EBU

OPERATING EUROVISION AND EURORADIO

TR 070

EBU HDR WORKSHOP 2022 – FREQUENTLY ASKED QUESTIONS

TECHNICAL REPORT

Geneva
August 2022

This page is intentionally left blank

Preamble

The EBU HDR Implementation Task Force [1] organized an HDR workshop at the German broadcaster SWR from 16-20 May 2022 [2]. Prior to the workshop, in March 2022, three preparatory HDR production webinars were convened [3][4][5].

Figure 1 Part of the set-up used at the EBU HDR Workshop at SWR in May 2022

This report distils the main issues that emerged from attendees at the workshop and its preparatory webinars, setting them out as a series of frequently asked questions (FAQ) and their corresponding answers, that should prove informative for those embarking on High Dynamic Range (HDR) production.

Note that related acronyms and abbreviations can be found at: https://tech.ebu.ch/uhdtv/glossary

Contents

EBU HDR Workshop 2022 - FAQs

EBU Committee	First Issued	Revised	Re-issued
TC	2022		

Keywords: High Dynamic Range, HDR, HLG, SDR, S-Log3, OETF, EOTF

1. Which production formats are in use for live production?

The broadcasters that took part in the webinars [3][4][5].(and major host broadcasters such as HBS and OBS) have, following extensive experimentation, settled on scene-referred systems, either HLG (BBC, HBS, NBC Universal, OBS, Sky) or S-Log3 (BT Sport).

By shading HDR cameras in SDR via a down-mapper, these offer operational staff a similar workflow to conventional SDR BT.709 productions. As the camera OETF has primacy, they allow simple and accurate transforms for matching camera systems from a different video format.

2. What about metadata?

For HLG based live productions, metadata is not created in the live production process, but some proprietary equipment does exist that may be used to add static or dynamic metadata at the distribution point. The EBU has not tested this. At the workshop it was suggested that it should be proved useful by technology proponents for the distribution targets you are interested in (e.g. range of screens, range of viewing conditions), before being deployed. HLG is widely used in distribution without metadata (e.g. BBC iPlayer, Sky Europe).

There is at least one proprietary HDR production format (S-Log3) that passes camera data between the camera control unit and converters. Such systems usually require all video processing equipment to be from a single manufacturer.

3. Do I have to have the same HDR format for production and distribution?

No, at the workshop [2] we showed that visually lossless, display-referred, cross-conversion between HLG and PQ is possible in accordance with the ITU's guideline method and with Sony's S-Log3 using a proprietary converter.

