

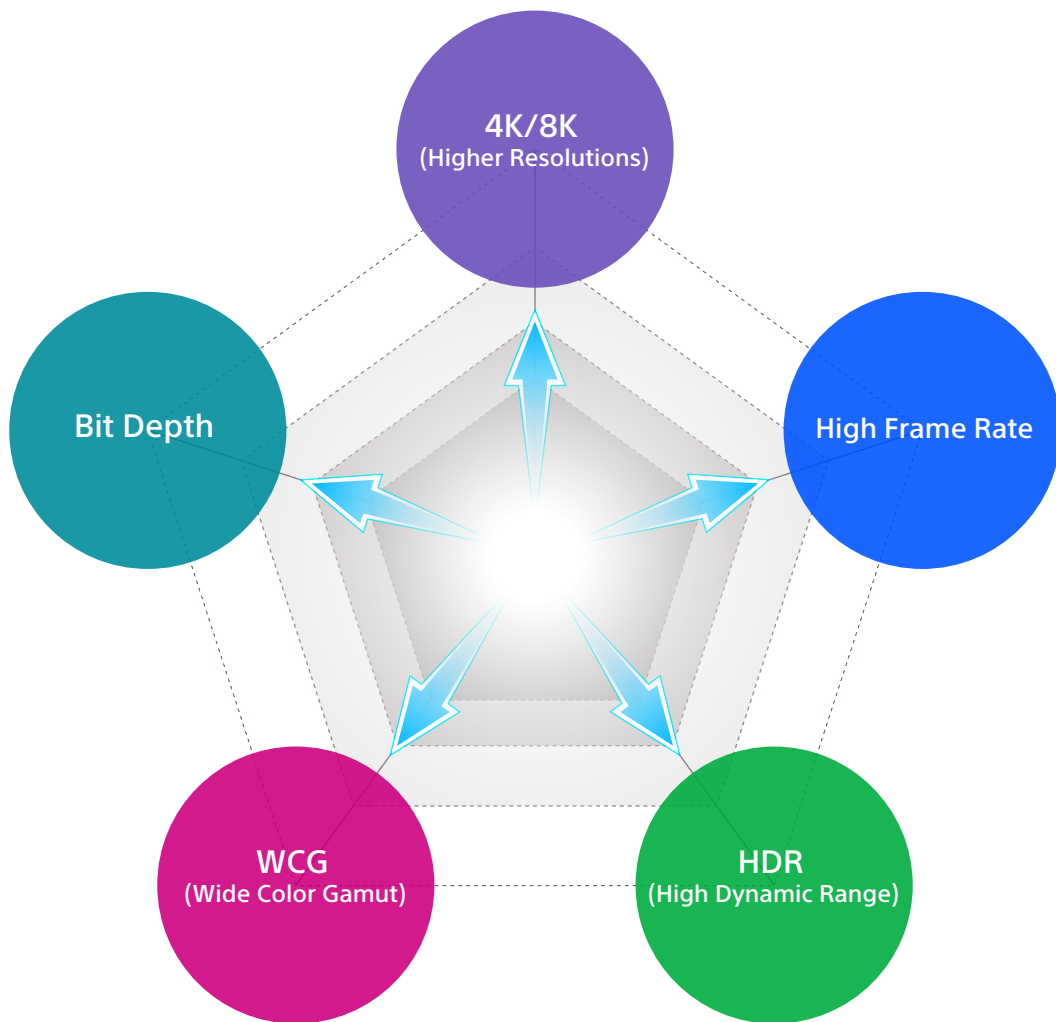
# HDR (High Dynamic Range)

## Introduction

A big wave of change is coming to live image production – this is the new trend of 4K and even higher 8K resolution content creation.

Aligned with this trend, live image reproduction is achieving an impressive new reality with the combination of HDR (high dynamic range) and WCG (wide color gamut). Furthermore, high-frame-rate shooting and deeper bit depth are making significant contributions to the next generation of high-quality image production.

This brochure highlights HDR imaging, introducing this technology and describing its effects and benefits, its impact on workflow, and more.

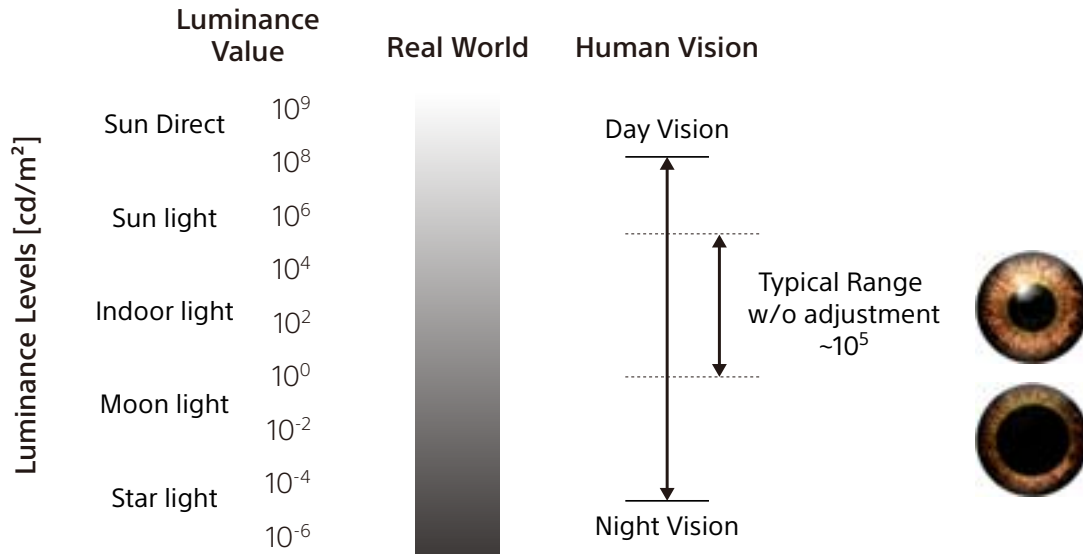


Five major elements to create the next generation of high-quality image production.

