SMPTE ST 2094-30:2016

SMPTE STANDARD

Dynamic Metadata for Color Volume Transform — Application #3

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Approved
July 6, 2016

Foreword

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SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual.

SMPTE ST 2094-30 was prepared by Technology Committee 10E.

Intellectual Property

SMPTE draws attention to the fact that it is claimed that compliance with this Standard may involve the use of one or more patents or other intellectual property rights (collectively, "IPR"). The Society takes no position concerning the evidence, validity, or scope of this IPR.

Each holder of claimed IPR has assured the Society that it is willing to License all IPR it owns, and any third party IPR it has the right to sublicense, that is essential to the implementation of this Standard to those (Members and non-Members alike) desiring to implement this Standard under reasonable terms and conditions, demonstrably free of discrimination. Each holder of claimed IPR has filed a statement to such effect with SMPTE. Information may be obtained from the Director, Standards & Engineering at SMPTE Headquarters.

Attention is also drawn to the possibility that elements of this Standard may be subject to IPR other than those identified above. The Society shall not be responsible for identifying any or all such IPR.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

The Color Volume Transform Application #3 uses content-dependent, dynamic metadata generated through the comparison of input image essence graded using a mastering display having characteristics such as High Dynamic Range (HDR) and Wide Color Gamut (WCG), with a reference image essence graded using a mastering display having the characteristics of a different color volume, such as Standard Dynamic Range (SDR). This Application is therefore called "Reference-based Color Volume Remapping". Herein, the mastering display used for grading the reference image essence is identified as the Targeted System Display.

Color Volume Transform Application #3 uses Pre-Matrix Tone Mapping (1D LUT), Color Remapping Matrix (3x3 scalar), and Post-Matrix Tone Mapping (1D LUT) processing blocks as conceptualized in the generalized Color Volume Transform Model described in SMPTE ST 2094-1.

The dynamic metadata for Application #3 is made using two image essence color grades, as when new image essence is originated and mastered in HDR and WCG and is also mastered in Standard Dynamic Range (SDR) for legacy video distribution; or when library image essence that already exists as an SDR grade is remastered to produce a grade in HDR and WCG.

An example use case is a content creator producing both an “HDR grade” master for HDR home video distribution made using a reference mastering display having a peak luminance of 1000 candelas per square meter and Rec. ITU-R BT.2020 color gamut, and an “SDR grade” master for legacy SDR home video distribution made using a reference mastering display having a peak luminance of 100 candelas per square meter and Rec. ITU-R BT.709 color gamut. These two graded masters are used as the input to a tool that generates the dynamic metadata for the Application #3 Reference-based Color Volume Remapping system. This dynamic metadata can then be delivered with the “HDR grade” image essence so it can be used by a downstream SDR rendering device to provide a color volume transform so that the displayed image closely matches the artistic intent expressed in the “SDR grade” image essence.

Application #3 also supports the use case where the dynamic metadata is generated as part of the content creator’s color grading session used to produce an “SDR grade” master from the “HDR grade” master.

The Reference-based Color Volume Remapping dynamic metadata related to the processing blocks described above can be carried in compressed image essence encoded under the Rec. ITU-T H.265 High Efficiency Video Coding (HEVC) standard by using the Colour Remapping Information (CRI) Supplemental Enhancement Information (SEI) message defined in Rec. ITU-T H.265.

The metadata set associated with Reference-based Color Volume Remapping is specified in Section 8.1.

