American Society of Cinematographers Technology Committee Progress Report

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American Society of Cinematographers Technology Committee Progress Report

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

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

Since the inception of our ASC Technology Committee in 2003 we have been continuously and actively engaged with the emergence and evolution of digital imaging technologies, beginning with Digital Intermediate (DI) and its relentless march to becoming the pervasive post finishing environment. In fact, our Technology Committee has been continuously and integrally involved with key major phases of the paradigm shift from predominantly analog to increasingly digital imaging technologies. Having successfully collaborated with DCI to produce the crucial StEM test footage which contributed to the creation of the current digital cinema standards, we then partnered with the PGA to produce the Camera Assessment Series (CAS) which was designed to assess the capability of the seven leading digital motion picture cameras to effectively compete with film origination. As always, a fundamental objective of our Committee is to understand how technology developments, both digital and analog, affect the cinematographer's ability, working in collaboration with a director, production designer and VFX supervisor, to realize a photographic vision.

Much of our 2009 ASC Technology Committee report was focused on the intensely challenging, but immensely important work of our Camera Assessment Series. Digital motion picture camera manufacturers who participated in CAS have gained invaluable experience regarding the imaging strengths and weaknesses of their respective cameras and the dependence of digital camera imaging performance on Digital Intermediate workflow implementation.

As a result of that prolonged and painstaking effort, vital lessons have been learned about the importance of understanding the limitations of current DI workflow practices, especially regarding their ability to achieve optimal imaging performance for digital motion picture cameras, as well as film capture. As I said in my introduction to our 2009 report, "The pressing issues concerning workflow color management and the need for unambiguous transforms between log, video "linear" (gamma), and scene referenced linear encoded images have been intensified by the rapid adoption rate of digital motion picture cameras for both feature and TV production." Those limitations, which include color bit depth, along with ambiguous transforms between log encoding and scene linear are now being successfully addressed in test bed implementations of workflows based on the Academy of Motion Picture Arts & Sciences (AMPAS) developed Image Interchange Framework (IIF)-Academy Color Encoding Specification (ACES).

The ASC, via our ASC Technology Committee, has fully endorsed IIF-ACES as the "next generation" best practice successor to current DI workflow practice and our Technology Committee is actively collaborating with the AMPAS Science & Technology Council to further its development and encourage industry adoption. We believe that IIF-ACES enables effective solutions that resolve current ambiguities and impediments inherent in much of today's DI workflow practices which can inadvertently restrict optimal imaging performance, especially for the integration of live action with CGI VFX.

Also, our widely adopted ASC CDL is being further developed to become a key IIF-ACES Look Modification Transform (LMT). Development work is being led by our Digital Intermediate Subcommittee and includes the additional implementation of a 6-axis (6-vector) function that will facilitate separate RGB primary and YCM second-

ary color saturation controls. These additional functions will further reinforce the value of our ASC CDL as an effective cross-platform look management tool that is able to coordinate cinematographer look references for "on-set" dailies with VFX, as well as provide look reference starting points for final Digital Intermediate color grading.

The Subcommittee reports that follow, address various key issues that our ASC Technology Committee will be focusing on during the coming year, including the recent surge of 3D, as well as the emergence of the "virtual camera" pioneered on *Avatar*. This "virtual production" workflow is being addressed by our newly formed Joint Technology Subcommittee on Virtual Production that is collaboratively shared with the Art Directors Guild (ADG), Visual Effects Society (VES) and Producers Guild of America (PGA). Also, we have a report from the newly formed Previsualization Society which, I am proud to say, is the outcome of a successful conclusion to our ASC-ADG-VES Joint Technology Subcommittee on Previsualization. We will also be tracking the emergence of the DSLR motion image capture option.

The ASC Technology Committee will continue its mission to be a leading motion picture industry forum that actively engages motion imaging technology developments while addressing their impact on the art of filmmaking.

ASC President's Letter **ASC President:** Michael Goi, ASC

Dear SMPTE Members,

There is an ancient Chinese curse that states, "May you live in interesting times." With the seemingly constant influx of new technologies being utilized for creating entertainment content, to describe our current era as being interesting may be a bit of an understatement. The challenges we face to separate the fact from the fiction, and the responsibility we have to provide our industry with well-considered and informed examinations of these technologies, affects the artistry of our profession as well as the financial structure of the industry.

These are the times that determine how smoothly we will handle transitions. With an ever-expanding toolbox, which includes digital motion picture cameras, virtual production, DSLR's and increasingly sophisticated previs, we find ourselves in a constant state of exploration. And with important ongoing examinations of issues such as archiving and preserving the work we do, it takes a committed consortium of industry activists to make it work.

That's what we have with the ASC Technology Committee, and with its growing relationships with other industry crafts in ventures like the Virtual Production Committee and the Previsualization Society. Whether you have noticed it or not, what we are experiencing is an unprecedented spirit of collaboration between the key crafts in the industry to enter into these technological transitions in a manner that makes sense and has a defined structure, and all the participants do this regardless of personal agendas or corporate objectives. We do it because it is what needs to be done.

So to those of you who spend all your free time actually counting how many bits are claimed to be contained on a sensor, who argue that good enough is not good enough, and who contribute your experience and intelligence for the betterment of all, I salute you and encourage your efforts, and I encourage more to join your ranks. You are pioneers struggling to establish order in a time of perceived chaos, and we will look back on this era and recognize that our efforts molded a better future.

In words more profound than mine, I believe this will be our finest hour.

Secretary's Comment **ASC Technology Committee Secretary:** David Reisner

In keeping with its more than 90-year tradition, the ASC is continuing to help lead the art and technology of motion picture making through technological transitions. The recent pace of change has been extreme—in many respects revolutionary—and we will still experience rapid change for the immediately foreseeable future.

We are starting to see digital motion picture cameras with ranges rivaling film. Of course, we are also seeing new film stocks…

The AMPAS Image Interchange Framework has high dynamic range, large color gamut, floating point representation for accurate computation, and provides a structure for more "scientific" handling of images (linear light, known format, input and output transforms). Just

as DI was adopted at a higher rate than anyone expected, there are hints that IIF-based workflows may be adopted quite quickly. Hopefully, the adoption of IIF will also encourage the already in-process transition to file-based workflows.

We have also seen substantial use of the ASC Color Decision List (ASC CDL). ASC CDL is used in many productions and in the majority of movies made/posted by at least one major studio and one major post facility. Almost all major color correction systems support the ASC CDL, and the ASC CDL will be one of the key transforms supported in the IIF Look Modification Transform (LMT).

We are now solidly in the post-CRT display era for post-production. Although we do not yet have the ultimate, ideal CRT replacement display, with appropriate attention facilities are using flat panel displays to good effect. We see development and await wide availability of flat panels with greater bit depth, wider color gamut, higher contrast, and appropriate signal interfaces. We are also seeing an increased use of projection displays in post-production, though usually not full digital cinema projectors.

