The Status of Cinematography Today

HISTORICAL PERSPECTIVE ON THE TRANSITION TO DIGITAL MOTION PICTURE CAMERAS

Curtis Clark, ASC

A Controversial Beginning

As anyone involved with feature film and/or TV production knows, cinematography has recently been experiencing acceleration in the routine use of digital motion picture cameras as viable alternatives to shooting with film. The beginning of this transitional process started with George Lucas in April 2000.

When Lucas received the first 24p Sony F900 HD camera to shoot Star Wars Episode II, *Attack of the Clones*, cinematography was introduced to what was the beginning of perhaps the most disruptive motion imaging technology in the history of motion picture production. The initial marketing hype that accompanied 24p 8-bit 4:2:2 HD video claiming “film is dead” effectively and prematurely undermined any potential that digital cinematography might have had back then for establishing an early beach head toward industry acceptance.

What was missing at that time was a clear understanding of the requirements for a ‘digital motion picture camera’ that would be able to go beyond the imaging constraints of broadcast TV-based HD toward the image capture capabilities of motion picture film.

The majority of filmmakers recognized that the claim of imaging parity with 35mm film capture was preposterous. It wasn’t primarily the limitation of its 1920 x 1080 spatial resolution, but rather its limited dynamic range and color bit depth within the restrictive Rec.709 gamut, along with the camera’s 2/3 in. sensor size which significantly altered depth of field and necessitated using lenses designed for the world of HD video. Establishing a convincing “film look” was generally elusive and the prevailing non-DI (Digital Intermediate) post workflows of that time presented further challenges with film-outs for theatrical distribution. Also, it’s worth remembering that, at that time, Digital Cinema was not yet on the horizon.

An Early Turning Point

Perhaps the initial turning point that eventually led toward industry receptiveness of digital image capture as a potentially viable alternative to shooting film, or at least as a companion to be used in conjunction with film, was Michael Mann’s 2004 motion picture *Collateral*. Most digital 24p cameras at that time (e.g., Sony F900) were routinely limited to 8-bit HD Cam recording, using 4:2:2 video gamma-based HD Rec.709 color gamut imaging parameters. The Thomson Viper in “Film Stream” mode was able to output 10-bit RGB (4:4:4) 1920 x 1080 HD Rec.709 images, which could be recorded to an SRW 5500 studio deck that was first introduced by Sony in 2004. The F900 could also output 10-bit images to the SRW 5500, but only 4:2:2. Both cameras used 2/3 in. sensors that were incompatible with film-based PL or PV mounted 35mm lenses. Both the Sony F900 with on-board HDCam recording and the Thomson Viper tethered to an external SRW 5500 studio deck were used to shoot the night scenes for *Collateral*. The F900 was selected only for those scenes where the camera setup required unrestricted mobility free from being tethered to an external recorder.

Although Digital Intermediate workflow and Digital Cinema exhibition were both in the early stages of implementation, the advent of DI-based post workflows facilitated an easier integration of digitally captured images, especially when combined with film scans that were usually 2K 10-bit DPX.

Mann’s widely publicized desire to reproduce extremely challenging shadow detail in the nighttime scenes was effectively realized via the digital cameras’ ability to handle that creative challenge at low light level exposures better than film could. The brighter daytime scenes were shot on film, which was better able to reproduce highlight detail with greater latitude than the digital cameras could at that time. In effect, Mann along with cinematographers Dion Beebe, ASC, and Paul Cameron, ASC, chose digital for specific scene reproduction attributes that served their creative intent while using film for the scenes that benefitted from its reproduction attributes. Blending the two imaging platforms in the post finishing was certainly a photographic challenge.

The three 2/3 in. charge-coupled device (CCD) chip 24p platform evolved further toward the digital motion picture camera paradigm with the introduction of the Sony F23 in 2006. By providing an option for log encoding of its 4:4:4 RGB output using S-Log in conjunction with S-Gamut, the camera offered an alternative configuration that was not based on HD video thereby enabled the capture of a wider dynamic range and color space closer to film.

