DATE
2nd September 2014

DVB-EBU HDR WORKSHOP
IRT, MUNICH, GERMANY, 17JUNE 2014

SUMMARY REPORT

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EXECUTIVE SUMMARY

The EBU and the DVB Project jointly convened a workshop dedicated to fact-finding on HDR – High Dynamic Range video held on 17 June 2014 in Munich.

The workshop was well attended by enthusiastic and knowledgeable representatives from across the TV industry. It provided attendees an opportunity to debate and to be updated on the latest status of HDR in the end to end chain from Production through to Displays. A great deal of detail was discussed throughout the day which is summarised within this document. The following observations were made:

- HDR has a strong level of support across the spectrum of attendees (operators and vendors) – many, but not all, believe that HDR will be a key technology in the future of TV / Video.
- A number of consumer displays are expected to be available in the market before the end of 2014 which include proprietary HDR-like functionality.
- Production of non-real-time content supporting HDR appears practical in the short term while real-time (linear) content production is currently at early stages of development and will take longer to be practical.
- A number of proposals on how to encode/decode and distribute HDR signals are on the table and it is expected that selection of one or more solution will be made by ITU-R/MPEG and DVB within the following year.
- The timeline for HDR introduction is widely diverse depending on use cases. Some commercial on-demand services are expected to be introduced in the very near term based on proprietary technologies while some broadcasters will wait until full standardisation is complete before introducing services. Many participants believe that broadcast services will not start before 2016 and so, for them, standardisation during 2015 looks to be appropriate.
- HDR video could be an important element of the set of enhanced technical characteristics that may be part of future phases of UHDTV. HDR goes hand-in-hand with WCG (Wider Colour Gamut) and HFR (Higher Frame Rate) in enhancing the UHDTV viewing experience. HDR will make it possible to utilise the BT.2020 colour primaries more fully.
- Although the HDR topic has risen from discussions on UHDTV services, from the discussions held within the workshop environment, some organisations are considering HDR as a feature for spatial resolutions below 2160p, down to spatial resolutions that are compatible with HD services as they are currently defined. A key challenge in defining HDR is to achieve a specification that is feasible to implement in consumer equipment as regards limited complexity and reasonable power consumption.
- Another key challenge, especially for broadcasters, is backwards compatibility with current infrastructure.

- The formal standardisation process for HDR signal and exchange format is ongoing in ITU-R WP6C (RG-24) and in SMPTE 10-E. Of the four approaches demonstrated and presented at the workshop, three have already been submitted to the ITU-R for consideration. The door is still open for further proposals there. At this point it is planned that an ITU-R specification of, or a specification including, HDR algorithms should be published in/by mid-2015.

ABBREVIATIONS

CCFL	Cold Cathode Fluorescent Lamp device
DICOM	Digital Imaging and Communications in Medicine
EDR	Extended Dynamic Range
EOTF	Electro-optical Transfer Function
HDR	High Dynamic Range (video)
HFR	Higher Frame Rate
HVS	Human Visual System
OETF	Opto-electrical Transfer Function
PQ	Perceptual Quantiser
SDR	Standard Dynamic Range (video)
TF	Transfer Function
WCG	Wider Colour Gamut
UHDTV	Ultra High Definition Television

INTRODUCTION

The EBU and the DVB Project jointly convened a workshop dedicated to fact-finding on HDR – High Dynamic Range video, on 17 June 2014 in Munich.

High Dynamic Range video (HDR) was a key topic discussed at the preceding DVB-EBU workshop on UHDTV in May 2013. At the CM-UHDTV meeting in February 2014 the need was identified for a dedicated workshop on the subject of HDR, in order to identify the challenges, opportunities and limitations, and to better understand the influence of HDR on the whole chain, i.e. production, services and consumer receiving equipment. The outcome will be an important help for the discussion about the commercial requirements for a UHDTV Phase 2.

Workshop sessions were dedicated to the following topics:

- HDR definitions and background neuroscience
- Artistic needs & constraints
- Current technology proposals
- Broadcast and production infrastructure

The full meeting agenda is attached as Annex A.

In parallel to the presentation and discussion sessions, several related demonstrations were given around the venue. These are summarised in Annex B.

The final publishable versions of the workshop presentations were made available to EBU and DVB members on their respective group websites.

This report contains a summary of each session of the workshop, the presentations contained therein, and a section on conclusions about HDR from of the workshop.

