Telestream
Whitepaper

New Postproduction Tools Equip Workflows for HDR & 4K Surge

Telestream Quality Tools Enable Adaptation for the New Era of Viewing Experience

With Telestream's introduction of the widely used PRISM QC waveform monitor for use as a primary tool in postproduction, personnel can now cover all the bases for managing HDR color and luminance along with 4K and even 8K pixel density within a single workflow. Complementing PRISM, Telestream's VidChecker QC monitoring system and Switch player provide the additional elements professionals need to keep pace with all the tasks related not only to HDR but to processing SDR-formatted 4K content and ensuring conversions between HDR and SDR are executed as intended.

Contents

Introduction

Video postproduction teams are facing challenges posed by new dynamics in coloration, luminance and pixel density which can only be met with the aid of quality management tools that have been designed for the tasks at hand.

The most far-reaching changes involve content formatted to various high dynamic range (HDR) and HDR-related wide color gamut (WCG) templates now in commercial operation. These bring into play a mind-boggling array of complexities that need to be addressed with meticulous attention at new levels of frame-to-frame and in-frame granularity.

But there are also many new nuances apart from HDR that must be addressed with content mapped to the pixel densities of 4K ultra HD. And there are even new considerations that need to be given to color- and luminance-related details associated with standard dynamic range (SDR) formatting resulting from up and down conversions between HDR and SDR. Complicating matters, postproduction teams must process content in all these formats while maintaining a consistent look with close adherence to artistic intent.

Considering all these developments, distributors are setting new requirements to ensure the best possible viewing experience on UHD displays and with all displays when HDR is in play. Standards of acceptance on completed workorders are more stringent than ever.

These demands have important bottom-line implications for postproduction operations. Teams that rely solely on tools that weren't designed to support management of contrast and coloration in conformance with these new parameters incur higher risks of rejection by distributors. Moreover, there's a cost that comes with workorder completion delays when editors and colorists lack automation support for time-consuming manual processes.

Such concerns are about to become far more significant to postproduction balance sheets.

While the evolution to 4K- and HDR-formatted content progressed slowly at first, the pace is accelerating now that 4K TV set penetration has reached mass market proportions worldwide. With first movers like Netflix and Amazon leading the way, content producers of every stripe realize there's a price to pay in lost audience appeal if they don't deliver the kinds of viewing experiences subscribers to these OTT services have come to expect.

As a result, what was a trickle is about to become a flood of content tuned to new display parameters that have the potential to overwhelm under-equipped postproduction workflows. Getting things right the first time through is becoming harder but more essential than ever.

Clearly, the time has come to make the adjustments in toolsets and workflows essential to addressing these developments. Rather than depending solely on Vector displays and other basic QC tools used in SD and HD workflows, technicians must have solutions that can expedite much more detailed evaluations and corrections of elements related to 4K, HDR and WCG.

As post managers contemplate their options, it's also important to recognize that the pace of technology-driven change has greatly shortened the generational cycles in TV formats. With 8K UHD sets now in commercial production and more extraordinary advances in display technology on the horizon, new challenges won't be long in coming. Toolsets acquired to meet current quality-assurance requirements should be designed for upgradeable adaptations to future needs.

In the discussion that follows, we begin with an exploration of how the changes in display technology are impacting content strategies. In Part 2 we turn to the implications of those strategies for postproduction processes.

In Part 3 we explain how Telestream has made it possible for postproduction professionals to address these challenges. Notably, the solutions include PRISM software features optimized for postproduction in the HDR/UHD era. As the long-standing mainstay for quality control (QC) in cinematic and TV production, PRISM brings to postproduction a next-generation monitoring and analytics tool that can be integrated into workflows in any SDI or IP environment.

With support for grading and maintaining QC across all HDR standards and video formats from SD to 8K in a single workflow, PRISM provides colorists and editors an objective fast track to determining whether intra-frame as well as frame-to-frame nuances in luminance, color and audio dynamics meet their criteria. And it gives them a clear understanding of what needs to be done when corrections are in order.

PRISM works alongside other postproduction QC assets in the Telestream portfolio, including Vidchecker, the file-based QC and correction tool, and Switch, the frame-accurate player that enables playback across all the video, audio, text and metadata essences in content files. Telestream's Lightspeed Live Capture is a multi-channel capture solution for ingesting live or tape-based media directly into production, post-production, and broadcast workflows. Together these solutions provide postproduction professionals the resources they need to address all the issues discussed in Part 2.

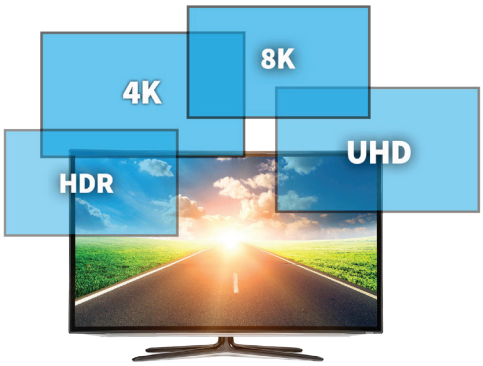
Part 1 – Display Trends Reshaping Postproduction Workflows

While video postproduction workloads remain largely focused on processing SDR-based HD and SD content, it's not hard to see why this won't be the case for long. There are many reasons to assume that the steady, slow rise in tasks related to processing 4K UHD and HDR-enhanced 4K and HD content is about to accelerate very rapidly.

