

High Dynamic Range

What does it mean for broadcasters?

David Wood
Consultant, EBU
Technology and
Innovation



EBU

OPERATING EUROVISION AND EURORADIO

ASBU

Arab States Broadcasting Union

جامعة الدول العربية



HDR may eventually mean TV images with more ‘sparkle’.





A few more HDR images. With an alternative HDR system...

‘White-out’ - the classic shortcoming of Standard Dynamic Range (SDR)



The HDR story

- What is HDR?
 - Where and when is it used?
- How will it change our world of broadcasting?
 - What do we need to do now?

Here's a short video to explain
HDR.

<https://youtu.be/47BoQH6jl1c>

A word to the wise about science and experimentation

التجربة العلم الكبير

There is still much to learn about HDR in practice! We don't have all the answers yet.

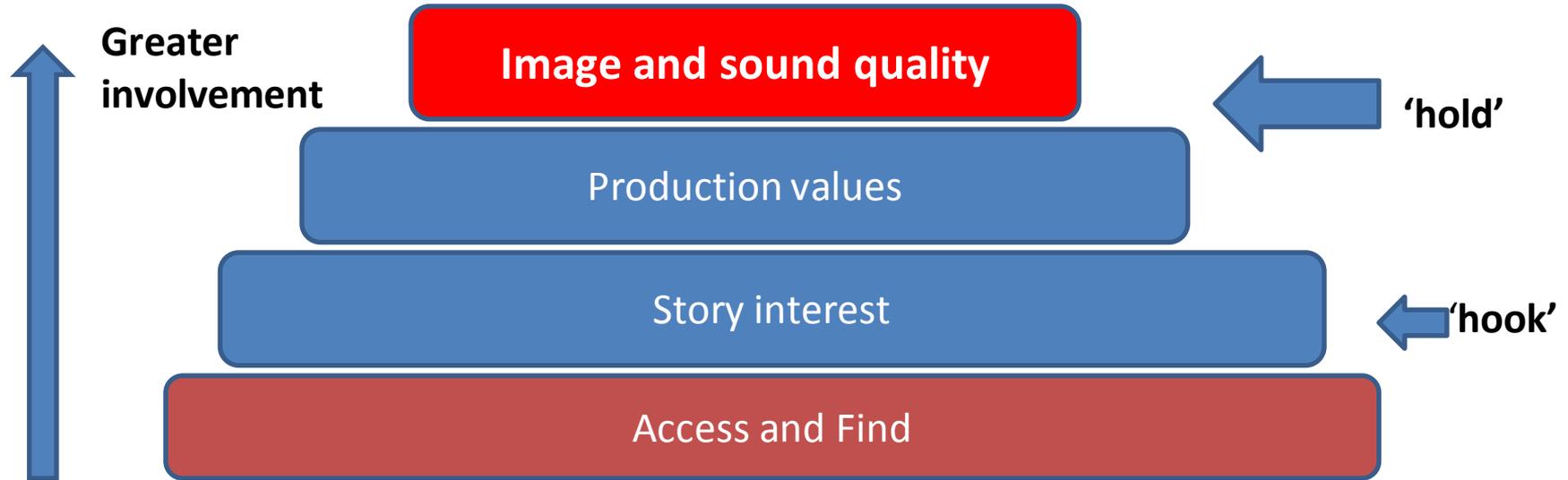
Guiding the future of TV.

Television image quality will continue to improve over time, and images will become more like real life.

+ TV set makers always need new products to sell

+ geographical centre of gravity of TV-set manufacture is changing.

The Wood Triangle – the staircase to viewer involvement. How does technical quality help?