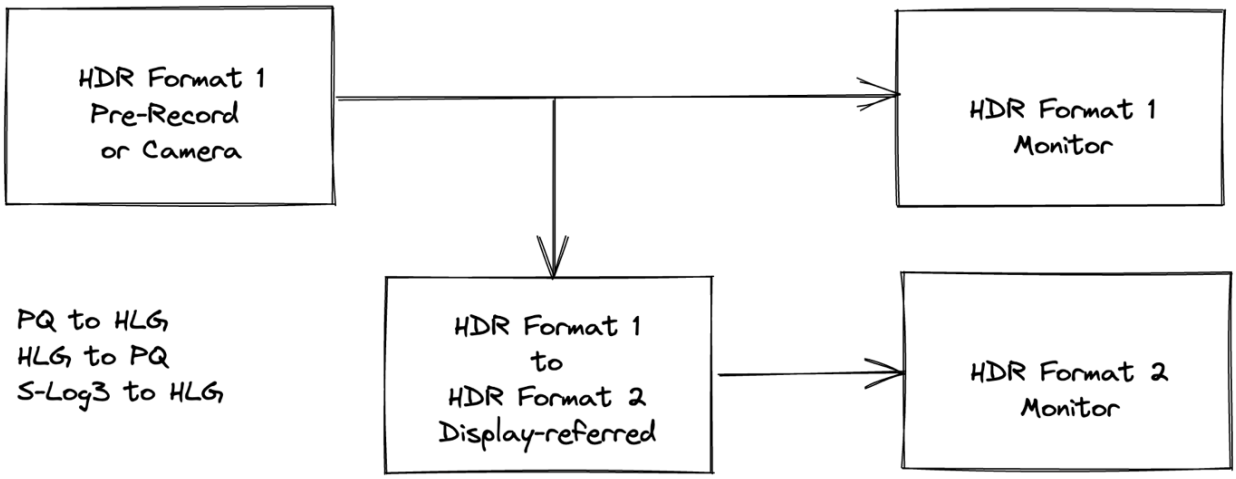

Figure 2

In the conversions shown at the event, a 1000 cd/m^2 bridge point was used (as that is what is given in the ITU-R guidelines and as it was the nominal peak brightness of the display used), however as HLG is a relative system, it can be scaled to any peak brightness, using the HLG OOTF formulas provided in ITU-R BT.2100 [6], if a different bridge condition is required, e.g. if a Digital Cinema deliverable is required.

In the webinars prior to the event, both NBC Universal [3] and BT Sport [4] showed that their final distribution format did not match their production format.

4. Two broad types of conversion were mentioned in the workshop, can you expand on this a bit?

Different HDR and SDR formats have different native looks.

There are two types of conversion between formats:

1. **Scene-referred** – converts the source format camera feed to have the same look as a target format camera pointed at the same scene (as closely as possible). These are mainly used for camera feeds.

2. **Display-referred** – converts a feed from source format to target format maintaining the colour and look of the source format (as closely as possible). These are used to add pre-recorded SDR content, graphics etc. to an HDR programme feed and to create an SDR programme feed from the HDR programme feed.

5. Can I use SDR Cameras?

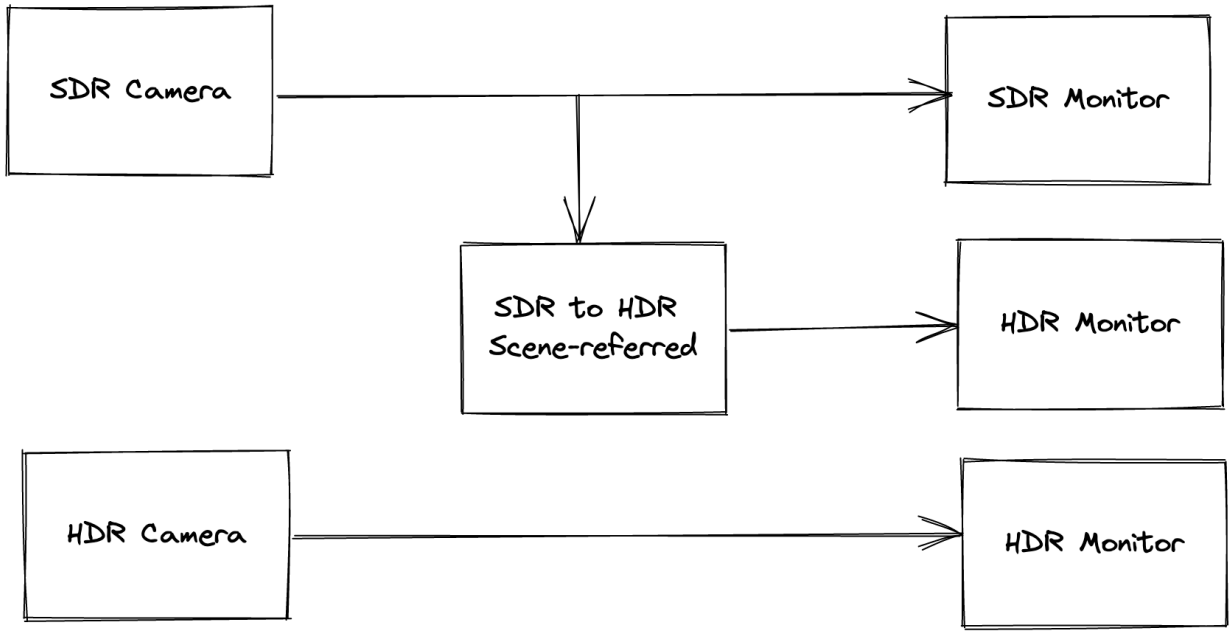

Figure 3

Yes, using a scene-referred conversion will create a signal with the same look as a camera set to the target HDR format (but obviously without the extended highlights or wide colour gamut). This camera can be intercut easily into an HDR programme feed, but colours outside the BT.709 gamut may change across the cut boundary.

