTICE

The Society of Cable Telecommunications Engineers (SCTE) / International Society of Broadband Experts (ISBE) Standards and Operational Practices (hereafter called "documents") are intended to serve the public interest by providing specifications, test methods and procedures that promote uniformity of product, interoperability, interchangeability, best practices, and the long term reliability of broadband communications facilities. These documents shall not in any way preclude any member or non-member of SCTE•ISBE from manufacturing or selling products not conforming to such documents, nor shall the existence of such standards preclude their voluntary use by those other than SCTE•ISBE members.

SCTE•ISBE assumes no obligations or liability whatsoever to any party who may adopt the documents. Such adopting party assumes all risks associated with adoption of these documents and accepts full responsibility for any damage and/or claims arising from the adoption of such documents.

NOTE: The user's attention is called to the possibility that compliance with this document may require the use of an invention covered by patent rights. By publication of this document, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer. SCTE•ISBE shall not be responsible for identifying patents for which a license may be required or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Patent holders who believe that they hold patents which are essential to the implementation of this document have been requested to provide information about those patents and any related licensing terms and conditions. Any such declarations made before or after publication of this document are available on the SCTE•ISBE web site at https://scte.org.

140 Philips Road
Exton, PA 19341

Table of Contents

Title **Page Number**

List of Tables

Title **Page Number**

1. Introduction

1.1. Executive Summary

This document in combination with SCTE 215-1 specifies the creation of an HDR10 HEVC coded video elementary stream and is intended for cable video services applications such as broadcast, time-shifting (e.g., PVR/DVR service), Video-on-Demand services, and splicing (e.g., Ad-insertion) that could employ the specifications in this document. However, constraints specific to those applications are outside of the scope of this document.

Dynamic metadata applications can be used to adapt HDR imagery to a multiplicity of displays that have different characteristics than the underlying content.

The means to carry SCTE dynamic metadata Application #1 (DM App #1) and Application #4 (DM App #4) in an HEVC bitstream is described in Section 7 and in Appendices A and B. SCTE DM Apps describe parametric data sets to be used to adapt the imagery for viewers' displays and environment.

Section 9 describes the CMAF bindings to carry SCTE DM Apps #1 and #4 in a CMAF container.

1.2. Scope

This document defines the additional coding constraints on SCTE 215-1 HDR video streams using an HDR10 format.

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

[1] ANSI/SCTE 215-1, HEVC Video Constraints for Cable Television Part 1- Coding.
[2] ANSI/SCTE 128-1, AVC Video Constraints for Cable Television Part 1- Coding.

2.2. Standards from Other Organizations

[3] ITU-R BT.2100-2:2018 Image parameter values for high dynamic range television for use in production and international programme exchange.
[4] SMPTE ST 2094-1:2016, "Dynamic Metadata for Color Volume Transformation – Core Components".
[5] SMPTE ST 2094-10:2016, "Dynamic Metadata for Color Volume Transformation – Application #1".
[6] SMPTE ST 2086:2018, "Mastering Display Color Volume Metadata Supporting High Luminance and Wide Color Gamut".
[7] ISO/IEC 23000-19:2020, "Information technology -- Multimedia application format (MPEG-A) -- Part 19: Common media application format (CMAF) for segmented media".
[8] IETF RFC 6381, The 'Codecs' and 'Profiles' Parameters for "Bucket" Media Types, 15 August 2011.

[9] ISO/IEC 23008-8:2018, “Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 8: Conformance specification for HEVC”
[10] CTA-5001-B (2019), Web Application Video Ecosystem – Content Specification
[11] CTA-861-H "A DTV Profile for Uncompressed High Speed Digital Interfaces"

2.3. Published Materials

- No normative references are applicable.

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

[12] ANSI/SCTE 215-2, HEVC Video Constraints for Cable Television Part 2- Transport.

3.2. Standards from Other Organizations

[13] SMPTE ST 2036-1, Ultra High Definition Television- Image Parameter Values for Program Production.
[14] ITU: Report ITU-R BT.2390, “High dynamic range television for production and international programme exchange,” International Telecommunications Union, Geneva.

3.3. Published Materials

- No informative references are applicable.