The thicker the layers you include, the greater the viewer's involvement

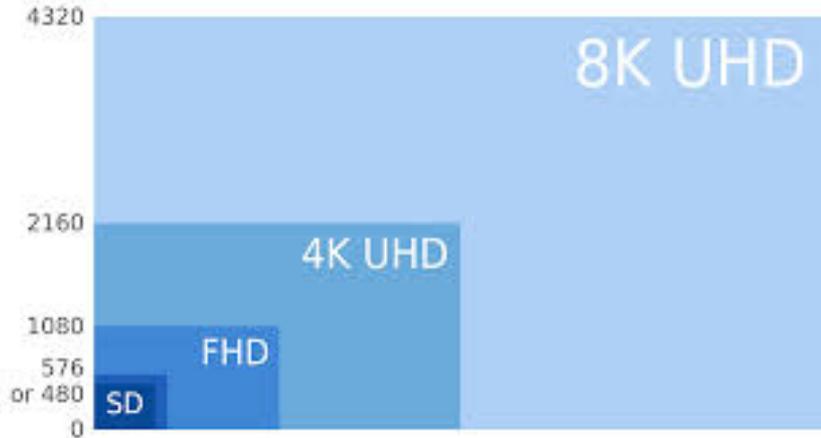
UHDTV - ITU-R BT 2020

- **Parameter values were chosen to be ‘future-proof’, so...**
- **Two UHDTV levels – 8Mpixels and 32Mpixels images – 2160p and 4320p – also known as 4K and 8K**
- **Assembled multiples of 1080p/1920 – 4 and 16.**
- **Image rates up to 120Hz (including 120/1.001Hz)**
- **New wider ‘colour primaries’ (beyond OLED).**
- ***Bit depth 10 and 12 bits/sample.***
- ***option of additional OETF for HDR (with consequential EOTF).***
- **Advanced Sound System**

ITU-R specifications are
nominally for production and
programme exchange.

But they are always used also as a basis
for broadcast standards and are shaped
by the eventual need to broadcast them.

Higher technical image quality?



- ITU-R defines two levels for UHDTV programme production: 2160p and 4320p with additional features: wider colour gamut, greater sample resolution, higher frame rates.
- There is also now a New second draft ITU-R Recommendation for HDR that would apply to both HDTV and UHDTV.
- Broadcast profiles need to draw on the available production parameters and use with MPEG compression systems.
- DVB and others are developing broadcast and broadband profiles - **combinations of parameter values that are believed will be commercially successful for delivery to the home.**

Where will UHDTV broadcasting lie – what factors should influence the choice?

	Small disruption	Large disruption
Small benefit	Low impact BACKLIT TV	Failure DVD RECORDERS
Large benefit	Big hit TABLET	Slow burner CONNECTED TV



UHDTV?

What elements of BT 2020 affect UHDTV Quality?

- Spatial (or static) resolution
- Temporal (or dynamic) resolution
- Dynamic (or contrast) range
- Colour gamut
- Component coding
- Sound System
- Compression artefacts