Some transforms add a highlight boost to the SDR camera, to better match HDR cameras. If you are using a quality SDR camera and have full control, then this is an artistic choice you could use.

6. Can I use SDR archive content, action replays, graphics etc.?

Yes, using a display-referred conversion will accurately match the colours of the pre-produced original SDR content when converted and used in the HDR programme feed. The HDR Reference White Level for insertion of SDR and graphics is recommended by the ITU to be 75% for HLG.

A simpler workflow and better results for action replays will be attained by running the replay server, and any attached editing systems in HDR mode.

Graphics are currently all SDR (or at least that's what the metadata says). However, recently PNG and other graphics formats have adopted the signalling technique that ITU-T standardised for video [7]. We expect HDR image formats and VR/AR rendering software that utilises the new signalling to appear soon.

7. What about tetrahedral vs trilinear?

Use transform hardware with tetrahedral interpolators. NBC Universal has shown that trilinear is not good enough for broadcast and adds "ripples" to luminance ramps, which will appear as artefacts in highlights of real video.

8. How do we make the HD SDR programme feed?

You can use a display-referred conversion between HDR and SDR which should give a similar perceptual look to shadows and midtones and compress the HDR highlights to fit within the SDR

image. Colours outside the capability of the HD BT.709 system will be mapped to a colour that it can display.

One item to remember is that this conversion reduces the local contrast in the image (and thus, perceived sharpness), you may need to add some edge enhancement to the SDR signal after conversion.

9. Does this affect SDR viewers?

The down mapped SDR pictures should have both better highlight reproduction and better out of gamut colour handling than pictures from a traditional SDR camera that typically clips in the luminance and chrominance domains. The SDR picture will not look as good as an HDR picture, but it will maintain details and colour gradations that would normally be lost in an SDR camera output.

The HDR highlights can be compressed into the top of the SDR signal range, with the SDR image being very slightly darker than a traditional SDR image to create space for these compressed highlights. By using EBU R 103 [8] preferred signal ranges (up to 105%), only a very small portion of the nominal SDR range needs to be reserved for this and the viewer should not be aware of any brightness differences, especially as side-by-side comparison is not available.

10. Do we need a lot of HDR monitors?

No, you may need as few as one. The cameras are being shaded looking at the SDR down-mapping, and non-critical monitoring can be done on TVs or SDR monitors. If ITU-R BT.2020 [9] capable SDR monitoring is available, the backwards compatible nature of an HLG signal can be used. Colours, shadows and midtones will look correct if the ITU-R BT.2020 SDR display gamma is set to 2.2.

Care should be taken when positioning the HDR reference monitor in relation to other monitors to prevent light spill on to the SDR monitors and to ensure that it does not affect the adaptation state of SDR operators' eyes.

11. Can we cut down on the number of these transform boxes needed?

Yes. Most cameras can have HDR on both the 2160p/50 and 1080p/50 outputs, so the 1080p/50 can be used for camera shading, action replays, and monitoring in production areas. The 2160p/50 is used for the main programme feed into the mixer.

It should also be noted that many new mixers, monitors, etc., now have built in conversion technology; separate boxes are not always needed.

For non-critical viewing, or for camera shading when you have very good control of the lighting conditions within the scene, an SDR BT.2020 monitor with a gamma of 2.2 can be used to monitor a BT.2100 HLG video signal. This can be used for multi-viewers, directors' monitors, contribution link monitoring, etc.

