Report from the **American Society of Cinematographers Technology Committee**

By Curtis Clark**, ASC; **David Reisner**; **Don Eklund**; **Michael Karagosian**; **Eric Rodli**; **Steve Schklair**; **Gary Demos**; **Jim Fancher**; **Greg Ciaccio**; **Lou Levinson**; **David Stump**, ASC; **David Morin

ASC Technology Committee Officers

***Chair:** Curtis Clark, ASC*
***Vice-Chair:** Richard Edlund, ASC*
***Vice-Chair:** Steven Poster, ASC*
***Secretary:** David Reisner, D-Cinema Consulting*

Introduction

***ASC Technology Committee Chair:** Curtis Clark, ASC*

In the year since our last (2014) ASC Technology Committee Progress Report for *SMPTE Motion Imaging Journal*, there has been an escalation of interest in several game-changing digital motion imaging technology developments that we had previously identified. These include: high dynamic range (HDR) camera image capture and image content display (for both next-generation TV monitors and digital cinema laser projection); wide gamut color image capture and image display (beyond both DCI P3 for digital cinema and Rec. 709 for HDTV); and the Academy Color Encoding System (ACES), which provides vital color and tone scale management. There is also growing interest in high frame rate (HFR) shooting, sometimes mated with HFR digital cinema projection that increases temporal resolution in addition to the already pervasive 4K spatial resolution for cameras, digital cinema projection, and ultra-high-definition television (UHDTV).

As "home theater" displays become larger with greater resolution, higher contrast, wider gamut color (targeting Rec. 2020), HDR reproduction is being added to new consumer display panels that incorporate luminance levels over 1000 nits. The result is an enhanced creative canvass and palette that expands beyond the brightness, contrast, and color constraints of current consumer HDTVs.

Also, with the advent of laser-based digital cinema projection, the potential of HDR is becoming a new reality for cinema screen brightness in excess of 30 fL. There is a shared convergence value between HDR in digital cinema laser projection and the latest generation of UHDTV displays since filmmakers require consistency of a creative look across different distribution platforms.

The two sides of HDR include image capture capable of recording a high dynamic range of original scene tones (14 to 15 stops between the darkest shadow detail and the brightest highlight detail), as well as the ability to show that extended range of scene tones via high brightness displays.

The key to proper HDR display is to expand the luminance level of upper mid-tones and highlights, which adds greater depth and dimensionality to their reproduction while retaining the richness of a solid black level with nuanced shadow detail, good contrast gradation, and proper color reproduction throughout the entire dynamic range.

The UHDTV and Next Generation Cinema Display subcommittees have been vigorously engaging these issues, along with the technology developments specific to their respective imaging display agendas: UHDTV and digital cinema laser projection.

The Advanced Imaging subcommittee has been diligently exploring the parameters for a viable single source graded master that accommodates the possibility of maintaining the consistency of creative look across differing HDR display brightness levels.

There are, of course, important update reports from our Camera subcommittee, Motion Imaging Workflow subcommittee, Digital Finishing subcommittee, and Virtual Production joint committee.

The ASC Technology Committee is guided by its primary mission to engage and influence motion imaging technology developments in ways that better serve and protect the filmmaker's creative intent and the role of the cinematographer in realizing a creative vision that best serves that creative intent.

I would like to thank all those who devote their time and expertise to support the mission of the ASC Technology Committee.

Secretary's Comment

***ASC Technology Committee Secretary:** David Reisner*

Aside from collecting awards for the ASC Color Decision List (CDL), during the past year, the ASC Technology Committee has been focused on helping to coordinate the industry and find paths forward through some very significant changes in technology, post-production, and in both theatrical and home viewers expectations. The pace and magnitude of change has not slowed. We continue to work in support of technology development to support creative intent and audience experience across the expanding and wide range of delivery platforms.

Only a year ago, the adoption of 4K seemed uncertain. Now, it is at least in concept the default, and not just in the U.S. (China may be the widest user of 4K in cinema, at this point). NAB 2015 saw the 1.0 release of ACES and demonstration of many products supporting ACES. ACES has the potential to regularize workflows and the meaning of the image data being processed, but we haven't had enough time yet to know if the industry will take the smart and general approach.

The ASC Technology Committee has participated in, or originated developments that affect the vast majority of viewer experiences. We worked with DCI to create StEM (the ASC-DCI Standard Evaluation Material) to help establish the requirements for digital cinema, and

about 97% of theater screens worldwide are now digital. We identified the need for and created the Academy, Emmy, and HPA Award-winning ASC CDL, now used as part of the workflow of more than 90% of movies, 70% of scripted series TV, and 99% of visual effects (VFX) turn over.

We are now working actively with the key industry participants and groups on laser and other new higher luminance illumination systems, wide color gamut, and actually making and delivering content in the still evolving UHDTV, Rec. 3 2020 envelope world.

