UHD World Association
世界超高清视频产业联盟

Testing Criteria and Results for HDR-Vivid 1.0

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Testing Criteria and Results for HDR-Vivid 1.0

1 Scope

High Dynamic Range (HDR) technology has substantially extended the luminance range and color gamut of video systems. However, discrepancies between HDR formats (e.g., HLG and PQ) used in production and distribution, together with the varying peak luminance, contrast, and gamut characteristics of consumer displays, make it difficult to reproduce the intended appearance of source images across different displays. To address this issue, the HDR Vivid solution enables encoders to generate dynamic metadata for both HLG and PQ content, which is received and processed by set-top boxes to perform tone mapping adapted to the specific display in use. This UWA Technical Report describes the testing criteria and result for the mapping of HLG and PQ HDR images comparing the subjective quality performance with and without HDR Vivid metadata.

2 Terms and Definitions

Image Size
Measured horizontally and vertically. Unless stated otherwise, the image size in this document is assumed to be 3 840 x 2 160 pixels.

Frame Rate
The frame refresh frequency. Unless stated otherwise, the image frame rate in this document is assumed to be 50 progressing frames per second.

EOTF
Electronic to Optical Transfer Function, the transformation curves used for mapping between electrical image signals and a displays optical processing.

Bit Depth
The number of bits used to quantize each pixel of an image.

Colour Gamut
The range of colours that meets certain conditions in a chromaticity diagram or colour space.

Sampling ratio.
Luminance to chrominance sampling e.g. 4:4:4, 4:2:0, 4:2:2, …

Transformation Curve
The opto-electrical/electro-optical transfer functions when processing and image.

3 Test sequences

The sequences used for testing were chosen so to include different styles of video content, e.g., bright scene, dark scene, colour saturation, and high contrast.

Some of the test sequences used are defined in Report ITU-R BT.2245-10. Table 1 below shows the test sequences format. Table 2 shows the test sequences thumbnail and characteristics. They have rich brightness levels and high contrast, which are suitable for HDR tests.

TABLE 1
Test sequences format

No.	Item	Parameter
1	Image size	3 840 × 2 160
2	Frame rate	50 Hz
3	EOTF	HLG and PQ
4	Sampling ratio	YUV 4:2:2
5	Bit depth	10bit
6	Colourimetry	BT.2020
7	Duration	10s

TABLE 2
Thumbnails and characteristics of test sequences

No.	Name of Sequence	Characteristics	Thumbnail
1	Top of the mountain with snow	Average level of the image is high.	
2	Jade article	Rich Luminance levels	
3	A sightseeing boat in the night	Dark scene, Average level of the image is low.	
4	White clouds, hillside	Hillside in autumn with blue sky and white clouds	
5	Embroidery in the field	High saturation colours and Outdoor character skin colour	
6	Flowers	High saturation colours	

4 Tone mapping to an SDR display

4.1 Test process HLG

1) Devices and instruments

TABLE 3
Devices and instruments for the test of tone mapping to the SDR display

No.	Name	Device
1	Blackmagic DaVinci Resolve software	DaVinci Resolve STUDIO 19 (Version 19.1.4 BUILD 11 or later)
2	HEVC encoder	DangHong
3	Uncompressed Recorder	ABP
4	UHD-TV set-top box	China Mobile HIGH DEFINITION set-top box TBx1_2e-2
5	Consumer Display	TCL 98Q10K
6	TS analyser	R&S DVM400
7	Video workstation	HP Z840

2) Test stream generation and test setup

The HEVC encoder encodes the HLG input source clips and generates transport streams (TS) with and without HDR Vivid metadata. The streams are captured by the TS analyser. Figure 1 shows the details of the HLG clip stream with and without HDR Vivid.

Two ultra-high definition set-top boxes set to SDR mode receive the transport streams (one with and the other without HDR Vivid metadata). When HDR Vivid metadata is present, the set-top box performs HLG-to-SDR mapping in accordance with T/UWA 005.1-2022 Chapter 10. When HDR Vivid metadata is not present, the set-top box performs HLG-to-SDR mapping in accordance with T/UWA 005.1-2022 Chapter 11. The signals are decoded and displayed on two consumer televisions simultaneously to allow subjective comparisons to be carried out.

