SONY

Opening a new chapter

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Document history

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June 2020	**Opening a new chapter** **- SR Live for HDR -**	**Second version**
November 2016	What's "SR Live for HDR" Workflow proposals for 4K HDR and HD SDR simultaneous Live Production	First version

Pre-note: For our writing conveniences, the referenced ITU recommendations and reports will be mentioned in the following abbreviation forms in this document.

Recommendation ITU-R BT.709	BT.709
Recommendation ITU-R BT.1886	BT.1886
Recommendation ITU-R BT.2020	BT.2020
Recommendation ITU-R BT.2100	BT.2100
Report ITU-R BT.2390	BT.2390
Report ITU-R BT.2408	BT.2408

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Introduction

After a long period of introductory trials, technical enhancements and real-world implementations, the technologies of High Dynamic Range (HDR) are having a positive impact on the transition to the new Ultra HD television formats. A large number of high-profile sports, including 2018 FIFA World Cup, music and live media events have been produced in HDR with Wide Color Gamut (WCG), with great technical success.

HDR technology is commonly used in the distribution of movie titles, episodic TV and documentaries via streaming services and Ultra HD Blu-ray discs. Regular sports services featuring HDR are also available to viewers.

Sony continues to contribute to the work of international technical committees for the creation of HDR techniques and operational practices. The resulting workflows have been adopted by production companies and broadcasters transitioning from today's SDR world to a new HDR content creation environment. It is of paramount importance that, during this progression, the SDR programs continue to be made without compromise in production workflows and creative control. Maintaining the highest levels of picture quality for both the SDR and HDR signal formats is key.

Sony introduced the SR Live system for the creation of SDR and HDR programs in live production in 2016. The system is in use by leading organizations around the world. This white paper outlines the benefits of Sony's SR Live system. It describes the latest developments in HDR signal processing and new technical advances for the further enhancement of picture quality. It also highlights recent improvements in efficiency in operational workflow during the creation of HDR/SDR programs.

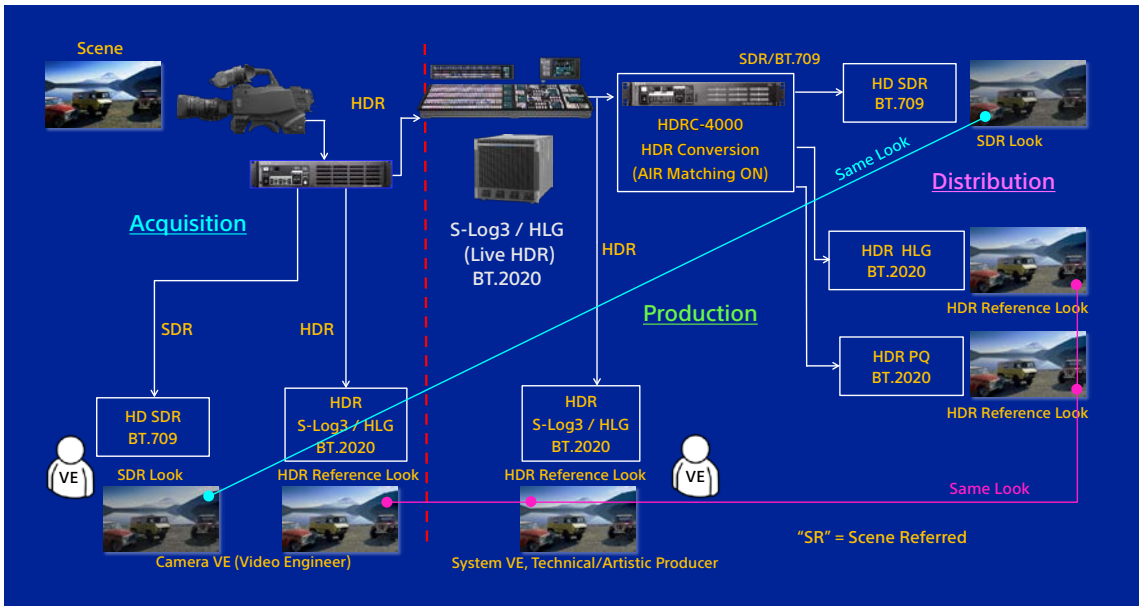

Figure 1: What's SR Live?

A Brief recap:
Sony's "SR Live for HDR" system

As documented in our 2016 white paper, SR Live for HDR stands for Scene Referred Live production for HDR applications.

The SR Live system was developed to meet several key objectives and to offer significant benefits for the producers of live HDR content:

- The realization of a Scene Referred HDR production workflow.
- The simultaneous creation of both HDR and SDR programs.
- The use of SDR-based camera shading using existing tools and techniques.
- "As-seen" conversion to maintain the creative intent throughout the production and delivery chain.

Scene Referred HDR Production

SR Live enables the capture, processing and distribution of programs with an accurate representation of the image characteristics in the scene being shot. This is the fundamental design philosophy of a Scene Referred HDR production system.

HDR and SDR from a single live workflow

SR Live produces HDR and SDR programs with outstanding picture quality. A single production crew can create images without compromising either format.

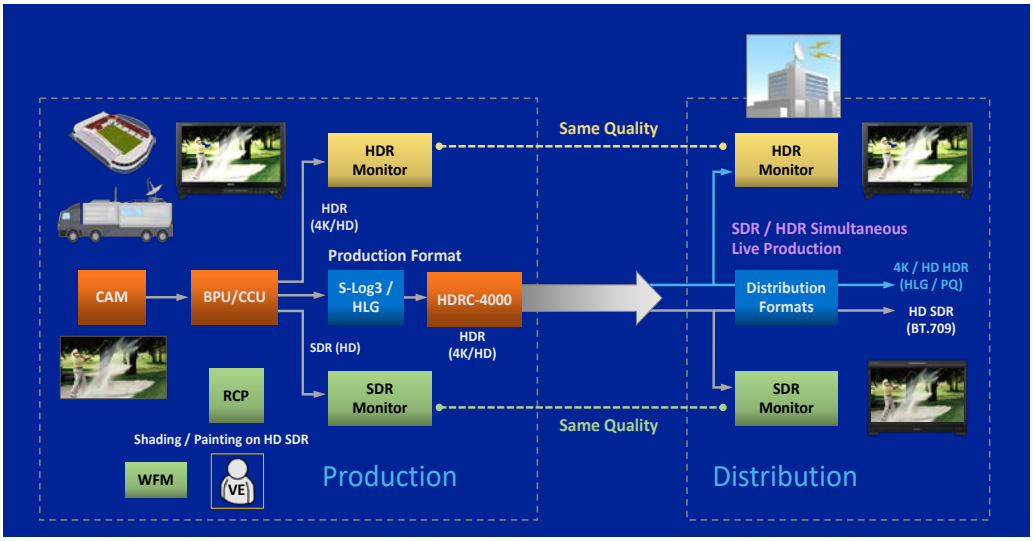

Figure 2: Image of simultaneous HDR and SDR production by one single system and crew

SDR-based camera shading

A mixed SDR/HDR media environment is expected to exist for many years. During this time, production and broadcast companies will not tolerate any degradation of the SDR product. The camera operators (shaders/painters) can continue to use their knowledge of picture quality production in SDR, to create excellent SDR and HDR images at the same time.

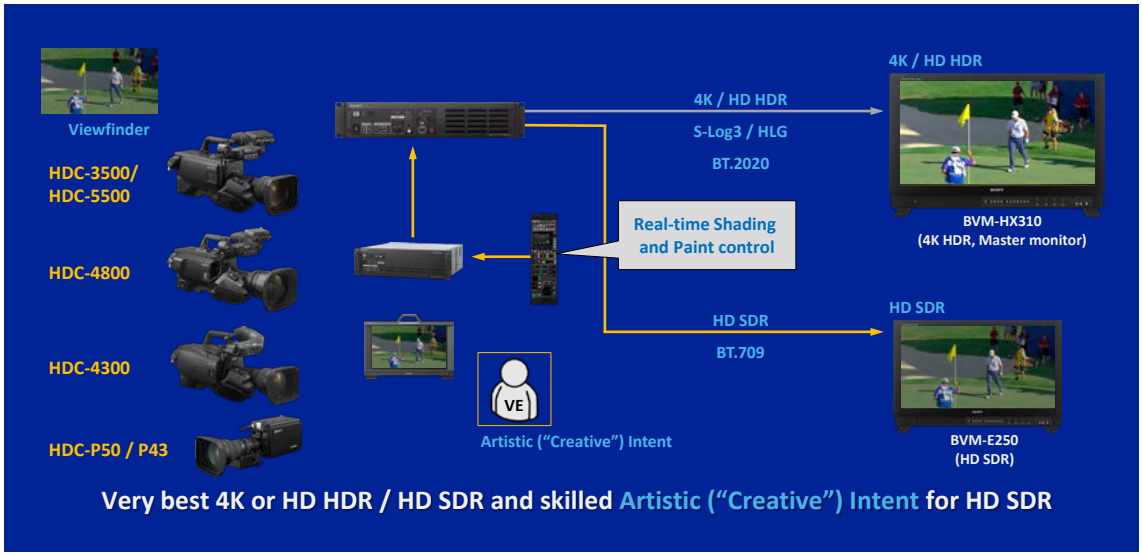

Figure 3: Image of SDR-based camera shading

"As-seen" conversion to maintain creative intent

The picture quality and creative intent established within the production environment must be maintained as the images move along the content production and distribution chains to the viewer's TV, laptop, smartphone or tablet.

