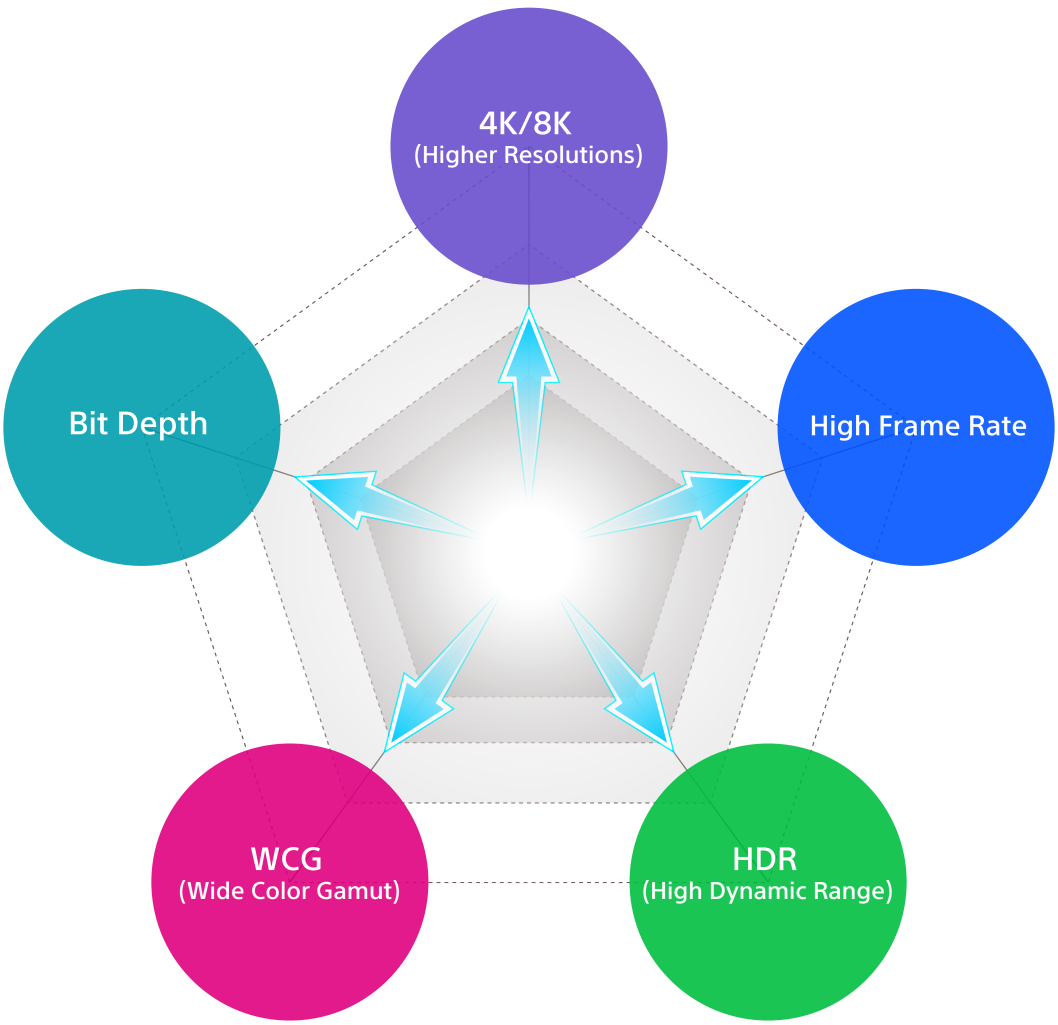
HDR (High Dynamic Range)

Introduction

A big wave is coming to live image production; this is the trend of 4K or even higher 8K resolution content creation.

Along with this trend, live image reproduction achieves 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 key elements for 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.

