

HDR (High Dynamic Range)

Technical Considerations for Live Production and Distribution Workflows

Hugo Gaggioni

CTO

Sony Professional Solutions Americas

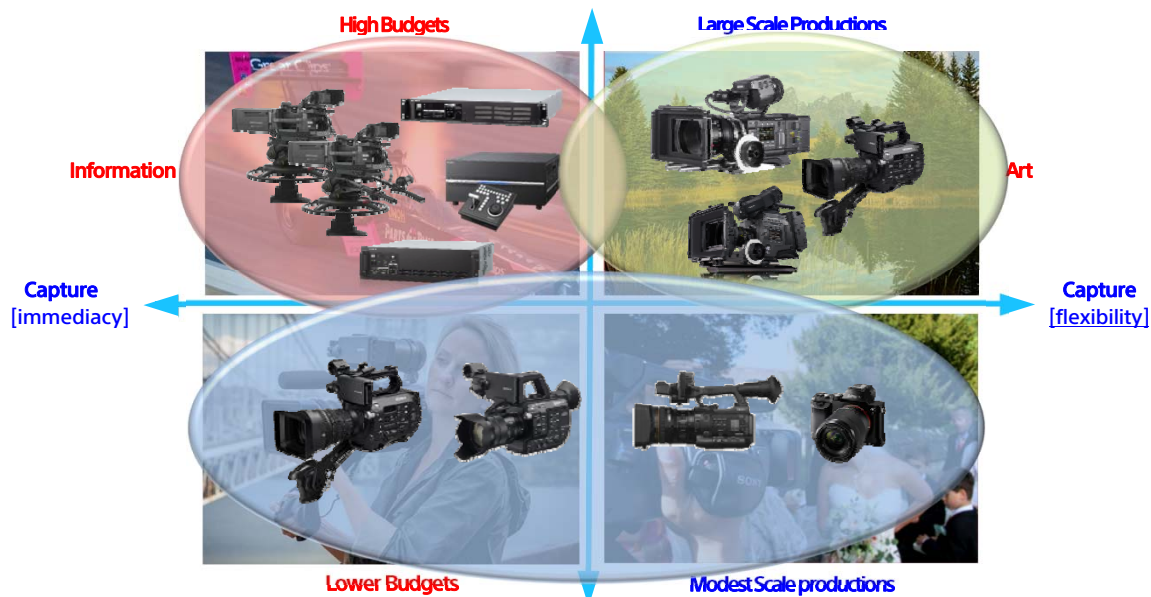
HDR Session Agenda

- **HDR Applications Map and Content Production Techniques**
 - Cinema Studio/Production
 - Sports/Broadcast Live
 - Independent/Small Productions
- **HDR Standards for Distribution Applications**
- **SR Live: HDR workflows for Live Applications**
 - S-Log3_Live and HLG_Live for Production Mastering Formats
 - AIR Matching for Home Viewing of Rendering Intent
- **Video Compression of HDR signals**

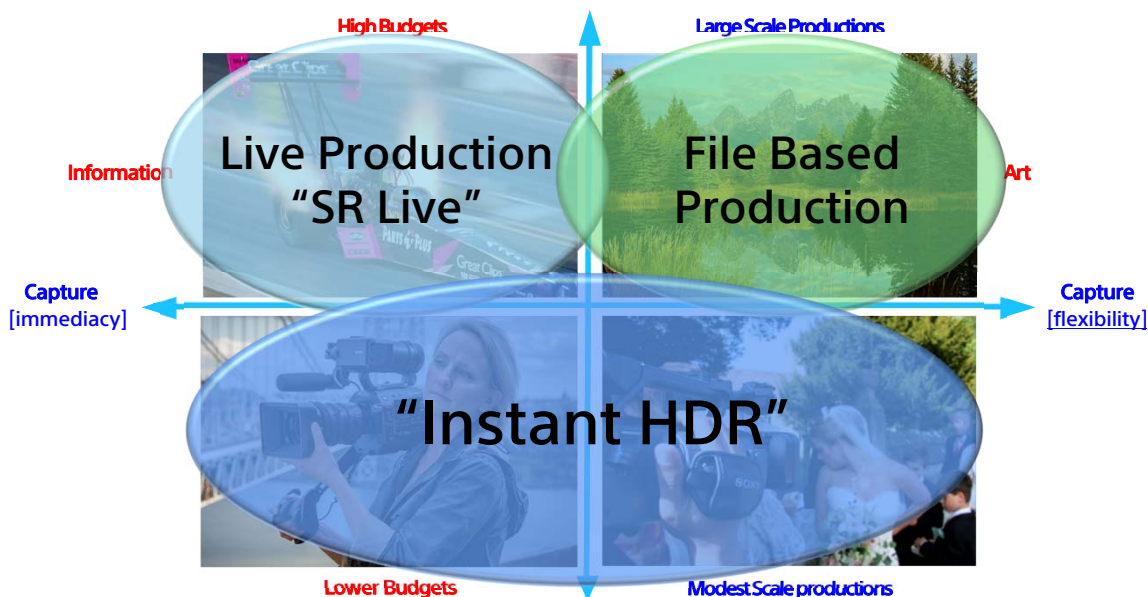
HDR Applications Map



HDR Applications Map



HDR Applications Map



Sony Expansion of HDR production techniques

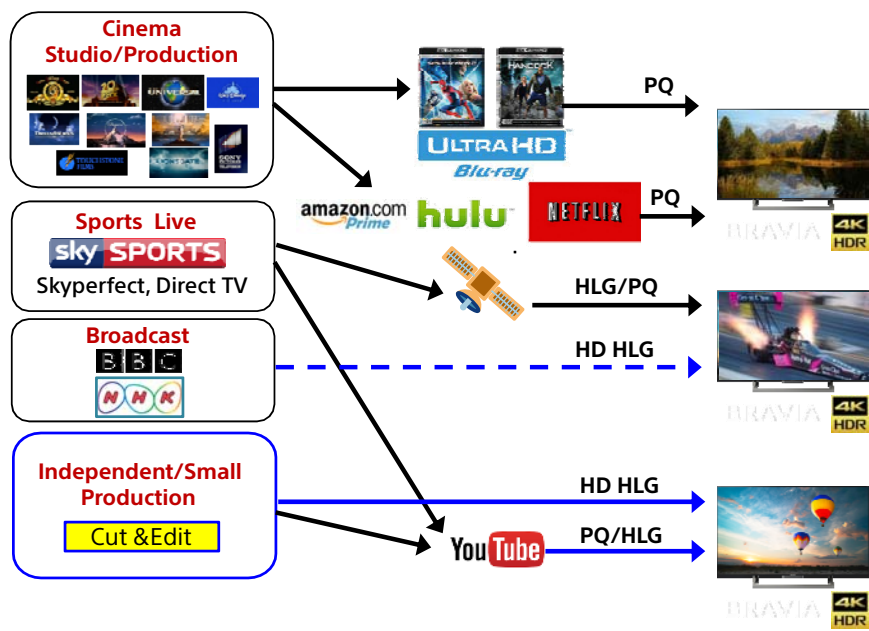
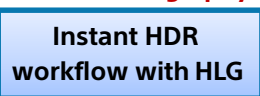
File-based Production



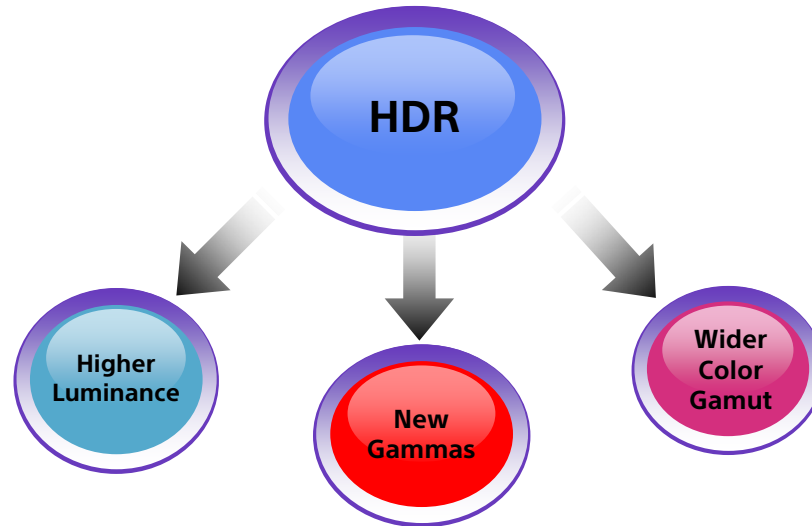
Live Production



Corporate/Event Videography



Components of an HDR Image



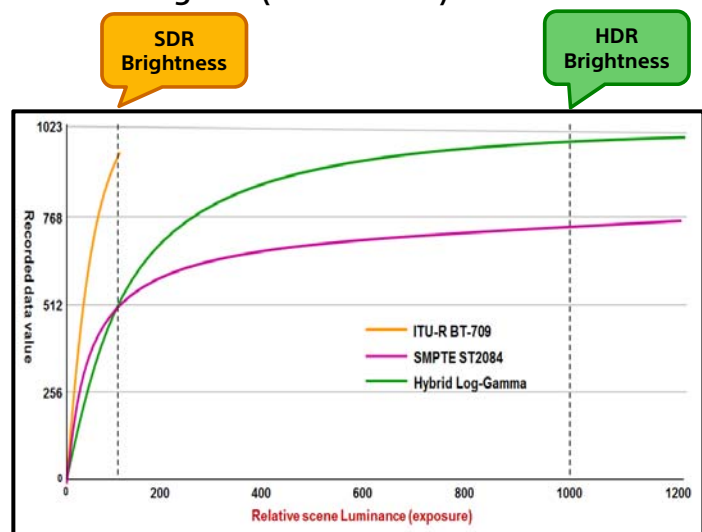
New 'Gamma' curves for HDR signals

- Input/output curves for transmission of HDR signals (OETF/EOTF)

- "PQ" (SMPTE standard ST.2084)