We are also seeing some moves to 4K workflows. At least one of the major studios has made a major commitment to 4K workflows; watch for significant moves to support/encourage 4K production in the industry. Work continues on true 4K cameras. Some very high quality consumer Blu-ray releases have been mastered with 4K workflows. And, giving some pressure or at least attention from below, YouTube has announced that they will be supporting 4K (or quad-HDTV).

We continue to see a great deal of industry attention on 3D, enabled by the on-going transition to digital cinema. Studios have good slates of 3D movies coming out, mostly animation and VFX. As an industry, we are working on developing our technical chops and artistic approaches for 3D—particularly an issue for live-action. But we still need to see higher brightness (>9fL) delivered to the audience's eyes, so their eye-brain systems can respond fully to color, detail, and motion.

The ASC has been a key participant in facilitating the formation of industry groups who are exploring the techniques and applications of Previsualization and now Virtual Production. These two approaches may significantly change the way some motion pictures are created, potentially going as far as allowing performance to be captured and then designing and framing the shot. As often occurs due to the wide and diverse industry participation in ASC Technology Committee activities, the Previsualization subcommittee set and the Virtual Production Committee is setting new industry standards for productive collaboration between a broad range of industry societies and guilds. If that helps encourage productions to have earlier and increased collaboration between key members of the creative filmmaking team that will have as big a positive impact as any technological change.

Camera Subcommittee

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

In January 2009, the ASC in collaboration with Revelations Entertainment and the Producer's Guild of America shot the Camera Assessment Series (CAS)—a series of tests with one film reference and seven digital cameras shot round-robin and side-by-side on the "Desperate Housewives" standing sets (Wisteria Lane) on Universal's back lot. The Camera Assessment Series involved about 250 crew, cast, and manufacturers' representatives, in five location teams and with eight camera teams. Each location team was anchored by an ASC cinematographer and each camera team was anchored by a manufacturer- approved cinematographer and appropriate crew. The film camera was an Arri 435 with 5207, 5217, and 5219 stock—Walter Lindenlaub, ASC. The digital cameras were the Sony F23—Stephen Lighthill, ASC, and Peter Anderson, ASC; Sony F35—Kramer Morgenthau, ASC, and Sam Nicholson; Panasonic AJ-HPX3700— Roberto Schaeffer, ASC and Mark Doering Powell; Arri D-21—Bill Bennett, ASC; Panavision Genesis—Shelly Johnson, ASC; RED One—Nancy Schreiber, ASC; and Thomson Viper—Marty Ollstein. The locations were Jaws Lake—Curtis Clark, ASC, and David Stump, ASC; Night Interior— Michael Goi, ASC; Picket Fence—Steven Fierberg, ASC; House Exterior—Richard Edlund, ASC; Garage Interior and Blue/Greenscreen— Bob Primes, ASC; Day Interior—Matthew Leonetti, ASC; Wisteria Park—John Toll, ASC. (For additional information on the production of the

Camera Assessment Series, see the ASC Technology Committee Progress Report, *SMPTE Motion Imaging Journal*, September 2009.)

During the work of finishing the CAS for presentation, we encountered questions about image processing arising from proprietary input transforms from camera output to Cineon DPX. As a result, several manufacturers created new reference transforms so that any user of that camera can get material from camera into post at the higher quality and efficiency. More importantly, the manufacturing community got first-hand experience of the difficulties of usefully transforming their camera output.

The CAS experience with the Cineon-based workflow strongly suggested that even 12-bit DPX will only be a stop-gap during a transition to a wide gamut, high dynamic range workflow with clearly defined transforms from log to linear and vice-versa—very probably based on the AMPAS' proposed Image Interchange Framework architecture. The ASC and AMPAS' Science & Technology Council are jointly working to process several camera's CAS data using IIF components, with particular attention being paid to the ACES color encoding specification. Any potential future "CAS II" will probably be finished in a 4K IIF workflow, continuing to include the ASC CDL to allow interchange and interoperation of basic primary color corrections.

Public presentations of the CAS material have been given at several venues over the course of the past year, including The PGA Produced By Conference, IBC 2009, The ASC in combination with the Academy's Linwood Dunn Theater, and separately at the Academy's Goldwyn Theater, NAB2010, and most recently at The Cinematographers Combine Conference for the Indian Society of Cinematographers in Mumbai, India.

To fully understand the performance of the individual cameras—especially color and contrast—the CAS must be seen in a full digital cinema presentation. For those who do not have that opportunity, and to allow some of the making-of and background material to be shared, we have produced a Blu-ray disk of the CAS. (The Blu-ray disc can be purchased from DVD International at www.dvdinternational.com/pd-camera-assessment-series.cfm)

The next step in the efforts of the ASC Camera subcommittee will be exploration of doing a similar evaluation of the issues of 3D acquisition.

3D

With the continued integration of 3D stereoscopic technology into the production pipeline, the ASC Technology Committee is now handling each aspect of 3D within the relevant subcommittee—cameras and production in Camera, post-production in DI, exhibition and display in Display and Non-Theatrical Distribution, Mastering, and Display. We are currently considering the possibility of creating a 3D "StEM"—Standard Evaluation Material for 3D. The goal in creating a 3D StEM test library would be to create 3D content that could be used to evaluate and explore creative and technical elements of 3D production; to examine the effects of shooting, production, and exhibition choices; and to examine the differences between 2D to 3D conversion techniques and photographed 3D.

We would want to create a 3D StEM with content that is rights-unencumbered, so that it could be used widely as a standard reference and for demonstration for both theatrical and consumer. In addition to helping us understand where we presently are with 3D, we hope to identify and highlight areas for improvement—both creatively and technically.

As we know from our experience with the 2D StEM and the Camera Assessment Series (CAS), a 3D StEM would be a large project. The important first step is to create the "shot list." We share here some first steps in that process…

CONCEPTS FOR 3D STEM CONTENT

Brightness tests: Create a suite of brightness settings for the same scene, starting at the earliest possible point in production/post, ranging from very dim to very bright. Master for full brightness display as per SMPTE specs, and for lower luminances often found in commercial theaters. Useful for testing how 3D perception varies with brightness, as well as for determining performance parameters for displays and glasses.

Colorimetry and gamma: Place objects in a scene that stress the color and gamma performance of the display and glasses. Useful for studying what role color plays in 3D perception, and as reference material for display and glasses manufacturers.

Parallel and convergence capture/depth and depth distortion/Orthostereoscopy conditions: Vary depth and roundness in test scenes by varying the camera-pair capture positions from parallel to highly convergent, and through a range of interaxial distances. Useful for viewer comfort and large population perception studies.