To implement the HDR to SDR conversion, the HDR Vivid standard incorporates two sets of dynamic metadata. One set can be used to perform tone mapping from HDR to HDR for the PQ to HLG formats. The second set of dynamic metadata supports the direct conversion of PQ or HLG formatted HDR signals, to SDR.

The test system used an uncompressed recorder to capture signals from the two set-top boxes and DaVinci Resolve was used to analyze waveforms and Colour Gamut as detailed in Figure 2.

FIGURE 1
Stream generation of HLG Clips with or without HDR Vivid

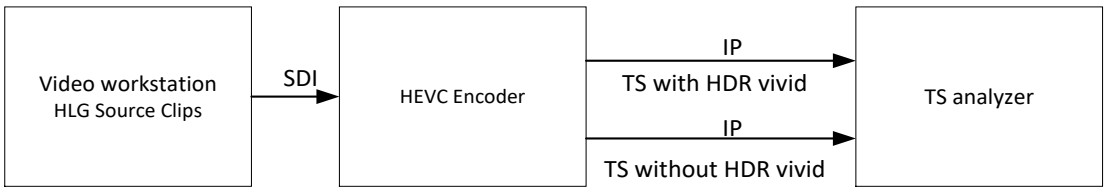
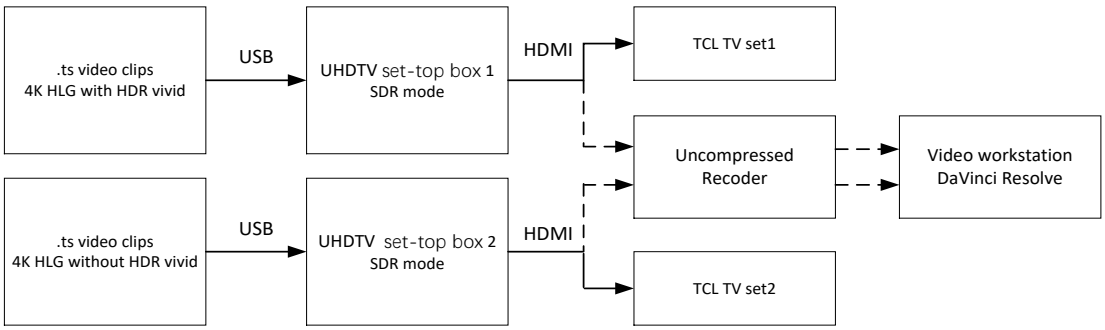