The Display Base for 4K/HDR Content

Smart TVs

First and foremost, the transition to a new generation of smart TV sets is now a fait accompli worldwide. According to projections from IHS Markit, Internet-connected smart TV penetration was on pace to top 50% in the U.S., Japan, U.K., France and Germany by 2019 with China close behind at 46%.[i]



Most of these are 4K UHD sets. According to Futuresource Consulting, global shipments of 4K sets will account for 52% of TV shipments in 2020, at which point the vast majority of television households in North America, Western Europe, Japan, South Korea and many other parts of the world will be watching TV on the big displays.[ii]

Initially, 4K had minimal impact on content production. As it turned out, gains in perceived picture quality achieved by quadrupling the pixel density with 4K UHD weren't enough to move content producers and distributors to go all-in with 4K. But HDR, now a feature of virtually every 4K TV set sold, is a game changer.

With the expanded luminance and color ranges specified by the various HDR formats, viewers see greater detail in both dark and bright segments of the video and richer variations in color, resulting in a closer approximation of the real-life viewing experience. The dramatic improvement over SDR is relevant to HDR-enhanced HD video as well as UHD content.

Other Devices

Paralleling the penetration of 4K TV sets, expansion of the market base for HDR content has been fostered by pay TV providers' deployments of 4K-capable set-top boxes and an outpouring of 4K-compabile streaming media players (SMPs) from suppliers like Roku, Amazon and Google. Major multichannel video programming distributors (MVPDs) with 4K STBs in play include Comcast, BT, Sky, NHK, AT&T, Vodafone, Dish, Charter, Altice and many more.

OTT providers are benefitting from that fact that, as of 2018, more than half of the SMPs shipped in North America and Europe were equipped to support UHD, according to S&P Global Market Intelligence.[iii] This was also expected to be the case with shipment tallies for Asia in 2019,

OTT providers can also take advantage of the fact that a growing market base of personal connected devices can display HDR-formatted content. Since early 2017 the UHD Alliance, a global industry consortium devoted to specifying features and device performance levels, has been extending its Mobile HDR Premium certification to the latest generations of smartphones, tablets and laptops produced by Samsung, Apple, LG and other suppliers.

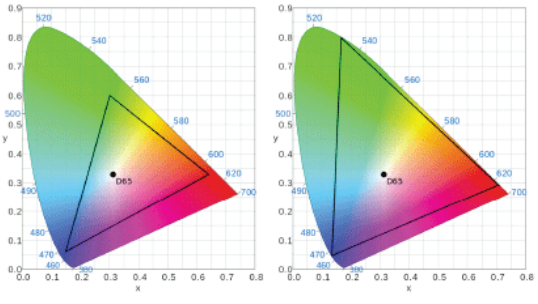
New Dimensions in Luminance and Color

HDR formats support variations in contrast ranging from 2,048:1 to multiple factors above that. Measuring in stops, where each stop represents a luminance increase by a power of two, the dynamic range of SDR, at about seven stops, represents a contrast ratio of 128:1, which is 1/16th the baseline HDR ratio.

The contrast ratios enabled through enhancements used with templates supported by some of the other HDR formats go up from there, approaching but never reaching the limits of human perception. With everyday experience in the natural world, the maximum contrast ratio registered by the human eye in instances that require minimal adaptation is about 20 stops, which equates to a 1,048,576:1 contrast ratio.

Where color gamut is concerned, the goal is to set a benchmark for production that minimizes the amount of color lost from original camera capture, such as occurs when producing content that maps to the legacy Rec. 709 standard. The ITU has developed Rec. 2020 as the successor to Rec. 709 with a standardized wide color gamut (WCG) that comes much closer to the limits of human perception.

Whereas, with 8-bit encoding, Rec. 709 encompasses 16.78 million colors, Rec. 2020 with 10-bit encoding offers 1.07 billion colors. With 12-bit encoding the Rec. 2020 color count tops 68.7 billion colors.



HDR productions typically adhere to the DCI P3 color gamut used in cinematic production, which, unlike Rec. 2020, is within the reach of most UHD displays. With 10-bit encoding, DCI P3 encompasses a range of 756.6 million colors.

HDR Modes and Mitigation of Fragmentation

Some Degrees of Commonality

Early impediments to HDR-enhanced services caused by competing formats that threatened to fragment the viewing audiences have been mitigated to a significant extent, though issues remain. Virtually all HDR-enabled TV sets support HDR10, the CE industry's de facto open standard worked out under the auspices of the Consumer Technology Association (CTA), and Hybrid Log Gamma (HLG), a standard developed by the BBC and NHK, which, unlike HDR10, enables backward compatibility of HDR content with SDR displays.

However, other types of devices designed for HDR reception through online feeds, including some set-top boxes (STBs) as well as streaming media players (SMPs) and personal devices, don't work with HLG. Producers of traditional TV programming have gravitated to HLG, eliminating the need to simulcast in SDR, while HDR10, which avoids compromises in quality imposed by HLG, is generally preferred by producers of content exclusively targeted for OTT distribution.

