In a moment, we will start the webinar

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Technologies and workflows for using High Dynamic Range (HDR) formats in live content Productions

SPEAKER

HUGO GAGGIONI

CHIEF TECHNOLOGY OFFICER
SONY PROFESSIONAL SOLUTIONS AMERICAS, SONY ELECTRONIC, INC.
FELLOW OF SMPTE.
2018 SMPTE DAVID SARNOFF MEDAL
2019 EMMY LIFE TIME ACHIEVEMENT AWARD

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Outline

- Video Performance Evolution
- What is HDR: Basics, OETF/EOTF/OOTF, Standards, Consumer Adoption
- Broadcast HDR/SDR Workflows: Simul-production of HDR and SDR
- SR Live: S-Log3/HLG, AIR matching, HDR/SDR calibration, SR Live Metadata, Acquisition devices
- Further enhancement of HDRC-4000 HDR Production Converter
  - What's Picture Appearance: "Looks"?
  - SR/DR Conversions
  - Considerations and case-by-case proposals for SDR/HDR/SDR Round-trip
- Conclusions

5 Key Elements that define picture quality

Defined by ITU-R BT.709
Defined by ITU-R BT.2020
Defined by ITU-R BT.2100

Resolution

Frame Rate

Quantization

Color Space

Dynamic Range
(Luminance)

HDR-related Terminology

Scene
Illumination

Scene Illumination

Luminous Flux

Luminous Intensity

Illuminance (Lux)

Luminance (Nits)

Object

The Sun (or Moon) in the outdoors
'ILLUMINATE'
the scene

Studio Light in the indoors
'ILLUMINATE'
the scene

ILLUMINANCE
Is measured in LUX

Real World Scene illuminance (Lux)

HDR-related Terminology

An Introduction To "Nits"

Scene Illumination

Luminous Flux

Luminous Intensity

Illuminance (Lux)

Luminance (Nits)

Object

The Human Visual System (HVS)
sees the scene
as *reflected* illuminance
which is called LUMINANCE

LUMINANCE
is Technically measured in
Candelas per Square Meter

Typical brightness levels

Sunlight : 500,000 nits & more
Bright sunlight can reach 100,000,000 nits. Direct sunlight is about 1,600,000,000 nits.

Lighting : 15 to 500 nits
Moody lighting can be as low as 15 nits, and normal room lighting at about 500 nits. However shop and exhibition lighting may be about 1,500 nits.

LCD televisions : 200 to 300 nits
Most televisions are designed around high definition standards that do not exceed 300 nits. Their black response is also quite poor at about 0.1 nits, which does not produce good dense blacks.

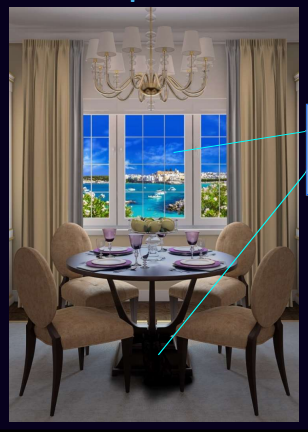
Computers : 200 nits
Most laptops will achieve 200 nits, while some of the brighter laptops can achieve 400 nits. Some desktop computer screens can achieve 500 nits or more.

Shadows : below 1 nit
Shadows are a relative concept. In a bright room the shadows may be 10 nits. However deep shadows can be lower than 1 nit.

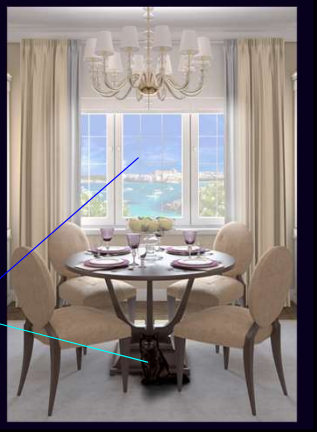
Mobile phones & tablets : 200 nits
Most mobile phones and tablets will achieve 200 nits brightness, while some of the brighter devices can achieve 400 nits.

Nit = [cd/m²]

The problem with SDR (Standard Dynamic Range)



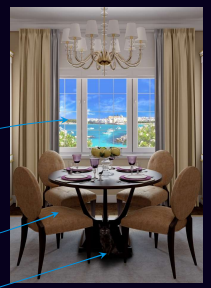
Video level set low
The high levels of brightness outside are well balanced with lots of well saturated color. However detail in the shadows are lost.

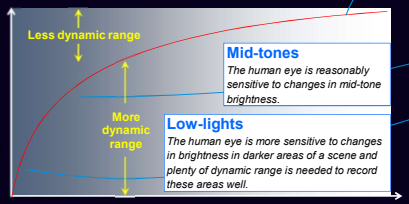


Video level set high
The outside is now burnt out, but detail in the shadows are clearly visible.

Human Eye Sensitivity

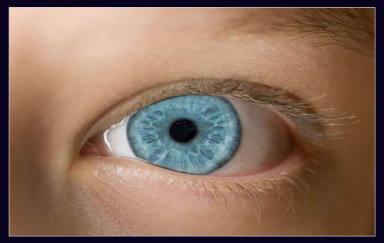
Highlights
The human eye is less sensitive to changes in brightness for bright areas of a scene. Not so much dynamic range is required for these areas and they can be compressed without reducing display quality.

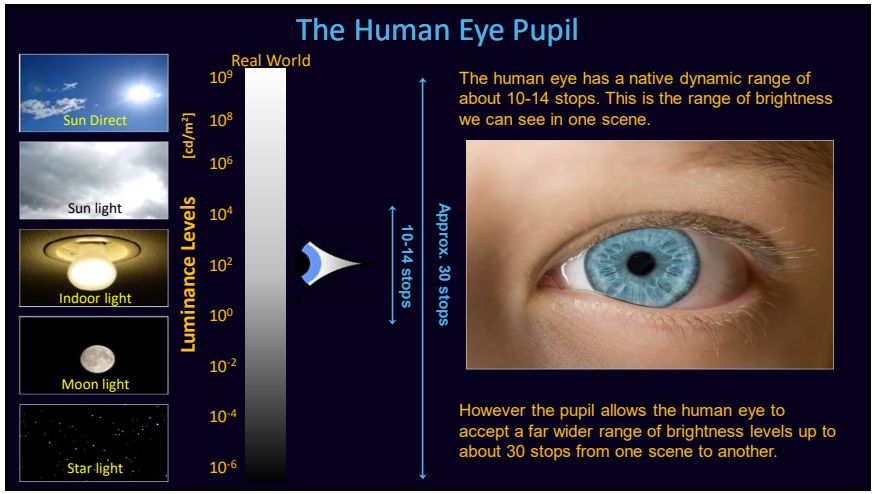


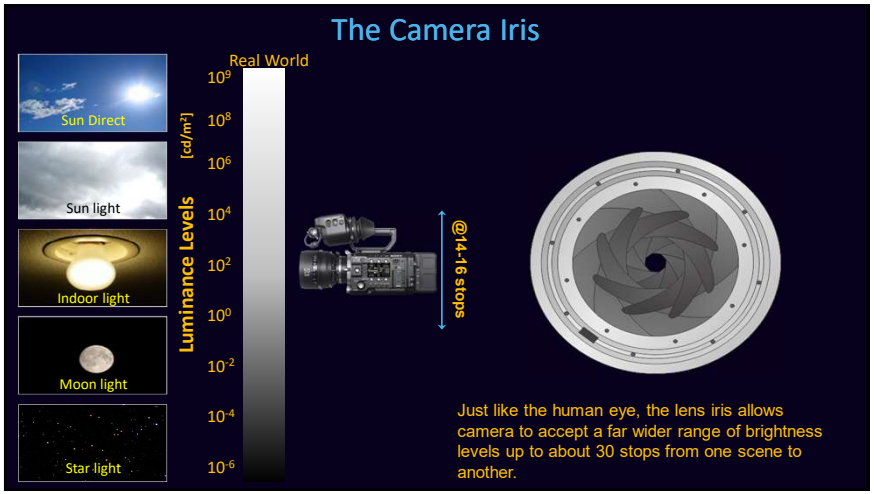


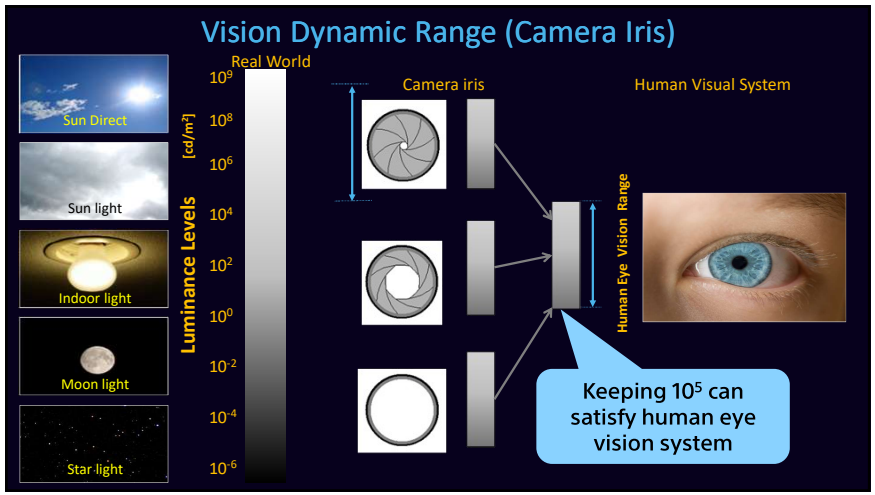
Dynamic range of Human Eye Vision

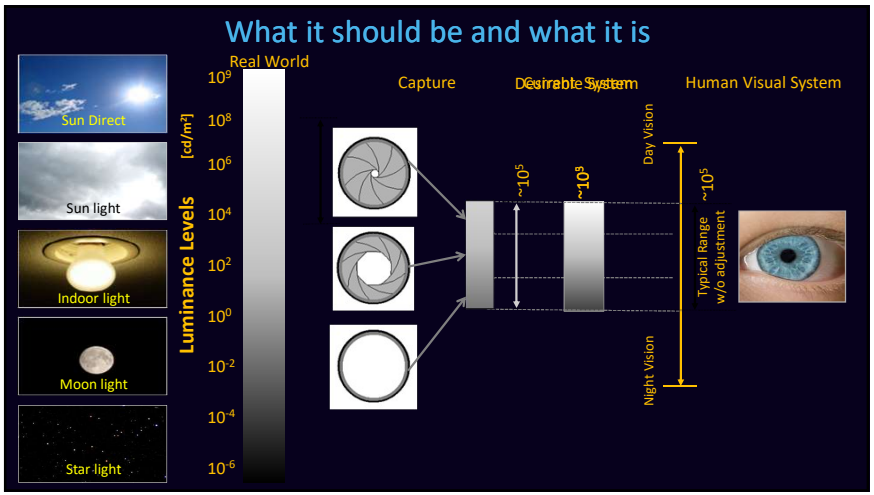
The human eye has a native dynamic range of about 10-14 stops. This is the range of brightness we can see in one scene.

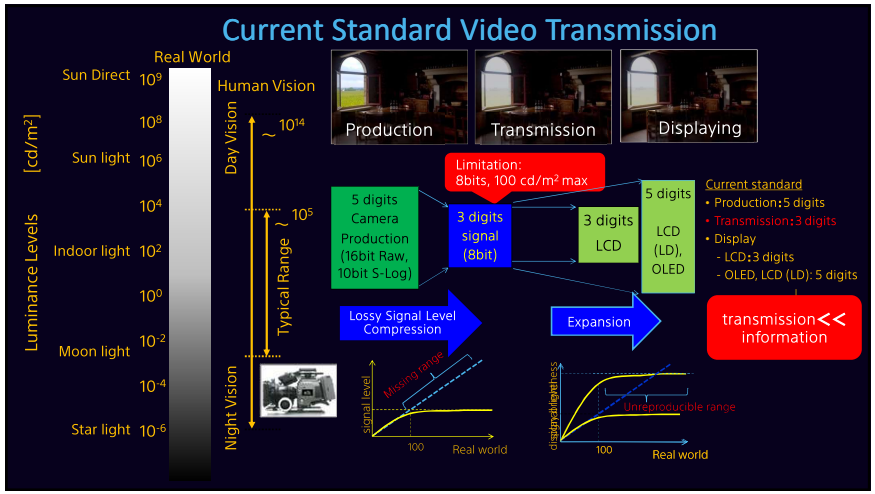


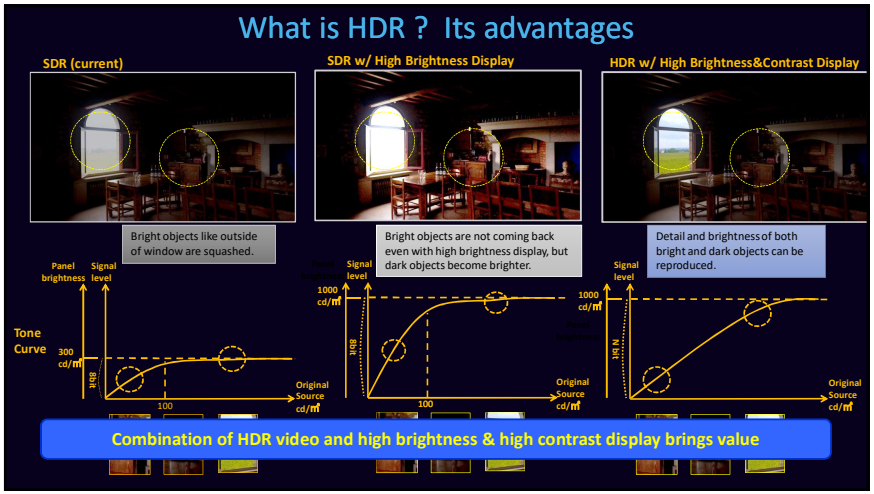

The Human Eye Pupil
Real World
Sun Direct
Sun light
Indoor light
Moon light
Star light
Luminance Levels
[cd/m²]
10⁹
10⁸
10⁶
10⁴
10²
10⁰
10⁻²
10⁻⁴
10⁻⁶
10-14 stops
Approx. 30 stops
The human eye has a native dynamic range of about 10-14 stops. This is the range of brightness we can see in one scene.
However the pupil allows the human eye to accept a far wider range of brightness levels up to about 30 stops from one scene to another.