UHDTV Subcommittee

Chair: *Don Eklund*

The UHDTV subcommittee has been meeting periodically, as a group and with outside organizations, in an effort to study the current state of UHD, particularly with respect to HDR. This effort has had two parallel explorations—HDR mastering and HDR professional and consumer displays.

With the help and expertise of members, the group has made good progress mastering content suitable for evaluation and has used this content as a source for multiple displays including prototypes, as well as current consumer and professional models. In May 2015, the ASC hosted an HDR demo day for filmmakers and a wide collection of other industry professionals. Each session included a briefing on the technical, practical, and artistic issues being raised by HDR, then allowed participants to view and ask questions about a number of recent production and prototype liquid crystal display (LCD) and organic light-emitting diode (OLED) display models with varying capabilities, using the same reference images displayed on all devices.

Many days of testing and evaluation with the cooperation of manufacturers have given us a foundation on which to understand the unique requirements for reproducing HDR images with various content and display types. The use of test signals and content has also been essential to verify that the systems under test are working as expected. For example, it is important to verify that HDMI devices used for testing are HDMI 2.0 compliant in order to avoid truncation of color depth to 8bpp and verify that the signal path is supporting 10 bits using a ramp signal.

Over recent months, we have seen significant improvement in the HDR performance of consumer displays. With that said, there are still key aspects of mastering and rendering HDR that continue to need study:

- EOTF (Electro-Optical Transfer Function) in the case of Perceptual Quantization (PQ) radiometric luminance performance is specified (SMPTE 2084) for a given code value, but in practice, consumer displays appear to implement a compression curve with an asymptote compatible with the maximum brightness the device can achieve (which also is dependent on the area illuminated). The parameters of these compression curves do not appear to be standardized and as such, it is not possible to predict precisely how images will be reproduced across a range of HDR devices. PQ also is specified as a luminance value and care must be taken when signal processing and transmission is performed in color components.
- Presenting the intended image to a viewer in high definition has always depended on viewing conditions, specifically ambient light. If during color grading it is determined that information near black is important, it may be adjusted (gain applied) in order to ensure it can be resolved on typical consumer standard dynamic range displays. In the case of HDR displays, a substantially wider luminance space can be coded, but this has no value if the image being displayed is too bright or too dark for a given viewing condition. Accordingly, it is clear that it has become increasingly important for displays to adequately address this issue (note that mobile phone displays have been doing so in some form for years).

Through discussion with content owners, it is clear that the "correct" way to master HDR has yet to be determined. For example, the practice of grading masters while looking through a luminance compression curve or with a display that has a specific brightness/illuminated area limitation will certainly give unexpected results if the master is viewed on a range of consumer and professional displays. Similarly, if an attempt is made to keep the observed luminance of mid gray at the same level for both standard dynamic range (SDR) and HDR displays with the objective of maintaining HDR for brightness headroom, are we wasting dynamic resolution below mid gray that could improve the viewing experience?

Having mastering tools and methods that allow creative control and help the operator avoid creating unpredictable images is critical. It is now possible to encode color range and picture levels that far exceed what commercially available displays can reproduce. While having new standards that allow coding pictures with extraordinary properties is exciting, having the tools and expertise on hand to put guardrails in place is now essential.

Input to the group is welcome, provided that it can be shared on a non-confidential basis. Contact asc-uhdtv (at) d-cinema (dot) us.

Next Generation Cinema Display Subcommittee

Co-Chair: *Michael Karagosian*
Co-Chair: *Eric Rodli*
Co-Chair: *Steve Schklair*

The Next Generation Cinema Display subcommittee is concerned with satisfying the creative intent of filmmakers during the emergence of laser-illuminated projectors. The group seeks to work with technology developers and manufacturers, offering expert review and guidance in the aesthetics and presentation quality of the projected image.

For example, much attention has been paid to the causally related effects of metameric variability, where multiple viewers simultaneously experience differences in color, and speckle, a sparkly effect caused by wave interference at the projection screen. Both effects are the result of narrow-band primaries. While technology developers have techniques for mitigating these effects, there has been little study across demographics of the perception of these effects in commercial illuminators. Other factors such as the production and distribution workflows required when adopting wider color gamuts also deserve attention. The ASC is the ideal group to provide guidance and feedback to the manufacturers, especially for

the difficult to measure perceptual aspects of new motion picture projection technologies.

In an effort to better understand the facts of laser illumination, the group developed and submitted a Request for Information (RFI) to eight technology providers. At the time of this writing, the group is gathering responses. The RFI explores multiple areas:

- Information and recommendations concerning the achievement of wide color gamut (e.g. Rec. 2020) and the selection of color primaries in projectors to support wide color.
- Information related to cinema high dynamic range, including black and peak white illumination levels.
- Observations of metameric variability, and the relationship, if any, to color primary selection.
- Observations of speckle, and the relationship, if any, to color primary selection.
- Information regarding 3D applications, including recommendations for color space and light levels. Information regarding achievement of uniform light levels at the eye between 2D and 3D projection.
- Information and issues regarding measurements, such as discrepancies in measurement accuracy.
- Information regarding observer perception due to color matching functions.
- Identification of ambient light levels for respective test conditions.
- Interaction of screen type on performance.