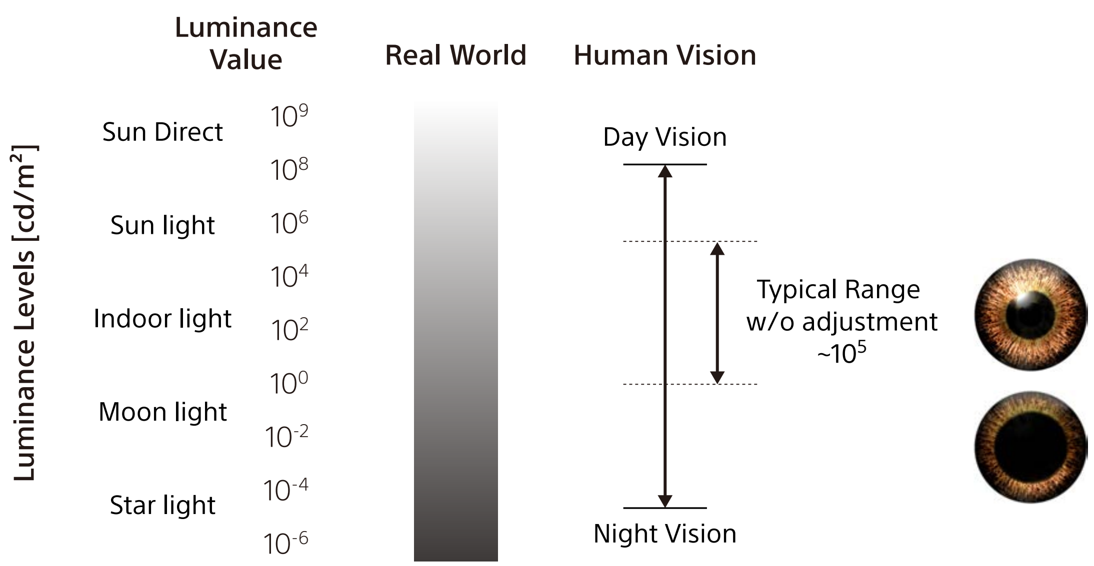


Five major elements to create the next generation of high-quality image production.

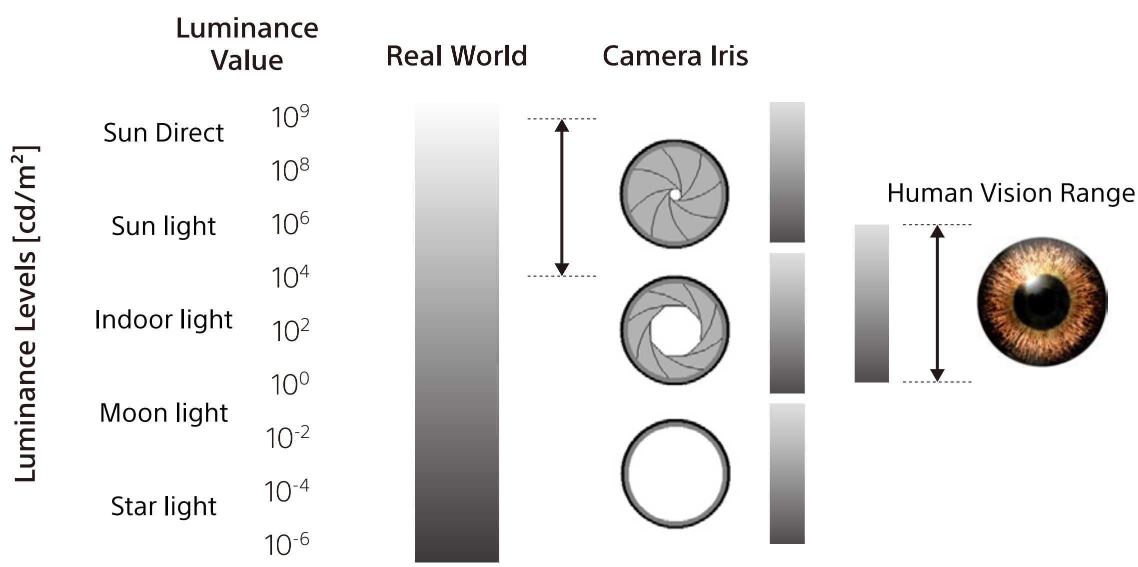
What is HDR?

