# American Society of Cinematographers Motion Imaging Technology Council Progress Report 2023

By Curtis Clark, ASC; Michael Goi, ASC, Jay Holben; David Reisner; Christopher Probst, ASC; Tim Kang; Greg Ciaccio, Joshua Pines, Lou Levinson, Annie Chang, Jesse Korosi, Patrick Renner, David Hall; Joachim Zell; Gary Mandle, Gary Demos; Pete Ludé, Michael Zink

## Strategic Planning / Steering Committee

Made up of the chairs, co-chairs and/or vice-chairs of various committees, subcommittees and working groups.

Chair: Curtis Clark, ASC
Co-Chair: Michael Goi, ASC
Co-Chair: Wendy Aylsworth
Co-Chair: Jay Holben
Council Vice-Chair & Secretary:
David Reisner
Vice-Chair Emeritus: Steven Poster, ASC
Vice-Chair Emeritus: Richard Edlund, ASC

## Introduction

Chair, ASC Motion Imaging Technology Council (MITC): Curtis Clark, ASC

2023 marks the 20th anniversary of our **ASC Motion Imaging Technology Council**. Initially formed as the ASC Technology Committee at the dawn of Digital Cinema, we soon recognized the daunting challenges we were facing and responded with a determined commitment to play our part in shaping Digital Cinema technologies.

For 20 years the ASC MITC has provided consistent leadership throughout the entire transition of our industry from film to digital, including the development of new tools along with development of digital techniques and technologies for making movies and scripted narrative content for broadcast television and streaming services. Continued developments and advances in digital motion imaging technologies, along with significant changes in the production environment, require our continued leadership to best ensure that these rapidly advancing technologies effectively serve the creative interests of cinematographers and their filmmaking collaborators to further enhance their ability to achieve their uncompromised creative vision!

The reports in this 2023 ASC MITC Annual Progress Report contain important initiatives from our various MITC Committees, Subcommittees and Working Groups, including our **StEM3 VP** (Standard Evaluation Material 3.0 - Virtual production) from our **Joint Technology Committee on Virtual Production**.

Also, the release of two new imaging workflow applications that provide critical solutions for imaging workflow management: the **ASC Media Hash List (MHL)** and the **ASC Framing Decision List (FDL)**. We have also formed a new committee **Academy Color Encoding System 2.0 (ACES 2.0) Color Management Committee,** which will address, working in collaboration with Academy of Motion Picture Arts and Sciences (AMPAS), the need for a comprehensive robust color management system that will provide end-to-end color management control enabling the cinematographer to utilize the power of ACES to create and control the chosen look throughout the production workflow. We continue to focus on advanced display technologies that are able to accurately reproduce creative looks that take full advantage of wide color gamut and High Dynamic Range (HDR).

ASC MITC is diligently tracking the emergence of **Artificial Intelligence (AI)** and the potentially disruptive impact it could have on our Motion Picture industry, affecting virtually all facets of filmmaking. This especially concerns creative human talent both in front of and behind the camera. We are just beginning to grasp the enormity of this technological challenge and how it might be used constructively in ways that facilitate the occurrence of new tools to be used by filmmakers in the creative process. The ASC MITC has formed the **ASC MITC Artificial Intelligence Committee,** which will address these developments.

I would like to extend my grateful appreciation for the work being done by our dedicated ASC MITC participants. Without their enthusiastic participation, ASC MITC could not achieve our ambitious objectives!

## Camera Committee

Co-Chair: David Stump, ASC
Co-Chair: Bill Bennett, ASC
Co-Chair: Christopher Probst, ASC

Even with the setbacks from the pandemic, there has been significant activity with motion picture camera systems. Just within the last three years, six high-end cameras have been released from major manufacturers like Arri (Alexa 35), Sony (Venice 2) and Red (V-Raptor,V-Raptor XL,

*Digital Object Identifier 10.5594/JMI.2023.3295469*
*Date of publication: xx xxx xxxx*


1545-0279/23©2023SMPTE

Komodo, Komodo-X). Toward that end, the Camera Committee has been actively involved in tracking the latest developments, collaborating with the manufacturers and providing critical feedback on their individual features, as well as organizing educational events to help inform the cinematographic community on the latest developments each system presents.

For example, on the 14th and 15th of January, committee co-chairs David Stump, ASC, and Bill Bennett, ASC, collaborated with Arri at their Burbank facility/stage to organize a "Master Class for Masters," an intensive workshop for the ASC membership to explore in depth the Arri Alexa 35's new features and capabilities. An integral part of that training included a deep dive into profiling the Alexa 35's new Reveal color science pipeline and its improved exchange with ACES.

The committee is also working with other MITC initiatives such as the Joint Committee on Virtual Production and Lens committee to facilitate synergy between the various hardware systems utilized within that technology – camera, lens, tracking, LED panels, and the game engine/media server systems.

# Lens Committee

Chair: Jay Holben
Vice-Chair: Christopher Probst, ASC

The ASC MITC Lens Committee has held two events specifically aimed at ASC Members to provide the opportunity to evaluate the latest offerings in cinema optics hands-on. The ASC Lens Days were held in December 2022 at the ASC Clubhouse and featured 14 main manufacturers with display spaces presenting their newest offerings since 2019. Each manufacturer had a trade-show-like "booth" with their lenses. We also provided a lit model setup with cameras to test the lenses. The event also featured a separate area focused on rehoused lenses from five different companies with another lit model and cameras for testing. ASC Members Markus Förderer and Autumn Durald Arkpaw also offered presentations on the use of creative lenses in their projects.