FIGURE 2
HLG tone mapping to SDR test

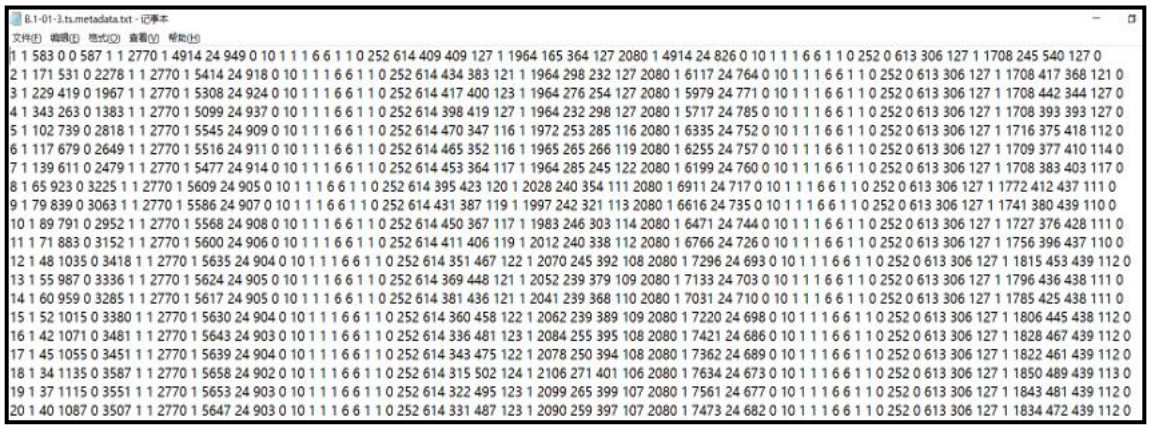


4.1.1 HDR Vivid metadata analysis results

The HDR Vivid metadata extraction tool[1] can analyze the transport stream and view metadata information. An example of the HDR Vivid metadata data is shown in Figure 3.

Analysing the output stream files without metadata (using the ffmpeg tool recommended by UWA), it can be seen that the metadata information complies with the T/UWA 005.1.

FIGURE 3
HDR Vivid metadata extracted by the tool (vivid_data-v0.9.4. exe)



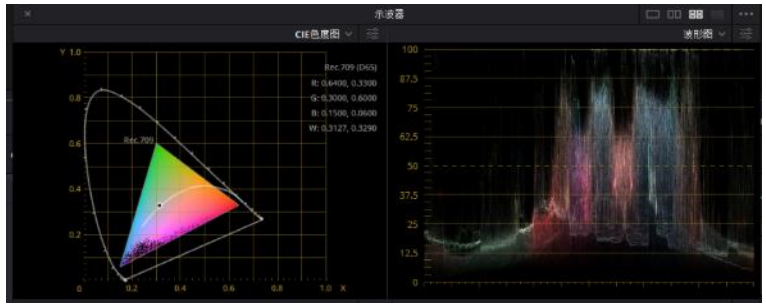
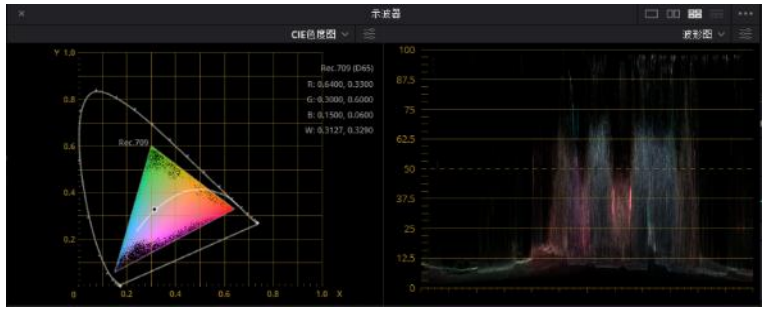
[1] The metadata extraction tool is available from https://theuwa.com/tech/hdrvivid/vividmetadata_v0.9.4_for_windows.zip, https://theuwa.com/tech/hdrvivid/vividmetadata_v0.9.4_MacOS.tar.gz, https://theuwa.com/tech/hdrvivid/vividmetadata_v0.9.4_Linux.tar.gz, and is available in Windows, macOS and Linux versions.

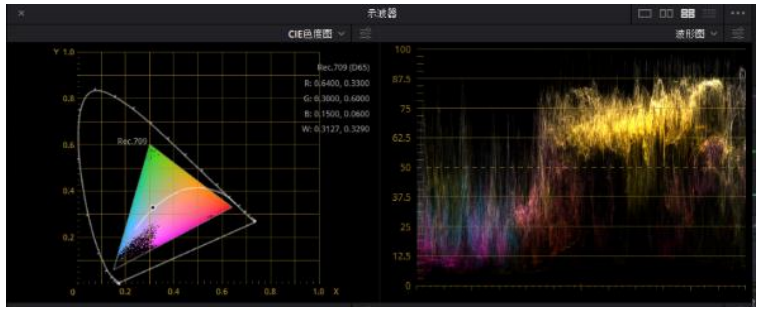
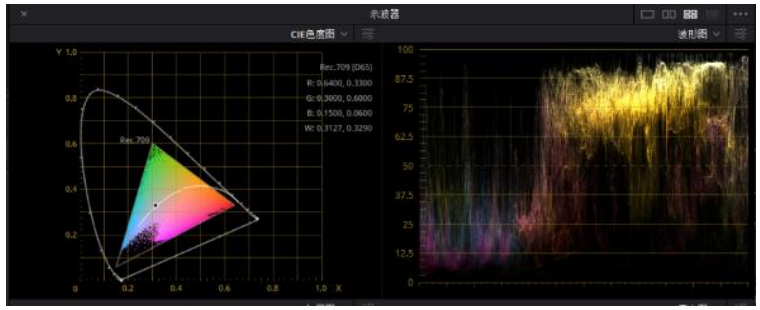
4.1.2 Test results HLG