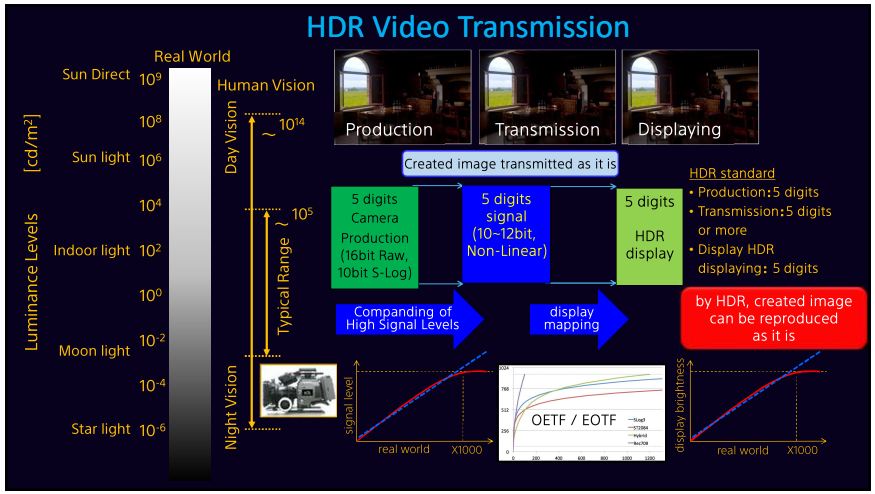

The Camera Iris
Real World
Sun Direct
Sun light
Indoor light
Moon light
Star light
Luminance Levels
[cd/m²]
10⁹
10⁸
10⁶
10⁴
10²
10⁰
10⁻²
10⁻⁴
10⁻⁶
@14-16 stops
Just like the human eye, the lens iris allows camera to accept a far wider range of brightness levels up to about 30 stops from one scene to another.

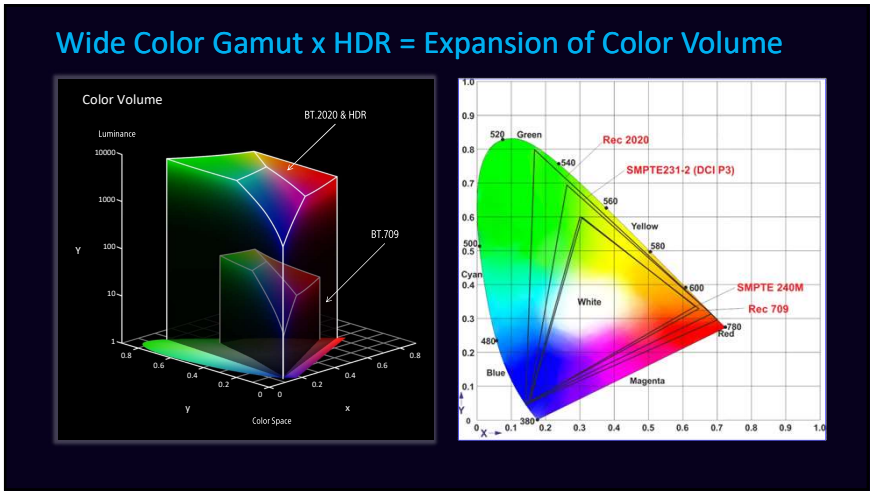

Vision Dynamic Range (Camera Iris)
Real World
Sun Direct
Sun light
Indoor light
Moon light
Star light
Luminance Levels
[cd/m²]
10⁹
10⁸
10⁶
10⁴
10²
10⁰
10⁻²
10⁻⁴
10⁻⁶
Camera iris
Human Visual System
Human Eye Vision Range
Keeping 10⁵ can satisfy human eye vision system


What it should be and what it is
Real World
Sun Direct
Sun light
Indoor light
Moon light
Star light
Luminance Levels
[cd/m²]
10⁹
10⁸
10⁶
10⁴
10²
10⁰
10⁻²
10⁻⁴
10⁻⁶
Capture
Human Visual System
~10⁵
~10⁵
Day Vision
Night Vision
~10⁵
Typical Range w/o adjustment

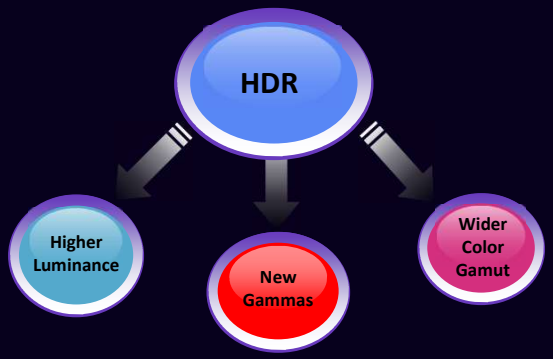

Current Standard Video Transmission
Real World
Human Vision
Luminance Levels [cd/m²]
Sun Direct 10⁹
10⁸
Sun light 10⁶
10⁴
Indoor light 10²
10⁰
Moon light 10⁻²
10⁻⁴
Star light 10⁻⁶
Day Vision
~ 10¹⁴
~ 10⁵
Typical Range
Night Vision
Production
Transmission
Displaying
Limitation: 8bits, 100 cd/m² max
5 digits Camera Production (16bit Raw, 10bit S-Log)
3 digits signal (8bit)
3 digits LCD
5 digits LCD (LD), OLED
Current standard
• Production:5 digits
• Transmission:3 digits
• Display
- LCD:3 digits
- OLED, LCD (LD): 5 digits
Lossy Signal Level Compression
Expansion
transmission<< information
signal level
Missing range
100
Real world
display brightness
Unreproducible range
100
Real world


What is HDR ? Its advantages
SDR (current)
SDR w/ High Brightness Display
HDR w/ High Brightness&Contrast Display
Bright objects like outside of window are squashed.
Bright objects are not coming back even with high brightness display, but dark objects become brighter.
Detail and brightness of both bright and dark objects can be reproduced.
Tone Curve
Panel brightness
Signal level
300 cd/m²
8bit
100
Original Source cd/m²
1000 cd/m²
10bit
Combination of HDR video and high brightness & high contrast display brings value


HDR Video Transmission
Real World
Human Vision
Luminance Levels [cd/m²]
Sun Direct 10⁹
10⁸
Sun light 10⁶
10⁴
Indoor light 10²
10⁰
Moon light 10⁻²
10⁻⁴
Star light 10⁻⁶
Day Vision
~ 10¹⁴
~ 10⁵
Typical Range
Night Vision
Production
Transmission
Displaying
Created image transmitted as it is
5 digits Camera Production (16bit Raw, 10bit S-Log)
5 digits signal (10~12bit, Non-Linear)
5 digits HDR display
HDR standard
• Production:5 digits
• Transmission:5 digits or more
• Display HDR displaying: 5 digits
Companding of High Signal Levels
display mapping
by HDR, created image can be reproduced as it is
signal level
real world
X1000
OETF / EOTF
display brightness
real world
X1000

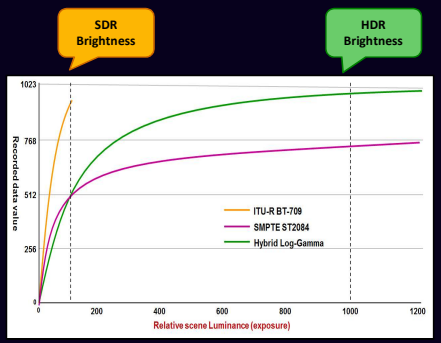

Wide Color Gamut x HDR = Expansion of Color Volume
Color Volume
Luminance
BT.2020 & HDR
BT.709
Color Space
Green
Rec 2020
SMPTE231-2 (DCI P3)
Yellow
Cyan
White
SMPTE 240M
Rec 709
Blue
Magenta
Red

Components of an HDR Image



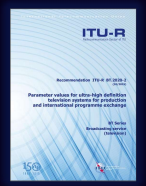
New 'Gamma' curves for HDR signals

- Input/output curves for transmission of HDR signals (OETF/EOTF
- "PQ" (SMPTE standard ST.2084)
- "HLG" (Hybrid Log-Gamma) developed by BBC/NHK
- Both techniques standardized in ITU-R BT.2100-2



HDR: International Standards and Practices

(Production & Program Exchange)



ITU-R BT.2020

Ultra HDTV Parameters

ITU-R BT.2100

HDR Parameters

ITU-R BT.2408-1

HDR Operational Practices

ITU-R BT.2390

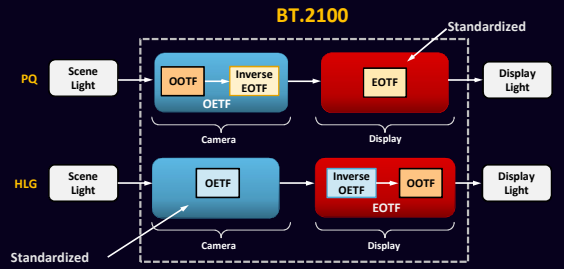
HDR Television

Two Specifications Defined for HDR in ITU

Recommendation ITU-R BT.2100

PQ (Perceptual Quantization)

HLG (Hybrid-Log Gamma)

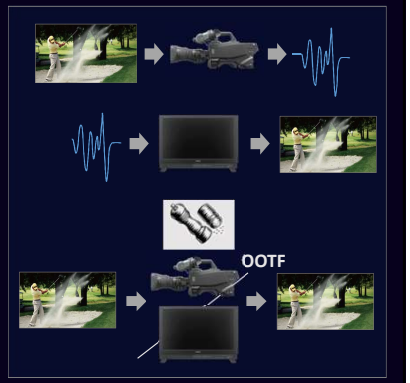


What are OETF/EOTF/OOTF?

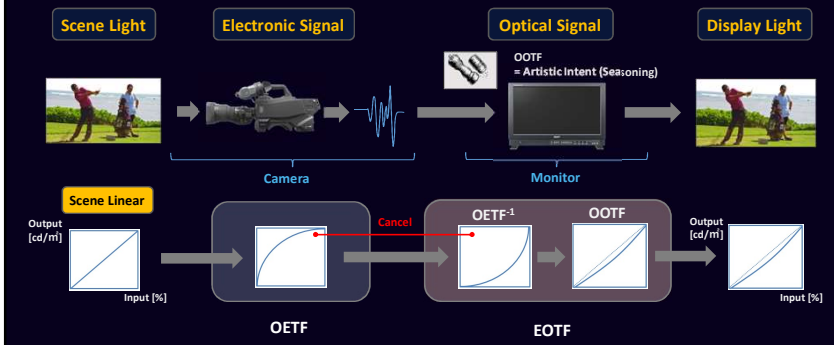
OETF (Opto-Electrical Transfer Function)
- Converts lights to electric signals
  = Camera's gamma curve

EOTF (Electro-Optical Transfer Function)
- Converts electric signals to display luminance
  = Display's gamma curve

OOTF (Opto-Optical Transfer Function)
- Transfer function between the actual scene light and the display luminance
- Varies according to viewing environment and brightness of the display
- Includes the image control and artistic intent of the production process (= Look)

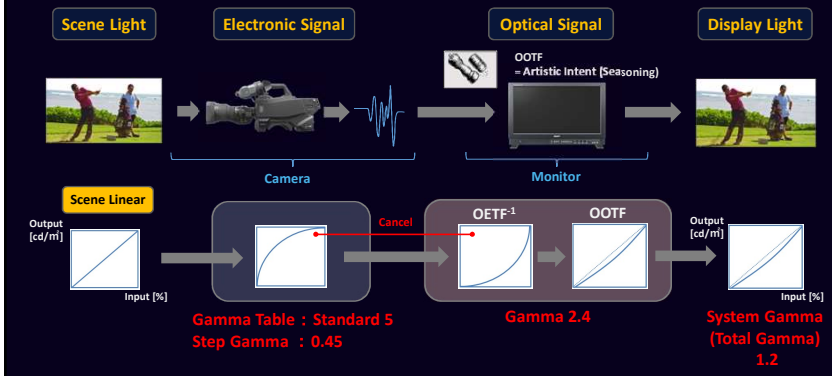


Relationship between OETF/EOTF/OOTF

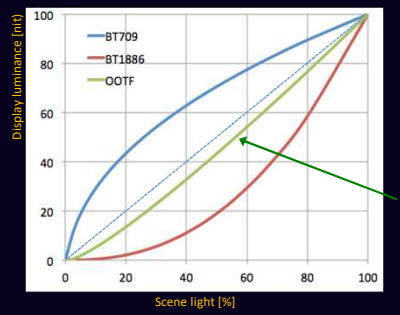


To display HDR accurately, same settings between OETF of camera and EOTF of display are needed!!
--> Different settings make HDR signal and display to look wrong

SDR (BT.1886)