The second event was recently held in Brooklyn, NY, at the AbelCine facility. Mirroring the event that was held in Los Angeles, CA, 16 vendors brought their lenses for East Coast-based ASC Members to evaluate a wide variety of lenses covering Super 35, full frame, spherical, anamorphic, prime and zoom. The event also featured a presentation by Associate ASC Member and Lens Committee Chair, Jay Holben, on the science and creative implementation of lens customization or lens tuning as well as a panel discussion featuring ASC members Stuary Dryburg, Fred Elmes, Frankie DeMarco, and Anastas Michos.

The Lens Committee will embark on an investigation of the character of optics in relation to LED displays utilized in LED walls for virtual production and in-camera visual effects production.

The ASC MITC Lens Committee has been progressing with two Working Groups, both under the leadership of Associate ASC member Matthew Duclos.

## Filter Classification System Working Group

Chair: Matthew Duclos

The Filter Classification System is a project that strives to measure and classify camera diffusion filters in terms of a numeric system specifying individual variables of halation, contrast, and resolution. The testing will consist of subjective practical measurements taken through traditional photographic means, an empirical photographic measurement utilizing specially crafted tools to exploit the various attributes and a proprietary system custom made to measure these filter characteristics completely agnostic of any camera or lens. Once completed, the system will allow cinematographers to identify the specific image-altering characteristics of every diffusion filter so that they may make more informed decisions and utilize more precise variations in their productions.

## Flange Focal Distance Working Group

Chair: Matthew Duclos

The Camera Flange Standards Working Group is investigating the current practices of both lens and camera manufacturers in setting their lens mount flange depth specifications. It has come to the attention of the committee that due to the variation in digital sensor optical block thicknesses and layers, the physical adjustment of flange depth has deviated from the standard into an individual manufacturer solution. The result is that not all digital cameras have their image plane at the precise mount flange depth, nor are they all adjusted for that flange "in air," but rather there is a mishmash of interpretations of the standards. Likewise, some lens manufacturers are sending out their lenses specifically collimated to an individual camera rather than to a standard flange for that mount. The Working Group is currently investigating the matter thoroughly and speaking to engineers from both camera and lens manufacturers and will strive to publish best recommended practices for both.

# Lighting Committee

Chair: Tim Kang
Vice-Chair: Jon Miller

*The following report incorporates contributions from the Lighting Committee and the Lighting Color Science Subcommittee, Integrated Lighting Systems Working Group and Lighting Education Subcommittee.*

The ASC MITC Lighting Committee continues its mission to usher technological rigor and clarity to

increasingly complex lighting ecosystems in modern motion picture productions.

From tackling LED spectral metamerism to bridging the gap between legacy lighting control practices and modern image-based lighting approaches, the Lighting Committee currently addresses the following initiatives and activities:

- Defining legacy filtration-based lighting color control practices with spectral bases and standardized colorimetric practices.
- Provide rigorous technical definitions for the pandora's box of novel on-set lighting practices ushered in by virtual production. These novel techniques include: on-set application of legacy computer graphics rendering Image-Based Lighting workflows; video-signal-based colorimetric control protocols; novel lighting color control signal methodologies.
- Educating lighting manufacturers and filmmakers to understand, support, and use these updated lighting color control practices.

### *Past:*

The Lighting committee was created in 2019 to address wide spectral variance in the LED industry leading to significant post-production color issues from the resultant metameric failure in camera. Initial work recognized spectral definitions as outlined in Illuminating Engineering Society (IES) TM-30 reference illuminant specifications for blackbody, CIE (International Commission on Illumination) Daylight, and the "transition" Co-related Color Temperature (CCT) region from 4000K to 5000K.

It promoted the use of AMPAS Spectral Similarity Index and recognized it as a reasonable spectral target for manufacturers to pursue with lighting fixture products.

For white point "tint" control, it also traced legacy lighting filter tint correction conventions back to Kodak Wratten CC (Color Compensating) filters, and redefined lighting colorimetric definitions for green/magenta tinted white light. Specifically, the committee defined Wratten CC36G as a reasonable spectral filter definition for common "plus green" tint lighting filters used by set lighting technicians, and Wratten CC30M as a reasonable spectral filter definition for common "minus green" tint filters (**Fig. 1**).

By combining these filters with the entire TM-30 reference illuminant series, the resultant spectral outputs formed colorimetric extents of the CIE 1961 Δuv values per CCT— a colorimetric value commonly used by the lighting industry to define tint for a given CCT as well as CCT "pre-adjustment" values to provide the correct final CCT+ filter adjustment spectral targets for a desired tint value.

These standards have formed the basis of creating spectral targets for the use of LED display tiles and LED lighting fixtures in virtual production to project video-based environments onto sets in virtual production.

### *Present:*

In addition to spectral standards, the committee recognized two additional needs in on-set Image Based Lighting applications in virtual production sets:

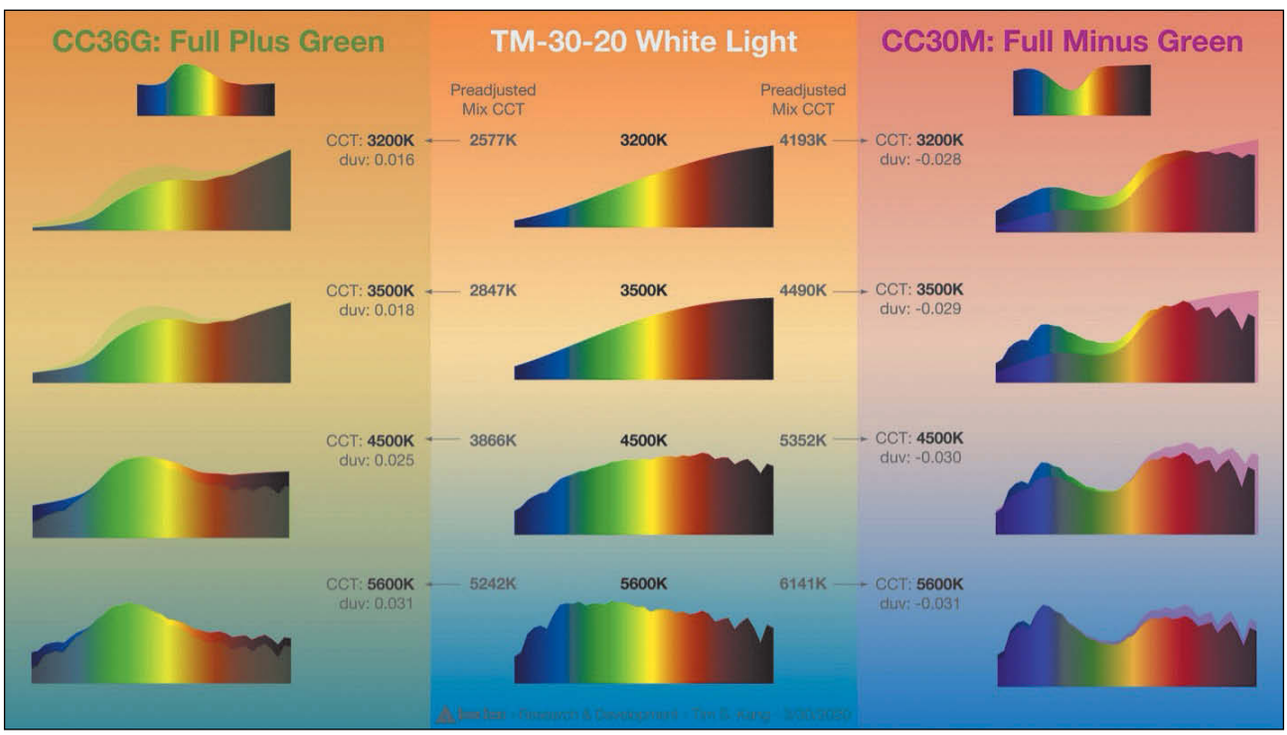



**FIGURE 1.** Spectral power distribution graphs showing reasonable spectral targets for common "plus green" and "minus green" standards at different correlated color temperatures using a TM-30 reference illuminant.

FIGURE 2. Set up for the demonstration of image based lighting techniques using LED lighting fixtures and LED display panels at the ASC Clubhouse during the SMPTE 2022 Media Technology Summit.

1) A common standard DMX lighting protocol profile definition for interpreting video RGB signals
2) The need for high-output, point source light capability for day exterior/day interior lighting environments unachievable by display tiles.

To this end, the Lighting Committee organized an Image-Based Lighting volume demonstration in the ASC clubhouse during the SMPTE 2022 Media Technology Summit (**Fig. 2**).

The demonstration achieved the following goals:

1) Demonstrate the power of spectrally optimizing fixture output for broadcast Rec. 709 gamma 2.4 color space for legacy video signals as an RGB colorimetric control signal.
2) Using point source lights provided by member manufacturers physically forming a sun path as real-life video pixels.
3) Lighting fixture arrays as the environmental light sources defined by video signals.
4) Digital photographic backdrop projected by a ROE BP2 LED wall, sourced from a preexisting 22K resolution backdrop image database provided by Rosco Laboratories.

All three subcommittees devoted significant time to organize this event: Lighting Color Science specified the Rec. 709 gamma 2.4 DMX profile spectral and colorimetric behavior for manufacturers; Integrated Lighting Systems brought in Original Syndicate to drive the demonstration with a disguise D3 media server; and Lighting Education organized over 13 different vendors to produce the entire prep and vendor process.

*Ongoing:*

5) Using High Dynamic Range image (HDRi) content commonly used in visual effects (VFX) computer rendering workflows as the basis for driving photometrically accurate lighting arrays on set.
6) Defining a relative, 0 -> 1 version value of HDR signals as lighting control data, not as absolute nit luminance-based values.
7) Creating a "simple" AP0 Linear 16 bit RGB-only DMX profile, as well as Rec. 709, DisplayP3, Rec. 2100, etc.
8) Pilot ASC lighting committee LED color science basics class for Local 728 lighting technicians.
9) Pilot ASC lighting committee Advanced Image Based Lighting class for Local 728 lighting programmers.

*Future:*

1) Recommend and test a new lighting control profile that supercedes DMX. Organize a plug-fest for manufacturers to test in a stress-free, collegial, collaborative environment.
2) Present and educate ASC members of the expanding role of the lighting programmer as "the DIT" of lighting department.
3) Organize a plugfest for testing AP0 linear 16 bit RGB DMX profile and other RGB profiles.
4) Organize ASC Lighting Day for ASC membership.

## Motion Imaging Workflow Group

Chair: Greg Ciaccio
Vice-Chair: Joshua Pines
Vice-Chair: Lou Levinson

As motion imaging workflows become increasingly connected, from pre-production through production and post, interchange between these phases is becoming increasingly essential. The ASC MITC Motion Imaging Workflow Group, which includes the Committees and Working Groups attached to those Committees, is dedicated to the preservation of the filmmaking creative process, and the tools developed should allow for the enablement of creative expression simply and effectively for maximum accessibility to cinematographers and their crews.

The ASC Color Decision List (CDL) is a great example of a simple cross-platform color language, which allows looks to be conveyed throughout the filmmaking process, including visual effects. This remains the de facto standard.

Our Image Data Management Committee's Working Groups continue work on the two below important initiatives, and much progress has been made as we've moved from the design phase, to implementation, socialization, and future version refinement.

## Image Data Management Committee

Chair: Jesse Korosi

### ASC MHL Working Group

Chair: Patrick Renner


The specification for Media Hash List (MHL) was published in 2022, defining an exchange format that records hash values and keeps track of the history and life cycle of media files throughout media workflows. Adoption started quickly with updates for on-set data management software products with native support for ASC MHL.