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

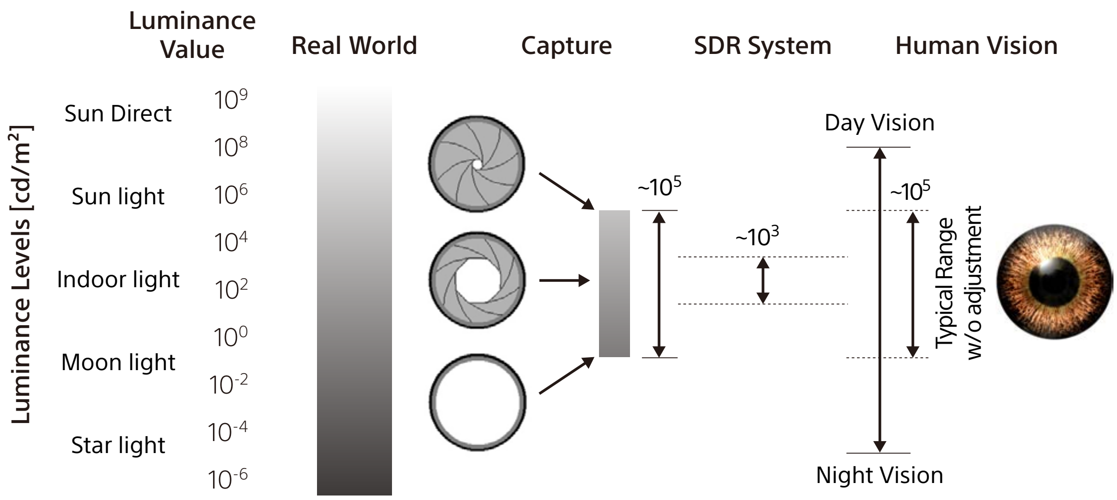
The dynamic range of the human eye with a fixed pupil is normally 10^5 (10 to the power of 5). The action of opening and closing the pupil, however, enables the human eye to perceive the dynamic range of luminance levels in the natural world.



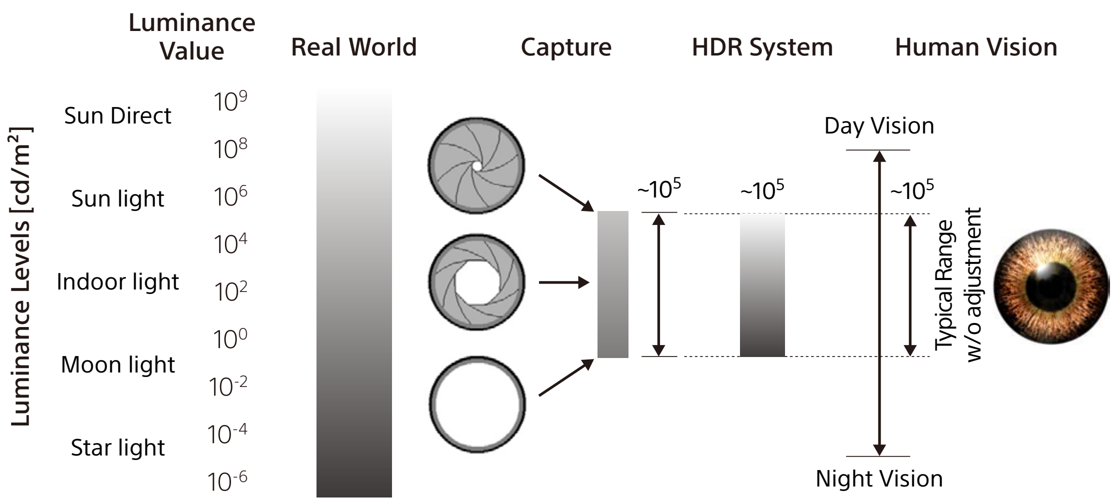
In a similar way, the dynamic range of a camera and lens system is typically 10^5 (10 to the power of 5) with a fixed iris. The camera's dynamic range is adjusted to perceive the natural world's dynamic range of luminance levels by opening and closing the iris.



Camera systems can capture the dynamic range of luminance levels up to 10^5 (10 to the power of 5). However, this capability is constrained by the conventional image production process and/or the CRT or other display system, restricting the camera-captured dynamic range to only 10^3 (10 to the power of 3).



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



For this high-quality image reproduction, the HDR system requires a total end-to-end high-quality system including the camera and storage system, network/transmission system, editing system, and monitoring system. And key to implementing the HDR system is optimally defined transfer functions (OETF/EOTF).

