MasterClass

Preparing for HDR launch
Ultra HD Forum Master Class: Preparing for the HDR launch

• 16:30 Forum Update – Ben Schwarz & Thierry Fautier, Ultra HD Forum
• 16:40 HDR spotlight
  – SKY Germany HDR trials - Stephan Heimbecher, Sky Germany
  – SKY PerfecTV! HDR commercial launch - Akira Shimazu, SKY Perfect Jsat
• 16:55 KPN on IPTV 4K launch with Euro’16 – Kristel van Grinsven, KPN
• 17:05 Guidelines Deep Dive – Madeleine Noland, LG; Chair, Guidelines WG
• 17:30 DVB and ATSC UHD updates – David Wood, EBU; Skip Pizzi, NAB
• 17:55 Panel/Q&A – Speakers + Matthew Goldman, Ericsson; moderated by Pat Griffis (Ultra HD Forum)
• 18:25 Summary, Conclusions, Next steps – Thierry Fautier, Ultra HD Forum
• 18:30 Close
Thanks to our sponsors for tonight’s party
Ultra HD Forum Update

Thierry Fautier
VP Video Strategy at Harmonic, Inc.
Ultra HD Forum President
End-to-end advocacy for next generation A/V delivery

15 CHARTER MEMBERS | 16 CONTRIBUTORS | 23 ASSOCIATES
Survey: What’s Important in UHD

<table>
<thead>
<tr>
<th>Feature</th>
<th>Phase A</th>
<th>Phase B</th>
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<td>Next-Gen Audio</td>
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<td>WCG</td>
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<td>New EOTF</td>
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<td>HFR &gt; 60 fps</td>
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<td>Screen Size</td>
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n=52
Ultra HD Forum’s Relevance

- **OTT/Media**: UHD Alliance & proprietary formats
- **Live**: Specific requirements
- **SDO**: SMPTE, MPEG, ATSC, DVB: Entropy keeps increasing
- **Ultra HD Forum**: We aim to reduce entropy with a pragmatic approach and a 2016 service-provider focus
- **Good Signs**: Aligned with ITU’s New Rec. BT.2100
## Operator Members’ Deployments

<table>
<thead>
<tr>
<th>DATE</th>
<th>OPERATOR</th>
<th>HDR</th>
<th>AUDIO</th>
<th>STATUS</th>
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<tr>
<td>May ’16</td>
<td>DIRECTV</td>
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<td>Commercial service</td>
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## HDR/NGA Deployments

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<td>HLG10</td>
<td>5.1</td>
<td>Commercial service</td>
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Live Multi-camera Ultra HD HDR trial

Stephan Heimbecher
Director Standards & Innovations, Technology
Sky Deutschland
Sky D high-level UHD test roadmap
Road to multi-camera HDR trial

**Sky** continuation of HDR “offline” testing

- **Aug 2015** 1st UHD/HDR live production test
- **Dec 2015** 3rd UHD Plugfest (incl. HDR tests)
- **Jan 2016** Publication of UHDA specs
- **Apr 2016** 4th UHD Plugfest (incl. HDR tests)
- **Apr 2016** Publication of UHDF Guidelines
- **Jul 2016** BT.2100 (HDR production)
- **Jul 2016** Multi-camera live UHD/HDR trial

Work towards HDR distribution specification
Beach volleyball chosen for HDR trial

29-31 Jul 2016
Sankt Peter-Ording
Beach volleyball chosen for HDR trial
High-level goals and motivation

• demonstrate HDR live production flow, especially racking/shading
• multi-camera approach with different angles with respect to sunlight
• demonstrate graphics overlay/interstitial material etc.
• demonstrate combining UHD HDR and HD SDR content in a live production

Most of this could be achieved during the 3-day beach volleyball trial in St. Peter-Ording (29-31 July 2016):

• the absence of any official/commercial (HD) production allowed for complete freedom on site to run as many tests/experiments as possible
• the length of the event allowed for maximum possibility to run in-depth testing including repetitive test scenarios during different weather/light conditions
• the beach location provided for a challenging HDR setting
Camera plan

Camera – UHD#1
- Sony HDC-4300
- 27x Canon HD box lens
- on separate aerial work platform (ca. 6 m high)

Camera – UHD#2
- Sony HDC-4300
- 95x Canon HD box lens
- on platform (ca. 6 m high) behind right grandstand (sea view)