4. Compliance Notation

shall	This word or the adjective “***required***” means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified shall never be used.
should	This word or the adjective “*recommended*” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
should not	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
may	This word or the adjective “*optional*” means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.
deprecated	Use is permissible for legacy purposes only. Deprecated features may be removed from future versions of this document. Implementations should avoid use of deprecated features.

This document contains symbolic references to syntactic elements used in the video and transport coding subsystems. These references are typographically distinguished by the use of a different font (e.g., reserved), *may* contain the underscore character (e.g., constraint_set0_flag) and *may* consist of character strings that are not English words (e.g., pic_width_in_mbs_minus1).

5. Abbreviations and Definitions

5.1. Abbreviations

CLLI	Content Light Level information
CLL	Content Light Level
DM	dynamic metadata
DVB	Digital Video Broadcasting
DVS	Digital Video Subcommittee
ETSI	European Telecommunications Standards Institute
FALL	Frame Average Light Level
HDR	High Dynamic Range
HDTV	High Definition Television
MDCV	Mastering Display Color Volume
MPEG	Moving Picture Experts Group
PALL	Picture Average Light Level
SEI	Supplemental Enhancement Information
VUI	Video Usability Information
WCG	Wide Color Gamut

5.2. Definitions

DM App	Dynamic metadata associated with a specific application used on the HDR video content stream. This type of information is encapsulated within an SEI message used by the application in a post decode process.
HDR DM	Additional information about an HDR video content stream. Use is optional and intended to enhance video presentation quality. It is dynamic in that it may change at each access unit or group of access units. It may be transmitted either along with the content stream or by other delivery means.
HDR10	High Dynamic Range with a PQ EOTF, BT.2100 WCG container, 10 bit pixel values which may include MaxCLL, MaxFALL, and Mastering Display Color Volume information
HEVC	ITU-T Rec. H. 265 | ISO/IEC 23008-2:2014 High Efficiency Video Coding [1]

Numerical formats are defined in Table 1.

Table 1 - Numerical Format Definitions

Example Values	Description
12345	Example of a decimal value format
0x2A	Example of a hexadecimal value format
‘10010100’	Example of a string of binary digits

6. Possible Video Inputs – HDR10

Video streams can also be in the form of high dynamic range (HDR) which consists of streams of dynamic range types identified in Table 2.

Table 2 - HDR Dynamic Range Types of Video

HDR Type	Transfer Function	Color Gamut	Bits Per Pixel	Additional Info
HDR10	PQ	BT.2100	10	**Optional:** MDCV SEI CLLI SEI
HDR10 with SCTE DM App #1	PQ	BT.2100	10	**Mandatory:** MDCV SEI SCTE DM App #1 SEI **Optional:** CLLI SEI
HDR10 with SCTE DM App #4	PQ	BT.2100	10	**Mandatory:** MDCV SEI SCTE DM App #4 SEI **Optional:** CLLI SEI

NOTE 1: Resolution of video can be considered orthogonal to the dynamic range properties of video. For example, HDR10 streams may be either HDTV or UHDTV1 resolution.

NOTE 2: Syntax and semantics for SCTE DM App #1 can be found in Appendix A.

NOTE 3: Syntax and semantics for SCTE DM App #4 can be found in Appendix B.

NOTE 4: A single HDR10-based program may have neither, either or both Dynamic Metadata types present.

7. Additional Video Coding Constraints for HDR10 HEVC Coded Streams

7.1.1. Additional VUI Constraints

Additional VUI constraint sets for colorimetry information for HDR10 are listed in Table 3:

Table 3 - Video Usability Information Constraints

VUI Header Syntactic Element	Allowed Value
	HDR10
colour_primaries	9
transfer_characteristics	16
matrix_coeffs	9
video_full_range_flag	0

It is required that the colorimetry information be sent for Level 5 and Level 5.1 (UHDTV1) bitstreams and for all HDR10 type bitstreams.

7.1.2. Additional Supplemental Enhancement Information (SEI) Constraints

HDR10 usage constraints on types of SEI messages are listed in Table 4.