The workshop was opened, and participants welcomed, by Yvonne Thomas (EBU) and Dietrich Westerkamp (Technicolor). Rainer Schäfer (IRT) welcomed the attendees to the IRT facility.

1 INTRODUCTORY SESSION

HDR definition and agreements - Andy Quested (BBC)

- HDR is the least investigated factor of a future UHDTV system (amongst increased resolution, increased bit depth, higher frame rate, wider colour gamut).
- HDR is noticeable by the viewer at any viewing distance, not only close to the display – in contrast to increased resolution.
- Production chain equipment is increasingly able to accommodate HDR video capture and processing.
- Bodies working on HDR include ITU-R WP6C, MPEG, SMPTE, VQEG, EBU, ARIB.
- What is missing so far are standards for HDR and for reference monitors.
- Four key questions need to be answered:
    1. Will we need to add 'exposure_norm' metadata?
    2. Do we need a revised BT.2020 television standard?
    3. In particular, does ITU-R BT.2020 need a new OETF/EOTF?
    4. Is there a consumer desire for HDR?
- Note that BT.2020 includes a provision for adding an improved OETF/EOTF, if it is proven to be beneficial.
- Image sharpness might have been an issue with HDTV, it is not for UHDTV; unnatural sharpness is not good.

Neuroscience and HDR - Jenny Read (Newcastle University)

- The HVS has a huge dynamic range: from $<10^{-4}$ cd/m^2 (starlight) up to $>10^5$cd/m^2 (bright sunshine); conventional TV displays reproduce a very small part of this range.
- HDR on TV will need to take HVS 'adaptation states' into account.
- Light to dark adaptation slow (8 to 30 minutes)
- Dark to light adaptation much quicker (just a few minutes)
- Dynamic range of a single adaptation state – 10^4 (Kunkel & Reinhard)
- HDR has great potential for increased realism, with much increased peak brightness and deeper low luminance, but more bits per pixel are needed in order to avoid coding artefacts.
- Encoding schemes must reflect human contrast sensitivity.
- The film industry has used Log-curves for many years that are quite near the HVS and much more efficient than the old BT.1886 Transfer Function (TF) used for SDR TV today.
- DICOM (Part 14) specifies an EOTF valid between 0.05 and 4000 cd/m^2 whereby each 1-bit luminance increment is equally visible according to Barten.
- The existing Gamma curve is reasonable at low luminance levels, but not efficient for higher luminance ranges.

2 ARTISTIC NEEDS& CONSTRAINTS

A Colourist´s perspective - Video of NAB Panel (NAB)

- HDR is seen as a significant new tool in the creative arsenal for content production, in particular alongside WCG. Contrast range is the key parameter rather than peak brightness.
- "Telescope" HDR capture project, deployed Dolby Extended Dynamic Range (EDR), presented on Dolby demo.
- Clear "wow" effect with HDR, but there might be a need to moderate the dynamic range. HDR can even result in physical reactions to bright screen image.
- Discussion:
    - Does HDR make the experience too realistic? The Hobbit movie used for the first time HFR (48 fps) in cinema and received some negative comments. It may be that audiences need to get used to it. Creatives can selectively apply tools to varying degrees for the cinematic product.
    - Influence on production cost? Most important to provide a good master. Recent EBU-DE FAME Lucca event discussion reflected this – creatives need to learn to use the tools. Some believe that eventually there will be no added cost in programme production.

"HDR" in television applications - Masayuki Sugawara (NHK)

- OOTF (optical-optical) and EETF (end-to-end) is more important than OETF/EOTF.
- Cinema is a more controlled viewing environment than TV in the home where there are variable conditions. Movies are tailored for cinema viewing, and tone expression is individual, whereas for TV this needs to be consistent for a single broadcaster and between broadcasters.
- Current practice in effect compresses high luminance, resulting in hue shifts, loss in colour saturation, loss of detail.
- Production is geared to optimal flesh tones, images are made as bright as possible until artefacts are introduced.
- Need guidelines for tone mapping; more important than OETF/EOTF; need to consider end to end chain.

