Linaro connect
San Francisco 2017

# UHD + HDR

**SFO17-101**

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San Francisco 2017

ENGINEERS
AND DEVICES
WORKING
TOGETHER

# Overview

- Introduction
- UHDTV - Technologies
- HDR TV Standards
- HDR support in Android/AOSP
- HDR support in Linux/V4L2

LHG
Digital Home

# Introduction

- The migration from High Definition TV (HDTV) to Ultra High Definition TV (UHDTV) is upon us
- UHDTV brings not only enhanced spatial resolution, but other important advanced technologies
- The important thing to remember is that these technologies used in UHDTVs reflect an upgrade to the entire content ecosystem, from capture, transmission, and display
- The goal is to bring the original dynamic range of mastered content to the viewer at home

# Preserving the human vision: Capture to Display

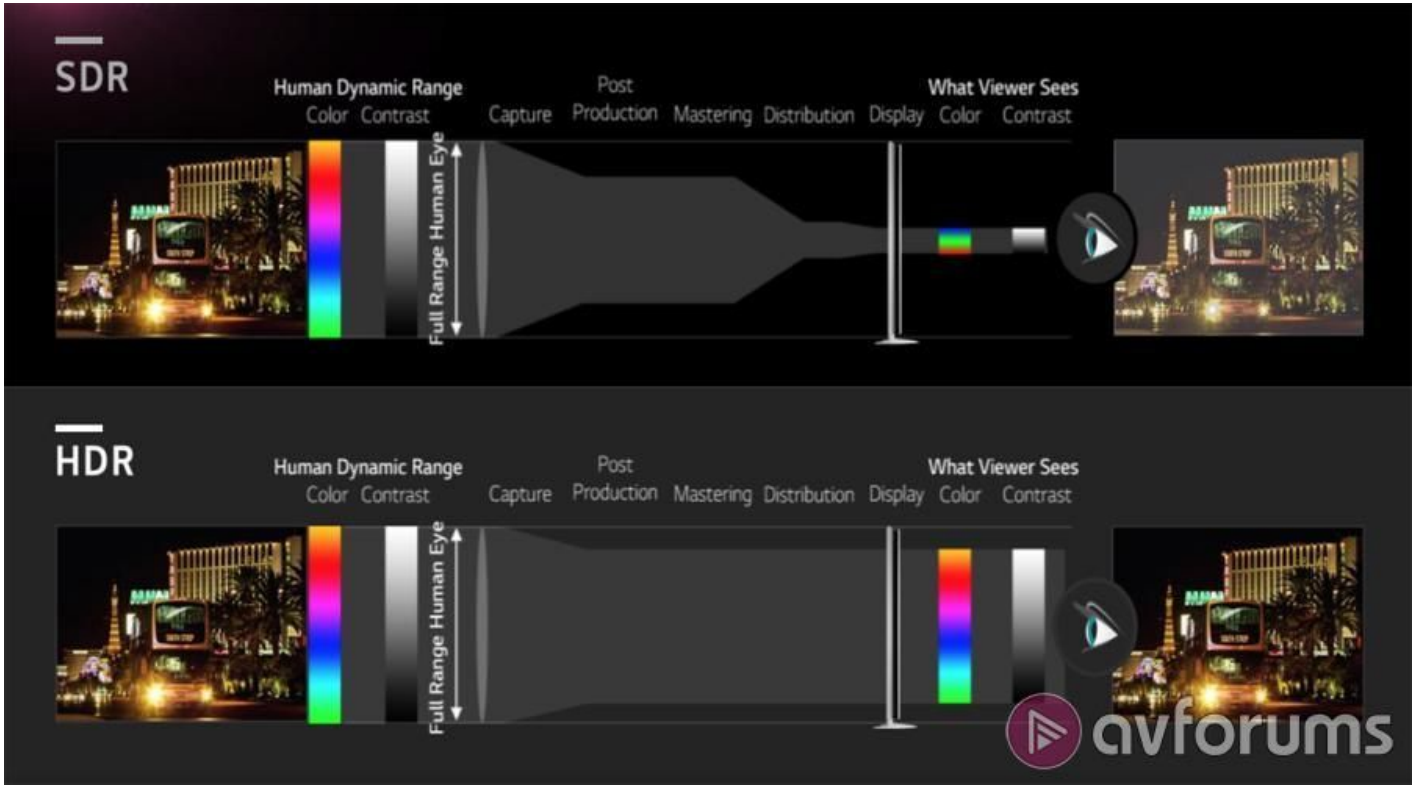



Image source: avforums

# UHDTV System Technologies

- High Resolution Video: 3820x2160 pixels (~4x HDTV pixels)
- High Dynamic Range (HDR) - the dynamic range refers to the luminance and the max and min amount of light a TV can produce
  - Luminance is expressed in ‘nits’ a unit of brightness density
  - Today’s Standard Dynamic Range (SDR) luminance is in the range of 0.0002 to 100 nits