# What is HDR?

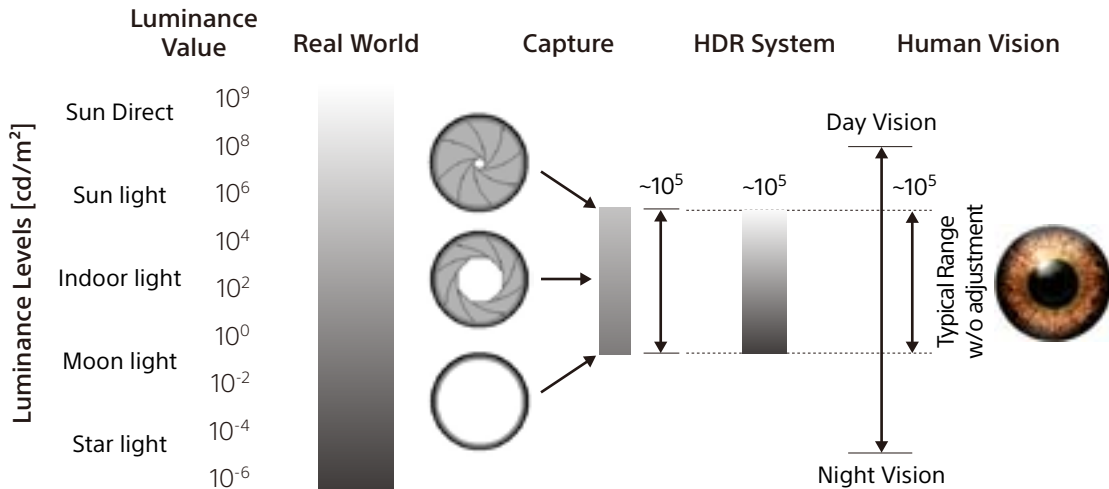
The natural world has a huge dynamic range of luminance values – it reaches from around  $10^{-6}$  (10 to the power of minus 6)  $\text{cd}/\text{m}^2$  for star light to around  $10^9$  (10 to the power of 9)  $\text{cd}/\text{m}^2$ , equal to 10 billion  $\text{cd}/\text{m}^2$ , for direct sunlight.

The dynamic range of the human eye with a fixed pupil is normally  $10^5$  (10 to the power of 5). When the pupil opens and closes, however, the human eye can perceive a full range of luminance levels in the natural world.



In a similar way, the dynamic range of a camera and lens system is typically  $10^5$  (10 to the power of 5) with a fixed iris. The camera's dynamic range is adjusted to perceive the natural world's dynamic range of luminance levels by opening and closing this iris.

A high-dynamic-range (HDR) system is able to transmit the camera-captured dynamic range of luminance levels from the production process all the way to the consumer end without any degradation in this dynamic range.



# What Are The Effects And Benefits?

Today's high-performance camera systems including cinematography cameras and studio cameras can capture HDR and WCG images. But due to the technological limitations of conventional CRT displays, current standard-dynamic-range (SDR) production restricts luminance levels to a maximum of 100 cd/m<sup>2</sup> (nit) and supports only the ITU-R BT.709 standard color space.

In recent years, LCD and OLED displays have become widely used, and the technology of these devices enables higher luminance and wide color space reproduction. Extending beyond this most recent technological evolution, HDR image reproduction can now be achieved using the most appropriate transfer functions (OETF/EOTF) for both the production side and the consumer side.

## SDR workflow (left):

Due to transmission path and monitoring environment limitations, the high-light portion of the window is white-clipped and detail is lost in the shadow image.

## SDR with a high-luminance display/monitor (center):

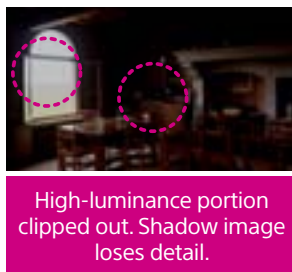
This system with a high-luminance display increases the luminance levels of the whole image. The high-light portion with the window is washed out and the dark portion is improved.

## HDR workflow (right):

The high-light window image is reproduced correctly without any white-clipping, and the dark portion of the room image is also reproduced correctly.

## Effects of HDR

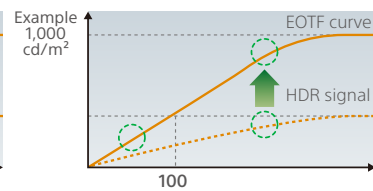
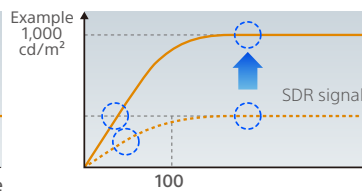
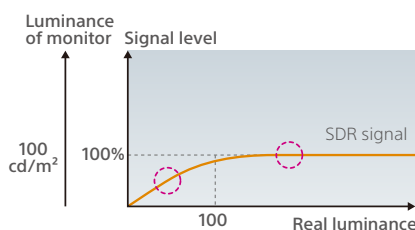
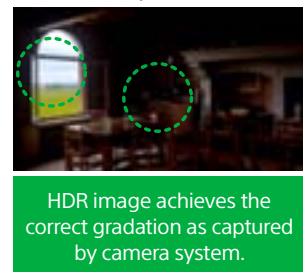
SDR reproduction



SDR reproduction with high-luminance display



End-to-end HDR reproduction



# Image Comparison Of SDR And HDR

If you watch sports live video captured by an SDR system in a sunny stadium, it can be hard to follow the action when it moves between bright and shaded areas. Compare this to an HDR system which dramatically improves high-contrast viewing, offering the audience video image reproduction that's almost as if they're watching the action in person in the stadium. And there's no requirement to clip-out the sunny portions and black-out the shadow portions of the scene.

SDR image



HDR image



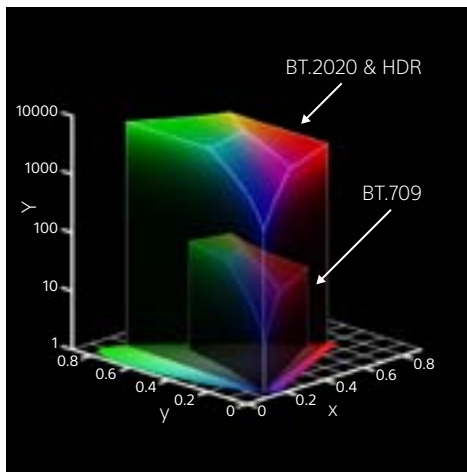
Images are simulated.