Display technologies - Prof. Norbert Frühauf (University of Stuttgart)

- Current best-of-breed display can in fact reproduce a claimed 93% of the BT.2020 gamut - Nanosys-Dolby HDR display, awarded best of show award at SID 2014.
- To achieve WCG you need an HDR display, so the two go "hand in hand".
- We need 10^5 range, current displays achieve only 10^3.
- Transmissive vs. self-emissive display technologies. Former has advantage that brightness can be increased (backlight) independently of image reproduction.
- Problems with current displays:
    - Output light is actually polarised elliptically.
    - Leakage in off state reduces dynamic range considerably.

  - Need accurate constant thickness of panel substrate to avoid dynamic range artefacts – can have variations only in the nm range over 1-2m size.
  - Contrast ratio drops away from centre of view.
- Two approaches to improve dynamic range:
  - Two actuators in series.
  - LED backlight and LCD. The higher the LED density the better – cost impact.
- Comparison cost structure of display, 1998 and 2007 – LED backlights likely even more expensive now than Cold Cathode Fluorescent Lamp device CCFL.
- OLED has not entirely fulfilled its promise; LCD is easier to work with to optimise reproduction.
- A current OLED tablet does achieve 10^5 dynamic range, with ca. 300 cd/m^2 peak, but increased brightness reduces display lifetime.
- Are affordable HDR displays still a long way off? → not coming soon, more likely in 4-5 years for mass-market.

Introducing 4K X-tended Dynamic Range - Ikuo Tsukagoshi (Sony)

- Announcement of Bravia 4K X-DR at CES 2014, now coming onto market.
- Essentially backlight control technology, achieves 3x brighter and darker images respectively. By combining dynamic dimming and boosting LED backlight, get deeper levels of darkness and lower backlight power. Power saved at the dark area is utilised to boost peak brightness of objects, enabling wider dynamic range.
- XDR applicable for non-HDR content, applies display-side enhancement.
- Working assumptions for HDR standard – OETF/EOTF definition and luminance info e.g. peak.
- Standard needs to be open and viable for CE TV, with respect to power consumption and cost to implement.
- BBC demo uses an XDR display.

3 CURRENT TECHNOLOGY PROPOSALS

In this session, four mature technical propositions for HDR solutions were presented, each of them backed up by a demonstration, summarised in annex B.

The propositions from BBC, US delegation (Dolby) and Philips have already been submitted to ITU-R for consideration towards an International Standard on HDR techniques. The Technicolor technology has been presented to MPEG in January 2014, then submitted in more detail to MPEG and JCTVC in July 2014, and JCTVC in July 2014 (contributions JCTVC-R0139 and JCTVC-R0267).

Technicolor´s HDR coding proposal - Edouard François (Technicolor)

- This proposal operates on coding rather than transfer functions.
- Principle of splitting HDR signal into two SDR versions – modulation and residual SDR signals. Requires some metadata to create the modulation bitstream.
- Coding of residual signal adds little cost, three methods being considered - encode it as auxiliary picture, frame packing or in an SEI message – will submit proposal to MPEG.
- Backwards-compatible with SDR if required, in other cases coding efficiency can be further optimised.

BBC´s compatible High Dynamic Range proposal - Andrew Cotton (BBC)

- HDR approach that is compatible with SDR systems.
- Exploit dynamic range enhancements for specular highlights, rest of image stays the same.
- Splice a log-curve onto BT.709 gamma-curve to increase luminance range and avoid problems with “knee”.
- Addition of log-curve enables 4x DR.
- Exploiting headroom above “reference white” (code words 941 – 1019) increases to 6.4x DR
- Going from 8 to 10 bits in Distribution further increases DR 4x (total 25.6x).
- Gamma (low brightness) + log curves (high brightness) match human visual perception well.
- 12-bit format allows going up to 23.6 stops.
- No issues with flesh tones in compatible images (some slight de-saturation)
- Demo shows HDR on Sony XDR consumer TV, high-brightness display and conventional display.

Dolby´s Extended Dynamic Range proposal - David Brooks (Dolby)

- Recall presentation and demo at DVB-EBU UHDTV workshop May 2013.
- Subjective HDR test performed at EPFL, will be presented at IBC conference 2014.

- Barten BT.2246-2, 10-bit PQ can produce contours, but generally masked by noise in current cameras; 12-bit avoids this.
- No advantage in reducing peak brightness, displeases viewers in any case.
- EDR enhancement layer in coded video, supports both 10-bit and 12-bit PQ.
- US proposal to ITU-R WP6C, April 2012.
- SMPTE work in progress to define PQ, and mastering metadata (required for both SDR and HDR systems).
- MPEG HEVC amendment contains signalling for these SMPTE draft specifications. Experiments ongoing to determine whether HDR requires new tools in HEVC to improve coding efficiency.
- Dolby is working with partners to bring EDR to market by end of 2014.