  - HDR luminance variation is 0.0005 nits to >1000 nits
- Wide Color Gamut (WCG) - a TV’s color gamut indicates the level of saturation and number of colors a TV can produce
- Electro-Optical Transfer Functions
  - More closely model the human visual system
- Metadata: Data that accompanies the content with information on mastering and dealing with display types

# HDR TV Standards

- Standards have been defined and continue to evolve for every aspect of HDR content creation, transport, delivery, and display
- Colorspace:
  - ITU-R Recommendation BT.2020 defines a wide gamut color space
- Transfer functions:
  - Adoption of new transfer functions not based on CRT technology (i.e. SMPTE ST.2084)
- Metadata:
  - SMPTE ST2086:2014 defines static metadata of the associated video content
    - Supported by HDMI 2.0a, included with mastered HDR content to convey color volume of the mastering display and luminance of the content
- CTA has defined minimum guidelines for a TV to be referred to as an HDR-Compatible Display
- UHD Alliance: promotes UHD standards development, branding and certification
- Blu-ray Disc Association (BDA) new Ultra HD Blu-ray Disc specification

# Wide Color Gamut (Rec.709, P3, Rec.2020)

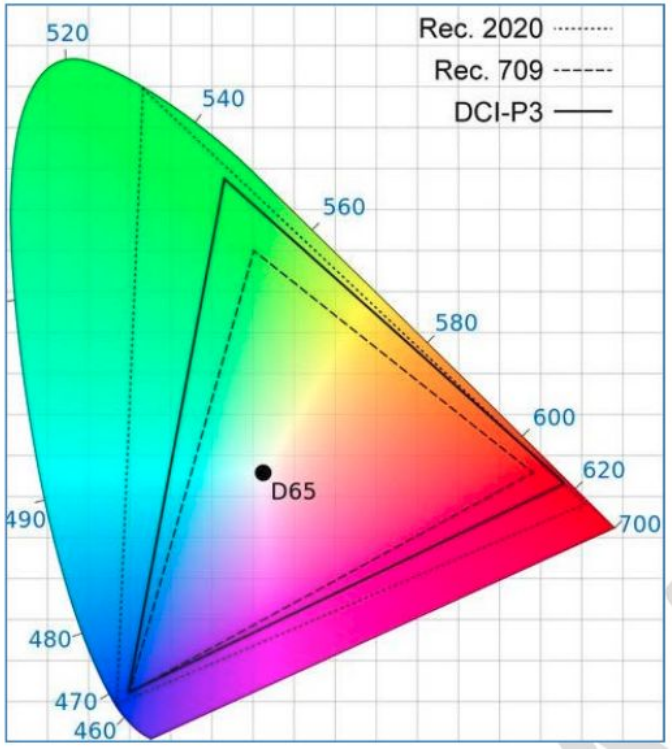
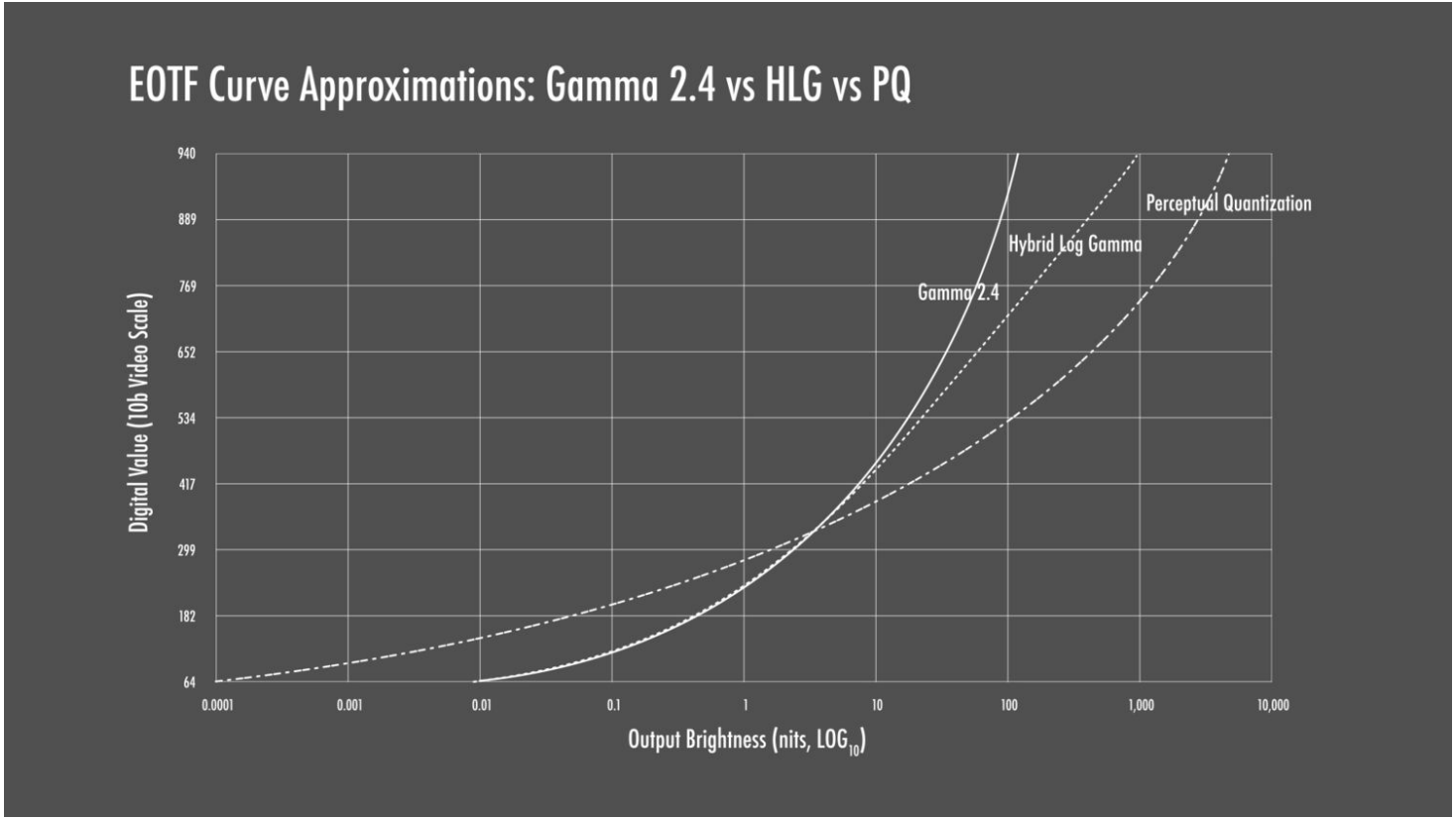



