THE BROADCAST BRIDGE

# Practical High Dynamic Range (HDR) Broadcast Workflows

# Essential Guide

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ESSENTIAL GUIDES

# Introduction

HDR is taking the broadcasting world by storm. The combination of a greater dynamic range and wider color gamut is delivering images that truly bring the immersive experience to home viewers. Vibrant colors and detailed specular highlights build a kind of realism into broadcast productions that our predecessors could only ever have dreamed of.

To completely understand how we can leverage the benefits of HDR we must look deep into the HVS (Human Visual System) to gain insight in to exactly what we're trying to achieve. At first this may seem obvious as we want to improve the immersive experience, but television, like all things engineering, is a compromise. Consequently, understanding the trade-offs between what we can achieve and what is required is critical to delivering the immersive experience.

The HVS is a complex interaction of the physical sensors in the eye, the visual cortex, and the psychology of how we perceive moving images. The HVS responds differently to still and moving pictures, and to static and dynamic range.

Then there is the color to consider. Although a greater dynamic range can be achieved in the luma domain, to deliver the optimal viewing experience, we've expanded the color gamut to greatly extend the greens as well as improving the reds and blues. If done correctly, the pictures will look outstanding.

However, making HDR work in production workflows, whether live or pre-recorded, requires us to reconsider our established and proven working practices. Although program makers will want to move as quickly as possible to delivering HDR productions, there are an unimaginable number of televisions already in people's homes that are not HDR compatible. This leads to maintaining backwards compatibility and the challenges associated with it.

Two dominant HDR systems are evolving; HLG (Hybrid Log Gamma) and PQ (Perceptual Quantizer). Both have their advantages, and both work well in broadcast workflows. However, each has its own idiosyncrasies and tends to lend itself to a particular method of working. Again, understanding the HVS helps us decide which system is better for our particular use-case.

"Scene referred" and "display referred" are terms and concepts that have existed in television and film since their inception, but it's only recently that as broadcasters, we have had to consider the differences between them and the consequence of the true impact on broadcast workflows. This has led to the concept of metadata and a whole new vocabulary has crept into the broadcast community to help optimize images for different types of television.

HDR has not only forced us to rethink our approach to workflows but also how we monitor signals. Peak white isn't as obvious as it was in the days of standard dynamic range and gamut detection is more important now than ever, especially as we've moved to a much wider color space.

Tony Orme.

This Essential Guide takes us on a journey of understanding to discover what exactly we are providing with HDR and why. The practical aspects of the HVS are considered along with the requirements of the broadcast HDR workflows.

The sponsors perspective, written by Telestream, investigates how HDR works for program makers, the signal levels we need to achieve, and the anomalies we must all look for and fix, to deliver the best immersive experience possible.

Tony Orme
Editor, The Broadcast Bridge

# Practical High Dynamic Range (HDR) Broadcast Workflows

By Tony Orme, Editor at The Broadcast Bridge

**HDR is gaining incredible momentum in broadcasting, but the revolution isn't just about higher dynamic range in the luma, it also embraces a much higher chroma space to deliver outstanding vibrant colors, more presence, and a deeper immersive viewing experience. Although the pictures may look outstanding, creating them requires a deeper understanding of the underlying technology and the systems to monitor.**

To create a more immersive viewing experience, broadcast innovators have been attempting to replicate nature as much as possible and bring the outside scene into our homes. This includes a greater increase in the difference between the highlights, and the details in the shadows with smoother blacks that produce the dynamic range in the image. Although we are far from truly replicating nature, increasing both the luminance range of HDR and the associated color gamut of DCI-P3 and BT.2020, delivers the optimal viewing experience.

## NITs and Candela's

Traditional standard dynamic range (SDR) uses fixed signal voltage levels to define peak white and black, but as we move to HDR we tend to think more in terms of light levels. The term NIT is a non-SI unit but has been adopted by some in the television and broadcast community to refer to the SI measurement of luminance. One NIT equals one candela per meter squared (1 NIT = 1 cd/m$^2$).

Cathode Ray Tube (CRT) television typically had a brightness of 100 NITs (100 cd/m$^2$), OLED has a maximum of 600 – 700 cd/m$^2$ with modern LCD and QLED screens easily reaching 1,000 cd/m$^2$ to 1,500 cd/m$^2$, and the new Sony 8K monitors have been reported to reach 10,000 cd/m$^2$ (although this is not yet commercially available). However, great care must be taken in interpreting these specifications. Sometimes, vendors do not always specify whether the maximum brightness value refers to the whole screen or just parts of it.

This is particularly interesting when we look at what HDR is supposed to do as opposed to what we can make it do. Technically, it would be possible to display alternate black and white stripes of 0 cd/m$^2$ and 1,000 cd/m$^2$ on a monitor. However, the intense brightness of the 1,000 cd/m$^2$ bar and the contrast it provides compared to the 0 cd/m$^2$ bar would likely cause discomfort for the viewer.

Instead, it is the specular and transient highlights that display the 1,000 cd/m$^2$ (and beyond) levels. It is perfectly possible to provide a display that can light large parts of the panel with high level display, but this may create discomfort for the viewer and require potentially huge power supplies making significant demands on a home-owners electricity supply.

## Human Vision System (HVS) Requirements

The concept of dynamic range has two components; the ability of a system to replicate a wide difference between the highlights and the lowlights, and the effects on the human visual system. A home SDR television set can display approximately 6 f-stops and professional SDR about 10 f-stops. Each increase in f-stop is a doubling of brightness. In this instance a display with 6 f-stops gives a range of 64:1 and a display with 10 f-stops gives a range of 1024:1.

Research has demonstrated the human visual system can adapt to a range of 10-6 to 102 cd/m$^2$ for the scotopic light levels, where the rods dominate, and 10-2 to 105 cd/m$^2$ for the photopic light levels, where the cones dominate. The mesopic area covers the overlap between the scotopic and photopic light levels from 10-2 to 10 cd/m$^2$. This gives a complete range of 10-6 to 105 cd/m$^2$ or 10,000,000,000:1, approximately 33 f-stops.

However, the HVS is only able to operate over a fraction of this range due to the various mechanical, photomechanical and neuronal adaptive processes that move the range to facilitate the appropriate light sensitivity, thus allowing the HVS to be maximized under any light conditions. This reduced range is referred to as the steady-state dynamic range.

One reason for this reduction in dynamic range is that even with 33 stops of range, the brightest objects have a much higher luminance than the top of our range. For example, the sun has a luminance level of approximately 109 cd/m$^2$. An example of how our HVS automatically adapts is seen when we look out of a bright window and then into a dark room. Our HVS is quickly and automatically adjusting between the two scenes to give the perception of a much higher dynamic range.

Our static dynamic range may only be 11 stops, but this automatic adjustment effect gives the perception of the range of 14 stops, or even 20 stops in the right lighting conditions.