OOTF (System Gamma) in HD SDR



BT.709 (Camera)
Transfer Function
to Display ≒ 1/2

BT.1886 (Display)
Display gamma for
flat panel display = 2.4
(2011)

OOTF (System Gamma)
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

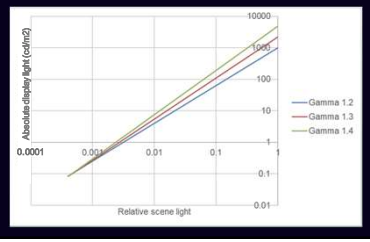
"Rendering Intent", "System Gamma", "OOTF", "Look"

Critical with variations in Display Brightness and Viewing Conditions

Gamma too low

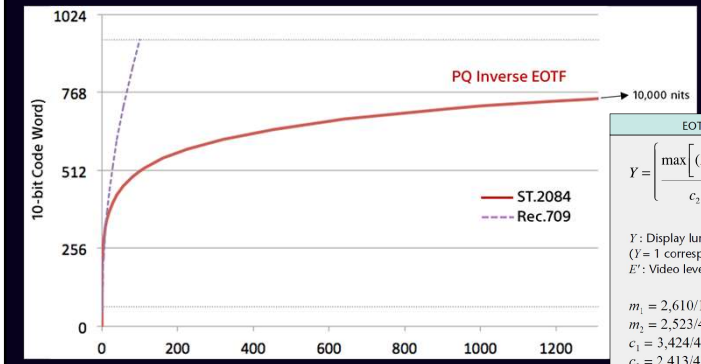
Gamma correct

Gamma too high



- Brighter viewing environments require lower gamma values
- Lower display gamma lifts details out of the shadows

ST.2084 = PQ



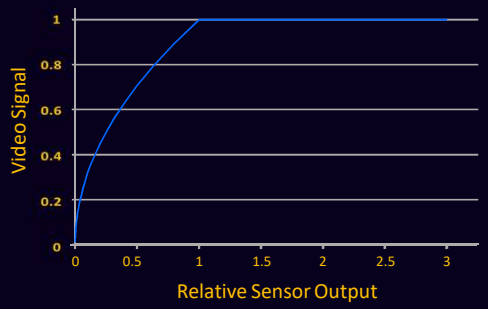
EOTF of PQ format

$$Y = \left\{ \frac{\max\left[(E'^{1/m_2} - c_1), 0 \right]}{c_2 - c_3 E'^{1/m_2}} \right\}^{1/m_1}$$

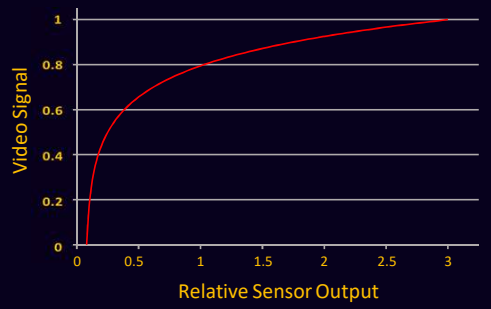
Y : Display luminance [0:1]
(Y = 1 corresponds to 10,000 cd/m²)
E' : Video level

$m_1 = 2{,}610/16{,}384$
$m_2 = 2{,}523/4{,}096 \times 128$
$c_1 = 3{,}424/4{,}096$
$c_2 = 2{,}413/4{,}096 \times 32$
$c_3 = 2{,}392/4{,}096 \times 32$

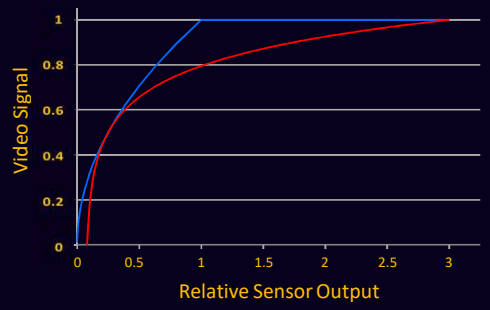
Conventional SDR Camera Curve



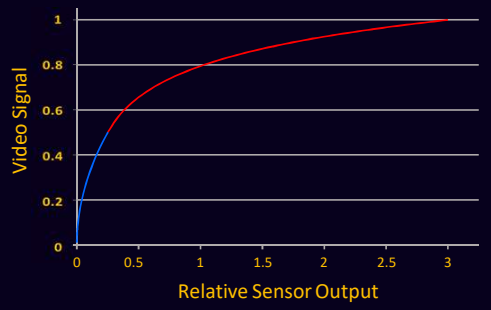
Camera Log Curve



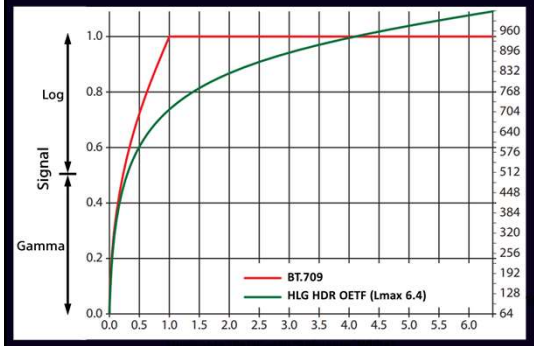
Best of Both



Hybrid Log Gamma HDR Camera Curve



Hybrid Log Gamma HDR Camera Curve



OETF of HLG format

$$E' = \begin{cases} \sqrt{3E} & 1 \le E \le 1/12 \\ a \cdot \ln(12E - b) + c & 1/12 < E \le 1 \end{cases}$$

E : Scene linear light normalized to the range [0:1]
E' : Video level

$a = 0.17883277$
$b = 1 - 4a$
$c = 0.5 - a \ln(4a)$

Comparison of PQ & HLG solutions

HLG is "Scene-Referred"

Scene Light → OETF → Scene Referred Video Signal

HLG

- Developed by BBC & NHK (Japan)
- The HLG signal describes the **relative** light in the scene.
- Similar to BT.601, BT.709, S-Log3, Panalog, etc.,
- It is specified by the OETF - the camera's transfer characteristic.

PQ is "Display-Referred"

- Developed by Dolby
- The signal describes the **absolute** light output from the mastering display.
- The signal is specified by the display EOTF

Display Referred Video Signal → EOTF → Display Light

PQ

ITU-R BT.2100 – Hybrid Log-Gamma (HLG)

Output Range varies depending on peak luminance display

Luminance Levels [cd/m²]

10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6}

Human Visual System (approx. 30 stops)

Adaptation — Simultaneous HVS (~14 stops) — Adaptation

Adaptation — HLG 10-bit (~17 stops) Scene Referred — Adaptation

HLG Represents Relative Brightness

600 cd/m² "shading"
e.g. OB truck

Code Values 64 - 940

1000 cd/m² "shading"
e.g. studio master control

Code Values 64 - 940

2000 cd/m² "grade"
Post-prod. room

Code Values 64 - 940

The signal is constant with mastering display.
Display adaptation inherent part of HLG EOTF

e.g. 400 cd/m² home theatre

Code Values 64-940

e.g. 1000 cd/m² evening viewing

Code Values 64-940

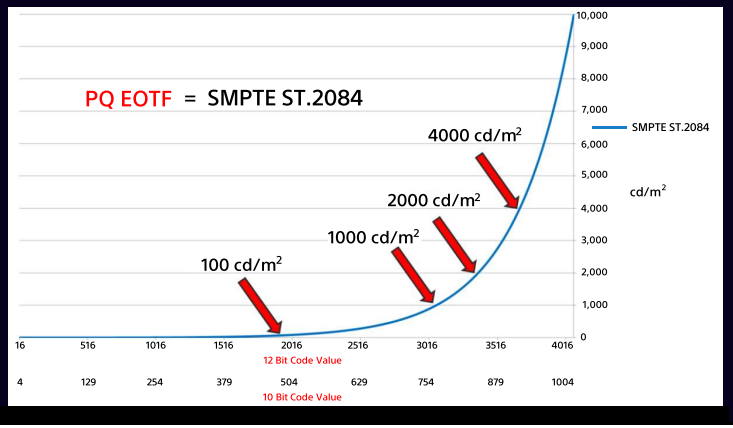
e.g. 2000 cd/m² daytime viewing

Code Values 64-940

e.g. 4000 cd/m² signage display

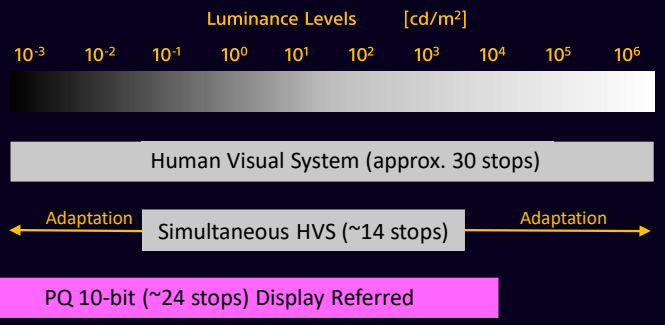
Code Values 64-940

PQ display luminance defined by Absolute code

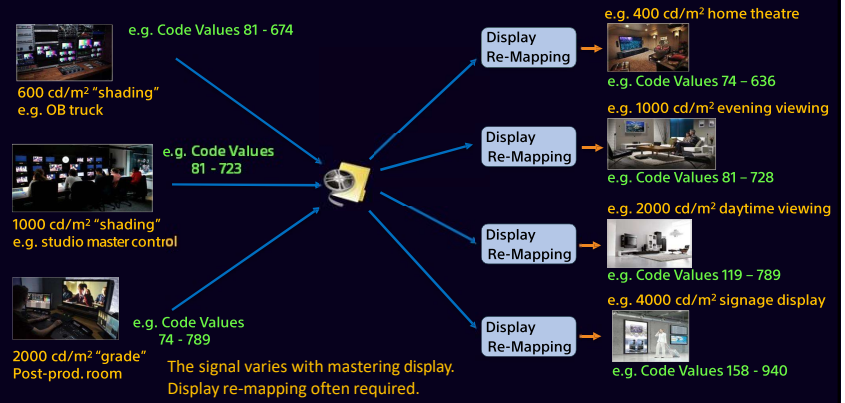


ITU-R BT.2100 – Perceptual Quantizer (PQ)

Fixed output range



PQ represents Absolute display luminance



Need for tone mapping by display devices

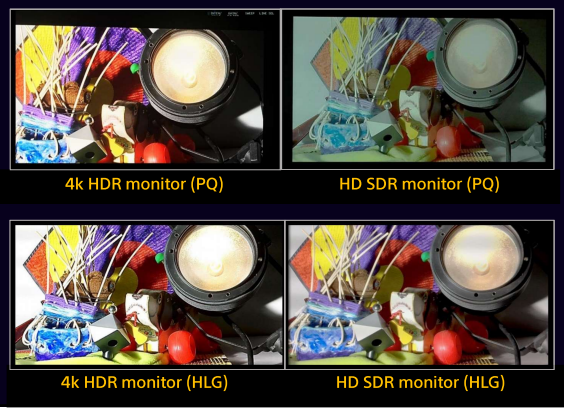


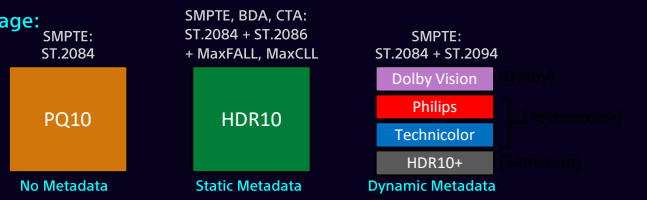
Image Presentation

- HLG
  - Brighter displays for brighter environments
  - Image brightness changes with display brightness
  - Dynamic range of highlights constant -- determined by diffuse white
- PQ
  - Brighter displays for more highlights
  - Image brightness constant with display peak brightness
  - Dynamic range of highlights increases with peak brightness of the display used for mastering

HDR Formats for Content Distribution

HDR Formats for Content Distribution

- HLG (Hybrid Log Gamma) : No metadata required
- PQ (Perceptual Quantizer) (SMPTE standard ST.2084):
  - PQ10: No metadata and implemented with 10bits
  - HDR10: PQ10 + Static Metadata (SMPTE ST.2086) + MaxFALL, MaxCLL
  - Dolby Vision: SDR + Dolby Dynamic Metadata (SMPTE ST.2094-10)
  - SL-HDR1: SDR + Philips/Technicolor Dynamic Metadata (SMPTE ST.2094-30)
  - HDR10+ : PQ + Samsung Dynamic Metadata (SMPTE ST.2094-40)
- PQ Usage:



HDR10 Media Profile

Video on Demand (VoD) / Over The Top (OTT) - (non-Live) content

HDR10 Media Profile is defined as:

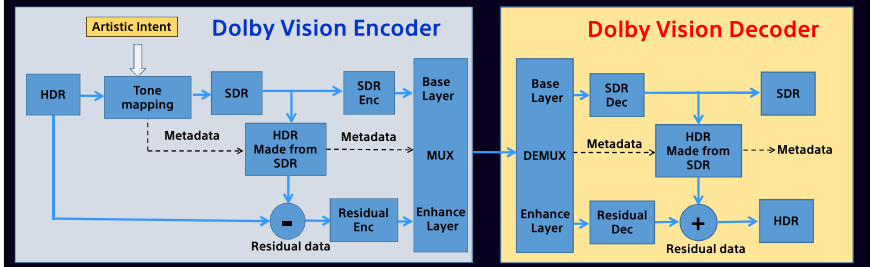
- 3840x2160 & 1920x1080 picture raster
- EOTF: SMPTE ST. 2084
- Color Sub-sampling: 4:2:0 (for compressed video sources)
- Frame rates: 23.9760p / 24p / 25p / 50p / 59.94p / 60p
- Bit Depth: 10 bit
- Color Primaries: ITU-R BT.2020
- Static Metadata: SMPTE ST. 2086, MaxFALL, MaxCLL
- Interface between TV and STB: HDMI 2.0a utilizing CEA 861.3 for inclusion of EOTF signaling and meta-data

What is Dolby Vision?