The Genesis of the 35mm Single Chip Digital Motion Picture Camera

The first camera to commercially introduce a single-chip sensor (CCD) the size of a Super 35mm motion picture frame was the Panavision Genesis. Developed by Panavision in conjunction with Sony, the Genesis marked an innovative breakthrough in digital motion picture camera design. It enabled the use of existing 35mm motion picture lenses, along with an advanced log encoding of its image capture (Panalog) that facilitated the reproduction of a wider dynamic range of scene tones. Its 4:4:4 RGB (1920 x 1080) output proved effective in the DI post workflow enabling it to better emulate a more filmic look and feel for cinema productions. The first feature film to use the Genesis was the 2005 production of *Superman Returns*. It has subsequently been used on numerous cinema and TV drama productions.

Introduced by Arri in November 2005, the D-20 camera was the second camera to incorporate a Super 35mm size single-chip sensor (CMOS Bayer pattern). The camera initially recorded out 10-bit images to SRW tape at 1920 x 1080 but subsequently, in the upgraded D-21, was able to output 12-bit ArriRAW images with greater resolution from its 2880 x 2160 active pixels. The D-20 (and its successor D-21) also provided the option of a "Log C" image encoding.

In 2006, Dalsa Digital Cinema introduced the Origin with a Super 35mm size single-chip sensor (CCD) that in many respects was ahead of its time. The Dalsa Origin was the first commercially available digital motion picture camera to claim image capture at 4K resolution. The Origin also output uncompressed RAW Bayer pattern 16-bit images that provided considerably greater bit depth than other digital motion picture cameras which, at that time, were still mainly limited to 8-bit or 10-bit, with the exception of 12-bit Arri RAW. The camera never succeeded in finding industry adoption and was subsequently discontinued in 2008, mainly due to its physical form factor and the challenges that its uncompressed 4K image file size presented for the 2K DI post workflows prevailing at that time.

In 2007, the Red Digital Cinema Camera Company introduced the Red One. It featured a single Super 35-sized CMOS Bayer pattern sensor and a cinematography industry standard PL mount. Like the Dalsa Origin, the Red One also claimed 4K resolution but incorporated a non-optional variable bit rate wavelet compression codec that significantly reduced the image file size.

Sony first introduced their Super 35mm single chip (CCD) sensor camera, the F35, in January 2008 with 10-bit S-Log and S-Gamut (4:4:4 RGB wide color space) image encoding which rapidly became a favorite choice among filmmakers for its ability to reproduce a very wide dynamic range of scene tones and a filmic look within the 10-bit DPX Cineon-based DI workflows that were prevalent at that time. A subsequent upgrade to the F35 that enabled 12-bit S-Log and S-Gamut 4:4:4 RGB output was introduced at NAB 2011.

"Coming of Age" with the ASC-PGA Camera Assessment Series (CAS)

In January 2009, the ASC in partnership with the PGA undertook the pivotal Camera Assessment Series (CAS) which was carefully designed to assess whether or not the then most frequently used digital motion picture cameras were able to match film's status as the undisputed and desirable photograph bench mark. We wanted to assess whether or not the participating digital cameras were able to transcend their HD video legacy with the resulting "HD video look" and be worthy of being referred to as "digital motion picture cameras," i.e., capable of reproducing a photographic look comparable to that produced by a 35mm motion picture film camera. Our targeted displays were digital cinema projection, along with film projection via film-out.

Several carefully designed and orchestrated test scenes were shot with the seven digital cameras considered by the group to be the best of the commercially available options at that time. The 35mm single chip cameras included Sony F35, Panavision Genesis, Arri D-21 and Red One. The 2/3 in. three chip cameras included Sony F23, Panasonic 3700, and Thomson Viper. The same test scenes were also shot with a film camera using Kodak 5219, 5207, and 5217 negative stocks as the film reference.

Specifying a single, consistent post workflow was considered vital to creating a level playing field for the CAS. After numerous discussions we reached a consensus to use a film-centric Cineon-based DI workflow with 10-bit log DPX files as the common denominator. We agreed that an open and transparent post workflow process would be used by all participating cameras without applying "secret sauce" transforms or special image processing during post finishing. It was further agreed that the digital camera manufacturers would be responsible for delivering their CAS recorded images for post ingest as log-encoded 10-bit DPX files that would ideally be able to reference film print color space via Cineon Printing Density, thereby enabling those cameras to use the same film print emulation LUT during color grading that would also be applied when color grading the film reference.