- "Hybrid Log-Gamma" (HLG) developed by BBC/NHK

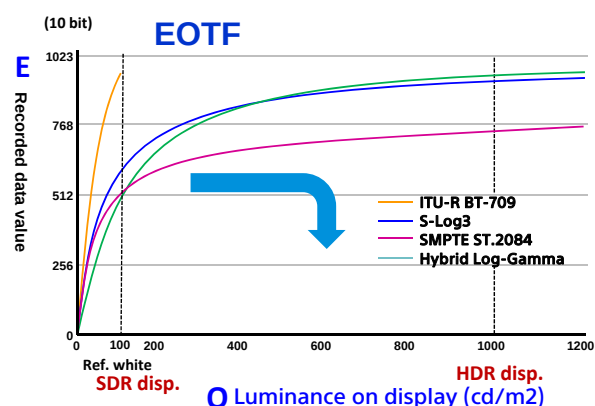
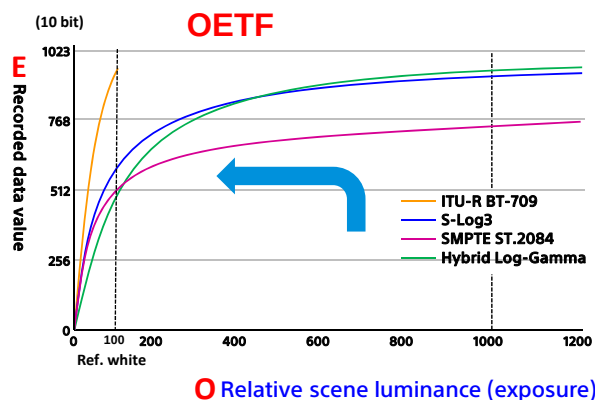
- Both techniques also standardized in ITU-R BT-2100-1



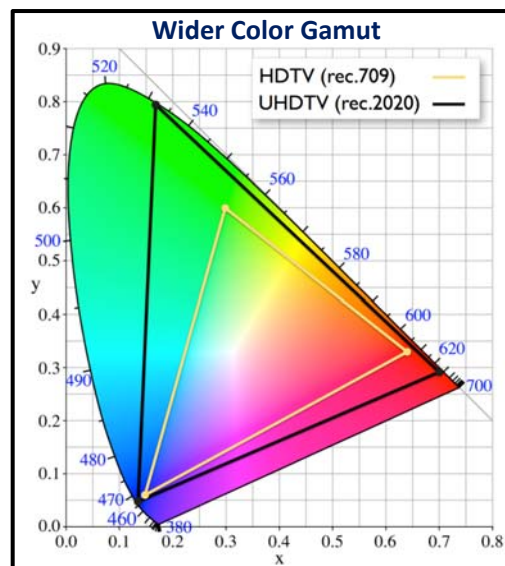
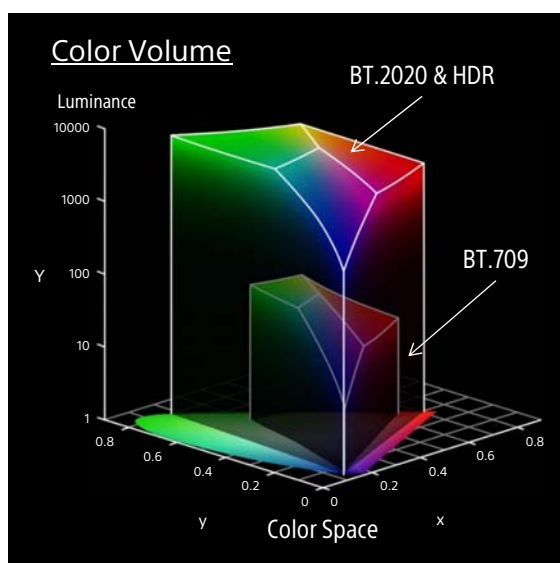
What is OETF/EOTF?

Opto-Electrical and Electro-Optical transfer functions

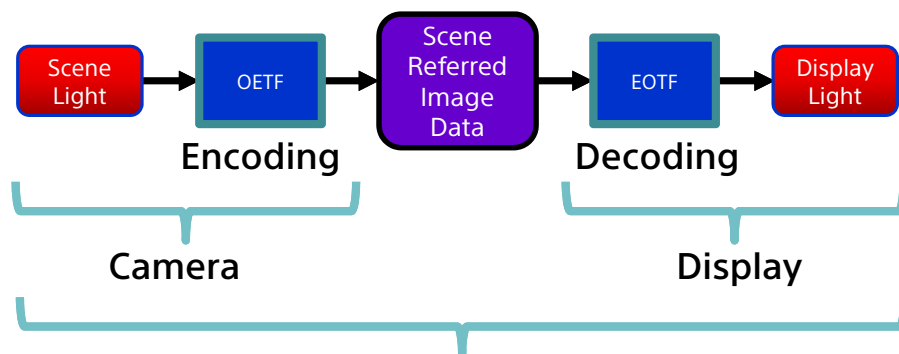
- OETF describes the action of the sensor, converting from scene brightness to data.
- EOTF describes the action of the display, converting from data to screen brightness.



Color Volume with Wide Color Gamut & HDR



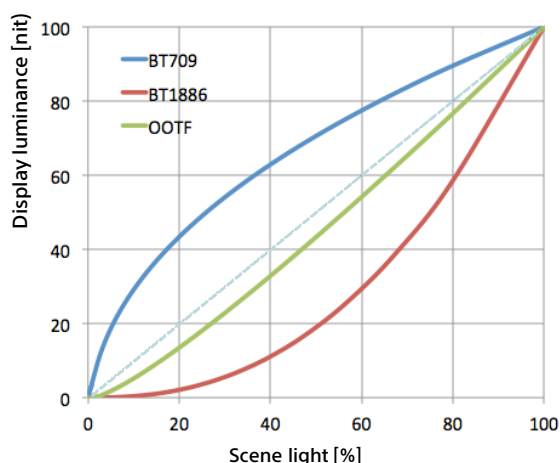
End-to-End Television Signal Chain: OOTF



Opto-Optical Transfer Function (OOTF)

OOTF : Transfer function to convert the actual scene light to display luminance; varies according to viewing environment and brightness of the display

OOTF (System Gamma) in HD SDR



BT.709 (Camera)

Transfer Function to Display $\approx 1/2.2$

BT.1886 (Display)

Display gamma for flat panel display = 2.4 (2011)

OOTF
Opto-Optical
Transfer Function
(System Gamma)
= 1.2

is known as good picture in current TVs

When viewing the images on a flat screen display, such as LCD, Plasma, without OOTF, it appears as if the black level is elevated a little.

In order to compensate the black level elevation and to make the reproduced images look closer to those on a CRT, a display gamma for flat panel display = 2.4 has been defined under BT.1886.

As a result, OOTF = 1.2 has been adopted.

Current broadcast system uses an OOTF (System Gamma) of 1.2

Overall Transfer Function (OOTF) Non-Linear

Opto-Optical Transfer Function (OOTF)

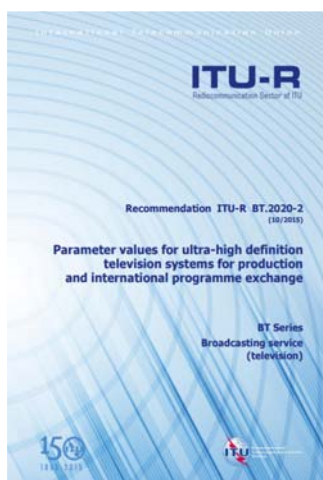
Also known as:

Overall System Gamma

Artistic Rendering Intent

ITU-R BT.2100-1
International Standard for an
HDR UHD System

Standards (Production & Program Exchange)



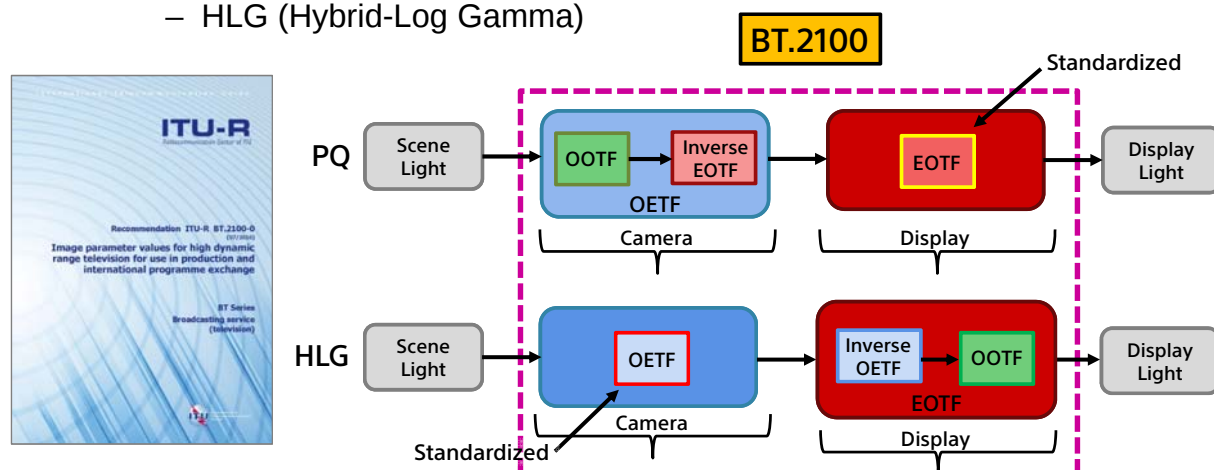
ITU-R BT.2020
Ultra HDTV Parameters



ITU-R BT.2100
HDR Parameters

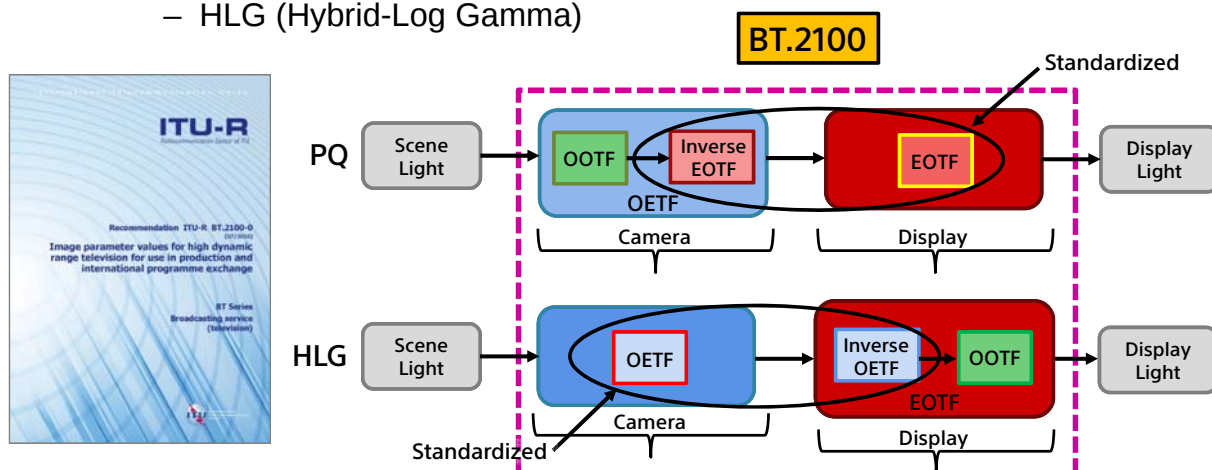
Two specifications defined for HDR in ITU

