WHITE PAPER

The Impact of New Production Formats and Workflows to Camera Control

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Abstract – Today, camera control solutions in live broadcast productions are mainly used to adapt the camera's capabilities to a given light situation, and to achieve a certain "look" and style of the images. New formats such as high dynamic range (HDR), wide color gamut (WCG), 4K UHD, IP and simultaneous HDR/SDR or HD/4K UHD operations, require more agile controls. Now with more features to be controlled, managing the various settings becomes very difficult. A broadcast camera control solution that leverages the developments from grading applications used in post-production and other widely used image control applications, such as Photoshop, will benefit from new ideas and the new talents grown with these solutions. It's time for a change! This paper will explain the background of today's camera control solutions and show, based on extensive customer feedback, how it should develop in the future.

Introduction

The main operational differentiator between a camera system used for live broadcast production, a camcorder used for news acquisition and a digital cinematography camera used for file-based productions is the live control of the image by the operator. Since there is no post production in live broadcast, the images have to be perfect all of the time, and the cameras must deliver the best image quality for the any shooting condition. Additionally, it is important that all cameras have the same "look" as required by the production.

Another thing to consider is that production formats and workflows are constantly changing, but the tools available to control images have not fundamentally changed since the beginning of live television production.

Background of Camera Shading

Earlier generations of cameras used for live television productions required shading mainly to compensate for technical imperfections of the equipment caused by temperature drift or aging effects of the analog circuits and components.

Especially difficult, cameras based on pick-up tubes had to be pre-heated and fully calibrated before every use and multiple parameters needed to be controlled and adjusted — even during operation. These adjustments (some of which are no longer available) included registration, electrical focus, beam current and ABO, bias light and many more.

Because of the limited stability of the technology available at the time [Ref. 1], it was a very demanding job to keep the image quality as high as possible at all times during a production. For this reason, the number of cameras controlled by one operator was very limited, and in some cases it was only one camera per operator (Figure 1).

With the current generation of fully digital CMOS-based cameras [Ref. 2], there is no longer any drift to be compensated for and camera shading is only required to achieve a certain "look" and style, or to best adapt the camera's capabilities to a given lighting situation [Ref. 3].

Figure 1 – Camera shading in the early days

From technical to artistic image control, or from “shading to grading”

Signal flow-based camera control solutions

The control solutions used in today’s broadcast camera systems for live production are based on controlling individual parameters inside the camera’s processing. They typically follow the flow of the signal inside the camera, starting with several settings around the optical system, such as selection of optical filters and lens iris control, followed by imager corrections mainly for black levels, gains, sharpness and multiple nonlinear processing steps.

In earlier cameras, these controls were realized by analog amplifiers, filters and the like. These were then controlled by hardwired potentiometers. In today’s cameras, functions inside the digital signal processor are controlled by rotary encoders.

However, the way they interact has NOT fundamentally changed over time and they are more or less following the camera processing block diagram (Figure 2).