# Color Volume And Color Space

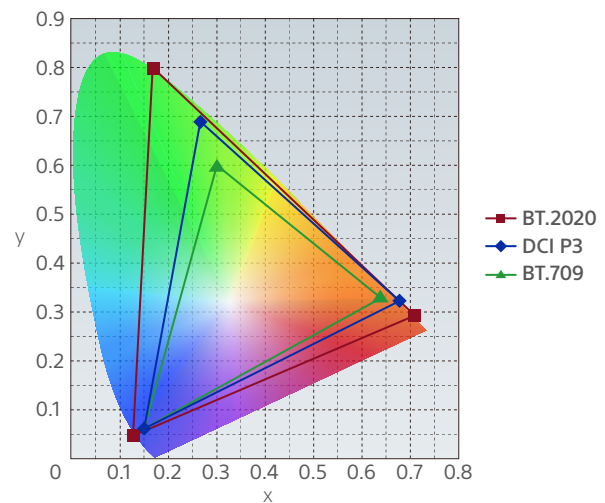
The color gamut works together with the HDR function, as higher resolution intrinsically requires a wider color gamut. The ITU-R BT.2020 prescribes a much wider color gamut than the BT.709 in support of higher resolution images.

The color volume increases dramatically in an HDR system compared to an SDR system; the color gamut increases horizontally and the luminance level increases vertically. This has a synergistic effect – combining the high-resolution HDR and WCG gives a much more realistic and three-dimensional effect in image reproduction. And this in turn produces high-level, high-quality natural images.

Color Volume



Wider Color Gamut



# SR Live for HDR Workflow

Responding to today's growing interest in HDR production in the live environment, Sony offers a new workflow and production technique. This achieves simultaneous creation of 4K\* HDR and HD SDR in a highly efficient way – SR Live for HDR (SR is an acronym for 'scene referred' and 'super reality').



\* In this brochure, 4K refers to QFHD (3840 x 2160) unless otherwise specified.

## Overview Of The SR Live for HDR Workflow

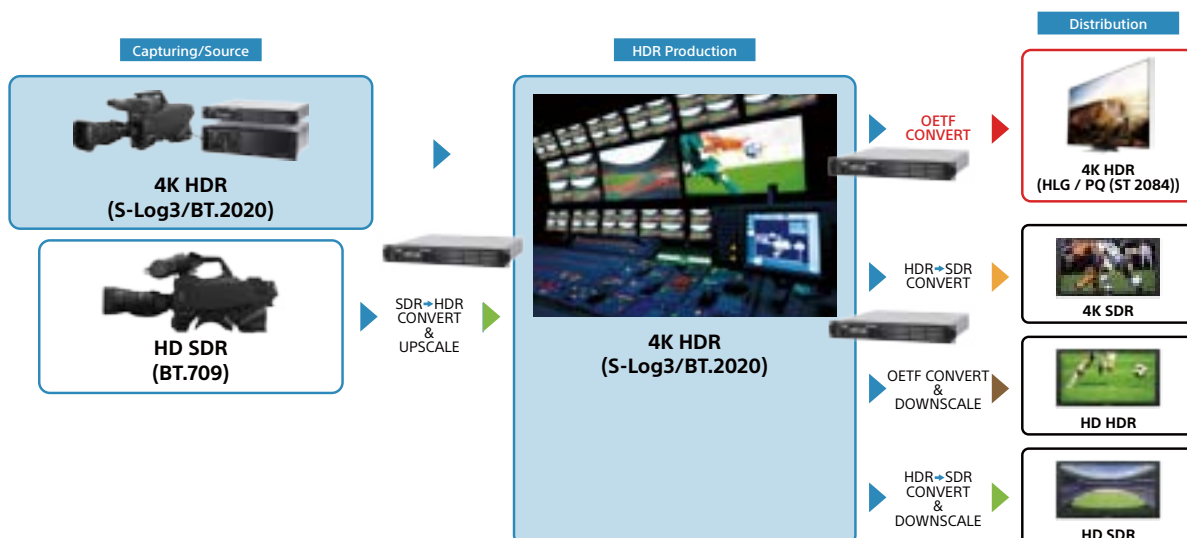
### - 4K HDR-Based Multi-Purpose Production

Sony offers 4K HDR-based multi-purpose live production. An integrated operation in single format to the 4K HDR (S-Log3, BT.2020), this system improves workflow efficiency for multi-purpose distribution including 4K HDR (PQ (ST 2084) and HLG), 4K SDR, HD HDR, and HD SDR.

This system's mainstream imagery is 4K HDR which is captured with the HDC-4300 4K System Camera and a baseband processor unit (BPU). Its 4K HDR signal (S-Log3, BT.2020) is sent to the 4K HDR production process. Other HD-based source signals are brought into the same process after being up-converted to the 4K HDR format with the HDRC-4000 HDR Production Converter.

Also, by installing the HDRC-4000 in the final stage of the production process, the intermediate production format in 4K HDR signal (S-Log3, BT.2020) can be converted to a variety of distribution formats including 4K HDR (PQ (ST 2084) or HLG), 4K SDR, HD HDR, and HD SDR without loss.

The BVM-X300 30" OLED TRIMASTER EL™ Master Monitor incorporates HDR mode, and supports S-Log3 (HDR) EOTF and both the ST 2084 (PQ) and Hybrid Log-Gamma (HLG) HDR transfer functions.



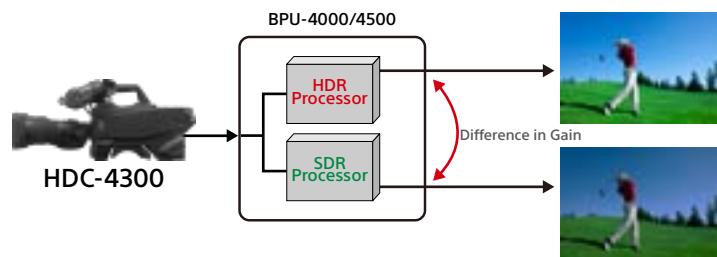
\* images are simulated.

# Simultaneous 4K HDR/HD SDR Production

Using a single camera for simultaneous production offers a significant advantage – it ensures that 4K HDR output and HD SDR output have the same look, despite the difference in output signals. However, this approach also makes it necessary to adjust the dynamic range separately for both HDR and SDR. Adjusting only for SDR or only for HDR won't work. If the iris is set to optimize the SDR signal, the resulting HDR image will be too dark and will lack contrast. And if the iris is set to optimize the HDR signal, to preserve broad contrast and reality, the SDR image will suffer from wash-out throughout the bright areas of the scene.