Most of the cameras required the use of an additional input conversion transform that more closely aligned camera exposure code values with the appropriate Cineon printing density target code values. This transform function was initially implemented via the ASC CDL "power function" and in some cases, such as F35 S-Log, was further refined by the use of a 1D LUT. The digital cameras delivered images that were 1920 x 1080. The film was scanned at 4K and down-converted to 2K (2048 x 1556), following the most commonly used DI post workflow practice at that time.

During the CAS final color grading it became increasingly apparent that the digital cameras that came closest to reproducing a film look were those that effectively used a log encoding of their RGB image output, which corresponded more closely to film printing density (code values) vs. those cameras that relied on video gamma (aka video 'linear') within the constraints of Rec.709. As a result, the digital cameras with log output were not only able to extend their dynamic range but also fit more compatibly within the film-centric color space of a film print emulation LUT.

The Sony F35 (S-Log), the Panavision Genesis (Panalog), and the Arri D-21 (Log C) were generally considered to be the best examples of effective log encoding among the single-chip (Super 35mm imager size) cameras participating in CAS. Although these cameras demonstrated their "coming of age" as digital motion picture cameras that were in varying degrees worthy of being favorably compared with film, they also left, in varying degrees, room for improvement concerning dynamic range, sensor sensitivity and wide gamut color reproduction.

The Next Level of Advancement

In the two years and six months since shooting the CAS in January 2009 there have been significant technology developments that further advance digital motion picture camera imaging technologies, as well as major advances in DI post workflow architecture. True 4K resolution is now a reality for both digital camera image capture and DI workflow. In addition, the inadequacies inherent in Cineon-based DI workflows that pertain to image transforms, such as ambiguities between log and linear image encoding and ambiguities in transforms between color spaces, have been comprehensively addressed and solved by the AMPAS Image Interchange Framework (IIF).

Developed by the AMPAS Science and Technology Council, the Image Interchange Framework (IIF) is a new digital motion imaging architecture for scanned film, digital cameras and CGI that specifies the use of unambiguously defined image encodings and transforms (e.g., log vs. linear; narrow vs. wide gamut color spaces). IIF employs 16-bit floating point calculations to achieve greater precision of color management for color grading with the objective of more effectively and efficiently serving the creative intent (of the cinematographer and director)…from dailies through mastering, inclusive of all content distribution platforms: digital cinema; film print release; HD mastering for TV broadcast and/or Blu-ray. This method is now being standardized in SMPTE 10E.

Have we now finally arrived at an evolutionary stage of cinematography where the diminishing use of film negative urgently requires access to refined digital motion picture cameras, along with improved production and post-production DI workflows (incorporating AMPAS IIF), which not only preserve but also expand beyond the best of what film has provided our culturally rich filmmaking tradition?

Three cameras have emerged since the 2009 CAS that, in different ways and measures, advance the imaging capabilities of the Digital Motion Picture Camera: the Arri Alexa, the Red Epic and the Sony F65. All three cameras to varying degrees expand beyond the imaging parameters of the CAS generation of digital motion picture cameras. All three cameras lay claim to enhanced spatial resolutions beyond 1920 x 1080 (Alexa: 2K+; Epic: 4K; F65: 4K+). All three cameras also claim 14 or more stops of dynamic range with increased sensitivity, an improved signal-to-noise ratio, and wide color gamut reproduction with greater bit depth.

Photographic performance claims for digital motion picture cameras can, of course, be embellished with a marketing message that tells filmmakers what they want to hear. Can any of these digital motion picture cameras conclusively demonstrate their ability to truly deliver photographic imaging parameters that unequivocally match or even exceed the imaging parameters for 35mm motion picture film scanned at 8K and down-converted to 4K? The most recent entrant into the evolving realm of the digital motion picture camera is the Sony F65. Introduced at NAB 2011, the F65 aims to further raise the bar for a digital motion picture camera that can actually meet and/or exceed these fundamental imaging parameters.

Knowing the days are numbered for shooting with film as a routine option, cinematographers first and foremost need digital motion picture cameras that can perform as well as, or even better than, film while being able to retain the aesthetics of a film look.

Can a digital motion picture camera actually enable us to protect and preserve the vital photographic parameters that are the foundation of our cinematic filmmaking tradition and the cornerstone of cinematographic art?