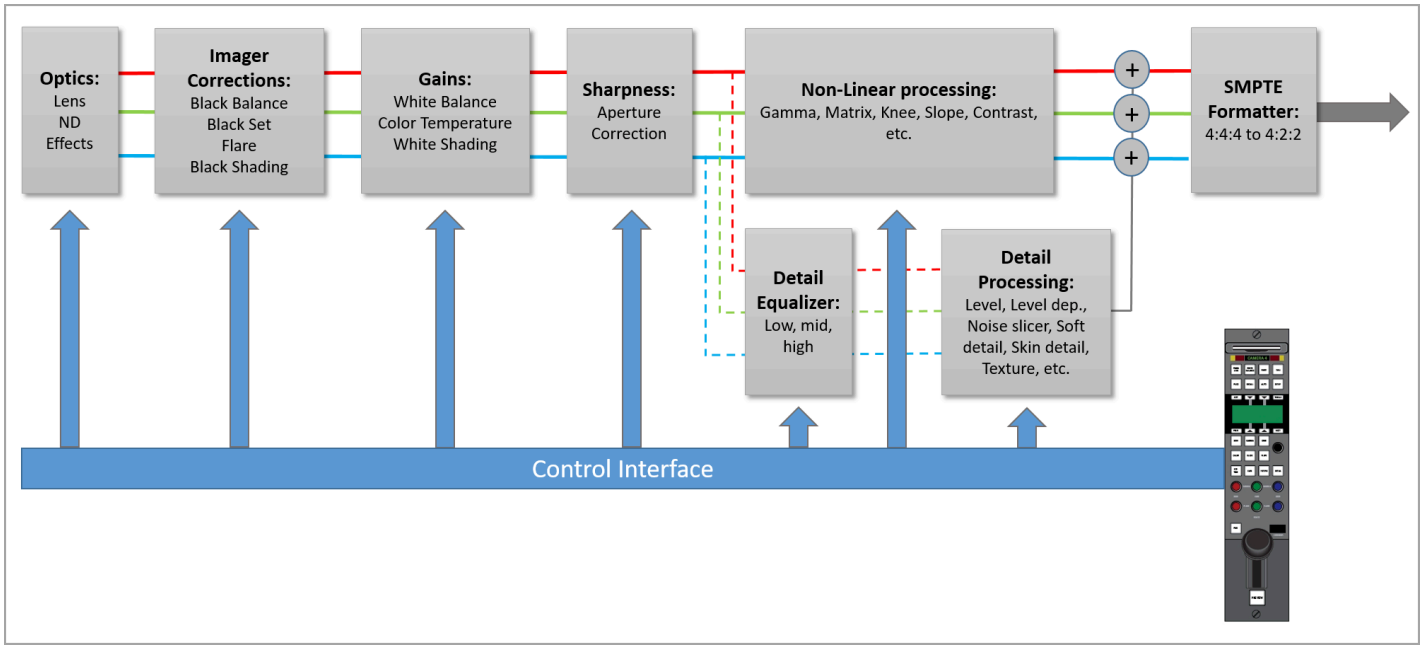

Figure 2 – Signal flow block diagram

Even though this is a well proven and accepted workflow in the broadcast industry, there are several limitations and shortcomings of such a solution. The camera shader must fully understand what they need to do if they want to achieve a certain change to the image and they must always be aware of how a specific operation might have an impact on any other parameter that could also be changing the images.

“Look”-based camera control solutions

Rather than a technically optimized setting, some productions require a certain defined “look” be achieved and maintained throughout the full production. People involved in this definition of the “look” can include lighting directors and producers, and sometimes stakeholders from the final customer.

Their request might include the reproduction of specific colors in their company logos or their products. Sports production in an indoor stadium is another example where a specific shade of green of the grass is expected even if in reality the color has faded because of dry weather conditions.

For these more artistic controls of the camera images, a different workflow could offer a better solution. If we use a typical post-production system in a file-based workflow (Figure 3) as reference, there is a completely different way of controlling the “look” of an image compared to today’s broadcast camera shading.

Figure 3 – Typical post production system

First, there are many different pre-defined LUTs that can be easily selected and compared one-by-one. Next, several groups of parameters can be modified to specific requirements, and there is always the option to reset any of the settings one-by-one and to quickly toggle between the updated image and the original image for a fast and easy comparison.

With today’s broadcast camera control solutions, some of this can be achieved by the use of multiple individual controls that often interact. However, this can be quite time consuming and therefore not the best process. There are many examples of image control software solutions achieving the same result with less broadcast specific knowledge required.

New Formats Require New Ways of Control

Status

There are two versions of camera control panels, each with their own set of strengths and limitations.

The first version is trying to offer a fixed direct control button and knob for every function that might be required. This is a good solution if a limited number of functions need to be controlled, and no flexibility or upgradability is required.

The second version uses menu-controlled operation where the control functions can be selected through a menu structure allowing access to all controllable items. Nonetheless, with this version some functions required in the different application types are not available on direct control.

New requirements

The latest developments in the broadcast market with the addition of new formats such as HDR, WCG, 4K UHD [Ref. 4], IP, and simultaneous HDR/SDR [Ref. 5] or HD/4K UHD, require more agile operator controls. With more features to be controlled it becomes very difficult to oversee all of the settings.

For example, with HDR operation, fixed defined Opto-Electronic Transfer Functions (OETFs) are used. One might think less control would be required, but this is not the case. In early HDR test productions, one of the first things requested by camera shaders was a way to control the "look" of the image, which requires modifying the OETF. Since the two worldwide specified HDR OETFs [Ref. 6] do not have an adjustable gamma, a knee point or black stretch, new ways to modify the characteristics needed to be defined and implemented. Some of the latest native HDR cameras for live production offer control of the characteristics in the lower as well as the upper part of the OETF — with the ability to shift the point between the two control areas up and down the signal range. This allows for better control of the look of the image.