12 How do we control cameras?

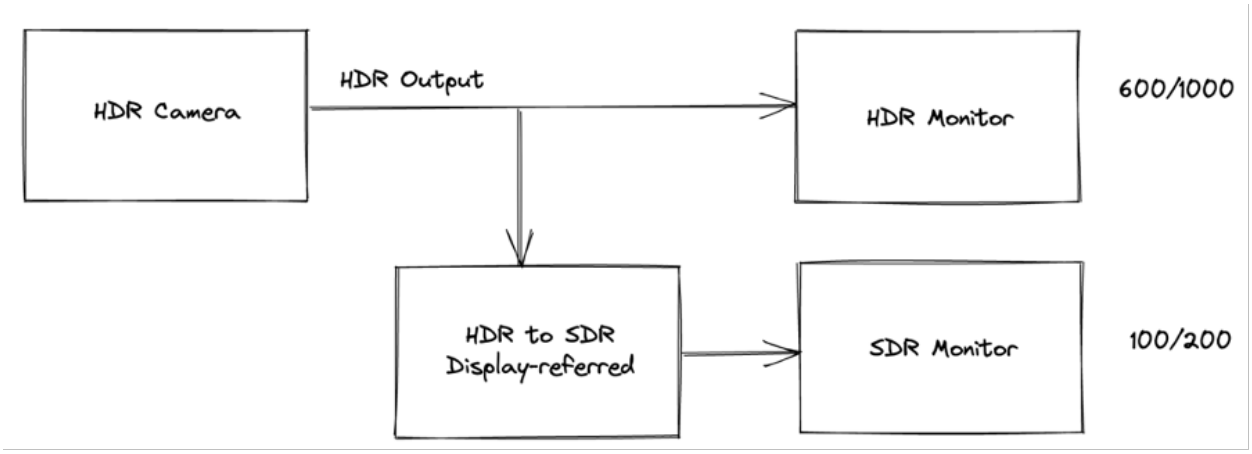

Figure 4

The major output for most broadcasters is still the SDR HD programme feed. To ensure the quality of this feed, it is common practice at the moment to use SDR monitors at the camera control stations and to feed these via the same down-mapper that is being used to create the SDR programme stream. This is sometimes referred to as "closed loop" shading.

Should there be a need to use HDR and SDR monitors in close proximity, it may be useful to align their luminance levels. There are two choices for this: either increasing the SDR reference monitor contrast to approximately 200 cd/m^2 or reducing the HDR monitor contrast to approximately 600 cd/m^2 and changing the HLG system gamma in the display to a value of 1.1. Both will align the diffuse white in the HDR and SDR images.

If shading is carried out using waveform monitors to ensure technical compliance, then some of the information below is less relevant, however, the dominant practice is to shade visually and therefore this information is important. Two important questions present themselves:

What are the advantages and disadvantages of decreasing HDR monitor contrast to 600 cd/m^2 whilst maintaining SDR at 100 cd/m^2?

Advantages:

1. Closer alignment of luminance level between SDR and HDR.
2. More comfortable viewing level for production staff using (HDR or SDR) monitors for an extended period of time.
3. Potentially a better luminance level for working in dark, lighting-controlled environments.
4. Allows for super-whites (>100% HLG) to be resolved and displayed by a 1000 cd/m^2 monitor; a picture range that would ordinarily not be monitored anywhere.
5. Maintains compliance with ITU-R Recommendation BT.2035 [10] for SDR programme production, and hence all previously created HD programme feeds.

Disadvantages:

1. Monitor setups using auto detection of VPID will need to be tested to ensure they don't change contrast or system gamma settings.

2. Operators need to be aware of this workflow and to expect darker pictures than they may have seen previously on the HDR monitor, however the eye will quickly adapt to the lower nominal peak luminance.

What are the advantages and disadvantages of increasing SDR monitor contrast to 200 cd/m^2 whilst maintaining HDR at 1000 cd/m^2?

Advantages:

1. Closer alignment of luminance level between SDR and HDR.

2. Possibly closer alignment to domestic televisions (depending on processing undertaken within the television).

Disadvantages:

1. Monitor setups using auto detection of VPID will need to be tested to ensure they don't change contrast or system gamma settings.

2. There may be viewer discomfort for production staff when viewing (HDR or SDR) monitors for any prolonged period of time.

3. Operators need to be aware of this workflow and to expect brighter pictures on the SDR monitor

4. Does not maintain compliance with ITU-R Recommendation BT.2035 and may lead to different luminance levels in the SDR signal to previously created HD programme feeds. Mid-tones in 200 cd/m^2 SDR content may have a lower signal level than the equivalent mid-tones in 100 cd/m^2 SDR content.