3D image quality has long been a concern of the ASC. The ASC target for 3D illumination level is 14 fL, as stated in our report last year. We're pleased that DCI has now raised its target for 3D illumination to 14 fL from 7 fL for RGB-laser installations.

While the group's attention was originally directed towards laser illumination, the scope of this group is expanding to include all emerging display technologies for cinema. Laser illumination technology not only includes RGB-laser, producing narrow-band primaries, which also tend to be costly, but other laser-driven solutions, such as laser-excited phosphor, where lasers are applied in a much lower-cost manner. New display technologies do not stop with lasers, however. The push in Europe for widespread use of solid state lighting will reduce the cost of certain LEDs, and is driving R&D for new projector illuminator technologies that take advantage of this. In addition, direct emission LED light walls now exceed the pixel density of 4K projectors and will soon have color spaces approaching Rec. 2020. As the cost of this technology is reduced, it could prove to be effective for HDR in cinema.

The days of xenon illuminators will be numbered as more cost-efficient and/or more capable projection and display technologies emerge. Effort is needed to guide the development of these new technologies for the betterment of visual quality and workflow. Recognizing this need, the ASC Technology Committee is exploring its options for a venue where new display technologies can be evaluated in partnership with content providers, technology developers, and manufacturers.

Advanced Imaging Subcommittee

Chair: *Gary Demos*
Vice-Chair: *Jim Fancher*
Vice-Chair: *Phil Feiner*
Secretary: *David Reisner*

The Advanced Imaging subcommittee has been very active in support of HDR image processing in conjunction with the UHD subcommittee. Special emphasis has been given to investigating whether a single master can serve a useful range of maximum brightnesses.

In order to make this work as tractable as possible, the range of emphasis has been limited to presentation with maximum brightnesses between 250 nit and 1000 nit. This range has in part been selected because there have been a number of successful HDR mastered example presentations within this range. At higher brightnesses, the lower portion of the brightness range can be handled using simpler and more natural processing. Below 250 nits there are complexities stemming from the required reduction in range needed for pleasing presentation. The bottom portion of an S-Curve, and its impact on color appearance, causes challenges specific to the lower brightness levels. The relationship of mid-grey to mid-white and bright-highlight-white is also not fully understood. Above 1000 nits, pleasing aesthetics often seem to be difficult to achieve.

In the 250 nit to 1000 nit range of mastering and presentation, algorithms are being explored that provide mechanisms for adjusting for consistent appearance throughout this range by having each display adapt for its specific characteristics (and settings and environment).

In addition to the range being limited, the exploration effort is also staying within the P3 gamut (the deployed "minimum gamut" Digital Cinema color range). The P3 gamut provides significant color improvement over Rec. 709's gamut, while not extending into Rec. 2020's more extreme color saturation levels that are likely to raise issues and may vary significantly between displays.

An essential ingredient in this work has been a set of HDR processes that preserve the relative ratios of red, green, and blue, and thus preserve chromaticities. The chromaticity-preserving tools span the end-to-end system from camera through presentation display or projection. Although aesthetic adjustments will typically alter chromaticities, it has proven highly beneficial to have a chromaticity-preserving system architecture "spine" for calibration. The affect of each system process that might alter chromaticity can be isolated while testing. Radiometric tools such as chroma meters and spectral radiometers can be utilized directly with the HDR system tools.

Within this dynamic range and gamut range, a specific challenge is the need to color grade in HDR. This should optimally be possible without increasing noise, and without limiting dark detail, highest brightness, or color gamut. Further, it seems beneficial for the graded HDR master to retain the same scene-referred characteristics as

the camera sources (and other images) that are used as input to color grading. Preliminary testing has demonstrated that this is feasible.

There is also an ongoing effort to explore appearance affects in HDR presentation. These include "colorfulness" as a function of absolute brightness, as well as the appearance effect of the ambient room brightness surrounding the display. The goal is to initially attempt to reproduce a consistent appearance over the range of presentation attributes. Specific algorithmic mechanisms for adjusting for colorfulness and ambient surround are being investigated, with promising results thus far.

Eventually, the appearance intent from HDR grading will need to be combined with the appearance adjustments related to presentation variations, to yield an HDR mastering and distribution system that provides full creative control. That system will then need to be integrated with the aesthetic control of HDR principal photography to yield the HDR visual language and HDR methodologies that support such control.

Professional Display Subcommittee

Chair: *Jim Fancher*

The past year has been very active with the delivery of professional level displays capable of P3 and HDR. Most notably, the Sony OLED and the Canon LCD displays, which were instrumental in demonstrating some of the HDR material with which we have been working. Most of our efforts have been in focused on HDR and UHD, participating with other subcommittees, particularly the Advanced Imaging subcommittee, to further their goals. We have also been supporting their efforts to provide educational demonstrations to the ASC membership.