The trend towards IP connectivity, including the use of IP networks for remote productions [Ref. 7], has a direct impact on camera control solutions since new parameters need to be controlled and managed — often over large distances. For this reason, remote diagnostics will become more important and displaying more parameters and settings around this area will be required.

Now the question is how to handle these new parameters with today's camera control panel, since these are new functions not foreseen in the layout of the control buttons. If any of the existing buttons are to be used, the problem is how to control the original functions of these buttons. This could explain how future requirements will impact the control solutions. This means a more agile control offers many benefits.

How the Human Interface Might Need to Change

Defining customer requirements

To better understand customer requirements, extensive workshops, meetings and discussions with many broadcast customers around the world have been held in the last few years. Starting from very simple drawings on paper, some of the potential control panels have been built as non-functional 3D models (see Figure 4) for further discussion and feedback.

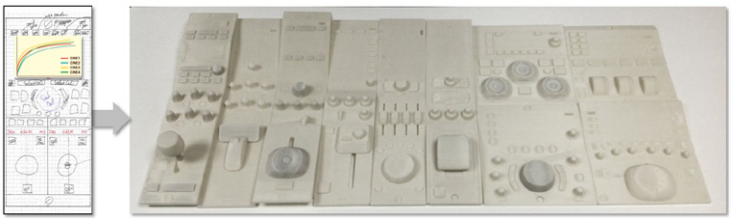

Figure 4 – Non-functional control panel concepts

Something that became clear very early on is that for live operation, a dedicated control panel per camera with direct access and "blind" control of several functions is required. However, the functions requested with direct access are not always the same and depend on the application and the customer's way of operating. Having direct control for every function, which could be required by any customer in any operational mode, would mean a huge amount of buttons and controls. This is not an option considering the limited space available with the potential of adding more functions in the future.

By using dual-concentric rotary encoders with push buttons, three functions can be assigned and controlled in a space where typically only one function has been controlled (see Figure 5). This offers a simple and flexible way to delegate functions to a reasonable number of hard control buttons and controls and is ultimately a better solution.

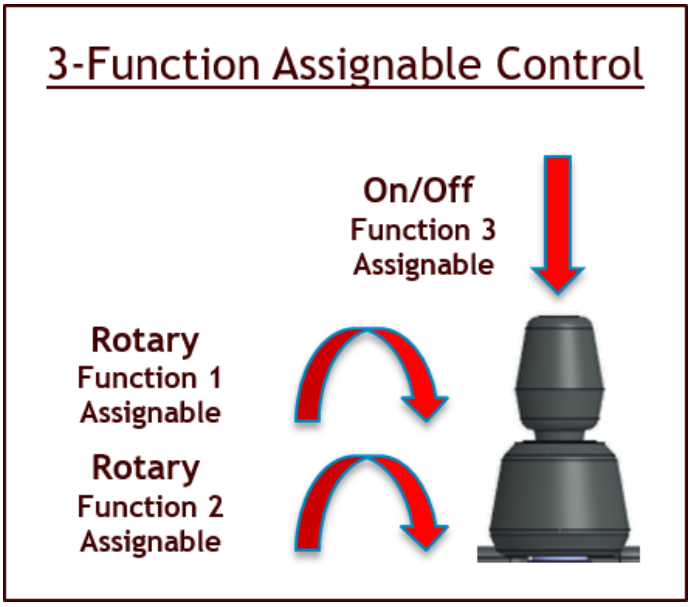

Figure 5 – Assignable controls

With an assignable control solution, there is no fixed position for additional controls. There must be a way to clearly indicate all the controls and settings. A display close to the assignable controls can be used to show all of the configurations and the state of the settings (Figure 6).