Depth perception: Place a series of objects in depth space with tags or metrics associated with each one. Useful for seeing how depth and roundness are impacted by screen size, and in large population perception studies.

Horizontal-panning motion: Used to stress the various projection technologies.

Edge-of-frame artifacting: Test the effects of breaking the left and right frame edges at various speeds, various distances, and with various sized objects. This will also give the user base a meaningful test set to evaluate the use of floating windows in display and projection.

Flicker rate and the human perceptual system: Test to see if there is an ideal or minimum acceptable frame and shutter angle rate.

Ghosting and reflections: Use an extremely contrasty set of subject

matter to stress the ability of systems to deal with ghosting issues and anti-ghosting processing.

Dimensionalization: A set of well shot 3D material that can be handed off as single camera material (as either left eye or right eye, identified as such) for dimensionalization vendors to work with. Dimensionalized results can then be compared to actual 3D photography to evaluate the effectiveness of the dimensionalization process in question.

Interaxial distance brackets: A variety of test subjects including; (1) a normal interior scene, (2) a normal exterior scene, and (3) a scene with a great deal of perspective and z depth of subject matter, all shot at a wide variety of interaxial distances for uniform convergence settings.

Convergence interocular relationship test: A set of tests done at a wide variety of convergences and interoculars, carried all the way through enough of a variety of settings to break any visual system.

Leading of convergence test: A variety of shots that lead convergence from near to far and back so that they may be intercut to determine the stress on viewers from cutting between varied and conflicting convergences and convergence travel directions. Include subtitles/captions to particularly examine viewer stress.

Contributors to this document: David Stump ASC, Phil Lelyveld, Dave Drzewiecki, David Wertheimer, David Reisner

For additional information or to offer assistance with the 3D StEM, contact David Stump, ASC via the ASC; Rob Engle at 3DStEM @robengle.com; or David Reisner at dreisner @d-cinema.us.

Digital Intermediate Subcommittee

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

For the Digital Intermediate (DI) Subcommittee much of the past year's work has been in support of other activities of the ASC Technology Committee, other subcommittees, and other groups we work with. Within the DI subcommittee, most of our work has been planning. In association with the Producers Guild, the ASC Technology Committee's big project this year has been the Camera Assessment Series, or CAS, accomplished with large investments of time and effort by many of the subcommittees, Committee members, vendors, and a very large number of volunteers. Planning was a big project. Shooting was a big project. And posting was a big project. No one really knew how much they were getting into up-front. We learned as much about the production and post process as we did about the various cameras being assessed, and that may turn out in the long run to be the most valuable information. I would highly recommend that if you have not seen the CAS test images, that you look into finding a way to see it soon. (Information on CAS presentations can be found at theasc.com.)

More to the point of the DI subcommittee itself, what we have accomplished are some embellishments to the current ASC CDL in the form of version 1.2 . Discussions are well under way to make some fairly large upgrades in the coming months, and call it version 2.0. The most significant upgrade to the CDL comes in response to calls from the field and vendors for more sophisticated processing, calls that need to be balanced with the need to keep it simple and not put vendors in a position to compromise their intellectual properties. We will most likely add a limited set of six vector color processing. The new processes being considered would be strictly RGBYCM, most likely centered on the proposed Academy primaries and white point, with no hue or luminance tweaks and a limited range of saturation modification. There are also some proposed changes to CDL metadata that will improve flexibility and functionality, and improve reliable integration in workflow.

A number of us are working with AMPAS on various facets of their proposed IIF pipeline, which includes working with 12-bit sources, using an OpenEXR pipeline and the Academy Color Encoding Specification (ACES) gamut, instead of DPX. That includes work on assessing the validity of a new white point to supplant the DCI white point in general use, and possibly having new intermediate and print stocks for film-outs to support ACES.

IIF will also incorporate the ASC CDL as a key component of the Look Modification Transform (LMT) – the place within IIF where artistic intent is encoded. Use in the LMT also motivates some of the

version 2.0 changes. We are hopeful that eventually the work of the ASC Technology Committee and AMPAS will result in some RPs, with your venerable organization's blessings.

We view one of the principal missions of the DI subcommittee as keeping up with (if indeed, not causing) changes in our fields, and looking down the road to the next year or two, there will be many changes as our capture methods diversify, as our image handling gets more sophisticated and decentralized, and as our markets and delivery needs change with changing consumption patterns.

This is all mostly still in a fluid state as our industry is currently heading into what will undoubtedly be a period of rapid change for us all. We expect that the DI subcommittee will be a key player in the ASC Technology Committee's activities for the coming year.

To get the current ASC CDL specification, send an e-mail to asc-cdl@theasc.com; an auto-responder will send terms and instructions. For additional information about the ASC CDL or DI subcommittee, contact Joshua Pines at jzp@technicolor.com, Lou Levinson at joe.beats@yahoo.com, or David Reisner at dreisner@d-cinema.us.

Advanced Imaging Subcommittee

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

From its early years, the Advanced Imaging subcommittee has been advocating use of high dynamic range, wide gamut image coding systems using scene referred radiometrically linear light and floating point data representation. Currently under development, the Academy of Motion Picture Arts & Sciences, Science and Technology Council's Image Interchange Framework (IIF) is that type of system. The Advanced Imaging subcommittee members have been active participants in IIF development, and in experiments to "ring-out" and test IIF and assess its suitability for practical use.

The Advanced Imaging subgroup has also continued its work characterizing displays and projectors using spectral radiometry. The spectral energy radiated from displays is measured in radiometrically linear units of energy for each wavelength (color, 2nm to 4nm) band by spectral radiometers.

The procedures and tools for taking these measurements are ingredients of calibrating and studying D-Cinema projection systems, reference displays, and consumer displays. Jim Fancher has helped to work out these procedures in the Advanced Imaging subgroup, and is now applying these procedures to the Display subgroup. Note also that the IIF output path requires and utilizes characterization and calibration with similar procedures.

When we did our large set of monitor characterizations in 2006, subcommittee Vice-chair Jim Fancher wrangled the large set of spectroradiometric data, building it into a form that helped us look at both monitor behaviors and at suitability of the CIE 1931 2-degree standard observer for cinema work. While Jim will remain active Vice-chair and key participant of our Advanced Imaging subcommittee, he will now also be Co-Chair of the Digital Display subcommittee. Monitoring onset and in post, and monitoring appropriate to the delivery format, are critical issues for color and image management. If you don't know what you're looking at, well, you don't know what you're looking at. We can think of no one better than Jim and Co-chair Al Hart to help us make intelligent evaluation and choices in this critical area.