The first learnings from these implementations have been collected by the ASC MHL working group in an "ASC MHL Implementation Guide document" published in March 2023. The implementation guidelines build on the specification document and add informal examples, use cases, and proposed conventions for illustrating the concepts of the ASC MHL specification and allowing for an easy-to-follow guide for vendors implementing ASC MHL.

Currently, post-production software vendors are joining the discussion for integrating ASC MHL manifest histories in facility workflows to further verify and track file integrity and completeness along the media workflow.

For more information, please visit the ASC MHL page (theasc.com/society/ascmitc/asc-media-hash-list).

### ASC FDL Working Group

Chair: David Hall


The specification for the Framing Decision List (FDL), which defines a mechanism to document framing decisions throughout all phases of a post-production's life cycle from pre-visualization through post-production, was published in Q1 2023. The full specification is available via the ASC FDL page (theasc.com/society/ascmitc/asc-framing-decision-list).

The FDL can exist in the form of a sidecar JavaScript Object Notation (JSON) file or embedded into another data structure like camera original files. Anytime an application renders media for downstream use, an accompanying set of ASC FDL data should be created and delivered. Therefore, any downstream applications are able to apply the intended frame.

Since its release, the ASC's Advanced Data Management Subcommittee hosted a roundtable at the Hollywood Professional Association (HPA) Tech Retreat, had a presence at the National Association of Broadcasters (NAB) show gaining support for the specification's implementation, and worked with Light Iron to realize the first implementation of the FDL in a frame line generation tool. Many software and hardware manufacturers have indicated that the ASC FDL is on their roadmap in 2023 for adoption, with Colorfront being the first to implement and release an official ASC FDL tool.

For more background and details, please visit the ASC MITC Image Data Management page (above) as well as last year's SMPTE Progress Report published (September 2022).

## ACES 2.0 Color Management Committee

Chair: Annie Chang

The Academy Color Encoding System (ACES) is a free, open color management system from camera/animation through finishing and archive, developed by the Academy of Motion Picture Arts and Sciences (AMPAS). In 2017, new ACES leadership embarked on a listening tour to understand what improvements were needed to ACES 1.0, which kicked off a myriad of updates to better document the color pipelines, provide standardized look-up tables, mitigate color space conversion artifacts, improve the camera conversions to ACES and most importantly, create an improved output section that removed undesirable features and provides invertibility. This last item, the improved output transform, will culminate into the highly anticipated ACES 2.0 release.

The ASC MITC has kicked off an ACES 2.0 Color Management Committee that will collaborate directly with the ACES effort at AMPAS to review ACES 2.0 items before the release and provide feedback and guidance for subsequent releases. The Committee will also guide implementers and manufacturers with adoption requirements. ACES 2.0 and follow-up education and training materials will help make color management easier and more consistent for creatives and their crew. ASC MITC members have participated in ACES design from the earliest days. The ASC MITC has historically been a strong supporter of ACES efforts, and with this new Committee will have an even stronger influence and impact on the future of ACES through collaboration, testing, and feedback.

## Digital Intermediate Committee – *Au Revoir*

Co-Chair: Lou Levinson
Vice-Chair: Joshua Pines
Secretary: David Reisner


After decades of working on the forefront of post-production technologies and workflows, and making such

significant industry contributions as the ASC CDL (used tens to hundreds of times in almost every path and component of the production and post workflows of the vast majority of movies and most scripted TV in the world) and important components of ACES, it falls to me as Chair of what started as the Digital Intermediate sub-committee of the ASC Technology Committee, along with my Vice-Chair Joshua Pines and Secretary David Reisner, to announce that Digital Intermediate is now providing part of the fabric of the Motion Imaging Workflow Group of the ASC Motion Imaging Technology Council. Joshua and I will be Vice-Chairs under Chair Greg Ciaccio; David is now Vice-Chair and Secretary of the ASC MITC Strategic Planning / Steering Committee.

We are looking forward to continuing to provide impact, enlightenment, and the most solid technical basis for artistic expression to the production and post-production community moving forward.

We would like to express our grateful thanks to all who have contributed along the way.

## Next-Generation Cinema Display Committee

Co-Chair: Wendy Aylsworth
Co-Chair: Joachim Zell

The Next Generation Cinema Display Committee oversaw the creation of the StEM2 (Standard Evaluation Material 2.0) film, and it was a great success (see report below).

Currently, NGCD is working with the ASC MITC Joint Committee on Virtual Production on the StEM3-VP project, which will be used to test and evaluate Virtual Production LED stages.

An upcoming project is a metamerism test defining the needed offset between xenon lamp-based projection, laser projection and narrow bandwidth LED wall exhibition. Golden eye groups will be invited to view similar content side by side with the aim to find a common offset for these different devices.

### Standard Evaluation Material 2.0 (StEM2) Working Group

Chair: Jay Holben

In 2022, the ASC released the StEM2 short film, *The Mission*, first publicly shown at the HPA Tech Retreat in Palm Springs, CA.

StEM2 was crafted to incorporate narrative visual material to push the limits of dynamic range, color gamut, high resolution, motion judder, and more. A 17-minute sci-fi action film *The Mission* delivers multiple locations, times of day, variety of skin tones, variety of lighting conditions, and test chart material all incorporated into the narrative.

Since its release, the StEM2 material has been quickly adopted by the industry at large in evaluation of display imagery and image processing hardware/software. One cannot attend a trade show without seeing StEM2 on the exhibit floor demonstrating monitors or processing software. It has been displayed at technology demonstrations such as NAB Las Vegas, IBC Amsterdam, Cine Gear Hollywood, ASC Monitor Test Day, HPA Innovation Zone, SMPTE LED Wall Demo Day and many other events.

