# Design Changes from HDR10 Solution based on HDR10+ and China HDR Standard

## 1. HDR10+

Note: the design changes are based on SMPTE ST 2094-40:2020.

### 1.1 Processing Windows

* Multiple processing windows can be defined in ST 2094-1
* In ST 2094-40, processing windows can be as large as 3
  + Window 0 covers all pixels and is always present in the dynamic metadata
  + Window 1 & 2 can be present, and should be **eclipse-shaped** (exclusive to ST 2094-40)
* Design changes
  + We have to support multiple eclipse-shaped ROI for HDR tone mapping
  + Otherwise we ignore HDR10+ processing if there are multiple processing windows present

### 1.2 Luminance Parameters

* Several parameters are defined as an alternative to Bezier curve mapping and must be present in the dynamic metadata
* The tone mapping method based on the above parameters is **determined by vendor**
* Design changes
  + No change: we can **ignore these metadata** (MaxSCL, AverageMaxRGB, DistributionMaxRGB, and FractionBrightPixels) and only process HDR10+ data if Bezier-curve-related metadata is present

### 1.3 Bezier Curve Mapping

* No design change, but we have to use more general precision settings for 1D-LUTs related to PQ EOTF + tone mapper combination
  + Input LUT (X-axis of the tone mapping curve): consider uniform sampling on log scale linear RGB values (0 + ~ ), and use their inverse EOTF values as input

### 1.4 Color Saturation Mapping

* Design changes
  + We need to support conversion between linear RGB and Y’CbCr as the mapping is done on Cb & Cr channels
  + We need to support the computation (log) of color saturation gain s for each pixel:
    - : color saturation weight in the dynamic metadata
    - & in range [0, 10000] (computed parameters from dynamic metadata)
    - (input linear RGB) and (tonemapped linear RGB) are normalized to [0, 1]
    - : maximum sat gain allowed
* Note: in [A/341 Amendment, 2094-40](https://www.atsc.org/wp-content/uploads/2018/02/A341S34-1-582r4-A341-Amendment-2094-40.pdf) from ATSC, saturation mapping is disabled in all application versions 0 & 1 from ST 2094-40

### 1.5 Other Notes

* How to use current LUT to generate high-quality tone mapping curve based on Bezier curve?
  + Current design: EOTF and tone mapping curve are combined into one curve
* Regenerate LUT every frame, is that possible?

## 2. China HDR Standard (from CUVA)

TODO: input and output ranges for the LUTs need to be evaluated

### 2.1 Processing Windows

* Multiple processing windows (max: 3) can be defined (same as ST 2094-1)
* In the standard, it seems that **only 1 window** is used as no ROI coordination is specified in the dynamic metadata (see section 7.3)
* Design changes
  + Same with HDR10+: ignore dynamic metadata if num\_windows > 1

### 2.2 PQ HDR-to-HDR Display Adaption

#### 2.2.1 Base Curve Parameter Generation

* Involve computing various parameters based on dynamic metadata
* No design change: all operations can be done in SW

#### 2.2.2 Cubic Spline Parameter Generation

* Same as 2.2.1
* No design change: all operations can be done in SW

#### 2.2.3 Tone Mapping Procedure

* Tone mapper:
  + Case 1:
    - : -th pixel’s max nonlinear R’G’B’ channel
    - : tonemapped
    - ~ : parameters computed from dynamic metadata
  + Case 2:
    - ~ : parameters computed from dynamic metadata
  + Case 3:
    - ~ : parameters computed from dynamic metadata
* Tone mapping operation
  + Compute gain :
  + Tonemap input R’G’B’ for each channel:
    - Note: result is in linear RGB space (display light)
* Design changes
  + We need to support the polynomial operations (these do not need LUTs) in the case 3 of the above tone mapper
  + The 2 sets of LUTs in current design can be enough for tone mapping procedure alone
    - 1st set of LUTs are used specifically for PQ EOTF, and cannot combine EOTF with the tone mapping curve
    - 2nd set of LUTs are used to compute operations in the case 1 of the above tone mapper
    - Alternative solution for the 2nd set of LUTs: directly compute case 1 of the tone mapper instead of basic operation

#### 2.2.4 Color Correction Procedure

* Computation of color adjustment parameter
  + Case 1: or
    - ~ are parameters computed from dynamic metadata
  + Case 2:
    - is a parameter computed from dynamic metadata
* Design changes
  + Similar to color saturation mapping in ST 2094-40, we need to support conversion between Y’CbCr and R’G’B’
  + We need to support the case 1 above of computation
  + We need to **add one more set of LUTs** for the operations in case 2 of computation
    - Note: compute or ?

### 2.3 PQ HDR-to-SDR Display Adaption

* No design changes

### 2.4 Other Notes

* Output differences for PQ HDR-to-HDR and PQ HDR-to-SDR cases
  + In PQ HDR-to-HDR case, final output is tonemapped linear RGB signal
  + In PQ HDR-to-SDR case, final output seems to be tonemapped nonlinear R’G’B’ signal with applied SDR inverse EOTF
* No color space conversion in PQ HDR-to-SDR case: is that included in the color correction procedure?