Most mid-range and higher-priced TV models as well as some other connected devices also support one or more additional HDR formats that enable further gains in picture quality. The most common alternative is Dolby Vision (DV). Others include Samsung's HDR10+ and the SL-HDR1 format developed by Technicolor, Philips and STMicroelectronics.

All these formats use 10-bit encoding except DV, which requires 12-bit encoding. The latter, as well as HDR10+, entails sending two payloads, one a baseline picture conforming to Rec. 709 to accommodate viewing on SDR sets and the other a metadata overlay conveying enhancements to be executed by display systems that can support Rec. 2020. HLG and SL-HDR1 do not require a second metadata stream to accommodate SDR backward compatibility.

Luminance ranges in TV display technology use the nit measurement, roughly representing the brightness of a candle (candela per meter squared commonly expressed as cd/m2), with current low- to mid-range models operating in the 300- to 500-nit range. This is well above the SDR 100-nit level but well below the 1,000-nit maximum set by the HDR10 standard and far below the 4,000-nit range supported by DV, HDR10+ and SL-HDR1.

With the exception of HLG, all these HDR modes rely on the perceptual quantization (PQ) optical transfer function (OTF) or SMPTE 2084. Both OTFs are accommodated in the ITU's Rec. 2100 standard, with HLG supporting a nominal peak luminance of 1,000 nits and PQ extending to 10,000 nits.

The HLG OTF conveys the basic instructions for rendering content in SDR but includes metadata that enables HDR-level rendering on HLG-compatible displays. PQ incorporates metadata used with any of the other HDR modes to convey rendering instructions referencing HDR and WCG parameters, which means instructions suited to SDR rendering can only be conveyed through separate metadata overlays.

HLG relies on the fact that at lower luminance levels banding is not visible, and so it's possible to retain the traditional non-linear gamma function used with SDR to cover luminance up to 200 nits while employing logarithmic functions to convey highlights to 1000 nits. PQ (SMPTE 2084) defines an Electro-Optical Transfer Function (EOTF) that is meant to replace the gamma function in order to extend the range of the color gamut and contrast transfer into the realms defined by REC 2020.

As things stand today, producers need to be mindful of the limitations of displays, no matter what HDR mode they're using. Practical limitations can limit a display rated at 1,000 nits to rendering at that level on just a small portion of the screen.

Hype and Reality: The Implications for Postproduction

With even the most expensive displays topping out at around 2,000 nits, it will be a long time before 4,000-nit ranges come into play. But, at some point, even that limit will be passed, which is why PQ is designed to support luminance ranges all the way to 10,000 nits.

In the current environment, nit ranges are not much of a factor when it comes to labeling displays as HDR compatible. Even TV sets with nit ranges well below 1,000 are commonly equipped to execute multiple transfer functions that can support HDR.

Consequently, while most HDR-capable TV sets fall short of the quality levels supported by the baseline HDR10 and HLG standards, they all represent a foundation for targeting HDR content. As of 2020 nearly every 4K set shipped was HDR compatible, according to IHS Markit, but only 30% had the luminance ranges recognized as true HDR.[iv]

From a postproduction perspective, the nit range to prepare for is the one supported by HDR10. Consumers are now being prompted to be alert to the difference in HDR rendering that comes with higher nit ranges as many manufacturers use the "Premium HDR" label to identify TV sets in the mid-price ranges with 1,000-nit displays.

With no industry agreement on the best approach to HDR, content providers' postproduction operations must be able to shape playout profiles suited to the requirements of their targeted distributors. For example, Netflix requires that any content formatted in HDR for distribution to its customers be delivered as DV masters, which it then converts for delivery in both the DV and HDR10 formats while using the DV mode for backward compatibility with SDR displays. Amazon has taken a similar backward-compatibility approach with HDR10+, which marks a departure from past practices that required HDR masters be formatted to HDR10 with separate masters in SDR.

The Shift to HDR-Enabled UHD and HD Content

The volume of 4K UHD content available from MVPDs has been accelerating rapidly judging from the latest global channel count from S&P, which was at 197 at the end of 2019, up 16.6% from 2018 and nearly triple the number from three years earlier.[v] The Asia Pacific region led with 85 channels, followed by Western Europe with 73. North America was far behind with about 30.

The OTT Production Surge

The biggest force behind 4K and 4K HDR content availability by far comes from global OTT providers, many of which are headquartered in the U.S. They've been able to take advantage of a rapid expansion in access network bandwidth that has largely eliminated a major barrier to 4K distribution in many parts of the world.[vi] As of May 2018, average download speeds in 23 countries topped the 25 Mbps 4K access requirement set by Netflix[vii], and access tiers above that rate were available nearly everywhere other than in Africa and Latin America.[viii]

Virtually all the leading OTT services are offering portions of their content in 4K UHD mode, much of it with HDR enhancements. Nearly all original content produced by Netflix and Amazon is offered in UHD, much of it enhanced with HDR.