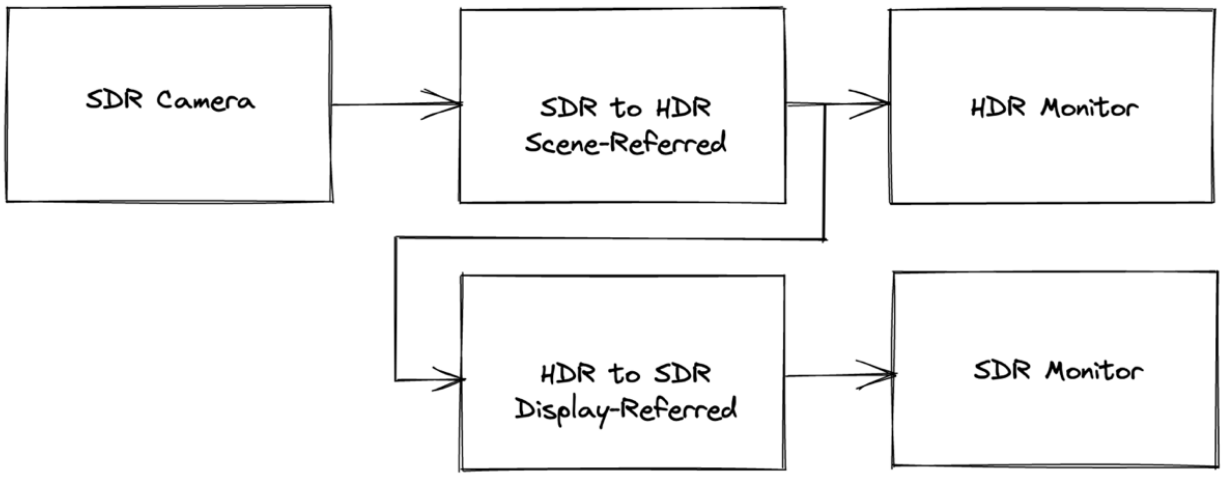

Figure 4: SDR Cameras

When using SDR cameras, the camera signal should be converted to HDR first, before being sent to the camera control station. The SDR output of the camera CCU should not be used directly, as it will look different from the main SDR programme feed. This approach ensures that the signal that the camera operator sees matches the signal that is viewed in the home. Also, as all camera feeds are either native HDR or converted to HDR, every camera control station is configured so that it can control every camera in use. There is no confusion between HDR and SDR camera control stations or misrouting of signals.

Care needs to be taken with HDR camera viewfinders. On some types of viewfinder, only the camera's internally generated SDR output can be used. This can be a particular problem on certain sports such as golf and cricket where a camera operator may need to track a ball through the sky or in situations where focus must be maintained in darker areas of the image which may be difficult to view due to a poor match in black level between HDR and the camera-generated SDR. Care must be taken to ensure the usability of the SDR signal from the camera is maintained to a level that is suitable for the operator, for example by using a "hypergamma" setting which will attempt to maintain highlights. This does not need to match the quality of the down-mapping used for broadcast.

13. What are the differences between down-mappers?

When considering HDR signals, some colours will be too bright or too saturated (or both) to be displayed on an HD BT.709 system monitor. Designers will have chosen a method to either darken, desaturate, or alter the hue of colours to fit within the BT.709 capability whilst maintaining as far as possible the colours already within the BT.709 colour volume. They will also have designed differing tone mappings to try and keep some highlight detail – some will be more aggressive; some may allow some highlights to "blow out", etc.

Two different approaches have emerged for the handling of mid-tones and shadows within HDR to SDR down-mapping. One approach applies a linear scaling of the displayed luminance from the HDR to SDR signal range, the other applies a non-linear scaling taking account of the non-linear response of the human visual system.

Problems can arise if you use an HDR feed from a third party who uses a different approach in down-mapping in their production. The look of your down-mapped SDR video stream may either be too dark or too bright, depending on which LUTs are in use and where.