Sony resolves this problem by interposing a BPU multi-digital signal processing engine featuring an original SDR gain adjustment capability. This feature sets an appropriate gain difference between HDR and SDR circuits, resulting in optical brightness ranges both for 4K HDR and HD SDR. This feature makes it possible to simultaneously capture and record optimal 4K HDR and HD SDR content with a single camera.

## Simultaneous 4K HDR /HD SDR Production



## Why S-Log3 For Production Format?

S-Log3 works as an OETF (opto-electronic transfer function) and carries the full range of the camera-captured HDR signal to the subsequent production process. S-Log3 has been widely adopted in the production industry and is favorably received by users. To expand the use of S-Log3 to HDR live production, Sony has further defined S-Log3 inclusive of the OOTF (opto-optical transfer function) for HDR, and installed it in the BVM-X300 TRIMASTER EL OLED Master Monitor which supports HDR.

S-Log3 OOTF (Live HDR), which is compatible with SDR OOTF, delivers effective clear HDR images. In this way, by operating S-Log3 for the production master format, you can produce HDR programming simply by using the SDR production process.

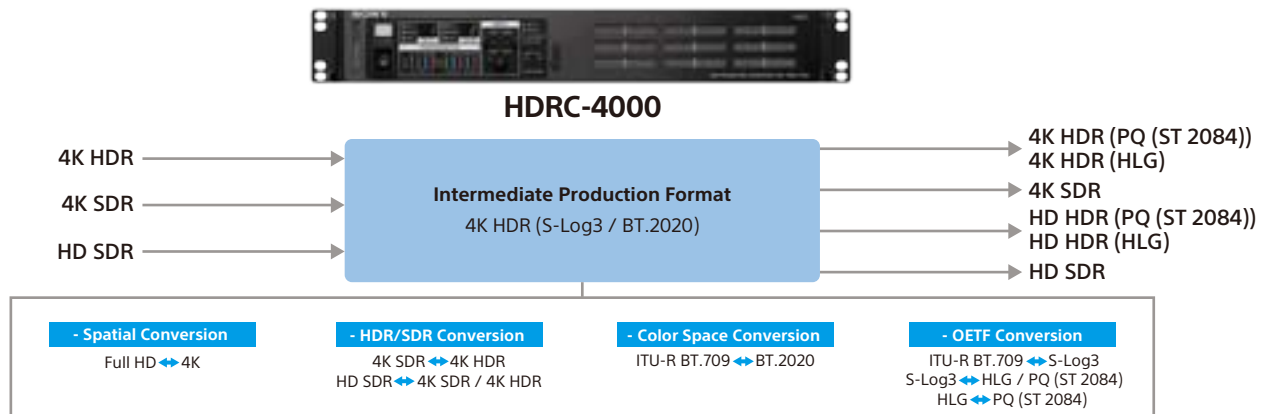
Furthermore, the HDRC-4000 HDR Production Converter with the same-look function provides versatile conversion from the production master in S-Log3 to PQ, HLG, 4K SDR, and HD SDR. This is why Sony recommends using S-log3 for the production master format. By maintaining the marginal value of the HDR and SDR gain level, you achieve consistent operation when down-converting from HDR to SDR.

# Versatile Real-Time Conversion Functions

A key product to complete the SR Live for HDR workflow is the HDRC-4000 HDR Production Converter Unit. This supports a real-time signal conversion capability on a range of video signals from 4K HDR to HD SDR – a capability that is essential in both the signal input and signal distribution stages of the workflow. Incorporating Sony’s unique algorithm, the HDRC-4000 faithfully retains the producer’s creative/artistic intent (the look of the picture that he or she finalized in the OB truck or master control room) to any distribution format for broadcast.

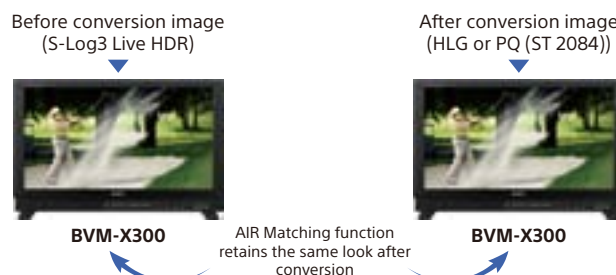
The HDRC-4000 offers multiple signal conversion capabilities to accommodate various distribution standards – spatial conversion, HDR/SDR conversion, color space conversion, and OETF conversion.

Incorporating a built-in frame synchronizer, the HDRC-4000 can receive outside feed signals even without genlock.



## AIR Matching Function

AIR stands for Artistic Intent Rendering. This feature enables conversion of the intermediate production format (Sony recommends using 4K resolution, S-Log3 OETF, and the BT.2020 color space for mainstream production) to any desired distribution format, such as HLG (Hybrid Log-Gamma), PQ (Perceptual Quantization), or SDR on an “as-seen” basis. With this feature turned on, the HDRC-4000 faithfully retains the producer’s creative/artistic intent – in other words, the final look of the picture – onto the master monitor in the OB truck or master control room in the process of converting the intermediate production format to any desired distribution master format for broadcast.



\* Images are simulated.