Philips' High Dynamic Range proposal - René van der Vleuten (Philips)

- EOTF and OETF are not the inverse of each other in order to provide the correct colour reproduction
- on the EOTF should be optimized to best use the available bit depth; in this respect, the proposed EOTFimproves on BT.1886, gamma 2.4.
- Different EOTFs optimised for bright & dark images – middle curve is best compromise and this is what is proposed and depends on peak luminance. Proposes to set peak brightness limit of EOTF by metadata.
- A different colour encoding as proposed by using Y'u'v' (not Y'Cb'Cr') provides significant benefits in terms of colour accuracy with HDR.
- Philips made "Missing Minny", possibly the first ever HDR film, in 2011.
- Y'u'v' proposal will be presented in a conference paper at IBC 2014.

Discussion on the four proposals

- Are the proposals proprietary licensed-based technologies? Costs?
    - Many basic technologies in use in broadcast TV are subject to FRND licensing; this is a usual way to fund research & development.
    - The BBC has filed a patent to cover their HDR proposal. Any BBC IPR in that proposal will be made available on a royalty-free basis.
    - There could be room for both kinds of ecosystems, licensed proprietary solutions and an open industry standard.
- Can the four proposals be reconciled to a single method?
    - The ITU plan to get consensus by March 2015.
    - Similarly in MPEG.
    - DVB should provide CRs.
- Is metadata needed for HDR, even static metadata to signal SDR / HDR?
    - Yes, at least at the service level, it seems to be clear that at least static metadata is necessary.
- Which method is most viable depends partly on the boundary conditions, e.g. how much re-use of existing infrastructure is a condition.

4 BROADCAST AND PRODUCTION INFRASTRUCTURE

Status of MPEG/JCT-VC activities on HDR/WCG - Edouard François (Technicolor)

- Work on HDR/WCG video coding initiated by the studios in July 2013; scope extended to broadcast, streaming and storage media; latest requirements in document w14510.
- Need more reference content & displays.
- CfP late 2014 or early 2015, input from DVB invited, want to satisfy DVB's timeline.

SMPTE´s work on HDR - Hans Hoffmann (EBU)

- New study group on HDR ecosystem and three related standards projects have launched.
- DVB is encouraged to request details from SMPTE.

Interfaces for 10/12/14 bit - Friedrich Gierlinger (IRT) and Nigel Seth-Smith (Semtech)

- SDI – copper and optical, various generations (6 and 12 Gbps coming soon; 24 Gbps on the horizon) – can transport UHDTV formats in real time, uncompressed, although often multiple links are needed.
- 12 bit seems to be a sweet spot for interfaces.

Future-Proof High Dynamic Range Capture - Michael Koppetz (ARRI)

- Alexa and Amira cameras for HDR capture; latter achieves 15.5 stops in a single take.
- 16bit linear output from sensor; logarithmic mapping to 12bits in camera; distribution of code values to correspond to brightness values.
- Need to find right compromise between the elements "more pixels" and "better pixels".

Format conversion for HDR - Mike Knee (Snell)

- Linear filtering is ideal in display domain; broadcasting processing is done in the video domain.
- With new EOTFs processing, the errors are significantly greater than when using gamma.
- Processing in display domain is more important for HDR systems; care needed with cascaded mappings; eased by floating point processing.
- Would we have to go back to linear light to do simple processing such as lightening the image? Constant Luminance may have more value in HDR environment.

5 DISCUSSION ROUND

David Wood (Chair, DVB CM-UHDTV) & Tim Sheppard (Chair, DVB CM-AVC)

Tim and David explained the DVB process to introduce new technologies into the DVB toolbox including the importance of

a) Understanding the Benefits
b) Ensuring commercial (or public) interest
c) Checking that an end to end chain will be possible in the foreseeable future
d) Validating performance (against benefits)
e) Standards compliance
f) Ensuring that organisations contributing IPR agree to provide licenses on a Fair Reasonable and Non-Discriminatory (FRAND) basis.
g) Required timing for a standard

The output of this discussion session will be shared with and influence the progress within DVB CM-UHDTV and CM-AVC groups in defining commercial requirements as well as any potential subsequent work from the DVB Technical Module.