- Recommendation ITU-R BT.2100-0 (07/2016)
 - PQ (Perceptual Quantization)
 - HLG (Hybrid-Log Gamma)



Two specifications defined for HDR in ITU

- Recommendation ITU-R BT.2100-0 (07/2016)
 - PQ (Perceptual Quantization)
 - HLG (Hybrid-Log Gamma)



Summary

Item	Parameters
Format	HLG, PQ
Spatial Resolution	HD: 1920 x 1080 4K UHD: 3840 x 2160 8K UHD: 7680 x 4320
Color Space	BT.2020
Bit depth	10bit, 12bit
Frame rate	120, 120/1.001 (119.88), 100, 60, 60/1.001 (59.94), 50, 30, 30/1.001 (29.97), 25, 24, 24/1.001 (23.98)
Scan	Progressive Only

Comparison of PQ & HLG solutions

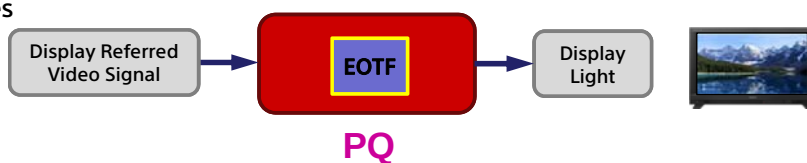
HLG is "Scene-Referred"



- Like BT.601, BT.709, Slog3, PanaLog, etc., the HLG signal describes the **relative** light in the scene.
- It is specified by the OETF (Opto-Electronic Transfer Function), the camera characteristic

PQ is "Display-Referred"

- Like the digital cinema standards, the signal describes the **absolute** light output from the mastering display.
- The signal is specified by the display EOTF



And PQ and HLG work differently

- **HLG**

- Image brightness changes with display brightness
- Dynamic range of highlights **constant**
- **Brighter displays for brighter environments**

- **PQ**

- Image brightness is constant with display brightness
- Dynamic range of highlights **increases** with display brightness
- **Brighter displays for more highlights**

HDR Live Workflow

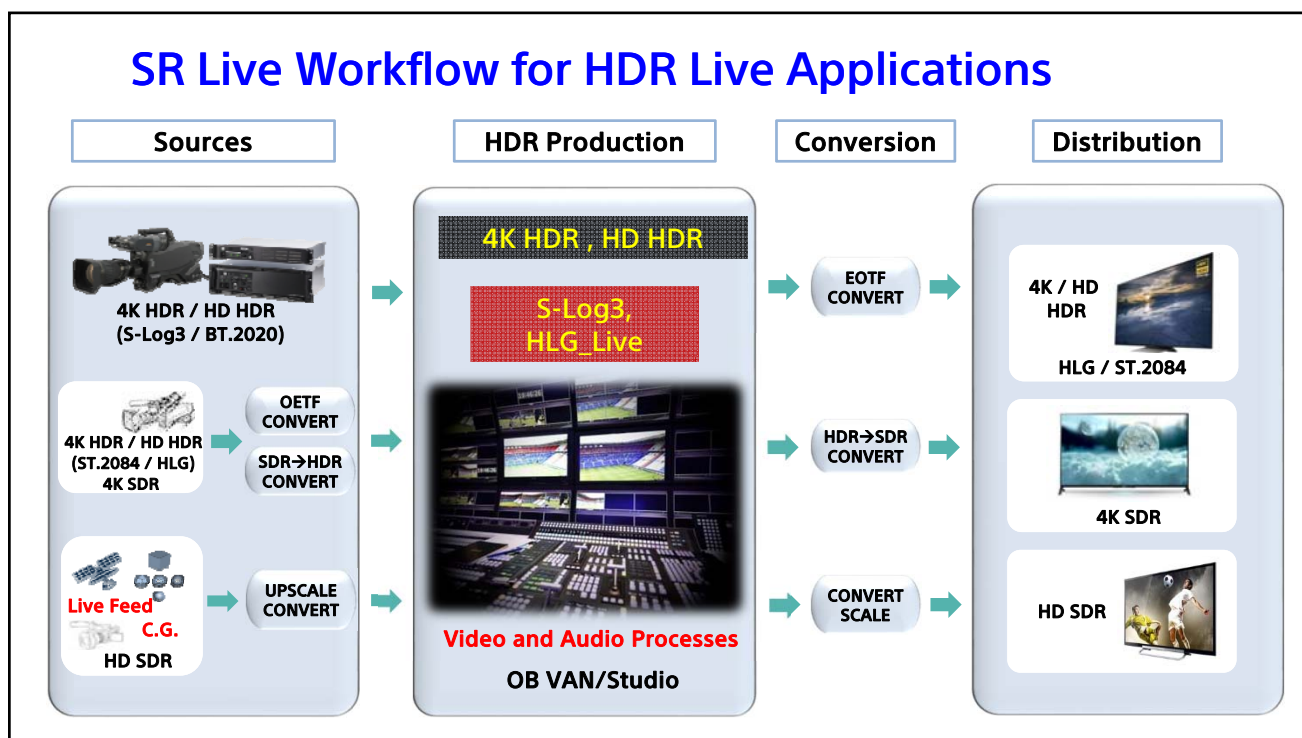
"Scene Referred Live Workflow"



SR Live for HDR Live Production Workflows

1. Efficient utilization of infrastructure and personnel to enable uncompromised production of **HDR and SDR video signals simultaneously**
2. To enable camera shading and painting operations, based on **well experienced and/or skilled techniques**, on HD-SDR monitors/WFM's
3. Creation of best production live HDR images, which can be easily converted to distribution standards on an **"As-Seen" basis**. Use of BT.2100 compliant delivery formats: HLG or PQ
4. Full artistic control on content rendering intent from production to home

SR Live Workflow for HDR Live Applications



HDR and SDR from a single camera system

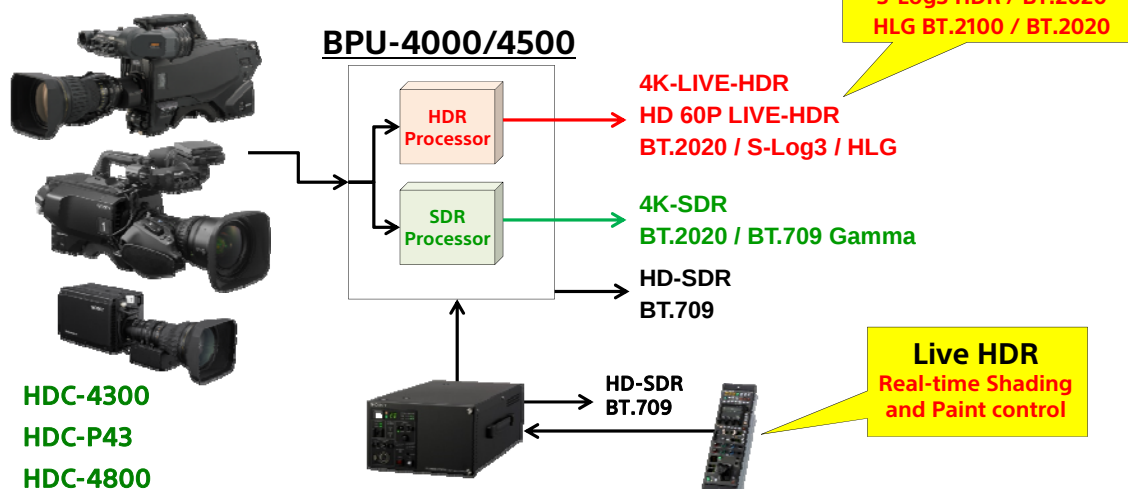
4K/HD HDR & HD SDR Simultaneous Production