System of Double Layer on single stream

How to reduce data rate?

-- Send Base Layer with Enhance Layer and metadata



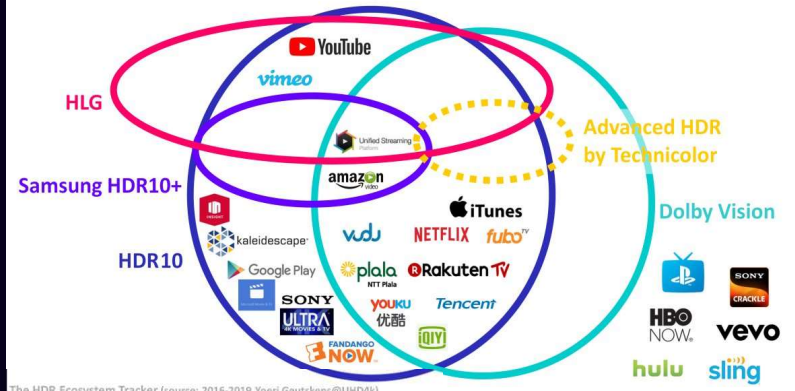
SDR & HDR Systems: Static and Dynamic Metadata

SDR
BT.709

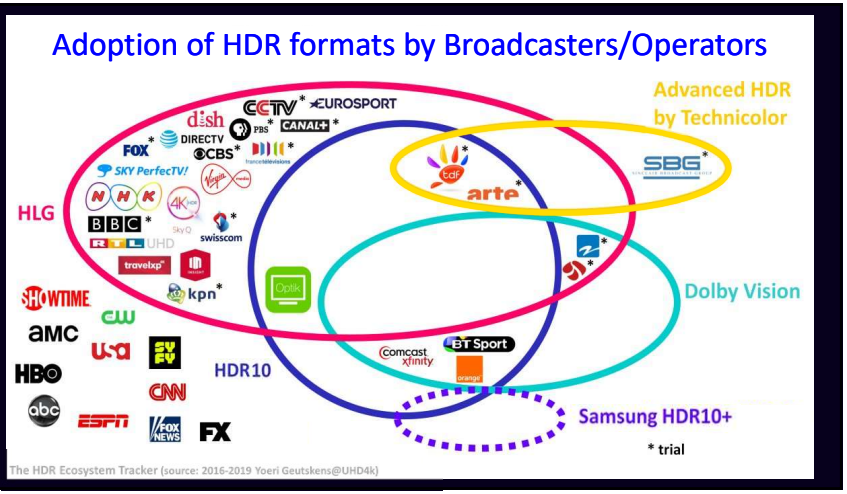
Static HDR-WCG
PQ (with static metadata)
HLG (No metadata)

Dynamic HDR-WCG
Multiple Systems

Adoption of HDR formats by Streaming Services



Adoption of HDR formats by Broadcasters/Operators



HDR Image Formats defined in ITU-R BT.2100

Items	Substance	
Format	HLG	PQ
Special Resolution	1,920 x 1,080 3,840 x 2,160 7,680 x 4,320	
Color Space	BT.2020	
Transfer Function	Relative Value OETF	Absolute Value EOTF
Bit depth	10~12bit	
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	

Sony Introduced 3 Solutions for HDR at NAB'2016

Sony's Ecosystem for HDR Live Production

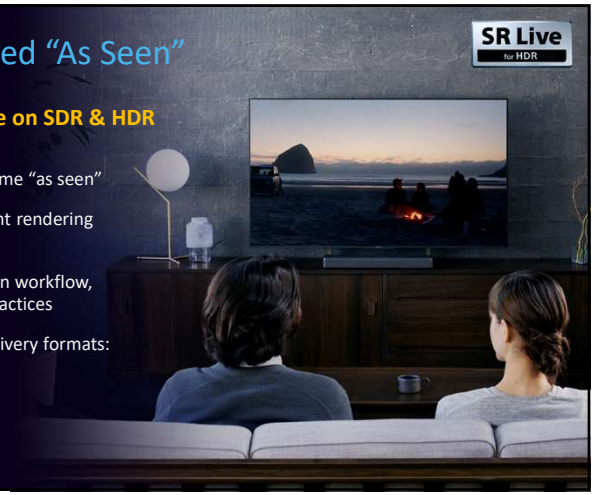
SR Live for HDR

Scene Referred Live Production for HDR Applications

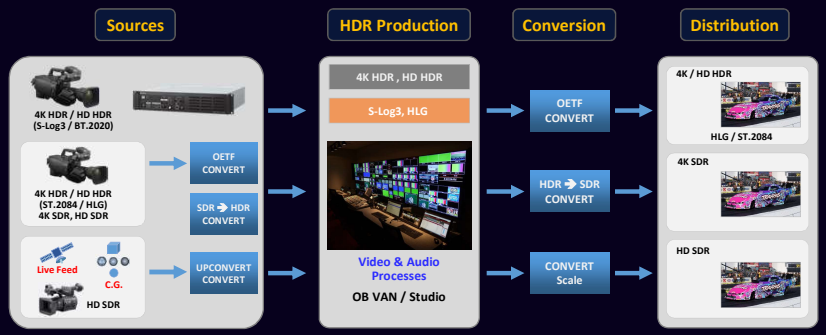
Contents Delivered "As Seen"

SR Live offer a workflow without any compromise on SDR & HDR

- Contents are delivered at home "as seen"
- Full artistic control on content rendering from production to home
- All with one single production workflow, keeping usual operational practices
- Use of BT2100 compliant delivery formats: HLG or PQ

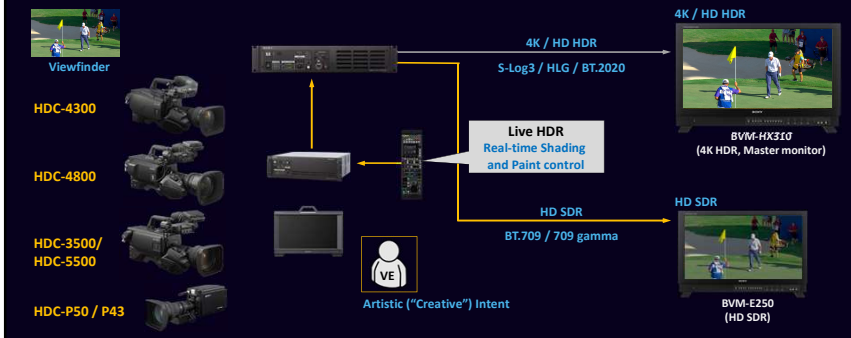


SR Live Workflow for HDR Live Applications



HDR and SDR from a Single Camera System

4K/HD HDR & HD SDR Simultaneous Production



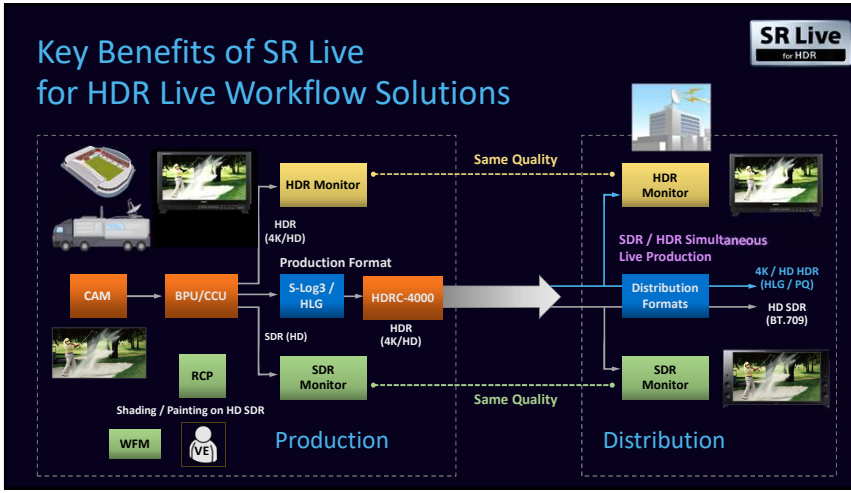
Very best 4K / HD HDR / HD SDR and skilled Artistic ("Creative") Intent for HD SDR

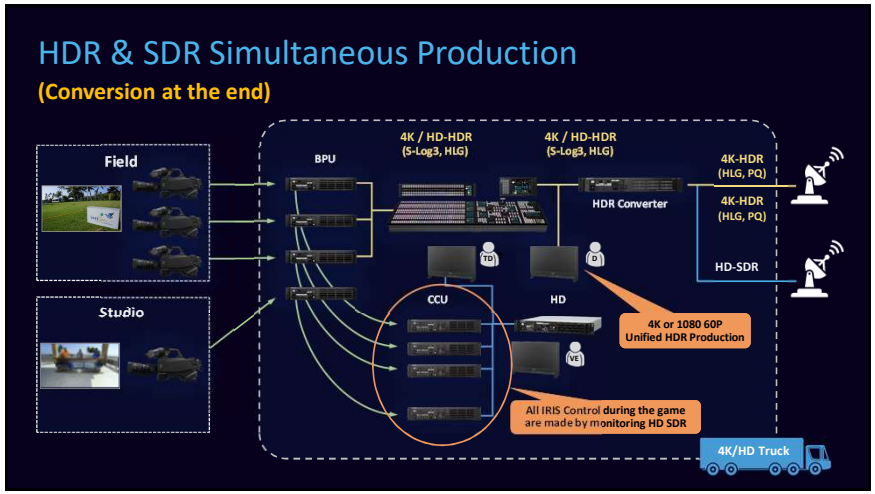
Precision Conversion and Format Processing

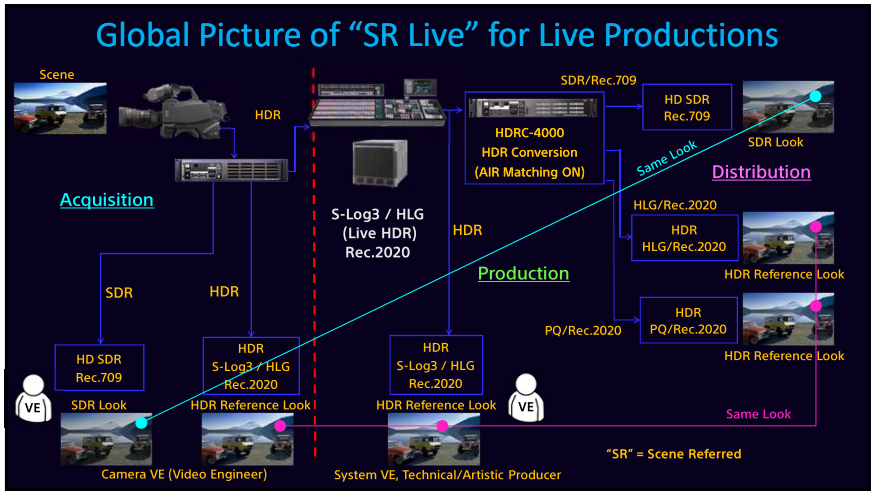
HDRC-4000

- 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

Key Benefits of SR Live for HDR Live Workflow Solutions




HDR & SDR Simultaneous Production
(Conversion at the end)
Field
Studio
BPU
4K / HD-HDR
(S-Log3, HLG)
4K / HD-HDR
(S-Log3, HLG)
HDR Converter
4K-HDR
(HLG, PQ)
4K-HDR
(HLG, PQ)
HD-SDR
CCU
HD
4K or 1080 60P
Unified HDR Production
All IRIS Control during the game
are made by monitoring HD SDR
4K/HD Truck


Global Picture of "SR Live" for Live Productions
Scene
HDR
Acquisition
SDR
HDR
HD SDR
Rec.709
HDR
S-Log3 / HLG
Rec.2020
SDR Look
HDR Reference Look
S-Log3 / HLG
(Live HDR)
Rec.2020
HDR
Production
HDR
S-Log3 / HLG
Rec.2020
HDR Reference Look
SDR/Rec.709
HDRC-4000
HDR Conversion
(AIR Matching ON)
HD SDR
Rec.709
SDR Look
Same Look
Distribution
HLG/Rec.2020
HDR
HLG/Rec.2020
HDR Reference Look
PQ/Rec.2020
HDR
PQ/Rec.2020
HDR Reference Look
Same Look
"SR" = Scene Referred
Camera VE (Video Engineer)
System VE, Technical/Artistic Producer


Worldwide HDR Live Production Events!
4K HDR
SR Live for HDR
UEFA Champions League Final 2017
S-Log3 Production ➔ PQ / HLG Distribution
FIFA World Cup 2018!
S-Log3 Production ➔ PQ / HLG Distribution
UHD AT WORLD CUP RUSSIA 2018
Montreux Jazz Festival 2017
S-Log3 Production ➔ PQ / HLG Distribution
Golf Tournaments


FIFA World Cup 2018
4K HDR
SR Live for HDR
UHD/HDR AT WORLD CUP 2018

HDC-3000/5500 Series of HDR Camera Systems

The world's first 2/3-inch 4K global shutter 3-CMOS sensor camera system

Professional 4K HDR MONITORS

From on-set to post production

NEW **PVM-X2400 (24") and PVM-X1800 (18") UHD Production Monitors**

- Precise Color match to BVM-HX310
- Portable, lightweight for mobile applications
- HDR to SDR Conversion technology in upcoming firmware upgrade