NHK STRL results for static resolution : benefit is viewing distance dependent

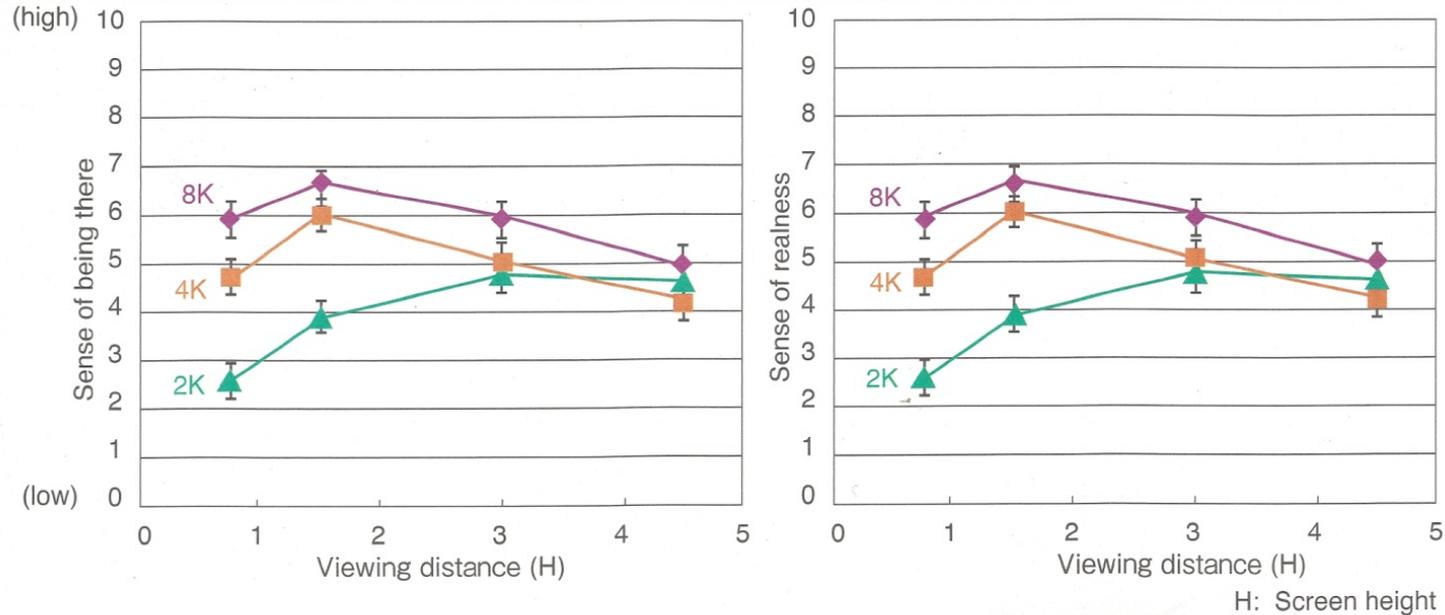
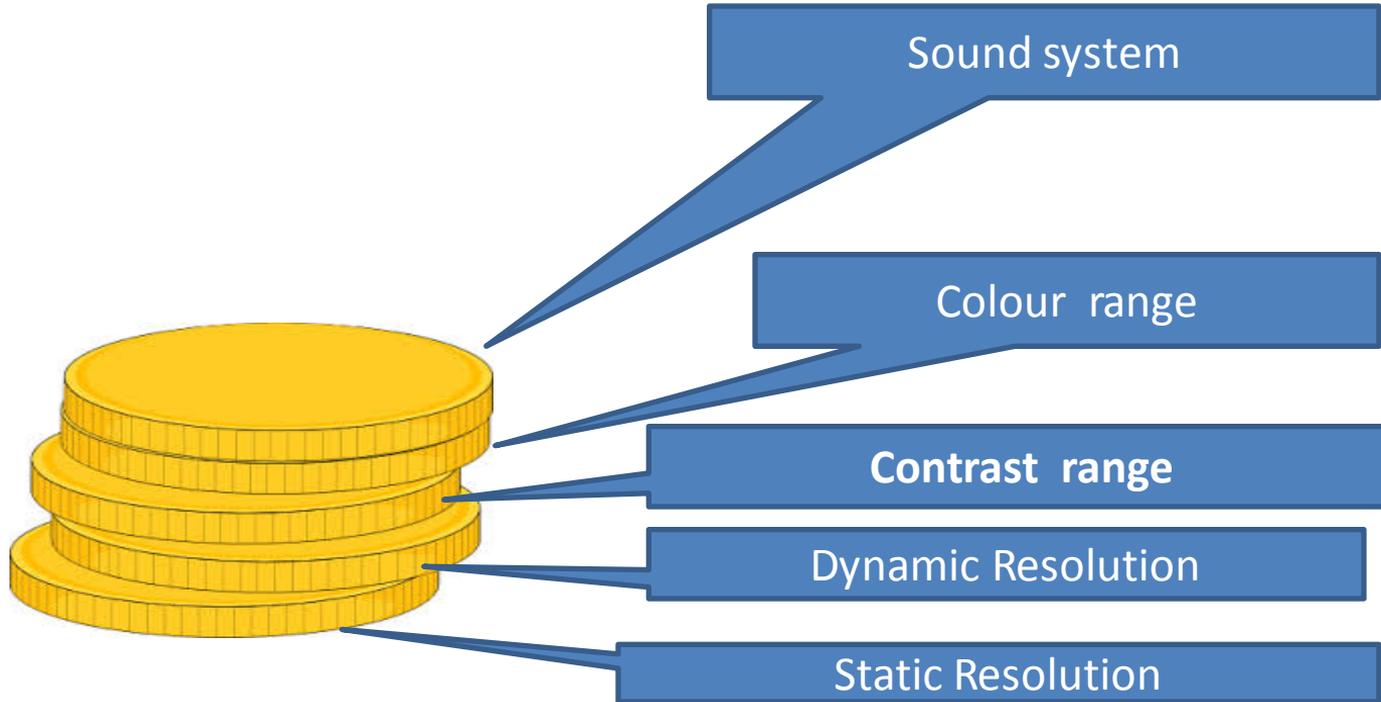