Very best 4K/HD HDR / HD SDR and skilled Artistic ("Creative") Intent for HD SDR

Sony's 4K/HD HDR Live System

4K/HD **HDR** & HD **SDR** Simultaneous Production



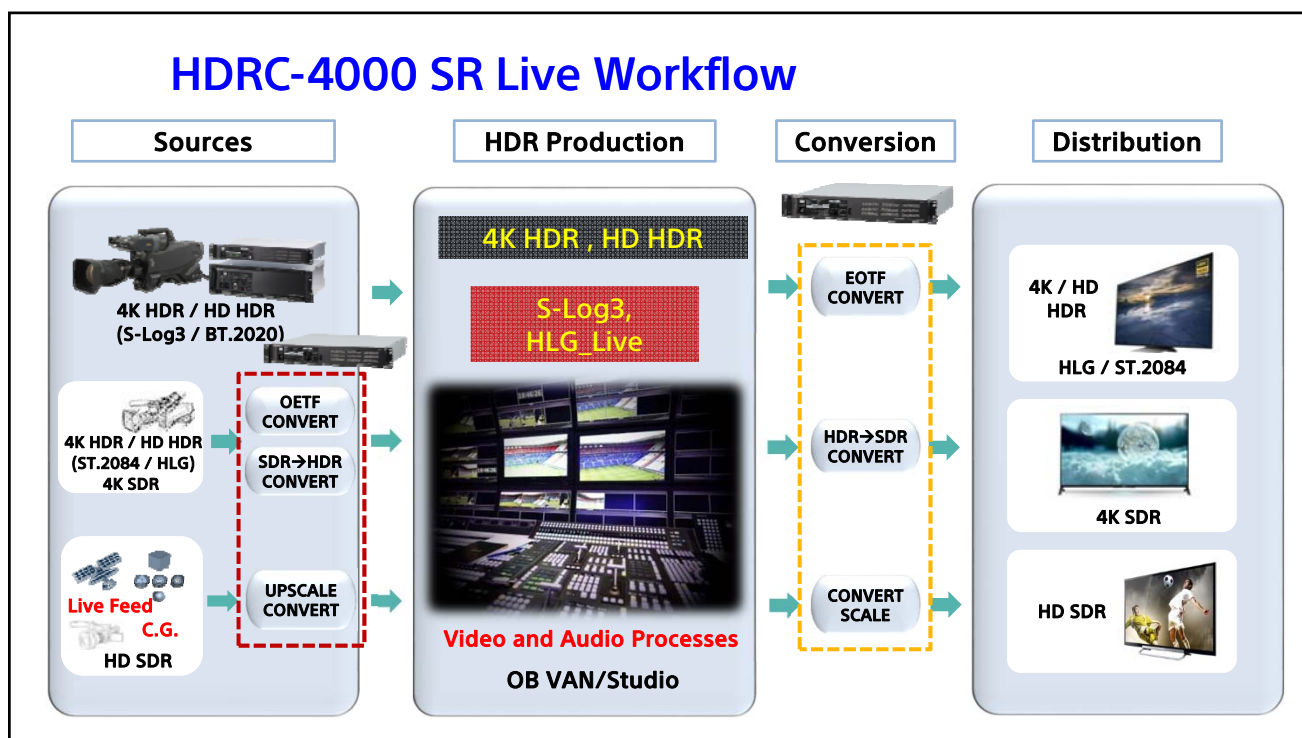
Precision Conversion and Format Processing



- Multi format conversion
 - 4K ↔ HD
 - HDR ↔ SDR
 - HDR ↔ HDR, S-Log3/HLG/PQ
 - BT.2020 / BT.709

- 12G-SDI / 6G-SDI support
- 2x4K or 8xHD; HD input x 4 mode
- MSU/RCP Configuration (file export/import)
- 'Display Referred' Function
- 6 channel embedded audio

HDRC-4000 SR Live Workflow



Accurate Monitoring/HDR Image Reproduction



BVM-X300

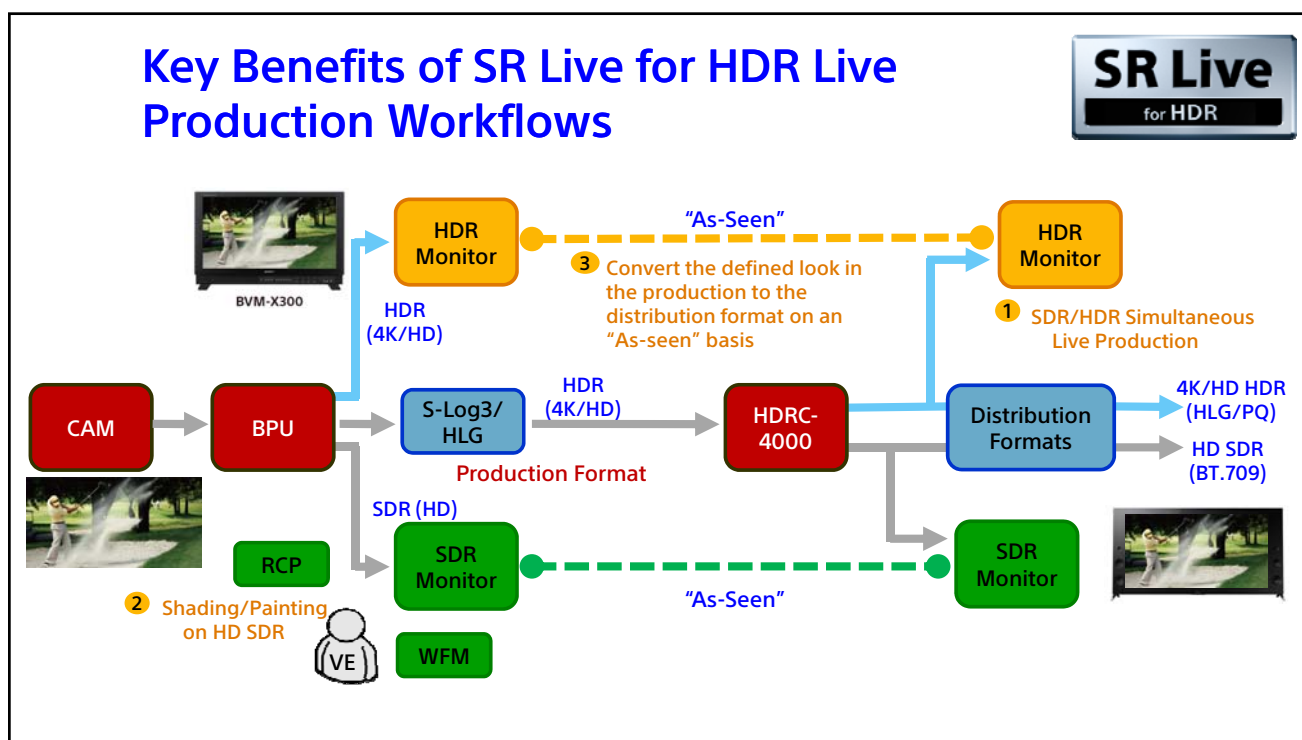
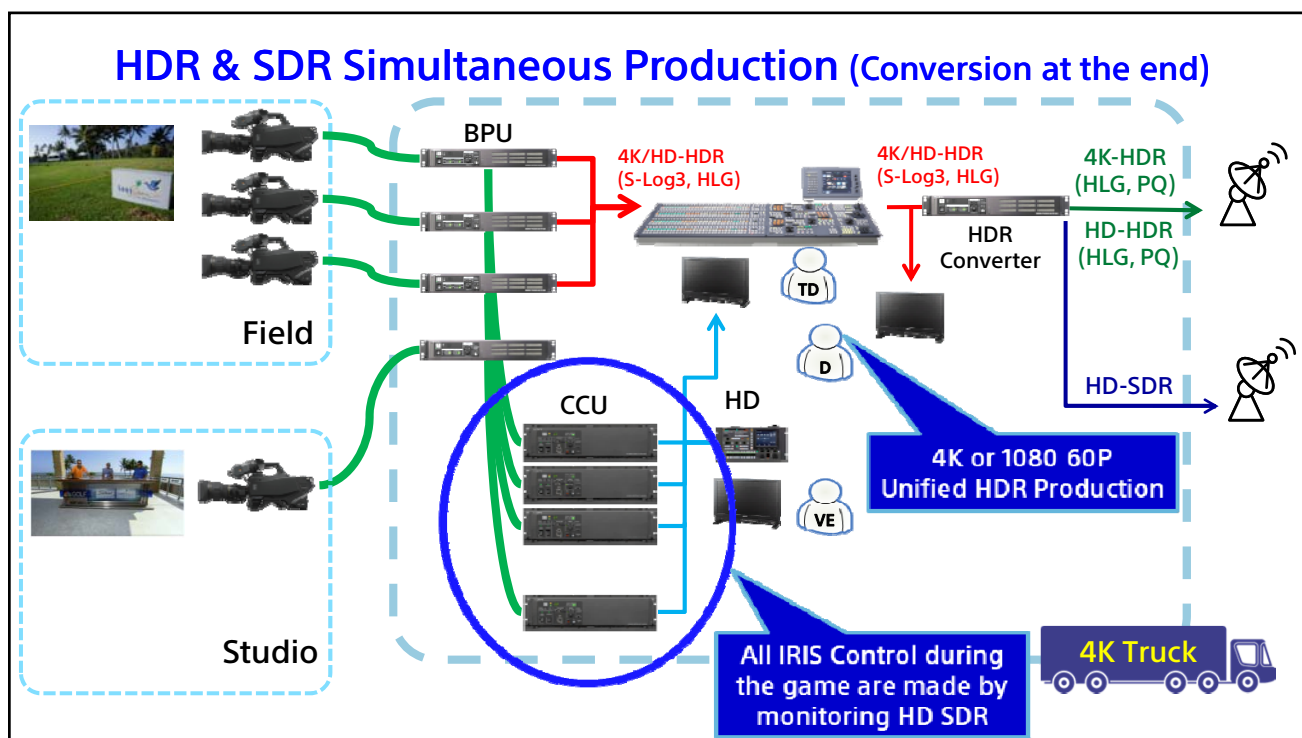
Supporting various EOTF's

- SMPTE ST 2084 (HDR)
- HLG BT.2100 (HDR)
- S-Log3/HLG (Live HDR)^(*)