Camera – UHD#3
- Sony F55
- Canon 17-120 mm 4K lens
- handheld camera on floor level

Camera – HD#4
- Sony HDC-2500
- 22x Canon HDxs zoom lens
- right corner on floor level
Simplified test approach

Scenario 1
- Camera
- BPU S-Log3
- Switcher/mixer S-Log3
- S-Log3 HLG Converter

Scenario 2
- Camera
- BPU S-Log3
- S-Log3 HLG Converter
- Switcher/mixer HLG

Scenario 3
- Camera
- BPU S-Log3
- S-Log3 PQ Converter
- Switcher/mixer PQ

Scenario 4
- Camera
- BPU S-Log3
- Switcher/mixer S-Log3
- S-Log3 PQ Converter

Scenario 5
- Camera
- BPU HLG
- Switcher/mixer HLG

Scenarios tested repeatedly during different weather and light conditions.
Recording for later evaluation

Sony PWS-4400 #1
- XAVC 4:2:2 10 bit Class 480
- BPU (S-Log3 or HLG) output of all camera feeds

Sony PWS-4400 #2
- XAVC 4:2:2 10 bit Class 480
- post HDR converter of all UHD camera feeds
- program feed (mixer output)

AJA Ki Pro Ultra
- Apple ProRes 422
- program feed (mixer output)

EVS XT 3
- DNxHD 240
- CCU (HD, BT.709) output of all camera feeds
Initial results & findings (1)

Racking guidelines (for simultaneous UHD HDR & HD SDR workflow)

1. run initial camera setup to correctly expose for HDR
2. determine the negative gain offset ("SDR gain") by making sure that SDR looks right
   - depends on weather/light situation and balance of the scene
3. continue racking in SDR (CCU’s BT.709 output)
4. fix misalignment of HDR and SDR by adjusting the individual back level controls
Initial results & findings (2)

Overall HDR production (independent of scenario/transfer function used)

- changing light situations are challenging, e.g. during temporary cloud coverage
  - “HDR wow” almost more visible in cloudy weather with soft light (e.g. cloud structure)
- integration of (up-res) HD camera feed visible, but manageable
  - depending on “SDR gain” and respective settings of the HD camera color converter
- focus pulling still demanding in UHD
  - however, mainly semi-professional camera man used at this trial

Make sure to bring a Highly Durable Rope
SKY PerfecTV!
Commercial Launch of HDR Broadcasting

Akira Shimazu
SKY Perfect JSAT
Benefit of HDR

In addition to HDR effect, HDR enhances all other factors for reality.

- HDR best utilize 10bit tone
- HDR enhances finer resolution image
- HDR reproduces color of highlight
- Currently broadcasting three 4K channels with all 4K/10bit/BT2020/60P
Effective Programs of HDR

- Outdoor sport (half shadow football field)
- Music live (laser, spotlight)
- Drama (sunset scene)
- Movie (explosion scene, person/hair)
- Motor sports (the pits of racing, material feeling of car)
- Nature (high contrast scene, snow/ski)
- City (reflection, window, aerial shot of night city)
- Theater play (person & clothes under spotlight)

Tested all scene with HLG, and HDR was very effective.
Reasons to select HLG

- HLG is made by broadcaster for broadcasting.
- HLG is made to fully utilize camera capability (1300%) and TV capability (1000nits), and optimized code value allocation to it.
- HLG is ITU-R standard and ARIB Japanese standard.
- HLG has backward compatibility, which allows mixed programming with conventional SDR programs.
- Tested various aspect of HLG and PQ, and are comfortable to use HLG for broadcasting. (next page)

SKY Perfect will use HLG for all HDR programming, including movies.
Confirmed items before the decision to start HDR with HLG

- Live production work flow ✔
- Simul-production work flow of 4K HDR and HD SDR ✔
- Test broadcast using current 4K playout system and current 4K channel ✔
- HDR effect on various shooting objects ✔
- Movie conversion accuracy from PQ master to HLG ✔
- HEVC encoding quality and cost ✔
- HDMI implementation (CTA standard will be reflected) ✔
- Worked with TV makers on HLG picture quality ✔
- Minor modification of system with limited investment ✔
Live HDR workflow
- S-Log3 and HLG centric production workflow -

**Live shooting**
- PWM-F55 (RAW)
- HDC-4300 (S-Log3/S-gamut3)
- C300 (C-Log2)
- BT.709 (709)

**Editing & OB van**
- S-Log3/ or HLG BT2020 (One system)
- HDR Monitoring (HLG/BT.2020)
- SDR Monitoring (SDR/BT.709)
- Conv.
- Conv.