Table 4 - Additional Supplementary Enhancement Information Constraints for Carriage of HDR10 Metadata

SEI Header Syntactic Element	Usage Constraints
Mastering Display Colour Volume SEI message	Optionally used at Sequence Level
Content Light Level Information SEI message	Optionally used at Sequence Level

NOTE 5: The MaxCLL and MaxPALL information are conveyed respectively in max_content_light_level and max_pic_average_light_level parameters of the Content Light Level Information SEI message. MaxPALL is also more commonly known as MaxFALL.

NOTE 6: The use of the SEI messages listed in Table 4 *is optional.*

7.1.3. Constraints on HEVC Coding for HDR10 Streams with SCTE DM App #1

7.1.3.1. Additional Constraints for SCTE DM App #1

Where a SCTE DM App #1 metadata message is present, the following constraints ***shall*** apply:

- The SCTE DM App #1 metadata message ***shall*** be associated with every access unit of 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 16.
- The number of extension blocks with ext_block_level equal to 4 ***shall*** be constrained to be equal 0 or 1.
- The number of extension blocks with ext_block_level equal to 5 ***shall*** be constrained to be equal 0 or 1.

7.1.3.2. Additional Supplemental Enhancement Information (SEI) Constraints

When SCTE DM App #1 is present in the bitstream, the MDCV SEI message ***shall*** also be present.

7.1.4. Constraints on HEVC Coding for HDR10 Streams with SCTE DM App #4

7.1.4.1. Additional Constraints for SCTE DM App #4

SCTE DM App #4 uses a NAL_unit_type set equal to PREFIX_SEI_NUT to convey the metadata message. Where a SCTE DM App #4 metadata message is present, the following constraint ***shall*** apply:

- The SCTE DM App #4 metadata message ***shall*** be associated with every access unit of the bitstream.

7.1.4.2. Additional Supplemental Enhancement Information (SEI) Constraints

When SCTE DM App #4 is present in the bitstream, the MDCV SEI message ***shall*** also be present.

8. The HDR10 (video) Media Profile

This media profile is defined in CMAF [7], and is referenced CTA WAVE in CTA-5001-B 2019 [10], Table 1, as reproduced below in Table 5.

NOTE 7: Guidelines for CMAF Video Profiles are given in Section 12.1.3 of the CMAF specification.

Table 5 - CTA-5001-B 2019 HDR10 (Video) Media Profile Definition

Media Profile Name	***INFORMATIVE*** Codec	***INFORMATIVE*** Profile	***INFORMATIVE*** Level	***INFORMATIVE*** Color Primaries & Matrix Coefficients	***INFORMATIVE*** Transfer Characteristics	***INFORMATIVE*** 'codecs' MIME subparameters	**NORMATIVE** CMAF Brand	**NORMATIVE** Normative Reference
HDR10	HEVC	Main 10 Main Tier 10-bit	5.1	9 (BT.2020)	16 (BT2100 Table 4 PQ EOTF)	hev1.2.4.L153.BO hvc 1.2.4.L153.BO	'chd1'	(CMAF) Table B.1

9. SCTE Dynamic Metadata In The MPEG Common Media Application Format (CMAF)

9.1. Introduction

This section defines how to package and encode the Media Profiles of SCTE DM App(s) information in the CMAF recognized (Video) Media Profile HDR10 (i.e., CMAF file brand ‘chd1’ is contained in the CMAF filetype box “ftyp”), as specified in CMAF [7], Annex B.

The nominal use case for cable has one HDR rendering that can be decoded by multiple types of decoders. This is described in normative text in this section. Where appropriate, additional text is provided for specialized use cases. It also identifies accommodations that may address alternate implementations closely aligned with this specification.

Dynamic metadata may be carried in HEVC video streams. Carriage of DM App #1 is as specified in Appendix A; carriage of DM App #4 is as specified in Appendix B. This dynamic metadata relies on the

constraints, conformance requirements, and playback requirements specified in the CMAF Media Profile HDR10 as defined in CMAF [7]

9.2. Constraints on HEVC elementary streams carrying SCTE HDR Dynamic Metadata

9.2.1. General

This specification defines a CMAF HEVC Media Profile. This profile ***shall*** conform to the CMAF "HDR10" HEVC Media Profile with CMAF file type ('chd1') Media Profile as defined in CMAF [7] Annex B except as constrained and extended here. All specifications in CMAF [7] clause 9.3.2, "CMAF Track Format Constraints for NAL Structured Video" ***shall*** apply.