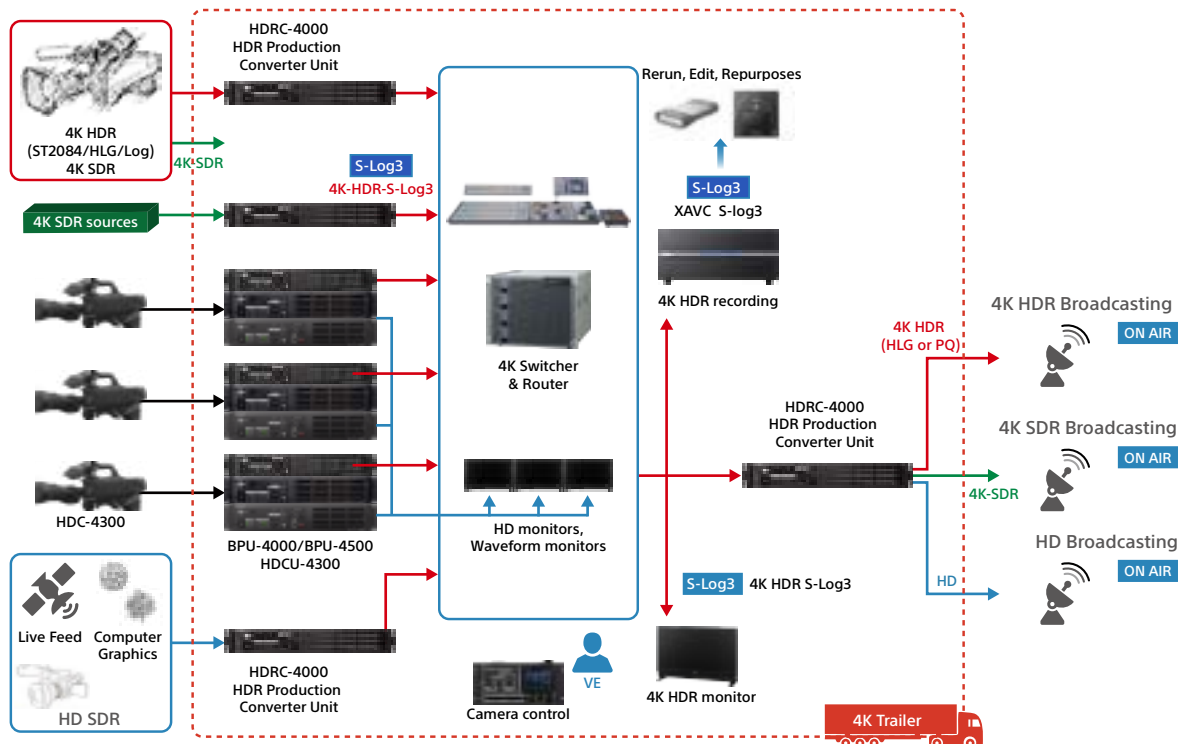
# System Example Of Live HDR Workflow Using S-Log3

The SR Live for HDR workflow can deliver simultaneous live production with just a single truck. Shooting operation is based on the HD SDR signal (the video engineer monitors the HD SDR signal when setting the iris and adjusting the color space), while actual production uses the 4K HDR signal. The necessary format conversions occur at the last stage prior to transmission. As a result, one live truck is sufficient to accommodate simultaneous 4K HDR (PQ or HLG), HD HDR, and HD SDR.

Image acquisition with the HDC-4300 4K System Camera and the 4K HDR baseband signal (S-log3, BT.2020) is brought to the 4K HDR production process through the BPU-4000/BPU-4500 Baseband Processor Unit. When the source signal is other than 4K HDR, it can be converted to the 4K HDR production format (S-Log3, BT.2020) with the HDRC-4000 HDR Production Converter Unit.

Installing the HDRC-4000 in the final stage of the production process, the production format (S-Log3, BT.2020) can be converted to a variety of distribution formats including 4K HDR (PQ or HLG), 4K SDR, HD HDR, and HD SDR without loss.

## Example system of Live HDR workflow using S-Log3 format



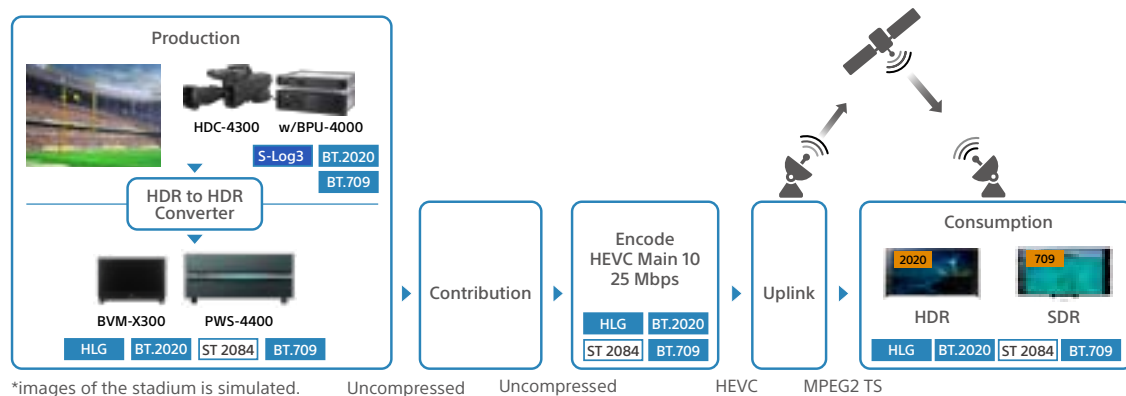
# Examples Of HDR Production (Live Production)

Sony has been a leader in the field of 4K live production for many years, and so it's no surprise that the company is also playing a key role in the deployment of HDR for live production.

Sony's unique HDC-4300 Studio Camera System is trailblazing with superb picture quality and HDR capabilities. It was put to the test at the Octo British Grand Prix MotoGP on the UK's Silverstone circuit, and excelled by providing outstanding HDR effects such as more lifelike reproduction of racing suit colors and stereoscopic imagery of each motorcycle body.



Sony took part in a cutting-edge, world-first, live end-to-end ultra-high-definition HDR trial with Sky Germany. Once again, pictures were captured with the HDC-4300 camera, and these were transmitted via satellite to the audience. During the event, a comparison of ST 2084 and HLG performance was provided, with pictures displayed on both HDR and SDR TV.