*The Mission* has been used to evaluate advanced cinema exhibition laser projection HDR systems, direct-view emissive HDR theatrical screens, and even to evaluate LED walls for virtual production and ICVFX stages, as well as image-based lighting pixel-addressable LED technology.

More information, including a behind-the-scenes documentary, can be found on the ASC's website at theasc.com/society/stem2. The StEM2 is hosted by the Academy of Motion Picture Arts and Sciences on the Academy Software Foundation Project (ASWF) website as part of the Digital Production Example Library (DPEL) and is free for use to anyone in the industry with a basic creative-commons-type license agreement at dpel.aswf.io/asc-stem2. Users are able to download StEM2 as DCP or QuickTime, SDR or HDR version; in Rec. 709 or P3 or Rec. 2020 color space. A future deliverable will be the IMF App5 master archive file.

## Professional Monitors Committee

Chair: Gary Mandle

Last October, the MITC held an event at the ASC Clubhouse showing ASC Members and industry friends developments and new technologies introduced for production and postproduction applications. In addition, the Professional Monitors Committee hosted a range of monitor manufacturers introducing models intended for on-set usage (**Fig. 3**).

Boland, SmallHD, and TVLogic demonstrated new models based on JOLED-made OLED panels. This was an exciting development, and the Committee wanted to test them once they became available.

JOLED used a new process where the organic layers were deposited lithographically rather than by the more common vacuum disposition. However, this proved too difficult and never allowed for a stable manufacturing process, and on 27 March 2023, JOLED filed for bankruptcy with a 33.7 billion yen debt (about $244M), with the assets then sold to Japan Display (JDI). So, at this time, we do not know when these new monitor models will be available, if at all.

FIGURE 3. ASC MITC Technology Showcase 2022 Professional Monitor Exhibit.

The absence of JOLED panels leaves a hole in the availability of imaging devices developed for critical monitoring and on-set and other processes that require monitoring in sizes under 50 inches.

In sizes over that, there are still significant developments in OLED and Quantum Dot technologies. Most recently, Samsung's introduction of quantum dot backlight technology exciting an OLED emitter. QD-OLED was shown at the October event, and the images were impressive.

The committee hopes to have access to a QD-OLED and Sony's new reference monitor before the end of this year.

Looking further into the future, the committee is taking a closer look at microLED (μLED) technologies. μLED seems to be the next technology that we will see in monitoring. The current development is toward AR/VR applications which require very small pixel sizes. Some are as small as 50 μm and are manufactured as monolithic substrates. But this technology has also been used in large panel assemblies, such as video wall displays and others as wall-mounted monitors. Some are as large as 272 inches at 8K resolution. The technology is modular, so display aspect and size are variables that open up some exciting opportunities.

Finally, another development on the horizon is the possibility of displays using more than just RGB for color primaries. A company named 6P Color, in cooperation with Baylor University, has been demonstrating a display using RGBC primaries, allowing it to exceed the boundaries of ITU-R BT.2020.

Key to their development are simple modifications to the data used in any serial transmission. Instead of formatting image data as RGB, they format it as Yxy. The same data format we use to calibrate a monitor. This formatting is very similar to the DCI method of formatting as XYZ. However, since luminance information is absent in xy, Yxy can be down-sampled to 4:2:2 or even 4:2:0 images yet contain every visible color. Yxy signal formatting eliminates gamut conversion between sources and puts the Yxy to RGB process at the display. The display then formats the information to its particular specifications. One advantage is that two entirely different displays with different primaries will exhibit the same color image until the data exceeds the limits of the lower-performing display. Steps beyond that include the possibility of sending image information to multi-primary displays.

## UHDTV & Advanced Consumer Displays

Co-Chair: Michael Zink
Co-Chair: Bill Mandel

The UHDTV & Advanced Consumer Displays group is focused on educating ASC members on the latest display technologies in home entertainment, with a goal of maintaining the original creative intent. Throughout the past decade, the technological advancements in consumer displays have been staggering – allowing for incredible viewing experiences while at the same time leaving many options for things to go wrong sometimes in ways that may be difficult to perceive to the viewer.

The most recent of these advancements is the introduction of QD-OLED displays to the market (**Fig. 4**). This type of display leverages Quantum Dots (QD) in combination with OLED technology. Quantum Dots were previously used with LED displays (marketed as QLED) to create very vibrant clean spectrum colors and increased peak brightness performance. OLED displays on the other hand, are known for high contrast due to very low black levels and increased viewing angles. QD-OLED displays represent the best of both worlds – combining the benefits of QLED with those of OLED displays.

At the core, QD-OLED displays use a blue OLED layer as the base for each pixel, which is divided into 3 sub-pixels. In addition to the blue sub-pixel, which is the unchanged base layer, the QD layer will turn the blue OLED sub-pixel into green and red sub-pixels. Due to the efficiency of quantum dots, the result is a display with full brightness capabilities for each of the RGB color components and true color reproduction supporting bright saturated colors.

During the ASC MITC Showcase in October 2022, Samsung Display, the leading manufacturer of QD-OLED displays presented the technology, which was implemented in commercial displays from multiple manufacturers, at the ASC Clubhouse. The video of the StEM 2 material was also demonstrated on a QD-OLED display during the event with stunning visual results.

At the June 2023 CineGear show Flanders Scientific announced a new XMP550 55 in. QD-OLED HDR Mastering Monitor, which will be available in September.

An additional demonstration during the ASC MITC Showcase was the implementation of Filmmaker Mode®, a technology solution developed by the UHD Alliance with support from the ASC. Filmmaker Mode disables all post-processing in the displays, preserving the correct aspect ratios, colors and frame rates for a more cinematic experience. This picture mode has been implemented by most of the leading television manufacturers.