Subcommittee Chair Gary Demos has taken CAS scenes from the Thomson Viper and the ARRI D21 and run them through his own OpenEXR-based workflow—quite similar to IIF but with his own choices for each component. This process is providing useful insight into the alternatives being considered for various parts of IIF, especially the IDT (Input Device Transform). He has also been looking at issues of OpenEXR half-float precision, color space issues, and in-workflow effects of a number of other areas we've been looking at in Advanced Imaging for several years. We hope this process will help refine the IIF architecture. Gary is working with the Academy to prepare a document presenting what has been learned by this testing. (The document is somewhat technical and theoretical but is based on practical testing. To see that document when available, send e-mail to Subcommittee Secretary dreisner@d-cinema.us.)

We have recently seen a flood of digital SLR cameras (DSLR) that also have video modes. Gary has worked with cinematographer Bob Primes, ASC, to shoot several minutes of 24 fps time lapse stills with a Canon 5D Mk II—images 5600 x 3700 pre-deBayer, large format 8-perf VistaVision size sensor—and compared those results to the cameras video mode. Comparing the results at Deluxe, the difference was startling. In still camera mode the sensor produces something spectacular; much less in video mode. Gary and Jack Holm have deBayered the camera data into linear light with no rendering, color mapping, etc. Jack measured the spectral sensing function of his 5D and built Input Device Transforms (IDTs) to bring the data into ACES, assuming various color temperatures of light.

The first features done with IIF workflows, which use radiometrically linear light, are coming into the pipe. As IIF-based workflows come into practical use we yet again have new motivation to visit

a critical issue that we have addressed every year—accurate understanding of log and linear image representations and correct use of terms to describe what is actually there. The industry continues to incorrectly use "linear" to describe every form of video gamma. This encourages errors and problems in post-production, and potentially in production as well.

Linear light—radiometrically linear light—values are proportional to the photon counts of light in the scene or striking the camera imager or on the display or projector. For example, light meters, spectral radiometers, and chroma meters all use linear light values. The term linear is often misused to describe nonlinear signals containing video gamma.

Gamma, commonly used for video signals, is a non-linear exponent. Linear light is exponentiated to the power of the inverse of gamma (e.g., 1/2.222) to create the nonlinear video signal. The video signal is converted back into linear light by exponentiating the nonlinear video signal to the power of gamma (e.g., 2.222) usually as part of the monitor or projector. (The SMPTE digital cinema gamma is 2.6—a "pure" gamma as opposed to video signals, which usually have a linear "toe" segment near black.)

Fortunately, all forms of video gamma representation, when precisely specified, can be converted to and from linear light.

Logarithmic representations of linear light include pure logarithmic and quasi-logarithmic representations. An example of a pure logarithmic representation is the log of the linear photon count of light at each pixel. At all luminances, all pure logarithmic representations vary by an equal percentage for an equal step in value. Most digital motion picture cameras offer some form of quasi-logarithmic representation to fit a broader dynamic range into a 10-bit HD-SDI or 12-bit dual HD-SDI output and to provide coding somewhat in the direction of film printing density.

All forms of logarithmic representation, when precisely specified, can be converted to and from linear light.

Logarithmic Printing Density is the density of a film negative, as used in printing and scanning. It is usually collected by scanning a film negative and using an "encoding function" (as opposed to the "rendering transform" used for output). Cineon and DPX formats most commonly use a density range of 2.048 using 10-bit (1024) units to specify the red, green, and blue densities of film negative. There is also a new 12-bit DPX format.

Because film emulsion characteristics are quite complex and densities will vary from lab processing run to processing run (temperature, state of the chemicals in the film bath, etc.), accurate conversion of logarithmic printing density to linear light is more complicated. Conversion usually requires use of a three dimensional cross-color Look-Up Table (LUT), or a cross-color matrix/LUT combination, constructed by a combination of engineering and art. 3D cross-color processing is required to encode the interaction between the color primaries. Currently, the construction of these 3D LUTs involves some art and provides some facility-specific "secret sauce," but we believe IIF's well-defined input and output transforms, especially when combined with new film stocks specifically designed to support IIF, should substantially regularize this practice. Also important, the proposed Academy Printing Density (APD) and Academy Density Exchange (ADX) should provide a common convention for design of density-based film scanners, recorders and workflows.

EXPOSURE INVARIANCE TEST

The Advanced Imaging subcommittee has proposed an Exposure Invariance Test to quickly and easily examine whether a camera's output is truly linear or can be transformed to truly linear. In a linear representation, whether camera output or an intermediate representation like ACES, simple mathematical operations such as doubling or halving values (the mathematical equivalent of going up or down a Stop) should preserve hue and relative exposure within the scene. The middle section of film's response curve behaves in this way, but the toe and shoulder regions do not—they are not linear.

The Exposure Invariance Test takes images of a chart or scene, starting with something near the camera's maximum exposure and taking a series of images each with exposure reduced by one stop (by lens T-stop adjustment, ND filters, or changes in lighting). Each stop down should reduce the linear code values by half.

The series of images are scaled up to "reference" exposure by multiplying by factors of two. They are then printed and visually compared.

Images taken at lower exposure will exhibit more noise, but if the camera response is otherwise linear, then within the limits of the camera's exposure range, the scaled up images will look very much like the reference image—darks, highlights, tonal scale, hue. Cameras where the imager does not respond linearly or where internal processing or the output representation cannot be mapped to linear will produce a scaled up image with noticeably different characteristics.

An upcoming *SMPTE Motion Imaging Journal* article will describe the Exposure Invariance Test in more detail.

Metadata Subcommittee

Chair: Dave Stump, ASC; Jim Houston

The ASC Technology Committee's Metadata subcommittee has been working actively with the Academy of Motion Picture Arts & Sciences' Science & Technology Council's Image Interchange Framework (IIF) project. We expect that, in future, IIF will provide one of the main paths for carrying metadata in production and post. The Metadata Subcommittee will continue to work on defining the set of Metadata to include, particularly metadata related to production. Storage and interchange of the metadata will, in practice, continue to be a joint effort of the Metadata Subcommittee, the IIF project, and the SMPTE metadata working group.

The first result of the joint work of the Metadata subcommittee and the Academy—the Common LUT Format—was discussed in the 2009 Progress Report (*SMPTE Motion Imaging Journal*, September 2009, pp. 60 and 61). For additional information, contact Jim Houston at jim.houston@mindspring.com.

Digital Display Subcommittee

Co-Chair: Jim Fancher **Co-Chair:** Alan Hart

Under the leadership of Al Hart the Digital Display subcommittee has continued to examine new displays as they are introduced. Analysis has included the cost of displays for use in professional settings. Al Hart prepared an analysis which compared various displays with regard to their size and purchase price. We also surveyed popular viewing distances for the new larger displays which are being used for color correction, QC, and dailies viewing. Many post facilities are currently using displays in the 50 in. range at 1920 x 1080 for color correction and QC. Popular viewing distances seem to be 5 to 14 feet, with some colorists working at about 6 ft.