The following discussion was lively and focussed on Benefits, End to End Chain and Timing.

Benefits

The question posed was related to the consumer impact of HDR e.g. will it be sufficient for consumers to buy new TVs (or other devices) or to pay for new services?

Most attendees believe that HDR will be an important component of UHD Phase 2, with one operator being more cautious about this.

Comments made included the following.

- Some comments that the demos shown do not provide a clear comparison with the current formats. E.g. not including display device processing methods that are already available. Dolby had such a demo 1 year ago.
- Is HDR for 1000 cd/m², 4000, 7000? Most convincing argument for CE is services.
- Current TVs can do more than 100 nits, need HDR content!
- Convincing demos, but worry about ability to watch it for prolonged periods. Actually reduced audio dynamic range at night – could think of something similar for HDR video.
- HDR difference clearly visible. Need to see if broadcasters adopt phase 1 UHD or go straight in with phase 2. Need a backwards-compatible phase 2 with HDR?
- HDR with 1080p HD or even SD could be relevant.
- Sports events as important triggers for take-up of new TV formats.

End to End Chain – Displays / Production / Distribution

Displays

- Availability of displays, what kind of peak brightness and when?
- Some displays are doing enhanced parameters already, again need services. Other delivery channels might go their own way even without broadcast, let's not get bogged down with the marketing name for phase 2 – make the "wow" effect and it will happen.
- As described in presentation, HDR aware CE monitor, XDR, can be migrated to support delivered HDR service and display it. Important that the spec takes into account the cost and power consumption as well as peak brightness. It must be viable to implement the HDR approach specified in the phase-2 timeline.

Production

- Cost impact on production is critical too. (Indeed, e.g. for live production. Studios already very interested in HDR).
- HDR could be more trouble in production than it's worth. HDR as definitely worthwhile. Need to look at things like transitions e.g. to adverts.
- Contribution? 12 bit looks like the sweet spot. Since we're dropping interlaced, for which 4:2:2 was targeted initially, should we not concentrate on 4:4:4 now for contribution?
- Live with HDR should be included, even if more challenging. Carriage in distribution not an issue. DVB would not discriminate between live and offline in the standard. No need for contribution to use same codec as distribution.
- Not considered to be a big issue to get HDR content onto existing SDI infrastructure.
- All programme genres will benefit from HDR.
- Cameras are getting wider dynamic range already.

Distribution

- Distribution is highest cost item. Definitely need a backwards compatible solution.
- Simulcast could be done at 540p! i.e. could be done "cheaply". Also might be an option for green-field UHD phase 2.
- Initially the majority of HDR content may be at 1080p, must be able to have layered carriage, since will take time for HDR content to become available in quantity.
- TM-AVC would need a statement about how important back-compatible is, i.e. balance with effort needed to enable back-compatible scalable services. CM could inform about point in time when it can be expected for sufficient population of displays that can show clear improvement cf. UHD phase-1. Existing forecast of 2017-18 for phase 2 does look reasonable to include HDR.
- OTT servers getting closer to consumers, need more storage, obviously for UHD, so have clear request for one format to cover all clients.
- Feedback from the FAME Lucca event indicated thatthe roadmap for UHDTV in Europe, also confirmed 2017-18 was ok.
- Current single-sensor cameras choke the DR. EBU TR 118 gives advice on getting more out of cameras.

- At least experiments have already started. Sees potential with HDR with HD resolution, indeed by 2017-18, but of course not every broadcaster in every country.
- Need backwards compatible transmission for HDR? Broadcaster generally does not want to simulcast, so yes we do need backwards compatibility.
- A lot depends on when services will be launched.
- First CRs then tech solution, but often need to have some ideas about tech to be able to derive CRs. Need some kind of study mission in DVB to put forward the possible options, though work already underway in ITU and MPEG?
- 1 of the 4 proposals has not been proposed to ITU. Could expect it, need by Nov.

6 OPEN ACTIONS & OUTLOOK

Studies on potential viewer comfort issues with HDR seem to be appropriate. While members of the production community have commented that they experience (positive) physical reactions with appropriately applied peak luminances above 1000 cd/m^2, there is some concern about potential negative reactions to higher peak brightness's in TV content. Also transitions between SDR and HDR material might need to be moderated, e.g. with production guidelines, to avoid video issues equivalent to those that have occurred with audio levels with adverts.