Motion Imaging Workflow Subcommittee

Chair: *Al Barton*
Vice-Chair: *Greg Ciaccio*
Vice-Chair: *George Joblove*
Vice-Chair: *Bill Feightner*

Current Subcommittee Focus: ACES

Since last year, the ASC Technology Committee's Motion Imaging Workflow subcommittee has continued to focus on helping educate and prepare the industry for the introduction and subsequent release of ACES, in parallel with the education efforts of the AMPAS Science and Technology Council.

The subcommittee is composed of key individuals in a variety of positions involved in production and post, who provide valuable real-world feedback. Frequently, prominent cinematographers attend and contribute fresh perspectives.

ACES 1.0 was introduced at the end of 2014 and released to vendors, and various ACES-enabled solutions were available by the 2014 NAB Show in April.

Our subcommittee worked diligently in conjunction with the Academy of Motion Picture Arts and Sciences (AMPAS) to prepare talking points for the Academy ACES booth at the 2014 NAB Show.

A key to hastening widespread adoption of ACES involved the creation of a clear and concise single-line definition of ACES:

The Academy Color Encoding System (ACES) is becoming the industry standard for managing color throughout the life cycle of a motion picture or television production.

Since ACES benefits many areas of our industry, recent action items include role-specific marketing documents highlighting key advantages for each industry area. As was outlined in the September 2014 Progress Report, the purpose of this subcommittee is to create several different documents that will cover the use of ACES and the ASC CDL:

(1) An overview of how ACES is used in workflows that is appropriate to present to executives in about 15 minutes. This will be an 80,000 ft view with enough information to understand the advantages of using ACES, without getting bogged down in the gritty details.

(2) A set of documents describing Best Practices for using ACES in ACES-enabled workflows. These documents will have an initial focus on the on-set and near-set area, since they are the "stake in the ground" point for setting the look of the image. The group will then continue documenting Best Practices that can be used throughout the process all the way to archival.

(3) The next documents will help answer questions in much greater technical detail as ACES becomes the de-facto standard used by the industry.

As ACES user experiences are shared within our industry, the practical benefits are being realized. Presenters and panelists at various trade events, such as the HPA Tech Retreat and CineGear, have presented real ACES benefits to attendees. At least one major studio has expressed great interest in integrating ACES into their production and post pipelines as the benefits of ACES were realized in cost and time savings, as well as in archival.

More information regarding ACES is available at http://www.oscars.org/science-technology/sci-tech-projects/aces.

Digital Finishing Subcommittee

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

We opened up the last progress report with a comment about how fast things in our industry are moving. The past 12 months have seen an acceleration of that pace above and beyond what we've previously experienced. There is much to occupy our attention as part of the team of gatekeepers of creative possibilities and intent. Our subcommittee has been more quiet than in years past; this is due more to time and geography issues with its principles than to any dearth of exciting issues.

Concerning the ASC CDL, the work has to do with extending the application of CDL formulae to floating point, EXR files, and high dynamic range support. I believe that there's also some minor XML polishing to be done.

Looking forward, we're entering an era where the worst fears of some are being realized, and workflows are getting more "snowflakey"

than ever. It will take this subcommittee and, no doubt, the work of the entire ASC Technology Committee to make rational sense of the world we find ourselves heading towards. With the profusion of sometimes competing ideas comes the possibility to expand and control the creative aspects of visual storytelling even beyond the current day. Those still concerned with snowflakes need only remember that to the right snow shovel, all snowflakes look the same. Success in the coming world will depend on a combination of the nimble and the heavy metal. It will not be an all-desktop world just yet.

It may well prove to be a good thing that this subcommittee has been a bit removed from the action. There need to be voices that can stand a bit apart, and with deliberate cogitation, take a sober, common-sense look, not at what's possible, or cool, or touted by the many voices vying to get heard, but what fosters and protects the creative authors as our industry moves forward.

Our thanks to the ASC for support, and our best wishes for everyone going forward from here.

To get the current ASC CDL specification, send an e-mail to asccdl (at) theasc (dot) com; an auto-responder will send terms and instructions. For additional information about the ASC CDL or Digital Finishing subcommittee, contact Joshua Pines at jzp (at) technicolor (dot) com, Lou Levinson at western.light (at) yahoo (dot) com, or David Reisner at dreisner (at) d-cinema (dot) us.

Camera Subcommittee

Chair: *David Stump, ASC*
Vice-Chair: *Richard Edlund, ASC*
Vice-Chair: *Bill Bennett, ASC*

In the past year, the Camera subcommittee made several presentations available to the ASC Technology Committee and to the general membership of the ASC.