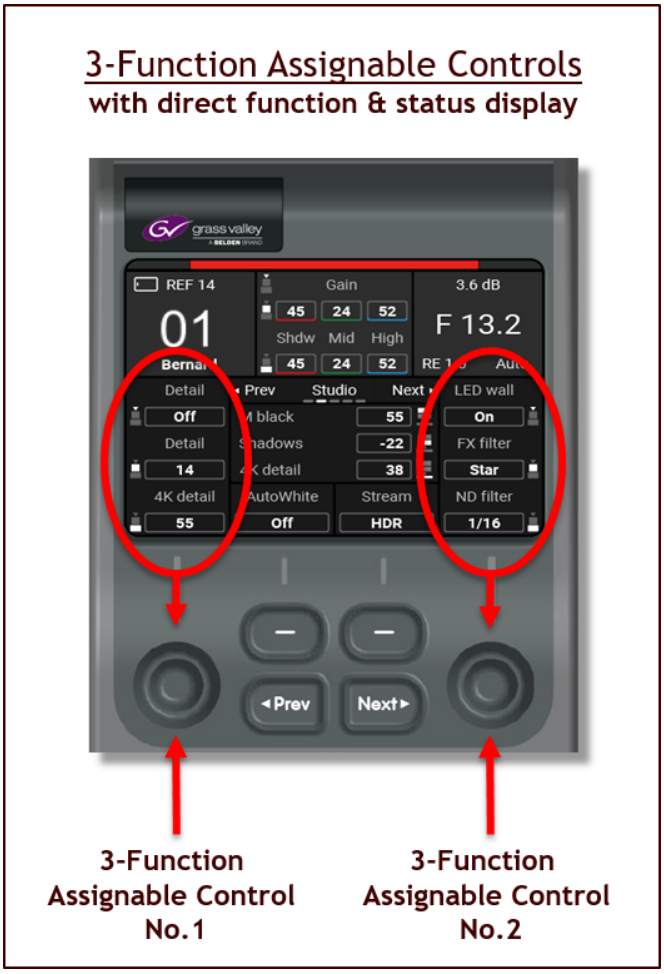

Figure 6 -Display showing state of assignable controls

Multiformat Productions

Introduction

Today, HDR is winning over consumers because of its ability to deliver a visibly wider range of highlights and shadows as well as more realistic color and detail. HDR also allows more dependable results under difficult shooting conditions — such as irregular lighting or partial shade — found at many outside broadcast venues. An additional advantage of HDR is that it is fully format independent, and does not need any specialized viewing conditions to showcase its advantages.

For broadcasters and content creators, embracing an HDR workflow raises a number of questions and poses some challenges. Most notable is the need for a parallel SDR/HDR production workflow.

HDR/SDR-compatible workflows

A full parallel HDR and SDR workflow is the easiest way to produce both at the same time, from a single camera system, through the full production chain.

In a full parallel scenario, the camera delivers two simultaneous signals, one HDR and one SDR. In this simultaneous HDR and SDR production workflow, the camera lens iris is set to HDR output and the SDR gain is used to control the SDR output to the required level. However, with current camera control panels the simultaneous control of two signals in parallel has not been accommodated. One option is to use two of the current camera control panels (one for the HDR output and one for the SDR output) which would require increased operational cost and a larger space requirement.

Another solution could be to add more direct controls at the main user interface or joystick. For many years, nearly all camera control panels used a joystick. The joystick is where the move of one lever controlled the lens iris setting and a rotary control on the same lever adjusted the master black level.

By adding one additional rotary control to the joystick, such as the SDR gain, this can now be controlled simultaneously by the same operator. By adding even more controls around the camera joystick, such as an additional rotary control at the bottom of the lever (Figure 7), even more functions can be controlled in a very easy and ergonomic way.

These additional direct controls are not limited to gain control in HDR operation but can include control of color temperature, sensitivity, detail enhancement and many more. Being able to assign the functions controlled by the joystick allows the operator to personalize the camera control depending on the application and user preference.