What are the Effects and Benefits?

Today's high-performance camera systems including cinematography cameras and studio cameras can capture high dynamic range and wide color gamut images. But due to technological limitations of conventional CRT displays, current standard-dynamic-range (SDR) production restricts luminance levels to a maximum of 100 cd/m^2 (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 gamut reproduction. Extending beyond this most recent technological evolution, you can now achieve HDR image reproduction by using the most appropriate transfer functions (OETF/EOTF) (see below for details) for both the production side and the consumer side.

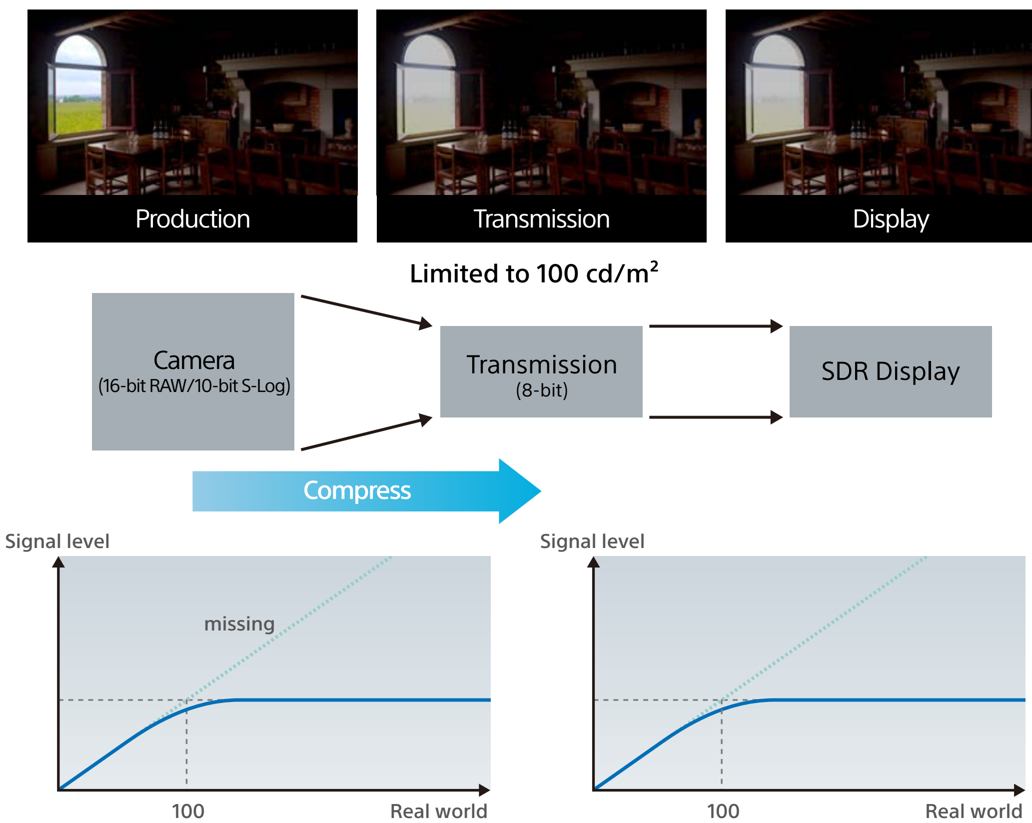
This chapter provides an explanation about effects of HDR, using the example of a video scene in which sunshine extends into a darkened room.

1. SDR system

At the production stage, the camera-captured scene image retains a high dynamic range, from the window's high-luminance level to the room's dark image (see left).

However, the current transmission path with 8-bit depth compromises image quality (see center). Furthermore, as the display limits maximum luminance to 100 cd/m^2 (nit), the system loses both the camera-captured luminance levels and the dynamic range (see right).