The core component of the SR Live system is the HDRC-4000 HDR Production Converter. This device has a unique feature called "AIR Matching" to ensure the above requirement is met.

AIR Matching - Artistic Intent Rendering

- Performs scene referred conversion of an incoming HDR signal to any desired HDR format, while preserving the "look" or artistic intent of the original signal.
- Up-converts from SDR to HDR, targeting the specified "look" of the output HDR signal.
- Down-converts from HDR to SDR, which has a closer "look" with an SDR camera output.
- Ensures that the SDR program (created by the HDRC-4000 from the HDR switcher output) matches the "look" and creative intent of the SDR image created by the camera shader

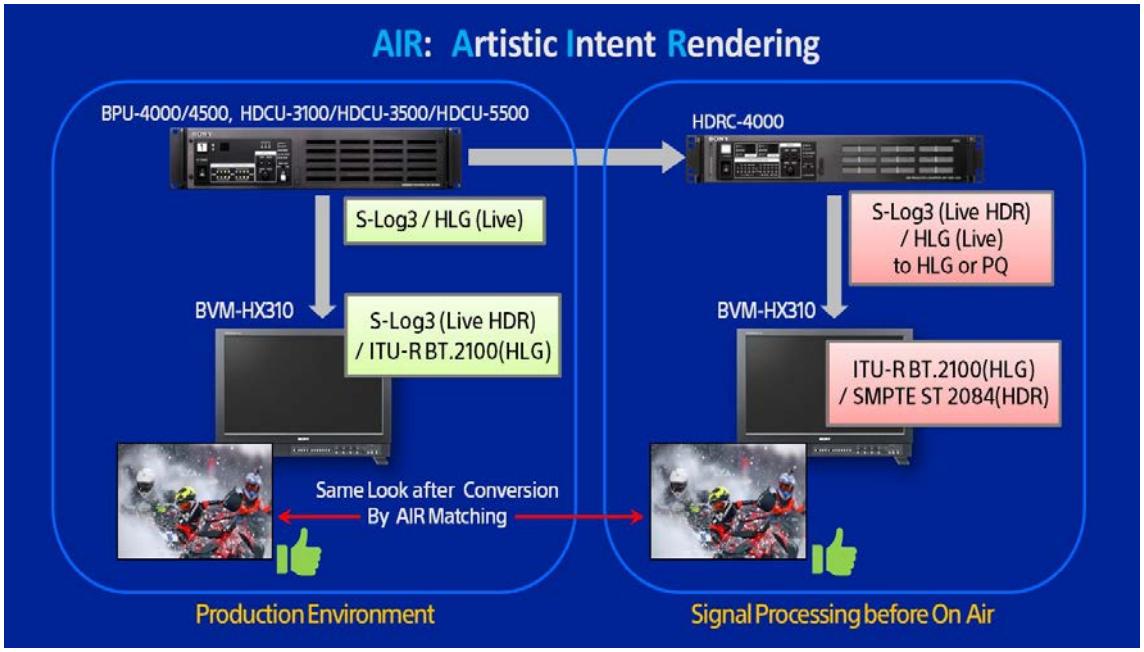

Figure 4: How AIR Matching works

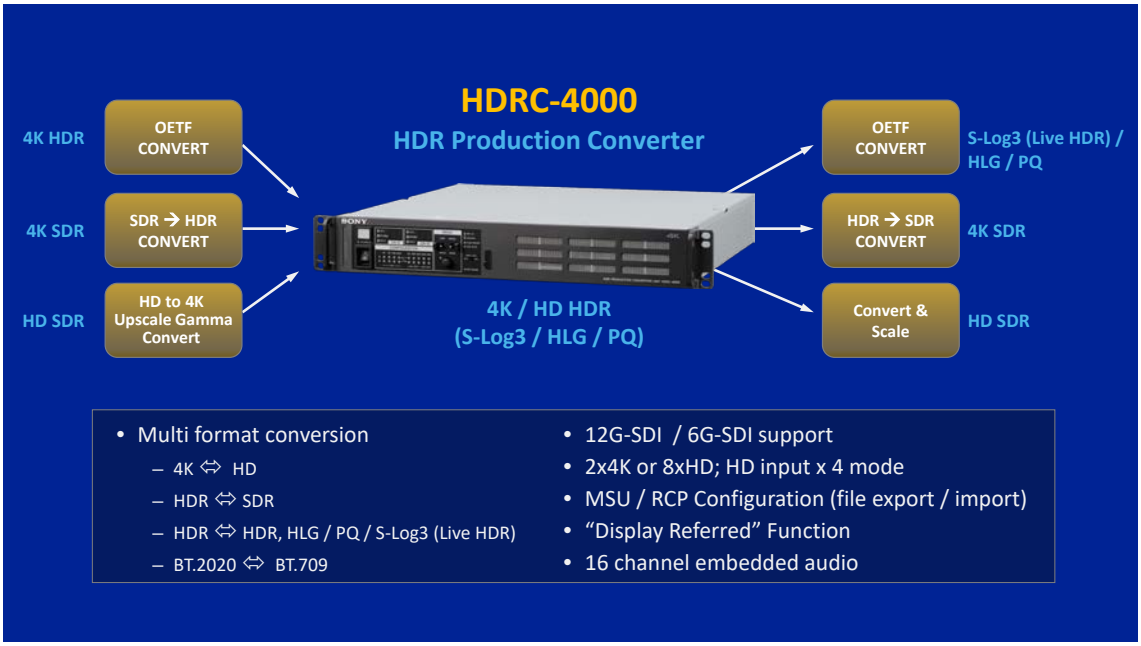

Figure 5: HDRC-4000 Features

What’s new in SR Live for HDR V2.0?

The SR Live HDR system has seen great acceptance by broadcasting groups and production companies worldwide due to its high levels of picture quality in both the HDR and SDR formats while enabling savings in personnel and equipment during live operations. Still, Sony believes that further enhancements are possible by the introduction of technologies that create greater efficiencies in production workflows and can offer further opportunities in processing for today’s acquired content in future HDR services.

Sony has developed the following technologies which are currently being incorporated in our professional products**.**

- MSU Simul-setting feature
- SR Live Metadata
- HDR Processing Engine
- Introduction of HDR Look

MSU Simul-setting feature

It is vitally important to accurately derive the final SDR signal from the main HDR stream, to satisfy the viewers who are watching on SDR devices at home or on the move. This is best achieved if the same value settings are applied to all camera systems and to all HDR converters, both at the source and output sides of the production chain. The initial design of SR Live required production operators to configure each device individually. This took time and introduced the possibility of human error.

A new MSU, Master Setup Unit, Simul-setting feature has been added to simplify set up and reduce the chance of mistakes. A single setting can be distributed, by an MSU to each device in the system. Sony cameras, CCUs, BPUs and HDRC-4000 converters can be identically configured from a single control panel.

For this operation, total seventeen (17) parameters in four (4) categories have been defined and can be distributed via ethernet connection.

The categories and the parameters that are distributed can be seen in table 1. The use of the MSU Simul-setting can be seen in Figure 6.

No	Item	Category
1	HDR Black Compression	Look Setting
2	SDR Gain	HDR/SDR Relationship
3	Master Black	
4	HDR Black Offset	
5	Gamma Table	SDR Adjustment
6	Gamma Step	
7	Gamma Level	
8	Knee	
9	Knee Point	
10	Kee Slope	
11	Knee Saturation	
12	Knee Saturation Level	
13	SDR White Clip	
14	SDR White Clip Level	
15	HDR Knee	HDR Adjustment
16	HDR Knee Point	
17	HDR Knee Slope	

Table 1: Control Items

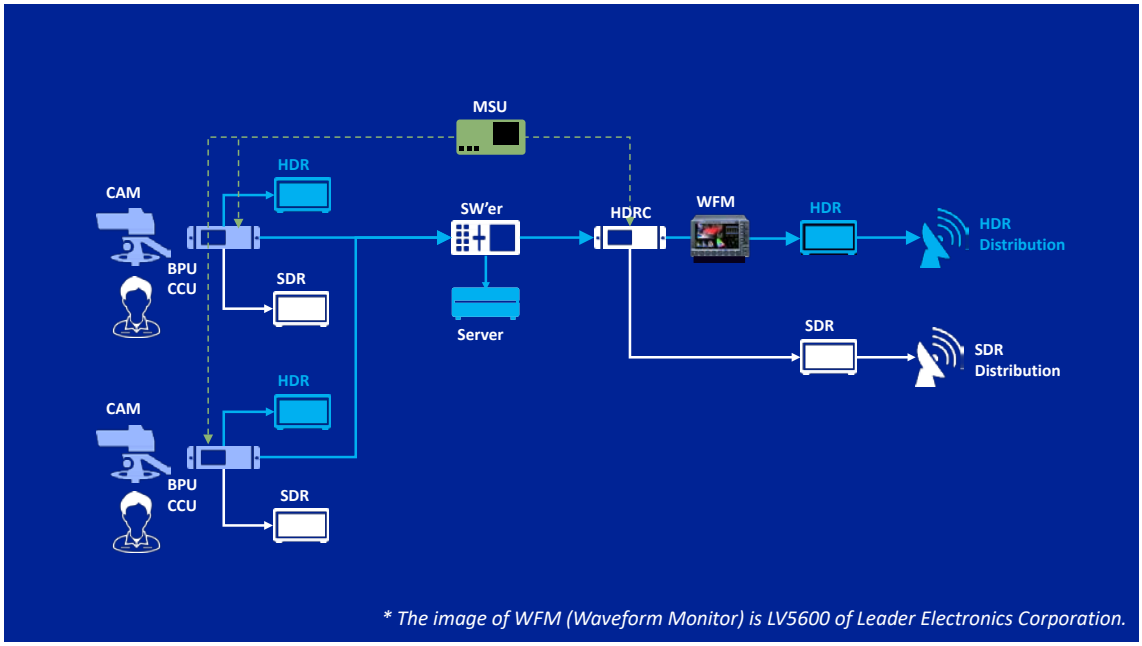

Figure 6: Image of MSU Simul-setting

SR Live Metadata

Technical overview

SR Live has been successfully used at some of the world's largest live international events. HDR and SDR pictures produced by the system have been enjoyed by many millions of viewers around the world. Production teams have gained significant experience of producing in HDR and are keen to add more diverse live and non-real time production scenarios into their operation.