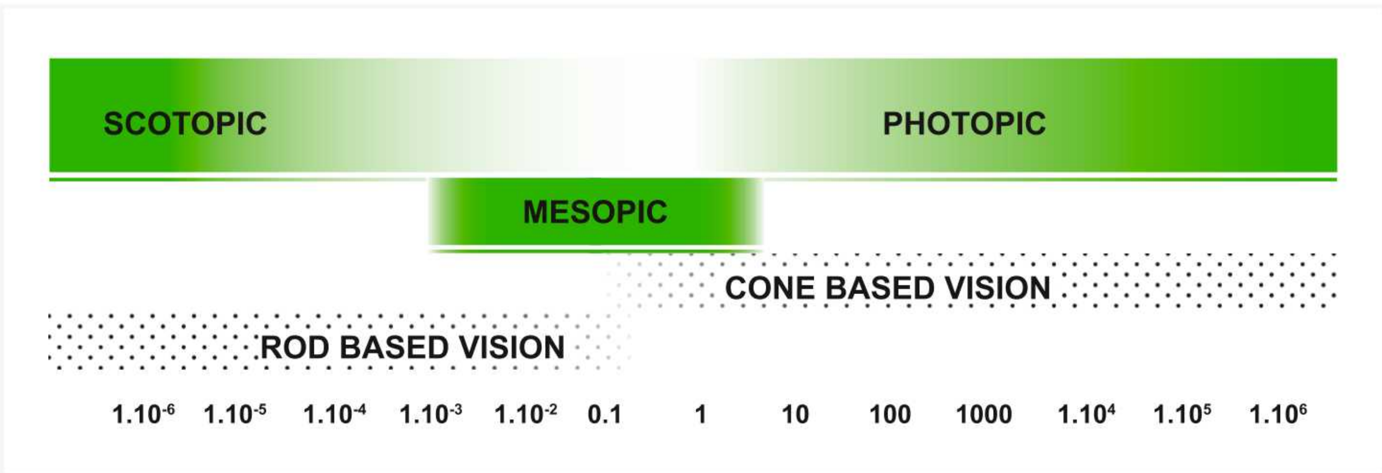



Figure 1 – Human luminance detection is formed by the scotopic (rods), mesopic, and photopic (cones) receptors of the eye. The mesopic region uses combined rod and cone response to give a cross over between them.

There is a school of thought that suggests increasing the brightness through the contrast control on a television will give a higher dynamic range. However, this doesn't necessarily increase the contrast ratio. Quantization noise is the enemy of dynamic range and increasing brightness in a system with a low bit depth makes quantizing banding obvious. When banding occurs, the brightness must be turned down to remove it or, the bit depth should be increased.

## Immersive Enhancing with Wide Color Gamut (WCG)

HDR also embraces wider color gamuts. Rec.709 is based on the sensor and monitor capabilities of the 1960's when color television was first mooted and was later developed for HD Colorimetry around 1993. Technology has now advanced and much wider color gamuts are available, leading to the Rec.2020 color space. The greens are particularly extended, resulting in an enhanced viewing experience. This is particularly useful for sports events played on grass.

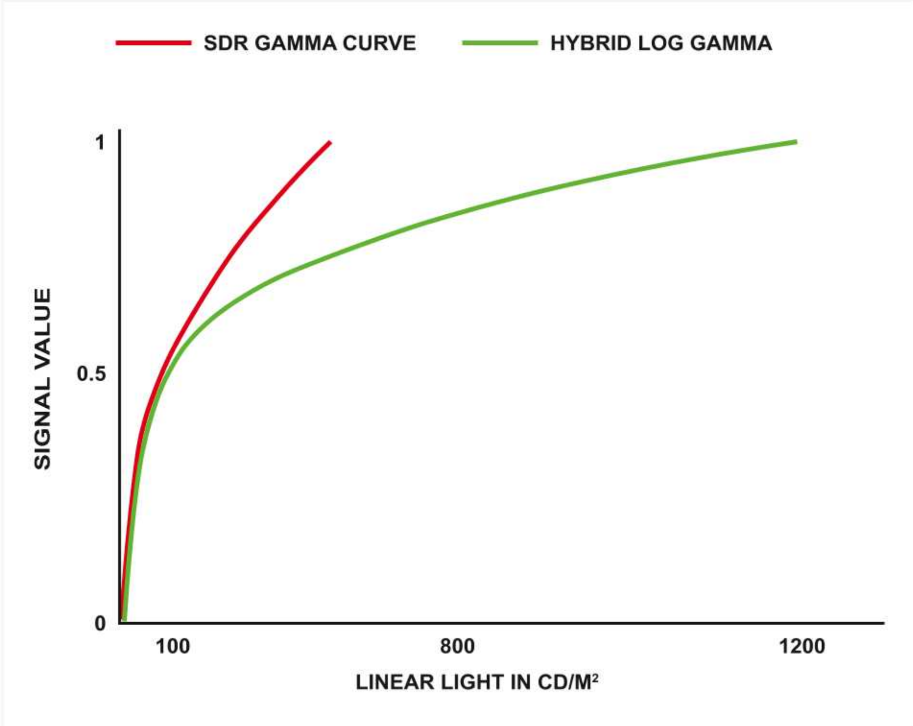



Figure 2 – SDR and HDR HLG are similar up to about 0.6 of the input luminance level, after which, the HLG curve continues to sympathetically compress the highlights. This helps maintain backwards compatibility with SDR.

Making HDR work in real-live broadcast workflows always requires compromises and to provide greater choice, there are essentially two versions of HDR, both defined in BT.2100; Hybrid Log Gamma (HLG) and Perceptual Quantization (PQ). Both have their merits and provide optimized solutions for two different workflows.

HLG was designed to provide the fastest possible migration from SDR to HDR for broadcasters and it satisfies two fundamental requirements for them; it is scene referred and it is backwards compatible with SDR.

## Non-linear HVS Characteristics

The De Vries-Rose law demonstrates that the threshold of visibility of banding becomes higher as the picture gets darker. In other words, in the low lights, it becomes increasingly difficult to see banding. Weber's law tells us that the threshold for perceiving quantization in the highlights is approximately linear.

The original CRT's were relatively dim with an output of 100 cd/m$^2$ and the gamma curves chosen for them closely match the De Vries-Rose law. Although banding didn't exist in the early days of broadcasting as the signal processing was in the analogue domain, noise certainly did, and it is the noise that gamma correction helps minimize.

This gives us two distinct curves, gamma for low lights and shadows, and logarithmic for highlights. The term "hybrid" in HLG is the joining of these two functions to provide the best of all worlds for both SDR and the extended highlights of HDR.

Scene referred is the working practice broadcasters have been using since the inception of television. It makes the fundamental assumption that we have no control over the viewers television and have to provide an image that can be displayed on many different types of screen, but all fairly similar.

Images are shaded (racked) for a reference monitor in the studio and it is assumed this will give the best image for home viewers. SDR monitor luminance outputs have increased over the years and levels of 100 cd/m$^2$ to 200 cd/m$^2$ are readily available. Although the average picture levels will have changed and there will be some differences in relative areas of grey, higher output televisions still provide a picture similar to that of the studio reference monitor.