Netflix with the largest UHD catalog has over 200 HDR titles formatted for availability in two options, HDR10 and DV. As of mid-2018, 30% of Netflix subscribers had opted for the higher priced 4K/HDR service tier.[ix] The SVOD provider has since mandated that all in-house films be produced in HDR.

Amazon has less than half as many HDR titles but has been pushing the envelope with live sports offerings in HDR, all based on the HDR10+ format. Other providers of 4K and HDR-enhanced 4K content include Disney+, Hulu, Apple TV Plus, UltraFlix, FuboTV, Fandango Now, VUDU and YouTube.

Disney+ appears intent on taking a leadership role on the HDR front with public commitments to the format not only with new productions but with films reformatted for HDR from its legacy catalog. Disney's reformatting strategy highlights a significant aspect to expansion of HDR content that could have important implications for postproduction workloads going forward.

Digital cinema cameras, which have supplanted film cameras at most studios in recent years, capture footage in dynamic ranges well beyond current HDR display ranges, and even filmed movies often surpass those levels. Consequently, there's a vast archive of motion pictures available for up conversion to HDR for the home market. While up-conversion platforms are also available for use with SDR-produced TV programs it remains to be seen how much of the content in these archives will be pushed in that direction.

HDR is also factoring into studios' approaches to new projects. While most studios remain committed to initial production based on parameters that retain the soft edges of traditional filmmaking, there's growing support for HDR as a second-order deliverable in postproduction workflows.

HDR in Live Sports Production

Another important development on the 4K/HDR content front is the emergence of HDR formatting in live sports productions. In late 2019 BT Sport laid claim to being the first European broadcaster to offer HDR-formatted 4K coverage of events year round, which were slated to include Premiere League and Union of European Football Association games before 2020 schedules were sidetracked by the Coronavirus. These BT Sport Premiere games, including ones played in December 2019, were also scheduled for streaming as part of Amazon's new live sports agenda.

Also planned but being rescheduled were 4K/HDR broadcasts of the 2020 Euro Soccer Championship and the Tokyo Summer Olympics. One thing that did occur as planned in 2020 was Fox's broadcast of the NFL Super Bowl in HDR, which followed several HDR-enhanced NFL Thursday night game broadcasts in 2019.

By one estimate, about 900,000 people viewed the game in full HDR through outlets carrying the Fox feed, including Dish, DirecTV, Comcast Xfinity, Altice, Verizon FiOS, Apple TV, Roku and Amazon Fire TV.[x] The previous record for HDR audience size at just 50,000 was set with the BBC's broadcast of the 2018 world soccer championships.

The 2020 Super Bowl marked a significant move up the learning curve for Fox and, by extension, the rest of the broadcast industry. In the process, the experience demonstrated there are good solutions to some of the issues impeding sports broadcasting in HDR.

Fox in 2019 had relied solely on HLG with its SDR backward compatibility as the preferred mode for live broadcasting, not realizing that most users who were promised OTT delivery of the games in HDR were on HDR10-compatible devices that don't work with HLG.[xi] It took months to create a workable solution, which involved converting the HLG feeds to HDR10 on the fly for OTT distribution at reasonably low latency.

Fox also had to deal with the restrictions intrinsic to broadcasting NFL games. Such productions, involving dozens of cameras and special slow-motion equipment, don't yet allow for use of 4K cameras, so Fox had to capture everything in 1080p and upconvert to 2160p on the fly.

While experts detected some artifacts related to compression and HDR formatting, all this processing did not significantly undermine the quality of the OTT feeds, which were reviewed as generally on par with broadcast distribution. There was a 15-20 second lag on OTT behind broadcast, but that was viewed as a remarkable reduction in latency compared to previous experiences with the technology.

Beyond 4K UHD

As managers prepare postproduction processes to accommodate the onset of 4K and HDR, it's important to keep in mind the accelerating pace of change in TV display technology. To whatever extent possible, consideration should be given to whether new solutions brought into workflows to handle current requirements will remain useful as new requirements emerge.

8K UHD

Nobody knows how fast 8K UHD will gain traction, but the technology has advanced to where the market can begin to make that determination. The prices of 8K TV sets, in commercial production since 2015, have fallen by orders of magnitude with 55" models dropping to $3,500 in 2019 and 65" models slated to debut at that price point in 2020. At the high end, 88" home theater models were selling for $30,000.

At four times the resolution of 4K, the CE industry is anticipating 8K UHD will draw adherents, especially when HDR is involved. The CTA has set certification criteria for 8K UHD sets that require support for HDR.

Of course, there is no 8K-produced content to speak of, although YouTube and Vimeo tout availability of several thousand videos for viewing online in 8K. A more likely driver to consumer interest in 8K is the fact that the TV sets support automatic upscaling of 4K to 8K.

It may be that the first significant amount of 8K content production occurs in the video game space. Sony is supporting 8K graphics rendering in its PlayStation 5 game consoles, and Microsoft is reported to be considering a similar move with its next Xbox X series console.

Part 2 – The New Dimension in Postproduction QC

The shift in content production toward output more aligned with the 4K and HDR display capabilities of devices now in use by most consumers in many regions of the world adds new dimensions to postproduction workloads relative to all formats. The changes are most pronounced with postproduction of HDR-enhanced video but also impact treatment of SDR-formatted 4K UHD.