1 Scope

This standard specifies Dynamic Metadata for Color Volume Transform Application #3, Reference-based Color Volume Remapping. It is a specialization of the content-dependent transform metadata entries and processing blocks of the generalized color volume transform model defined in the SMPTE ST 2094-1 Dynamic Metadata for Color Volume Transform – Core Components standard.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this engineering document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this engineering document are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 428-1: 2006, D-Cinema Distribution Master — Image Characteristics

SMPTE ST 431-1: 2006, D-Cinema Quality — Screen Luminance Level, Chromaticity and Uniformity

SMPTE RP 2077:2013, Full-Range Image Mapping

SMPTE ST 2084:2014, High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays

SMPTE ST 2094-1:2016, Dynamic Metadata for Color Volume Transform – Core Components

Recommendation ITU-R BT.709-6 (06/2015), Parameter values for HDTV Standards for Production and International Programme Exchange

Recommendation ITU-R BT.1886 (03/2011), Reference Electro-Optical Transfer Function for Flat Panel Displays Used in HDTV Studio Production

Recommendation ITU-R BT.2020-2 (10/2015), Parameter Values for Ultra-High Definition Television Systems for Production and International Programme Exchange

4 Terms and Definitions

For the purposes of this document, the terms and definitions given in SMPTE ST 2094-1, SMPTE RP 2077, and the following apply:

4.1 Transfer Function

mapping of a digital code value to another quantity (e.g., luminance)

4.2 Input image essence

image essence to which the color volume transform is applied

5 Application Identification

The **ApplicationIdentifier** item value shall be 3 and the **ApplicationVersion** item value shall be 0 to identify this version of Application #3.

These two values identify this document as the defining document for the Application-specific metadata specified in Section 8.1.

6 Targeted System Display

6.1 Introduction

The **TargetedSystemDisplay** metadata group associated with Application #3 Reference-based Color Volume Remapping contains the metadata item defined in Section 6.2.

Application of the **ColorVolumeTransform** (see Section 7.1) to input image essence in the **MetadataColorCodingWorkspace** (see Section 7.3) will result in image essence intended for a display having the characteristics identified in **TargetedSystemDisplay**. **TargetedSystemDisplay** facilitates selection of a metadata set best matching the actual targeted system display.

6.2 Targeted System Display Signal Format

The **TargetedSystemDisplaySignalFormat** value defined in Table 1 describes the characteristics of the signal format of the targeted system display for which the color volume transform output is computed. These characteristics comprise the transfer function, color components, and quantization.

TargetedSystemDisplaySignalFormat shall be an enumerator containing one value selected from the list defined in Table 1. The default value shall be 0.

In Table 1, *n* represents the component bit depth of the image essence and $D = 2^{n-8}$.

Table 1 – Values for TargetedSystemDisplaySignalFormat

Value	Signal Format of the Targeted System Display
0	The transfer function is as defined in Rec. ITU-R BT.1886 (with *a*=1, *b*=0), quantized such that a digital code value of 235 × *D* for each of R', G', and B', or Y' corresponds to reference white and a digital code value of 16 × *D* corresponds to reference black. The color components are R', G', B' when the Metadata Color Coding Workspace value is 0, 1, or 2; and are Y', C'_B, C'_R when such value is 3, respectively corresponding to E'_R, E'_G, E'_B and E'_Y, E'_{CB}, E'_{CR}, as specified in ITU−R BT.709−6. Note: This corresponds to a narrow-range image as specified in SMPTE RP 2077, for HDTV.
1	The transfer function is as defined in Rec. ITU-R BT.1886 (with *a*=1, *b*=0), quantized such that a digital code value of 235 × *D* for each of R', G', and B', or Y' corresponds to reference white and a digital code value of 16 × *D* corresponds to reference black. The color components are R', G', B' when the Metadata Color Coding Workspace value is 0, 1, or 2; and are Y', C'_B, C'_R when such value is 3, as specified in ITU−R BT.2020−2 as non-constant luminance. Note: This corresponds to a narrow-range image as specified in SMPTE RP 2077, for ultra-high definition television.
2	The transfer function is as defined in SMPTE ST 428-1:2006. The color components are X', Y', Z'. Note: This corresponds to a 12-bit, full-range image as specified in SMPTE RP 2077, for digital cinema.
3	The transfer function is as defined in SMPTE ST 2084:2014, quantized such that a digital code value of 235 × *D* for each of R', G', and B', or Y' corresponds to an optical output of 10 000 candelas per square meter (cd/m^2) and a digital code value of 16 × *D* corresponds to an optical output of 0 cd/m^2. The color components are R', G', B' when the Metadata Color Coding Workspace value is 0, 1, or 2; and are Y', C'_B, C'_R when such value is 3, as specified in ITU−R BT.2020−2 as non-constant luminance. Note: This corresponds to a narrow-range image as specified in SMPTE RP 2077, for high-dynamic range, ultra-high definition television.
4	The transfer function is as defined in SMPTE ST 2084:2014, quantized such that a digital code value of $2^n - 1$ for each of R', G', and B' corresponds to an optical output of 10 000 cd/m^2 and a digital code value of 0 corresponds to an optical output of 0 cd/m^2. The color components are R', G', and B', as specified in ITU−R BT.2020−2 as non-constant luminance. Note: This corresponds to a full-range image as specified in SMPTE RP 2077, for high-dynamic range, ultra-high definition television.