Figure 1. Sense of being there and the sense of realism for different video resolutions in relation to viewing distance

How high does the UHDTV coin pile need to be?

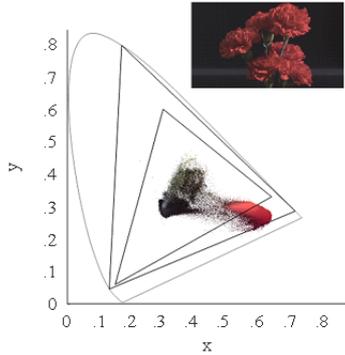


Enhanced Colour Gamut

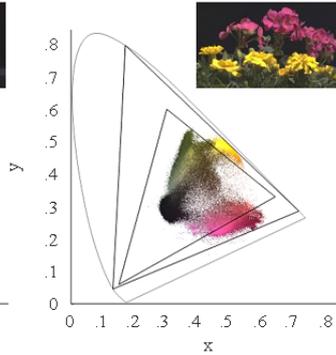
Colour distribution of objects on the x-y chromaticity coordinates

(Inner triangle: HDTV primaries, Outer triangle: UHD TV primaries)

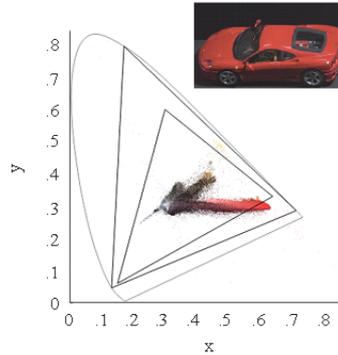
Report BT.2246-24



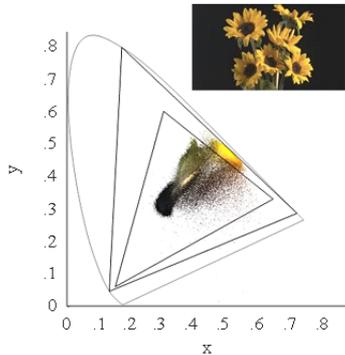
(a) Camation



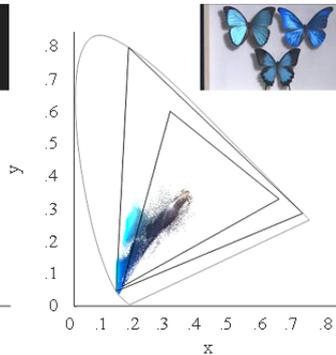
(b) Geranium and marigold



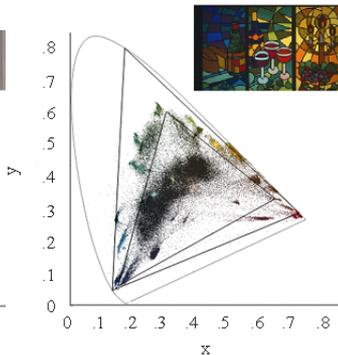
(e) Model car



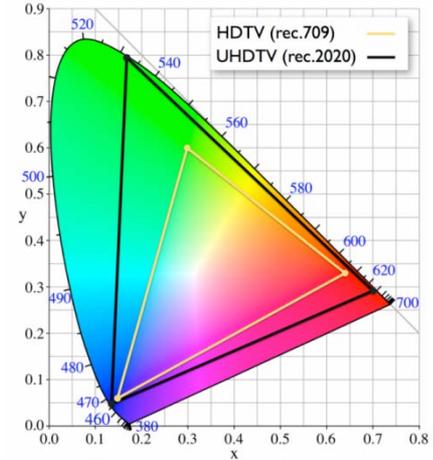
(c) Sunflower



(d) Butterfly



(f) Stained glass



UHD TV vs HDTV Color Gamuts

Surface color of real objects often lie outside HDTV gamut (Rec 709)

... but mostly within the UHD TV gamut
(ITU-R Rec. BT.2020)

From Report ITU-R BT.2246-1
(2012)

Dynamic Range and colour

- Future TV displays will allow higher peak screen brightness's than today. *The situation is complicated by possible regulation to limit to power consumption of future TV sets for ecological reasons.*