With the disappearance of the CRT as the trusted display in most post viewing environments, the committee is continuing to look at new displays as they are introduced and with input from the advanced imaging subcommittee continuing to characterize these displays as to their spectral characteristics. In addition to plasma displays, the committee is watching the emergence of emissive technologies such as SED and OLED, including Sony's small but attractive 7 in. professional OLED. For professional post-production use, the new variable backlight LED display from Dolby is of particular note. Along with very high contrast, it offers push button emulation of several different display types. Motion portrayal remains an elusive and difficult to measure aspect of these new display technologies.

While there are now several manufacturers offering near 4K displays, they are still not in widespread use in post facilities. A consumer-oriented 3480 = 2 x 1920 is not equal to a professional 4096, but consumer products fund most or all large display production lines. And the vast majority of consumer-based displays are only 8-bit, while we feel that a professional display requires at least 10 bits.

3D is becoming more a fact of everyday workflow at post houses and during production. As this market becomes more mature in its offerings, the committee hopes to look at 3D display systems.

FLAT PANELS IN PROFESSIONAL APPLICATIONS

The use of flat panel displays for the entire range of functions that take place in professional post-production is becoming the norm. This is certainly good from a cost and availability point of view, but it can be argued that it is also bad since standards have not changed to keep pace with the evolution in display technology. It is recognized that no known consumer display completely follows the established standards originally created for calibrating CRT displays and it is clear that new technology displays need standards/guidelines appropriate for each of the different technologies.

This leads individual facilities to develop internal practices for adjusting new technology displays based on CRT standards. Such practices and results are not typically shared outside a given organization. The level of expertise and test equipment available in professional television/film organizations do allow some professional versions of consumer display technology to be calibrated to accurately reproduce the same image across multiple displays, but is this the same image originally viewed on a professional CRT? The answer is NO and frankly that is a good result. New technology displays provide a superior image when compared to the CRT and are well-suited for the creation of images to serve the wide open world of consumer displays.

Current SMPTE CRT standards suggest a light output that is much higher than is required or desired for setting large screens to match a professional CRT display. This is only one of the differences between

old and new display technology that clearly demonstrates that new recommendations need to be created to guide image creators at all levels of expertise, from layman to professional.

Notwithstanding the complications of using consumer-based products for professional viewing environments, the benefits of seeing an "approximation" of what the consumer sees are undeniable. The days of finishing work on CRT-based displays and shipping masters, only to later find that a significant artifact was being masked by the display technology, are largely behind us. Conversely, it is true that consumer displays can produce acute, unnatural images, especially when they are not adjusted properly.

Even a picture that is not accurate is still useful when it reveals a problem that would otherwise be invisible to the creator but obvious to a potential audience of millions. We can think of this as if we had a magnifying glass with a pink tinted lens—yes it is turning what we see pink, but when the object under study is a distracting artifact or anomaly affecting the consistency of the overall presentation (unrelated to color accuracy), the lack of perfection of the looking glass is secondary.

What can't be argued is that high-resolution displays are in the hands of consumers and here to stay.

Displays are getting larger on a per dollar basis and constantly improving in terms of real-world performance. Ideally, the manufacturers that provide these displays for consumers could provide a model with the capability to match an industry color gamut as well as other essential parameters within and across like-modeled displays. In the event this is not supported, an opportunity exists for third-party solutions to fulfill this need.

Film and Digital Preservation/Archiving Subcommittee

Chair: John Bailey **Co-Chair:** Grover Crisp **Co-Chair:** Garrett Smith

We working cinematographers have a direct and compelling self-interest in the archiving, preservation, and restoration of our work, one that goes beyond our overall love of cinema and its history. It is our personal legacy. My own growing concern with these issues, as reflected in several of my blog essays, has compelled me to bring the matter before the Board of Governors of the ASC. While our Society has been discussing these mutual concerns among ourselves and with industry colleagues for many years, President Michael Goi has charged me with chairing our ASC Technology Committee's Film and Digital Preservation/Archiving Subcommittee to help further develop our efforts in the field of film and digital preservation.

Preservation has become of increasingly personal interest to me as I have become involved in the remastering of several classic silent films, as well as new editions of films I had worked on as an assistant or camera operator. I am myself of an age that some of the cinematographers I worked with early on are now deceased and I have become the de facto best link to their work. While we all have lost too much of our film history to the "benign neglect" of the past, much has been able to be restored because of the surpassing technology now possible in the digital suites. The recent release of a magnificent new version of Fritz Lang's *Metropolis* and of the 20th Century Fox box set of Murnau and Borzage films of the late silent era, are cases in point.

These issues are becoming even more urgent as we transition from film to digital production, the acceleration of which is driven by digital 3D—the aesthetics of which is another discussion. But there is no denying that this is an emerging reality and it has immediate consequences for issues of preservation. Bluntly put, there will be no camera original film master for the coming generation of 3D films. And we may well find ourselves a decade from now facing some of the same issues we now have on the table with the earliest generation of films finished from DIs.

The ASC is looking forward to engaging film historians, archivists and preservationists as we explore common concerns. We are eager to contribute to this ongoing dialogue.—*John Bailey, ASC*

A year from now, we will probably look at this past year as the tipping point in the complex arena of Digital Archive and Preservation. The long view of the pressures and concerns we are facing as an industry are accelerating at breakneck speed. Motion Pictures are being captured, finished, and distributed digitally on an increasing basis. It is becoming a norm—not an anomaly. Members of the ASC Technology Committee have been meeting with traditional industry

vendors, new types of vendors as well as potential strategic vendors outside of our industry in an effort to find a workable solution to solve the long-term preservation of the pictures and sounds that fill the stories we tell as an industry. Filmmakers and studios alike are increasingly aware of the need to find a stable and scaleable solution to make sure that for better or worse, we have a legacy that future generations can look back on and reflect upon in this transforming period of movie making—not to mention, repurposing movies for yet to be discovered digital distribution formats. Gone are the days of "store and forget." Gone are the periods of "benign neglect." If we do not rally as an industry, future generations may look at this period as "the digital nitrate years." In the next year we expect to see important developments in data management as well as online, nearline, MAID and yes, even tape migration. There is not industry consensus yet, but there is much discussion and development. To borrow from Peter Weir's film—*The Truman Show*, the industry is collectively wondering "How Will it End?"—*Garrett Smith*

Enlightenment Subcommittee

Chair: Richard Edlund, ASC; Stephanie Argy

The mission of the Enlightenment Subcommittee is to distill the research and findings of the ASC Technology Committee and make them more readily accessible to a wider audience.