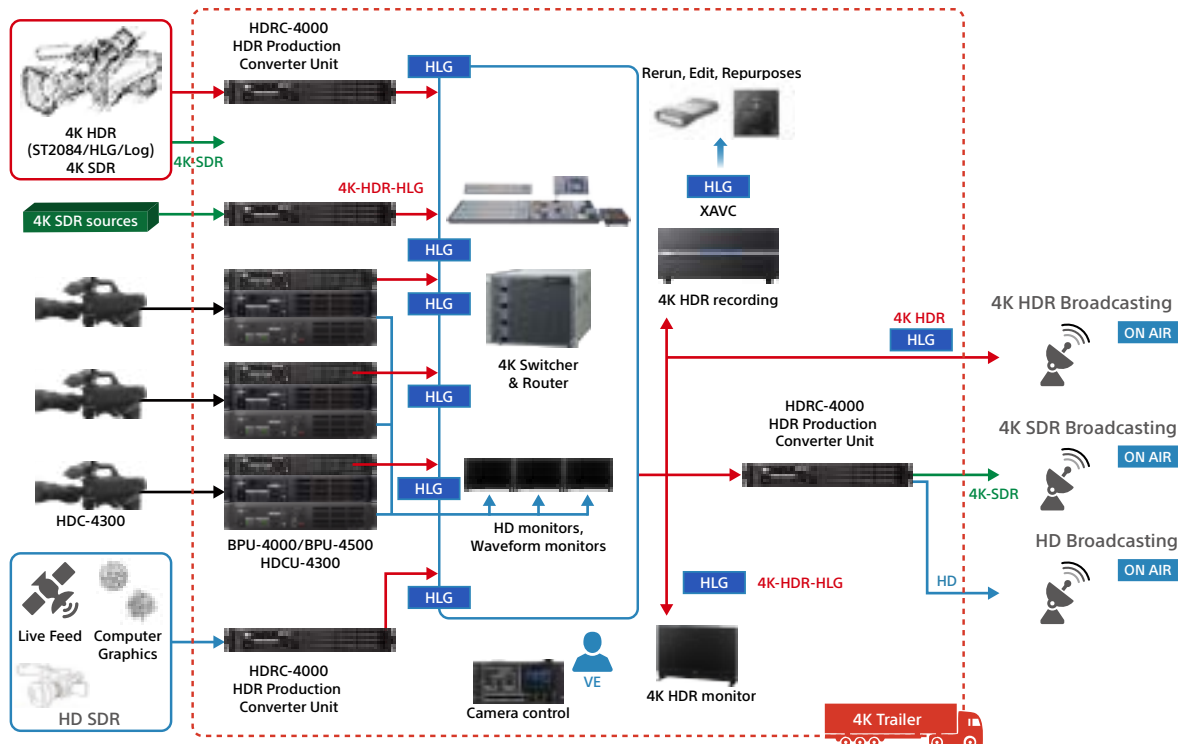
Sky Germany HDR Workflow

# System Example Of Live HDR Workflow Using HLG

In addition to the S-Log3-based SR Live HDR workflow, Sony offers HLG end-to-end HDR workflow. This also meets customer requests to realize HDR/SDR simultaneous production and experience SDR-based shading control, which is the SR Live concept.

Sony provides the HDCU/BPU (baseband processor unit) for its system cameras. This features two new output modes: HLG (BT.2100) and HLG\_Live. HLG\_Live mode supports the standard HLG (BT.2100) with the appearance of Live HDR. This achieves image quality that closely corresponds to the AIR (artistic intent rendering) matching HLG which is delivered with the HDRC-4000 HDR Converter Unit.

With this system, you can accomplish an HLG end-to-end HDR solution for HLG distribution without intermediate OETF/EOTF conversions.



# File-Based HDR Workflow

Image production is increasingly diversified and everyone wants greater efficiency. To meet these critical challenges, Sony offers a broad product lineup and a variety of practical operation formats.

## For premium production and high-end cinema:

Sony provides RAW 16-bit linear recording with the F65, its state-of-the-art CineAlta™ digital cinema camera, and PMW-F55/PMW-F5 CineAlta Cameras.

In addition, the PMW-F55/PMW-F5 with the AXS-R7 Portable Memory Recorder supports X-OCN (eXtended tonal range Original Camera Negative), a new recording format. The X-OCN combines full 2K and 4K resolution with extraordinary color reproduction, well suited to Sony's S-Gamut3. In particular, 16-bit scene linear tonal gradation retains the camera's full dynamic range, with far greater capacity for visual expression.

Compared to typical RAW, X-OCN features substantially smaller file sizes. At the highest 4K picture quality, X-OCN ST (standard) offers about 40% longer recording time and roughly 30% shorter file transfer time than F55RAW. The advantages of X-OCN LT (light) are greater still: about 2.3 times longer recording time and roughly 60% shorter file transfer time.

Consequently, Sony's RAW and X-OCN formats are optimal choices if you operate with an advanced specification transfer function such as ST 2084 (PQ).

## For medium- to high-class production:

As used in the Live HDR production workflow, Sony also recommends using S-Log3 for a file-based production intermediate format. In the edit/grading process, commercially available grading tools support both Sony's S-Log3 and S-Gamut3 color space. These tools and environments together enable efficient HDR workflow.

In the final process stage of finishing, different types of EOTF are used according to each application – broadcasting, OTT (streaming services on the network), and cinema/UHD BD packages – so this requires the production EOTF to be converted to other formats. The S-Log3 solution offers the best production EOTF as it ensures the lowest level of image quality degradation during this intermediate conversion process.

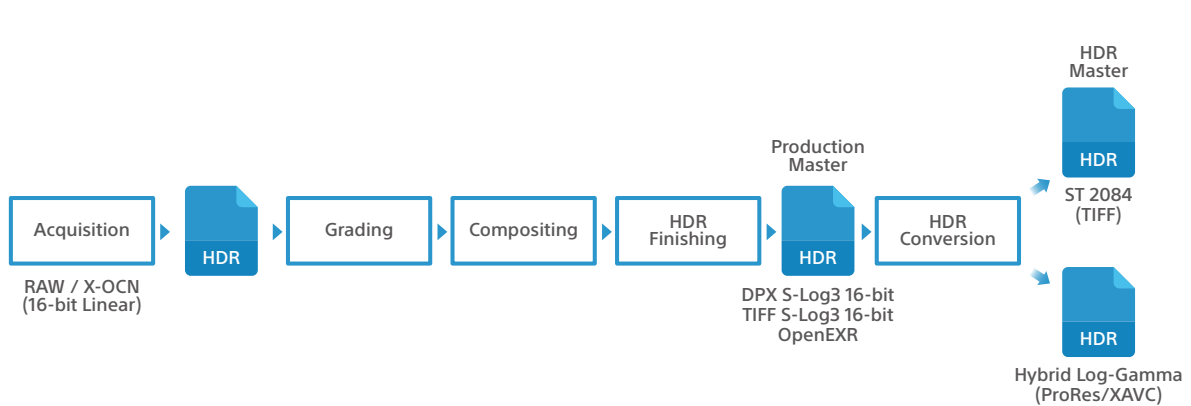
## File-based HDR Production Workflow

Applications	Production - setting, codec -	Postproduction - Inverse EOTF -	Distribution - EOTF -
Premium Drama/Documentary	RAW, X-OCN (16-bit, Scene-linear)	Inverse-PQ (12-bit)	PQ (ST 2084) (12-bit)
Mid to High Class	XAVC (10-bit, S-Log3)	S-Log3 (10-bit)	HLG, HDR10 (10-bit)

# File-Based Premium Production Workflow

Using Sony's CineAlta F65 and PMW-F55 cameras, various acquisition formats (F65RAW, F55RAW, or X-OCN) and 16-bit scene linear enable file-based premium drama, documentary, and cinema production. These high-end acquisition formats smoothly create the most popular production master formats such as DPX, TIFF, and OpenEXR. Operating these master formats in 16-bit scene linear offers flexible HDR conversion such as HLG (Hybrid Log-Gamma) and ST 2084 (PQ).