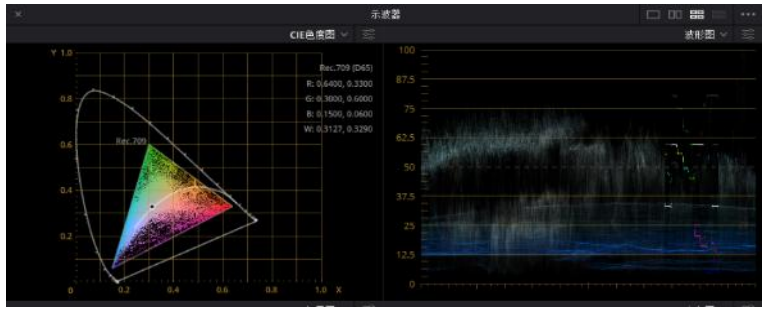
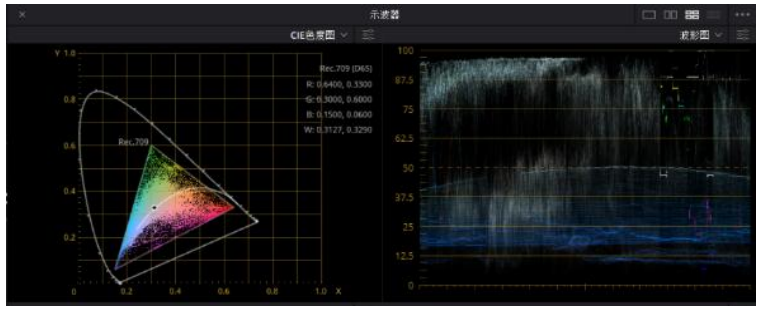
3) Waveforms and Colour Gamut testing results

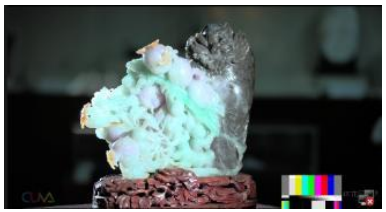
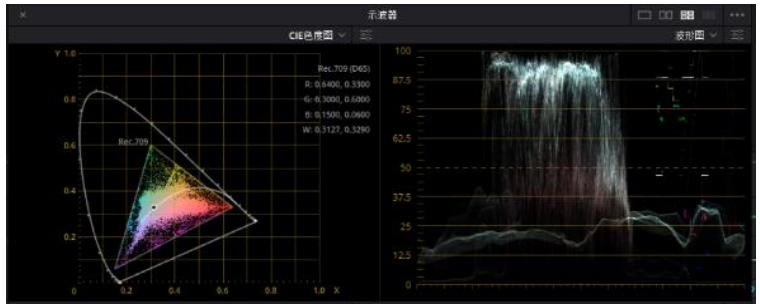
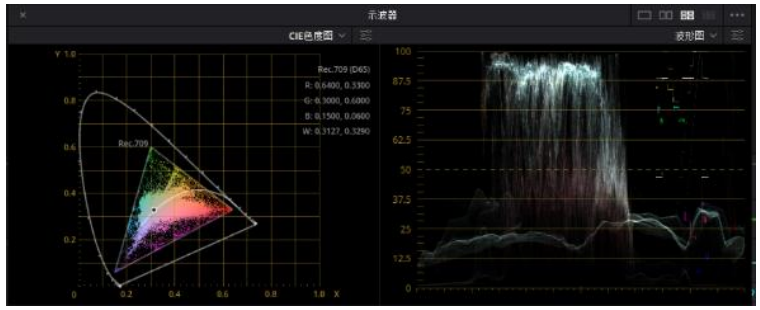
Multiple video clips from different scenes were selected for testing. The test results are as follows:

TABLE 4
Results of tests HLG mapping with and without HDR Vivid metadata

No.	Name of Sequence	Thumbnail	HDR Vivid	Da Vinci analysis results	Image
1	A sightseeing boat in the night		Yes		The overall brightness of the image is good. The high saturation colour reproduction is good. The dark layers are still visible
2			No		The brightness of the image becomes darker. Lost a significant number of layers.

No.	Name of Sequence	Thumbnail	HDR Vivid	Da Vinci analysis results	Image
3	Flowers		Yes		The overall brightness of the image is good. The high saturation colour reproduction is good. The definition and layers are still visible.
4			No		Overexposure at maximum brightness. Lost most of the layers.

No.	Name of Sequence	Thumbnail	HDR Vivid	Da Vinci analysis results	Image
5	Top of the mountain with snow		Yes		The overall brightness of the image is good. The high layers are still visible.
6			No		The overall brightness of the image is too high. The highlighted areas are overexposure.

No.	Name of Sequence	Thumbnail	HDR Vivid	Da Vinci analysis results	Image
7	Jade article		Yes		The overall brightness of the image is good. The definition and layers are still visible.
8			No		Most of the level information in the image is lost, which affects the clarity of the image.

4) TV display images testing results

Two identical consumer televisions setup to their default HDR mode were used side by side, as detailed in Figure 4. The image displayed on the left is without HDR Vivid metadata. The image displayed on the right is with HDR Vivid metadata.

FIGURE 4

A comparison of subjective evaluation results for various scenarios displayed on TCL TVs



4.1.3 Summary

After testing, HLG test clips with HDR Vivid metadata, when adapted by a set-top box, it was possible to produces images that were closer to the creative intent source.

4.2 Test process PQ

1) Devices and instruments

TABLE 5
Devices and instruments for the test of tone mapping to the Near HDR display

No.	Name	Model
1	Blackmagic DaVinci Resolve software	DaVinci Resolve STUDIO 19 (Version 19.1.4 BUILD 11 or later)
2	HEVC encoder	DangHong
3	Uncompressed Recorder	ABP
4	UHDTV set-top box	China Mobile HIGH DEFINITION set-top box TBx1_2e-2
5	TV set	LG OLED65G6P
6	TS analyser	R&S DVM400
7	Video workstation	HP Z840

2) Test stream generation and test setup

The HEVC encoder encodes the PQ input source clips and generates transport streams (TS) with and without HDR Vivid metadata. The streams are captured by the TS analyser. Figure 5 shows the details of the PQ clip stream with and without HDR Vivid.

Two ultra-high definition set-top boxes set to HDR 10 mode, receive the transport streams with and without HDR Vivid metadata. The signals are decoded and displayed on two consumer television sets simultaneously to allow subjective comparisons to be carried out. The Max Luminance of the display was 500 cd/m^2.

The test system used an uncompressed recorder to capture signals from the two set-top boxes and DaVinci Resolve was used to analyze waveforms and Colour Gamut as detailed in Figure 6.