- Future TV displays will have a wider range of colours.
- The combination of dynamic range and colour range influences the colours that can be seen.
- The dynamic range perceived by viewers is influenced by the transfer function of light to electrical signal at the camera (OETF) and the complement in the display (EOTF).
- The number of bits/sample affects the quality of the image.

Broadcast Parameters and costs of providing them



Cost factor

- high ←
- High ←
- Moderate ←
- Moderate ←
- High ←

Parameter

- Pixel density
- Frame rate and aperture angle
- Bits/sample and transfer curve
- Colour primaries
- NGA Discrete channels/scene capture/object based

Noticeable quality improvement windows

H = Screen Height

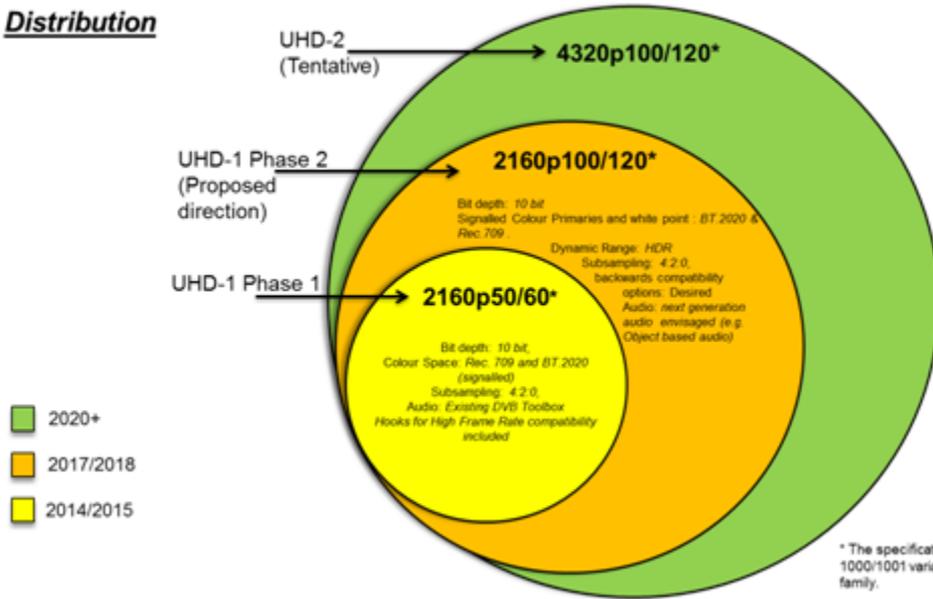
Quality factor	Approx. Distance sensitivity
• Static resolution (+)	• 1.5 to 3H
• Dynamic resolution (+)	• 1.5 to 6H
• Dynamic Range (++)	• 1.5 to way back
• Colour range (+)	• 1.5 to 6H
• Sound system (++)	• 1.5 to 8H

The additional cost of UHD TV

- UHD TV will need new production infrastructure and equipment
- UHD TV will need more care, and thus higher production operational costs.
- UHD TV will need higher bit rates for distribution.