HLG HDR has a relatively linear curve in the 100 – 200 cd/m$^2$ range and is similar to that of the SDR Rec.709 gamma specification, HLG then extends the Rec.709 curve to capture specular highlights. Consequently, it provides some backwards compatibility between HDR and SDR images. Again, this is a compromise and there are some differences, but in general, the system works well. This is particularly important for live events as all the production equipment is mostly backwards compatible with existing workflows.

## HLG Advantages for Live

This has even more advantages in the studio or outside broadcast truck as existing SDR monitors can be used to display the HLG images. There will still need to be an HDR reference monitor with appropriate waveform and vectorscope monitoring, but standard SDR monitors can be used by the rest of the crew.

PQ takes the view that the viewers display device has its own unique properties and display characteristics. The particular application for this type of system is high-end productions and movies as the whole system has its roots in cinema. Companies such as Dolby have developed PQ to maintain the artistic content of the creatives who made the production while at the same time maintaining compatibility with other types of viewing device.

For example, if a movie was edited on a 1,000 cd/m$^2$ reference monitor in the edit suite but was to be viewed on both a 500 cd/m$^2$ and a 2,000 cd/m$^2$ television at home, why not just apply the HLG techniques discussed earlier and maintain a good compromise between the two? The key is understanding the definition of “artistic intent” in this context. That is, if the DoP wants the face of the actor to be at 70 cd/m$^2$, then it should be 70 cd/m$^2$ on both screens.

## PQ Movie Quality

This beautifully illustrates the true power of HDR. Although both screens show the actors face at 70 cd/m$^2$, the 1,000 cd/m$^2$ television has significantly more “luminance headroom” than the 500 cd/m$^2$ television to display specular and point highlights, and this is the true power of HDR. It’s not about cranking up the metaphorical “luminance volume”, but it is about providing the best immersive experience. Furthermore, increasing the brightness on a 1,000 cd/m$^2$ is going to have a seriously detrimental effect on the viewer.

If, in the example above, the sequence was shot at night after it had been raining, there would be very narrow highly intense specular highlights as streetlamps reflect off the still rainwater. On the 500 cd/m$^2$ television these would reduce in clarity and become more of a blob than a specular highlight, but on the 1,000 cd/m$^2$ television, they would be shown in all their glory, further enhancing the immersive experience of the movie.

## PQ Metadata Improvements

The principle reason for metadata is to give the end display device the necessary information it needs to convert the PQ image to meet the level of brightness it can achieve. It can use an industry preset, but this is a significant compromise and negates the whole reason for having PQ in the first place.

Display devices use complex algorithms to convert from one brightness level to another and they work both globally across the entire screen, or locally on specific areas of the image. In a display referred device, as used in PQ, the act of converting from the master HDR range to the display HDR range is called tone mapping.

Tone mapping is an incredibly complex task and a great deal of academic research has been conducted into this as it isn’t unique to broadcasting and has many applications in industry and medical imaging. Transferring from one HDR range to another is not a simple task of applying a linear transform.

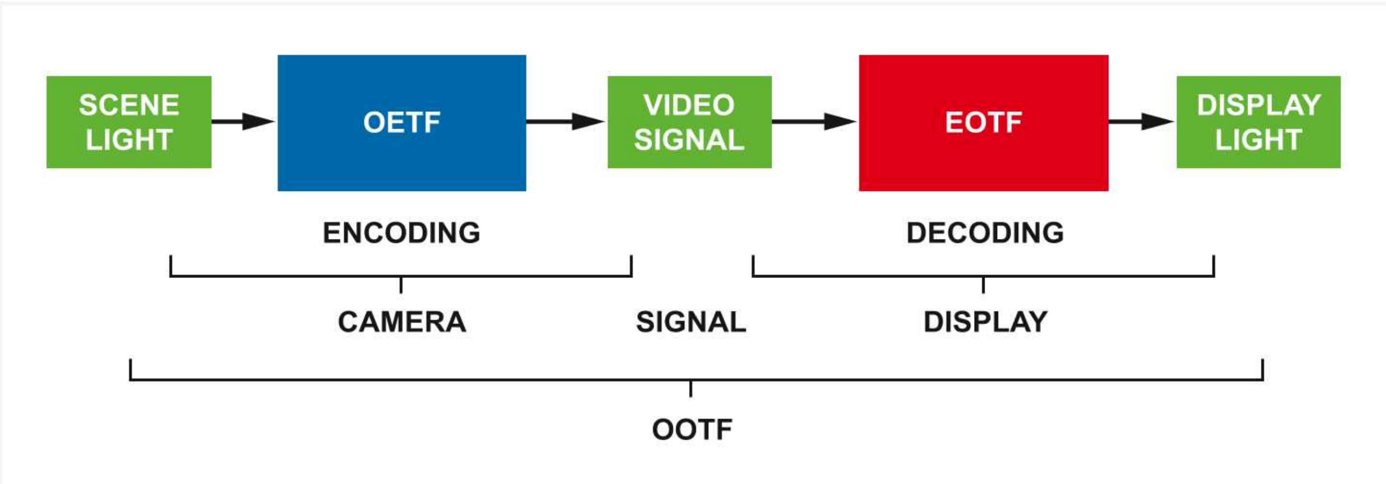



Figure 3 – The HDR workflow follows this model to help describe the interaction of the various stages. OETF is optical electrical transfer function (camera to video signal), EOTF is the electrical to optical transfer function (video signal to display) and the OOTF is the optical to optical transfer function, that is, the behavior of the whole system.