Image credit: Spectracal

# HDR Transfer Functions




Source: https://www.mysterybox.us/blog/2016/10/19/hdr-video-part-3-hdr-video-terms-explained

# UHD Alliance

- Multi-industry alliance to promote UHD standards development and UHD branding, including:
  - TV mfgs Samsung, Sony, LG, Panasonic...
  - Hollywood studios: Disney, Warner, Universal, Fox...
  - Amazon, Dolby, Netflix, DirecTV, Microsoft...


- UHD Alliance Premium Certified
  - Resolution: 3840x2160 (4K)
  - Color depth: 10-bit signal
  - Color palette: Wide Color Gamut
    - Signal input: BT.2020 color representation
    - Display Reproduction:  >90% of P3 color gamut
  - High dynamic range: SMPTE ST2084 EOTF
  - Minimum brightness and contrast ratios: Min brightness of 1,000 nits, with black level max 0.05 nits (20,000:1 contrast ratio)  OR  min brightness of 540 nits with black level maximum of 0.0005 (>1 million:1)
  - Also specifications for content and mastering to match the specs for the TVs

# HDR TV Delivery Systems

- HDR 10 Media Profile - CTA official HDR video standard for HDR TVs
  - HDR 10 requires use of SMPTE ST.2084 EOTF, BT.2020 color space, 10 bits per channel, 4:2:0 chroma subsampling and inclusion of SMPTE ST.2086 and MaxCLL and MaxFALL metadata
  - Static metadata, not compatible with SDR TVs
  - Playback requires minimum of HDMI 2.0a signal interface
- Dolby Vision™ - proprietary implementation of the PQ curve
  - DV supports both the BT.2020 and DCI-P3 color spaces at 10 and 12 bits per channel
  - Key feature is support of scene by scene transform metadata
  - Scalable solution that can optionally provide compatibility with HDR10 and SDR displays via base layer and enhancement layer
  - Optionally compatible with HDR10 TVs and SDR TVs
- BBC/NHK
  - Uses HLG transfer function
  - Does not require metadata
  - Playback on HLG-compatible HDR TVs or SDR TVs
  - Usually used for live broadcast