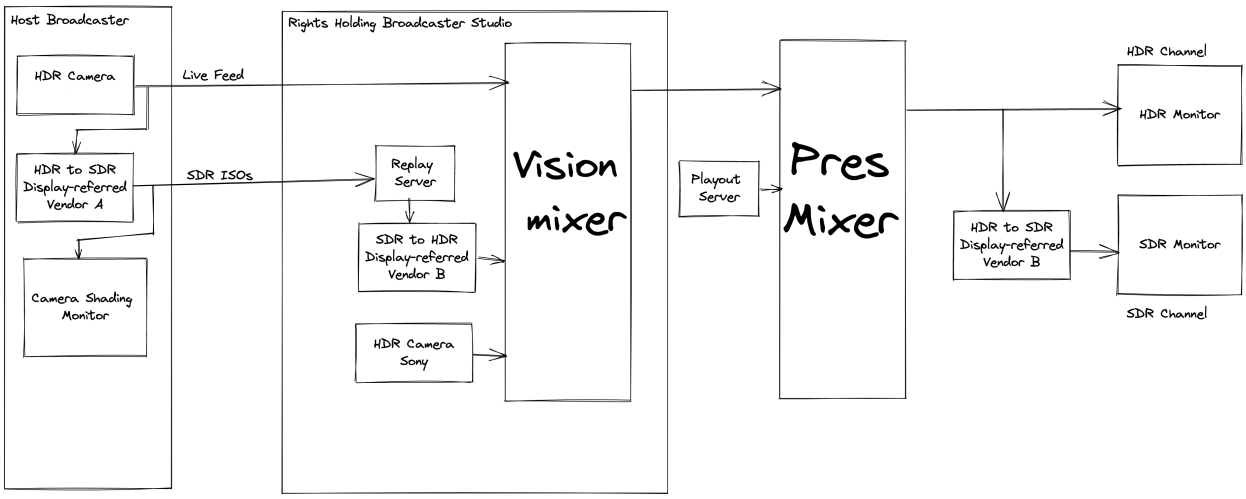

Figure 5

There will also be some differences between hardware implementations. Implementations that use tetrahedral interpolators and that work correctly for nominal range signals (as defined in EBU R 103 [8]) whilst processing the entire video range without clipping, are preferred.