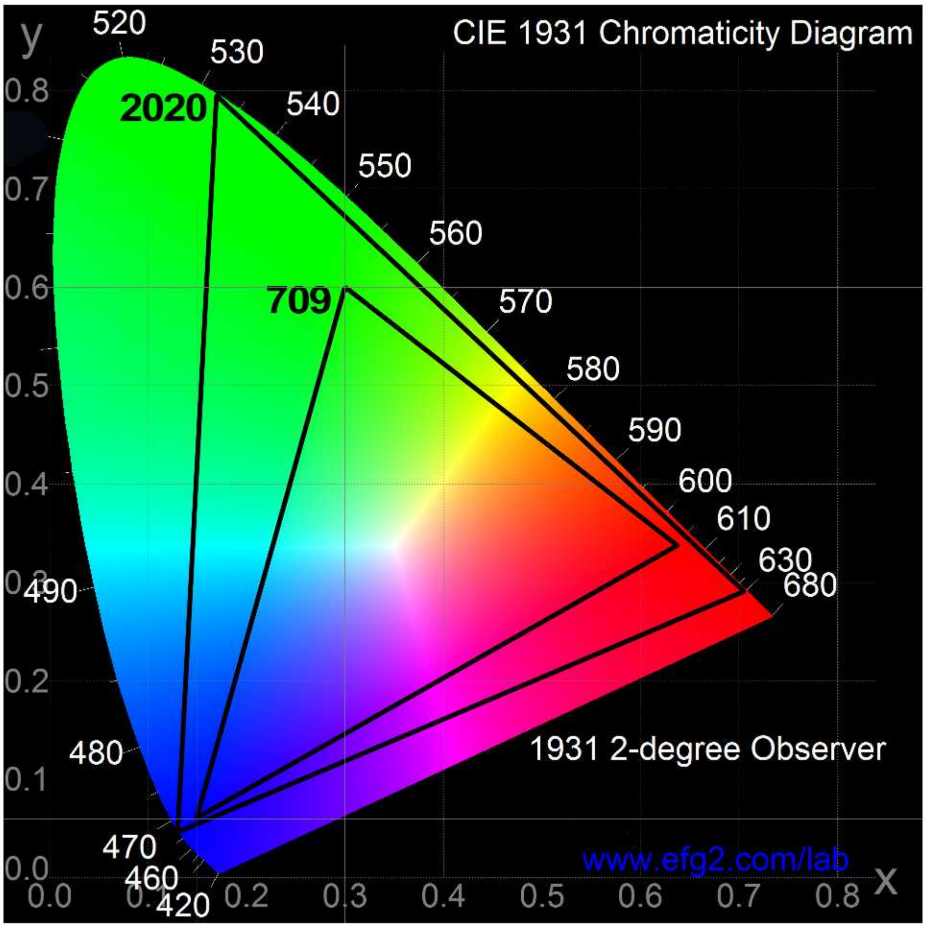



Figure 4 – Although color is traditionally represented using the CIE color gamut, this is a diagonal slice of the cuboid representation. The cube contains the luminance information and demonstrates how changing the luminance without reference to the chrominance can cause out of gamut errors. Image supplied by Telestream.

The specular highlights, for example, demonstrate localized conversion, the display would need to adjust the area within the locality of the highlight without affecting the rest of the image to provide the optimum image. On other occasions, the whole image will need to be adjusted.

Converting between video formats such as the raw camera output, or S-Log, takes place within the production as opposed to the display (as with PQ). Look Up Tables (LUTs) provide the method of converting between luminance dynamic ranges as well as color spaces and two fundamental types are in common use; 1D and 3D.

## Respect Color Gamut

1D LUTs provide a basic luminance and chrominance conversion but 3D LUTs improve on this to make sure the correct color space is respected.

Great care must be taken in any conversion process as the true color space, whether Rec.709 or Rec.2020, is a cube. The flat triangular CIE representation we often see is a diagonal slice across the color space cube. In effect, the luminance component has been removed. Converting between HDR and SDR isn't just about scaling the luminance, it also embraces the color transform. If this is not performed correctly, out of gamut errors can easily arise.

If a live production is simultaneously providing an HDR and SDR program, the color spaces of both Rec.709 and Rec.2020 must be monitored independently, but this is currently limited to DCI-P3 as Rec.2020 monitors are not yet available. It's not enough to look at just the HDR output. Several methods of monitoring are emerging to improve monitoring, especially when making simultaneous HDR and SDR programs with dual color spaces.

## Optimized Workflows

There is no suggestion that either HLG or PQ is better than the other, but they do have different use case applications where they appear to excel. That does not mean a broadcaster cannot use a PQ system for live sports, or they cannot use HLG for a block buster movie (the designers of HLG also argue they maintain the artistic intent), but each seems to have its own particular strengths and merits.

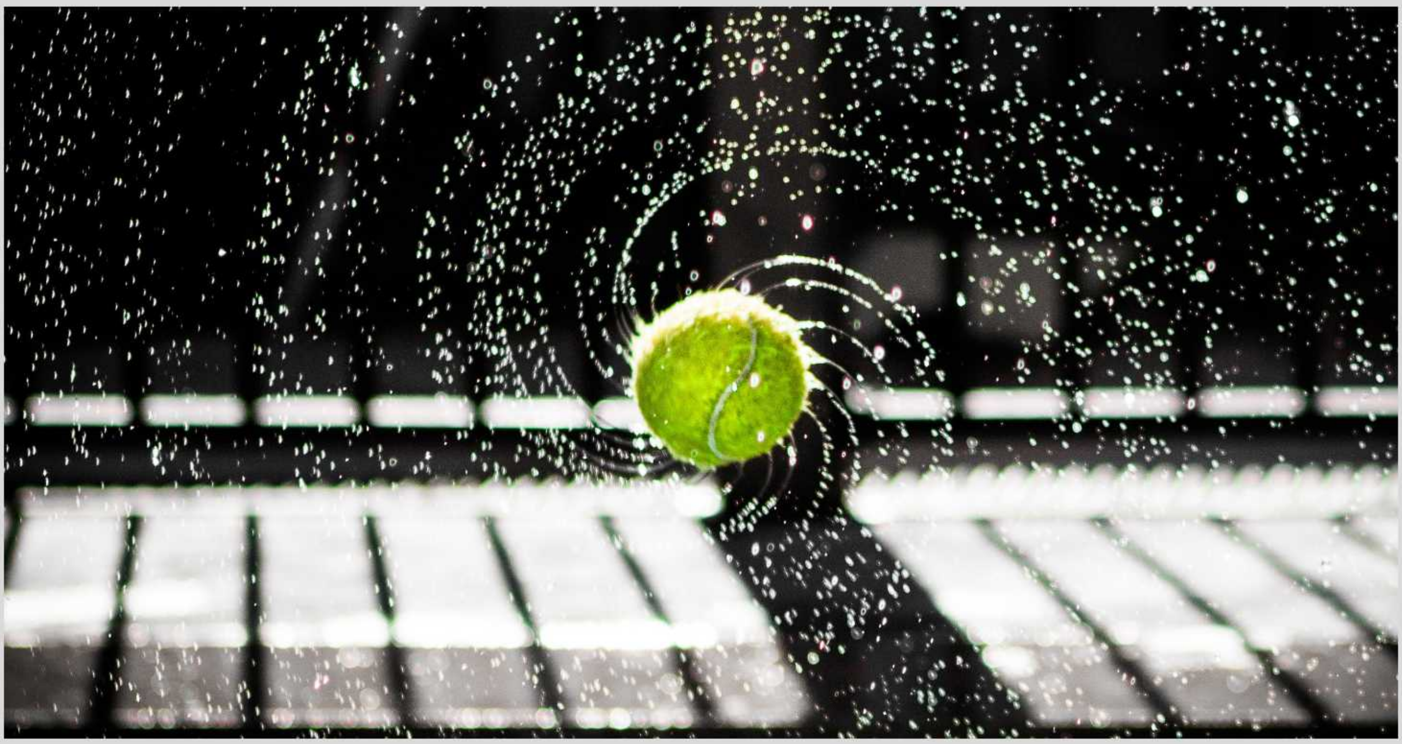
The immersive experience provided by the extended dynamic range and color space of HDR is taking broadcast television to a new level. However, as HDR is a relatively new technology and many viewers still require the SDR transmission, broadcasters are required to simultaneously provide both SDR and HDR feeds when making HDR programs, not only for live events, but also in post-production. The key to making high quality programs in both domains is to understand how HDR works in combination with the human visual system, and understand the optimal use of high quality monitoring in both workflows.