Among those presentations, Tony Davis of Tessive presented on the subject of temporal resampling of high frame rate materials. Davis presented at the ASC Clubhouse, facilitated by Bill Bennett, ASC, and explored new possibilities arising out of higher frame rate wider shutter angle capture.

Davis explored the use of words like "judder" and "strobing" and "tearing" to describe the problems with rolling square wave shutters, and explained that he refers to these artifacts as "sampling aliasing" and "reconstruction aliasing."

He explained that digital cinema cameras now allow for high-frame-rate shooting at wider shutter angles, and that there may be several benefits to doing this. For example, shooting at HFR with a 360º shutter can yield a 1 to 2.5 stop increase in dynamic range and noise reduction, compared with 24 frames/sec, 180º shutter.

Further, the precise data produced by shooting at a higher frame rate can give the cinematographer creative control over the look of motion in ways not possible with standard shooting rates. The source footage can be resampled to create different motion looks, speed ramps, or alternate output frame rates.

On a related subject, the ASC Technology Committee and the AMPAS Science and Technology Council co-sponsored a presentation at the Academy Dunn Theater by Jonathan Erland of the Pickfair Institute.

At the center of Erland's Creative Frame Rate research is a method of shooting at very high frame rates and creating effects by combining that material in different ways.

"Block Integration" is a method for combining frames in order to accurately reconstruct different output frame rates and camera shutter angles. "Block Integration" of multiple frames combined with frame deletion emulates conventional cinematography. "Rolling Integration" accomplishes a "persistence of vision" phenomena, but in the image rather than in the viewer's eye—a "persistence" that can be "dialed" in or out, at will.

This integration is accomplished by adding the densities of each combined frame to the total, such that each contributes in equal proportion, thus creating a uniform motion blur artifact in the composite image.

For example, to emulate a conventional film camera frame rate and shutter angle using 120 frame/sec 360° shutter acquired material, five contiguous frames are integrated, representing a 48th of a second, then the succeeding five frames are deleted. The deleted frames simulate the time in which the camera shutter is closed, stopping light from exposing the film. By varying the frames combined and discarded it is possible to emulate a multitude of camera shutters.

Of all of the interesting manipulations Erland was able to create during his research, one was particularly intriguing. More than simply incorporating the now standard motion picture camera shutter angles of 0 to 360°, Erland was able to synthesize an 8th of a second exposure image with a paradoxical 5400° (out of 360°!) camera shutter.

Erland's research can certainly serve to produce some interesting visual effects, and will likely provide a way to retain some cinematic ambiance when it is desired to achieve a high frame rate image stream. We can keep the exact same motion blur as conventional 24 frame/sec film, while the projected frame rate is 120 frames/sec. Perhaps this method could help to ease the controversial transition from 24 frames/sec to HFR.

The Camera subcommittee has also been supporting the work of the Advanced Imaging subcommittee in HDR image processing in conjunction with the UHD subcommittee. As we move forward into cinematography at increased dynamic range and wider color gamut range, a methodical investigation into the practicalities of whether a single master can serve a useful range of maximum luminance outputs becomes an absolute necessity.

The Camera subcommittee also supported the work of the UHD subcommittee, with assistance of the Professional Display subcommittee, in presenting a day-long demonstration of the latest HDR technology in monitors and displays. The presentation featured HDR-mastered material presented on a wide range of professional and consumer displays with HDR capability, with representatives of the major manufacturers on hand to interact with our membership.

Digital Preservation Subcommittee

Chair: *Grover Crisp*
Co-Chair: *Michael Friend*

In the past year, the pace of 4K production has picked up, leading to an increase in the amount of data stored by studio archives. This in turn has pushed archives even more urgently towards manageable contexts for big data such as cloud storage. It's not clear whether the commercial data storage industry will be able to effectively and economically accommodate studio needs. Development continues on novel storage technologies, but the preponderance of the digital archive consists of off-line physical magnetic media (LTO) or tape-based hierarchical systems (LTO, T-10000), with servers for immediate access requirements and interface with the deep archive. At present, studios have not publicly announced commitments of significant capital expenditure for the construction of digital storage facilities, but studies are under way and asset managers are working to define requirements for these facilities.

The ACES system developed by the Academy's Scientific and Technical Committees has been ratified as a standard. ACES offers the possibility of referencing color - not only can the color of moving image productions be accurately portrayed in different display contexts and devices, but it can also be referenced for the future. ACES eliminates the problems of subjective color reference and matching that have been a part of restoration since the 1970s, thus enabling a quantum advance in archival preservation practice. Not only will contemporary productions be accurately represented, but as digital restorations are effected, their color can be calibrated with ACES so that the exercise of restoration will not have to be done again. ACES combined with of high resolution and HDR scanning, will allow us to capture and accurately retain much more of the significant data in legacy films. An important development for archives is the emergence of the IMF format. This wrapped, scripted mezzanine format (which is similar to the DCI in structure) offers a way to de-duplicate, centralize and automate deployed moving image data for flexible distribution in a wide range of formats.