BVM-HX310 (31") TRIMASTER HX 4K Master Monitor

- Flagship, absolute level of black picture performance
- Sony's special panel technology
- Highest level of picture quality for color grading and mastering applications

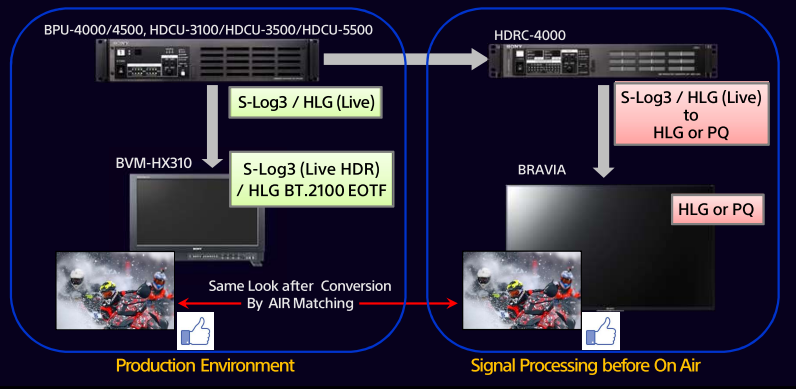
Common to both Monitor Platforms

- 1,000nits full screen performance
- Supports HDR (S-Log3, S-Log3 Live HDR, ITU-R BT.2100 (HGL), SMPTE ST2084 (PQ)
- Supports ITU-R BT.2020 and DCI-P3 color gamut
- Multiple custom 3D LUT function
- Automatic HDR setting by using payload ID (VPID)
- Quad View Display with individual settings for each quadrant

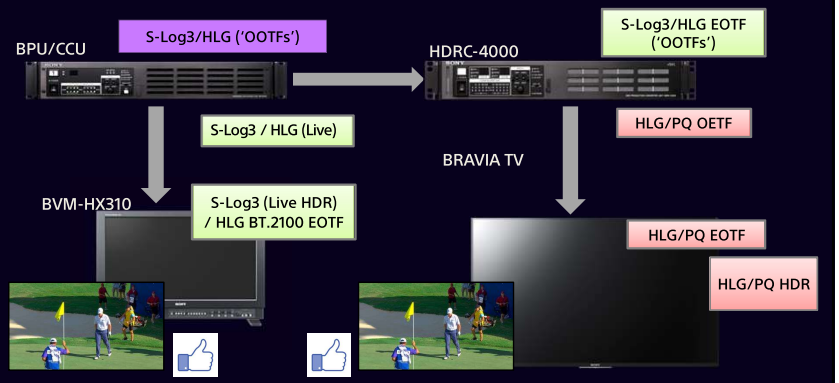
AIR Matching Function

Special Feature – AIR Matching Function

AIR: Artistic Intent Render



Sony's S-Log3/HLG (Live HDR) technique



Challenges for HDR Live Broadcast Production

Challenges for HDR Program Production

The guidelines for HDR program production are defined in ITU-R BT.2408

Key challenges encountered in HDR program production

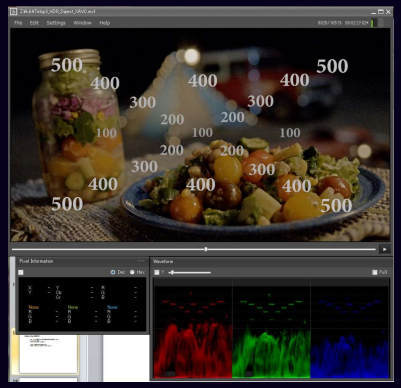
1 : Basic white level of HDR program production
- How much brightness is adequate in HDR program production?
- Are there any guidelines for production?

2 : Mapping modes for HDR/SDR contents
- Scene Referred Conversion or Display Referred Conversion

Graphics and Text Levels in SR Live Workflows

What level settings for SDR/HDR graphics?

How do we manage the white level in HDR?



What level is White?

Graphics and Text in HDR

Graphics in SDR

-Maximum luminance is 100nits because of the BT.709 standard

All signals at or beyond 100nits are severely contrast limited (clipped)

Reference White 100 nits

Black 0 nit

In case of SDR signals, Reference White is 100nits because of the maximum luminance of display.
→Therefore, Graphics are generated to fit this level of Reference White.

Graphics in HDR

1,000 nits

200 nits

(2)

(1)

To be able to display various levels of white !

Reference White 100 nits

Black 0 nit

SDR HDR

① According to ITU-R BT.2408, adequate Reference White is about 200nits (HLG IRE 75%)

② Almost all displays support HDR and are able to show 200nits or more.

→ Therefore, high quality Graphics can be produced to be displayed at 200nits or beyond with good tonal expression.

HDR Production: Guidance for Operational Practices

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

Operational Practices in HDR Television Production

Operational practices in HDR television production

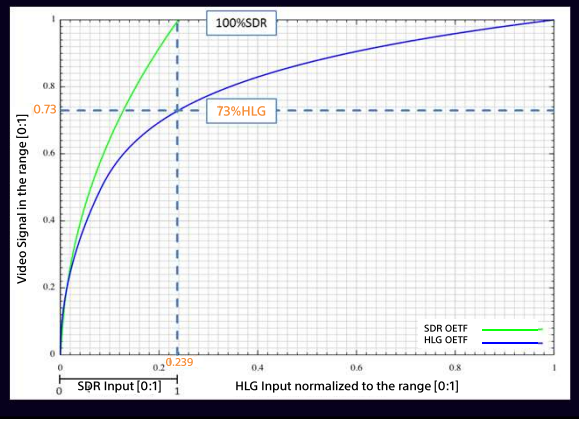
Nominal signal levels for PQ and HLG production

Reflectance Object or Reference (Luminance Factor , %)	Nominal Luminance cd/m² (PQ & 1 000 cd/m² 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

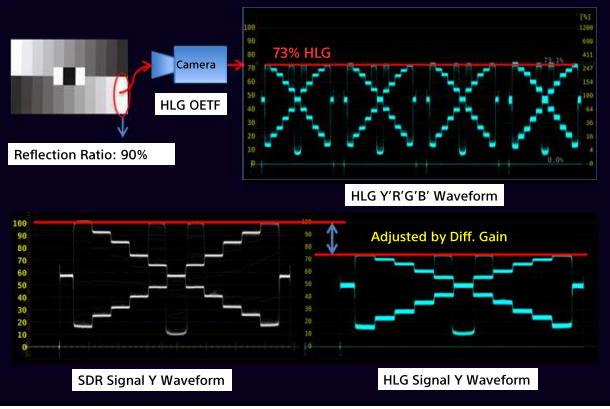
Approximate signal levels in PQ and HLG production

Reflectance Object	Nominal Luminance cd/m² (PQ & 1 000 cd/m² 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

Basic (Diffuse) White Level of HDR (HLG) Program Production



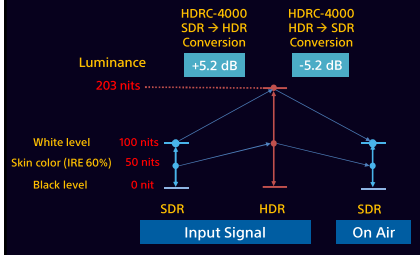
Basic (Diffuse) White Level of HDR (HLG) Program Production



Recommended Guideline for Graphics White Point

In SR Live for HDR Broadcast workflows,
"SDR Gain :-5.2dB" is recommended level for the production that conforms to the ITU guideline !!

Conversion SDR contents into HDR
(Scene Referred Conversion)



Recommended Setting of Graphics and Text in SR Live

	Recommended Setting
SDR Gain	-5.2 dB
Luminance of display	203 nits
S-Log3(Live HDR)	69 IRE
HLG_Live	75 IRE

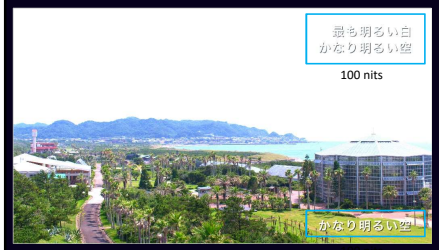
HDR gain level (SDR→HDR) and SDR gain level (HDR→SDR) must be of same value.

Advantage of Graphics generated in SDR

After the final conversion to SDR, Graphics retain the original quality that creators intended.

How to display 203 nits Graphics and Subtitles in HDR?

SDR Image

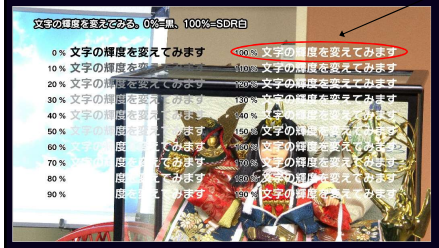


HDR Image

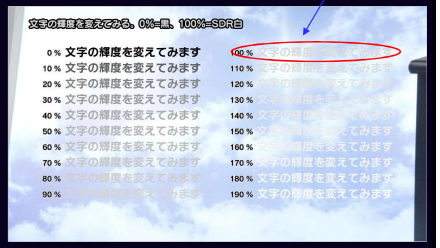
Same luminance signal looks different depending on the luminance of the background image in HDR. Careful assessment of image quality is needed during the production of graphics.

How to display 203 nits Graphics and Subtitles in HDR?

HDR Image

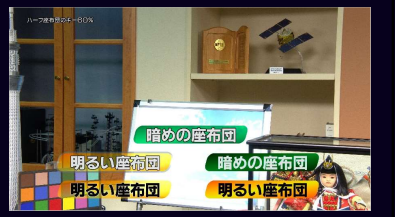


HDR Image



Depending on the background image, graphics would look gray in comparison.

How to display 203 nits Graphics and Subtitles in HDR?



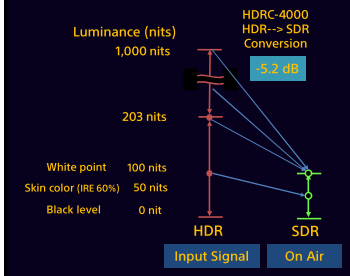
Addition of frame or outline for the graphics helps express the original quality of graphics.

Graphics created in HDR

Again, the most important feature of SR Live for HDR Broadacst Workflows is:

-- The workflow for simultaneous production of 4K/HD HDR & HD SDR.
-- SDR images can be viewed without quality issues, after conversion of SDR from 4K HDR.

Production of Graphics contents in HDR



Benefits of Graphics generated in HDR

Graphics in HDR make it possible to reproduce a variety of white levels that cannot be reproduced in SDR.

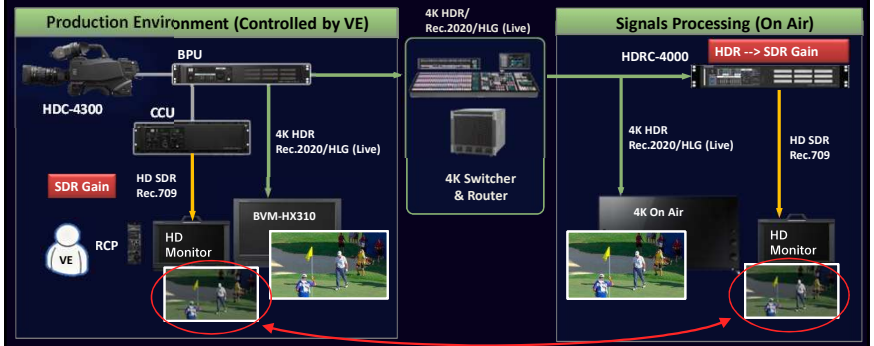
*Warning: The original gradation of the graphics in HDR may not be maintained in SDR when Graphics contents generated in HDR are converted to SDR at the final step of the production workflow.

Ex. SDR Gain -5.2dB

Gradations in the video signal at levels over 203nits may not be maintained because they will be saturated to 100nits level after conversion.

SR Live Metadata

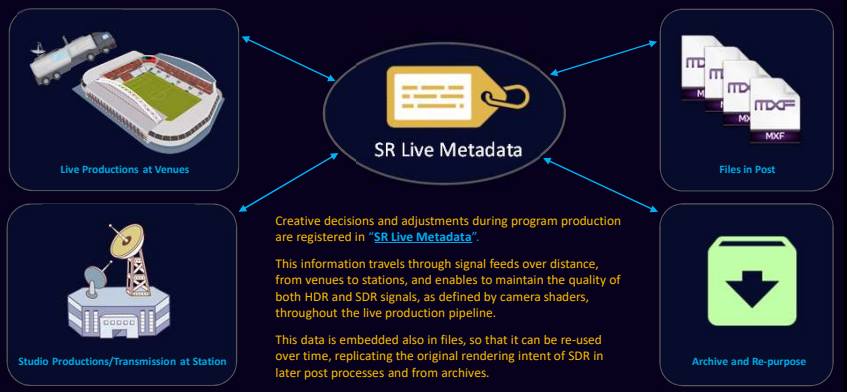
HDRC-4000 Use Case: 4K HLG (Live) -> HD SDR Conversion



4K HDR : No conversion needed because distribution format is HLG

HD SDR : Set up same SDR Gain Level between CCU and HDRC

Maintain HDR/SDR Quality across Distance and Time



Creative decisions and adjustments during program production are registered in "SR Live Metadata".

This information travels through signal feeds over distance, from venues to stations, and enables to maintain the quality of both HDR and SDR signals, as defined by camera shaders, throughout the live production pipeline.