6.3 Targeted System Display Default Values

If any metadata item of the **TargetedSystemDisplay** group is allowably omitted, other than the **TargetedSystemDisplaySignalFormat** item**,** the omitted item shall take the default value specified in Table 2 according to the value of **TargetedSystemDisplaySignalFormat**.

Table 2 – Default Values for Omitted Targeted System Display Metadata Items

Value	Targeted System Display Omitted Metadata Item Defaults
0	**TargetedSystemDisplayMaximumLuminance**: 100 cd/m^2 **TargetedSystemDisplayMinimumLuminance**: 0.05 cd/m^2 **TargetedSystemDisplayPrimaries**: as defined in Rec. ITU-R BT.709-6 **TargetedSystemDisplayWhitePointChromaticity**: as defined in Rec. ITU-R BT.709-6
1	**TargetedSystemDisplayMaximumLuminance**: 100 cd/m^2 **TargetedSystemDisplayMinimumLuminance**: 0.05 cd/m^2 **TargetedSystemDisplayPrimaries**: as defined in Rec. ITU-R BT.2020-2 **TargetedSystemDisplayWhitePointChromaticity**: as defined in Rec. ITU-R BT.2020-2
2	**TargetedSystemDisplayMaximumLuminance**: 48 cd/m^2 **TargetedSystemDisplayMinimumLuminance:** 0.024 cd/m^2 **TargetedSystemDisplayPrimaries**: Red = {0.6800, 0.3200}, Green = {0.2650, 0.6900}, Blue = {0.1500, 0.0600} (SMPTE RP 431-2:2011) **TargetedSystemDisplayWhitePointChromaticity**: as defined in SMPTE ST 431-1:2006
3, 4	**TargetedSystemDisplayMaximumLuminance**: 1000 cd/m^2 **TargetedSystemDisplayMinimumLuminance:** 0.03 cd/m^2 **TargetedSystemDisplayPrimaries**: as defined in Rec. ITU-R BT.2020 **TargetedSystemDisplayWhitePointChromaticity**: as defined in Rec. ITU-R BT.2020-2

7 Referenced-Based Color Volume Remapping

7.1 Introduction

The **ColorVolumeTransform** metadata group associated with Application #3 Reference-based Color Volume Remapping contains the metadata items defined in Sections 7.3 to 7.6.

7.2 Color Component Ordering

Color components shall have the following order in the metadata set: {R', G', B'}, {Y', C'$_B$, C'$_R$}, or {X', Y', Z'}.

7.3 Metadata Color Coding Workspace

The **MetadataColorCodingWorkspace** item value shall specify the color components and quantization range, as defined in Table 3. This is the color image encoding for the input image essence from which the ColorVolumeTransform metadata group was derived.