The first DVB Plan for UHDTV

Distribution



* The specification also includes 1000/1001 variants of the 60fps family.

The current DVB approach to UHDTV

- DVB **UHD-1 Phase 1** was/is the least complex decoder phase. It includes an 2160p image (4k), up to 60Hz frame rate, and either HDTV colorimetry (Rec. 709) or extended colour gamut (Rec. 2020). It was intended for services available from **2015**.
- DVB **UHD-1 Phase 2 Conformance Point A** calls for a more complex decoder. It allows for High Dynamic Range. Intended for services available from **2017**.
- DVB **UHD-1 Phase 2 Conformance Point B** calls for an more complex decoder than CPA. It allows for High Frame Rate up to 120Hz. Intended for services available from **2019** – but only if service providers announce services for then.
- There **is no demand yet from DVB members for a 4320p (8k) system**, but if ever needed it could be similar to UHD-1 Phase 2 Conformance Point B with additional static resolution.
- There are consequences in decoder complexity and necessary delivery bit rate for each of the phases.
- There are also consequences for programme production which need to be taken into account.

What increase in broadcast quality would be enough to justify the change?

- DVB UHD-1 Phase **1** (2160p/ up to 60)
- DVB UHD-1 Phase **2 CPA** (2160p/up to 60 plus HDR)
- DVB UHD-1 Phase **2 CPB** (2160p/up to 120 plus HDR)
- *DVB UHD-1 Phase 3 (4320p/120 plus HFR plus HDR)?*

The UHD TV HDR technical discussions today.

- Future TV sets will allow higher peak screen brightnesses, and thus a higher contrast (dynamic) range HDR may be available.
- An 'HDR' is said to introduce a sparkle to the image and remove white-out issues
- There are a number of ways of providing an HDR...



The UHDTV HDR technical discussions today.

- One new approach is to base the system on a new EOTF transfer curve – the ‘perceptual quantizer’ (**PQ**). Quantization steps are arranged to all give equal increases in perceived brightness. Original work done by Dolby in US.
- Another OETF gamma curve to higher brightnesses – the ‘log gamma’ compatible curve (**LG**). Original work done by BBC and NHK.
- Each has claimed advantages.



The main types of HDR systems.

- **PQ (Perceptual Quantizer)**
- A NEW curve for ‘voltage-in’ to ‘light-out’ at the screen that has equal brightness intervals for equal voltage intervals.
- Possible Advantage: highest quality
- **LG (Log Gamma)**
- A compatible curve for ‘light-in’ to ‘voltage-out’ at the camera that is an extension of the current SDR curve (“gamma”).
- Possible Advantage: simple compatibility.

Recent results in HDR

- Past two-three years there has been disagreement on the type of HDR systems to recommend.
- Three candidates; two PQ systems (USA and Philips), and the LG system (BBC/NHK) submitted.
- Draft New Recommendation finally agreed in February 2016 has only two systems – the US PQ system (defined by SMPTE ST 2084) and the LG system (BBC, NHK).
- Draft Rec. now under (slow) approvals procedure by administrations
- Will take some months.
- DNR includes **both** PQ and LG systems not a single system recommendation, so will other bodies need to choose between them?
- MPEG continues to work on HDR but seems unlikely to converge on a single system.