This report will be send to various bodies/organizations as liaisons by DVB and EBU to the following bodies to ask for specific actions:

- HDMI: is asked to take the summary of the HDR workshop into account for future versions of HDMI interfaces
- SMPTE: is asked to take the summary of the HDR workshop into account for their standardization of production interfaces
- ITU-R: is asked to take the summary of the HDR workshop into account in SG6 RG-24 report, which will be brought up to SG6
- DVB: Request to CM-UHDTV/AVC to formalize commercial requirements for HDR as soon as possible, and provide these to the bodies working on specifications of potential component technologies. These are: ITU-R, MPEG, SMPTE and the EBU.
- Digital Europe: Request early consideration of the vision for CE equipment and label for UHDTV in good time for phase 2 and establish dialogue with DVB

The following bodies are invited to read the report for their information:

- EBU
- MPEG/ITU
- Blu-ray Disc Association
- HbbTV
- FAME
- ATSC
- FoBTV
- ARIB
- CEA

Further discussion on the HDR topic will take place in various forums. At the IFA and IBC 2014 demos and discussions in the conferences are expected. The German TV-Plattform will release an updated version of their White paper on UHDTV that will also include HDR.

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ANNEX A WORKSHOP AGENDA

17thJune 2014

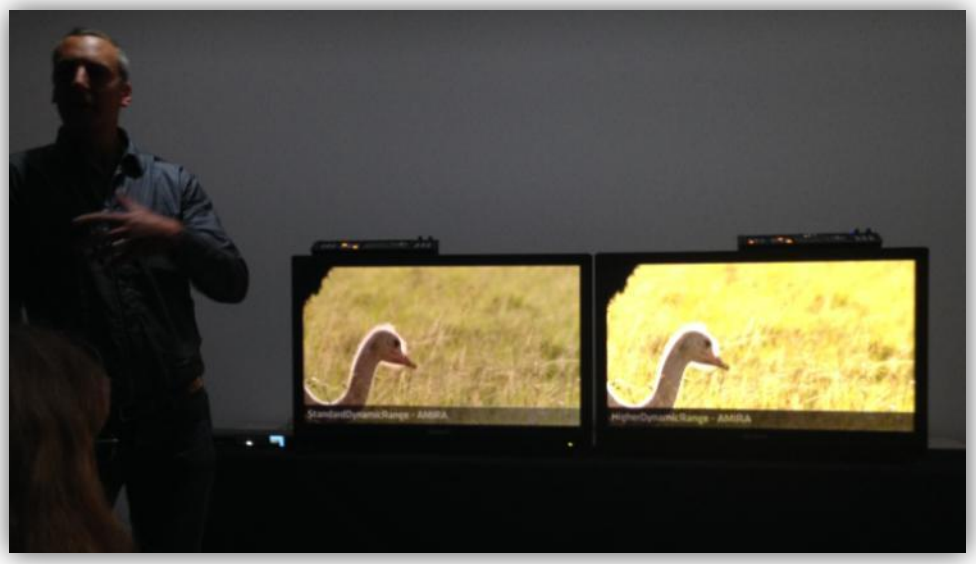
08:30-09:00	Registration		
09:00-09:10	Welcome and opening	Dietrich Westerkamp Yvonne Thomas	Technicolor EBU
Introduction			
09:10-09:25	HDR definition and agreements	Andy Quested	BBC
09:25-09:45	Neuroscience and HDR	Jenny Read	University Newcastle
Session 1: Artistic needs & constraints			
09:45-10:05	A Colourist´s perspective	Video of NAB Panel	NAB
10:05-10:25	"HDR" in television applications	Masayuki Sugawara	NHK
10:25-10:50	Display technologies	Prof. Norbert Frühauf	University Stuttgart
10:50-11:00	Introducing 4K X-tended Dynamic Range	Ikuo Tsukagoshi	Sony
11:00-11:30	*Coffee break*		
Session 2: Current Technology Proposals			
11:30-11:50	Technicolor´s HDR coding proposal	Edouard François	Technicolor
11:50-12:10	BBC´s compatible High Dynamic Range proposal	Andrew Cotton	BBC
12:10-12:30	Dolby´s Extended Dynamic Range proposal	David Brooks	Dolby
12:30-12:50	Philips' High Dynamic Range proposal	René van der Vleuten	Philips
12:50-14:15	*Lunch break & demos*		
Session 3: Broadcast & Production Infrastructure			
14:15-14:35	Status of MPEG/JCT-VC activities on HDR/WCG	Ajay Luthra Edouard François Walt Husak	ARRIS Technicolor Dolby
14:35-14:40	SMPTE´s work on HDR	Hans Hoffmann	EBU
14:40-15:00	Interfaces for 10/12/14 bit	Friedrich Gierlinger Nigel Seth-Smith	IRT Semtech
15:00-15:20	Future-Proof High Dynamic Range Capture	Michael Koppetz	ARRI
15:20-15:40	Format conversion for HDR	Mike Knee	Snell
15:40-16:00	*Coffee break*		
16:00-17:30	Discussion round	David Wood Tim Sheppard	DVB chair CM-UHDTV DVB chair CM-AVC