FIGURE 5
Stream generation of PQ Clips with or without HDR Vivid

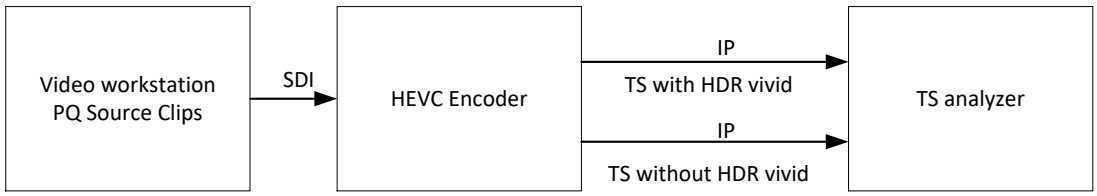
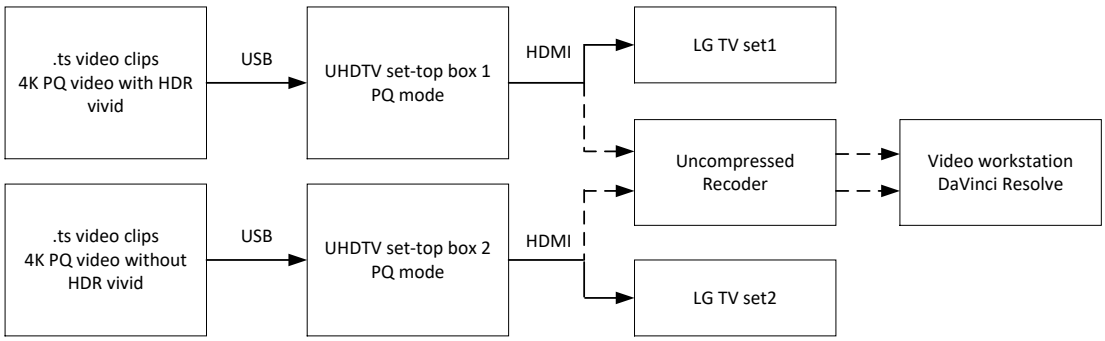


FIGURE 6
PQ tone mapping to near HDR test



4.2.1 HDR Vivid metadata analysis results

The HDR Vivid metadata extraction tool[2] can analyze the transport stream and view metadata information. An example of the HDR Vivid metadata data is shown in Figure 7.

Analysing the output stream files without metadata (using the ffmpeg tool recommended by UWA), it can be seen that the metadata information complies with the T/UWA 005.1.

FIGURE 7
HDR Vivid metadata extracted by the tool (vivid_data-v0.9.4. exe)

PQ1000_uncompressed+danghong(PQ+VIVID)22.ts.metadata.txt - 记事本
文件(F) 编辑(E) 格式(O) 查看(V) 帮助(H)

```
1 1 0 1538 1383 2957 1 0 2770 1 7372 24 818 122 10 1 1 1 6 6 1 1 0 244 40 613 777 118 2 0 1556 689 689 151 1 2 38 24
2 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
3 1 0 1540 1387 2957 1 0 2770 1 7372 24 818 122 10 1 1 1 6 6 1 1 0 244 40 613 777 118 2 0 1556 690 690 151 1 2 38 24
4 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
5 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
6 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
7 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
8 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
9 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
10 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
11 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
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13 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
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16 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
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18 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
19 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
20 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
21 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
22 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
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24 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
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26 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
27 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
28 1 0 2276 2335 3071 1 0 2770 1 7372 24 818 0 10 1 1 1 6 6 1 1 0 236 40 613 777 127 2 0 1556 749 749 157 1 2 38 24
```

[2] The metadata extraction tool is available from https://theuwa.com/tech/hdrvivid/vividmetadata_v0.9.4_for_windows.zip, https://theuwa.com/tech/hdrvivid/vividmetadata_v0.9.4_MacOS.tar.gz, https://theuwa.com/tech/hdrvivid/vividmetadata_v0.9.4_Linux.tar.gz, and is available in Windows, macOS and Linux versions.