Sony has recently introduced an SR Live Metadata packet which stores 26 parameters, describing the creative decisions and camera adjustments defined by the camera operators during production.

No	Item	Category
1	Table Version	---
2	OETF	Signal Profile
3	Transfer Matrix	
4	Color Gamut	
5	Conversion Mode	Look Setting
6	HDR Look	
7	HDR Black Compression	
8	SDR Gain	HDR/SDR Relationship
9	Master Black	
10	HDR Black Offset	
11	Gamma Table	SDR Adjustment
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 Adjustment
24	HDR Knee Point	
25	HDR Knee Slope	
26	HDR Target White	Information

Table 2: Items of SR Live Metadata

This list of data descriptors registered in a table, includes signal profiles, HDR/SDR relationship information and various values of HDR and SDR settings. (see Figure 7, below).

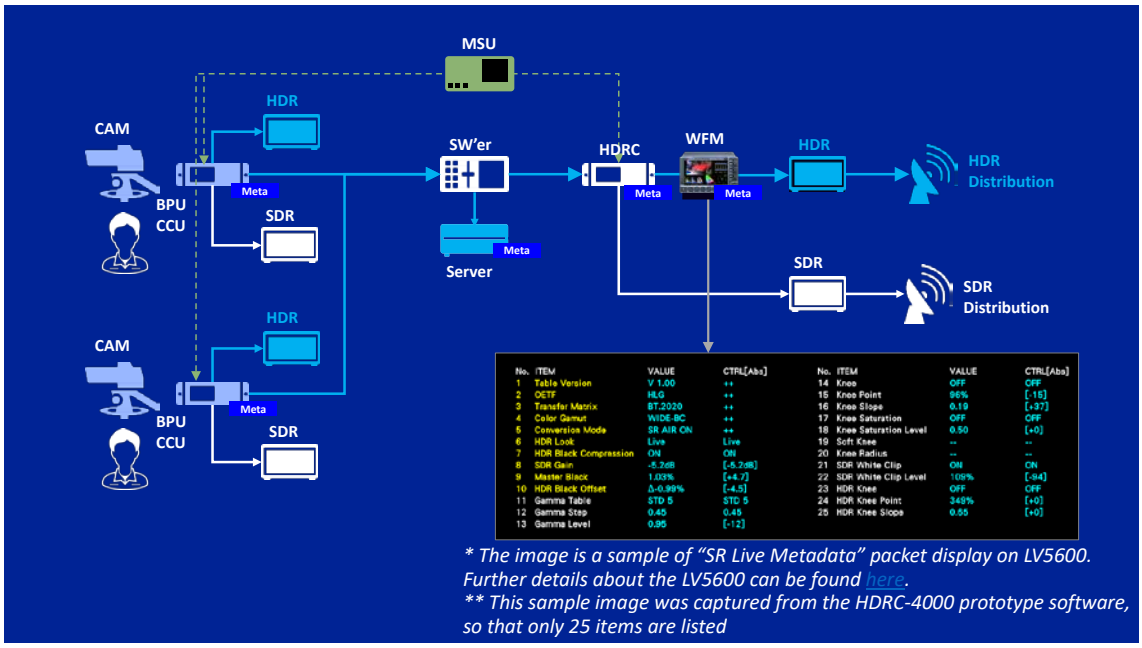

Figure 7: How SR Live Metadata travels through a production system and can be monitored

The SR Live metadata packet reacts in real time. It captures changes of parameter values as camera adjustments are made, under the creative control of the camera shader. The packet is embedded within the SDI signal and is ultimately recorded in files, making both signal feeds and files self-explanatory at every stage of the production chain.

SR Live metadata from the selected production camera, can be read by the HDRC-4000 converter to indicate the exact conditions of the camera during shooting. This provides the information required by the converter for exact duplication of the SDR program from the HDR layer. It also allows each metadata parameter to be visually checked, both live and during post production.

Example of use

In addition to providing enhancements for live production, SR Live Metadata can also bring new opportunities for non-live and post production applications. An example is the inclusion of recorded content shot in HDR with a shoulder camcorder, e.g. in a pit lane at a motorsport event, into an SDR program produced using SR Live. Here, the SR Live Metadata can be read by Sony's Catalyst Prepare media preparation application to derive an SDR output from the HDR camcorder content, at an equivalent quality to that created using an HDRC-4000.

Another example would be the creation of a compilation showreel for SDR replay assembled from a number of video clips shot in HDR at separate live events. In this scenario, knowledge of the original camera settings can be used to generate an optimum quality SDR compilation.

Furthermore, SR Live Metadata from source material recorded by a camcorder or Sony PWS-4500 production server can be stored with the video and audio essence within an MXF file. The SR Live Metadata can be used later, e.g. within Catalyst Prepare* for subsequent post production.

(** Please note that the original SR Live Metadata, captured by the camcorder or server, will not be stored within the post-produced file created by Catalyst Prepare.*)

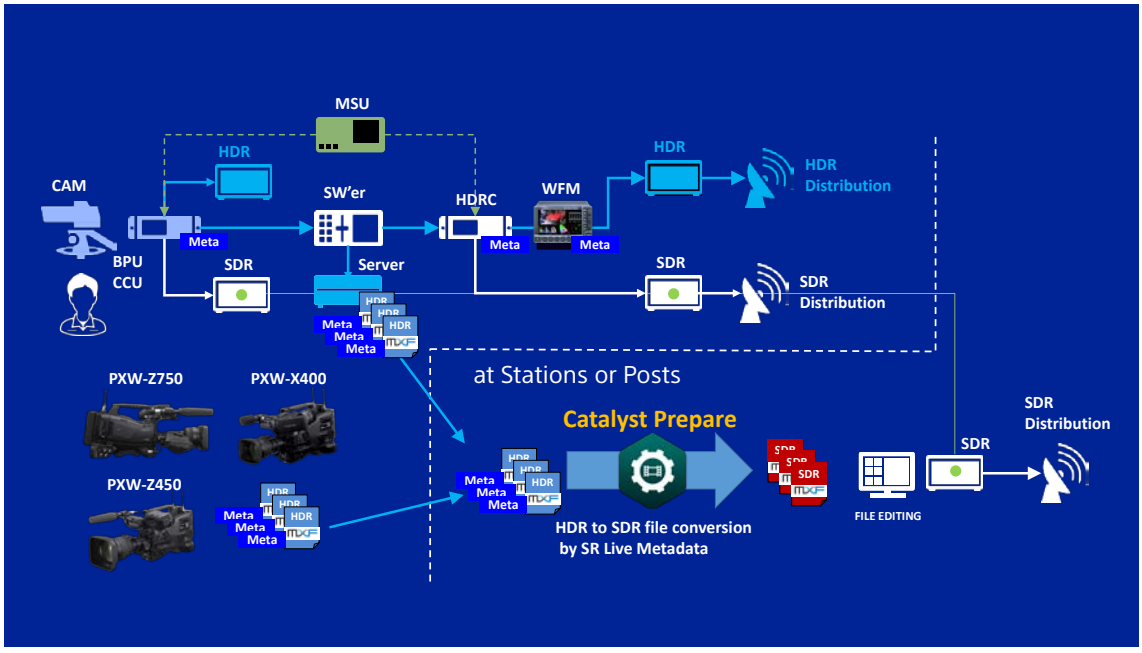

Figure 8: Utilization of SR Live Metadata in non-live productions

Future possibilities

There is a growing belief that the production and broadcast world will evolve from today's SDR infrastructures towards a future where, along with adoption of higher resolution formats, HDR will play an increasing role in image acquisition and processing.

SR Live metadata was developed to provide a snapshot of the settings of the image acquisition devices used to create an SDR/HDR program. Within this HDR environment, content can be repurposed with a knowledge of the imaging characteristics of the capturing device and the artistic intent of the production team.

Figure 9 depicts an SR Live ecosystem where production information travels over streaming interfaces and is stored within files, for full postproduction and archiving applications.