This data is embedded also in files, so that it can be re-used over time, replicating the original rendering intent of SDR in later post processes and from archives.

What's "SR Live Metadata"?

Metadata table

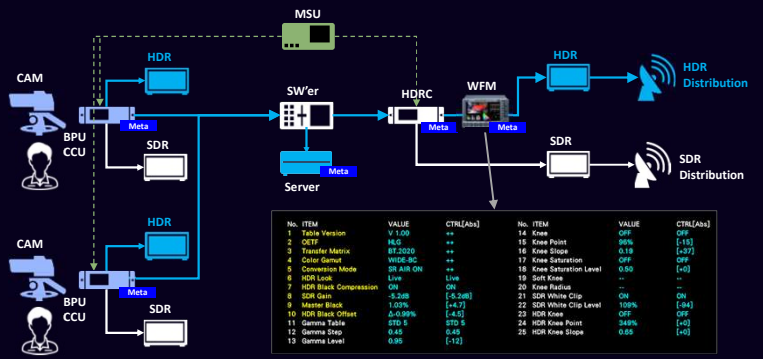
	Item	
1	Table Version	HDR (main stream) Signal Profile
2	OETF	
3	Transfer Matrix	
4	Color Mode	
5	SR Live	
6	HDR Black Compression	
7	(Reserved)	
8	SDR Gain	HDR/SDR Relationship
9	SDR Master Black	
10	HDR Master Black	
11	Gamma Table	SDR Adjustments
12	Gamma Step	
13	Gamma Level	
14	Knee	
15	Knee Point	
16	Knee Slope	
17	Knee Saturation	
18	Knee Saturation Level	
19	Soft Knee	
20	Knee Radius	
21	SDR White Clip	
22	SDR White Clip Level	
23	HDR Knee	HDR Adjustments
24	HDR Knee Point	
25	HDR Knee Slope	

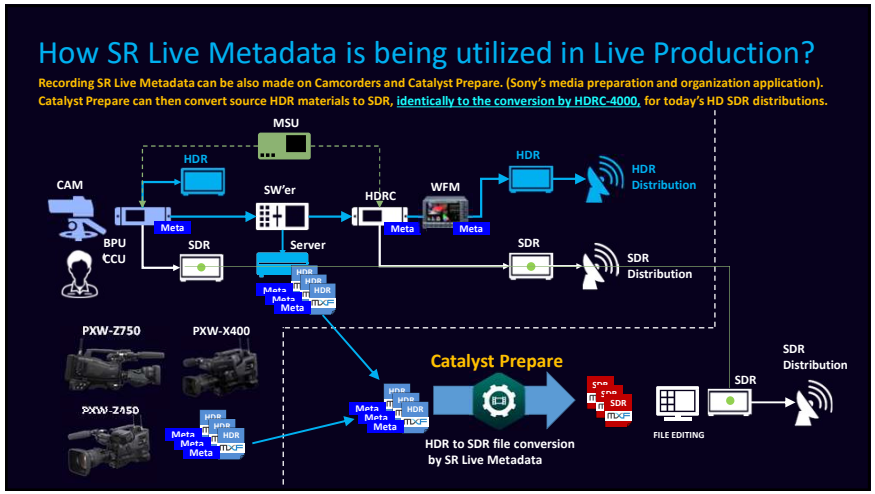
SR Live Metadata is a list of data descriptors registered in a table, which includes signal profiles, HDR/SDR relationship and various adjustment values for both HDR and SDR.

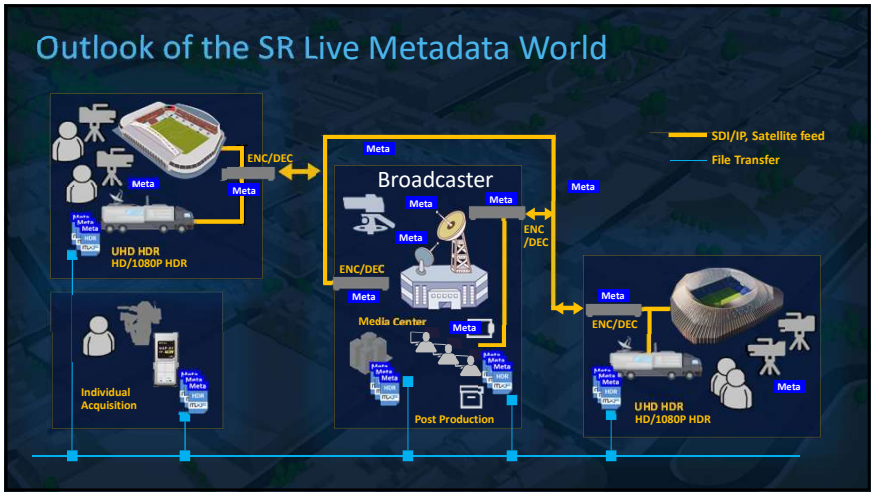
It is embedded in the SDI signal feed and ultimately recorded in files, making both signal feeds and files self-explanatory at every stage of program production.

How SR Live Metadata is being utilized in Live Production?

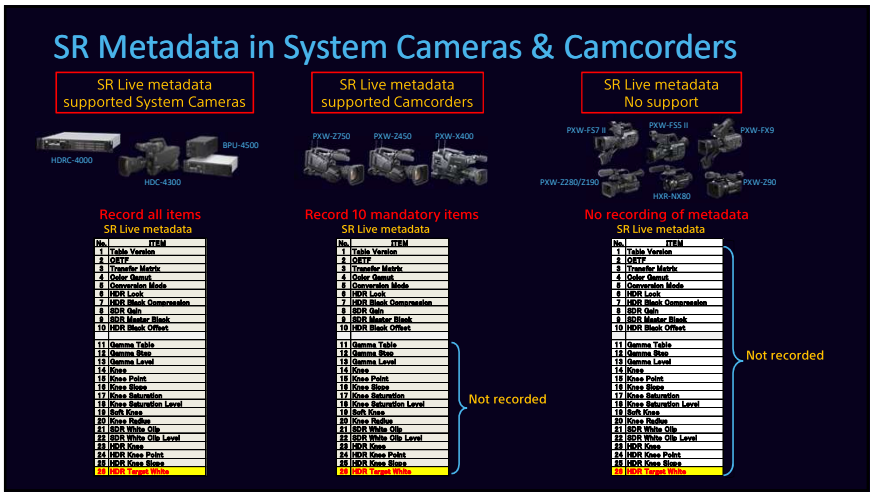
Adjustments or artistic intent by camera shader, along with relationship between HDR and SDR are registered in SR Live Metadata, enabling the visual verification that signal feeds have the same settings







SR Live Metadata: File Base Workflow
Catalysis Prepare Update



SR Metadata in System Cameras & Camcorders

SR Live metadata supported System Cameras

SR Live metadata supported Camcorders

SR Live metadata No support

Record all items
SR Live metadata

No.	ITEM
1	Table Version
2	OETF
3	Transfer Matrix
4	Color Gamut
5	Conversion Mode
6	HDR Look
7	HDR Black Compression
8	SDR Gain
9	SDR Master Black
10	HDR Black Offset
11	Gamma Table
12	Gamma Step
13	Gamma Level
14	Knee
15	Knee Point
16	Knee Slope
17	Knee Saturation
18	Knee Saturation Level
19	Soft Knee
20	Knee Radius
21	SDR White Clip
22	SDR White Clip Level
23	HDR Knee
24	HDR Knee Point
25	HDR Knee Slope
26	HDR Target White

Use all values in SR live metadata

Record 10 mandatory items
SR Live metadata

No.	ITEM
1	Table Version
2	OETF
3	Transfer Matrix
4	Color Gamut
5	Conversion Mode
6	HDR Look
7	HDR Black Compression
8	SDR Gain
9	SDR Master Black
10	HDR Black Offset
11	Gamma Table
12	Gamma Step
13	Gamma Level
14	Knee
15	Knee Point
16	Knee Slope
17	Knee Saturation
18	Knee Saturation Level
19	Soft Knee
20	Knee Radius
21	SDR White Clip
22	SDR White Clip Level
23	HDR Knee
24	HDR Knee Point
25	HDR Knee Slope
26	HDR Target White

Use all values in SR Live metadata

Use reference values for SDR conversion in Catalyst

No recording of metadata
SR Live metadata

No.	ITEM
1	Table Version
2	OETF
3	Transfer Matrix
4	Color Gamut
5	Conversion Mode
6	HDR Look
7	HDR Black Compression
8	SDR Gain
9	SDR Master Black
10	HDR Black Offset
11	Gamma Table
12	Gamma Step
13	Gamma Level
14	Knee
15	Knee Point
16	Knee Slope
17	Knee Saturation
18	Knee Saturation Level
19	Soft Knee
20	Knee Radius
21	SDR White Clip
22	SDR White Clip Level
23	HDR Knee
24	HDR Knee Point
25	HDR Knee Slope
26	HDR Target White

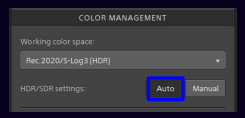
The following items are used in MXF header.
- No.2: OETF
- No.3: Transfer Matrix
- No.4: Color Gamut

Use reference values for SDR conversion in Catalyst

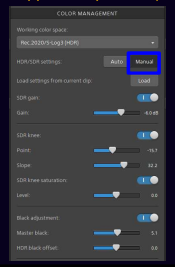
SR Live Metadata support in Catalyst

- Catalyst V2020.1 will support SR Live metadata (July release)

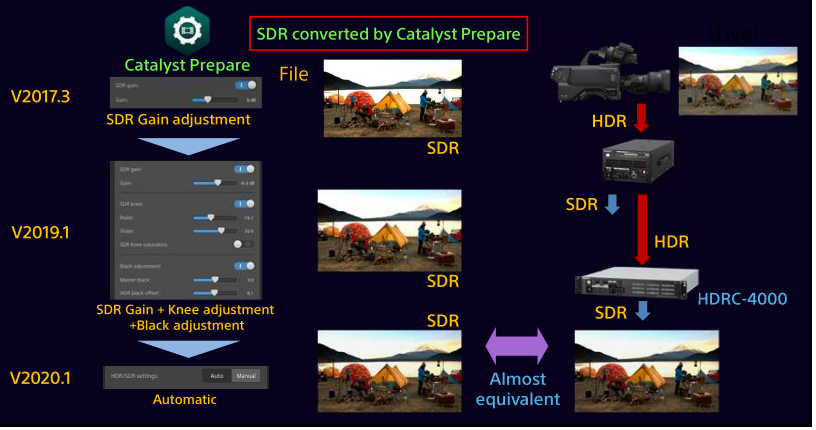
Auto mode:
SDR picture is converted from SR Live metadata automatically.



Manual mode:
SDR picture can be manually adjusted from SR Live metadata value.
(Only SDR Gain/Knee Adjustment/Black Adjustment which were supported by V2019.1)



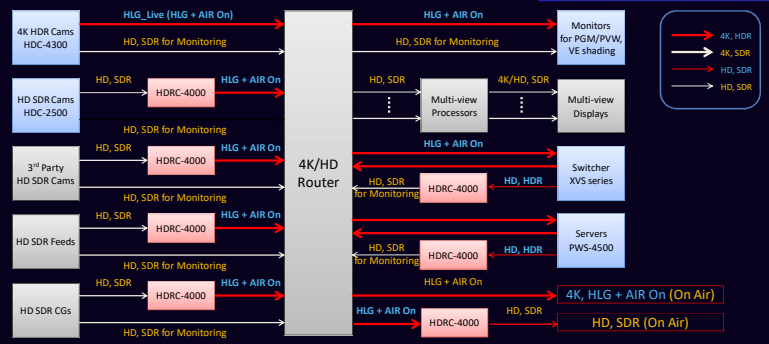
HDR to SDR Conversion Feature



SR Live Metadata: New Workflows in Live Productions

SR Live: New developments in WFs

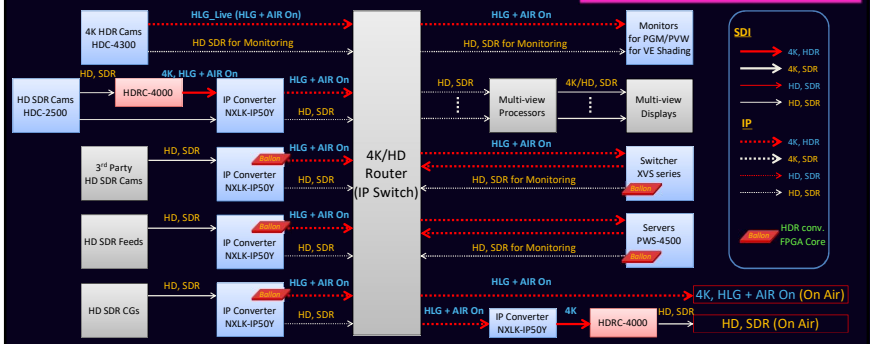
Current 4K HDR production WF



- Many converters are required.
- When evolving to IP interconnection, system becomes very complicated…!!!!

SR Live: New developments in WFs

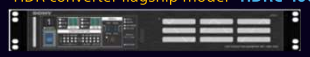
Future 4K/IP HDR production WF



- Built-in HDR function reduces complexity, while securing Sony camera & On-air picture qualities by HDRC-4000.

HDR implementation in Sony Products

HDR converter flagship model **"HDRC-4000"**



Code name: Ballon

Common FPGA IP Core
#Not an LSI/ASIC

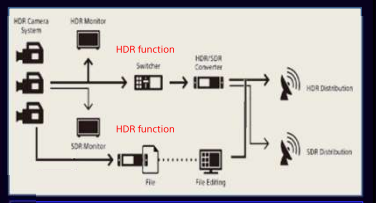
FPGA Design Optimization to shrink processing load

Implementation into Products

IP Converter NXLK-IP50Y/51Y | SW'er XVS | SW'er Future devices | Monitor New PVM

Algorithms optimized for each device depending on available processing resources.