The demonstration was focused on the "Automatic Switching" capabilities, which allows service providers to signal to the TV that Filmmaker Mode should be activated, creating a seamless experience for consumers. This capability was demonstrated with two separate services. One of the services was Kaleidescape, an external content server connected via HDMI. The other service was the Amazon Prime Video application natively running on the display. In both scenarios, when the movie started playing, the display automatically switched into Filmmaker Mode to provide the best viewing experience, maintaining the creative intent of the filmmakers.

Delivering the creative intent of the filmmakers through the entire production and distribution pipeline is of paramount importance to the ASC. As such, it supports the current efforts of the UHD Alliance to develop recommendations for appropriate ambient lighting adjustments to ensure that Filmmaker Mode will also deliver the best viewing experience in a varying (e.g., brighter) viewing environments.

## HDR Evaluation Working Group

Chair: Pete Ludé
Co-Chair: Michael Zink
Vice-Chair: Bill Mandel

The HDR Evaluation Working Group was recently launched by MITC to explore high dynamic range (HDR) imaging for theatrical cinema releases. The goal is to provide opportunities for the ASC community to evaluate the visual impact of HDR in a movie theater environment and to consider best practices for on-set monitoring. HDR content has been widely available in consumer's living rooms for several years through services such as Amazon Prime Video, Apple TV+, Disney+, HBO Max, and Netflix. But only recently HDR has also become available for movie theaters. In

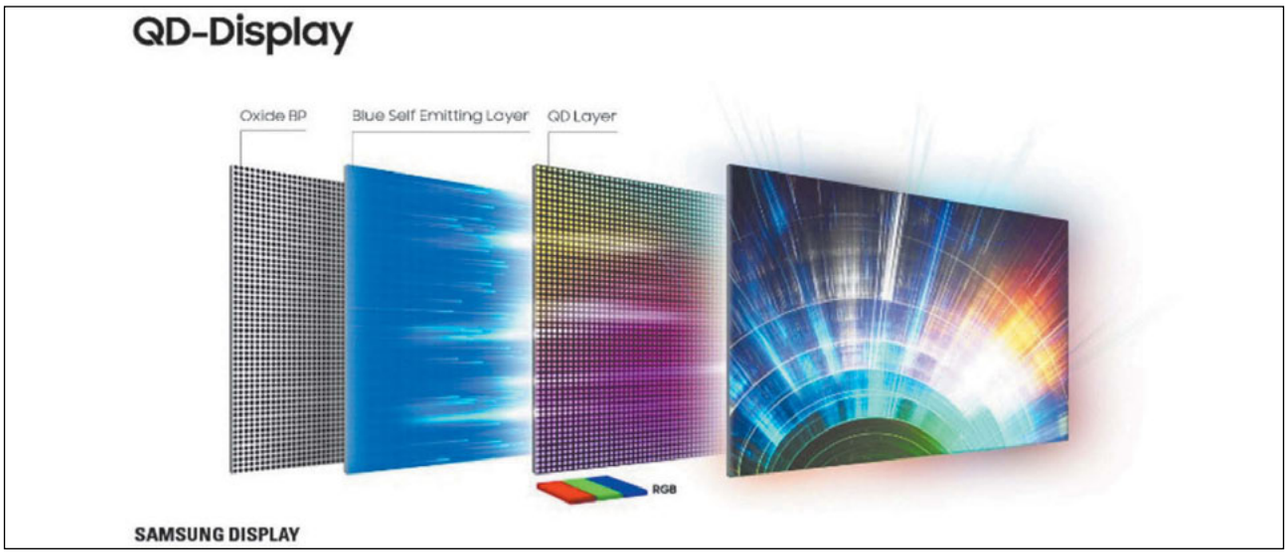



FIGURE 4. The world's first display to integrate printed Quantum Dots with self-emitting layers producing blue light.

March 2023 a major milestone was reached, with the Digital Cinema Initiative (DCI) publishing their High Dynamic Range D-Cinema Addendum, version 1.1. This document defines the specific HDR image parameters for cinema release, following an earlier version of the specification released last year. This HDR addendum is the first significant extension of the Digital Cinema imaging specification since it was released nearly 20 years ago, and it defines a new format with peak luminance up to 300 nits (87 fL) and black level far below today's cinema projectors.

HDR for cinema has become practical in the past few years because of new enabling technologies. One new development is the HDR Light-Steering laser projector introduced by Barco, which was showcased at an ASC Master Class in January 2023. Another novel technology is the LED direct-view display, in which a wall of fine-pitch LED pixels is used to replace the traditional projection screen in the cinema auditorium. Both display technologies are capable of peak luminance far beyond the 48 nits (14 fL) defined in DCI's original digital cinema specification, as well as contrast ratios of up to 60,000 to 1.

Today, there are only about a half-dozen theaters in North America capable of meeting these new HDR cinema specifications, yet there is clearly growing interest by theater owners, filmmakers and DCI-member studios. Already, seven equipment manufacturers have introduced DCI-compliant projectors or LED cinema displays capable of these new specifications. Given the already widespread adoption of HDR displays in homes, theater operators are watchful of how they can continue to provide the best possible experience for first-run motion picture releases – and HDR may be part of future ticket-buyer's expectations.

To prepare for this migration, this Working Group is preparing the first of several screenings to demonstrate HDR imaging to ASC members in a large-screen cinema environment. Participants will be presented with examples of various material specifically color-timed to the new DCI specification, with the opportunity for frank assessment of what works and what doesn't. A variety of content is available for such evaluation, including the new HDR grade of the ASC Standard Evaluation Material 2.0 (StEM2) described earlier in this report.