9.2.2. Sequence Parameter Set

The Sequence Parameter Set ***shall*** be set according to the provisions set forth in SCTE 215-1 [1], and in CMAF [7] Section B.3.3.4

9.2.3. Supplemental Enhancement Information messages

For SCTE DM App #1, SEI messages ***shall*** be encoded and transported as specified in SCTE 128-1 [2]. Exactly one SCTE dynamic metadata SEI message ***shall*** be sent for every access unit of the bitstream.

For SCTE DM App #4, SEI messages ***shall*** be encoded and transported as specified in CTA-861 [11].

9.3. Constraints on CMAF Tracks carrying HDR Dynamic Metadata

The constraints on the CMAF tracks are specified by the HEVC media profile, and the constraints are specified in CMAF [7], Annex B, and further constrained in Section 8 of this document.

9.3.1. Switching Sets

If more than one CMAF track is in a CMAF Switching Set, then the identical SCTE dynamic metadata SEI Message *should* be present in each CMAF track, except for metadata values that are resolution dependent, which ***shall*** be specified to match the resolution of that CMAF track.

9.3.2. Signaling of "codecs"

The values of the codecs parameter in HDR10 streams containing SCTE DM App(s) information ***shall*** be as specified in column 4 (SCTE DM 'codecs' parameter) of Table 6 – High Dynamic Range 'codecs' parameters. The base CMAF Media Profile of these streams is HDR10 ('chd1') as defined in CMAF [7], Annex B.

Table 6 - High Dynamic Range 'codecs' parameters

SCTE DM App	Sample Entry	Base CMAF Media Profile & 'codecs' Parameter	SCTE DM 'codecs' Parameter
SCTE DM App #1	hev1	HDR10 ('chd1'), hev1.2.4.L153.B0	dvhe.08.09
SCTE DM App #1	hvc1	HDR10 ('chd1'), hvc1.2.4.L153.B0	dvh1.08.09
SCTE DM App #4	hev1	HDR10 ('chd1'),	same as HDR10

		hev1.2.4.L153.B0	
SCTE DM App #4	hvc1	HDR10 ('chd1'), hev1.2.4.L153.B0	same as HDR10

For the nominal use case, content authors ***shall*** include all applicable codec parameters in the `codecs` parameter list per RFC6381[8]. This allows HDR10 decoders and those supporting identified dynamic metadata systems to decode the content. As an example, for DM App #1, a content author would encode the `codecs` parameter as `codecs="dvhe.08.09,hev1.2.4.L153.B0".` When multiple codecs are listed in the codecs string, the HDR10 codec string ***shall*** be last in the list.

For the specialized use case in which playback is to be limited to devices that only support DM App #1, the list ***shall*** include only "`dvhe.08.09`" or "`dvh1.08.09`".

NOTE 8: An alternate way of specifying cross compatible behavior is to include two separate adaptation sets in the Manifest, one adaptation set that includes only the DM App #1 codec string, and one adaptation set that includes only the HDR10 codec string, where all adaptation sets point to the same content stream. This allows for some flexibility in the implementation of HDR for legacy support.

9.3.3. SCTE Dynamic Metadata Compatible Brands

For the nominal use case, content providers ***shall*** include 'chd1' (HDR10) in the list of compatible brands in the 'ftyp' box, along with all applicable DM compatible_brands as defined in Table 7, column 2. HEVC Media Profiles and Track Brands ***shall*** conform to clause CMAF [7] Section B.5 except for Table 6.

For the specialized use case in which playback is to be limited to devices that support DM App#1, the ftyp list may be limited to the ftyp for DM App #1.

Table 7 - SCTE Dynamic Metadata CMAF Data

Name	Compatible Brand	Format	Notes
SCTE DM App #1	'cdm1'	Appendix A	SCTE DM App #1 Metadata in SEI messages
SCTE DM App #4	'cdm4'	Appendix B	SCTE DM App #4 Metadata in SEI messages

For SCTE DM App #1, the video stream ***shall*** contain metadata messages as specified in Appendix A, which ***shall*** be included in a "user_data_registered_itu_t_t35" SEI T.35 construct as defined in SCTE 128-1 Table 12 [2].