**Output**
- 4K/HLG BT.2020
- HD/SDR BT.709
- S-Log3/ BT.2020

**Broadcast master**
- HLG
- SDR
- PQ

**Various outputs**
- 4K/HDR channel
- HD/SDR channel

**Monitoring**
- S-Log3/BT.2020
- Conv.

**Off line**
- Disc master

**Various sources**
- Various outputs

**Camera control and QC**
- Live HDR workflow
Movie conversion to HLG

Converted PQ to HLG, using formula defined by ITU HLG standard

4K PQ / Peak 1,000nit Tiff 16bit Movie & test clips

Master 16bit master

PQ Master/Tiff

Conversion by formula using Mistika preset

HLG Master/Tiff

Picture comparison on two X300 monitors

Broadcast master

PQ 10bit Master/XAVC

HLG 10bit Master/XAVC

[Result]
Jointly tested with Hollywood studios, and had a consensus on the accuracy of conversion. Some studios verified by themselves and had same conclusion.

[Conclusion]
HLG can be used for movie distribution, if converted from more than 10bit PQ master with right tool.
HEVC encoding quality and cost

[Conclusion]
- Current 35Mbps of 4K/SDR is good enough for HDR/HLG.
- For broadcasting, HLG is more economical and simpler, as HLG case, one playout encoder per channel covers mixed HLG and SDR programming.
SKY Perfect JSAT Corporation (Head Office: Minato-ku, Tokyo; Representative Director, President & Chief Executive Officer: Shinji Takada) will commence the world’s first 4K HDR (High Dynamic Range) broadcast on October 4, 2016, during timeslots on its dedicated 4K channel “SKY PerfecTV! 4K Experience” (launched on May 1, 2016). This channel can be enjoyed free of charge by anyone with the necessary environment for receiving the SKY PerfecTV! Premium Service or SKY PerfecTV! Premium HIKARI Service.

In commemoration of the commencement of 4K HDR broadcasts, a program jointly produced with the Imagica Robot Group will air in 4K HDR along with all five episodes of the BS SKY PerfecTV! Original drama “Kera (Yakubyo-gami Series)” (starring Kazuki Kitamura and Gaku Hamada).

4K HDR broadcasts have a wider dynamic range, particularly in the expression of the contrast between light and dark imagery, and enable even more true-to-life depictions. For its 4K HDR broadcasts, SKY Perfect JSAT adopted the Hybrid Log-Gamma (HLG) standard, which was co-developed by the public broadcasters NHK (Japan Broadcasting Corporation) and BBC (British Broadcasting Corporation). Moreover, while there is a variety of HDR techniques, HLG was developed as the most suitable format for broadcasting and HLG became an international standard in July this year. …..
HDR broadcast plan

- **March 2015~**
  - **4K General**
  - **4K Movie**

- **May 2016~**
  - **4K Experience**

- **Oct 2016~**
  - **HDR**

- **Spring 2017**
  - **Major expansion**

 HDR experience for sub & non-sub

- **4K / SDR / BT2020 / 60P / 35Mbps HEVC**

 HDR(HLG) / SDR mixed programming in all 4K channels
Example of HDR programs

Original Drama “Kera”

Other programs

- Travel series: “My favorite place”
- Food series: “Midnight chocolatier”
- Documentary: Projection mapping event
- Nature program: National park (Wyoming / Yellowstone)

Ⓒ 2016 SKY Perfect JSAT
Preparation for HLG launch as an industry

In addition to the preparation of SKY Perfect, industry partners are also preparing for HLG.

- **4K HDR TV**
  Toshiba and Sony have announced to upgrade 4K TV with SKY Perfect 4K tuner, to HLG capable. Other TV makers are also working on update.

- **Monitors**
  In addition to Sony X300 & Canon monitors and Astrodesign waveform monitor, more to come at IBC.