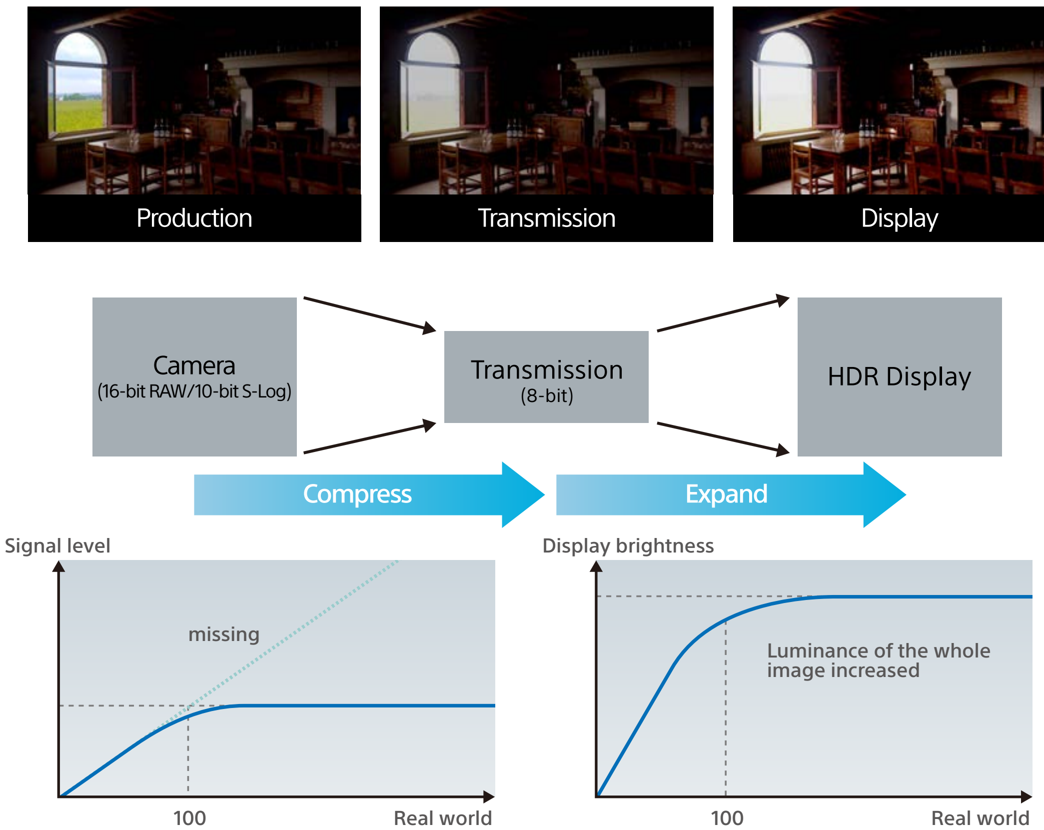
This means that, in the SDR system, the camera-captured dynamic range of luminance levels is compressed and, consequently, the high-light portion of the window is white-clipped while detail is lost in the shadow image.



2. SDR system with a high-luminance display

This system features a high-luminance display instead of a conventional SDR display. Although, this system delivers the same image reproduction as an SDR-equipped system in the transmission process, it is able with the high-luminance display to increase the luminance levels of the whole image.