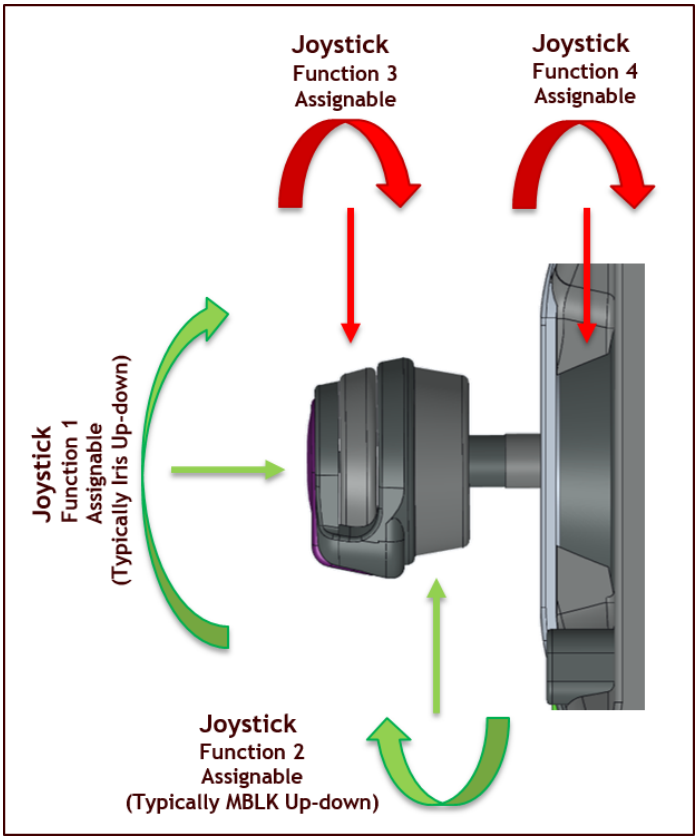

Figure 7 – Joystick with two additional direct controls

New Workflows and New Controls

Overview

Due to the increasing amount of controls and settings needed for today's productions, a clear and intuitive indication of the state of the settings is a critical requirement.

Having an additional graphical indication and control layer on top of the camera control panels will allow for new and intuitive ways for control. A graphical representation of all settings can be easily interpreted and, even more importantly, shows for the first time how settings interact with each other. This allows any user, but especially operators with a limited technical background, to modify settings in a more intuitive way. Through this additional control layer, a link can be established to grading solutions used in post-production applications.

Potential graphical representations

The following are illustrations of potential views of settings grouped into logical sets, representing an image and not necessarily the signal flow inside a camera system.

Figure 8 shows an example of the controls changing the contrast of an image. There, the graphical representation can be used to easily change the contrast in some areas of the signal. Such a graphical representation of the contrast characteristic can be of great help, particularly if SDR and HDR signals have to be managed simultaneously.

Figure 8 – Contrast overview

Here, it is easy to see how the different functions might interact with each other. In SDR operation, gamma has an influence in the overall contrast of the image, but several other settings might be required to change the contrast in only certain regions of the signal range, such as black stretch, black gamma, gamma initial gain, knee, slope and the like. In native HDR operations, some new functions are available to change the look of an image and to apply contrast control to only certain regions of the signal. In some of the latest cameras, these settings are called gamma low, gamma high and gamma break point.

A similar screen (Figure 9) can include all of the parameters related to light and/or the brightness of an image starting at the range extender of the lens and including all other functions, with an effect on the image brightness such as iris, ND filters, exposure time and camera gain.

Figure 9 – Level overview

Yet another screen (Figure 10) can include all the color settings of a camera system. Here, a CIE 1931 color space chromaticity diagram could deliver additional graphical data around WCG operation, but can also help in the use of the color corrector and any other control parameter changing the color representation of the images.

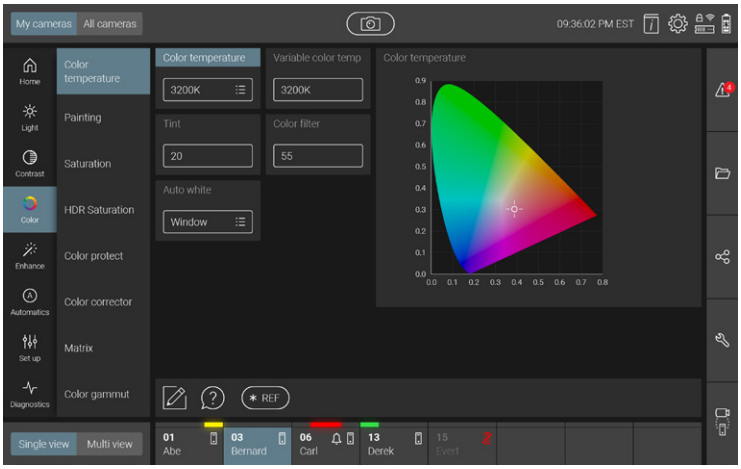

Figure 10 – Color overview

Another possibility is to show and control settings of multiple cameras at the same time. An operator can easily select the number of cameras and configure the functions to be compared, with direct access to all from one screen view (Figure 11). This is a function previously only available on master control panels. It's also a great feature for live camera shading.