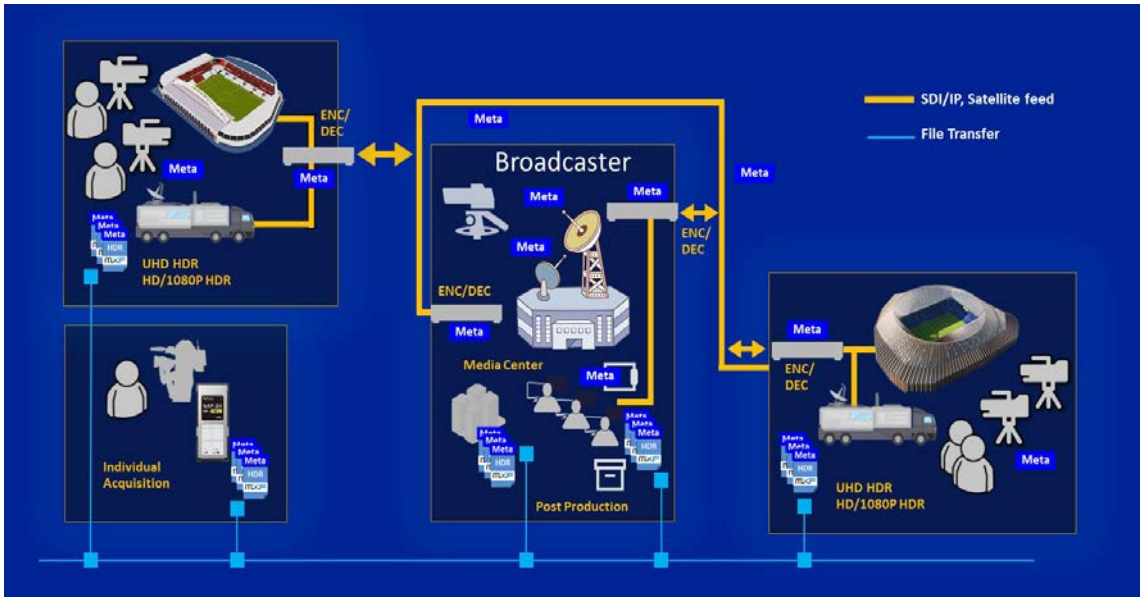

Figure 9: Ecosystem of SR Live Metadata

HDR Processing Engine

In large and complex broadcast installations, there will be a requirement for many conversions of signal format. These can include conversions in image resolution, color gamut and dynamic range characteristics.

Sony's HDRC-4000 is a powerful and accurate computational engine with sophisticated algorithms for HDR/SDR signal processing. However, it is possible that it cannot be used in all areas of HDR conversion because of size, complexity, and cost. Furthermore, as we transition to an all-IP infrastructure, it will be advantageous to combine an SDI/IP conversion stage with SDR/HDR conversion in many cases.

To achieve this goal, Sony has developed an HDR processing engine as an FPGA core, with similar processing algorithms to those used by the HDRC-4000 HDR converter. This new device can be embedded within professional live production devices such as SDI/IP converters, Video Switchers, professional display devices, etc.

Another aspect of this new HDR FPGA-based device is that its processing capabilities can be tailored to the requirements of the host product - be it a video switcher, a display monitor, etc. An optimized degree of HDR quality can be applied for each application, e.g. maximum quality for the main signal path from the HDR cameras, with a slightly relaxed performance level when recreating highlights during conversion from SDR to HDR. Another example is the presentation of images in a monitor wall, where an accurate display is less important than an overall assessment of SDR and HDR sources.
Figure 10 shows how the visual quality of the HDR conversion can be matched to the requirement of each application within a production infrastructure.

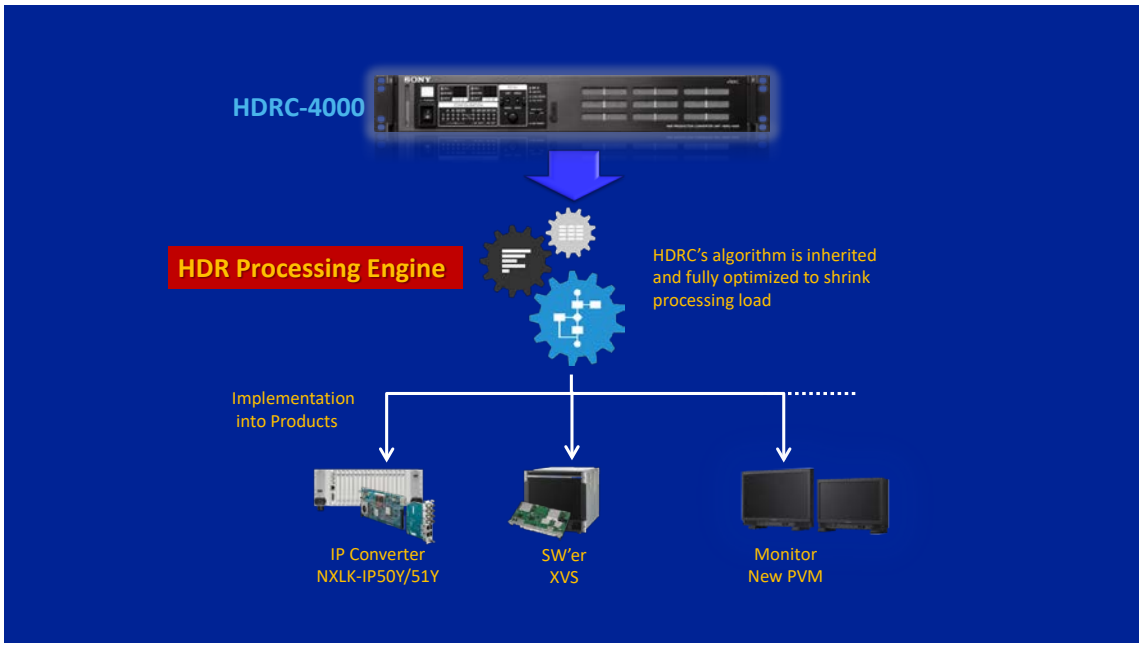

Figure 10: HDR Processing Engine

Introduction of HDR Look

In order to provide additional flexibility for the creative control of the HDR image, Sony has added a new range of signal processing tools into SR Live. These are called HDR Look and HDR Black Compression.
The setting of the “HDR look” is used to adjust the picture appearance throughout the full range of the video signal. The adjustment for “HDR Black Compression”, on the other hand, affects the look in the dark regions of an image.

The Introduction of this new feature is intended to clarify the signal settings of the video camera and HDRC-4000 HDR converter by clearly separating the selection of the OETF from the setting of the image looks (see Figure. 11).

Figure 11: Introduction of HDR Look

These modes of HDR operation maintain compatibility with their corresponding, standardized, OETFs, but provide the technical operators with options related to the selection of image looks.

The “HDR Look” feature in the SR Live system

This range of settings is used to define the picture appearance. The new options are called “Live”, “Mild” and “Natural” and their image characteristics are summarized in table 3.

Look Type	HDR Look	Characteristics
Traditional	Live	Produces high contrast and saturated pictures. It has a closer look to that of existing SDR images, which also have a ‘Traditional Look’.
	Mild	Maintains the Traditional / Live Look, but with a milder picture contrast and color saturation. It is best suited for shooting high contrast objects, such as sports events, sceneries, etc on sunny days.
Natural	Natural	The picture ‘look’ defined by ITU-R BT.2100 for Hybrid Log-Gamma. A more ‘Natural Look’ when compared with the more saturated and higher contrast ‘Traditional Look’.

Table 3: Characteristics of HDR Look

The images below are called “Three Sisters”.
This frame belongs to a video clip shot with Sony’s digital motion picture camera VENICE by Jeff Berlin, Director of Photography (BerlinCreativeFilm.com).

Figure 12: Simulated image comparison of HDR Look: Live, Mild and Natural

“HDR Black Compression”

With HDR Black Compression ON, the dark areas of the HDR and the derived SDR pictures can be closely matched. HDR Black Compression can be switched OFF if the priority is an HDR image with more detail and gradation in the dark areas of the image.

SR Live Production Recommendation

Due to the increase in worldwide HDR productions, there have also been an increase of inquiries from media producers relative to the handling of conventional video sources and the possible creation of less than optimal levels of picture quality during the HDR live production.
This section will discuss why these picture artifacts are happening and proposals will be presented to solve these problems which could occur throughout the production pipeline.

Operational Practices in HDR Television Production

In October of 2017 the ITU issued the first edition of a Report offering guidance on the production of HDR programs for live television applications. (Report ITU-R BT.2408-0, 10/2017).
The guidance very closely resembled the operational practices that Sony has been using for a number of years in the implementation of SR Live workflows (see Figure. 13).