MetadataColorCodingWorkspace shall be an enumerator containing one value selected from the list defined in Table 3. The default value shall be 0.

The following formula is used to determine normalized component values:

$$L' = (L'_D / (2^n-1)) \quad (1)$$

where

L' is the normalized component value
L'_D is the input image essence component code value
n is the component bit depth if the image essence.

Note: Formula (1) always maps all 2^n possible code values to the range from 0 to 1, regardless of whether or not the input image essence might use all possible code values.

In Table 3, n represents the component bit depth of the image essence and $D = 2^{n-8}$.

Table 3 – Values for MetadataColorCodingWorkspace

Value	Metadata Color Coding Workspace
0	The Metadata Color Coding Workspace uses the same color components and quantization as the image essence. The normalized component values shall be determined from Formula (1).
1	The Metadata Color Coding Workspace uses color components R', G', B' as defined for the specification to which the image essence conforms, quantized such that a digital code value of 235 × D corresponds to reference white, as in Rec. ITU-R BT.1886, or peak luminance, as in SMPTE ST 2084 and a digital code value of 16 × D corresponds to reference black, as in Rec. ITU-R BT.1886, or black level, as in SMPTE ST 2084. The normalized component values shall be determined from Formula (1). Note: This corresponds to a narrow range image as specified in SMPTE RP 2077.
2	The Metadata Color Coding Workspace uses color components R', G', B' as defined for the specification to which the image essence conforms, quantized as an integer from 0 to 2^n-1. The normalized component values shall be determined from Formula (1). Note: This corresponds to a full range image as specified in SMPTE RP 2077.
3	The Metadata Color Coding Workspace uses color components luma (Y'), blue color difference (C'_B), and red color difference (C'_R) as defined for the specification to which the image essence conforms, quantized such that digital code values of 235 × D for Y' and 128 × D for C'_B and for C'_R correspond to reference white, as in Rec. ITU-R BT.1886, or peak luminance, as in SMPTE ST 2084 and a digital code value of 16 × D for Y' corresponds to reference black, as in Rec. ITU-R BT.1886, or black level, as in SMPTE ST 2084. The normalized component values shall be determined from Formula (1). Note: This corresponds to a narrow range image as specified in SMPTE RP 2077.

7.4 Pre-Matrix Tone Mapping (1D LUT)

The **PreMatrixToneMapping** item shall be three sampled functions, as defined in SMPTE ST 2094-1, in component order as shown in Section 7.2, taking component input values and returning component output values.

These sampled functions each comprise a first pair { x_0, y_0 }, where $x_0 = 0.0$. The first pair may be omitted, in which case the first pair shall have the default value { 0.0, 0.0 }. These sampled functions each comprise a last pair { x_Z, y_Z } where $x_Z = 1.0$, $Z \leq 34$ and Z may be different for each sampled function. The last pair may be omitted, in which case this last pair shall have the default value { 1.0, 1.0 }. These sampled functions shall each comprise no more than 33 pairs, not counting omitted pairs. The x_i and y_i values shall be multiples of $1/(2^{14}-1)$, i.e., 1/16 383.

The default value for the **PreMatrixToneMapping** item shall be three sampled functions, each having the default value defined in SMPTE ST 2094-1. Any number of the three sampled functions may be omitted. If any sampled function is omitted, the remaining sampled functions shall retain their mapping to the corresponding color components. If the first sampled function is omitted, it shall have a default value defined in SMPTE ST 2094-1. If the second sampled function is omitted, it shall have a default value defined in SMPTE ST 2094-1. If the third sampled function is omitted, it shall have the value of the second sampled function.

7.5 Color Remapping Matrix (3x3 scalar)

The **ColorRemappingMatrix** item shall be a 3x3 matrix as defined in SMPTE ST 2094-1.

The elements of **ColorRemappingMatrix** shall be in the half-bounded range from -4 to, but not including 4, and shall be in multiples of 2^{-12}, i.e., 1/4096.