The Working Group will also explore on-set implications of HDR cinematography, including an initial hands-on workshop to demonstrate the practical aspects of on-set monitoring and evaluation for HDR shoots. Demonstrations will include several popular cameras and HDR displays. These sessions are intended to directly explore the configurations and workflow for on-set evaluation during productions intended for the new HDR Cinema release. Through these careful evaluations, candid discussions and hands-on experiences, we intend to be fully prepared for the evolution of the large-screen cinema experience toward an HDR future.

### ICVFX Display Technology Working Group

Chair: Jay Holben

In the past few years there has been a meteoric rise in the use of LED video walls for all kinds of production from modern rear-projection motion plates to full 3D rendered realtime game-engine in-camera visual effects. As a result, multiple manufacturers are now offering a variety of options in LED panels for this purpose while the established manufacturers are quickly evolving their product capabilities to better cater to this new market.

The newly-formed ICVFX – In-Camera Visual Effects – Display Working Group's goal will be to test, analyze and report on various LED panels used for production. Following in the footsteps of MITC's 2009 ASC-PGA (Producer's Guild of America) Camera Assessment Series (CAS) and the 2012 MITC's ASC-PGA Image Control Assessment Series, this committee will put the current technology through its paces so cinematographers can be better informed on the strengths and weaknesses of each variety of panel. Further, it will establish a methodology of evaluation that can be repeated overtime to keep up with advancements as they're released.

The core team behind this effort will be composed of ASC Members, color scientists, and technologists in collaboration with manufacturers and LED stage facilities.

## Joint Technology Committee on Virtual Production

Chair: David Morin
Vice-Chair: Michael Goi, ASC
Vice-Chair: Jay Holben

### StEM3-VP Working Group

Chair: David Morin
Vice-Chair: Jay Holben
Vice-Chair: Wendy Aylsworth

Because of new developments in game engines and large LED volumes, in-camera visual effects (ICVFX) or in-camera virtual production (ICVP) has become a common form of virtual production used by cinematographers, yet there is no Standard Evaluation Material for ICVFX available to filmmakers.

Following in the footsteps of the original StEM and StEM2, the ASC's Virtual Production Committee has undertaken the StEM3-VP Working Group, which includes David Morin, Jay Holben, Tim Kang, Rod

Bogart, Wendy Aylsworth, Joaquin Jochem Zell, James Fancher, Curtis Clark, ASC, and Michael Goi, ASC. The goal of the Working Group is to provide the industry with a suite of tools to evaluate and verify LED ICVFX stages prior to production. This suite will include 2D, 2.5D, and 3D media intended to expose any weaknesses or problems in the LED wall or the signal path to the camera and assist the cinematographer and production team in evaluating the proper performance of the wall and integration with the production camera for expected results.

StEM3-VP will provide freely and readily available content to evaluate in-camera visual effects stages, documentation, and recipes on what to expect and how to use the content, and technical and artistic evaluation tools to prepare for production.

The VP Committee and StEM3-VP Working Group have met more than two dozen times in the last year to strategize this project and to hear individual case studies presented by leading ICVFX companies on their experiences and methodologies. We have thus far had case studies presented by the likes of Nant, Pixomondo, Lux Machina, ICVR, Disguise, Orbital Studios, Vu Studios, the ETC, MELS, and more. Many of these companies have offered their own evaluation tools to the ASC to be presented within the StEM3-VP suite when that is released.

We are continuing our case studies and starting to gather assets provided by various companies, which we will begin to test on various stages throughout Los Angeles. The Working Group will then decide what components are missing from the collected assets and create those to form a cohesive suite of materials and tools to ease the setup of LED walls for a particular production by providing openly-available media and tools to help standardize the evaluation and proving process.

## Advanced Imaging Committee

Chair: Gary Demos
Vice-Chair: Bill Mandel
Vice-Chair: Pete Ludé
Vice-Chair: Joe Kane
Secretary: David Reisner

For more on the work of this group, see the White Paper at https://www.smpte.org/hubfs/Adv_Imaging_Report_Sept-2023.pdf.

### Computational Cinematography and Plenoptic Imaging Study Group

Chair: Pete Ludé
Co-Chair: Joshua Pines
Co-Chair: David Reisner

The MITC Computational Cinematography and Plenoptic Imaging study group first convened in 2018 in response to advances in light-field camera technology, and the potential impact of computational image processing. We have seen remarkable advances in these technologies over these past five years! Perhaps the most impactful use of computational imaging for motion pictures is the advancement in artificial intelligence (AI) – a topic now being studied in the new MITC AI Exploratory Committee, described earlier in this report.

The Computational Cinematography and Plenoptic Imaging group will be focusing specifically on image capture technologies that might affect future filmmaking. One example is neural radiance field (NeRF) imaging, an extension of light field cameras and photogrammetry, which leverages neural network computation to construct complex 3D scenes starting from a partial set of 2D images. The results coming from research laboratories hint at surprisingly high-quality results. In early 2023, the first television commercial was produced using an early implementation of NeRF on-set image capture, with good results. This study group will be seeking to understand future implications and uses for these developing areas including NeRF cinematography.

## MITC Educational Outreach

Co-Chair: Richard Crudo, ASC
Co-Chair: Bill Bennett, ASC

The MITC Educational Outreach Committee was formed to coordinate a series of events and classes – aptly dubbed "Master Classes for Masters" – focused internally on demonstrating for and educating the active membership of the ASC on the achievements and findings of the Technology Council. In some cases, these events may coincide with more open attendance to select organizations and groups within the industry (such as SMPTE, the HPA, Local 600 and others).