# The Sponsors Perspective

## High Dynamic Range And Wide Color Gamut Drives The Need For New Production Tools And Workflows

By Ian Valentine, VP of Product Management, Telestream

Within broadcast there has always been a quest for higher and higher resolution with improvements in wider color fidelity. The quest has always been to deliver what we see to the audience, often this is limited by technology or cost of production, but today there is the possibility to increase the resolution to 4K/UHD with High Dynamic Range (HDR) and Wide Color Gamut (WCG) that can convey that window on the world to the consumer.



However, these advances also pose a problem for content creators as they try to figure out how to produce content that looks great on the variety of displays that exist. It is becoming increasingly difficult to do this without a set of tools that provide some objective measurements rather than subjective observations on how the content will finally appear.

Artistic intent and composition aside, Exposure and Color Management are two key elements that content creators need to master and control to avoid costly mistakes resulting from acquired content that cannot be fixed in Post. How are these new technologies impacting the current workflows?

## Exposure Management

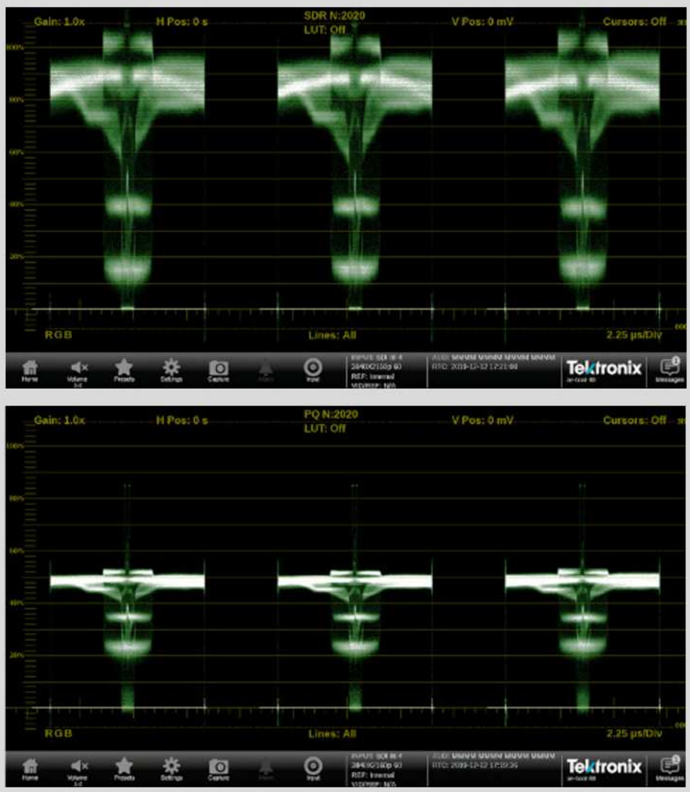
In its simplest form, exposure management in acquisition is about controlling the amount of light entering the camera and reaching the sensor. It is important to ensure that any captured image is neither overexposed, to avoid picture information being clipped in the highlights, nor underexposed causing the blacks or shadows to be crushed with the subsequent loss of information. Getting this wrong in acquisition will make it very difficult or impossible to fix the image in Post.

To handle exposure correctly Production staff cannot rely on looking at a monitor. A monitor provides no indication of exposure levels. Applying an HDR image to a standard monitor will produce an image that looks “washed out”. Even with a LUT applied to compensate for this, the image may improve but may not accurately reflect the final image desired or the exposure levels because of the response variations of LCD screens and external monitors. Objective measurements or tools based on measurements are required to ensure correct exposure.

There are two common tools used to assist cinematographers or camera operators in exposure management, the Waveform and False Color displays.

To objectively measure exposure (luminance levels) a waveform is used. The horizontal axis represents the frame and the vertical axis represents the brightness level associated with any chosen point in the frame. Traditionally the brightness level is represented by the IRE level that is better represented as a percentage scale where 100% is white and 0% is black. As the exposure level is adjusted the trace or display height will vary with the blacks being (ideally) anchored on the 0% line of the trace. With an SDR (ITU-R BT. Rec 709) gamma applied, as more light is allowed into the camera, the height of the display will increase until the brightest areas of the image hit the 100% point. Clipping will occur at levels above 100% to 109% depending on delivery specifications that define levels for maximum limits.

SDR Displays can be driven to the 100 to 200 Nit range in terms of maximum brightness. Initially 100 Nits (100 cd/$m^2$) was used as the reference white, but this has changed to around 203 Nits in HLG. However, modern displays are capable of handling 1000 Nits and above which allows content creators to take advantage of the greater dynamic range offered by the latest cameras. The cameras utilize Log gamma curves (e.g. S-Log 2, S-Log 3, C-Log, Log C) curves designed to help capture as much data as possible in the luminance spectrum i.e. shadows and highlights. The consequence of this is that when applied to the same scene, the SDR and Camera Log waveforms will look different as the equivalent SDR white point is repositioned at about 60% of the IRE scale on a Camera Log scale, allowing the camera levels to be shown above this (see Figure 1). This makes it difficult to compare the content and to assess if the content being captured is acceptable for both those environments.




[1] **Figure 1: Shows an SDR (top) and HDR (bottom) waveform of the same image (a SpyderCube). On the SDR waveform, highlights are clipped and the 90% reflectance white is shown at that level on the percentage IRE scale. On the HDR capture the white levels are adjusted to be at about 60% on the screen. This illustrates the problem of trying to compare SDR and HDR signals on the IRE scales.**

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[1] Image resolutions in this article are governed by the PRISM image capture function. These are real images from a real instrument making real measurements.

Additionally, for most people behind the camera the %IRE scale is meaningless as it essentially references mV level electrical signals from standards defined in the days of NTSC. Light levels and Stops are the common language of camera personnel. Converting the waveform to display in light levels now means that the reference levels, whether working in SDR, Camera Log or HDR, are consistent in vertical position and the waveforms are the same shape for easy comparison. PRISM can display these waveforms as a STOP Display where luminance levels are shown in NITs or STOPs. Unlike standard luminance waveforms, when using the STOP Display in acquisition, changes to the exposure settings will move the whole waveform trace up or down on the vertical (light level) scale and the operators can easily avoid highlight or shadow information being unexpectedly lost through clipping or crushing when trying to measure exposure levels. It also means the STOP display allows direct comparison between different cameras on different inputs of the instrument if the light levels remain unchanged. There are some key values to note when using this system; in acquisition 90% reflectance whites are normally set to be between 100 and 203 Nits, and 18% greys at around 26 to 32 Nits. These values will become important when using False Color to manage exposure.