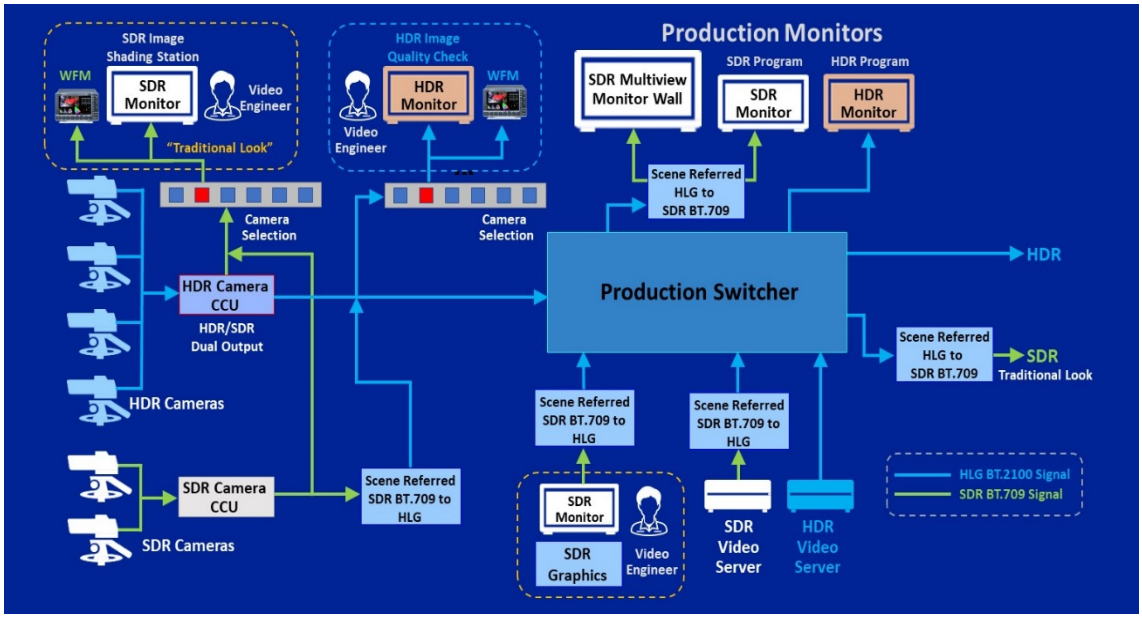

Figure 13: Scene Referred-based HDR/SDR simultaneous production

In particular:

- The use of SR 'Scene Referred' conversion techniques to match SDR and HDR camera operations
- Production cameras shaded while monitoring SDR
- Only HDR is passed through the production switcher
- Camera operator views a conventional SDR monitor with the "traditional" look
- The use of SR down-conversion from the HDR production master (down-mapping) for the creation of the SDR feed for distribution
- Correct SDR-HDR-SDR "Round-Tripping", since SR conversion is used throughout, to maintain the same SDR look at output of the cameras' CCUs and the SDR feed for distribution.

This guidance is in line with the technical foundation of SR Live which has been successfully employed by production companies in a multitude of sporting and live media events (see section on Customer Stories below).

Conversion Techniques: Avoiding pitfalls and picture side-effects

More recently "Report ITU-R BT.2408-3 (07/2019)", has suggested the need to consider both Scene Referred and Display Referred conversion techniques depending on circumstances.

More specifically:

- To continue with the use of the Scene Referred conversion technique for SDR camera signals.
- For SDR Graphics, commercials, legacy material (graded, archival), ITU-R BT.709 broadcast feeds, server-based content (Super Slow-Motion effects) to be converted into HDR using a Display Referred conversion technique, in order to preserve its original "look" and the artistic intent.
- A suggested use of the Display Referred process for the creation of the SDR distribution signal from the HDR production master

Referring to Figure 14, it is suggested that different processes to be applied at the various parts of the program chain. Production companies will need to take great care, as far as when to use what type of technique, since the incorrect selection of the type of conversion will lead to picture quality issues often called side-effects, and a lack of accurate round-tripping in the reconstruction of the SDR signal for distribution.

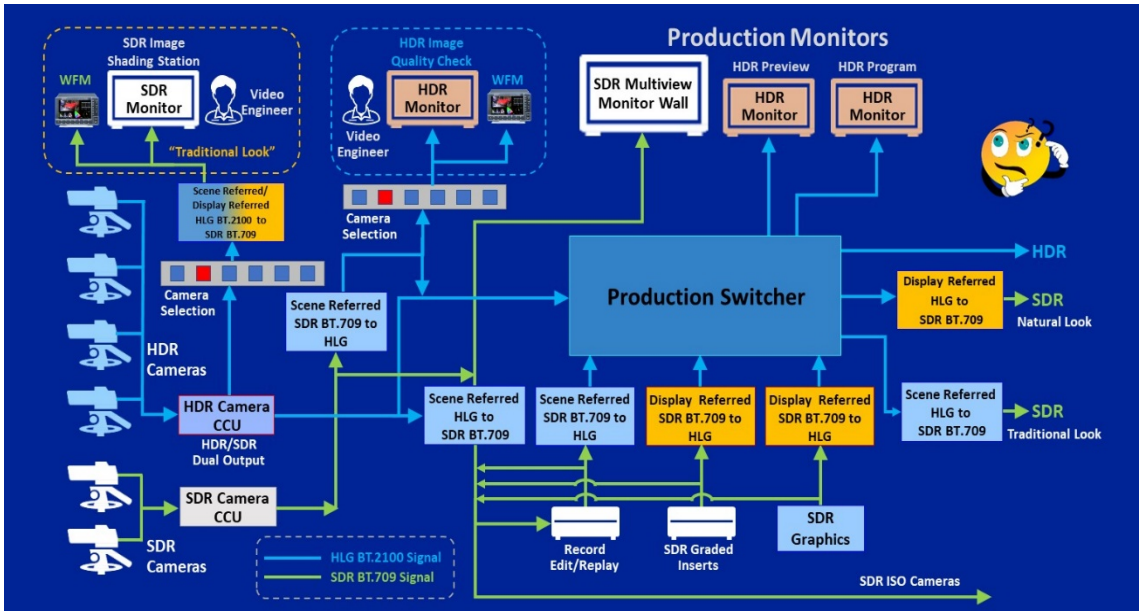

Figure 14: Mixed production of Scene Referred and Display Referred conversions

This can be illustrated by examining the side effects in the two example scenarios described below:

- In the first example, up-converted signals from the SDR cameras created by “Scene Referred” conversion are used in the HDR production layer. The output of the HLG HDR production master is then down-converted back to SDR for distribution, using a Display Referred conversion technique.
- In the second example, graded SDR material (e.g. graphic elements) is inserted into the HDR production layer by upconverting via a Display Referred process. An SDR signal is then created using a Scene Referred down-conversion, for contribution to other broadcasters who wish to match this SDR feed to the look of their production cameras.

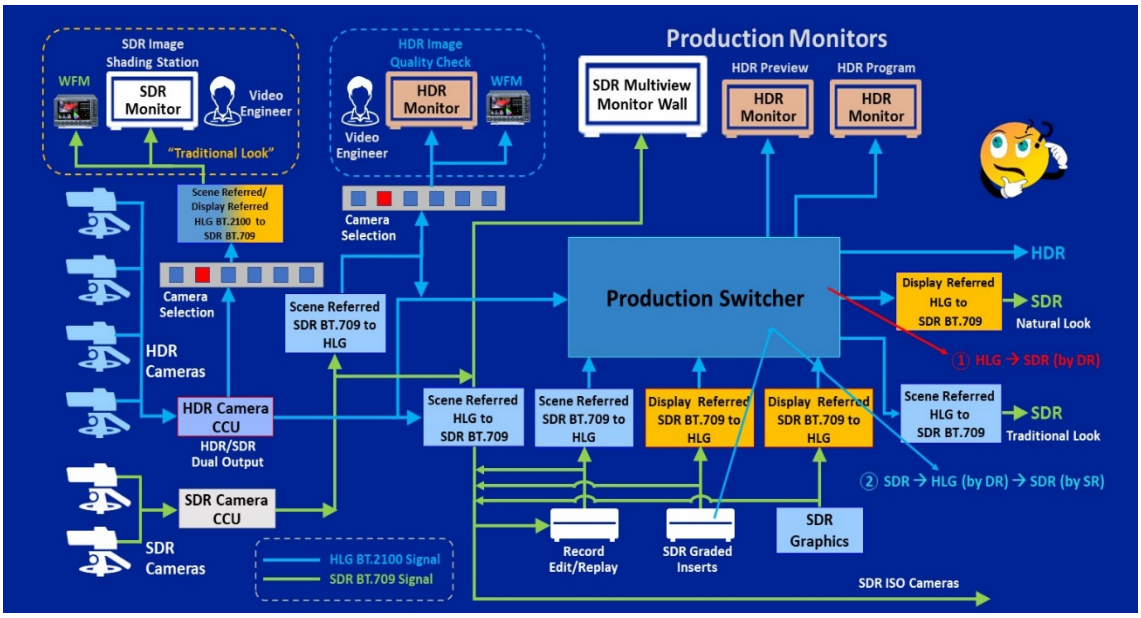

Figure 15: Examination of side effects by two scenarios

The picture side-effects are quite noticeable in both cases.

- For the first scenario, skin and color tones exhibit a “natural look” as the Display Referred process imparts the look of the HLG production master unto the SDR signal. For the second example, an oversaturation of skin and color tones can be observed on the SDR signal as the result of concatenating the Display Referred and Scene Referred conversion processes.

- In both cases, the mixing of two different conversion techniques in one single production prevents the proper reconstruction of an SDR signal which ideally should completely match the look of signals initially created by the camera operators during the SDR shading process.

Figure 16 depicts simulated images to compare the original SDR picture vs SDR images created by the round-trip process utilizing the conversion techniques of each scenario.

Figure 16: Simulated image samples of side effects over round-trip conversions

Considerations for Traditional and Natural Look production

Practical experience indicates that incorrect mixing of different conversion techniques in a single production pipeline can create objectionable picture side-effects.

In addition, another key factor is the preservation of the original look of the input sources. It is our belief that the adoption of end-to-end Scene Referred conversions along with the use of AIR Matching, with the selection of “Live” or “Mild” HDR Looks via the HDRC-4000, produce the highest quality and most accurate rendition of both the HDR and SDR programs.
As described earlier in this document, the AIR Matching works as follows:

- Performs up-conversion from SDR to HDR, by targeting the specified output HDR look, in this case the selection of either Live or Mild looks.
- Performs down-conversion from HDR to SDR by referring to the look of the incoming HDR signal, which is again either Live or Mild.