As the ASC Technology Committee has evolved, the Enlightenment Subcommittee has evolved along with it. Our initial impetus was to make ASC members and the filmmaking community as a whole more familiar with the work being done by the Technology Committee. As part of that effort, we have written articles published in *American Cinematographer*, and we have worked with other subcommittees in summarizing their results, as when we assisted the Previsualization Subcommittee and Virtual Production Subcommittee in writing reports about their meetings and outcomes.

While we remain committed to that original goal, we now also want to contribute to the increasing interaction between the ASC Technology Committee and vendors and manufacturers. One of the lessons of the Camera Assessment Series was that many manufacturers sought to include cinematographers and other filmmakers in their development process, making the creation of new tools a collaboration between the artist and the technologist. We think the ASC is an ideal entity to contribute to the growth of those kinds of constructive relationships.

Finally, we see a third part of our responsibility as fostering interaction between the various subcommittees, so that their efforts can be more closely linked together and integrated.

In its earliest days, the ASC Technology Committee was focused on the digital intermediate process, on film scans and on digital cinema. In the years since, technology has grown increasingly complex, and so has the work of the Technology Committee. Areas we see of special interest for the Enlightenment Subcommittee in the coming year include the ongoing evolution of digital cameras (including the development of 4K capture), digital image processing (including the solutions offered by Lowry Digital and ARRI), IFF/ACES, virtual production and developments in 3D/stereoscopic technology.

We welcome any comments, suggestions and requests. Please contact Richard Edlund (re @richardedlund.com) or Stephanie Argy (steph@mentalslapstick.com).

Previs Subcommittee

Co-Chair: David Morin **Co-Chair:** Ron Frankel **Secretary:** Georgia Scheele

As was originally planned when it was created on April 1st 2008, the ASC-ADG-VES Joint Technology Subcommittee on Previsualization (the Previs Subcommittee, for short) came to an end at its 12th meeting on August 13, 2009, when it delivered a final report that included a number of authoritative definitions and clarifications on the process of previsualization. The final report of the Previs Subcommittee is available on demand from any of the founding organizations.

More importantly, at its last meeting certain members of the Previs Subcommittee, including co-chair Ron Frankel, announced the formation of a permanent organization dedicated to previsualization:

The Previsualization Society. The Previsualization Society is a permanent non-profit trade organization that will continue to pursue the work started by the ASC-ADG-VES Joint Technology Subcommittee on Previsualization. More information on the Previsualization Society can be found at www.previssociety.com.

The Previs Subcommittee was an unprecedented joint effort between the ASC, the Art Directors Guild (ADG) and the Visual Effects Society (VES) that proved how existing organizations can collaborate successfully to foster better understanding of new process and technologies.

The other co-chair of the Previs Committee, David Morin, went on to create a new joint effort: the Virtual Production Committee (see below).

Previsualization Society **President:** Colin Green

The process of previsualization ("previs") has become increasingly integral to the conception and completion of film and television projects in recent years. Using previs based on 3D scene modeling and animation, directors, producers, cinematographers, production designers, visual effects supervisors and others are able to effectively flesh out creative ideas and technical scenarios in advance.

Recognizing the potential of previs to add value across many different departments and collaborators as content production continues to evolve in the digital age, the ASC-ADG-VES Joint Technology Subcommittee on Previsualization was formed in April 2008 to discuss and learn about advances in previs among the many of the disciplines that intersect with previs. An outcome of the committee upon its conclusion in August 2009 was formation of the Previsualization Society, a permanent non-profit organization dedicated to the advancement of previsualization for all who participate in or benefit from the previs process.

As its chief mission, the Previsualization Society is aimed at maximizing the current and future capabilities and contributions of the previs medium by building a community that is as collaborative and interdisciplinary as previs itself. The Previsualization Society also seeks to promote effective previs applications, standards and workflows as well as education through handbooks, tutorials, historical archives, downloadable tools, events, forums and practical knowledge exchange.

A further result of the ASC-ADG-VES Joint Technology Subcommittee on Previsualization was adoption of an accepted set of definitions for previsualization and its various types. In its main form, previs has been officially defined as "a collaborative process that generates preliminary versions of shots or sequences, predominantly using 3D animation tools and a virtual environment. It enables filmmakers to visually explore creative ideas, plan technical solutions, and communicate a shared vision for efficient production." A full set of definitions is available and maintained on the Previsualization Society website: www.previssociety.com.

The Previsualization Society is headquartered in Los Angeles, CA, and has chapters in Europe, Latin America, Australasia and other regions around the world. Membership in the Previsualization Society is open to previs supervisors and practitioners as well as directors, producers, storyboard artists, cinematographers, art directors, production designers, editors, visual effects professionals, studio executives and other industry personnel who engage with previs. Educator, student and general interest memberships are also offered.

Founders of the Previsualization Society are David Dozoretz, Chris Edwards, Ron Frankel, Colin Green (President), Daniel Gregoire (Treasurer) and Brian Pohl (Secretary).

For more information, visit www.previssociety.com or contact info@previssociety.com.

Virtual Production Committee

Chair: David Morin **Vice-Chair:** John Scheele **Secretary:** Stephanie Argy

The Joint Technology Subcommittee on Virtual Production (Virtual Production Committee, or VPC for short) is a new collaboration by some of the most prominent organizations in Hollywood, working together to explore how live-on-stage computer graphics may change the future of movie production.

The VPC is a joint technology subcommittee formed by the American Society of Cinematographers (ASC), the Art Directors Guild (ADG), the Visual Effects Society (VES), the Previsualization Society and the Producers Guild of America (PGA). The chair of the VPC is David Morin, and the vice-chair is John Scheele.

With the success of James Cameron's Avatar, there have been numerous one-time presentations in Hollywood about virtual production by organizations such as the AMPAS, the DGA and others. The Virtual Production Committee is an ongoing joint effort that will maintain a degree of continuity in the analysis of the new virtual production process. It is meant to give motion picture professionals interested in the topic a regular forum in which to express their views and concerns, and to learn about virtual production. As with the Previs Committee that preceded it, the VPC will hold a total of twelve meetings over a period of approximately two years, after which it will produce a final report and disband. Its first two meetings were held on April 1, 2010 and July 7, 2010.

The goal of the VPC is to create a better understanding of virtual production throughout the industry, to mitigate some of the fears and anxieties that have been raised about the process, and to create standardized definitions and best practices. As a starting point, the committee is defining virtual production as "computer graphics on stage," or the process of shooting a movie with realtime computer graphics, either for all-CG movies (such as *Christmas Carol* or *Tintin*) or for visual effects movies with live action (such as *Avatar*).

As the committee examines how the technology and craft could evolve, it will begin by asking itself these questions:

- What is virtual production?
- Is virtual production a fad, or is it here to stay?
- What does this mean for the future of moviemaking?
- How does it relate to other markets(scientific visualization, architecture, video games)?
- Is virtual production only for mega-budget productions, or will it become available to all?
- How do you tie a virtual production workflow onto an existing VFX pipeline?
- How are virtual productions best structured and organized, based on the experience of such productions to date?
- What is a simulcam?
- What is a virtual camera?
- How should both relate to the real camera?