Possible **Solution?**

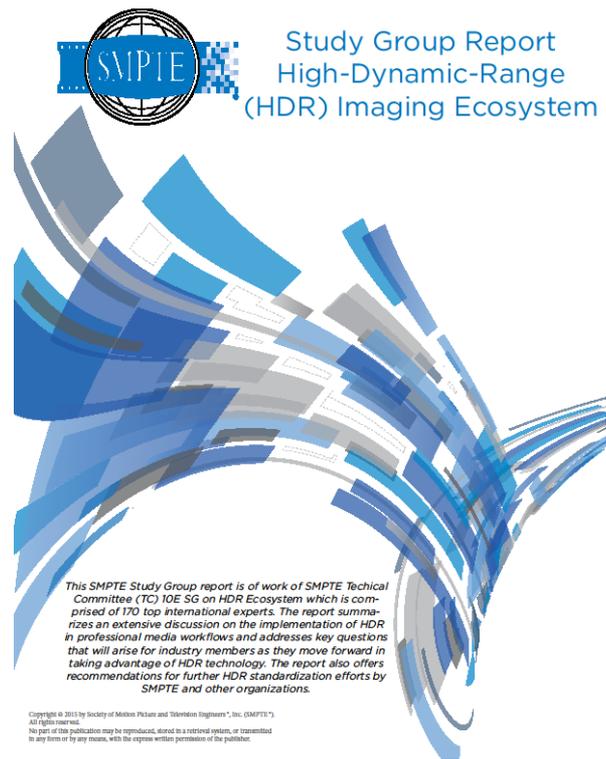
Include both approaches in UHDTV sets This should be possible for decoders.

Log-gamma primarily for real time programme production

PQ for non real time production?

Current SMPTE UHD activity

- SMPTE has recently published a report on the use of HDR. In it there are some concerns about the operational problems of a system that needs metadata being carried in the studio.
- SMPTE is developing a dynamic metadata system for use with the PQ approach.



Some more requirements for UHD-1

DVB Phase 2

- MPEG HEVC coding (as for Phase 1)
- Phase 2 spec must work with a **standardized interface** between a STB and TV set.
- System should allow the same receiver a service with both HDTV and UHD-1 programmes, on a programme by programme basis.
- Various video coding requirements to allow random access points, PVR support, and splicing
- Solution must have be shown to have adequate support from all parts of the chain. There must be companies who announce they will supply the programmes and make the equipment.

The DVB HDR system requirements include...

- Low complexity HDR system is favoured but must preserve artistic intent of source.
- HDR system must take into account the range of IRD and display capabilities available
- Should take into account the domestic viewing environment.

The broadcast timetable?

- The DVB specification for UHD-1 DVB Phase 2 will be available later in 2016, **provided there can be agreement on an HDR system.**
- The Conformance Point A UHD-1 services may begin in 2017, probably with Pay-TV services and Broadband services.
- The Conformance Point B services may begin in 2019, but...
- A critical issue for Conformance Point B will be whether broadcasters will announce services and thus trigger the development of decoder ICs.

The HDR story

- What is HDR?

The use of an extended dynamic range that can be made use of provided the TV display is one with a high screen peak brightness. It gives the image a greater sense of reality.

- Where and when is it used?

It can be used in television programme production, provided the production equipment allows. In principle it could be used for any quality level up to UHDTV, but it is most likely to be used for UHDTV.

The HDR story

- How will it change our world?

Unless and until viewers have TV sets with HDR, which may take some years, the effects of HDR will not be seen by viewers. Making programmes with HDR where possible now will future-proof the programme. In addition, an HDR image can be converted to SDR (Tone Mapping) and bring some of the quality advantages of end to end HDR.

- What do we need to do now?

Follow the discussions in the standards bodies about the choice of HDR system. Monitor the availability of TV sets with HDR. When purchasing new production equipment, buy HDR equipment if practical. Try UHD productions if you can.





wood@ebu.ch
skype: davidinnov