The Looks of all SDR signals, SDR cameras, SDR graphics, commercials, legacy material (graded, archival), ITU-R BT.709 broadcasting feeds or server-based content (Super Slow-Motion effects) basically exhibit a traditional look. The use of SR Live - with its traditional look signal processing approach - guarantees that colors and tones are preserved and rendered correctly even through multiple conversion stages before final delivery.

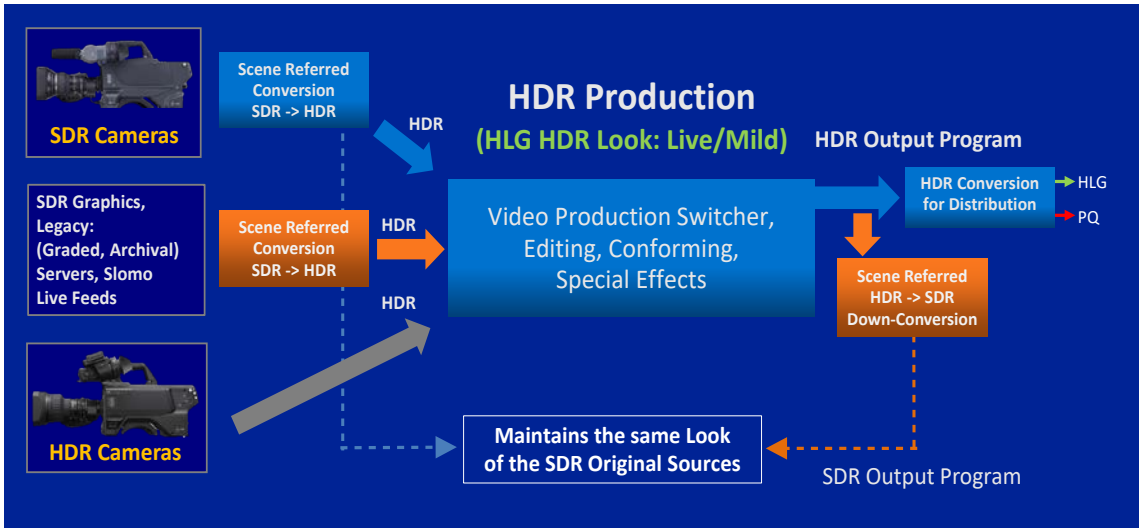

Figure 17: Benefits of using AIR Matching, with the selection of “Live” or “Mild” HDR Looks

Reference SDR (BT. 709)

① HLG (HDR Look: Live/Mild) -> SDR (by SR)

SDR Look

② SDR -> HLG (HDR Look: Live/Mild) -> SDR (by SR)

SDR Look

Figure 18: Simulated image samples of both down and round-trip conversions by AIR Matching, with the selection of “Live” or “Mild” HDR Looks

SR Live for HDR: Further practicalities

It is technically understandable and verifiable through practical results, that the final SDR signal is accurately reconstructed, when an end-to-end production chain based on an SR Live system from Sony is used. As previously mentioned, accurate reconstruction without compromise is important to satisfy the viewers around the world who are watching the program in SDR. There are, however, additional practicalities to be considered.

One example is how an accurate conversion to SDR can be achieved from an unprofiled HDR feed, such as an incoming broadcast contribution or a feed from a third-party vendor camera. As there is no reference look available in the incoming HDR signal, it may, on first consideration, appear better to employ a display-referred conversion process to create the SDR distribution signal, based on the 'look' and the artistic intent crafted into the HDR feed.

Similarly, for legacy SDR signals, such as SDR graphics, broadcast contribution feeds or archive material, a display-referred process could appear to be preferable, to up-convert from SDR to HDR and preserve the original look of the source material.

Sony believes that the AIR Matching process - with its 'Live' or 'Mild' options for the HDR Look is best suited for the creation of the highest quality HDR and SDR signals in these cases.

As stated, AIR Matching up-converts from SDR to HDR by targeting the specified output HDR look, in this case either 'Live' or 'Mild'. Both 'looks' employ the same traditional look processing used in conventional SDR signals. This ensures that the up-converted image exhibits a very pleasing HDR appearance while retaining the original colorfulness of the SDR look.

In the same manner, the down-converted SDR signal has a similar look to the original HDR, even when the original HDR is unprofiled.

As for the look of HDR picture, "HDR Black Compression" used with AIR matching is a pretty effective function. It can achieve closer matching to the conventional SDR look, especially about the dark areas of the picture.

In all of these cases, the use of SR Live with its Scene Referred conversion and AIR Matching capability provides superior results when compared to Display Referred conversion. Simple DR conversions often result in up-converted HDR images that appear as though the brightness of the SDR signal is the only attribute that has been increased. Down converted SDR signals with elevated black levels can also result.

SR Live Alliance partner program

Sony has created an alliance partner program to provide technical information and expertise to major industry players who wish to incorporate components of SR Live into their products, solutions and services. The program continues to expand, and the current list can be seen below.
For any inquiries about the SR Live Alliance program, please contact your closest Sony office or authorized dealers.

SR Live for HDR

ASTRO

AVID

Blackmagicdesign

calibrated software

CHYRONHEGO

DAYANG

deltatre

FilmLight

FOR-A

grass valley

Lambda Systems

Leader

matrox

nablet

NIXUS

PHABRIX

sobey

telestream

TVLogic

VIDEOTRON

vizrt

VRI Visual Research Inc.

The names of the SR Live Alliance Partners are listed in alphabetical order.
As of June 2020.

Customer stories

The SR Live workflow described in this paper has evolved over several years. Learnings have been incorporated through a series of technical trials, national and international broadcasts of high-profile events and via the HDR services that are on-air today. Many have been reported in the public domain, via press releases and presentations at industry conferences. The activities were the result of advances in technology throughout the content supply chain, alongside a close collaboration between the broadcasters, outside broadcast service providers, telecommunications providers and equipment vendors involved.

Below are just some examples, which we received permissions from those customers to list here. Since customer stories and/or studies keeps growing, please refer to Sony's global HDR website for the latest examples.

China

- **CCTV**
  - 回顾 CCTV 十一庆典 4K 全流程直播，索尼设备大放异彩
    (Review the 4K HDR live broadcast of CCTV's 70th National Day celebration, Sony equipment was brilliant.)
- **Jiangsu Satellite TV**
  - 江苏卫视跨年演唱会首次采用 HLG，向 4K 系统制作标准靠拢
    (Jiangsu TV adopts HLG for the first time in its cross year concert, moving closer to 4K system production standard)
- **Guizhou TV**
  - 贵州台 4K 全媒体转播车协同《贵州恋歌》一起唱响新时代
    (Guizhou station 4K all media broadcast car sings a new era together with Guizhou love song)
- **Omnibus Stories**
  - 金秋十月，索尼 4K/8K 转播系统精彩纷呈！
    (Golden October, Sony 4K / 8K broadcasting system is splendid!)

Japan

Broadcast Stations:

- **Nippon Television Network Corporation (NTV)**
  - **「4K HDR 対応の局内最大スタジオ。“必ず叶えてくれる”ソニーの SI を実感」**
    Newly built the largest studio in the station for 4K HDR. Realized Sony’s system design and integration ability, “They never fail. Make our demands all come true.”
- **FUKUOKA BROADCASTING SYSTEM CORP**
  - **九州初の 4K HDR 中継車。システム規模を大幅拡大も、空間の上手な活用で従来並の駐車サイズを実現**
    (Introduced the 1st 4K HDR ready OB-Truck in Kyushu area. The key objective was larger system on a conventional vehicle size.)
- **Yomiuri Telecasting Corporation**
  - **4K HDR 対応中継車報道・制作を 1 台で実現。車両サイズの制約の中で機能と規模は拡大**
    (Realized a multi-purpose 4K HDR ready OB-Truck that can be used for both news and event productions, such as sports.)
- **SKY Perfect JSAT Corporation**
  - **「4K 放送向けスタジオサブを更新、HDRC-4000 を中心に HDR 対応を実現」**
    (Renewal the studio sub-control room for 4K and HDR broadcasting, by adopting the HDRC-4000's as core device.)

Production Companies:

- **Cross TV Vision Co., Ltd**
  - **HLG_Live にも対応。HDC-4800 を 2 式搭載。スローの充実が強みの 4K HDR 大型中継車に XVS-9000 を搭載**
    (Introduced 4K HDR (HLG_Live) and Super Slomo ready OB-Truck that suites the most for every sports event live productions.)
- **Kyodo Television LTD.**
  - **「4K HDR に対応し、両拡幅・全拡幅も採用。広大な空間を確保した大型中継車を導入」**
    (Introduced a large-scale 4K HDR ready OB-Truck, supporting double-side and full-length (working area) expansions to secure a vast production space.)
- **LEMON STUDIO CORPORATION**
  - **「誰にでもすぐ使える 4K HDR スタジオを 12G-SDI と HLG_Live で実現」**
    (Realized very simple-to-use 4K HDR studio for everyone with 12G-SDI and HLG_Live.)

Summary

Sony continues to work with major media organizations and industry bodies to develop technology, operational workflows and practical guidelines to further the adoption of HDR for live production applications. Through ongoing dialogue with creative and technical teams, Sony has developed new capabilities and enhancements for the SR Live HDR system:

- MSU Simul-setting feature
- SR Live Metadata
- HDR Processing Engine
- Introduction of HDR Look

Sony believes that these new developments will bring additional benefits to each stage of the production pipeline and make it even more practical to simultaneously produce high-quality SDR and HDR programs.

We have addressed the requirement to incorporate unprofiled HDR feeds or HDR inputs from third-party camera systems and for the processing of legacy material.