# HDR Support in Android

- Initial HDR support introduced in Android 7.0
  - Includes the creation of proper constants for the discovery and setup of HDR video pipelines
  - HDR supported in tunneled video playback mode

As of Android 7.0 release, the following HDR technologies are supported.

| Technology | Dolby-Vision | HDR10 | VP9-HLG | VP9-PQ |
|---|---|---|---|---|
| Codec | AVC/HEVC | HEVC | VP9 | VP9 |
| Transfer Function | ST-2084 | ST-2084 | HLG | ST-2084 |
| HDR Metadata Type | Dynamic | Static | None | Static |

Source: https://source.android.com/devices/tech/display/hdr

# Android - HDR

- HDR Discovery
  - Display, Decoder [Dolby-Vision, HEVC HDR 10, VP9 HLG & PQ], Extractors for MP4 and WebM containers

Component requirements for each HDR technology are shown in the following table:

| Technology | Dolby-Vision | HDR10 | VP9-HLG | VP9-PQ |
|---|---|---|---|---|
| Supported HDR type (Display) | HDR_TYPE_DOLBY_VISION | HDR_TYPE_HDR10 | HDR_TYPE_HLG | HDR_TYPE_HDR10 |
| Container (Extractor) | MP4 | MP4 | WebM | WebM |
| Decoder | MIMETYPE_VIDEO_DOLBY_VISION | MIMETYPE_VIDEO_HEVC | MIMETYPE_VIDEO_VP9 | MIMETYPE_VIDEO_VP9 |
| Profile (Decoder) | One of the Dolby profiles | HEVCProfileMain10HDR10 | VP9Profile2HDR or VP9Profile3HDR | VP9Profile2HDR or VP9Profile3HDR |

Source: https://source.android.com/devices/tech/display/hdr

# Android - HDR Enablement

- SoC vendors and OEMs must do additional work to enable HDR support for a device
- Display
  - Hardware composition: must support blending HDR content with non-HDR content
  - Display discovery: HDR display discovery only supported by HWC2 via an adapter
    - HWC2 exposes a new API to propagate HDR Static Data to the framework and application
    - HDMI: Capabilities provided via HDMI EDID (CTA-861.3, sect. 4.2)
      - EOTF: Traditional Gamma (SDR, HDR), SMPTE 2084
    - Decoders: add HDR-capable tunneled decoders and advertise HDR support
      - Dolby Vision™: must add a D-V capable HDR OMX decoder
      - HDR10: must add an HDR10-capable OMX decoder
        - A tunneled HEVC decoder supporting parsing and handling of HDMI metadata, support parsing the mastering metadata SEI blocks and other HDR info in SPS
  - Extractors
    - Dolby Vision™ Extractor
    - HDR10 and VP9 HDR Extractor
  - Pipelines: HDR10 decoder pipeline, Dolby Vision™ decoder pipeline, VP9 decoder pipeline

# HDR Support in Linux - V4L2

- HDR fits under the V4L2 media subsystem
- HDR10 colorimetry is supported in the V4L2 API
- However, there is still no 10 and/or 12-bit RGB/YUV pixelformats defined
- Hybrid Log-Gamma signaling for the transfer function is not yet implemented … should not be too difficult
- Dolby Vision™ is proprietary and is its signaling is not supported
- There are patches in progress for HEVC support from Samsung (see https://lkml.org/lkml/2017/6/19/31)
  - Section 2.9 Compressed formats (has support for VP9 codec)
  - Section 1.10 Extended controls
  - Section 2.14 Colorspaces support for BT.2020 colorspace `V4L2_COLORSPACE_BT2020`
    - Support for SMPTE 2084 transfer function `V4L2_XFER_FUNC_SMPTE2084`

# HDR Implementation VPU vs GPU

- The majority of HDR solutions provided by SoC vendors are VPU based
- With respect to GPUs, there are 3D applications that already do HDR rendering
  - Proposal to render into FP16 (half-float) buffers and then composite HDR and SDR content with appropriate tone mapping based on the target monitor capabilities
  - Using the inverse EOTF encode the FP16 data into the display signal
  - Send to monitor with HDR metadata, where the monitor would apply the EOTF to decode the digital signal into HDR content
- Requires an API to get the HDR information from the display provided in the Extended Display Identification Data (EDID)
- Wayland compositors need to be FP16 aware

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# Thank You

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