Another milestone was passed when Archive eXcahge Format (AXF), a powerful new format for the organization and storage of archival data was standardized. The Library of Congress contributed to the development of AXF and has been exploring its use as the container for their massive audio-visual data archive. There is also interest in developing an IMF-based archival format. These formats, like IMF, support the highly automated and efficient data management indispensable for the maintenance of very large, complex archives of the studios and many public repositories.

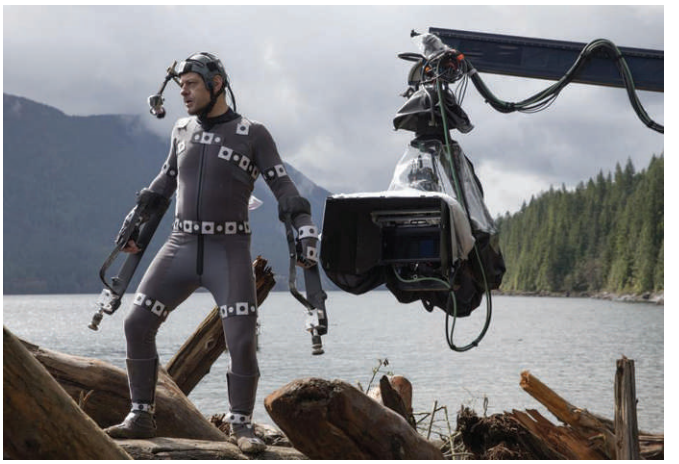
The media industry has entered a period of unprecedented change. This started with the introduction of high definition and has continued with the mainstreaming of 4K and file-based workflows. In the past two years, we have seen the emergence of HDR and HFR as well as developments in multichannel sound. 3D production persists and occupies a place in the archive (and represents a potential link to the future in terms of immersive systems known as VR-virtual reality). These extensions beyond the long-entrenched technical characteristics of film and video have created new challenges for the archive, not just in terms of volume, but in the complexity of the resources that must be conserved.

Joint Technology Subcommittee on Virtual Production

Chair: *David Morin*
Co-Chair: *John Scheele*

Over the period since the last SMPTE report, the Joint Subcommittee on Virtual Production of the ASC continued its series of case studies on the broadening use of realtime computer graphics on set.

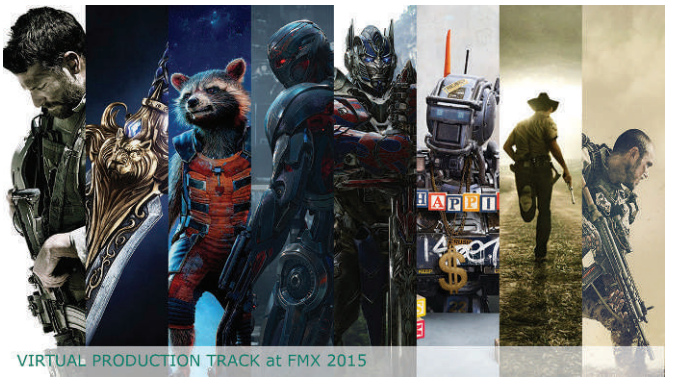
Case Study: "Dawn of the Planet of the Apes"



Andy Serkis performance for "Caesar" captured in the rain forest near Vancouver, BC.

The Virtual Production Committee held a case study of "Dawn of the Planet of the Apes" on 3 February 2014 at Fox Studios. Visual Effects Supervisor Dan Lemmon from Weta Digital showed footage from principal photography and performance capture done in challenging locations such as the rain forest of British Columbia, where rain and trees interfered with motion capture equipment and necessitated ingenious new developments that ultimately brought the titular apes, now more evolved and talking, to a stirring performance on the big screen.

The Virtual Production Track at FMX 2015

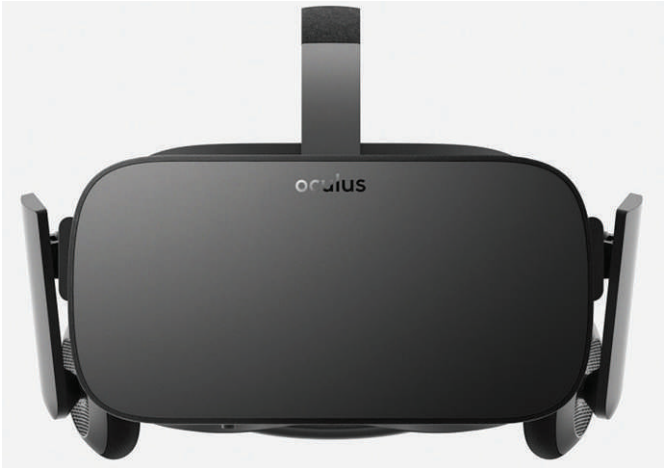


A series of seven case studies on virtual production were presented on 7 and 8 May 2014 at FMX 2015 in Stuttgart, Germany.