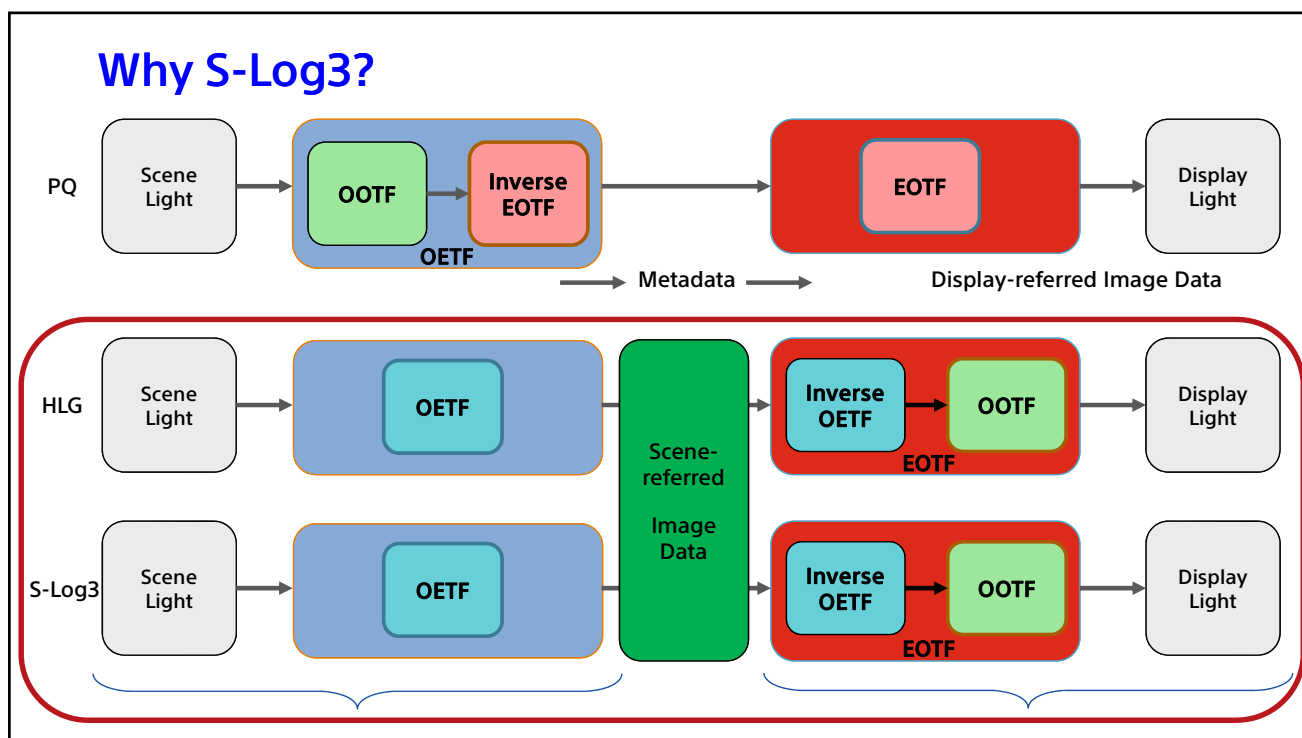
^(*) **S-Log3 / HLG (Live HDR)**

When [S-Log3/HLG (Live HDR)] is selected, BVM-X300 reproduces an S-Log3/HLG HDR image with System Gamma (or OOTF), in order to use this monitor as the reference for S-Log3/HLG Live HDR workflow, which Sony is proposing.

This System Gamma is optimized for HDR image creations and expressions. It is designed based on well-established camera control techniques for the current HD (SDR) imaging and monitoring.

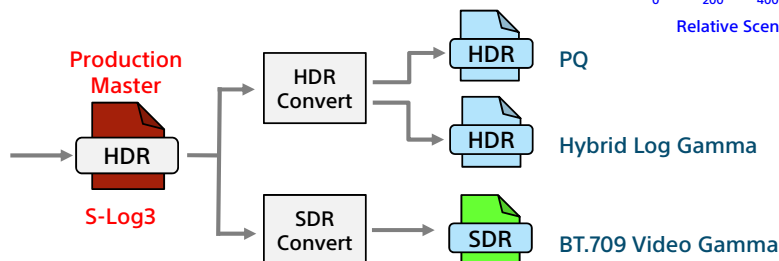
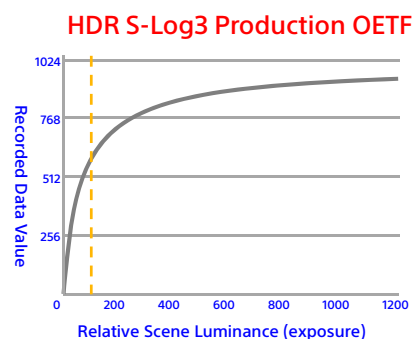


Why S-Log3?

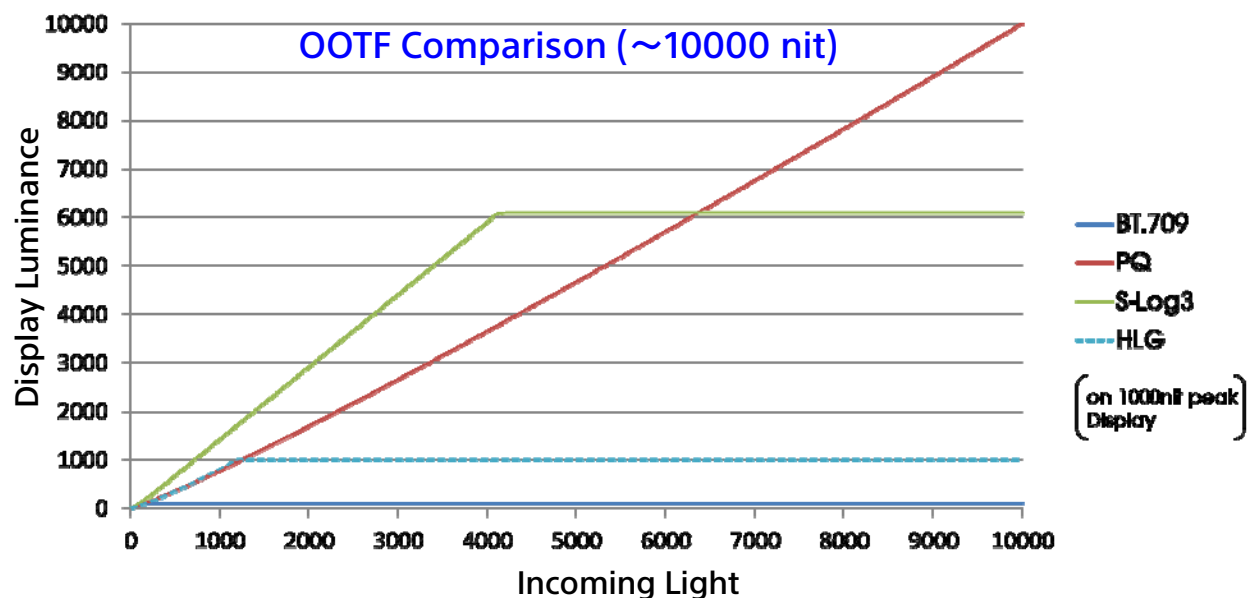


SR Live System: What is S-Log3 ?

- S-Log3 is the OETF used to derive the best performance of Sony camera's image reproduction capability
- Most suitable OETF for Color Grading Process under the condition of current 10-bit interfaces
- Excellent production master format when program is transformed to other distribution Gammas

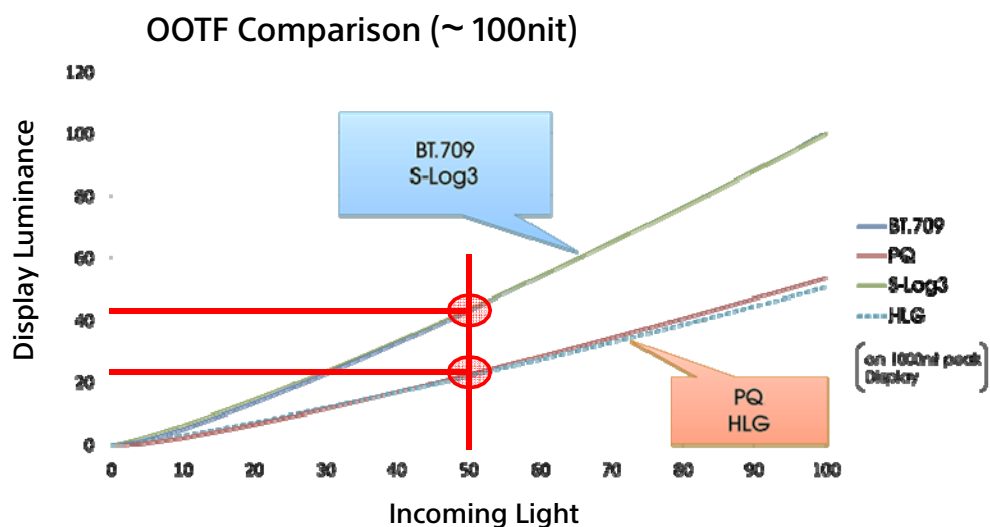


OOTF Performance



OOTF Performance (cont'd)

OOTF Performance of HDR OETF curves in SDR input signal range (0-100%)