- **Editing equipment**
  MISTIKA already has HLG capability, and other NLE makers are planning to prepare update for HLG.
KPN Feedback from IPTV 4K launch with Euro’16

Kristel van Grinsven
KPN Projectmanager TV & Media
iTV Innovatie
Key figures KPN – Q2 2016

Mobile retail subscribers: +23k
  Total: 3.630 mln subscribers

Broadband customers: +15k
  Total: 2.865 mln customers

iTV customers: +33k
  Total: 1.963 mln customers

TV market share:
YE 2015: 29%
2014: 26%
KPN launches UHD 4K package

Roll out strategy
- Launch on June 21
  - KPN press release
  - DM campaign
- Excellent customer response:
  - 40% has opened the mail
  - 25% has clicked through
- Customer registration to join the pilot on the 4K plaza on KPN.com
- Within couple of days the total of 1,000 pilot customers was reached
Why: Offer the best TV-experience

“We want to offer our customers always the best TV experience, that is why we are rolling this out step by step to our customers.

Through the introduction of 4K Ultra HD TV, we make TV watching more fun and easier and offer our customers superior user experience”

Bas van Vlierden, Director TV KPN.
What do we offer?

**EK 2016 semi finals and final in 4K**

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<th>Linear Channels</th>
<th>Video on Demand</th>
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<td>Channel 690</td>
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<td>FUN BOX 4K</td>
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<td>Festival 4K</td>
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<tr>
<td>hispasat tv</td>
<td>xite</td>
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New Set Top Box 4K Ultra HD TV

Selected for the prestigious reddot design award 2016!

• Modern and premium design
• The TV receiver as well as the remote control are backward compatible
• Remote control with bluetooth. Possibility to put the receiver out of sight
Feedback of the pilot customers:

1. Very impressed of the quality, the enormously sharp, bright and smooth images of the 4K UHD streams

2. Fading objects when objects are fast moving on the screen
   - Artefacts with moving objects are different for the different types of screens, further investigations are needed

3. Purple coloured screens occurring on certain TV’s in combination with KPN’s 4K STB (HDMI related)

4. Missing possibility of recording on the UHD 4K channels
   - The 4K service of KPN started with live TV only. Meanwhile this has been activated for all users, along with network pause live TV and Start over TV.

5. Wish for more 4K content
Next steps
Next steps

STB

HDR
Single layer

4K

Colou r space
2020
Next steps

Need for stable specs!
Forum Guidelines for Phase A

Madeleine Noland
LG Electronics
Guidelines Working Group Chair
Ultra HD Forum Phase A Guidelines

• Focus on end-to-end work flows for real-time program streams (aka “linear services”)
• Live and pre-recorded programming
• “On-the-fly” assembly of the service
  – Interstitial insertion and graphic overlays at multiple points in the supply chain
• Phase A = 2016
  – Technologies and procedures that can be used in 2016
• Phase A linear services are likely to be delivered via MVPDs and OTT
  – OTA broadcast services will commence in 2017 in Korea
**UHD Phase A – Definition**

<table>
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<tr>
<th>Feature</th>
<th>Specification</th>
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<tr>
<td>Spatial Resolution</td>
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<td>Color Space</td>
<td>BT.709, BT.2020</td>
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<tr>
<td>Bit Depth</td>
<td>10-bit</td>
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<tr>
<td>Dynamic Range</td>
<td>SDR, PQ, HLG</td>
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<td>Frame Rate**</td>
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*1080p together with WCG and HDR fulfills certain use cases for UHD Phase A services and is therefore considered to be an Ultra HD format for the purposes of these guidelines. 1080p without WCG or HDR is considered to be an HD format. The possibility of 1080i or 720p plus HDR and WCG are not considered here. HDR and WCG for multiscreen resolutions may be considered in the future.

**Fractional frame rates for 24, 30 and 60 fps are included, but not preferred. Lower frame rates may be best applied to cinematic content.**
# ITU-R BT.709, BT.2020, BT.2100

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<td>10, 12</td>
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<td>RGB, YCbCr</td>
<td>RGB, YCbCr, ICtCp</td>
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Phase A Guidelines uses BT.709 and BT.2020 as Color Space references.
UHD Phase A – HDR and WCG

• HDR Transfer functions in Phase A:
  – PQ
  – HLG

• HDR “Packages” in Phase A:
  – PQ10*  PQ EOTF, BT.2020 color gamut, 10-bit depth
  – HLG10* HLG OETF, BT.2020 color gamut, 10-bit depth
  – HDR10  PQ EOTF, BT.2020 color gamut, 10-bit depth
    plus metadata: SMPTE ST 2086, MaxFALL, MaxCLL