For SCTE DM App #4, the video stream ***shall*** contain metadata messages as specified in Appendix B.

9.4. Conformance and Playback Requirements for CMAF tracks carrying HDR Dynamic Metadata

Conformance and playback requirements on the CMAF tracks are specified by the HEVC media profile HDR10, including conformance requirements specified for HDR10 in CMAF [7], conformance requirements for HEVC specified in ISO/IEC 23008-8 [9].

Appendix A: Syntax and Semantics for SCTE DM App #1

A.1 Data structure for DM App #1

SCTE DM App #1 data structure is shown in Table 8.

Table 8- DM App #1

Syntax	No. of Bits	Format
SCTE_DM_App1() {		
if(full_preamble_flag){		
Preamble()		
Mastering_DisplayClass()		
}else{		
Persistence_Preamble()		
}		
dm_app1_data_payload()		
}		

A.2 DM App #1 structure

The internal structure is shown in the following paragraphs.

full_preamble_flag ***shall*** be set to a value of 1 at least for every IRAP.

A.2.1 Preamble structures for DM App #1

A preamble consists of a series of fixed 32-bit words. When pictures designated as IRAP are presented, the full Preamble() ***shall*** be included in the bit stream. The Preamble() data structure is shown in Table 9. When non-IRAP pictures are presented, the smaller Persistence_Preamble() ***shall*** be included in the bit stream. The Persistence_Preamble() data structure is shown in Table 10.

Table 9 - Preamble()

Syntax	No. of Bits	Format
Preamble(){		
Reserved_00	32	uimsbf
Reserved_01	32	uimsbf
Reserved_02	32	uimsbf
Reserved_03	32	uimsbf
Reserved_04	32	uimsbf
Reserved_05	32	uimsbf
Reserved_06	32	uimsbf
Reserved_07	32	uimsbf
Reserved_08	32	uimsbf
Reserved_09	32	uimsbf
Reserved_10	32	uimsbf
Reserved_11	32	uimsbf
Reserved_12	32	uimsbf
Reserved_13	32	uimsbf
Reserved_14	32	uimsbf
Reserved_15	32	uimsbf
Reserved_16	32	uimsbf
Reserved_17	32	uimsbf
Reserved_18	32	uimsbf
Reserved_19	32	uimsbf
Reserved_20	32	uimsbf
Reserved_21	32	uimsbf
Reserved_22	32	uimsbf
Reserved_23	32	uimsbf
}		

Table 10- Persistence_Preamble

Syntax	No. of Bits	Format
Persistence_Preamble(){		
Reserved_00	32	uimsbf
Reserved_24	32	uimsbf
marker_bits	2	'10'
}		

A.2.2 Mastering_DisplayClass() structure for DM App #1

Mastering_DisplayClass() data structure is shown in Table 11. The value of max_display is derived from the MDCV SEI message max_display_mastering_luminance value.

Table 11- Mastering_DisplayClass()

Syntax	No. of Bits	Format
Mastering_DisplayClass(){		
master_disp_class	32	uimsbf
reserved_bit	1	uimsbf
}		

A.2.3 dm_app1_data_payload() structure for DM Application #1

dm_app1_data_payload() data structure is shown in Table 12. max_display is extracted from the MDCV SEI message. If MCDV SEI is not present, the value ***shall*** be inferred to be less than 2000 cd/m^2.

Table 12- dm_app1_data_payload()

Syntax	No. of Bits	Format
dm_app1_data_payload() {		
num_ext_blocks	var	ue(v)
if (num_ext_blocks) {		
while(!byte_aligned())		
dm_alignment_zero_bit	1	uimsbf
for(i = 0; i < num_ext_blocks; i ++) {		
ext_metadata_block()		
}		
}		
}		

Table 13- DM App1 Extension Blocks

Syntax	No. of Bits	Format
ext_metadata_block() {		
ext_block_length	var	ue(v)
ext_block_level	8	uimsbf
ext_block_payload(ext_block_length, ext_block_level)		
}		