14. Is there an EBU Model Workflow?

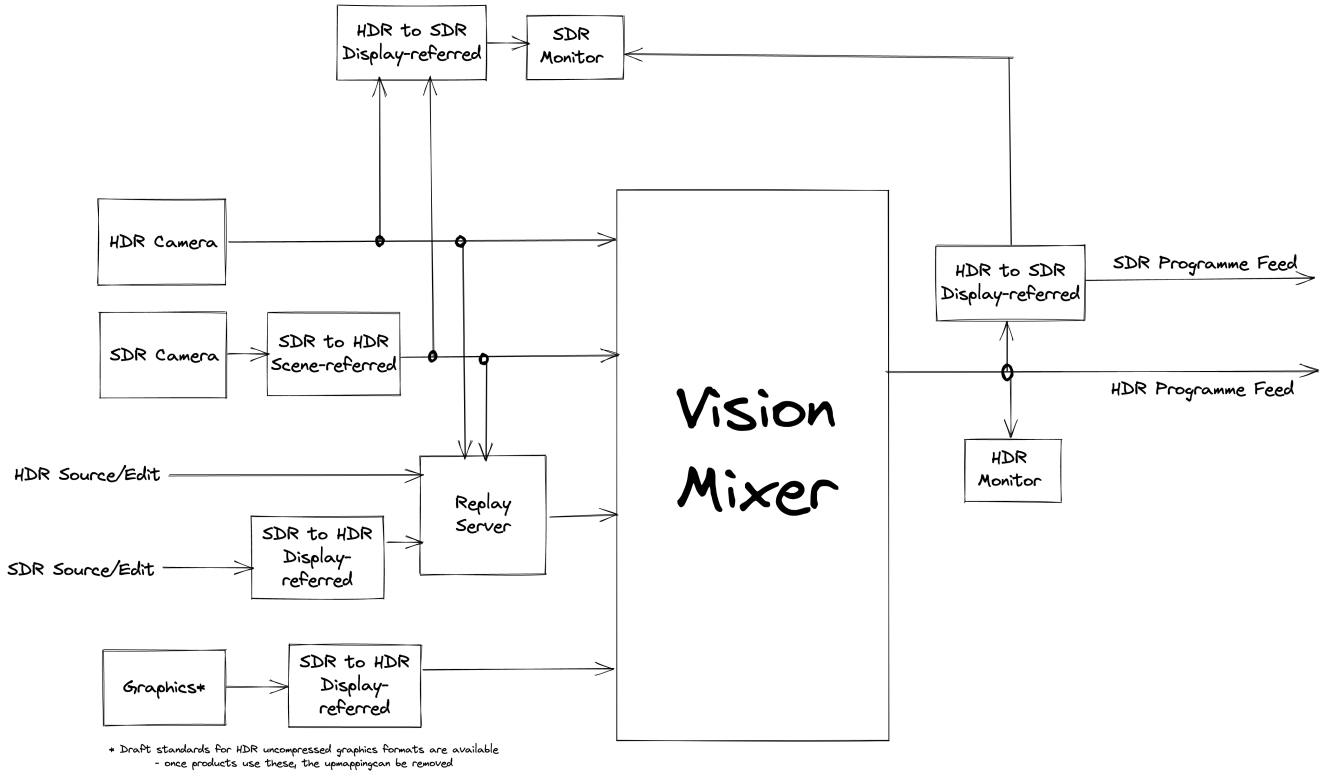

Figure 6

This is the model workflow for a small production. The vision mixer is running in HDR mode and as much equipment as possible should use HDR. As discussed previously, many modern vision mixers and broadcast monitors already have conversion technology built-in – you may not need separate devices. The density of conversions per rack unit is increasing and cameras are also appearing on the market with the LUT-based technology built in, so the SDR output is a down-map of the HDR rather than a completely separately controlled output.

Graphics and pre-recorded, graded content should use direct-mapping. High quality, controlled SDR cameras may use up-mapping. Lower quality or uncontrolled SDR cameras should be direct-mapped.

If you need to alter the workflow (e.g. your quick edits can only be in SDR or you need to create SDR ISOs for other broadcasters) this should be done with care. Conversions will be required to move from and to HDR, but the hardware requirements can be minimised – for example, you can take a 1080/p50 HDR output from the cameras which requires ¼ of the converter units compared to down-mapping 2160/p50.

15. What about AR/VR sets and inserts?

Figure 7 (© BBC Sport MMXXII)

Augmented Reality (AR) and Virtual Reality (VR) engines are improving, and some now include the ability to include HDR elements within the virtual image. Any cameras being included in the AR/VR system should operate in or be converted to the same system as the AR/VR system and, if SDR, the composite image should be treated as a graphics insert and mapped to HDR using a display-referred transform. Care should be taken with HDR AR/VR and the system should be tested to see what happens to HDR elements such as specular highlights at different levels of zoom.

16. Are there EBU delivery guidelines for UHD HDR?

Yes, the EBU recommends parameters for the live and file-based delivery of UHD/HDR programmes, in EBU R 153 [11] and EBU R 154 [12] respectively.

17. Are there any EBU test patterns for UHD HDR?

Yes, the EBU has a set of colour bars that are freely available, complete with usage documents, on the EBU website – EBU Tech 3373 [13].

18. Is there a difference for post-produced content?

There can be. Most of the guidance is relevant for both live and post-produced content, and the live workflow can create perfectly acceptable post-produced content.

However, there are *key ways* in which they can vary:

1. **Speed of operation**. By its definition, live production happens in real time and so compromises may have to be made to ensure that consistent output is achieved in both HDR and SDR, for example the use of a fixed conversion method between the two outputs. In a post-produced workflow, time can be taken to craft the most pleasing output in both formats.

2. **Use of a working colour volume**, for example, Academy Color Encoding System (ACES). This allows the post processing to be carried out in a very large colour volume before the final output for HDR and SDR is produced rather than creating the HDR and then converting it to SDR.