Figure 2: Shows the same SDR and HDR signals as in figure 1, but in this case, they are displayed in a STOP display with levels being set by light or luminance levels. Comparison is easier because both images look very similar, the light levels can be compared. The key difference is that the specular highlights are shown on the HDR waveform, but are cropped (as expected) on the SDR waveform.

False Color images provide an easy to interpret and powerful interface for looking at exposure for both SDR and HDR content. These displays work in conjunction with the luminance levels shown in a waveform but the False colors show regions of similar luminance ranges. This allows the camera operator to easily identify regions of the images with similar luminance levels and to easily measure exposure levels at different points in the image.

In acquisition False Color makes it easier for operators to quickly and accurately set the exposure of selected image elements (e.g. skin tones, white lines or green grass on a football field) to the correct level by simply adjusting the exposure until the correct color appears on the image element. This approach removes the need to subjectively set the exposure by eye when looking at the image.

False Color screens are often shown as a rainbow of colors from one extreme to the other (representing different luma levels from darks to whites in a wide array of colors) which can be distracting. PRISM allows users to select their colors in user defined bands so that they can limit the number of colors on the image to only those that are most important to them – for example 100 to 203 Nits for whites and 26 to 32 Nits for 18% Grey (see Figure 3).


Figure 3: Using banded False Color is an easy way to help set exposure levels.

The use of HDR is not simply about producing brighter images. To create realistic images HDR should be used to emphasize pinpoints or small bright areas (specular highlights) in the image. PQ and HLG with maximum luminance level and screen gamma defined are the two most common screen referenced HDR standards. While a modern display may be rated at 1000 Nits, only a small percentage of the display can be driven at this level at any one time. This means that understanding not only the exposure levels of these highlights, but what area of the screen is being driven in the HDR region is very important to those responsible for acquisition as well as those working in Post Production. PRISM provides a luminance False Color display that will highlight which areas of the screen are being driven in the HDR region (normally above 203 Nits) and will also provide measurements of what the minimum level of the brightest 1% and 10% of the screen and the maximum luminance level of the darkest 1% of the screen (see Figure 4). This allows cinematographers and video engineers to acquire correctly exposed HDR images and Post Production staff to objectively adjust levels to give a comfortable and realistic viewing experience.


Figure 4: Left display shows lightest and darkest areas in the HDR zone. Right display shows selected key luminance levels in the image.

## Color Management

Traditionally the tool used for color management is the Vectorscope. This is an X-Y plot of the R-Y and B-Y color difference signals. A specific color is represented as a vector plot of hue by the angle and saturation by distance from the center. There are normally target markers for each of the colors and these (for broadcast) mark the safe saturation level of that particular hue.

The Vectorscope, an effective tool for color measurement and management in SDR, becomes harder to use in an HDR environment. As different color spaces are applied it has the effect of shifting the colors which manifests itself as a rotation in the position of the color markers. Then as the gamma curves (PQ/HLG) are applied for the signal the vector trace appears as a smaller trace roughly 50% of a trace for a Rec. 709 SDR signal. Although a LUT can be applied to the HDR signals allowing users to “zoom” into the HDR signal to make it easier to read on the screen, these color shifts and the trace compression increase complexity when trying to master content for SDR and HDR in different color spaces.

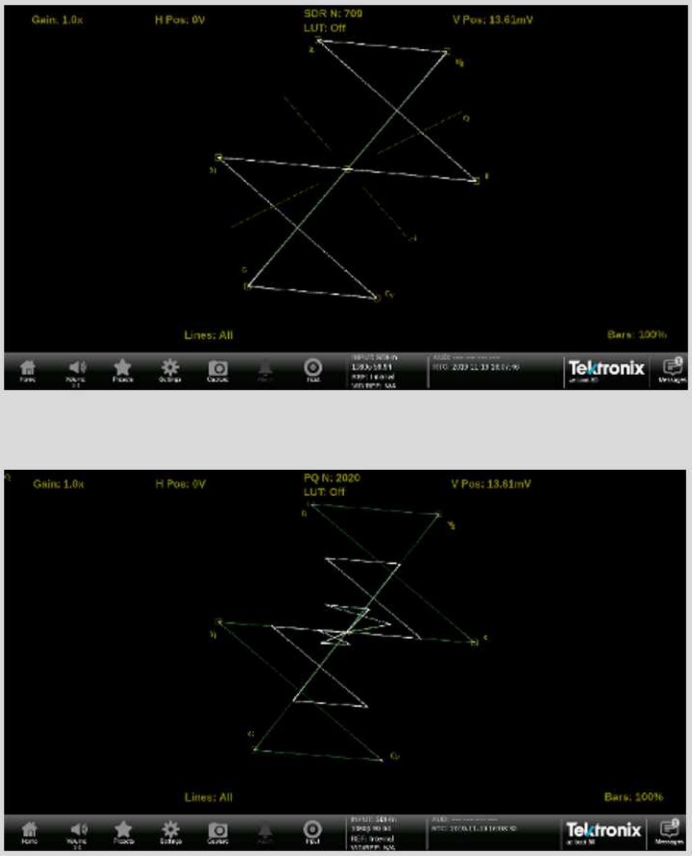


Figure 5: Vectorscope displays – top is for a Rec. 709 and bottom shows the impact of Rec. 2020 (for color bar input).

The Vectorscope is typically used for color matching between scenes, brand and logo matching (e.g. ensure labels and graphic colors for a brand are correct and consistent) and setting skin tones. However, gamut errors (image colors outside the declared or specified color space) are a key reason for having content rejected after Post Production and so it is essential that colorists and QC personnel know when this is a problem.

When working across multiple color spaces and using different gamma curves (e.g. PQ/HLG) an alternative or complementary tool for color management is the use of a CIE chart display based on the CIE 1931 color space chromaticity diagram. The CIE system characterizes colors using a luminance parameter (Y) and two color coordinates (x and y) which define a point on the chromaticity diagram. The CIE “horseshoe” shape represents all the colors the human eye can see. In most diagrams and displays triangles are added to the chart to represent the colors that can be matched by combining a set of three primary colors (Red, Green and Blue for televisions and displays). The PRISM CIE chart shows triangles for Rec. 709, DCI-P3 and Rec. 2020 and each triangle contains the gamut for those standards.

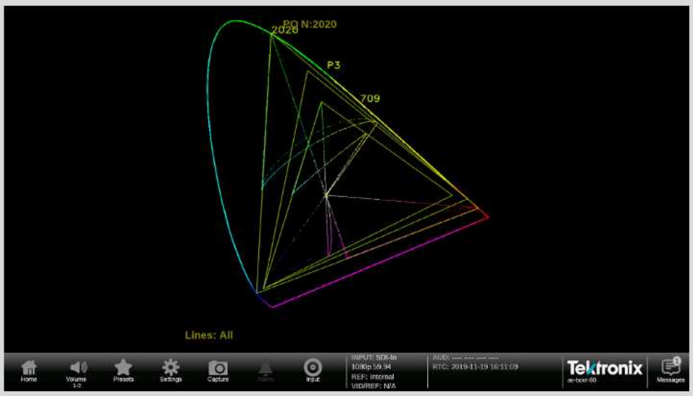


Figure 6: The CIE chart provides a single view of multiple color spaces.