The American Society of Cinematographers (ASC) and Producers Guild of America (PGA) are in the early stage of planning a follow-up to the 2009 CAS which will address this question. It is generally acknowledged that the imaging performance of both digital and film cameras cannot be properly assessed outside the imaging parameters of a DI-based production and post-production workflow. In the interest of removing potential constrains on the imaging performance of participating cameras, it has been agreed that we will use a 4K-based DI workflow that incorporates AMPAS IIF architecture. The film negative(s) used to shoot the test scenes will be scanned at 8K and down-converted to 4K. With this in mind, a new name has been selected for the next assessment series, which reflects this recognition: Imaging Control Assessment Series or ICAS.

ON-SET LOOK MANAGEMENT TOOLS FOR DIGITAL MOTION PICTURE CAMERAS

Curtis Clark, ASC

Progress is also being made in the integration of on-set look management applications into the production workflow. This is of special interest to the cinematographer who wants to control the photographic look for both dailies and editorial files (Avid/Final Cut), which are generated by an increasing number of on-set options. These look management applications are beginning to integrate the AMPAS IIF architecture which will further refine the color grading accuracy and effectiveness of these important applications. The ASC CDL (Color Decision List) has become the de facto standard for creating non-destructive cross-platform RGB primary color grading "look references" that can be transferred to the final DI color grading session as a "starting point" that represents the initial creative intent established by the cinematographer and director during principal photography.

STEREOSCOPIC CINEMATOGRAPHY

David Stump, ASC

It could almost be predicted that 3D would experience resurgence in the digital era, as it seems to make a comeback like clockwork in 25 to 30-year cycles. Driven by the successes of recent films such as *U23D*, *Journey to the Center of the Earth* and *Avatar*, this time it would appear that 3D can finally find lasting success. The advent of digital cinema workflows from acquisition through post and into exhibition has helped to overcome the multitude of technical issues that plagued stereo cinema in the past. Now that the technique of stereoscopic cinema is no longer severely compromised by basic fundamental flaws in workflow, the implementation of 3D in cinemas is moving very quickly—some might argue too quickly.

Cinematographers are faced with a dizzying variety of choices in equipment, rigs, and workflows, and the need to embrace such a constantly steepening learning curve is placing a substantial burden of education and training on cinematographers in order to keep pace with the demands of productions. Driven by the resurgence in box office that stereoscopic movies have generated, it is becoming imperative that cinematographers assimilate these new techniques and new paradigms of image capture.

A new style of film is emerging from the constraints that stereoscopic cinema impose on storytelling. The tools of 3D acquisition—larger and heavier camera rigs with an abundance of extra motors, controls and support gear, wide lenses, slower paced cutting, longer post schedules and increases in post-production costs—all these factors are beginning to affect the kind of films that are being made in 3D.

In addition, there is a growing portion of the market that is embracing the technique of 2D to 3D conversion as a post-production process. The technique initially was perceived to be flawed and visually unsatisfying, but in the last year or so refinements in software and a marked rise in the talent levels of the artists doing the work of conversion has made this option vastly more viable and appealing. Born out of techniques used in visual effects work and computer generated images, 2D to 3D conversion allows producers to postpone the decision whether or not to release in stereo until the movie is actually completed.

With the use of 3D for so many films, exhibitors are equipping theaters for screenings in both 2D and 3D. It is of growing concern to filmmakers and cinematographers that most theaters are installing systems that require a silver screen rather than the more common white screens. In theaters with silver screens, it can be very costly, time consuming, and difficult to accommodate both 3D and 2D exhibition in the same theater. In order to properly switch a theater from 3D to 2D, the silver screen must be swapped for a white screen, the 3D projection muxing system must be removed from the optical path, and the projector light level must be rebalanced from the common 4.5 fL light level of 3D to the industry standard 14 fL light level for 2D exhibition. It comes as no surprise that some exhibitors don't bother to spend the time and expense of implementing the changeover, thereby screening 2D movies on 3D systems and screens. This dramatically affects the light level, contrast, and effective screen viewing angle, drastically compromising the quality of the consumer's 2D experience.

One can only wonder what effect such debilitating compromises in theatrical exhibition have on audiences. Will it test their patience to the detriment of the theater experience?

How much longer will filmmakers tolerate such unacceptable creative compromises to their work?