SDR

When it comes to SDR, there are new issues to contend with having to do with both down conversion of HDR to SDR and up conversion of SDR to HDR. At this point, by far the more common instance relates to down conversion.

When content is produced using HLG, gradations mapped to SDR dimensions are an intrinsic part of the capture, whereas, when the content is produced using HDR10 with PQ, down conversion to SDR is a separate process. Either way, care needs to be taken in postproduction to ensure the SDR outputs are not distorted from SDR production norms and that the HDR and SDR versions are as closely matched as possible.

In the case of up conversion, a number of SDR-to-HDR upconverters have entered the market, some claiming to have the ability to perform the conversions in real time. So far, usage has been limited to converting archived movies and, more rarely, TV programs, primarily for use in OTT services.

Results can be a mixed bag. So, whenever such content goes through postproduction, there's a need for meticulous QC to ensure that SDR productions tweaked to faux HDR dimensions in the encoding process really do deliver a better viewing experience to people watching the content on HDR-enabled displays.

4K UHD

While HDR is shaping up as the primary mover beyond traditional norms in TV production, 4K took off well ahead of HDR in cinematic and OTT productions. As a result, 4K's 3840x2160 pixel palette has become an ever more common presence adding new dimensions to postproduction workflows.

For example, processing 4K content brings a new framerate into the mix. Producers of original content for OTT services are required to shoot at 23.98 frames per second (fps), which is better for ABR streaming than either the 24-fps cinematic mode or the 29.97 fps used in NTSC production.

Editors must also be able to support conversions to 4K UHD from 35 mm film, Digital Cinema Initiative (DCI) productions and 1080p HD programming. They need to be able to execute refinements like film grain filtering, artifact removal and color re-grading with 4K productions, which aren't necessary with less finely rendered HD video.

Complicating matters, quality specifications vary from one distributor to the next. Some may lower the quality threshold for up-converted HD content versus content originated in film or 4K. Some may set higher quality requirements for service tiers tied to early release windows or other premium features.

Additionally, quality variations may depend on the bitrate thresholds set by distributors, which presently range anywhere from 15 Mbps to 25 Mbps for transmitting HEVC-encoded 4K content. And content providers must be sure to adhere to whichever HEVC profile the customer prefers – Main, which supports 8-bit color with a sampling depth of 256 levels, or Main 10, which is designed for 10-bit color processing with 1,024 sampling levels. Variables tied to these HEVC profiles also include chroma subsampling levels at 4:2:0, 4:2:2 or 4:4:4.

HDR

HDR quality parameters operate independently of considerations tied to spatial resolution. While HDR is commonly associated with 4K UHD, the enhancements delivered through the PQ or HLG transforms can be and increasingly are being applied in HD productions.

Some of these HD productions, like the NFL broadcasts described in Part 1, are converted to 4K prior to distribution. But ever more HDR-enhanced content is entering the pipelines in HD mode. To many producers it makes more sense to take this approach insofar as HLG makes it possible to deliver an HDR experience to HLG-compatible devices without having to produce in 4K.

Luminance Dynamics and the Human Visual System

HDR whether in HD or 4K UHD mode provides a vastly improved viewing experience over SDR, provided the luminance and color dynamics are carefully mapped to the realities of the human visual system (HVS). This requires QC processes in postproduction that are mindful of nuances that haven't been factors in SDR productions.

The human eye can detect a luminance range from one millionth (0.000001) of a nit to about 100 million nits. For formulating HDR displays, the goal, of course, isn't to match this range but rather to operate within a dynamic contrast range that is closer to what the eye experiences in the natural world as a person's gaze moves from bright to dark backgrounds – in other words, the instantaneous dynamic range available to human perception as a function of pupil dilation and other opto-physiological processes in real-world situations.

Not only must HDR productions be responsive to HVS sensitivities to changes in luminance from one scene to the next; they must be responsive to the fact that variations in the light field across the frame can also profoundly influence visual responses to brightness and color.

In other words, to a much greater degree with HDR than SDR, what we see doesn't just depend on the intrinsic illumination of a pictorial element; it also depends on the context.

The viewing environment also plays a role. In bright home and mobile viewing situations, both light and dark adaptation to modulations in illumination may be expected to proceed on a time scale measured in seconds. In dark home and theater environments, rapid luminance changes might result in slower dark adaptation.

The Color Factor

Variations in the light field across the frame can profoundly influence visual responses to colors. As contrasts are adjusted in post there's a need to assess the impact those changes have on the original coloration with an eye toward compensating for any significant disparities.

Beyond the ways changes in luminance impact the viewer's ability to see details, including colors, there's also a direct relationship between luminance intensity and color perception. One obvious instance of this relationship is the fact that as luminance increases, so does the ability of the HVS to discriminate between colors at ever smaller gradations.

Consequently, as the luminance range expands, more bits are needed to code color in order to avoid introducing noticeable errors. At this point, the industry has settled on 10-bit color depth as preferable to 8-bit at current luminance ranges used in production. But the inevitable course, already taken by DV, is toward 12-bit color depth.