In practice, the SR Live system has proven to offer outstanding up-conversion of SDR sources to impactful and pleasing HDR pictures. It also delivers an accurate recreation of SDR signals, with their original looks, from the main HDR production master. Highest quality conversions are assured, not just during one-way conversion, from SDR to HDR or vice versa, but also in the execution of round-trip conversions which are critical where legacy SDR content is required within the production.

The growth in the number of partners within the SR Live alliance program and the continued rise in successful deployments by customers are key indicators that validate the technologies and workflows employed by the SR Live process.

Sony has developed SR Live for the most discerning production and broadcast organizations where high-quality production of HDR and SDR programs must be achieved simultaneously through an efficient workflow under stringent cost control.

A key component of the system is the HDRC-4000 HDR converter. Through careful design and configuration of the production infrastructure, its high-quality conversion algorithms ensure that conversions are performed with high precision at each stage of the production chain. Easy recall of stored operational settings help increasing the efficiency of set up and operation.

Sony is committed to a continuing dialogue with valued customers and alliance partners, to ensure that the SR Live HDR system continues to evolve to meet the requirements of the most demanding professionals.

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Glossaries

- OETF, EOTF and OOTF
- HDR Formats
- Operational Guidelines
- Scene Referred and Display Referred process
- Look - Natural Look and Traditional Look
- AIR Matching

OETF, EOTF and OOTF

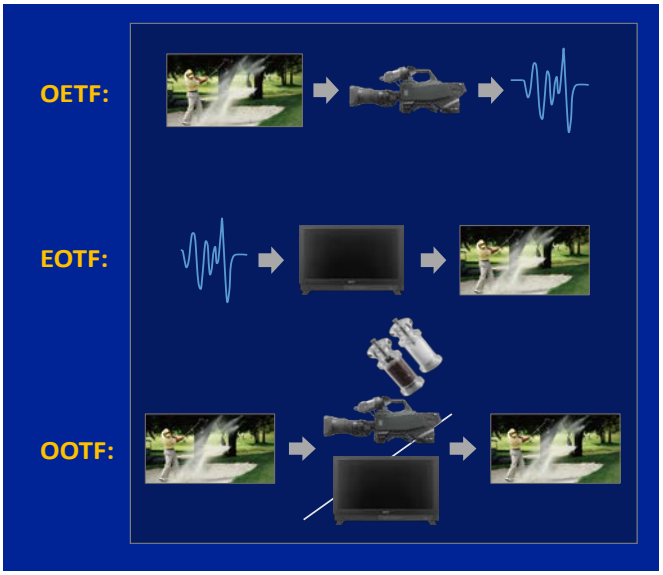

Figure 19

OETF: Opto-Electrical Transfer Function

This is the "gamma" transfer function that converts from linear light to an electrical signal. This "gamma curve", in the SDR world, has been a 0.45 exponent applied to the individual R, G and B color components of the input signal. The shadows and mid-range are elevated while the highlights are compressed.

EOTF: Electro-Optical Transfer Function

This is the gamma function that is implemented in the display device during the process of converting the electrical signal to display light. Initially, the EOTF curve was designed to reverse the initial OETF non-linearity in order to restore the display signal to linear light.

OOTF: Opto-Optical Transfer Function

This is a transfer function that describes the end-to-end relationship - from the light of the scene being captured to the light presented by the output display. The OOTF not only includes the "image appearance" or "look" resulting from the lack of linear light representation by the EOTF, but also may include artistic or rendering intent effects introduced during the creation of the program.

HDR Formats

The standardized HDR formats documented in Recommendation ITU-R-BT.2100 are the PQ format (Perceptual Quantization, standardized by SMPTE as the standard ST 2084) and the HLG (Hybrid Log-Gamma) format. PQ and HLG are implemented at different places in the television processing chain (Figure 20) along with their corresponding OOTF (or look). More specifically, the HLG format standardizes its OETF while it embeds its OOTF inside its EOTF conversion process, which is implemented in the output display.

In the case of the SMPTE ST 2084 format, it is the EOTF which is fully standardized and the OOTF is part of the OETF input process. These functions are depicted in Figure 20.

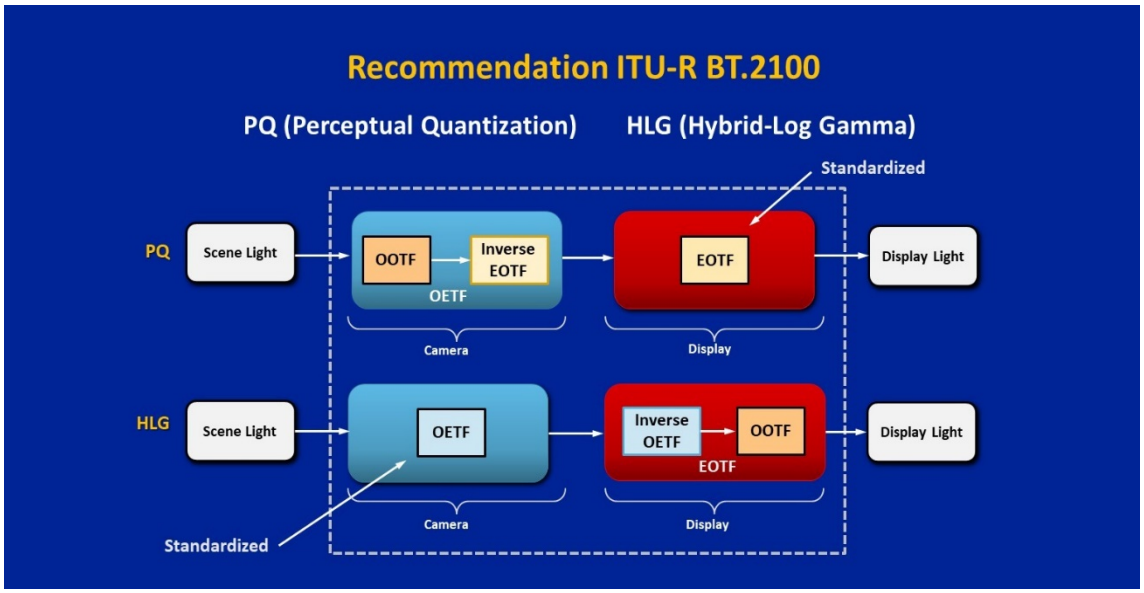

Figure 20: Processing diagrams of HLG and PQ

Operational Guidelines

Number	Title	Release history
Recommendation ITU-R BT.2100	Image parameter values for high dynamic range television for use in production and international programme exchange	● Originally published in July 2016 ● The latest release is BT.2100-2, published in July 2018
Report ITU-R BT.2390	High dynamic range television for production and international programme exchange	● Originally published in February 2016 ● The latest release is BT.2390-8, published in February 2020
Report ITU-R BT.2408	Guidance for operational practices in HDR television production	● Originally published in October 2017 ● The latest release is BT.2408-3, published in July 2019

Scene Referred and Display Referred process

These are terms that were originally associated with the definition of the HDR formats standardized in ITU-R-BT.2100. More specifically, the PQ signal is said to be a “Display Referred” format in that it describes, through its EOTF, the exact, absolute, luminance values exhibited by the display device during the mastering of the program.

The HLG signal, with its closer resemblance to the original gamma used in SDR television, defines with its OETF a signal that aims to represent the relative luminance values captured from the scene by the acquisition device. Hence, the HLG signal is said to be a “Scene Referred” format where the electrical signal represents the relative brightness present in the natural scene (Figure 21).

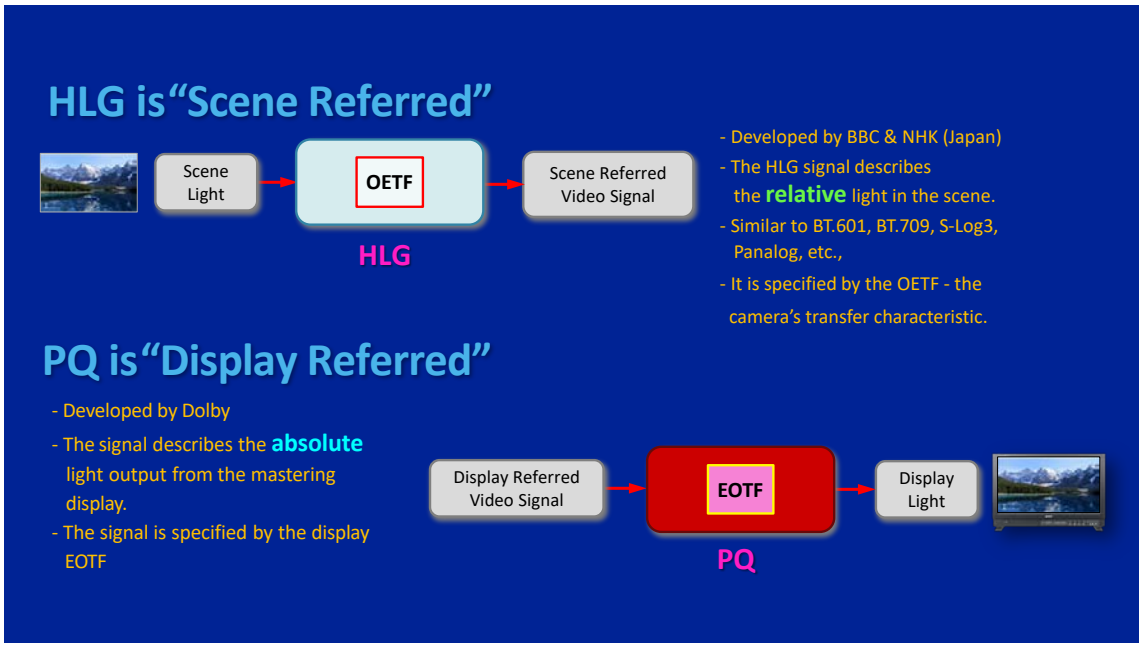

Figure 21: Comparison between HLG and PQ

These terms are also used in a different context: they can also apply to the type of conversion technique used for the creation of video material in SDR to/from HDR.