The S-Log3 16-bit process achieves high-quality mastering to deliver HLG 10-bit and ST 2084 (PQ) 12-bit.



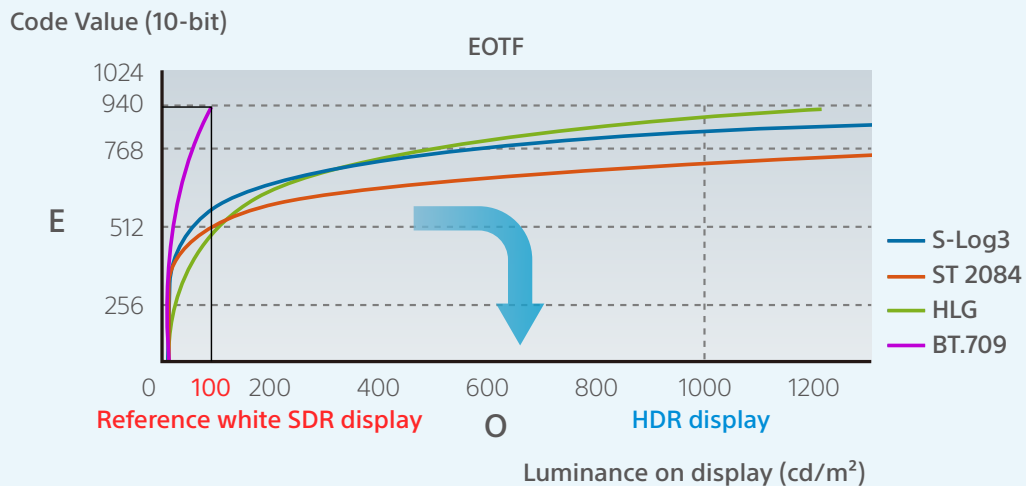
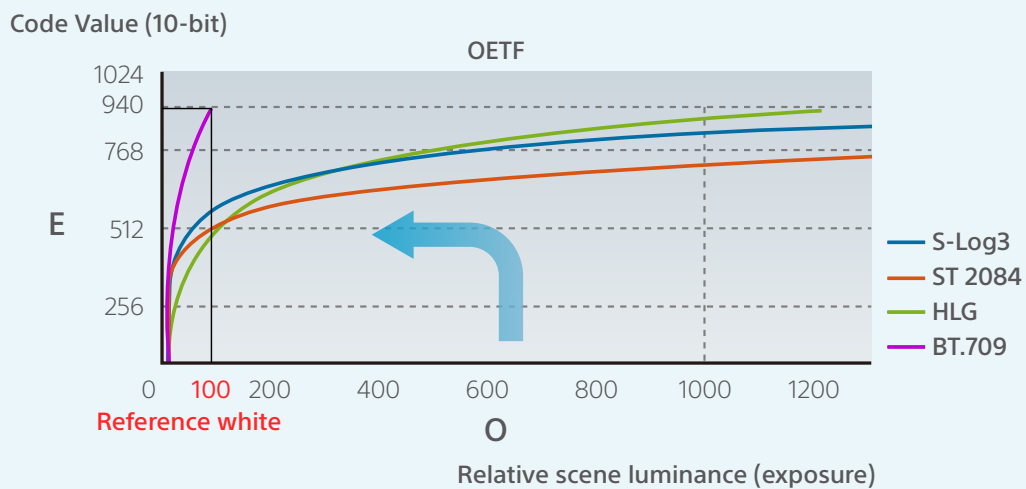
# About OETF/EOTF

In the image content creation process, the image signal captured by a camera system is transferred from an optical signal to an electrical signal. During this process, it is best to transmit the captured image intact, maintaining its high dynamic range, wide color gamut, and gradation to the editing process.

This conversion function is called the OETF (opto-electronic transfer function), while conversion in the opposite direction (the inverse function), from electronic signal to optical signal, is called the EOTF (electro-optical transfer function).

In the era of the CRT, conventional gamma simply worked to compensate for the CRT's light-emitting characteristics. In today's HDR systems, however, the latest OETFs and EOTFs work not only to compensate for display characteristics but also to enhance and even optimize image reproduction appropriately. These inverse functions are designed to transmit the HDR signal efficiently over limited bandwidth.

The International Telecommunication Union published the ITU-R HDR-TV Recommendation, BT.2100-0. The HDR broadcast standard presents two options for producing HDR images – Perceptual Quantization (PQ) and Hybrid Log-Gamma (HLG) – and opens the way towards wider adoption of HDR broadcasting.



# OETF/EOTF

## PQ (Perceptual Quantization)

PQ is standardized as SMPTE ST 2084. PQ defines the luminance levels up to 10,000 cd/m<sup>2</sup> (nit) with 12-bit depth.

## HLG (Hybrid Log-Gamma)

HLG provides a relative value tied to the gamma and logarithmic curve. This system supports practical luminance levels from 1,000 up to 2,000 cd/m<sup>2</sup>. HLG is compatible with conventional SDR systems, so TVs that do not support HDR can reproduce HDR.

## Sony S-Log3

In parallel with CineAlta Series cinematography camera development over many years, Sony has also developed S-Log/S-Log2 technologies for appropriate high-quality cinematography acquisition. These exploit camera performance, and are used in today's cinema production operations. Building on this, Sony now also offers the S-Log3 specification for HDR production, with the following advantages:

- 10-bit signal operation with S-Log3
- Image quality degradation is lower when converting from S-Log3 to other EOTFs
- Natural image reproduction is achieved as S-Log3 offers well-balanced luminance level bit allocation across the board

# OETF (Opto-Optical Transfer Function)

This function is recognized as a system gamma or total gamma to adjust the final look of displayed images. OETF on HDR, defined by ITU-R BT.2100, includes PQ (Perceptual Quantization) and HLG (Hybrid Log-Gamma). HLG has a relative OETF value according to the maximum luminance value of the display. This works to align the image look, which may differ with display brightness.



# Sony's HDR Products



For Sony, the major breakthrough came in 2011 with the launch of the revolutionary CineAlta F65. This camera can capture images in 4K and beyond with wide color gamut and 14 stops of latitude, and in 16-bit linear RAW – absolutely perfect for HDR imaging of the highest quality.