Acquisition normally uses the widest gamut possible (based on the camera gamut) since limiting the gamut at this stage will prevent expansion of the color space in Post. The captured content is then converted to the appropriate display gamut (Rec. 709, DCI-P3, Rec. 2020) in Post Production and Mastering. At this point it is important to know that the conversion has not placed colors outside the chosen display gamut (avoiding clipping and unpleasing images). Full 2020 is not practical to display on monitors today so limiting to P3 has become a practical choice with Post houses being asked to master in 2020 but limit to P3 colors.

For this application, PRISM provides a special false color display that highlights any parts of the image that are outside the P3 gamut for a Rec. 2020 encoded signal. Information on the area of the screen impacted by these issues is also provided (see Figure 7).

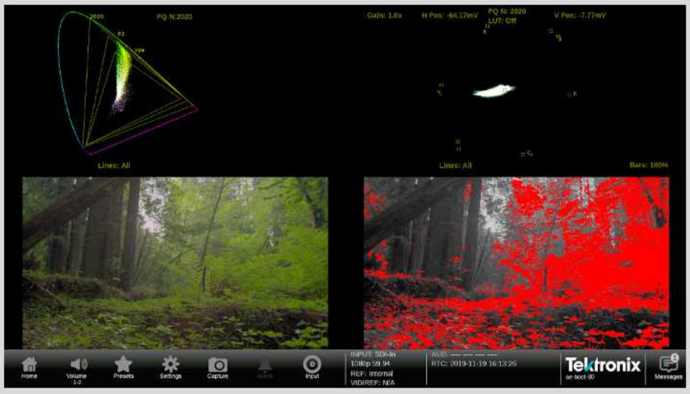


Figure 7: False Color (red) highlights P3 gamut errors in a Rec. 2020 encoded content.

## The Changing Workflow

In the current, and predominately HD, world there are a set of established tools for handling both exposure management and color management. These tools include a waveform for checking luminance levels, a Vectorscope for managing color and a picture display to check the appearance of the content. As demand for 4K/HDR/WCG content grows the traditional tools are beginning to hit limitations. Traditional tools need to be extended to address the new technologies and processes. It is possible to address some of the issues that arise by applying LUT’s that perform the appropriate conversion to allow the continued use of these tools. However, as Production and Post Production personnel are asked to work with multiple camera log gamma curves, multiple HDR display gamma curves, and at least 3 color spaces the existing workflow will need to evolve to use the next generation of production tools.

The new workflow will be built around a STOP waveform that works using light levels and will provide consistent measurements regardless of the camera gamma, a CIE chart that allows Post staff to easily work across multiple color spaces / gammas and check for conversion and encoding gamut errors and a false color display for different applications. False color can be used to show luminance levels, which parts of the image are in the HDR region, what area of the screen is in the HDR region, and where color gamut errors have occurred.

The Telestream PRISM provides all the traditional and future tools through a range of options that will allow customers to transition their workflow at their own pace (see Figure 8).

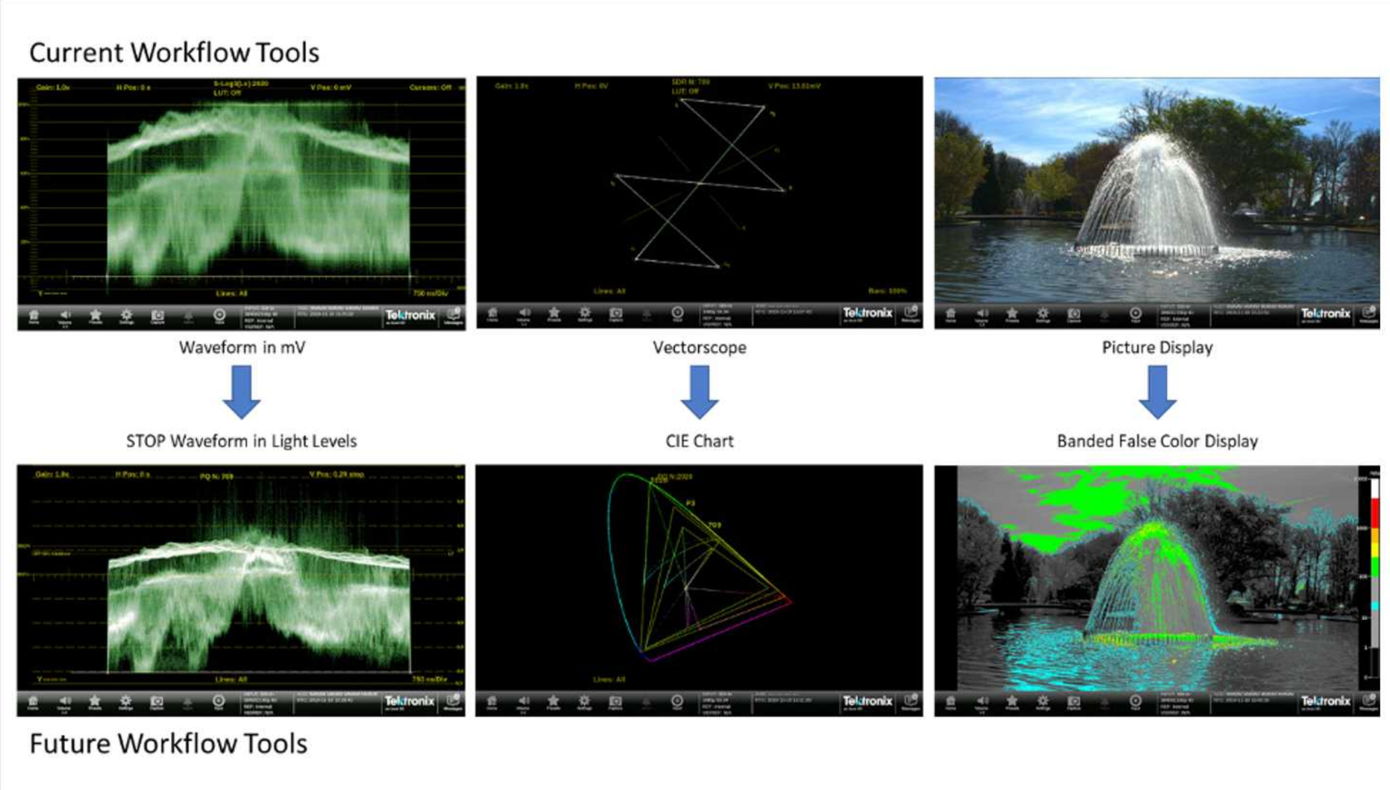


Figure 8: The transitions to be made in the current to future 4K/WCG/HDR workflow.