HIGHER FRAME RATES

David Stump, ASC

The spatial resolution of digital cinema cameras and displays has reached the point where the temporal resolution afforded by current frame rates has become one of the most significant limitations. Research has demonstrated that increasing the frame rate can significantly improve the apparent resolution of motion images. If the spatial resolution of digital cinema continues to increase, raising the frame rate to maintain the balance between static and dynamic resolution will become more imperative. Even at the 1920 x 1080 spatial resolution of HDTV, motion artifacts associated with 24/25 frame/sec frame rates will quickly become increasingly apparent. Capturing at higher frame rates can improve picture quality by virtue of temporal oversampling, yielding fewer temporal aliasing artifacts, less strobing and less judder, and offering another creative tool to the cinematographer.

The flicker fusion threshold of human vision has been the subject of much research; it has been observed that our flicker threshold is proportional to the amount of modulation. The threshold also varies with brightness and is dependent on the part of the retina where the flickering image lands. Rod cells have a faster response time than Cone cells, so flicker can be sensed in our peripheral vision at higher frequencies than in our foveal vision. Research has generally shown that while our eyes may be sensitive to flicker at rates upwards of 250 Hz in some special circumstances, the general flicker threshold in viewing image sequences is at about 60 Hz.

Digital cinema and high-definition television have increased in spatial resolution without commensurately increasing frame rates. Camera panning speeds to follow fast action are still constrained by flicker rates, exacerbated by the increase in spatial resolution. Reduced pan rate is not a practical solution if we are to continue our march toward higher resolution to 4K and beyond.

Recently Jim Cameron showed a comparison of 3D images that he shot at 24 frames/sec to images shot at 48 and 60 frames/sec. He pointed out distracting strobing and judder in the 24 frame/sec material and pointed out the quality gained by shooting at higher frame rates. He contended that higher frame rates give an "enhanced sense of detail" and "enhanced clarity." He said that he had considered shooting *Avatar* at 48 frames/sec but decided against it, as the time wasn't right.

He did say that he is committed to shooting *Avatar 2* and *3* at either 48 frames/sec or 60 frames/sec. He also said that he is not alone in his enthusiasm for higher frame rates, citing that George Lucas is "gung-ho," so is Peter Jackson, who "did testing for *The Hobbit*."

Many digital cinematography cameras are already capable of higher frame rates. Cameron's tests were shot with the Arri Alexa, Red Epic and Phantom high-speed cameras. Cameron also asserted that "Generation two (digital cinema) projectors are capable of doing what I show you with a software upgrade."

Douglas Trumbull blazed the trail in this area when he developed the Showscan process in the late '70s / early '80s in an attempt to increase realism in movies. Trumbull used 65mm film running at 60 frames/sec in an effort to increase resolution and reduce the effects of flicker, strobing and grain. He did biometric research to test the responses of his viewers and discovered that as frame rates increased, so did the audience's emotional reaction.

Showscan was expensive, using over 280 ft/min of expensive 65mm negative, so it didn't catch on then, but 30 years later he is again talking about using higher frame rates. Trumbull announced at the 2011 Digital Cinema Summit at the NAB Show in Las Vegas that he has begun preparing a film that will incorporate both a higher frame rate and 3D. He said he will use his recently developed Showscan Digital process, which allows filmmakers to convert 60 frame/sec sequences into 24 frame/sec sequences.

Peter Jackson was recently interviewed for the online site Film Ledger:

> *We are indeed shooting (The Hobbit) at a higher frame rate. The key thing to understand is that this process requires both shooting and projecting at 48 frames/sec, rather than the usual 24 frames/sec. So the result looks like normal speed, but the image has hugely enhanced clarity and smoothness. Looking at 24 frames every second may seem ok, and we've all seen thousands of films like this over the last 90 years—but there is often quite a lot of blur in each frame, during fast movements, and if the camera is moving around quickly, the image can judder or "strobe."*
>
> *Shooting and projecting at 48 frames/sec does a lot to get rid of these issues. It looks much more lifelike, and it is much easier to watch, especially in 3D. We've been watching Hobbit tests and dailies at 48 frames/sec now for several months, and we often sit through two hours worth of footage without getting any eye strain from the 3D. It looks great, and we've actually become used to it now, to the point that other film experiences look a little primitive.*
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> *Now that the world's cinemas are moving towards digital projection, and many films are being shot with digital cameras, increasing the frame rate becomes much easier. Most of the new digital projectors are capable of projecting at 48 frames/sec, with only the digital servers needing some firmware upgrades. We tested both 48 frames/sec and 60 frames/sec. The difference between those speeds is almost impossible to detect, but the increase in quality over 24 frames/sec is significant.*
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> *Film purists will criticize the lack of blur and strobing artifacts, but all of our crew—many of whom are film purists—are now converts. You get used to this new look very quickly and it becomes a much more lifelike and comfortable viewing experience. It's similar to the moment when vinyl records were supplanted by digital CDs. There's no doubt in my mind that we're heading toward movies being shot and projected at higher frame rates.*
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> *Warner Bros. have been very supportive, and allowed us to start shooting The Hobbit at 48 frames/sec, despite there never having been a wide release feature film filmed at this higher frame rate. We are hopeful that there will be enough theaters capable of projecting 48 frames/sec by the time The Hobbit comes out, where we can seriously explore that possibility with Warner Bros. However, while it's predicted that there may be over 10,000 screens capable of projecting The Hobbit at 48 frames/sec by our release date in December 2012; we don't yet know what the reality will be. It is a situation we will all be monitoring carefully. I see it as a way of future-proofing The Hobbit. Take it from me—if we do release in 48 frames/sec, those are the cinemas you should watch the movie in. It will look terrific!*