In Sony's PMW-F55 and PMW-F5 Cameras, which also feature wide color gamut, RAW recording, and 14 stops of latitude, CineAlta has been used to capture the highest-profile movies and TV drama productions of the past few years. These cameras have also become the go-to system for the new generation of 4K OTT providers launching big-budget original series for internet delivery.



The AXS-R7 Portable Memory Recorder is a new recorder for Sony's PMW-F55 and PMW-F5 CineAlta Cameras. Used with these cameras, the AXS-R7 offers a 4K RAW 120 fps recording function (on the PMW-F55 only) and cache recording function. In addition, the AXS-R7 offers the new X-OCN recording format, combining flexibility and efficiency in addition to the RAW format. This full-featured recorder is designed to match field performance.



# Sony's HDR Products



**HDC-4800**  
System Camera

The HDC-4800 Camera, combined with its dedicated BPU-4800 4K Baseband Processor, delivers breathtaking 4K Ultra HD images at up to 8x (479.52 fps)/4x (239.76 fps) slow motion\*<sup>1</sup> or Full HD at up to 16x (959.04 fps)/8x (479.52 fps) slow motion\*<sup>2</sup> and features Full HD cutout and zoom capabilities. Used on its own, the HDC-4800 delivers 4K Ultra HD standard speed images or Full HD at up to 4x slow motion with outstanding high sensitivity as standard.

\*<sup>1</sup> Optional SZC-4008 software is required.

\*<sup>2</sup> Optional SZC-2016 software is required.



**BPU-4800**  
Baseband Processor Unit



**HDC-4300**  
System Camera

It's not just drama and movies that are reaping the benefits of Sony's technology for HDR. With Sony's HDC-4300\*<sup>3</sup>, the world's first true 4K live system camera featuring three 4K resolution 2/3-inch image sensors, professionals have been able to undertake a number of recent high profile HDR trials.



**HDC-P43**  
System Camera

With the same three 2/3-inch CMOS sensors and circuitry design as the industry-acclaimed HDC-4300 4K/HD Studio Camera, the HDC-P43\*<sup>3</sup> is a compact POV camera that matches the performance levels and picture quality of the HDC-4300.

\*<sup>3</sup> The HDC-4300 and HDC-P43 support HD HDR as standard, and 4K HDR with optional SZC-4001 software.



**BPU-4000/BPU-4500**  
Baseband Processor Unit

BPU-4000 and BPU-4500 Baseband Processor Units offer real-time 4K digital signal processing. The signal can be simultaneously down-converted to an HD signal and output when connected to the HDC-4300 via an optical fiber cable. The detail process can be optimally adjusted in each signal.

- Parallel processors for 4K/HD
- Down-conversion from 4K to HD
- HD cutout and HD high-frame-rate operation by installing optional software (SZC-2001, SZC-4002)



**HDCU-4300**  
Camera Control Unit

The HDCU-4300 Camera Control Unit integrates a baseband processor function and a conventional camera control function. It connects directly to an HDC-4300. With its compact body, this unit is very suitable for space-constrained applications, and is easy to install in OB trucks or in the background at live events.

# Sony's HDR Products



HDC-1700/HDC-2000 Series  
System Camera

HDC-1700 and HDC-2000 Series system cameras incorporate Sony's advanced technologies for studio cameras. A 2/3-inch CCD and digital signal processing (DSP) with a 16-bit A/D converter provide amazing picture quality with very low noise and high dynamic range.



HDCU-2000/HDCU-2500  
Camera Control Unit

With the optional HKCU-2040 4K/HDR Processor Board and HZC-PRV20 Signal Format Software, the HDC-2000 Series (except HDC-2570)\*1 can be upgraded to create 4K resolution images as well as 4K/HD Live HDR images.

\*1 The HDC-2000 and HDC-2500 do not require the HZC-PRV20.



HDRC-4000  
HDR Production Converter Unit

The HDRC-4000 is the universal conversion unit used in Sony's proposed Live HDR workflow. This unit provides the all necessary real-time conversion capabilities in the Live HDR production environment – spatial conversion, OETF/EOTF conversion, HDR/SDR conversion, and color space conversion – in compact 1.5RU size.



PXW-Z450  
4K XDCAM Shoulder Camcorder

The PXW-Z450 is a 4K XDCAM shoulder camcorder which supports HDR features\* including:

- Hybrid Log-Gamma (HLG) and S-Log3 recording/output with BT.2020 color space
- 4K HDR / HD SDR simultaneous recording to one card
- HDR recording with BT.709 SDI output
- Display BT.709 picture on the viewfinder while shooting S-Log3 or HLG

\* Available from version 3.0 firmware in December 2017.

# Sony's HDR Products



**BVM-X300**  
4K OLED Monitor

Sony's BVM-X300 and PVM-X550 4K TRIMASTER EL™ OLED Monitors are the best choice for HDR workflow. Equipped with HDR mode, these monitors feature spectacular OLED picture performance for 4K projects. Their color capability is closer to ITU-R BT.2020 than any other monitor on the market. These monitors support the S-Log3 (HDR) EOTF and both the ST 2084 (PQ) and hybrid log-gamma (HLG) HDR transfer functions.



**PVM-X550**  
4K OLED Monitor

The PVM-X550 incorporates a quad-view display function and this enables simultaneous display of the S-Log3 production master and ST 2084, HLG, and SDR images.



**BVM-E171**

Sony's BVM-E171 HD TRIMASTER EL OLED Monitor, with second-generation OLED, dramatically improves the viewing angle for critical picture evaluation in the studio and on-set. This monitor can also be set to the ITU-R BT.2020 color space and it can accept one signal from 2SI Quad-3G-SDI signals. With the optional BVML-HE171 HDR Monitoring License, this master monitor supports S-Log3 (HDR), S-Log3 (Live HDR), SMPTE ST 2084 (PQ), and BT.2100 (HLG).

# SONY

©2017 Sony Imaging Products & Solutions Inc. All rights reserved.  
Reproduction in whole or in part without written permission is prohibited.  
Features and specifications are subject to change without notice.  
"SONY" is a registered trademark of Sony Corporation.  
"XAVC", "CineAlta", and "TRIMASTER EL" are trademarks of Sony Corporation.  
All other trademarks are the property of their respective owners.  
Please visit Sony's professional website or contact your Sony representative for  
specific models available in your region.