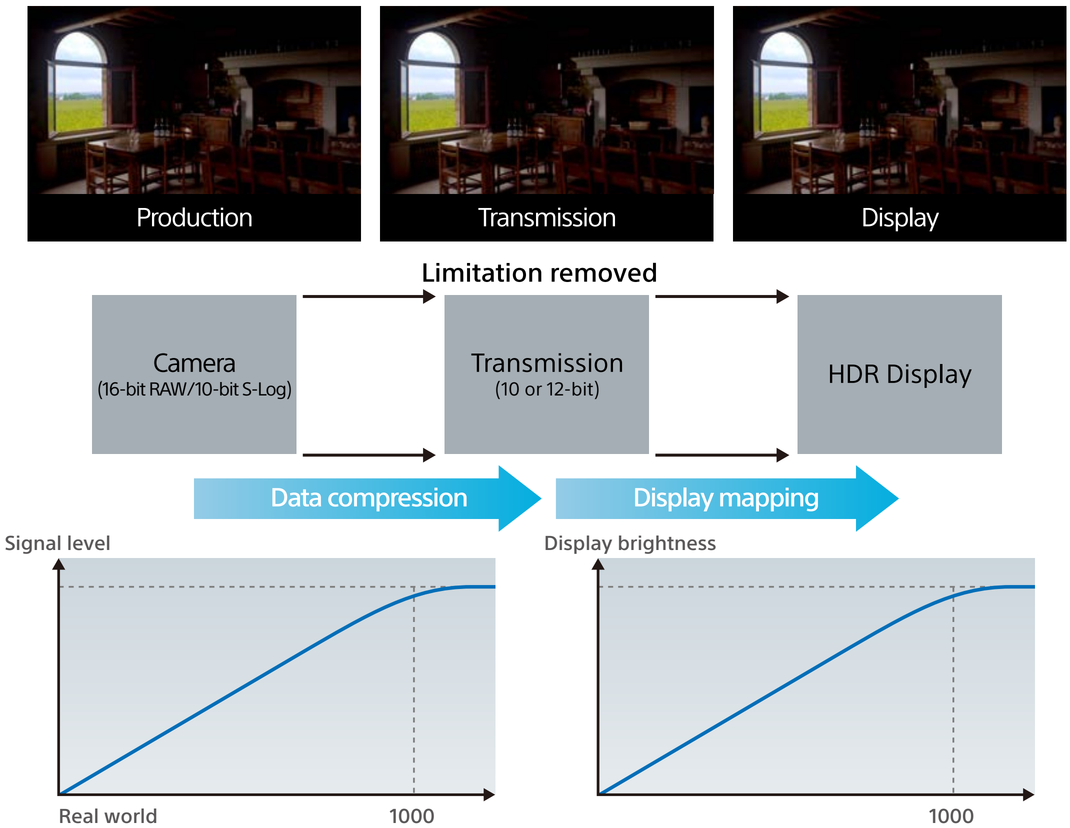
This means that the high-light portion of the window is clipped out while some details in gradation are lost. In addition, the luminance level of the dark portion is increased.



3. HDR system

A system with end-to-end HDR – from the camera, through transmission, and to the display – can deliver an HDR image from the high-light portion right through to the dark portion.

This means that the scene image on the window is reproduced correctly without white-clipping, and the dark room portion of the image is also reproduced correctly.



In summary:

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

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

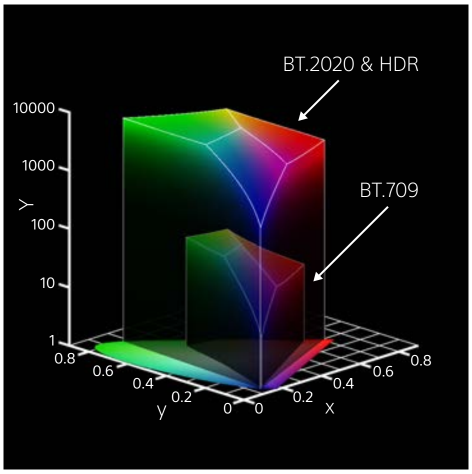
HDR image

Images are simulated.

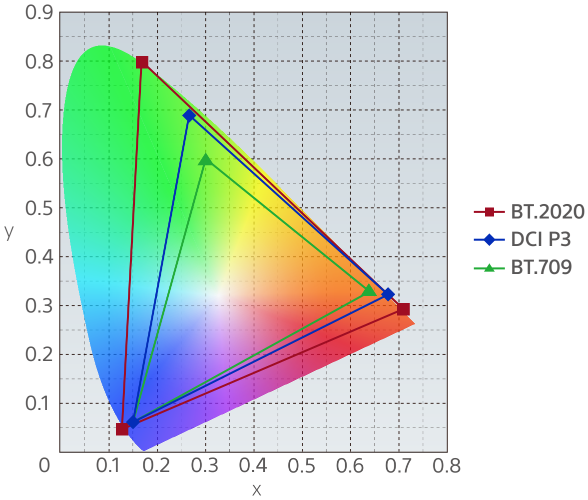
The color gamut works together with the HDR function, as higher resolution intrinsically requires a wider color gamut. The ITU-R BT.2020 prescribes a much wider color gamut than the BT.709 in support of higher resolution images.