The default value of the matrix shall be the identity matrix.

7.6 Post-Matrix Tone Mapping (1D LUT)

The **PostMatrixToneMapping** item shall be three sampled functions, as defined in SMPTE ST 2094-1, in component order as shown in Section 7.2, taking component input values and returning component output values.

These sampled functions each comprise a first pair { x_0, y_0 }, where $x_0 = 0.0$. The first pair may be omitted, in which case the first pair shall have the default value { 0.0, 0.0 }. These sampled functions each comprise a last pair { x_Z, y_Z } where $x_Z = 1.0$, $Z \leq 34$ and Z may be different for each sampled function. The last pair may be omitted, in which case this last pair shall have the default value { 1.0, 1.0 }. These sampled functions shall each comprise no more than 33 pairs, not counting omitted pairs. The x_i and y_i values shall be multiples of $1/(2^{-14}-1)$, i.e., 1/16 383.

The default value for the **PostMatrixToneMapping** item shall be three sampled functions, each having the default value defined in SMPTE ST 2094-1. Any number of the three sampled functions may be omitted. If any sampled function is omitted, the remaining sampled functions shall retain their mapping to the corresponding color components. If the first sampled function is omitted, it shall have a default value defined in SMPTE ST 2094-1. If the second sampled function is omitted, it shall have a default value defined in SMPTE ST 2094-1. If the third sampled function is omitted, it shall have the value of the second sampled function.

8 Application Constraints

8.1 Metadata Set

A metadata set shall comprise exactly one of each of the following:

- **ApplicationIdentifier** (= 3)
- **ApplicationVersion** (= 0)
- **TimeInterval**
- **ProcessingWindow**
- **TargetedSystemDisplay**
- **ColorVolumeTransform**

The **TimeInterval** group comprises the following metadata items, any of which may be omitted:

metadata items as defined in SMPTE ST 2094-1, where omitted items shall have the default value specified in Section 8.2:
TimeIntervalStart and
TimeIntervalDuration

The **ProcessingWindow** group comprises the following metadata items which shall be all omitted or all provided:

metadata items as defined in SMPTE ST 2094-1, where omitted items shall have the default values as specified in SMPTE ST 2094-1 and Section 8.3:
UpperLeftCorner;
LowerRightCorner; and
WindowNumber

The **TargetedSystemDisplay** group comprises the following metadata items, any of which may be omitted:

metadata items as defined in SMPTE ST 2094-1, where omitted items have the default value specified in Table 2:
TargetedSystemDisplayPrimaries;
TargetedSystemDisplayWhitePointChromaticity;
TargetedSystemDisplayMaximumLuminance; and
TargetedSystemDisplayMinimumLuminance
metadata item as defined in this document, which when omitted has the default value specified in Section 6.2:
TargetedSystemDisplaySignalFormat

The **ColorVolumeTransform** group comprises the following metadata items, any of which may be omitted:

metadata items as defined in this document, where omitted items have the default value specified in corresponding Sections 7.3 thru 7.6:
MetadataColorCodingWorkspace;
PreMatrixToneMapping;
ColorRemappingMatrix; and
PostMatrixToneMapping.

8.2 Time Interval Constraints

Where the metadata set is explicitly associated with at least one image, the default value of **TimeIntervalStart** shall be the first image with which the metadata set is explicitly associated, otherwise there is no default value and **TimeIntervalStart** shall be provided.

Where the metadata set is explicitly associated with at least one image, the default value of **TimeIntervalDuration** shall be the number of consecutive images with which the metadata set is explicitly associated, otherwise there is no default value and **TimeIntervalDuration** shall be provided.