HDR functions in WF products



Common FPGA IP Core

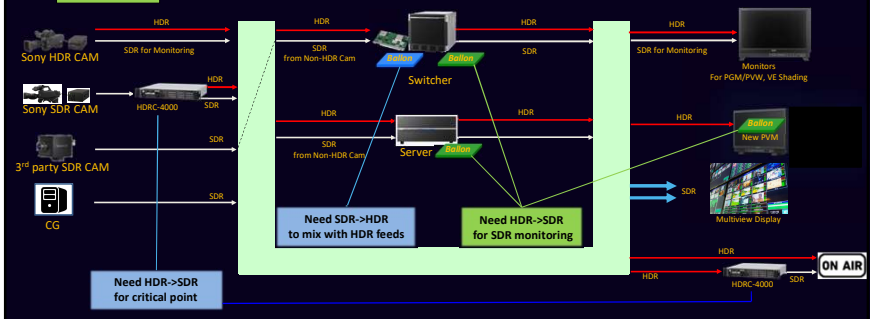
- Newly develop based on HDRC-4000 resources:
  - HDR⇔HDR Conversion (S-LOG3, HLG, PQ)
  - HDR⇔SDR Conversion
  - Color Space Conversion(2020⇔709)
- Trimmed-off the process size to fit HDR conversion into Sony products
  - XVS Switcher
  - IP Converter
  - Others

HDR implementation in Sony Products

HDR functions in WF products

HDR SDI
SDR SDI

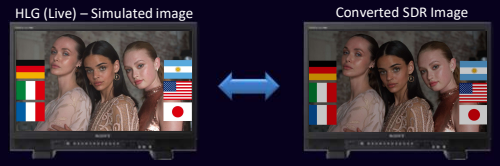
✓ HDRC is for quality-critical point : Sony SDR Camera & master playout.
✓ Ballon can be a reasonable suggestion for 3rd party SDR/monitoring.



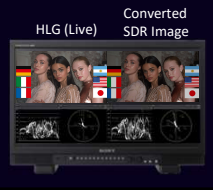
PVML-HSX1: HDR-SDR Conversion License for PVM-X series

- ✓ Enabling easy preview of converted SDR image.
- ✓ HDR to SDR conversion is carried out by the same processing algorithm used within HDRC, utilizing SR Live Metadata embedded in the incoming signal.

HDR/SDR Side-by-side



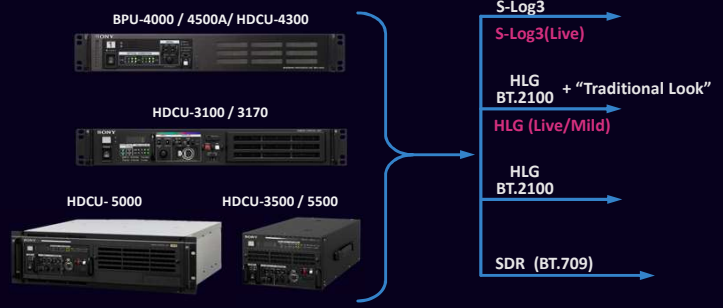
QUAD View Display



* Images are for illustration purposes only. Actual appearances may vary

HDC-3000/5500/4000 Series of HDR Camera Systems

HDR OETFs and SDR BT.709 from Sony's BPU / CCUs…



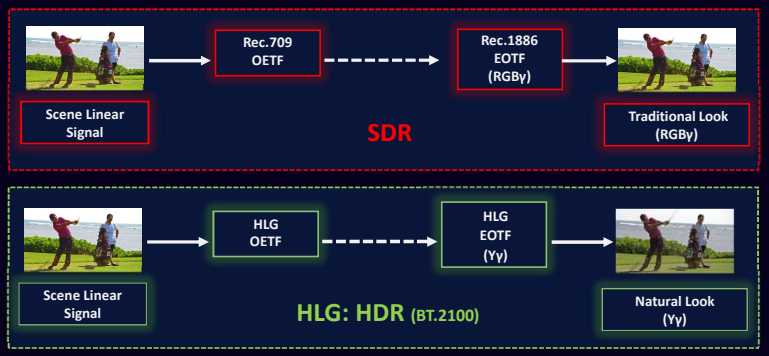
Conversion Techniques in HDR Live Production

TV Formats and their Picture Appearance - "Looks"

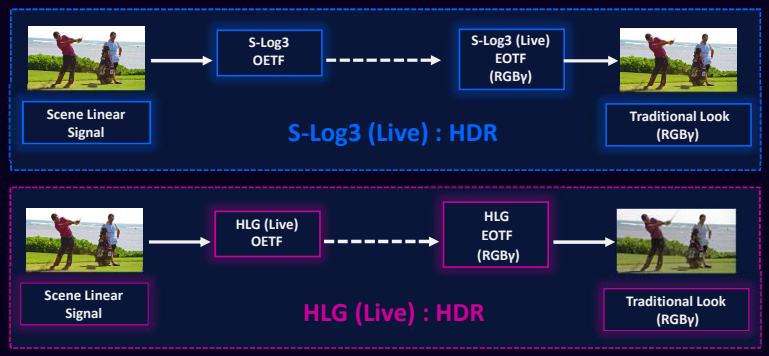
All TV Formats have their own "Look"

- "Look" implies a "Color Saturation and Image Tone"
- S-Log3 (Live), HLG (Live) and SDR have a similar "Traditional" look
  - OOTF "gamma" is applied on R, G, B components independently (as described in ITU-R BT.2390)
  - Increases saturation of displayed image
- HLG (per ITU-R BT.2100) has a "Natural" look
  - OOTF "gamma" is applied to luminance component only
  - Saturation of displayed images matches that of the scene

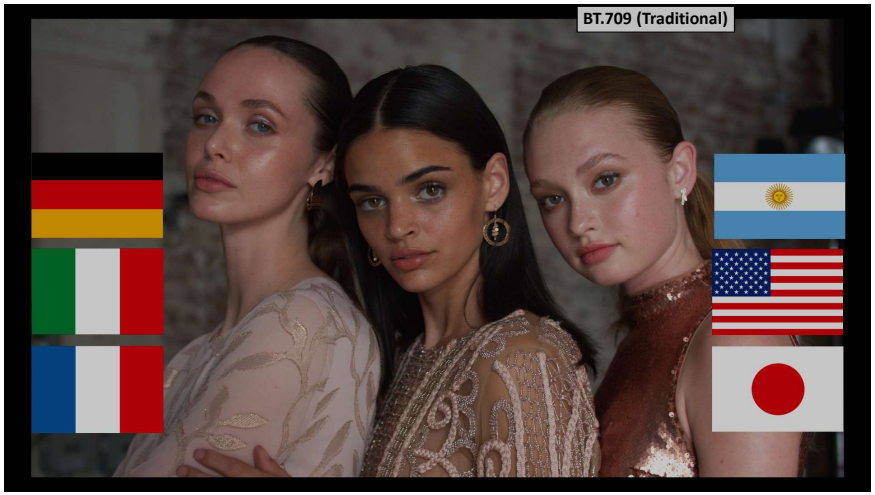
All TV formats have their own “look”

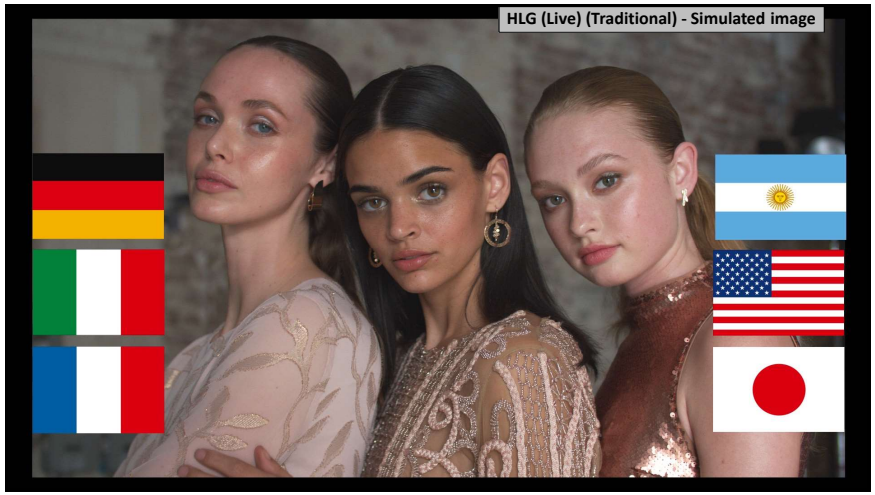


All TV formats have their own “look”



HDR ‘Look’ Comparison: SDR, HLG (Live), ‘Natural’





"ITU-R BT.2408 : Operational Practices": Guidance on SDR to/from HDR format conversion

ITU-R Definitions

Direct Mapping - placing SDR content in an HDR signal container, at the correct signal level, to preserve the "look" of the SDR content

Down-Mapping (aka, Tone Mapping) - converting HDR content to an SDR signal range (i.e. down-conversion with diminished HDR signal highlights)

Up-Mapping (aka, Inverse Tone Mapping) - placing SDR content in an HDR signal container with expanded highlight range to emulate an HDR look (i.e. up-conversion with artificial highlight expansion)

Conversion Techniques for SDR <-> HDR

Conversion Techniques for SDR <-> HDR

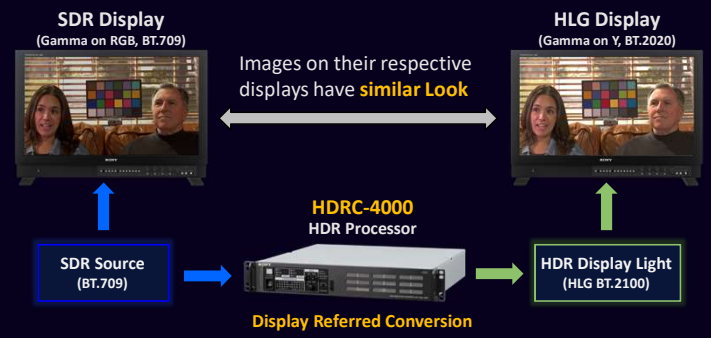
Different processes are needed for different applications
Exercise caution in signal conversions to prevent side-effects!

Display Referred (or Display Light) SDR to/from HDR conversion
- Maintains "look" (i.e. saturation and tone) of content when converted to a new format
- Graded content and graphics will appear in the new format as the colorist intended in the original pictures
- Should not be used for matching cameras

Scene Referred (or Scene Light) SDR to/from HDR conversion
- Matches the "look" of SDR (and S-Log3) cameras to HLG HDR cameras
- It should not be used for "graded or archival" SDR content - with HLG (Yγ) – as it will change the "look", and so the artistic intent

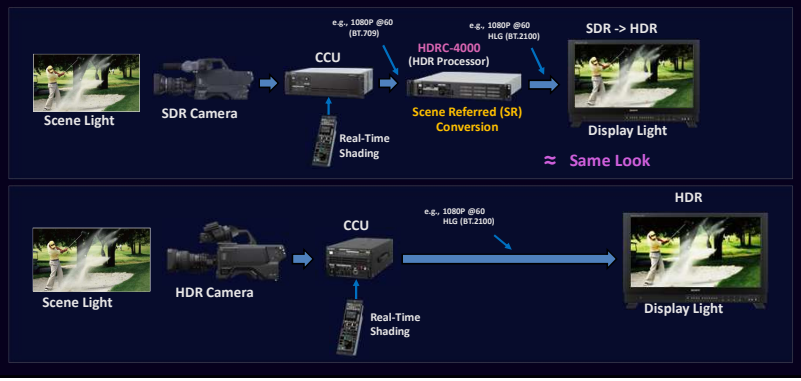
Display Referred (DR) Conversion (SDR <-> HDR)

DR preserves displayed colors – use for graded content and graphics



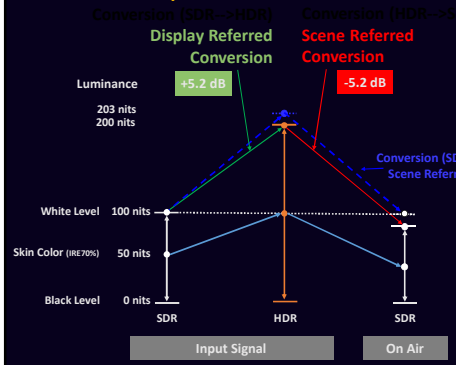
Scene Referred (SR) Conversion for Cameras (SDR → HDR)

SR preserves the colors of the camera sensor



Roundtrip Conversion (SDR → HDR → SDR)

The conversion process from SDR to HDR, then come back to SDR is called "Round-trip"

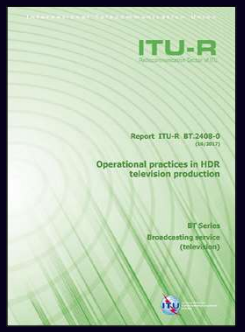


Caution:
Applying different conversion methods in a Round-trip process lowers the luminance of the final SDR compared to the original SDR image in case of same SDR Gain setting.

Applying same conversion method between I/O makes it possible to reproduce same luminance brightness in the On-Air SDR images.