The VPC has a steering committee composed of two members of each participating organization; Michael Goi, ASC and Curtis Clark, ASC, are representing the ASC.

Additional information on the VPC can be obtained from David Morin (davidmorin@)davidmorin.com) and John Scheele (johnscheele@gmail.com).

The Authors

Curtis Clark, ASC, Clark's credits include such artful narrative films as *The Draughtsman's Contract*, *Dominick and Eugene*, *Alamo Bay*, *Extremities* and *Talent for the Game*. His extensive commercial cinematography projects have put him on the cutting edge, working for some of the industry's top directors and agencies.

Clark currently heads the American Society of Cinematographers (ASC) Technology Committee, which examines and addresses imaging technology issues as they relate to the creation of motion pictures and cinematography. That committee worked closely with Digital Cinema Initiatives (DCI) to produce the ASC-DCI Standard Evaluation Material (StEM) used to evaluate the performance of digital projectors and other elements of digital cinema systems.

Michael Goi, ASC, is the president of the American Society of Cinematographers. His credits include the series "My Name Is Earl," for which he received an Emmy nomination, the original pilot for "Life On Mars," and the feature films *The Christmas Movie*, *Witness Protection*, and *The Dukes*. He recently wrote and directed the drama Megan Is Missing.

Goi is a member of the Academy of Motion Picture Arts & Sciences (AMPAS), the Academy of Television Arts & Sciences (ATAS), and serves on the National Executive Board of the International Cinematographers.

David Reisner's motion picture work emphasizes creative flexibility and best practices in image quality, color, workflow, DI, and digital and hybrid imaging in production, post-production, distribution, and exhibition for features. Digital cinema work also includes security, testing, interoperability, and standards.

Reisner has been Secretary of the ASC Technology Committee since its founding and is Secretary of the DI, Workflow, Advanced Imaging, Camera Assessment Series, and 3D StEM subcommittees. He has been a principal in planning, designing, and creating the ASC Color Decision List (ASC CDL), the ASC-PGA Camera Assessment Series, and the ASC-DCI StEM (Standard Evaluation Material) test movie (screen credit—Test Design). He has been an officer of SMPTE digital cinema working groups during the entire development of digital cinema standards and is presently Secretary of 21DC-10 Mastering. As Secretary and Vice-Chair of the Inter-Society Digital Cinema Forum (ISDCF) he had a principal role in design and execution of the 3D projection luminance demonstration. He was architect of proposed 2K and 4K proof-of-concept systems for DCI. Reisner is also working to start the Cinema Research Institute, www.cinemaresearch.org, for which he is seeking funding.

Work in other industries has included technical and business plans for internet-based music and movie distribution; computer hardware and software architecture (SGI, Sun Microsystems, etc.); and killer whale training.

Reisner also works with producers, directors, and cinematographers to help them make the best choices for their shows in our rapidly changing technical environment.

Dave Stump, ASC, began his career in film in the late 70s, first as a TV producer for several cable shows and then at ABC where he helped put together a late night TV show called "Completely Off the Wall." He worked on a number of pictures with Clive Donner then worked for Francis Coppola in his camera department at Zoetrope Studios, working on all Zoetrope pictures such as *One from the Heart* until the studio moved to San Francisco. He worked on *The Day After* TV miniseries that won a VFX Emmy Award.

In 1991 Stump started a rental company, Motion Control Rental Services, which grew into the model for Visual Effects rentals in Hollywood. He has worked as DP, VXF DP and VXF supervisor on numerous large motion pictures and television productions and earned another Emmy nomination and an Academy Award for Scientific and Technical Achievement. He is a member of the ASC and chairs the Camera subcommittee of the ASC Technology Committee, helping to shape the future of digital cinematography.

Richard Edlund, ASC, established his reputation winning four Oscars for the visual effects in *Star Wars*, *The Empire Strikes Back*, *Raiders of the Lost Ark*, and *Return of the Jedi*, with a nomination for *Poltergeist*. He has received six additional Oscar nominations, three Academy Scientific and Engineering Awards, an Emmy, and two BAFTA Awards.

In 1983, Edlund founded a VFX company called Boss Film Studios, which produced effects for thirty-plus movies, including *Ghostbusters*, *2010*, *Die Hard*, *Ghost*, *Poltergeist 2*, *Cliffhanger*, *Batman Returns*, *Alien3*, *Species*, *Multiplicity* and *Air Force One*, achieving ten Academy Award nominations.

Following Boss, Edlund supervised *Bedazzled*, *Angels in America*, *The Stepford Wives*, and *Charlie Wilson's War*.

Edlund is a governor of the Academy and chair of its Scientific & Technical Awards Committee. He was chair of their VFX Branch for its first 11 years. He also serves on the boards of the ASC and the VES. Recently, he was honored with the Academy's A. Bonner Medal of Commendation and the ASC's Presidents Award.

Edlund was a SMPTE member from 1978 to 1990 and was a manager of the San Francisco Section for several years in the early 1980s.

John Bailey, ASC (Director of Photography) has enjoyed relationships with directors as varied as Paul Schrader, Lawrence Kasdan, Michael Apted, John Schlesinger, Harold Ramis, Norman Mailer and Ken Kwapis.

In an eclectic career, Bailey has photographed such mainstream Hollywood films as *Ordinary People*, *Silverado*, *The Accidental Tourist*, *Groundhog Day*, *In the Line of Fire*, *As Good as It Gets*, *How to Lose a Guy in 10 Days*, *The Sisterhood of the Traveling Pants*, and *Must Love Dogs* to name few.

Bailey's other film credits include *Divine Secrets of the Ya-Ya Sisterhood*; *The Anniversary Party*; Paul Schrader's *American Gigolo* and *Mishima: A Life In Four Chapters*, for which he shares the 1985 Cannes Film Festival Award for Best Artistic Contribution with composer Philip Glass and production and costume designer Eiko Ishioka.

His recent projects include John Krasinski's directorial debut film *Brief Interviews with Hideous Men*, and Shana Feste's *The Greatest*. Both films were selected for competition in the 2009 Sundance Festival. His most recent work for Feste, *Country Strong*, will open in December. He is currently prepping *Saving the Whales* in Alaska for Ken Kwapis.

Bailey has served on the Board of Governors of the Academy of Motion Picture Arts & Sciences, and as vice president of the American Society of Cinematographers.