Figure 11 – Multicam overview

These are just a few examples of how graphical interpretations in a next generation broadcast camera control solution could deliver a more flexible, more intuitive and fully future-proof solution, where creative talents — even without an extensive technical background — could be delivering better and more dependable results. Likewise, experienced broadcast camera operators will discover many new tools and solutions that allow them to deliver the best results for any type of live production.

Conclusion

The way broadcast cameras are controlled today is based on the way broadcast cameras were controlled in the early days of television. However, the imaging and processing technologies used today offers a level of stability that ensures no deviation of camera signals caused by aging effects or temperature drift should occur. These innovations mean camera control becomes a much more artistic task rather than a technical task. New formats, features and workflows, including simultaneous production in different formats, require new tools to achieve the best results.

A control solution that combines control panels with an increased number of direct instant controls can now be easily configured based on production requirements. Moreover, an additional control layer with an extensive graphical representation of all controls in logical groups (see Figure 12) will very likely offer a more intuitive and future-proof solution.

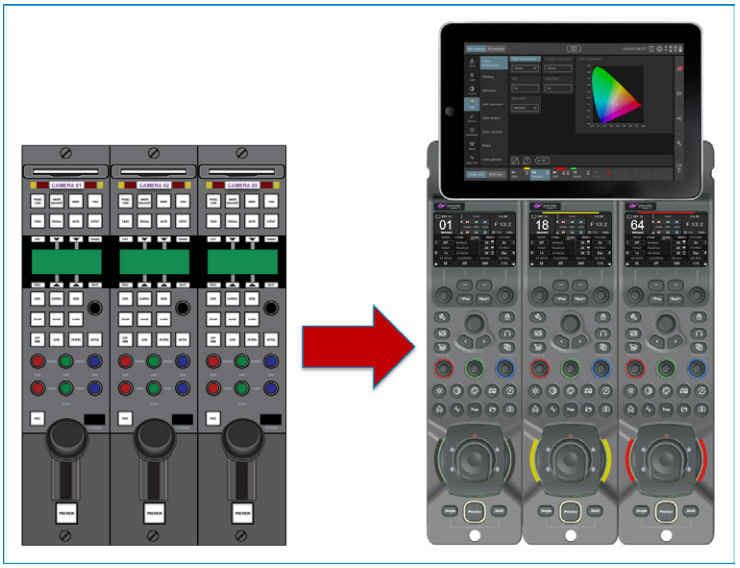

Figure 12 – From camera shading to creative grading

It's time for a change! Creative grading [Ref. 8] is a completely new concept for broadcast camera applications and has the potential to change the future of camera shading.

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References

1. Prof.em.Dr.-Ing.Dr.E.h. H. Schoenfelder, “1929-1967 Von den Anfängen bis zur Farbe” in 75 Jahre TeleVision - Fernseh AG, Thomson Broadcast & Media Solutions, 2004.

2. K. Weber, “Farbfernsehkameras: Technologie im schnellen Wandel” in 75 Jahre TeleVision - Fernseh AG, Thomson Broadcast & Media Solutions, 2004.

3. J. Boston, G. Hoover, “6 Cameras“ in TV on Wheels, 2013.

4. ITU-R ITU-R, BT.2020, “Parameter values for ultra-high definition television systems for production and international programme exchange”

5. K. Weber, “HDR: A guide to high dynamic range operation for live broadcast applications”, White Paper, Grass Valley.com website, December 2018.

6. ITU-R, BT.2100, “Image parameter values for high dynamic range television for use in production and international programme exchange”

7. K. Weber, L. Goerner, P. Walker, “Live At-Home Production 2.0,” *NAB Broadcast Engineering and Information Technology Conference Proceedings 2018* ‘pp. 69-74.

8. K. Weber, R. van Geel, “Creative Grading – Or why a new way of broadcast camera control is needed”, *SMPTE 2018 Conference*, Los Angeles October 2018