Additionally, and for the fourth year in a row, the Virtual Production Committee curated the "Virtual Production Track" at FMX 2015 in Stuttgart, Germany.

The virtual production track was curated by Virtual Production committee chair David Morin and showcased seven case studies that took place over two days on 7 and 8 May 2015. The presentations covered the use of previsualization and virtual production on films such as *American Sniper*, *Guardians of the Galaxy*, *Avengers: Age of Ultron*, *Chappie*, the upcoming *Warcraft* movie, television shows such as "Walking Dead," and video games such as "Call of Duty." Presentations in other tracks also highlighted virtual production in movies such as *The Hobbit: Battle of Five Armies*, and Lucasfilm presented their latest "V-Scout" visualization tools with *Star Wars* material.

New Developments in Virtual and Augmented Reality



The Oculus Rift virtual reality headset, scheduled to go on sale to the public in the first quarter of 2016.

Over the period since the last SMPTE report, Facebook and Google made large investments in virtual reality (VR) by buying companies such as Oculus for $2 billion and Magic Leap for $500 million. Venture capitalists followed suit and invested in a large number of VR companies, while the six major studios also invested in developing VR content, all with the goal to immerse viewers in live action or computer-generated worlds. Virtual production being virtual reality and augmented reality for production, these investments are expected to stimulate the development of new cameras and content creation tools for filmmakers. The Virtual Production committee is following these developments closely.

Future Activities

The Virtual Production Committee will continue to pursue its goal of educating and helping to define the new workflow, and is currently planning its meeting #10, along with other ancillary events, and the Virtual Production track at FMX 2016.

There is an ongoing Definition Workgroup, Publications Workgroup, and History Workgroup. Others may be created, when there is demand. Participation is encouraged. Those interested may contact:

David Morin, Chair, davidmorin (at) davidmorin (dot) com.

John Scheele, Co-Chair, johnscheele (at) gmail (dot) com.

Inquiries regarding the ASC Technology Committee should be sent to Holly Lowzik: holly (at) theasc (dot) com.

Curtis Clark, ASC, studied theater at the Art Institute of Chicago's Goodman School of Drama and cinematography at the London Film School. After graduation, he began his career by shooting numerous documentary films in Britain before transitioning to shooting feature films in Britain and the U.S. Following on the success of his short film, *The Arrival*, Clark more recently completed his highly praised short film *Eldorado*. Clark is chair of the ASC Technology Committee. Since its inception in 2003, the Committee under Clark's leadership has achieved a series of notable successes, including its collaborative work with Digital Cinema Initiatives, LLC, (DCI) to produce standardized evaluation material for assessing the performance of digital projectors and other elements of DCI standards-based digital cinema systems, as well as the 2009 Camera Assessment Series and 2012 Image Control Assessment Series. The ASC Technology Committee, at Clark's instigation, embarked on the development of a groundbreaking project to create cross-platform data exchange for primary RGB digital color correction known as the ASC CDL, which was recognized by the Academy of Television Arts and Sciences with a prestigious 2012 Primetime Emmy Engineering Award. Clark also received an AMPAS Technical Achievement Award recognizing his work developing the ASC CDL. Clark was also recipient of the prestigious ASC Presidents Award.

David Reisner received a 2014 Academy Technical Achievement Award and was recognized in a 2012 Primetime Emmy Engineering Award as co-designer of the ASC CDL, used in the workflow of 90% of motion pictures, 70% of scripted TV, and 99% of visual effects turn over. Reisner was lead designer of the ASC-DCI StEM Standard Evaluation Material used to determine the quality required for the deployment of digital cinema and Vice-Chair'ed the SMPTE Working Groups responsible for the digital cinema imaging and security standards. Ninety-five percent of cinema screens worldwide now use digital cinema. Reisner also had leading roles in activities including design and production of the ASC-PGA CAS Camera Assessment Series and elements of the Academy Color Encoding System. He made one of the first proposals for the Virtual Print Fee model used to fund the digital cinema roll-out. Reisner's "firsts" include portable computers; handheld video jukebox; other computer and consumer electronics; and VLIW computer architecture. He has produced concerts and trained killer whales. Reisner is well published in books, technical articles, and has spoken widely, including on manned space exploration at the 2014 International Space Development Conference. He is a member of SMPTE; the founding Secretary of the ASC Technology Committee and an ASC Associate; a member of the Visual Effects Society; and chaired a committee for the 2015 Academy Scientific and Technical Awards.

Don Eklund is vice president of business development at Verance Corp. in San Diego, CA. He previously held an executive position with Sony Pictures where he helped execute the launch of DVD, UMD, and Blu-ray.