Table 14- DM App1 Extension Block Levels

Syntax	No. of Bits	Format
ext_block_payload(ext_block_length, ext_block_level) {		
ext_block_len_bits = 8 * ext_block_length		
ext_block_use_bits = 0		
if(ext_block_level == 1) {		
min_PQ	12	uimsbf
max_PQ	12	uimsbf
avg_PQ	12	uimsbf

ext_block_use_bits += 36		
}		
if(ext_block_level == 2) {		
target_max_PQ	12	uimsbf
trim_slope	12	uimsbf
trim_offset	12	uimsbf
trim_power	12	uimsbf
trim_chroma_weight	12	uimsbf
trim_saturation_gain	12	uimsbf
ms_weight	13	uimsbf
ext_block_use_bits += 85		
}		
if(ext_block_level == 4) {		
TF_PQ_mean	12	uimsbf
TF_PQ_stdev	12	uimsbf
ext_block_use_bits += 24		
}		
if(ext_block_level == 5) {		
active_area_left_offset	13	uimsbf
active_area_right_offset	13	uimsbf
active_area_top_offset	13	uimsbf
active_area_bottom_offset	13	uimsbf
ext_block_use_bits += 52		
}		
while(ext_block_use_bits++ < ext_block_len_bits)		
ext_dm_alignment_zero_bit	1	uimsbf
}		

This clause defines the semantics for SCTE_DM_App1().

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

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

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

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

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

Round(x) = Sign(x)*Floor(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[5].

Table 15 contains the values of the reserved fields in this version of SCTE DM App #1. Each reserved field ***shall*** be set to the value as listed in Table 15.

Table 15- Reserved Fields in Preamble()

Fields	Value
Reserved_00	0x08090040
Reserved_01	0x6136506F
Reserved_02	0x003FF801
Reserved_03	0xFFC00FFF
Reserved_04	0xD0000008
Reserved_05	0x00000680
Reserved_06	0x00004000
Reserved_07	0x00340000
Reserved_08	0x02000001
Reserved_09	0xA2566000
Reserved_10	0x035EA256
Reserved_11	0x6F9FCEB1
Reserved_12	0xC256644C
Reserved_13	0xA0000010
Reserved_14	0x00000080
Reserved_15	0x00000080
Reserved_16	0x000001C3
Reserved_17	0x62243018
Reserved_18	0x60A5E308
Reserved_19	0xE0514000
Reserved_20	0x001A63E5
Reserved_21	0xAFFFF000
Reserved_22	0x00000000
Reserved_23	0x00000602
Reserved_24	0x6136517E

master_disp_class specifies whether the peak brightness described in the MDCV SEI message is less than 2000 cd/m^2 or greater than or equal to 2000 cd/m^2. If the **max_display_mastering_luminance** [7] in the MDCV SEI is less than 2000 cd/m^2, master_disp_class ***shall*** be 0x00F80E15, otherwise master_disp_class ***shall*** be 0x00FCE015. If a MCDV SEI message is not present, max_display ***shall*** be inferred to be less than 2000 cd/m^2.

reserved_bit ***shall*** be equal to 0.

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 16. Values of ext_block_level[i] that are SCTE/ATSC reserved ***shall not*** be present in the bitstreams conforming to this version of SCTE specification. Blocks using SCTE/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 4, the value of ext_block_length[i] ***shall*** be set equal to 3.
- 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 16- Definition of Extended Display Mapping Metadata Block Type

ext_block_level	extended display mapping metadata block type
0	SCTE/ATSC Reserved
1	Level 1 Metadata – Content Range
2	Level 2 Metadata – Trim Pass
3	SCTE/ATSC Reserved
4	Level 4 Metadata – Temporally Filtered Image Level
5	Level 5 Metadata – Active Area
6…254	SCTE/ATSC Reserved
255	***Forbidden***

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, 2 or 4.

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, 2 or 4.

No extended display mapping metadata block with ext_block_level equal to 1, 2 or 4 ***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, 2 or 4 ***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, 2 or 4 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 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:

$$min\_PQ = Clip3(0, 4095, Round(Min * 4095))$$

where Min ***shall*** be the lowest PQ-encoded minRGB value of the reduced pixel set. Its value ***shall*** be a number in the range [0, 1] and in multiples of 0.00001. minRGB is the minimum of the normalized R, G or B values.

