# TTML2 HDR Absolute Luminance Gain Attribute

## 1 Scope

This document specifies a TTML2 styling attribute that allows the luminance of a region to be controlled when compositing it onto images with a peak luminance level of up to 10,000 cd·m$^{-2}$.

## 2 Normative References

W3C Working Draft, Timed Text Markup Language 2 (TTML2). URL: http://www.w3.org/TR/ttml2/

## 3 Overview

TTML2 specifies colors using the sRGB colorspace, which uses a white point luminance of 80cd·m$^{-2}$. As a result, TTML2 documents cannot be reliably composited with high-dynamic range (HDR) images intended for display with significantly greater peak luminance, e.g. images that use the EOTF specified in SMPTE ST 2084. Specifically:

- TTML2 elements can appear too dim if they remains unscaled and the average luminance of the scene exceeds 80 cd·m$^{-2}$; and
- conversely, TTML2 elements can appear too bright if they are uniformly scaled to an arbitrary large luminance, say 10,000 cd·m$^{-2}$.

This document defines an `hdrAbsoluteLuminanceGain` attribute that allows the author to control the luminance of a region when compositing it onto HDR images.

## 4 Definition

The `hdrAbsoluteLuminanceGain` attribute shall conform to Table 1.

Table 1. **`hdrAbsoluteLuminanceGain`** attribute definition.

| | |
|---|---|
| **Namespace:** | `http://www.w3.org/ns/ttml#styling` |
| **Values:** | `hdrAbsoluteLuminanceGain : non-negative-number` |
| **Initial:** | 1 |
| **Applies to:** | region |
| **Inherited:** | no |
| **Percentages:** | N/A |
| **Animatable:** | discrete |

When compositing a region onto an image with a maximum peak luminance level of 10,000 cd·m$^{-2}$, the optical output value $(C_R \quad C_G \quad C_B)$ of the components of each pixel of a region shall be computed as follows:

$$(C_R \quad C_G \quad C_B) = 80\ \text{cd·m}^{-2} \cdot \texttt{hdrAbsoluteLuminanceGain} \cdot (r \quad g \quad b)$$

where $(r \quad g \quad b)$ are the normalized linear sRGB components of each pixel of the region, as rendered according to TTML2.

EXAMPLE: Given `hdrAbsoluteLuminanceGain="2"`, the optical output value of a rendered pixel with color rgb(218,165,32) is

$$(109.83 \quad 56.28 \quad 1.1)\text{cd·m}^{-2} \approx 80\ \text{cd·m}^{-2} \cdot 2 \cdot ((218/255)^{2.4} \quad (165/255)^{2.4} \quad (32/255)^{2.4})$$

The `hdrAbsoluteLuminanceGain` attribute may be specified by any element that permits use of attributes in the TT Style Namespace; however, the attribute applies as a style property only to those element types indicated in Table 1.

As illustrated in Annex A, and specified in Section 8.2.13 of TTML2, blending of a TTML2 document onto a target image is typically performed using pixel components encoded using the inverse EOTF of the target image, as opposed to pixel components expressed in linear light. As a result, the use of semi-transparent regions can yield perceptually different results depending on the inverse EOTF used by the target image, especially when there is a large luminance difference between the TTML2 document and the target image, e.g. video.

Authors should therefore carefully consider visual results involving semi-transparent elements.

## Annex A – Compositing Example

The following illustrates the use of `hdrAbsoluteLuminanceGain`. This example is strongly inspired from that described by Smith in "Ultra HD Blu-ray™ Format Video Characteristics."

1. Let $(r \quad g \quad b)$ be a full-range 8-bit sRGB pixel with opacity $a$ between 0 and 1.

2. Let $(R \quad G \quad B)$ and $(R_c \quad G_c \quad B_c)$ be full-range 10-bit pixels that use full-range quantization as specified in SMPTE RP 2077, colorimetry specified in ITU-T Rec. 2020 colorimetry and the EOTF specified in SMPTE ST 2084, with opacity $A$ and $A_c$ between 0 and 1.

3. Inverse the 8-bit full-range quantization:

$$(r \quad g \quad b)/255 \rightarrow (r \quad g \quad b)$$

4. Linearize using the sRGB EOTF:

$$(r^{2.4} \quad g^{2.4} \quad b^{2.4}) \rightarrow (r \quad g \quad b)$$

5. Compute HDR absolute luminance using the `hdrAbsoluteLuminanceGain` attribute and the sRGB illuminant:

$$80\ \text{cd·m}^{-2} \cdot \texttt{hdrAbsoluteLuminanceGain} \cdot (r \quad g \quad b) \rightarrow (r \quad g \quad b)$$

6. Convert from sRGB color space to BT.2020 color space:

$$\begin{pmatrix} 0.62740389593470 & 0.32928303837789 & 0.04331306568741 \\ 0.06909728935823 & 0.91954039507545 & 0.01136231556630 \\ 0.01639143887515 & 0.08801330787723 & 0.89559525324763 \end{pmatrix} \begin{pmatrix} r \\ g \\ b \end{pmatrix} \rightarrow (r \quad g \quad b)$$

7. Normalize to 10,000 cd·m$^{-2}$

$$(r \quad g \quad b)/10000 \text{ cd·m}^{-2} \rightarrow (r \quad g \quad b)$$

8. Apply SMPTE ST 2084 inverse EOTF

$$(PQ(r) \quad PQ(g) \quad PQ(b)) \rightarrow (r \quad g \quad b)$$

with $PQ(L) = [(\mathrm{c1} + \mathrm{c2} \cdot \mathrm{L}^{m1}) / (1 + \mathrm{c3} \cdot \mathrm{L}^{m1})]^{m2}$ and $m1$ = 0.1593017578125, $m2$ = 78.84375, $c1$ = 0.8359375, $c2$ = 18.8515625, and $c3$ = 18.6875.

9. Apply opacity

$$(1 - \mathrm{a}) \cdot (r \quad g \quad b) \rightarrow (r \quad g \quad b)$$

10. Apply 10-bit full-range quantization

$$(Q(r) \quad Q(g) \quad Q(b)) \rightarrow (r \quad g \quad b)$$

where $Q(N) = \mathrm{floor}(1023 \cdot N + 0.5)$

11. Composite to yield $(R_c \quad G_c \quad B_c)$

$$(\mathrm{clamp}(r + R) \quad \mathrm{clamp}(g + G) \quad \mathrm{clamp}(b + B)) \rightarrow (R_c \quad G_c \quad B_c)$$

$$1 + (1 - a)(A - 1) \rightarrow A_c$$

where

$$\mathrm{clamp}(x) = \begin{cases} x, & \text{if } x \in [0, 1023] \\ 1023, & \text{if } x > 1023 \end{cases}$$

# Bibliography

Smith, Michael D. "Ultra HD Blu-ray™ Format Video Characteristics." Proc. of SMPTE 2015 Annual Technical Conference & Exhibition, Los Angeles, CA

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

Recommendation ITU-R BT.2020 (08/2012), Parameter Values for Ultra-High Definition Television Systems for Production and International Programme Exchange

SMPTE RP 2077:2013, Full-Range Image Mapping

IEC 61966-2-1:1999, Multimedia systems and equipment - Colour measurement and management - Part 2-1: Colour management - Default RGB colour space - sRGB