*Ultra HD Forum terms
## Signaling PQ10 & HLG10 in HEVC

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Signaling & Format Changes

- Currently, Dynamic Range and Color Space cannot be signaled in SDI – SMPTE is working on this.
- Encoders can be set up to insert Dynamic Range and Color Space in HEVC output.
  - Changes in dynamic range and/or color space “on the fly” during a linear program service may not be feasible in Phase A.
  - Encoders operating in real-time may not be able to receive and implement a format change instantly.
- Downstream decoders may not process a format change seamlessly.
Mixing HDR with SDR

- HDR Camera
  - Native HDR
- HDR Camera
  - Native HDR
- SDR Camera
  - SDR
  - SDR→HDR Upconversion
  - Upconverted HDR
  - Playout server for Interstitials
    - SDR→HDR Upconversion
    - Upconverted HDR
  - Playout server for Movies
    - SDR→HDR Remapping
    - Remapped HDR
  - SDR legacy Contents
- Matrix Switch
- Live Encoder
- Headend
SDR<>HDR and PQ<>HLG

• Normalizing content in a linear service to one “house format” is recommended in Phase A
  – All program segments, interstitials, and graphic overlays comprising the linear service inserted at all points in the chain

• 3D LUTs are currently the *de facto* method
  – New information about “reference white” levels in conversions are emerging, e.g., 75IRE for HLG
  – Other methods such as SL-HDR1 are emerging for HDR->SDR conversions
Distribution Chain

- Guidelines covers the following at each point in the chain:
  - compression technologies
  - metadata carriage options
  - audio, captions and subtitles
  - content manipulation: ad insertion, graphic overlays, etc.
  - sample bitrate ranges
Signaling/Metadata Carriage

• Care needs to be taken at each decode/re-encode point in the chain since the signaling is “lost” at decode

• The transfer function and color space must reach the display for a reasonable picture
Decoding & Rendering

• UHD displays handle 2160p resolutions, but may not be capable of HDR or WCG
  – UHD SDR/BT.709
  – UHD HDR/BT.709
  – And there are HD SDR/BT.709 displays, too

• Backward compatibility for SDR and BT.709 cases discussed
Decoder/Display Architectures

- Integrated decoder/display for OTT services
  - Easiest case, since HDMI is not a factor and OTT can offer different streams for different devices
- Separate decoder/display (STB-Display) for MVPDs
  - Not all Ultra HD parameters are carried over HDMI 2.0a
  - STBs may provide some conversion capabilities for backward compatibility
Backward Compatibility

• Options include
  – Down-conversion at Production
  – Down-conversion at the Service Provider
    • Simulcast or unicast
  – Down-conversion at the STB
    • HDMI “hand-shake” to discover display capabilities
  – Spatial up-conversion of HD/SDR/BT.709 content in the UHD device

• Interoperability of channel-based immersive audio
  – Atmos using E-AC-3 includes a 5.1 feed for legacy devices
But Wait…
There’s More!

• Ultra HD Forum Guidelines is a “living document”
• Revisions are constantly underway as technology develops and matures and service providers work with new techniques
• Schedule is TBA – goal is to keep pace with the fast-changing industry
HDR: Can DVB Come up with the Goods?

David Wood
EBU
The HDR story in the ITU-R. New Recommendation for HDR for Programme Production and Exchange: BT 2100 (to add to BT 2020)
• Recommends two forms of HDR. They are essentially two new relationships between volts and light to allow a higher dynamic range.
• HLG (Hybrid Log Gamma aka the Happy London Gentlemen)
• PQ (Perceptual Quantizer aka the Palo alto Quasher).
• Explaining the relative advantages of each is a real whoop-de-doo!
• DVB defines commercially attractive profiles for broadcast and broadband drawing on existing standards, usually ITU-R and ITU-T/ MPEG.
DVB and HDR

• DVB UHD-1 is a series of specifications in ‘Phases’ to match, over time, the wishes of broadcasters and manufacturers
• DVB UHD-1 ‘Phase 1’ was prepared in 2014 to meet the needs of services in 2015 and later. It included only 4K resolution
• DVB UHD-1 2A is being prepared now to meet the needs of services in 2017 and later. It includes 4K resolution and HDR
• DVB UHD-1 2B is also being prepared now to meet the needs of services in 2019 and later. It includes 4K resolution, HDR, and HFR (Frame Rates up to and including 120 Hz)
• DVB UHD-1 2A and 2B specifications should be available later in 2016.
• DVB NGA/ASS should be available at the same time as 2A and 2B.
DVB HDR Commercial Requirements

• Different markets call for different HDR compatibility solutions.
• Both BC (backwards compatible) and NBC (non backwards compatible) HDR options are requested to be included in the spec.
• Including both options in receivers is not mandatory.
• More details in the DVB Commercial Requirements for UHD-1 Phase 2
• **Five** candidates have been put forward.
• Extensive discussions and analysis of characteristics have been made.
Chapter 4: A New Hope!