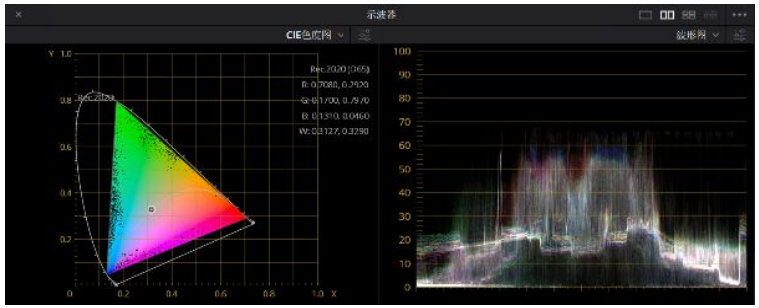
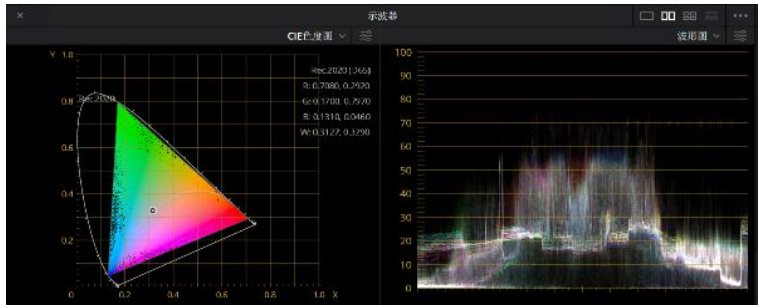
4.2.2 Test results

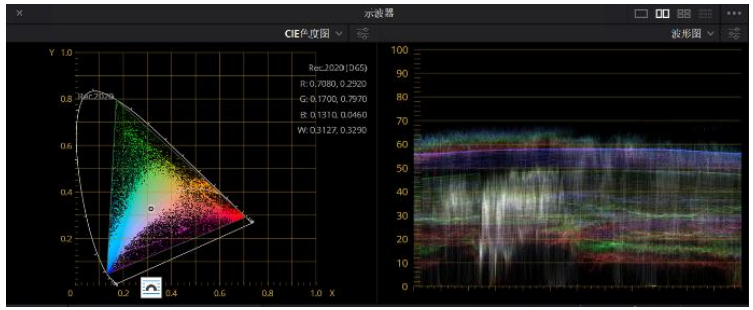
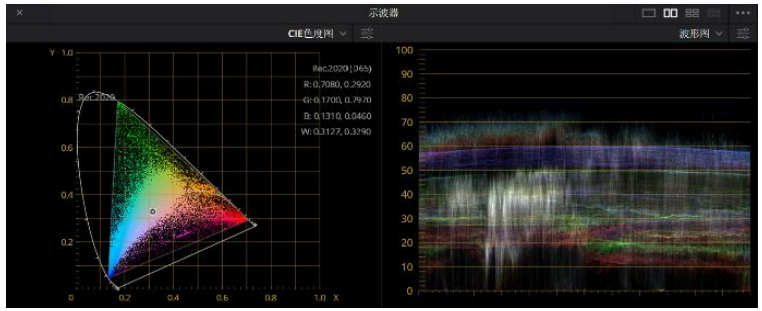
3) Waveforms and Colour Gamut testing results

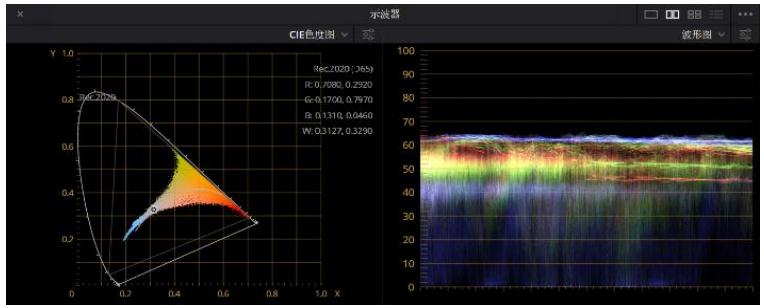
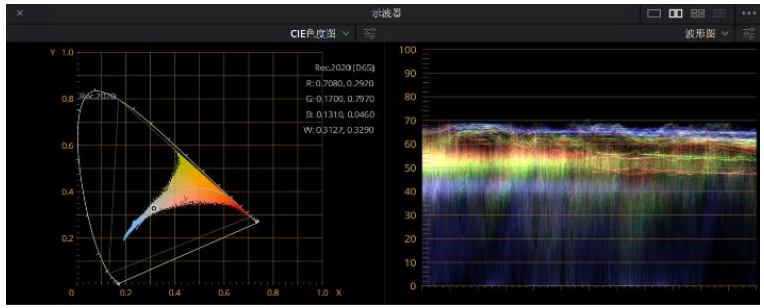
Multiple video clips from different scenes were selected for testing. The test results are as follows:

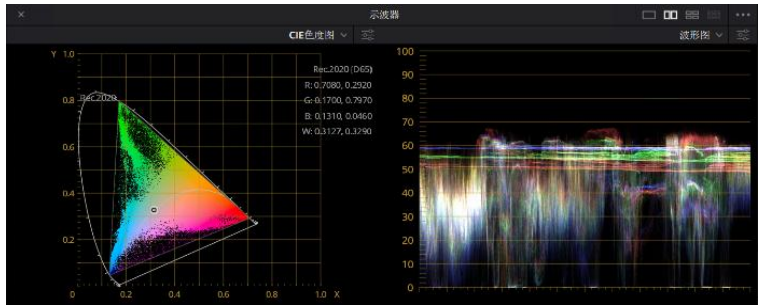
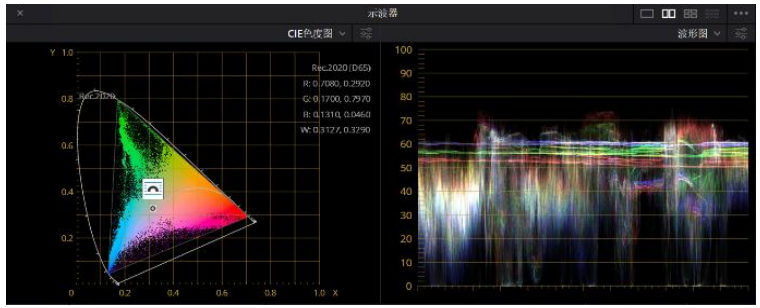
TABLE 6

Results of tests PQ mapping with and without HDR Vivid metadata

No.	Name of Sequence	Thumbnail	HDR Vivid	Da Vinci analysis results	Image
1	A sightseeing boat in the night		Yes		The brightness layers are still visible. The darker details are still visible.
2			No		The brightness of the image becomes darker. The dark details are still visible

No.	Name of Sequence	Thumbnail	HDR Vivid	Da Vinci analysis results	Image
3	Top of the mountain with snow		Yes		The overall luminance layer of the image is good. The detail in brighter areas is still visible.
4			No		The highlight areas are overexposed.

No.	Name of Sequence	Thumbnail	HDR Vivid	Da Vinci analysis results	Image
5	White clouds, hillside		Yes		The overall brightness of the image is good. The detail in brighter areas is still visible.
6			No		The highlight areas are overexposure.

No.	Name of Sequence	Thumbnail	HDR Vivid	Da Vinci analysis results	Image
7	Embroidery in the field		Yes		The overall brightness of the image is good. The high saturation colour reproduction is good. The definition and detail is still visible
8			No		The overall brightness of the image is too high. The highlighted areas are overexposure.

4) TV display images testing results

Two identical consumer televisions setup to their default HDR mode were used side by side, as detailed in Figure 8. The image displayed on the left is without HDR Vivid metadata. The image displayed on the right is with HDR Vivid metadata.

FIGURE 8

A comparison of subjective evaluation results for various scenarios displayed on LG TVs



4.2.3 Summary

After testing, PQ clips with HDR Vivid metadata, when adapted by a set-top box, displayed on a consumer televisoin with a maximum brightness of 500 cd/m^2, it was possible to produces images that were closer to the creative intent source.

5 Conclusion

It is possible for encoders to generate HDR Vivid metadata of both HLG and PQ content which can be received and processed by set-top boxes, tone mapping images to the display used. Images processed with HDR Vivid mapping to the display appear better, reproduced with greater accuracy and closer to the source images than those without HDR Vivid metadata.