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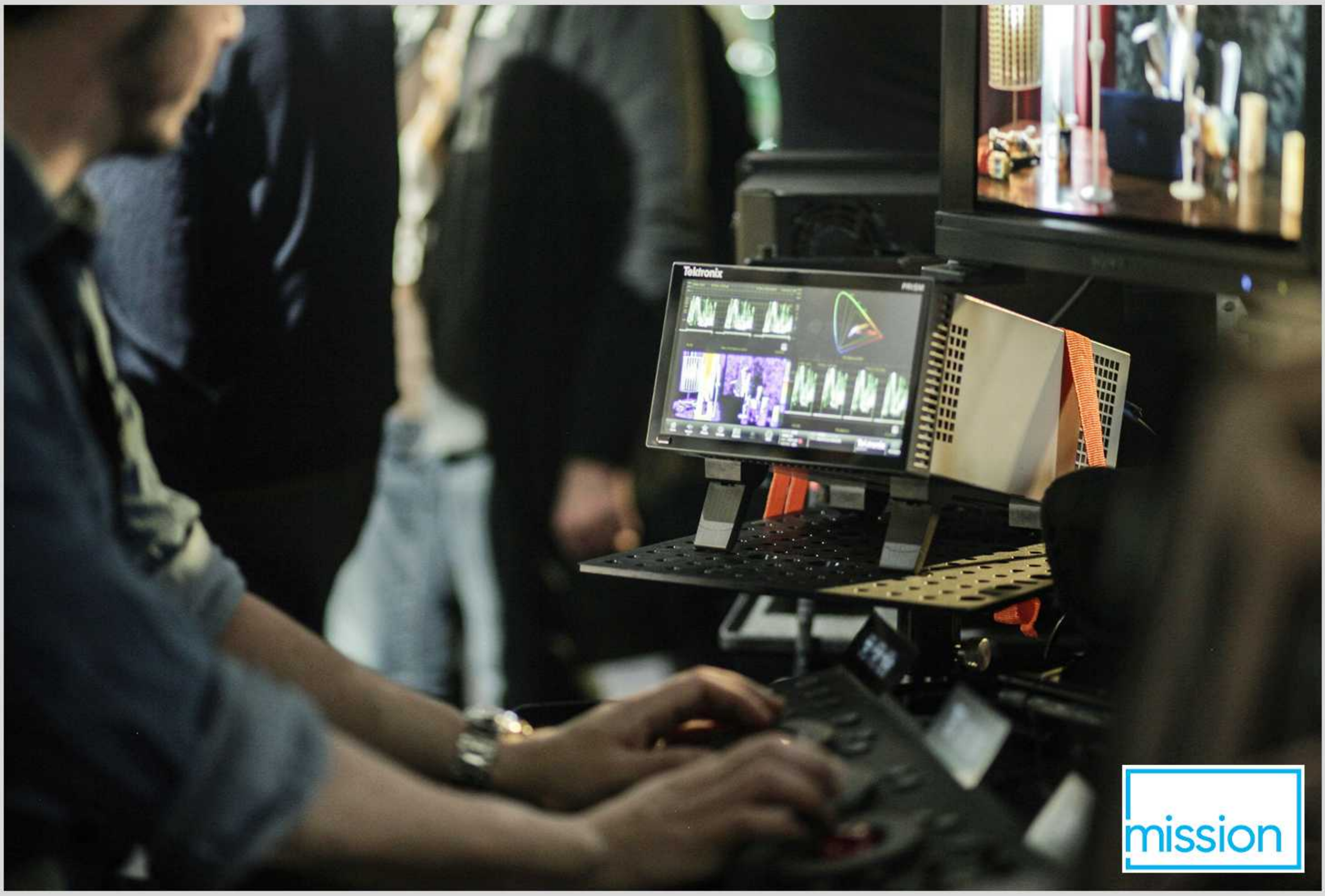
# User Story – Mission Digital




Pablo Garcia Soriano from Mission Digital. Image courtesy of Mission Digital / Pablo Garcia Soriano.

Pablo Garcia Soriano is Mission's Head of Color. Mission's core service is designing workflows and managing media and metadata to optimize visual authorship. Mission works with both cinematographers and broadcasters from Pre-production onwards with the aim of safeguarding color decisions and improving production workflows. He's also part of the Technical Implementation Council for the Oscars ACES (Academy Color Encoding System) Committee.

Prior to joining Mission, Pablo worked at Sony Europe as a 4K/HDR workflow specialist, training over 2300 people every year and running masterclasses all over Europe. In 2018 he oversaw the HDR and SDR delivery for the Football World Cup in Russia as HDR Image Supervisor. Pablo is now using that experience to provide consultancy services to the broadcasters (UEFA and Olympic Broadcast Services) responsible for producing key sporting events in 2020 where SDR and HDR (HLG) are produced together and then transmitted separately, and/or where the content is produced in HLG and the SDR will be derived from HLG.


PRISM Media Monitoring and Analysis Platform.

As part of his work Pablo has made some key observations. The broadcast and cinematography workflows are beginning to converge, and this is driving the need for standard approaches to broadcast production. "At the moment truck crews tend to only work either in SDR or in HDR, but it is imperative that they monitor both, since SDR can end up in the HLG streams as multiple cameras are used. Highlight handling and understanding separation between diffuse and specular, is a must, as highlights are compressed in "SDR" and expanded in HDR. Pablo has made use of PRISM in these environments, "the waveform monitor never lies, and you cannot get all the information you need from your high end $30,000 HDR monitor". Pablo also noted that much of the exposure management made use of waveforms based on IRE levels. However, understanding light levels is important, and so a STOP waveform providing luminance levels in both STOPS and Nits is a natural extension to the toolset to help with this. Pablo also makes extensive use of False Color as part of this process. "Broadcasters tend to expose for reflectance whites, but they should be shifting to expose for mid-tones (greys). Using false color makes it easy to see if the mid-tones are drifting or you are losing consistency. Being able to select and set your false colors simplifies adjustment and allows you to see exactly what changes are needed".

Color management is also a challenge. Pablo has noted that many of the broadcast infrastructure providers have their own color conversion devices and the interaction of those can impact the final product in unpredictable ways due to inconsistency throughout manufacturers. Part of his current work is to develop custom made LUTS that will be used as a standard color transform in upcoming sports productions. He is making extensive use of PRISM for this work, allowing him to see the results of any changes he makes to his LUTS parameters. "I really like the PRISM detail handling, trace and display quality. I use the CIE chart as I master. It makes it easier to see the tonality of the scene, the color palette and to check P3 in 2020 containers".

Telestream continues to work closely with Mission, and Pablo, where his roles include developing robust color pipelines and supervising HDR deliverables. He works with Mission's technicians to deepen their knowledge of color science and ACES so that they can better serve the needs of cinematographers. He also runs many workshops around Europe.

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