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 high dynamic range and wide color gamut 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



HDR Workflow and OETF/EOTF

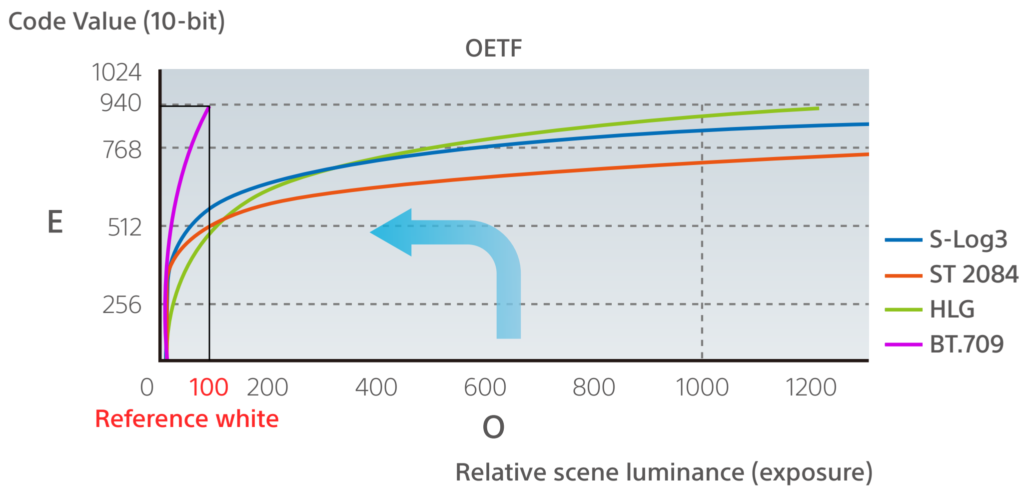
In the image content creation process, the image signal captured by a camera system is transferred from an optical signal to an electrical signal. In this process, it is best to transmit the captured image intact, maintaining its high dynamic range, wide color gamut, and gradation to the editing process.

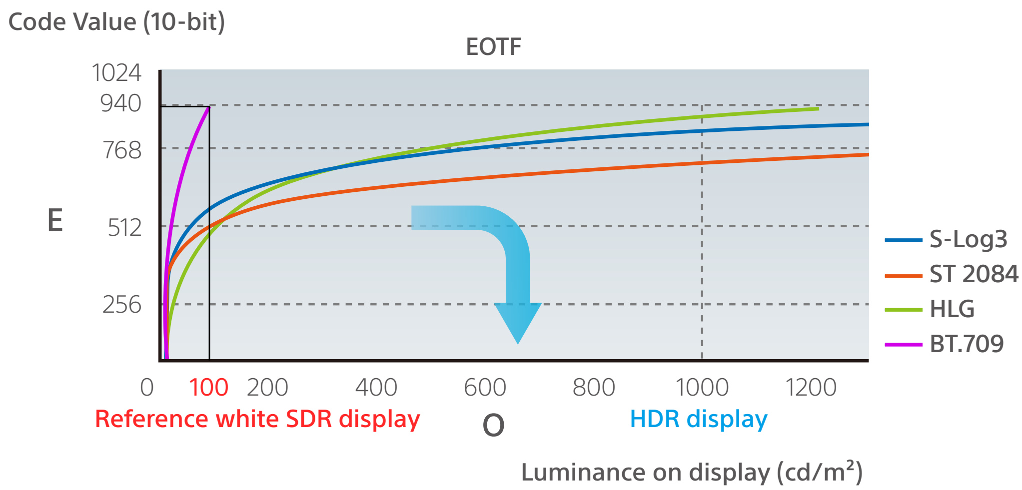
This conversion function is called the OETF (opto-electronic transfer function), while conversion in the opposite direction (the inverse function), from electronic signal to optical signal, is called the EOTF (electro-optical transfer function).

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.

Several different types of OETF/EOTF specifications are proposed to the industry today. These have been designed to maximize camera performance, achieve efficient workflow in the post-production process, and optimize HDR effects according to varying monitoring/viewing environments.

During the HDR production process, when handling high-luminance and wide-color-gamut signals, the OETF and EOTF prevent signal collapse.