Michael Karagosian is president of MKPE Consulting LLC, specializing in business development, strategy, and intellectual property for emerging technologies in cinema. Accomplishments include negotiating up to $300M in studio subsidies for digital projection equipment in South America, Philippines, and Ireland. He consulted to the National Association of Theatre Owners for 11 years, leading exhibition input to the DCI specification. He co-founded the CinemAcoustics division of Peavey Electronics in the 90s, and led the development of cinema and studio products at Dolby in the late 70s and early 80s. Karagosian is a SMPTE Fellow, and has chaired numerous SMPTE committees.

Eric Rodli has been involved in the management and development of entertainment technology since the late 1980s when he became president of Iwerks Entertainment; a pioneer in large format film, motion simulation theaters and other immersive technologies. He subsequently has had senior roles in a variety of entertainment and media organizations, including being a partner in the entertainment consulting practice of PwC as well as president of Kodak's Motion Picture Division. He is currently a consultant for Laser Light Engines, a leader in providing laser illumination systems for cinema and related applications. He is an associate member of the ASC. Rodli received a B.A. in economics from the University of California, San Diego, and an MBA from the University of Chicago.

Gary Demos has been a pioneer in the development of computer-generated images for use in motion pictures, and in digital film scanning and recording. He founded Digital Productions (1982-1986), and was awarded an Academy of Motion Picture Arts and Sciences (AMPAS) Scientific and Engineering Award in 1984 along with John Whitney Jr. "For the Practical Simulation of Motion Picture Photograph By Means of Computer-Generated Images." Demos also founded Whitney-Demos Productions (1986-1988), DemoGraFX (1988-2003), and Image Essence, LLC (in 2005). Demos is the recipient of the AMPAS 2005 Gordon E. Sawyer Oscar for lifetime technical achievement. Since 1990, he has been exploring layered compression coding and is active in preparing for future imaging and image processing technology. Demos is chair of the ASC Technology Committee Advance Imaging subcommittee and is involved in the AMPAS ACES project. Demos has presented numerous papers at SMPTE, and is a SMPTE Fellow.

Jim Fancher developed next-generation technology for Deluxe Digital Media in Burbank, CA. He was chief science officer at Thomson Corporate Research in Burbank, where he developed cluster-computing architectures for image processing, 3D color correction systems, and digital asset management technology. As chief technology officer for Technicolor Creative Services, Fancher was involved in the development of color management systems, image processing, and media asset management. He was a part of managing Technicolor's world-class Digital Intermediate facility. Fancher was chief science officer at Pacific Ocean Post, where he started POP Sound, POP Film, which won two Academy Awards for visual effects, and the POP— Cinram DVD center.

Greg Ciaccio is managing director of location services at Modern Videofilm, where he is focused primarily on finding new location-based technology and workflow solutions for their Motion Picture and Television clients. Previously, Ciaccio served in technical management roles for the respective Creative Services divisions for both Deluxe and Technicolor. Key developments include the first DP Lights deployments for Technicolor and full near-set dailies solutions for Deluxe Television. Ciaccio is a member of SMPTE, ASC Technology Committee, AMPAS Sci-Tech Council, Hollywood Professional Alliance (HPA), and DCS. He holds a B.A. degree in radio-television-film from California State University, Northridge.

Lou Levinson is a long-time associate member of the ASC, and the chair of the Digital Finishing subcommittee. A member of the ASC Technology Committee since its inception, he has been a frontline colorist from the "on the fly" analog era to today's advanced ACES and beyond digital pipelines, having worked with notables such as Woody Allen and Rob Zombie to name a few. He is currently working on special projects and consulting 15 minutes into the future under NDA.

David Stump, ASC, has worked on numerous motion pictures and television productions as director of photography, visual effects director of photography, visual effects supervisor, and stereographer, (including both live action work and 2D to 3D conversion work), earning an Emmy Award, an Academy Award for Scientific and Technical Achievement, and an International Cinematographers Guild Award. His credits include high profile projects such as *The Last Stand*, *Immortals*, *Flight Plan*, *Fantastic Four*, *X-Men 1* and *2*, *Into the Blue*, *Red Riding Hood*, *Garfield*, *Batman Forever*, *Hollow Man*, *Men of Honor*, *Deep Blue Sea*, *Stuart Little*, *Contact*, *Batman & Robin*, *Mars Attacks*, *Executive Decision*, *Stargate*, and *Free Willy*, among many others. Stump currently serves on the AMPAS' Science and Technology Council. He also serves as co-chair of a SMPTE study group on High Frame Rate for Digital Cinema.

David Morin is senior director, industry relations and business development at Autodesk Media & Entertainment. He chairs the Autodesk Film CTO Advisory Council, a product focus group composed of the 12 largest digital studios in the motion picture business. Morin is also chair of the Joint Technology Subcommittee on Virtual Production, a subcommittee of six Hollywood-based guilds and societies, exploring the impact of virtual production on the motion picture production workflow.

PHOTO NOT AVAILABLE

Michael Friend is the director of the digital archive in Sony Pictures Entertainment[1]'s Asset Management group and teaches at UCLA in the Moving Image Archives Studies Program.