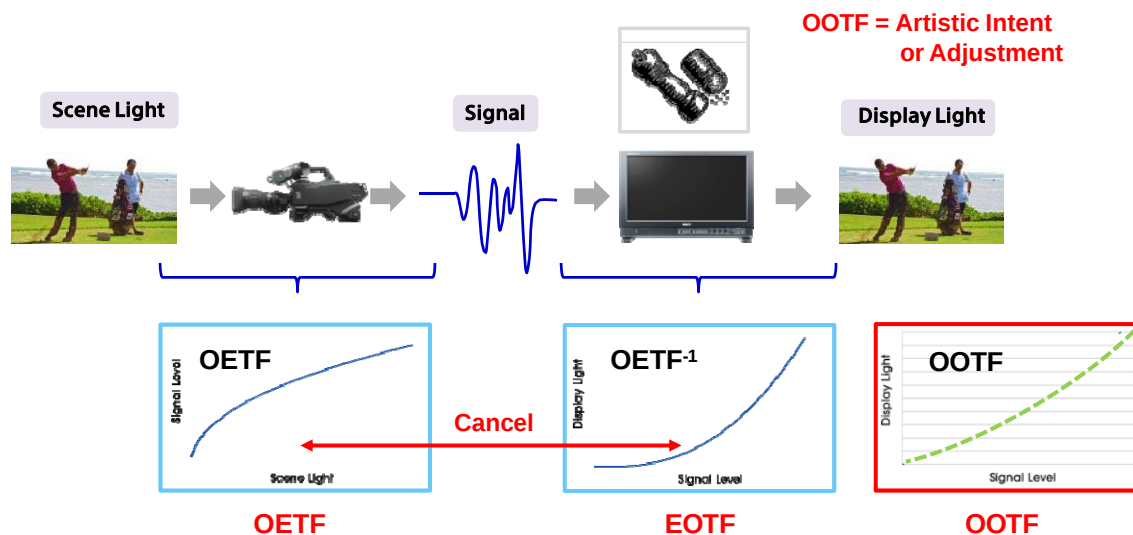
AIR Matching Function

Special Feature – AIR Matching Function

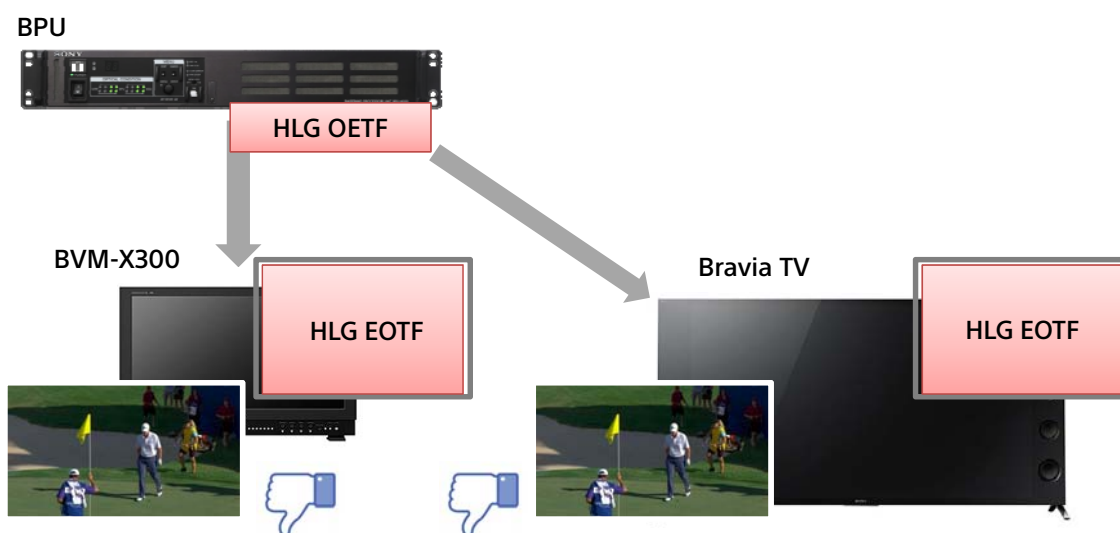
AIR: Artistic Intent Render



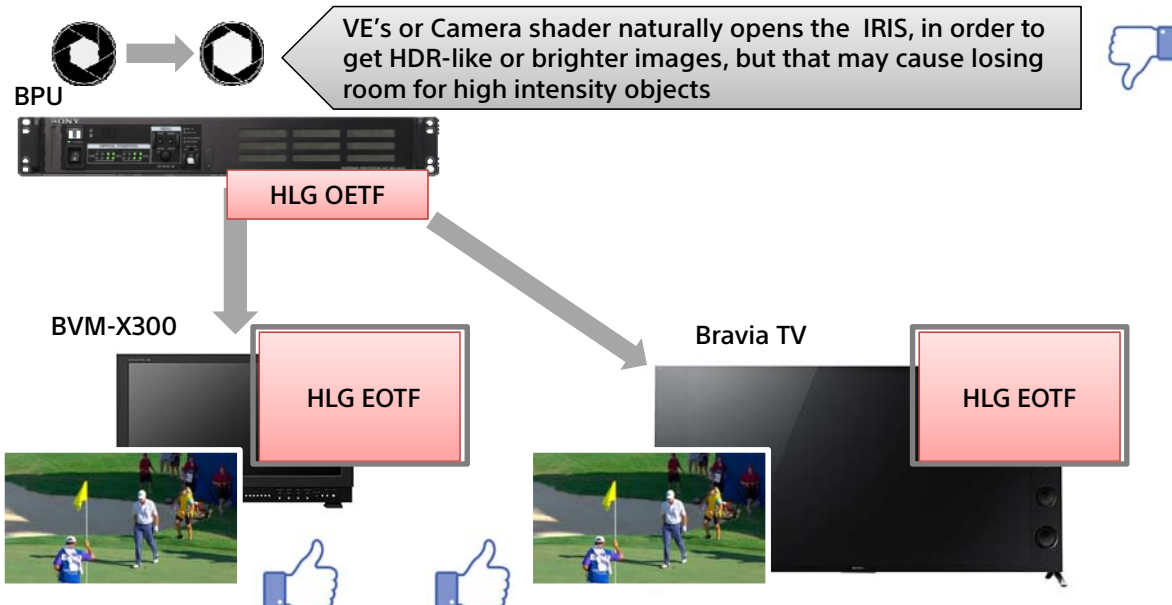
OETF – EOTF - OOTF



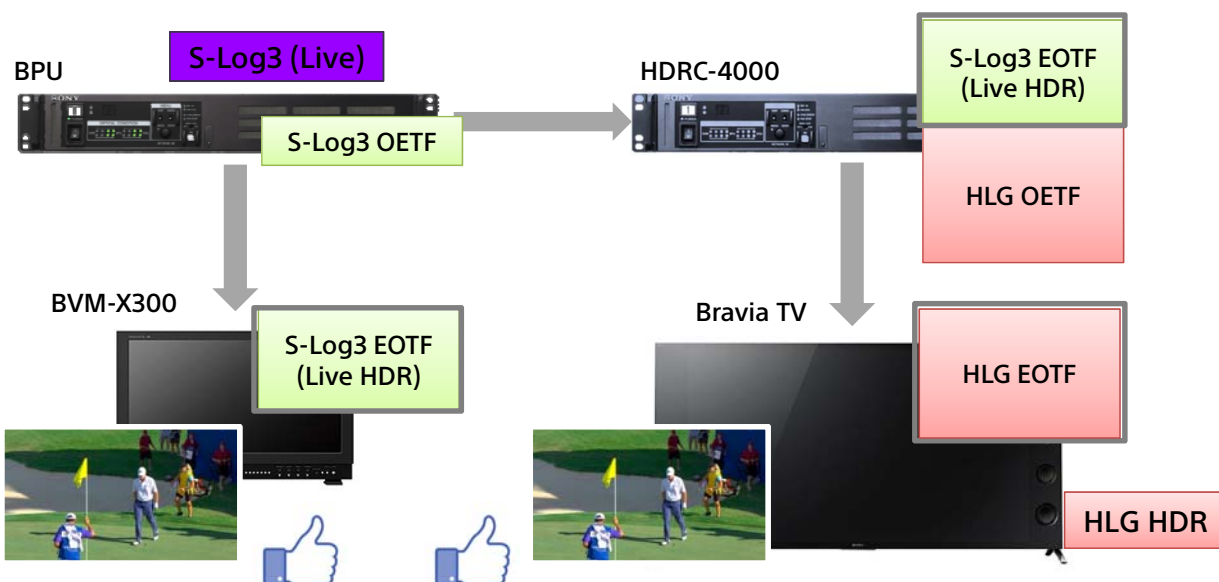
HLG End-to-End Processing: what is the result?



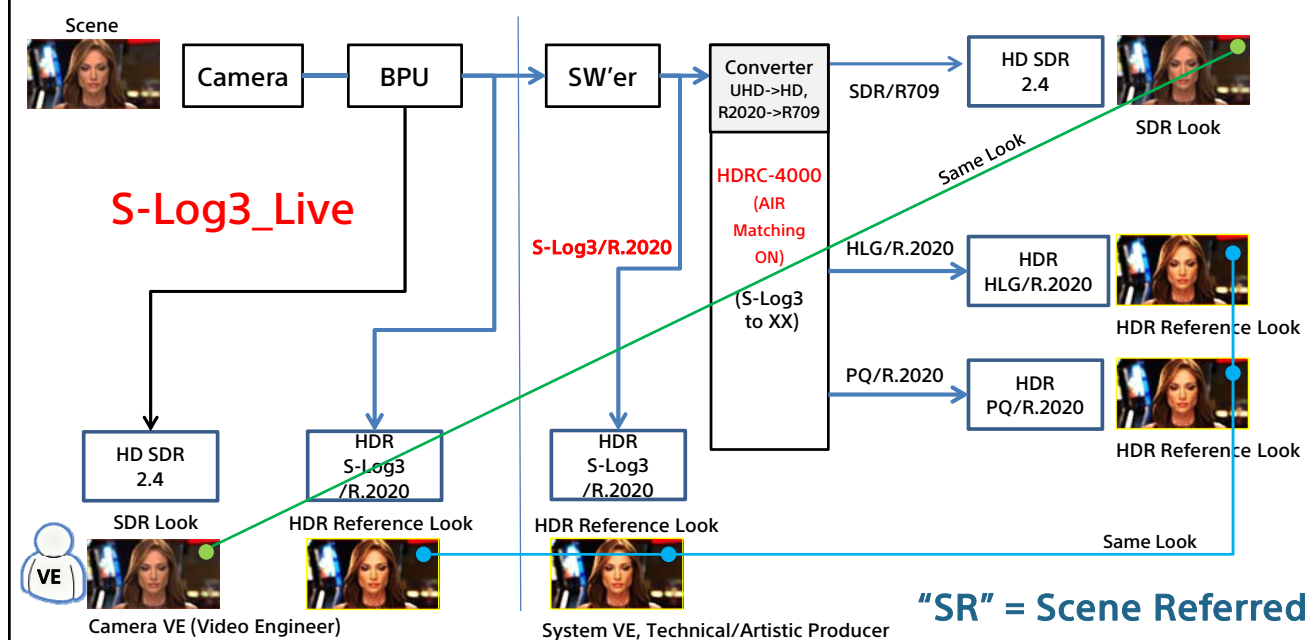
In order to gain HDR-Like Images:



Sony's S-Log3 (Live HDR) technique



Global Picture of "SR Live" for Live Productions



Worldwide HDR Live Production Events!