Scene Referred Conversion Process

For example, a Scene Referred or SR technique is usually applied when converting the output signal from an SDR camera to match the color appearance of a native HDR camera output. SR conversion uses an internal “linear light” processing stage to which the desired output OETF is applied.

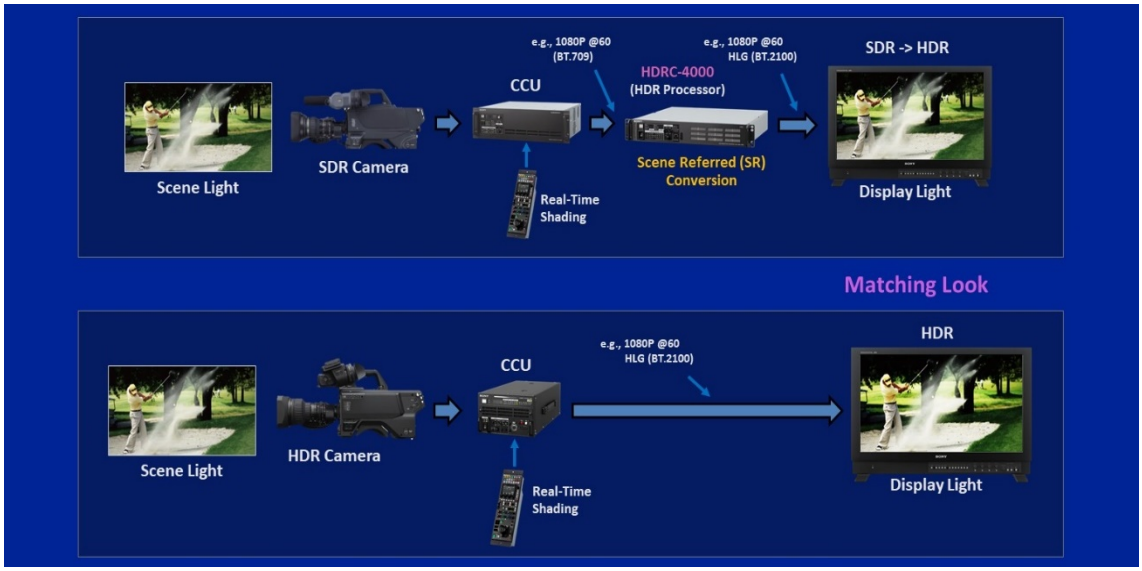

Figure 22: Scene Referred Conversion

Display Referred Conversion Process

Display Referred or DR conversion is the technique that permits pictures displayed in their native display format to have a similar image appearance when displayed on devices of a different format.

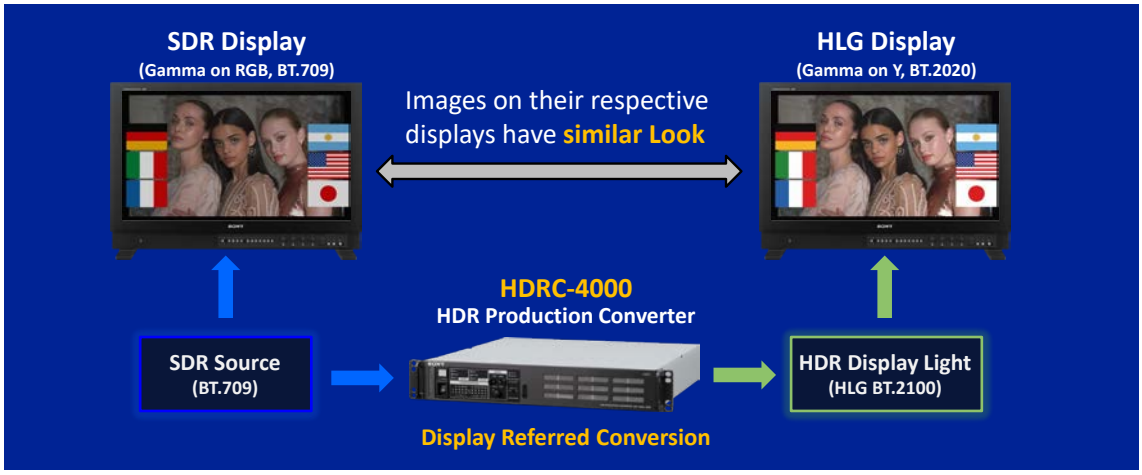

Figure 23: Image of Display Referred Conversion by HDRC-4000

The HDRC-4000 is also capable of supporting the DR conversion technique.

Look - Natural Look and Traditional Look

Let's define what is a "look", first.

"Look" is a term that describes the appearance of an image. In the television industry it is mostly considered as a combination of the color saturation and image tone of the picture.

It is technically defined by the combination of the video signal's OETF and the display EOTF, including as well, any creative intent imparted to the video signal by colorists/technical operators.

Originally, it was introduced by the OOTF of the CRT (Cathode Ray Tube), which was a combination of the video signal's OETF and the CRT's EOTF. After the discontinuation of the CRT device, flat panel displays adopted the EOTF defined in BT. 1886 (2011). This EOTF, in combination with the OETF of the traditional video signal, gave rise to today's non-linear OOTF.

Natural and Traditional Look

These are terms recently introduced in standardization activities related to HDR operational practices and that describe the picture appearance of a television signal process.

Natural Look is the most recent term and was used informally to describe the look of the HLG HDR format during the creation of the ITU-R- BT.2100 standard.

The HLG HDR format applies the gamma non-linearity to the luminance signal only and not to the individual RGB components. This process creates a more subtle color presentation, resulting in a match of the color characteristics of the native scene as imaged by the camera. For this reason, images created using HLG (BT.2100) are said to exhibit a "Natural Look".

With the Traditional Look the gamma curve is applied to the R, G and B, components individually which results in more saturated color pictures.

Since this process has been in use as the picture look of legacy, conventional and other television production formats, including PQ, it has been called "Traditional Look".

AIR Matching

“AIR” stands for Artistic Intent Rendering. See Figure 24.

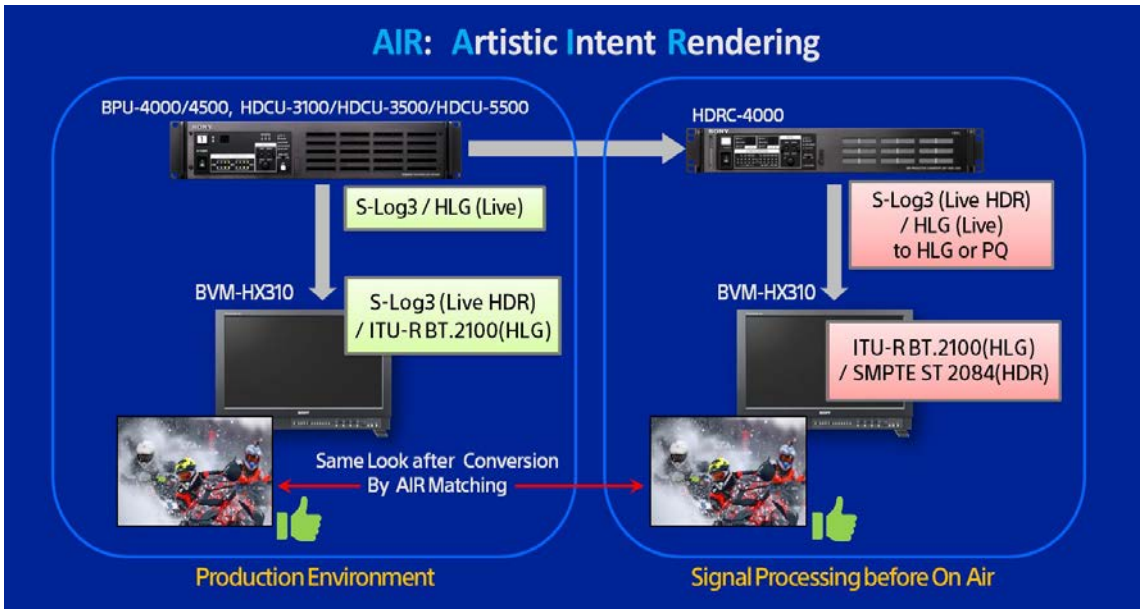

Figure 24: AIR Matching

It is a strong and useful feature to enable virtually any to any signal format conversion. The “AIR” process fundamentally uses a scene referred conversion technique along with the characteristics that each conversion case requires. They are as follows:

- HDR to HDR conversion: Converts the input HDR signal format to another one with preservation of the look of the input image.
- HDR to SDR conversion: Converts input HDR signal to SDR (traditional look)
- SDR to HDR conversion: Converts input SDR signal to HDR by targeting the specified HDR look

Making the best use of the above characteristics, the identical SDR image as compared to the SDR output from camera can be obtained when the same settings are applied to the HDRC-4000 HDR converter.