3. **Mathematical transforms**. Instead of using LUTs to perform conversions, more accurate transforms can be made mathematically without interpolation errors. These are more computationally complex than using LUTs and so are currently not practical for real-time conversions.

19. Is more EBU work planned on live HDR production?

The following 'EBU to do list' resulted from the HDR Workshop (May 2022).

1. Two groups of down-mappers have emerged, both valid implementations described in ITU documentation and both with different "looks". These are seen as interim solutions until fully dynamic mappers can be used with shading via HDR monitors.

   Broadcasters have fixed on one or other implementation and in many architectures, this cannot be changed on a per programme basis (e.g. implemented in a master control room or a set-top box in the home).

   There is an issue if broadcaster A uses one type and provides a feed to broadcaster B who uses the other – the output HD video will appear incorrect in terms of luminance. The membership and host broadcaster present have agreed to investigate a 2-stage interim solution:

   a. Documenting the production workflow to allow broadcasters to fully understand how an UHD HDR programme has been produced.

   b. Investigating a possible fixed transform applied to the HDR signal between the two implementations which – as far as possible – maintains the colours and appearance of the image after conversion to SDR.

   The EBU will contact host broadcasters for major events and will organise a meeting in the 2-3 months following the workshop.

2. Creation of a fixed look "EBU preset" with camera manufacturers. This will allow users to quickly set cameras from a range of manufacturers to a similar base look – it is not intended for broadcast, merely as a fixed base from which an artistic look can be applied.

3. Request conversion hardware manufacturers to implement both:

   a. edge enhancement/softening to correctly deal with changes in local contrast at edges caused by HDR to SDR and SDR to HDR conversions

   b. VPID insertion (this is not automatic as a LUT box cannot know what the output video format is)

4. Standardise a nomenclature to describe HDR production techniques, annotations on measurement equipment and conversions and attempt to get manufacturers to standardise.

5. Provide short test sequences to allow optimisation of dynamic converters.

6. Continue work on automation of camera and monitor testing.

References

[1] EBU HDR Implementation Task Force
https://tech.ebu.ch/groups/hdrtf

[2] EBU HDR Workshop 2022 at SWR, 16-20 May 2022
https://tech.ebu.ch/events/2022/ebu-hdr-workshop

[3] EBU Live HDR Production Webinar – NBC Universal, 18 March 2022
https://tech.ebu.ch/events/2022/live-hdr-production-workflows--nbc-universal

[4] EBU Live HDR Production Webinar – HBS & BT Sport, 22 March 2022
https://tech.ebu.ch/events/2022/live-hdr-production--sport

[5] EBU Live HDR Production Webinar – BBC and Sky UK, 30 March 2022
https://tech.ebu.ch/events/2022/live-hdr-production--bbc-and-sky-uk

[6] ITU-R BT.2100-2, Image parameter values for high dynamic range television for use in production and international programme exchange, July 2018
https://www.itu.int/rec/R-REC-BT.2100-2-201807-I/en

[7] ITU-T H.273, Coding-independent code points for video signal type identification, July 2021
https://www.itu.int/rec/T-REC-H.273-202107-I/en

[8] EBU R 103, Video Signal Tolerance in Digital Television Systems, 23 May 2022
https://tech.ebu.ch/publications/r103

[9] ITU-R BT.2020-2, Parameter values for ultra-high definition television systems for production and international programme exchange, October 2015
https://www.itu.int/rec/R-REC-BT.2020-2-201510-I/en

[10] ITU-R BT.2035, A reference viewing environment for evaluation of HDTV program material or completed programmes, July 2013
https://www.itu.int/rec/R-REC-BT.2035-0-201307-I/en

[11] EBU R 153, Parameters for Live Contribution of UHD/HDR Programmes, 15 September 2021
https://tech.ebu.ch/publications/r153

[12] EBU R 154, Parameters for UHD/HDR Programmes exchanged as Files, 15 September 2021
https://tech.ebu.ch/publications/r154

[13] EBU Tech 3373, Colour Bars for use in the production of Hybrid-Log Gamma (HDR)UHDTV, 21 March 2020
https://tech.ebu.ch/publications/tech3373