- The TM-AVC group led by Ken (“just a wee dram then!”) McCann are planning to prepare the draft specification for DVB Phase 2, CPA and CPB shortly.
- This will then be submitted to the DVB Technical Module (chair Kevin Murray) and DVB Steering Board (chair Peter Mac Avock) for approval by the end of the year.
- We Try Harder. DVB will deliver the goods (digits crossed).
- P.S. Don’t forget about the value of NGA!
ATSC 3.0 UHD Update

Skip Pizzi, NAB
Member, Ultra HD Forum Board of Directors
ATSC TG3 Vice-chair
Overall ATSC 3.0 Status

- ATSC 3.0 is a suite of ~20 separate Standards, organized in 3 layers
- Physical Layer is mostly Final or Proposed Standards
- Management & Protocols Layer mostly at Proposed or Candidate Standards
- Applications & Presentation Layer is mostly at Working Drafts or Candidate Standards
ATSC 3.0 Layered Structure

- Applications and Presentation
- Management
- Protocols
- Physical
ATSC 3.0 Document Structure and Status, September 2016

✓ ATSC 3.0 “Parent” System Standard A/300 (Points to Each Separate Standard Document)

RF Transmission
Scheduler/ALP
IP Delivery
Essence (Audio, Video, Captions)
Emergency Alerting
Watermarks
Interactivity
Personalization
Companion Devices
PHY Return Channel
Service Usage
Security

Video Standard: A/341
Audio Standard: A/342
Captions & Subtitles: A/343
Service Announcement: A/332
Delivery, Signaling & Sync: A/331
Link Layer Protocol (ALP): A/330
Scheduler, STL & SFN: A/324
PHY Layer D/L Standard: A/322
Sys. Discovery & Signaling: A/321
Companion Devices: A/338
App Runtime Environment: A/344
Application Signaling: A/337
Content Recovery in Redistribution Scenarios: A/336
Video Watermark Emission: A/335
Audio Watermark Emission: A/334
Security Standard: A/360
Personalization Standard: A/345
Service Usage Reporting: A/333
PHY Layer U/L Standard: A/323

✓ Working Draft
✓ Candidate Std. Ballot Open
✓ Candidate Standard
✓ Proposed Std. Ballot Open
✓ Proposed Standard
✓ Final Standard
ATSC 3.0 UHD Status

• A/341 Video (HEVC) Candidate Standard*
  – Uses HEVC Main10 profile, up to 2160p
  – Currently has TBDs for other HDR elements, HFR
  – Numerous HDR proposals under consideration
  – CBS-NY hosted comparative HDR demos in June
• Broadcasters may rely on 1080p+HDR/WCG
  – Especially during transition period
  – HEVC encoder optimization required for this approach
• A/342 Audio Candidate Standard*
  – Provides Immersive & Personalizable sound
  – Objects & Channels (11.1 req’d., 22.2 opt.) req’d., Scene-based opt.
  – Supports AC4 and MPEG-H 3D audio systems

* Subject to Change
Panel/Q&A Session

Pat Griffis, Moderator
Dolby Laboratories
Matthew Goldman
Ericsson
Skip Pizzi
NAB
Stephan Heimbecher
Sky Deutschland
Madeleine Noland
LG Electronics
Kristel van Grinsven
KPN
Akira Shimazu, Jsat
Conclusion and What’s Next

Thierry Fautier
VP Video Strategy at Harmonic, Inc.
Ultra HD Forum President
What is Next?

- **NGA**: Object-based coding, Immersive, Interactive
- **Scalable coding**: Dual layer, backward compatible
- **Video fidelity**: Greater than 10 bits, IC\textsubscript{T}C\textsubscript{P} color space, ...
- **HFR**: p100/120 fps
- **HDR**: Dynamic metadata, backward compatible
Thanks to our sponsors for tonight’s party
Thank You for your highly dynamic attention!

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