FIFA World Cup 2018



FIFA World Cup 2018

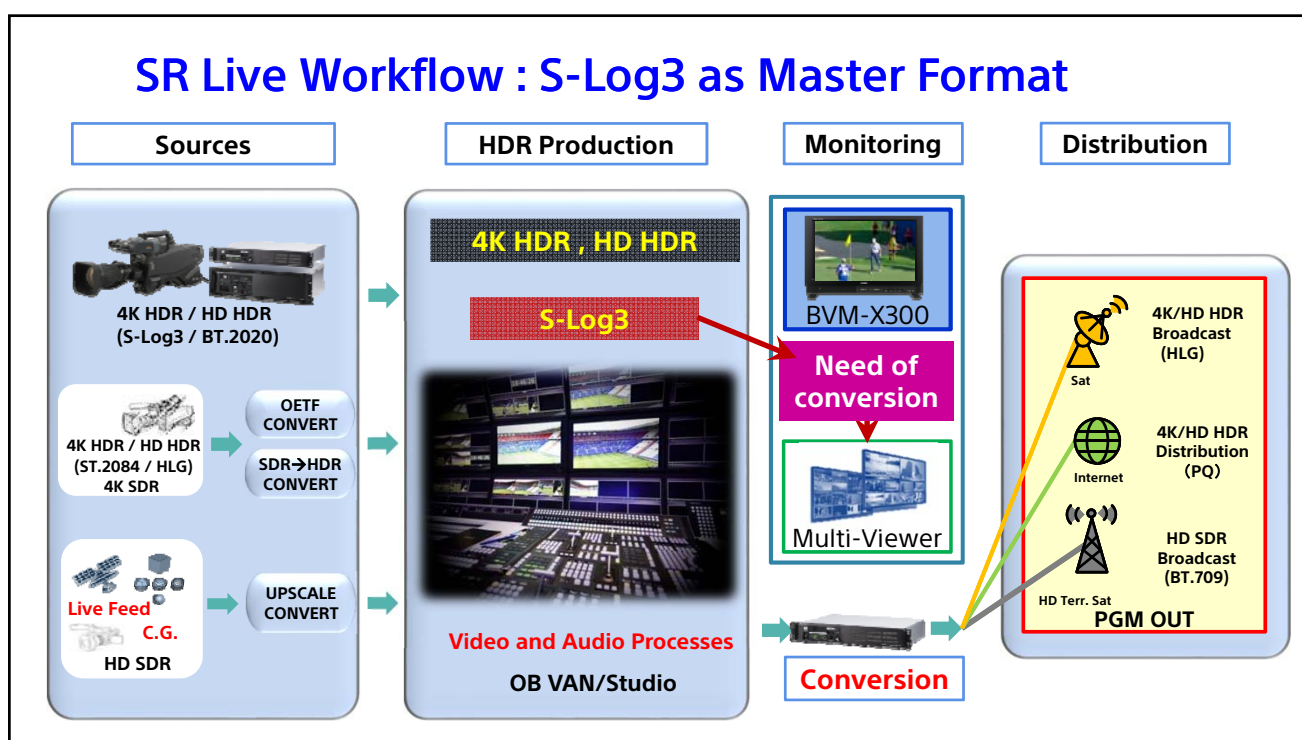
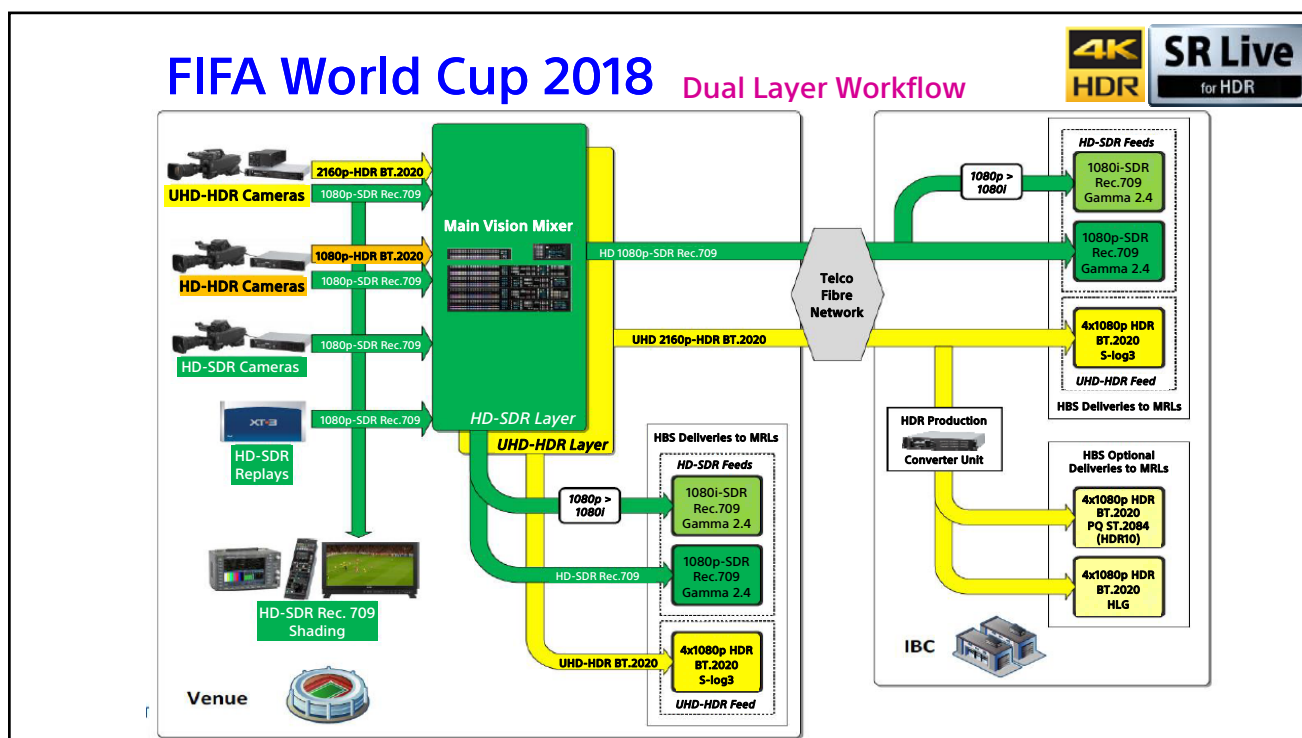


UHD/HDR Production

- 2 Layers
- Core layer 1080p/50 SDR REC.709 with HD Graphics
- Enhanced Layer UHD 2160p/50 HDR BT.2020 without Graphics
- Vision Mixer
 - 8 Cameras Dual output UHD/HDR and 1080p/SDR
 - 11 Cameras Dual output 1080p/HDR and 1080p/SDR
 - 21 Cameras Single output 1080p/SDR
 - All Replays 1080p/SDR
- Shading of all cameras is done on the 1080p/SDR layer

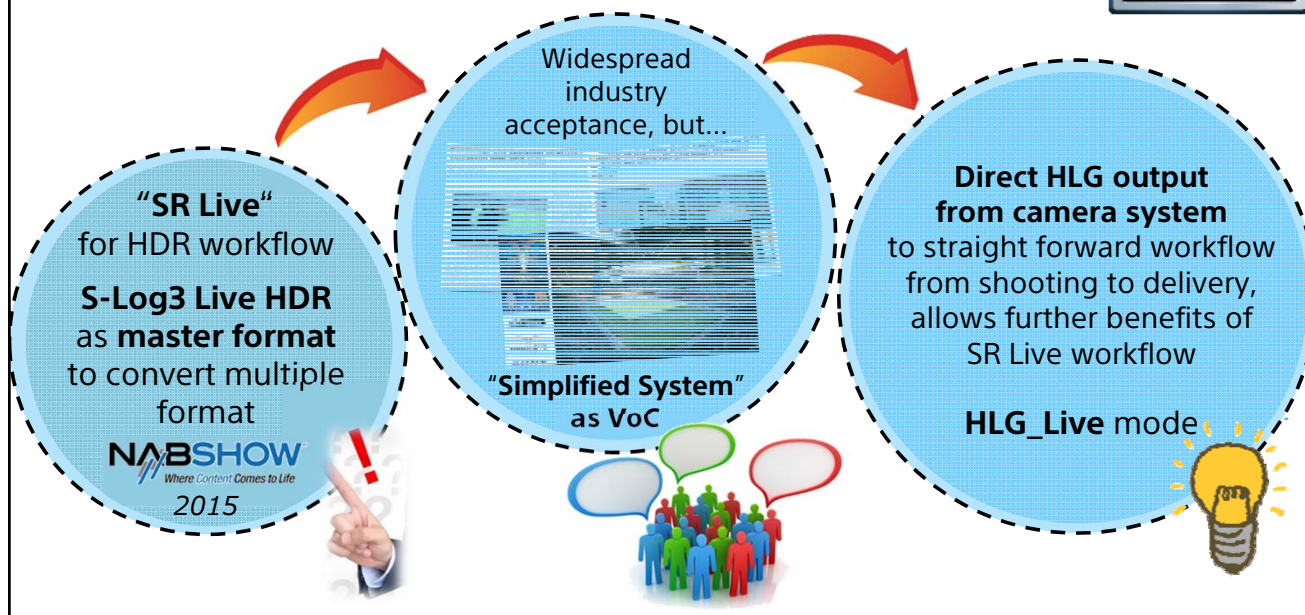
Standard Layer (HD / SDR)

- All cameras will operate in 3G 1080p50
 - Studio cams Sony HDC 4300
 - Special cams, RF, aerial
- SDR (OETF ITU-R-BT 709, gamma 2.4)
- Color space REC. 709
- Shading reference is REC. 709 and SDR Standard