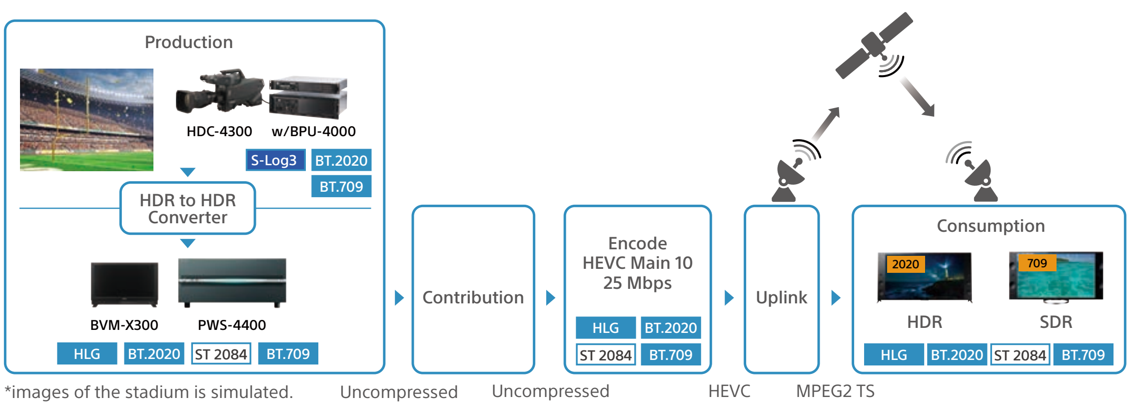


Examples of HDR Productions
(Live Production)

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 leading 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, examples of using ST 2084 and Hybrid Log-Gamma were provided, with pictures displayed on both HDR and SDR TV.



Sky Germany HDR Workflow

Sony's HDR Products


F65
CineAlta Camera

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, 14 stops of latitude, and in 16-bit linear RAW – absolutely perfect for HDR imaging of the highest quality.


PMW-F55
CineAlta Camera


PMW-F5
CineAlta Camera

Along with the F55, which also features 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.


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 new HDC-4300, the world's first true 4K live system camera featuring three full 4K resolution 2/3-inch image sensors, professionals have been able to undertake a number of recent high profile UHD HDR trials.


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 makes the most efficient utilization of the ITU-R BT.2020 color space. These monitors support the S-Log3 (HDR) EOTF and both of the ST 2084 (PQ) and Hybrid Log-Gamma (HLG) HDR transfer functions.


PVM-X550
4K OLED Monitor

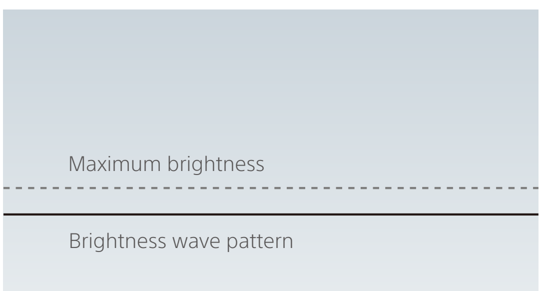
The PVM-X550 incorporates a Quad View display function and this enables simultaneous display of the S-Log3 production master and ST 2084, HLG, and SDR (standard dynamic range) images.

4K BRAVIA™ X93D Series TVs

The new X93D series of BRAVIA® 4K LCD TVs enable optimized HDR image reproduction. The secret is to combine leading-edge picture processing and exceptional color performance with active backlight control to boost or dim the picture in the bright or dark areas of the screen.
In addition, the X93D series incorporates a 4K X-Reality™ PRO 4K super resolution engine, TRILUMINOS™ Display, wide color gamut reproduction technology, and X-tended Dynamic Range™ PRO technology to achieve a luminance control system for optimized HDR reproduction..

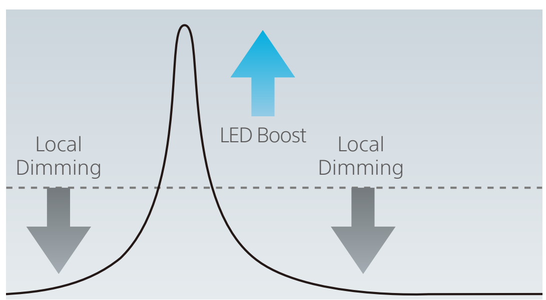
X-tended Dynamic Range™ PRO

Conventional



Constant backlight brightness

XDR PRO



Variable backlight brightness with peaking

SONY

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