This effort started with the leadership of the MITC Steering and Strategic Planning Committee identifying all of the MITC Committees, Subcommittees and Working Groups and structuring an educational plan for each. The results of this work were presented at two ASC Lens Day events in Hollywood and in New York, organized by Lens Committee Chair, Jay Holben, with each event featuring presentations on modern applications of cine optics including an advanced Mini-Master Class on lens customization presented in New York.

The ASC MITC hosted the Technology Showcase coinciding with SMPTE Hollywood's Media Technology Summit where several committees demonstrated the results of their efforts including the Lighting Committee, under the organization of chair Tim Kang, presenting demonstration of image-based lighting

techniques coinciding with an LED ICVFX wall; the Professional Monitors Committee under the organization of Co-Chair Gary Mandle, showcasing the current selections of professional and consumer monitors for on-set image evaluation; the MHL and FDL Working Groups under the organization of Motion Imaging Workflow Committee chair Greg Ciaccio and Working Group chair David Hall demonstrating the working ASC Media Hashlist (MHL) and ASC Framing Decision List (FDL) with examples of functionality. The StEM2 Working Group, under Next-Generation Cinema Display Committee, organized by Chair Joachim Zell, demonstrated the StEM2 *The Mission* short film and behind-the-scenes documentary on high-end QD-OLED consumer HDR monitors illustrating differences between HDR and SDR presentation in the home. The Next-Generation Cinema Display Committee has also showcased the StEM2 at multiple venues for wide audiences, including ASC members and MITC members in Xenon-lamp traditional digital theatrical projection, new cutting-edge laser HDR projection, and direct-view emissive screen LED exhibition with various comparison of HDR option emulations and Q&A discussions.

The Educational Outreach committee is now under the leadership of Richard Crudo, ASC, and Bill Bennett, ASC, who will continue the work started by the Steering and Strategic Planning Committee to evangelize the work of the Technology Council within the ASC membership and associated organizations.

## ASC MITC Artificial Intelligence Committee

Chair: Michael Goi, ASC
Co-Chair: Annie Chang
Vice-Chair: David Morin

The long-awaited coming of artificial intelligence is no longer science-fiction, it's here. Artificial Intelligence (AI) is leaping into the fray in every aspect of the motion picture industry and its technological capabilities are expanding exponentially on a near daily basis. What was previously considered implausible is already being done. Prompt-based computational imagery through artificial intelligence platforms is creating photo-realistic images and motion images as well.

The American Society of Cinematographers has been at the forefront of imaging technology and science since 1919 and through the ASC Motion Imaging Technology Council, the ASC will endeavor to thoroughly investigate the current and near-future capabilities of computational imagery and the implications to the work of cinematographers.

There's no denying that AI will integrate into every aspect of preproduction, production, and post-production in the same way that digital technology has proliferated in the industry. With this group, comprised of ASC active Member cinematographers, Associates, industry-leading technologists, and imaging scientists as well as manufacturers, the MITC will examine and report on AI as it impacts the cinematographer and, if necessary, develop tools to aid in its use.

The implications of this technology promise to be simultaneously a benefit and a danger to the role of the cinematographer. A guideline on future best practices with an eye toward preserving the artistic contributions of human imaging experts behind the cameras along with an understanding of the benefits of AI and how best to exploit them will be the goal of this committee.

### About the Authors

***Curtis Clark*, ASC**, is chair of the ASC Motion Imaging Technology Council.

***Michael Goi*, ASC,** ISC is a director, cinematographer and producer.

***Jay Holben*** is an independent producer and director in Los Angeles, CA.

***David Reisner*** is an entertainment, technology, business consultant, the vice-founder and the Vice-Chair of ASC MITC, and a Lead Designer of Academy, EMMY, HPA Award-winning ASC CDL and the StEM Standard Evaluation Material.

***Christopher Probst*, ASC**, is a cinematographer and a member of ASC.

***Annie Chang*** is Vice President Creative Technology at Universal Pictures.

***Tim Kang*** is a Los Angeles-based cinematographer. music video, and documentary projects.

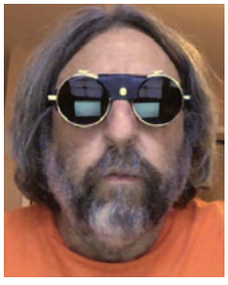
***Jesse Korosi*** is the Manager, Production Technology Solutions at Netflix, an Associate Member at the ASC.

***Greg Ciaccio***, Senior Director post-production, original content and image capture at IMAX.

***Patrick Renner*** is a specialist in designing and developing media management and video processing applications for production and post-production workflows.

***Joshua Pines*** oversees imaging and color science at pictureshop, has always thought that computers could be a useful tool in making movies better, and he still hopes that one day this may come true.

***David Hall*** Senior Manager, Production Technology at Netflix.

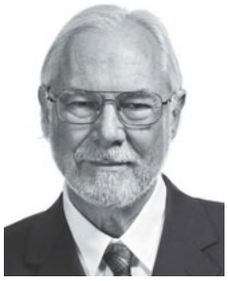


***Lou Levinson*** currently works at Apple in the San Francisco Bay Area. He is a long-time Associate Member of the ASC, the Vice-Chair of the MITC Digital Intermediate Committee, and a Member of the ASC Technology Committee since its inception.

***Joachim Zell*** is a consultant on production and post-production workflows, ACES and Imaging Science.

***Gary Mandle*** is CEO at Outtahand Industries.

***Pete Ludé*** serves as chief technology officer of Mission Rock Digital, a San Francisco-based engineering firm.



***Gary Demos*** has been a pioneer in the development of computer-generated images and digital image processing for use in motion pictures.

***Michael Zink*** is vice president of emerging & creative technologies at Warner Bros. Discovery (WBD). He is also Education Vice President at SMPTE.

*Inquiries regarding the ASC Motion Imaging Technology Council should be sent to Alex Lopez: alex@theasc.com*