HDR Production for Maximum SDR Compatibility

HDR Production: Guidance for Operational Practices

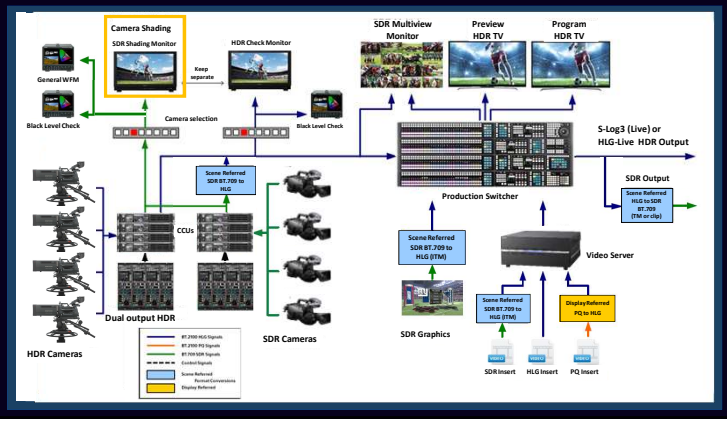


ITU-R BT.2408-0 (10/2017)

Operational Practices in HDR Television Production

HDR Production for Maximum SDR Compatibility:

SR Live for HDR



HDR Production for Maximum SDR Compatibility:

SR Live for HDR

- SR “Scene Referred” Production for Camera conversions
- Cameras shaded in SDR but only HDR is passed through the production switcher
- Camera operator views conventional SDR monitor with the “traditional” look
- SR “Scene Referred” down-Conversion from final HDR (down-mapping) for distribution SDR
- Correct SDR-HDR-SDR “Round-Trip”, since always SR is used so SDR look is kept

HDR Production: Guidance for Operational Practices

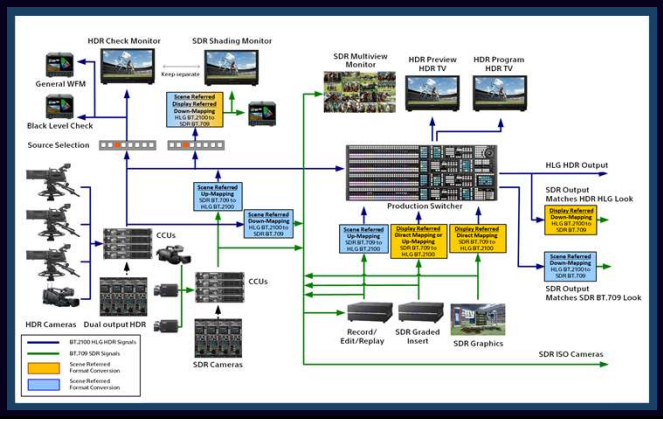
ITU-R BT.2408-3 (07/2019)

Guidance for Operational Practices in HDR Television Production

Guidelines for SDR <-> HDR Conversion in Live Operations

1. SDR, HDR Cameras should be matched in tone and color appearance using a Scene Referred (Scene Light) conversion process
2. SDR Graphics, Commercials, Legacy Material (graded, archival), BT.709 broadcasting feeds, Server-based material (Super Slow Motion effects) should be converted into HDR using a Display Referred (Display Light) conversion technique

Mixing of SR and DR in HDR Production: Practical Issues

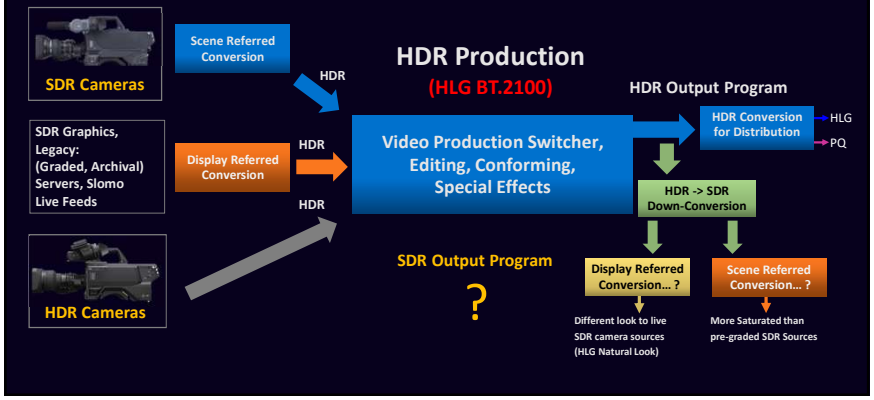


Mixing of SR and DR in HDR Production: Practical Issues

Mixed use of SR and DR in production can create image issues unless used with care

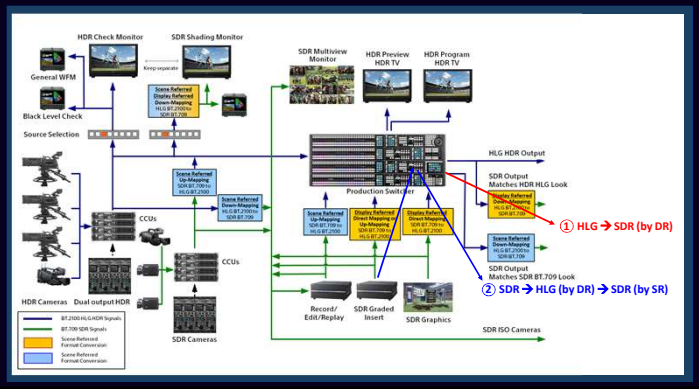
- SR "Scene Light" Production at Camera
- DR "Display Light" down-Conversion for distribution/TX SDR
- SR down-Conversion for SDR (re) used in Live WF
- DR up-Conversion from SDR Graphics and SDR Graded Inserts i.e archive contents
- SR up-Converting for Live Replay SDR content from Server
- In SDR-HDR-SDR "Round-Tripping", mixing of SR and DR conversions can produce image quality Side-Effects

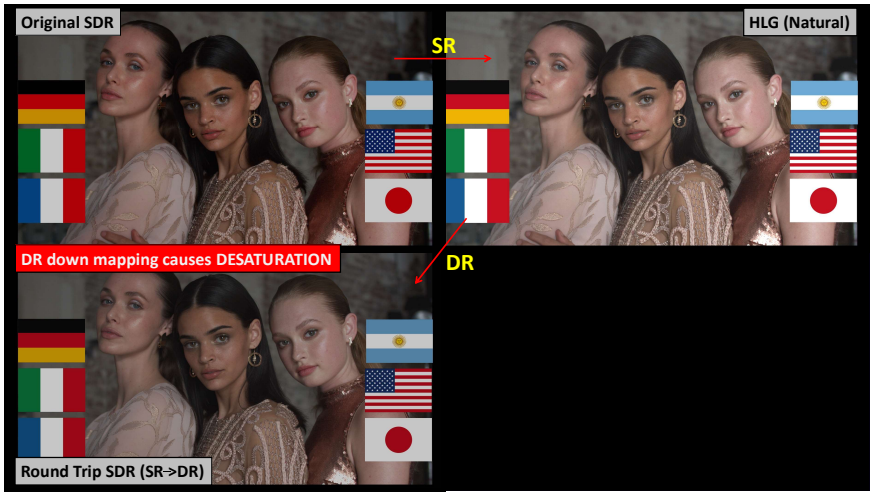
Live Production Conversions: Side Effects…!

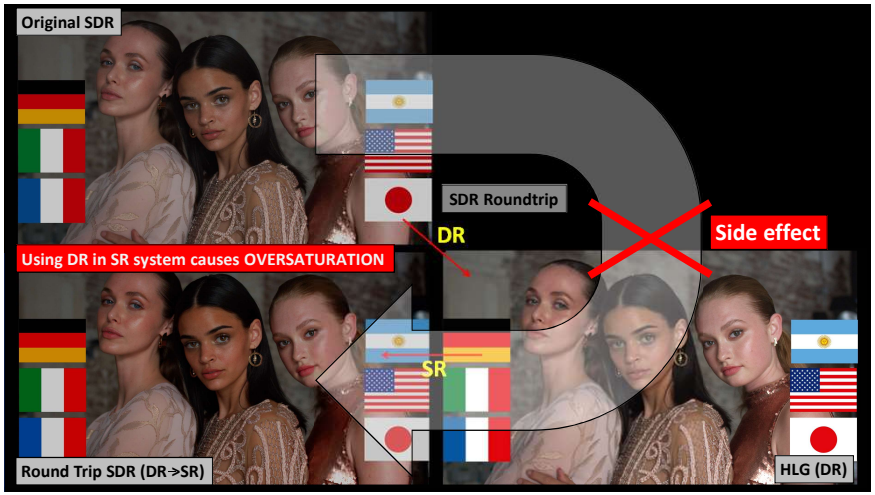


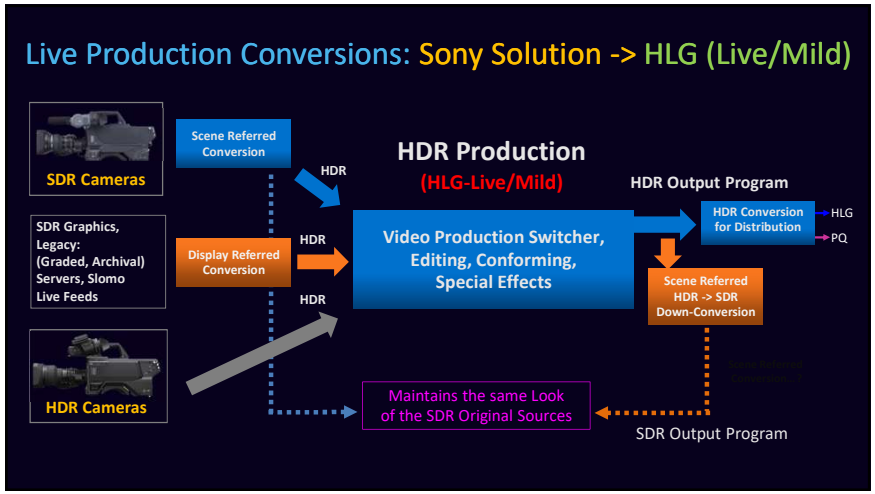
Mixing of SR and DR in HDR Production: Practical Issues

HDR production for maximum SDR compatibility with SDR derived by down-conversion









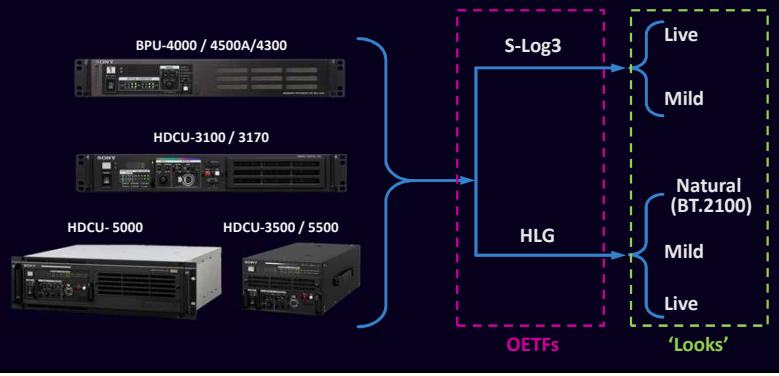
Sony's Modes of HDR Operation for Live Productions

BPU/CCU	OETF	HLG			S-Log3	
	HDR 'Look'	Live	Mild (New)	Natural	Live	Mild (New)
		- RGB γ Look (Traditional Look) - Original Look of S-Log3 (Live HDR)	- RGB γ Look (Traditional Look) - Mild Look of S-Log3 (Live HDR)	- Y γ Look (Natural Look) - Original Look of BT.2100 (HLG)	- RGB γ Look (Traditional Look) - Original Look of S-Log3 (Live HDR)	- RGB γ Look (Traditional Look) - Mild Look of S-Log3 (Live HDR)

Monitor	EOTF	ITU-R BT.2100 (HLG)	S-Log3 (Live HDR)

HDR OETFs and 'Looks' from Sony Studio Cameras

2 Possible HDR OETFs with different 'HDR Looks' from Sony's BPU / CCUs…



Mixing of SR and DR in HDR production: Requests

In order to support new requests from Broadcasters:

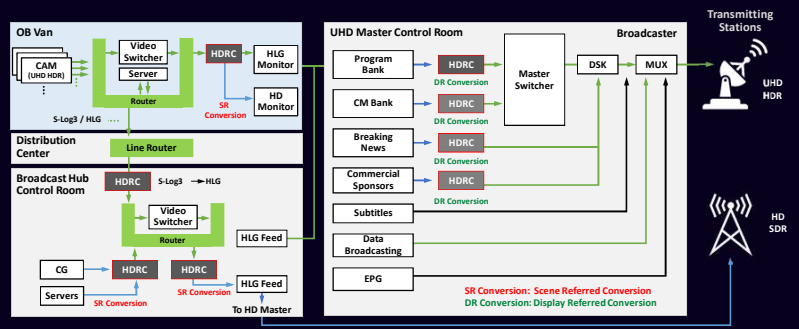
HDRC-4000 will have DR (Display Light) HDR to SDR conversion function implemented by next update of software version.

Note: DR in SDR to HDR is already available in HDRC

HDRC-4000
HDR Converter

A future software update will implement DR during the HDR to SDR conversion process, including not only Hard Clipping but also with the addition of Knee and Tone-Mapping functions in order to satisfy requests for live Broadcasting applications

HDR Live Broadcasting



- Display Referred Conversion is the method to be used in Master Control room
- Scene Referred Conversion is the method to be used in production systems such as OB Van, Studio, etc.
  - → Conversion methods should be chosen according to the type of application

Tools for Live HDR Production

SR Live for HDR

SONY

Obrigado!