ANNEX B SUMMARY OF DEMONSTRATIONS

Five demonstrations were provided by organisations participating in the workshop, nearby the workshop auditorium. They are summarised here in alphabetical order of presenting organisation.

B.1 ARRI: The colourist's work demo

High Dynamic Range displays are poised to bring new levels of image accuracy to HD productions. Screens with wider dynamic range and higher contrast can display the full latitude of today's high-end digital cameras producing images with precise colour accuracy and sharpness. This creative opportunity also represents a creative challenge, putting an emphasis on post-production and how to get the most from acquired rushes for today's and future HDR screens.



B.2 BBC R&D: Compatible OETF/EOTF demo

The introduction of high dynamic range (HDR) television is arguably the biggest change we've made to television production in over 70 years. To ensure its success, broadcasters and content producers will need HDR production systems that can make use of their existing production infrastructure, workflows, codecs and delivery systems. To that end the BBC has devised an OETF (opto-electronic transfer function) that enables HDR production and distribution, whilst being compatible with the existing BT.709 transfer function and BT.709 based systems. The demonstration is designed to show that the OETF is able to simultaneously deliver an excellent quality HDR image to HDR displays, and a high quality "compatible" image to legacy standard dynamic range (SDR) BT.709 displays.

The demonstration will show:

- The HDR signal displayed on a HDR Grading Monitor
- The HDR signal displayed on an ITU Rec.709 Grading Monitor
- The HDR signal displayed on a Consumer Display
- Experimental results of a HDR signal displayed on a high-brightness (5000 nit) digital signage display.

B.3 Dolby: Dolby Vision

Following on from the demonstration made during the UHDTV Workshop held in London in May 2013 where the benefits of providing an EDR chain to the consumer TVs were shown; at this event, Dolby demonstrated the ability to take an HDR / WCG (EDR) master and to automatically derive from this the standard BT.709 version.
This live demonstration showed studio content (including Telescope) which had been graded with a colour volume of 4000nit with DCI-P3 colour gamut being converted to a 100nit BT.709 colour volume in real-time. This system also allows the creative to adjust the BT.709 version through the use of metadata. The combination of the EDR master and this metadata, derived from both the algorithmic mapping process and the creative input is propagated throughout the Dolby Vision system and is used in the Dolby Vision TV receiver to match the signal to the capabilities of the TV display.
The demonstration showed the EDR images on Dolby's Pulsar 4000nit P3 monitor and the derived BT.709 images on Dolby's PRM 4200 Reference Monitor in 100nit mode. The colour volume mapping process was controlled and performed in BaseLight using Dolby's content mapping algorithm. Dolby would like to thank FilmLight for their support in making this demonstration.

B.4 Philips: Philips HDR Proposal

Philips demonstrated several elements of their high dynamic range proposal, including MPEG compression for storage and transmission and advanced format conversion between high dynamic range and standard dynamic range video.

- AVC compression of HDR and derived LDR
- Parametric conversion of HDR to LDR
- Benefits of Y'u'v' colour space (not Y'Cb'Cr') for 4:2:0 HDR video

B.5 Technicolor: HDR coding & LDR backwards-compatibility demo

The Technicolor HDR demo is made of 4 parts, showing different elements of an HDR video chain:

1. HDR video capture
2. HEVC-based HDR video compression
3. AVC-based HDR video compression illustrating the LDR backward compatibility
4. Dynamic Range Expansion