8.3 Processing Window Constraints

For any given image, there shall be at most 3 metadata sets with identical **TargetedSystemDisplay** values. This corresponds to a maximum of 3 processing windows associated with any image. The following constraints apply to the **WindowNumbers** in such a group of metadata sets:

1. If the group has only one metadata set, or has metadata sets in a defined order: **WindowNumber** shall be either all provided or all omitted, and if omitted, the **WindowNumber** shall be zero for the first metadata set, 1 for a second, and 2 for a third,

2. Otherwise (if the group does not have metadata sets in a defined order): **WindowNumber** shall be all provided.

Where processing windows overlap, the pixels of the input image essence in the overlapping window area shall be processed with the applicable metadata set corresponding to the processing window having the highest **WindowNumber**.

Annex A Mapping of Application #3 to the generalized Color Volume Transform Model (Informative)

The diagram in Figure A.1 describes Application #3 Reference-based Color Volume Remapping in the framework of the generalized Color Volume Transform Model described in SMPTE ST 2094-1. The processing blocks applied by Reference-based Color Volume Remapping are Pre-Matrix Tone Mapping (1D LUT), Color Remapping Matrix (3x3 scalar), Offset, and Post-Matrix Tone Mapping (1D LUT).

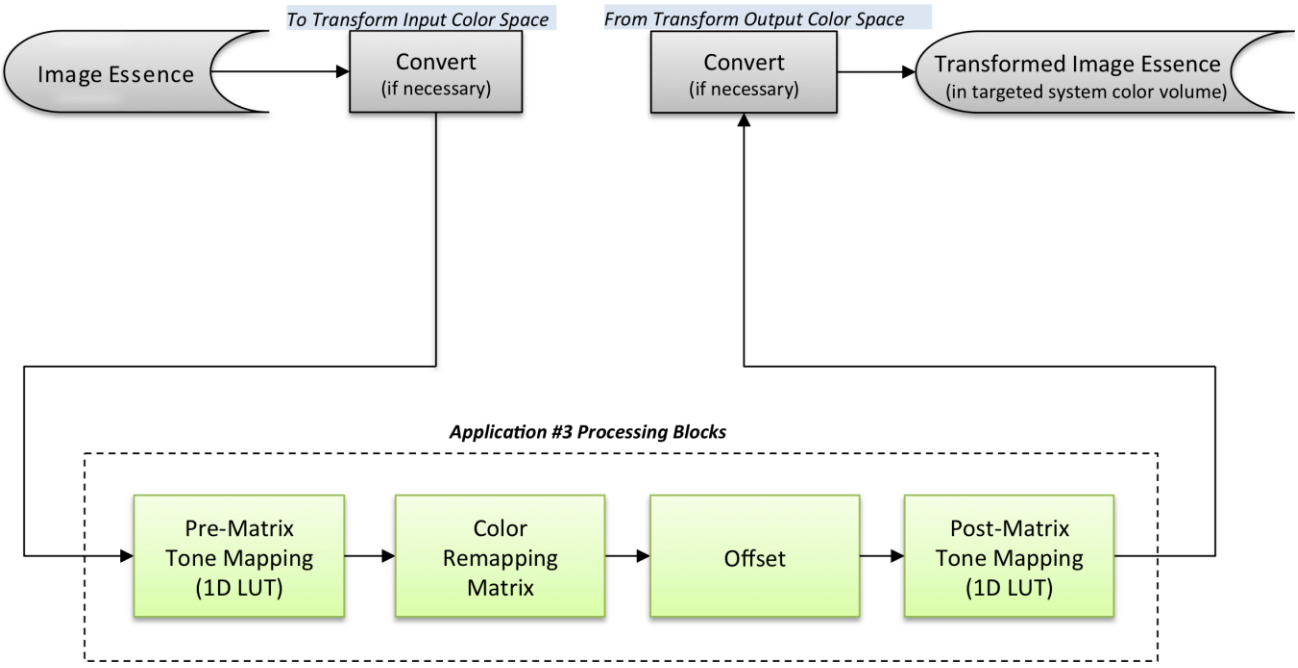

Figure A.1 – Processing blocks used by Reference-based Color Volume Remapping

Annex B Color Volume Transform Method Description (Informative)

This annex considers one metadata set as defined in Section 8.1. The color volume transform for Application #3 Reference-based Color Volume Remapping is applied directly to the color components of the input image essence when that essence is in the color encoding workspace specified by **MetadataColorCodingWorkspace** as defined in Section 7.3. If the input image essence is not in the color encoding workspace specified by **MetadataColorCodingWorkspace**, then that essence is converted to the specified color coding workspace prior to color volume transform processing.