Lou Levinson received an MFA from the School of the Art Institute of Chicago in the spring of 1979, having worked his way through school as a tape operator and colorist. After graduating he joined Columbia Pictures Videocassette services, where he helped to maintain the first flying spot scanner installed in the Midwest. In September of 1980, he was hired as a colorist at Modern VideoFilm, becoming the 13th employee. Thirteen years later, MVF had more than 200 employees, and Levinson left to become colorist at the MCA/MEI Telecine Research Center, working in what was the third HD telecine room on the planet. From 1998 to 2008 Levinson was senior colorist at Post Logic Studios. He is now supervising colorist—mastering at Laser Pacific. A longtime ASC associate member, he has been on the ASC Technology Committee since its inception and is currently chair of the Digital Intermediate subcommittee.

Joshua Pines is vice president of imaging research and development at Technicolor Digital Intermediates, where he is currently in charge of imaging and color science.

Pines joined technicolor after more than ten years at Industrial Light & Magic (ILM), where he supervised the film scanning/recording department from its inception, working extensively with both traditional and digital cinema technologies.

Pines started his career teaching film courses at the Cooper Union in New York City after earning a degree in electrical engineering. He began working in visual effects at MAGI in 1982 during its work on Tron. He also led the computer graphics division at r/Greenberg Associates, and supervised film effects and film recording at Degraf/Wahrman, before working for ILM. Pines is a member of the AMPAS, an associate member of the ASC, and has credits on numerous feature films.

Gary Demos has spent his career working with the physics of light in motion pictures, together with corresponding mathematical and computational analysis. Demos was integrally involved with the first generation of digitally simulated scenes—CGI—for motion pictures. Demos founded DemoGraFX in 1988, working in integer-DCT-based digital image compression for moving images, and with image-processing and image formats for HD and beyond. Since 2004, he has been working independently on wavelet-based and optimal-filter-based moving image compression.

Since July 2008, Demos has also been serving in R&D at Lowry Digital. Demos has authored dozens of technical papers and is the inventor of numerous patents in digital signal processing, image processing, and moving image compression. Demos received an Academy Scientific and Engineering award along with John Whitney Jr. "For the Practical Simulation of Motion Picture Photography by Means of Computer Generated Images" (1985), shared another for his work in digital film scanning (1995), and shared a Technical Achievement award for work in digital compositing systems (1998). In 2006, Demos received the Academy Gordon E. Sawyer Oscar for lifetime technical achievement.

Jim Fancher currently develops next-generation technology for Deluxe Digital Media in Burbank, CA. Previously, he was chief science officer at the Thomson Corporate Research facility 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, the post-production arm of Technicolor, Fancher was involved in the development of color management systems, image processing and media asset management. Fancher has been a part of managing Technicolor's world-class Digital Intermediate facility (formerly known as Technique), as well as the deployment of DI processes to Montreal and New York. Before his engagement at Technicolor, 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.

Alan Hart started his television career in 1967 with KCET Channel 28, the PBS station in Los Angeles. He served as Chief engineer from 1975 to 1978. In 1978 he joined RCA and was involved in videodisk technology before joining Modern VideoFilm in 1981 where he serves as executive vice president, engineering, responsible for all technical resources. A member of SMPTE since 1975, Hart served as Chair of the Hollywood Section, two years on the Board of Managers, two terms as National Governor , and is a SMPTE Fellow.

Garrett Smith is vice president of production technology for Paramount Pictures. Smith joined Paramount in 1988, where he has been involved with film-to-digital mastering and quality control for the electronic distribution of all Paramount theatrical films. He has also been active in the development of D-Cinema. He is a member of the Academy of Motion Pictures Arts & Sciences' Science and Technology Council, an adjunct associate professor at the University of Southern California (USC) School of Cinematic Arts and an associate member of the ASC, where he is also vice chair of the ASC-Technology Committee Digital Preservation subcommittee. Before Paramount Pictures, he worked in various post-production positions including director, post-production for New World Television; director, post-production for Columbia Pictures filmed television; and Manager, Film Services for CBS Television Network.

Stephanie Argy is a filmmaker and journalist. Her films as a writer/director (in collaboration with her partner Alec Boehm) include the award-winning feature *The Red Machine*, which is currently touring the film festival circuit. Argy has written extensively on the art, craft and technology of filmmaking for many periodicals and websites, including *American Cinematographer*, *Variety*, *Hollywood Reporter* and many more. She holds a B.A. in history from UCLA and an M.S. from the Graduate School of Journalism at Columbia University.

David Morin earned a B.Sc.A. in computer science from Laval University (Quebec City, Canada) in 1982 and then worked as an artist in traditional media. In 1991, he joined Softimage, where he participated in the early development of 3D software technologies and supported product sales and marketing in various functions worldwide. Morin also opened an office in Santa Monica, CA, where he headed the special projects group as director when Softimage was acquired by Microsoft. He later worked as vice president when the division was sold to Avid Technology. In 2000, Morin joined Manex Entertainment as president of the MVFX division, a VFX house. In 2001, he retired from the industry, and in 2007 returned as an independent consultant. Morin currently represents the Media & Entertainment division of Autodesk, Inc., in the Los Angeles area.

Colin Green entered the film industry in the early 1990s, working on breakthrough simulation and special venue projects for legendary cinematic innovator Doug Trumbull. Having recognized the potential of fledgling 3D animation applications on the Trumbull projects, he began applying these tools to design and technically plan shots for feature film. His first project using this technique was 1995's *Judge Dredd*, which successfully aligned live-action footage, extensive miniature photography and computer-generated imagery via digital previsualizations. *Judge Dredd* also achieved a motion control data delivery workflow that allowed the shooting of miniatures to be tightly integrated into a 3D pipeline, and organized a group specifically called and known as the previs department. Green founded Pixel Liberation Front (PLF), a company dedicated to producing previs, that same year.

In his tenure as president of PLF, Green has worked as a hands-on previs supervisor and artist on dozens of feature film projects, collaborating with David Fincher, Larry and Andy Wachowski, Bryan Singer and other top Hollywood storytellers and their crews to map out complex visual effects sequences in advance of shooting and help make previs a true director's tool. Green's screen credits include such movies as *Starship Troopers*, *Fight Club*, *Minority Report*, *iRobot*, *Panic Room* and *The Matrix* sequels.

Located in Venice, CA, PLF has been a leader in completing previs and final visual effects for film, commercial, game and music video clients. The company's previs filmography includes *Iron Man*, *Speed Racer*, *Terminator: Salvation*, *Spider-Man 3*, *Pirates of the Caribbean: Curse of the Black Pearl*, *The Last Samurai*, *Minority Report*, *The Bourne Supremecy*, *Zathura*, *Dreamgirls*, *The Ring* and many other films.

An important mission for Green and PLF over the years has been providing hands-on experience and training to young animators and designers to help cultivate and grow today's previs artist pool. Green holds a bachelor's degree from the Yale School of Architecture and studied graduate-level architecture and design at Harvard and MIT.