Luminance also affects the perception of the hue. As luminance increases, there is a slight shift of how a color at a given wavelength is perceived, which is most noticeable with an expansion of green and orange spectral ranges and a corresponding narrowing of turquoise and the darkest reds.

Flicker and Judder

HDR in combination with large displays also has an impact on two other aspects to HVS perception: flicker, which is the sensitivity to temporal changes across video frame sequences, and judder, which results from uneven or jerky video playback that arises from movement of objects, edges or detail from one frame to the next.

Flicker hasn't been at issue with the framerates used in video mapped to Rec. 709, but these sensitivities can become issues with HDR if frame and refresh rates are too low. Traditional framerate settings for film and TV programming are likely to be problematic in this regard.

The same holds true for judder. Increases in contrast, sharpness of detail and motion speed can cause judder, especially with increased screen sizes, which, for any given viewing distance, have the effect of bringing the images closer to the viewer.

Juxtaposing HDR with SDR Content

The dramatic changes resulting from HDR have important implications for QoE when it comes to sequential juxtapositions of HDR with non-HDR content. The HVS characteristics described here make clear that HDR-formatted commercials must be pegged to the same parameter set for HDR programming. It's also clear that non-HDR compliant commercials should not be placed with HDR programming.

Another juxtaposition issue has to do with graphic material. For example, SDR-formatted still images associated with movie and TV program titles lose their appeal when used with HDR-enhanced content.

Similarly, any graphic overlays associated with the HDR-enhanced programming need to be tailored to the expected light/dark adaption state. Work orders should include provisions for executing needed graphic adjustments in postproduction.

Part 3 – Accommodating HDR in the Postproduction Workflow

From a postproduction perspective, the variations in HDR modes that really matter come down to whether HLG or PQ is employed. Otherwise, what matters are the luminance and color dynamics expressed within any given mode and what needs to be done in postproduction to mitigate issues highlighted in Part 2 with close adherence to creative intent and consistency between SDR and HDR outputs.

Outdated Tools

With so many issues to address, there's no getting around the need for new tools that can facilitate processing of HDR and SDR-based 4K content in postproduction. Specifically, the basic tools as traditionally designed for use in SDR QC, namely Vectorscopes that fall short of meeting new requirements.

Telestream Solutions

Postproduction teams can accommodate the full scope of steps required for accommodating HDR processing requirements related to coloring, editing and QC in a single workflow with the aid of three solutions provided by Telestream.

PRISM

The core component is PRISM, the advanced QC waveform monitor widely used in cinematic and TV production that has been optimized for use in postproduction. With support for 4:4:4 RGB sampling at 12-bit color depth, PRISM can be used with any gamut within REC 2020 color spectrum. It also supports the full luminance range encompassed by PQ.

PRISM works in any SDI and IP networking environment, including 25GE, with support for all formats from SD to 8K. PRISM, available in 3RU half-rack and 1 RU full-rack form factors, operates in a single workflow to streamline QC with grading and editing of content mapped to SDR and any of the leading HDR parameters.

The platform, along with supporting Waveform, Vector and Diamond displays, offers CIE color space chromatic diagram providing accurate measures across the full Rec. 2020 color spectrum and compliments the Vector scope.

PRISM false color detection

For any given workflow, the PRISM CIE chart displays the full gamut of the relevant Rec. 709, DCI-P3 and Rec. 2020 triangles to enable measurements of each SDR and HDR version and direct comparisons between them. Given the fact that the full Rec. 2020 spectrum is not used with current displays, the platform provides a special false color display that highlights the measured area and percent of the image outside the P3 gamut on a Rec. 2020-encoded signal.