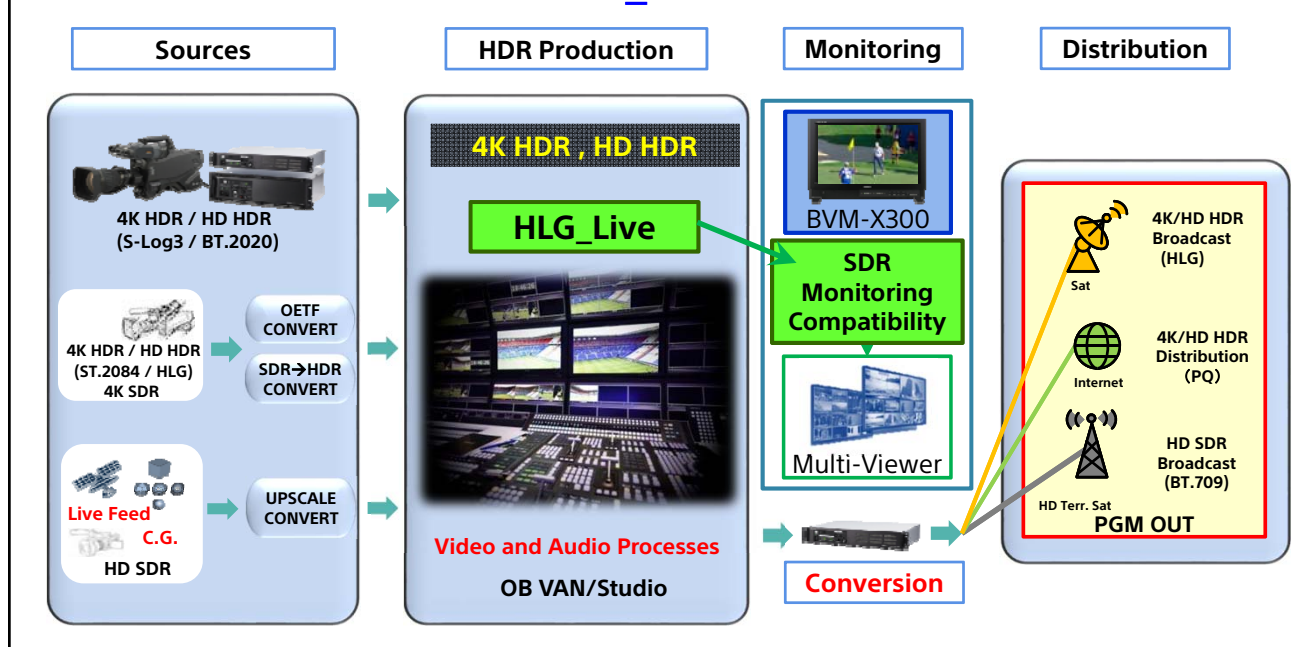


Introducing "HLG_Live" end-to-end solution

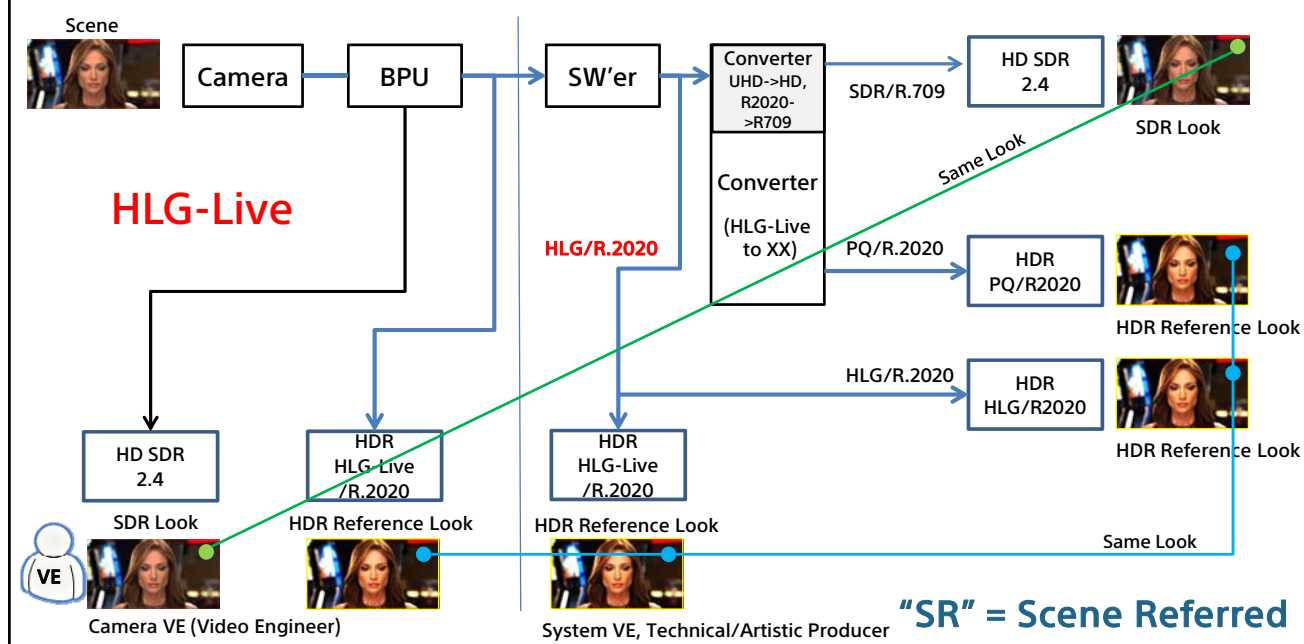
SR Live
for HDR



SR Live Workflow : HLG_Live as Master Format



Global Picture of "HLG-Live" for Live Productions



In Summary.....

3 Possible HDR OETFs created from Sony's BPU's

BPU-4000/4500



S-Log3 (Live)

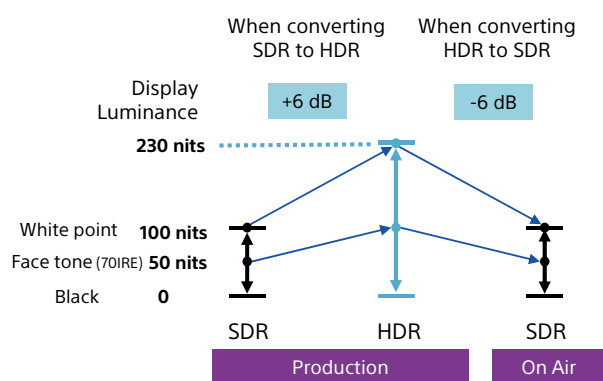
HLG_Live

HLG (BT.2100)

Some updates of Graphics and Text Levels in SR Live Workflows

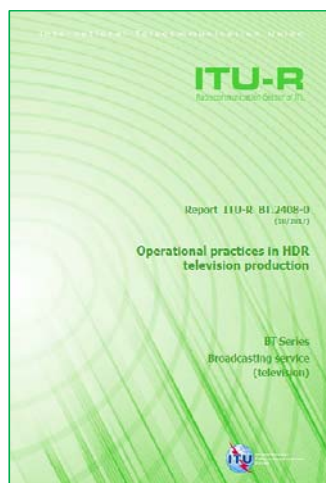
What level settings for SDR graphics?

Recommended Guideline for White Point



	Recommended Settings
SDR Gain	-6 dB
Display Luminance	230 nits
S-Log3 (Live HDR)	70 IRE (200)
HLG_Live	77 IRE (352)

HDR Production: Operational guidelines



ITU-R BT.2408-0 (10/2017)

Operational practices in HDR television production

Operational practices in HDR television production

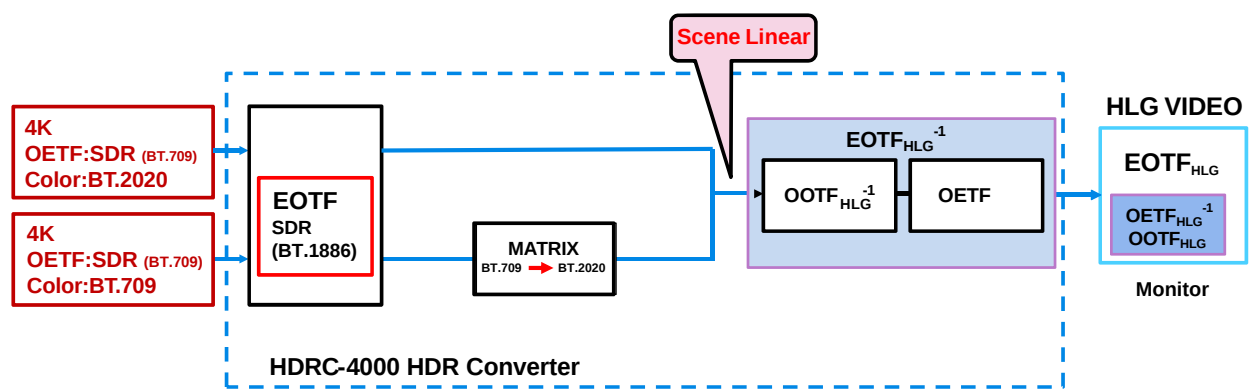
Nominal signal levels for PQ and HLG production

Reflectance Object or Reference (Luminance Factor , %)	Nominal Luminance cd/m ² (PQ & 1 000 cd/m ² HLG)	Nominal Signal Level	
		%PQ	%HLG
Grey Card (18%)	26	38	38
Greyscale Chart Max (83%)	162	56	71
Greyscale Chart Max (90%)	179	57	73
Reference Level: HDR Reference White (100%) also diffuse white and Graphics White	203	58	75

Approximate signal levels in PQ and HLG production

Reflectance Object	Nominal Luminance cd/m ² (PQ & 1 000 cd/m ² HLG)	Signal Level	
		%PQ	%HLG
Skin Tones (Fitzpatrick Scale)			
Type 1 - 2 Light skin tone	65 - 110	45 - 55	55 - 65
Type 3 - 4 Medium skin tone	40 - 85	40 - 50	45 - 60
Type 5 - 6 Dark skin tone	10 - 40	30 - 40	25 - 45
Grass	30 - 65	40 - 45	40 - 55
Ice Rink	155	55	70
White Objects	140-425	54-66	70-75

Display Referred



HDR Monitoring

HDR Monitoring Solution for 4K and HD Productions

EOTF support:

- SMPTE ST.208
- ITU-R BT.2100
- S-Log2, S-Log3, HLG (Live HDR)

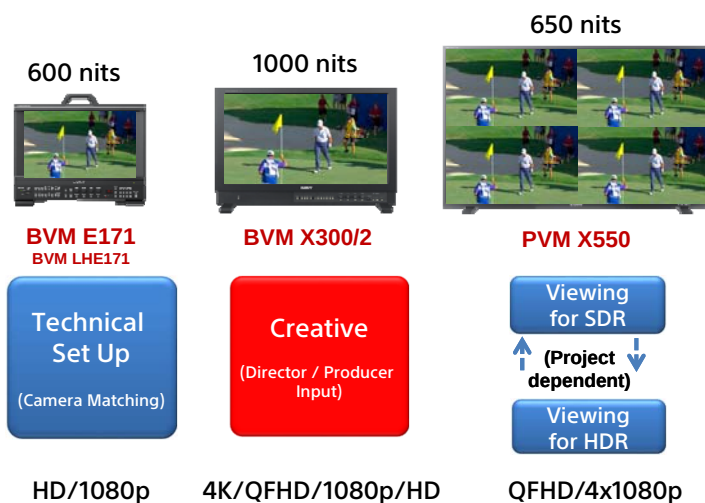
BVM E171 (HD)

& BVM X300/2 (4K/HD)

- Reference grade with 12 bit support
- WCG support of
 - ITU-R BT.2020
 - SMPTE RP.431-2 DCI P3

PVM X550 (4K/HD)

- Same processing as BVM X300/2
- OLED technology
- 4 Quadrant Display (1080P)



Tools for Live HDR Production

SR Live
for HDR



THANK YOU..... !!!!!!!

SONY