Reduced pixel set is defined in section 6.1.2 of SMPTE ST 2094-10 [5].

max_PQ specifies the maximum 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:

$$max\_PQ = Clip3(0, 4095, Round(Max * 4095))$$

where Max is MaximumPqencodedMaxrgb as defined in clause 6.1.5 of SMPTE ST 2094-10 [5].

avg_PQ specifies the average PQ code value 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:

$$avg\_PQ = Clip3(0, 4095, Round(Avg * 4095))$$

where Avg is AveragePqencodedMaxrgb as defined in section 6.1.4 of SMPTE ST 2094-10 [5].

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 [4].

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:

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

where *S* is the ToneMappingGain as defined in clause 6.2.3 of SMPTE ST 2094-10 [5].

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:

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

where *O* is the ToneMappingOffset as defined in clause 6.2.2 of SMPTE ST 2094-10 [5].

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:

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

where *P* is the ToneMappingGamma as defined in clause 6.2.4 of SMPTE ST 2094-10 [5].

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:

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

where *CW* is the ChromaCompensationWeight as defined in clause 6.3.1 of SMPTE ST 2094-10 [5].

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:

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

where *SG* is the SaturationGain as defined in clause 6.3.2 of SMPTE ST 2094-10 [5].

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

TF_PQ_mean specifies the temporally filtered mean of the maximum RGB value of the current frame. The value ***shall*** be in the range of 0 to 4095, inclusive. Note that the 12-bit TF_PQ_mean value for i^{th} frame TF_PQ_mean_i is calculated as follows:

$$TF\_PQ\_norm\_mean_i = TF\_PQ\_norm\_mean_{i-1} * (1 - \alpha) + \text{mean}\big(\text{PQ}(maxRGB_i)\big) * \alpha$$

where *maxRGB* is defined in section 4.1.1 of SMPTE ST 2094-1 [4] and in the range [0, 1], and

$$\alpha = \min\big(1, SC * \big|\text{mean}\big(\text{PQ}(maxRGB_i)\big) - \text{mean}\big(\text{PQ}(maxRGB_{i-1})\big)\big| * 8 + 0.1\big)$$

The value of *SC* is set to 1 at a scene boundary; otherwise the value of *SC* is set to 0.

$$TF\_PQ\_mean_i = Clip3(0, 4095, \text{Round}(TF\_PQ\_norm\_mean_i * 4095))$$

TF_PQ_stdev specifies the temporally filtered standard deviation of the maximum RGB value of the current frame. The value ***shall*** be in the range of 0 to 4095, inclusive. Note that the 12bit - value for i^{th} frame TF_PQ_stdev_i is calculated as follows:

$$TF\_PQ\_norm\_stdev_i = TF\_PQ\_norm\_stdev_{i-1} * (1 - \alpha) + \text{stdev}\big(\text{PQ}(maxRGB_i)\big) * \alpha$$

where *maxRGB* is defined in section 4.1.1 of SMPTE ST 2094-1 [4] and in the range [0, 1], and

$$\alpha = \min\big(1, SC * \big|\text{mean}\big(\text{PQ}(maxRGB_i)\big) - \text{mean}\big(\text{PQ}(maxRGB_{i-1})\big)\big| * 8 + 0.1\big)$$

The value of *SC* is set to 1 at a scene boundary; otherwise the value of *SC* is set to 0.

$$TF\_PQ\_stdev_i = Clip3(0, 4095, \text{Round}(TF\_PQ\_norm\_stdev_i * 4095))$$

Note: The alpha value is calculated on each new scene boundary; this permits a smooth transition between scenes. The scene boundary can be determined by an appropriate mechanism, such as in the encoder.

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 [5].

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[5] as follows:

UpperLeftCorner = (active_area_left_offset, active_area_top_offset)
LowerRightCorner = (XSize - 1 - active_area_right_offset , YSize - 1 - active_area_bottom_offset)

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.

Appendix B: Syntax and Semantics for SCTE DM App #4

The syntax and semantics of DM App #4 in SEI ITU T.35 messages is defined in CTA-861 [11]. This includes identification of the SEI T.35 Construct information, including itu_t_t35_country_code, itu_t_t35_terminal_provider_code, and user_identifier information.