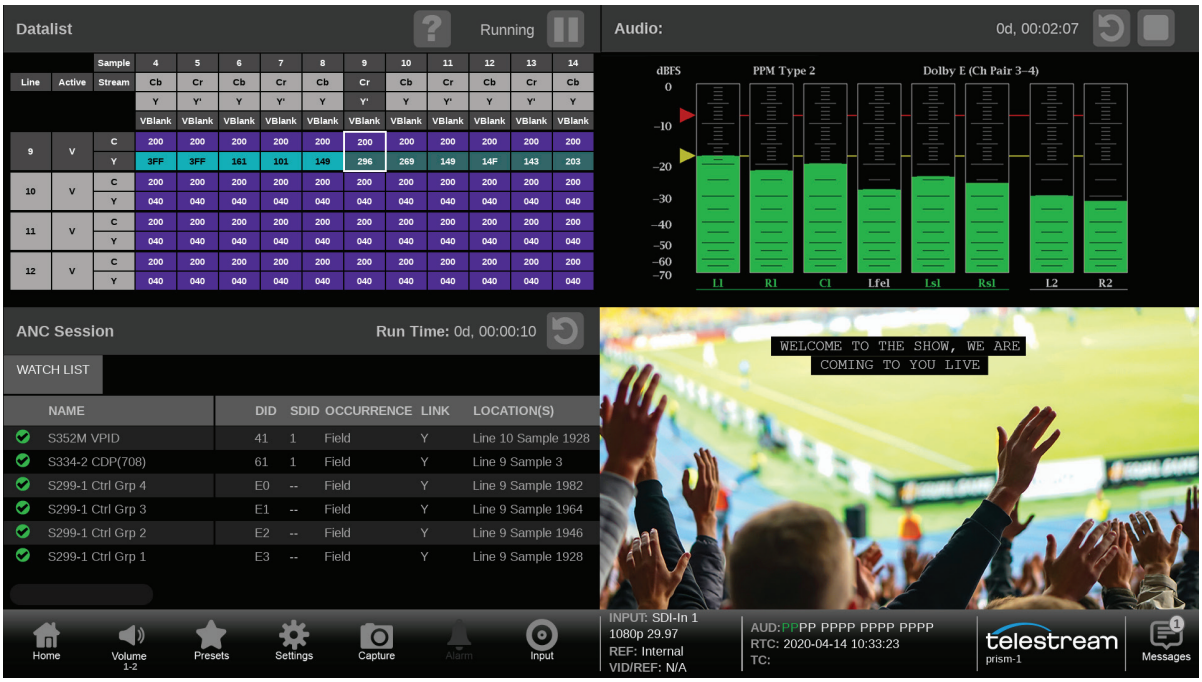
The CIE display provides a trace based on x, y color coordinates, so that a single color is always placed on the correct location regardless of the video format the user specifies. This means operators can create/ evaluate color in consistent and objective ways regardless of the video format the operator is working with. This also means that color monitoring for SD/SDR/ 709 mastering forDVD and 4K/HDR/ 2020 mastering for Video on Demand (VOD) can be done using the same workflow.

Colorists can use PRISM's luminance False Color to readily identify luminance levels of selected objects or set the luminance to a level identified by a false color. The display allows them to limit the range of colors chosen for images to bands of greatest interest, which can be configured in nits or stop units.

Along with identifying which areas of the screen fall exclusively within the HDR range, the False Color display reports the minimum level of the brightest 1% and 10% of the screen and the maximum luminance level of the darkest 1% to calculate the dynamic range of the scene. This affords postproduction staff maximum flexibility to adjust levels to optimize quality and comfort of the viewing experience.

The PRISM Stop display provides a uniform approach to analyzing SDR and HDR waveforms that has been missing from traditional luminance waveforms. The display, which can show luminance levels in stops or nits, executes trace that linearly corresponds with what the user sees in a reference picture monitor, making it easy to set black, white and gray levels and to control specular highlights.

The PRISM Diamond and Split Diamond displays simplify the process of identifying and correcting RGB gamut errors in digital video signals. Reflecting traces on G/R and G/B planes, the trace position moves linearly as a response to RGB adjustments, allowing the colorist to quickly identify and correct gamut issues.



PRISM compliance analysis

Utilizing PRISM's ability to monitor the content compliant with 12-bit DV including HDR requirements, postproduction personnel can further streamline the workflow by eliminating the need to work with more than one master output in the color management and QC processes. With DV, personnel can perform optimization on a single master file and then review in SD, HD and 4K resolutions for any final adjustments and approval.

Lightspeed Live Capture

Lightspeed Live Capture is a scalable, multi-channel on-premise capture solution for ingesting live, live linear or tape-based media directly into production, postproduction and broadcast workflows– and perfect for Edit@Home real-time remote production and postproduction.

Lightspeed Live Capture offers six easy ways to capture your video:

- 24/7/365 scheduled recording of live feeds
- RS-422 controlled capture from a VTR
- Manual record including Gang control
- DAI (SCTE-104) triggering
- Recurring segment creation
- Automated control through a simple Web Service REST API

Lightspeed Live Capture supports all major HD codecs, and provides powerful production tools, such as simultaneous edit-while-capture, transcode-while-capture and deliver-while-capture.

The Lightspeed Live Capture system creates growing files that directly support 3rd party media edit solutions, including Avid Interplay, Avid Media Composer, Adobe Premiere, DaVinci Resolve and Apple Final Cut Pro.

Lightspeed Live Capture comes in 2-channel and 8-channel configurations that share all of the same high quality and tested features used in enterprise-class workflows. There is tight integration with the Vantage Media Processing Platform to enable sophisticated automation and orchestration of media files. Of particular interest is that the 2-channel version of Lightspeed Live Capture can run Vantage natively for an all-in-one, cost efficient ingest and media processing system.

Lightspeed Live Capture

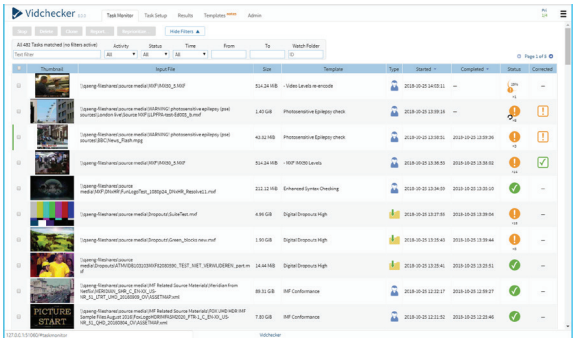
Vidchecker

Vidchecker is the file-based QC platform postproduction professionals use to execute fast but comprehensive tests for video, audio and other asset quality at multiple points in their workflows. The highly automated system can validate high volumes of content for quality compliance and syntax with blanket QC testing support for all commonly used formats, including HLG- and PQ-encoded files mapped to the major HDR modes.