MetadataColorCodingWorkspace is used to determine whether the input image essence must be converted to the transform input color space prior to color volume transform processing and provides limited support for such a pre-conversion when needed. Pre-conversion does not support altering the color primaries or white point and pre-conversion cannot alter the non-linear encoding. Pre-conversion between additive and color difference encodings are outside the scope of this document, but are described in Rec. ITU-R BT.709-6, Rec. ITU-R BT.2020-2, and SMPTE ST 2085.

In an initial step, the **PreMatrixToneMapping** (7.4) is applied to normalized component values *x*, for each component *i* ∈{0,1,2}:

$$y_i = f_i(x_i) \quad \text{(B.1)}$$

where:

y_i= **PreMatrixToneMapping** output value for component *i*
x_i= normalized component value for component *i*
$f_i(\,)$ = **PreMatrixToneMapping** sampled function for component *i*

In a second step, **ColorRemappingMatrix** (7.5) is applied on the output sample values y_i of (B.1) preceded and followed respectively by the subtraction and addition of an offset o_i:

$$m_i = \sum_j ((y_j - o_j) \times c_{i,j}) + o_i \quad \text{(B.2)}$$

where:

m_i= **ColorRemappingMatrix** output value for component *i*
$c_{i,j}$= coefficient value in **ColorRemappingMatrix** at position *(i,j)*
o_b = offset value for component *b*, with *o* derived from **MetadataColorCodingWorkspace** metadata as follows:

Table B.1 – Offset Values for Components, by MetadataColorCodingWorkspace

MetadataColorCodingWorkspace	o value
0, 2	{0, 0, 0}
1	$\{\frac{16D}{2^n-1}, \frac{16D}{2^n-1}, \frac{16D}{2^n-1}\}$
3	$\{\frac{16D}{2^n-1}, \frac{128D}{2^n-1}, \frac{128D}{2^n-1}\}$

In Table B.1, *n* is the component depth of the input image essence, D = 2^{n-8} and the offset values o_0, o_1, o_2 are provided as a triplet representing the three color components in the order defined in Section 7.2.

In a third and last step, **PostMatrixToneMapping** (Section 7.6) is applied to each **ColorRemappingMatrix** output value m_i, for each component *i* identically to (B.1):

$$z_i = g_i(m_i) \quad \text{(B.3)}$$

where:

z_i = **PostMatrixToneMapping** output value for component *i* (i.e. remapped sample value for component *i*)
$g_i(\,)$ = **PostMatrixToneMapping** sampled function for component *i*

$f_i(\,), g_i(\,), c_{i,j}$ data are determined by mapping the input image essence to a reference image essence that was made using a mastering display having the characteristics of the Targeted System.

A more robust implementation might clamp input values to be within the designated domain of functions such as $f_i(\,)$ and $g_i(\,)$, however metadata authoring systems might deliberately detect and fault on such out-of-domain conditions, to help ensure that only compliant metadata is produced.

Annex C Bibliography (Informative)

SMPTE RP 431-2:2011, D-Cinema Quality — Reference Projector and Environment

SMPTE ST 2085:2015, Y′D′$_Z$D′$_X$ Color-Difference Computations for High Dynamic Range X′Y′Z′ Signals

Recommendation ITU-T H.265 (04/2015), High Efficiency Video Coding