The platform achieves high efficiency in the testing processes by employing techniques that eliminate false positives and that maintain a high degree of correlation to human perception across all the nuances associated with QC over 4K UHD and HDR-enhanced content. It utilizes intelligent file correction to automatically fix issues such as RGB gamut, luminance, and audio levels.

Vidchecker supports Interoperable Mastering Format (IMF)-based QC analysis in instances where that format is used to deliver completed files in accord with the latest industry practices. When pointed at the asset map or any of the composition playlist (CPL) assets, the system automatically parses and tests the CPLs and provides the results in a QC Test Report.

The platform also performs in-depth Material eXchange Format (MXF) analysis with support for (MXF) constraints such as Advanced Media Workflow Association (AMWA) AS-11 and AS-10. It supports other high-end formats as well, including ProRes, J2K, DPX and OpenEXR.



Vidchecker file-based QC

Switch

Postproduction personnel rely on the Telestream Switch player used with PRISM and Vidchecker to gain content visibility with color and luminance management across multiple resolution and HDR formats. The multiformat player and encoder supports frame-accurate, high-quality playback of all media files in all the major coding, resolution and HDR formats with a well-organized display of container, video, audio and subtitle information.

Switch media player and inspector

Playback can be executed at any speed, including frame by frame, in slow motion and fast forward with support for rewind at single-frame as well as rapid rates. On the Switch interface, editors can perform tasks such as trim, scale or cropping of video, adding metadata and inserting chapter markers, and they can specify new file formats and new video and audio codecs.

The player platform supports collaboration by enabling users to create, view and comment on flags without changing the content. In live postproduction, personnel can open files and play them back for quality review or extract segments for promotional purposes as they're written to disk. And with the ability to load a second video or audio file, Switch gives operators' a comparative insight in to two different assets at the same time, offering the ability to visually compare and contrast different files as part of their Quality Control process.

Conclusion

The new era in video production has finally arrived.

With OTT market leaders setting the bar in 4K UHD and HDR production, broadcasters, MVPDs and other OTT distributors have been forced to move out of their legacy comfort zones. They never felt the 4K benefits by themselves were worth the costs, but failure to deliver the dramatic improvements in viewing experience enabled by HDR poses risks they don't want to take.

As the volume of HDR-formatted original productions expands and the catalogs of motion pictures upconverted to HDR grow ever larger, postproduction professionals can no longer rely on old tools to handle the challenges posed by the new dimensions in pixel density, luminance and color gamut. 1,000-nit luminance ranges and color counts topping one billion can be managed to create stunning new viewing experiences. But, without due respect for the human visual system, they can also be mismanaged to deliver poor results.

Distributors, well aware of the pitfalls, have set rigorous requirements that must be met to ensure their customers are well served. The costs of not meeting those requirements fall directly to postproduction operations.

Fortunately, post processes can be adjusted to accommodate these requirements without serious disruptions to the pace of workorder fulfillment. With Telestream's introduction of the widely used PRISM QC waveform monitor for use as a primary tool in postproduction, personnel can now cover all the bases for managing HDR color and luminance along with 4K and even 8K pixel density within a single workflow.

PRISM incorporates the advances post professionals need for:

- Accurate WCG management.
- Uniform SDR and HDR waveform rendering.
- Efficient use of False Color in luminance adjustments.

Complementing PRISM, Telestream's Lightspeed Live Capture, Vidchecker QC monitoring system and Switch player provide the additional elements professionals need to keep pace with all the tasks related not only to HDR but to processing SDR-formatted 4K content and ensuring conversions between HDR and SDR are executed as intended.

Footnotes

[i] *Digital TV News, >50% Smart TV Penetration in Major TV Markets by 2019, February 2016*

[ii] *Futuresource Consulting, 4K UHD Is Key Sales Driver for Flat TV Screen Market, April 2016*

[iii] *S&P Global Market Intelligence, OTT Video and Connected Devices Drive 4K UHD, December 2018*

[iv] *Fierce Video, HDR TV Shipments Will Pass Up 4K by 2020, May 2017*

[v] *S&P Global Market Intelligence, Asia and Europe Continue to Dominate the UHD Scene, October 2019*

***Note:** Availability of 4K content in some regions was temporarily interrupted with traffic congestion caused by surges in OTT video streaming during the Coronavirus outbreak.*

[vii] *Fastmetrics, Average Internet Speeds by Country, May 2018*

[viii] *World Population Review, Internet Speeds by Country, April 2020*

[ix] *Multichannel News, 30% of Netflix Customers Subscribe to Premium Tier, July 2018*

[x] *Harmonic, 4K for Sports: Getting the Big Game in UHD HDR, February 2020*

[xi] *The Verge, The NFL in 4K HDR Gets Off to a Rock Start, September 2019*

To Learn More

- Visit www.telestream.net

www.telestream.net | info@telestream.net | tel +1 530 470 1300