METADATA

David Stump, ASC

The ASC Metadata Subcommittee has been working in close collaboration with the Academy of Motion Picture Arts and Sciences on the ACES IIF project for almost two years in an effort to unify the goals of both organizations. At the outset of the ACES IIF project, the ASC working group donated its XML format proposal to the Academy group and it was accepted as the first backbone document in the effort. In addition, this year a small working group of the ASC Metadata Subcommittee worked closely with Sony to refine their Metadata RDD proposal for eventual integration into the ACES IIF workflow as well. The intent of the subcommittee has been to drive the community toward automated collection and preservation of metadata in many areas of production. The combined work group has made much progress on the ACES IIF proposal in the areas of:

Tracking Recording and Preservation

Pre-Production—Script & Change Tracking, Production Design, Storyboards, Blueprints, Drawings, Animatics.

Production—Automated Film Inventory, Camera and Lens Serial #s, Lens Focal Length, Zoom and Iris, P/T Head Data, Camera Report Data, Color and Look Management including CDLs, Processing, Camera Settings, Motion Data, Angular Displacements - Pan, Tilt, Roll, Liner Displacements - Dolly, Boom, Track, XYZ, Exposure Adjustments - Focus, Iris, Zoom, Shutter, Filtration, Script Supervisor Data, Sound Data, VFX Data, Locators and Links to all Data, Security.

Editorial and Post-Production—Dailies, File Naming Conventions, Editorial Ingest & Workflow, VFX Version Tracking, Color Correction including CDLs, Audio, Dialog & Music Tracking, Locators and Links to all Data, Security.

Distribution and Archival—A substantial effort is under way to map which metadata fields are important to whom, and to map that data so that a meaningful **and** practical data set arrives at both the distribution and archival doorsteps. From a cinematography point of view, distribution and archival require very specialized sets of data that minimally include:

- Original Cut Picture Negative or One Original Digital Output Negatives, 2D & 3D
- Digital Intermediate Original Data Files 2D & 3D
- D.I. delivered in both P3 Color Space and REC709 Color Space
- LTO Tape Backup Details
- 3D Picture Elements
- 35mm Timed Interpositives 2D & 3D
- 35mm Final Approved Original or Digital Negative Answer Print 2D & 3D
- 35mm Internegative 2D & 3D
- 35mm Internegative Check Print 2D & 3D
- Textless Backgrounds
- ProRes 4.2.2 Mez File Quicktime proxy
- Title Elements

- 35mm YCM or RGB Separation Wet Gate Protective Masters 2D & 3D

Distribution Elements—35mm 2D Release Prints, 35mm 3D Release Prints, 2D DCDM. 2D DCP. 3D DCDM. 3D DCP, Digital Cinema Package Details, All Print Film Dailies, All "A" Negative Trims, Outs and Lifts, All "B" Negative, Two Lined Scripts, Two Editor's Code Books, All Camera and Lab Reports, Combined Continuity/ Spotting Script, All Editorial Materials + Production Screen Tests.

Sound Elements—35mm Quad Optical Sound Track Negative, 6+2 Printmaster, 2-Track Printmaster, Dolby Magneto Optical Disc (MOD), Set of DTS Audio Master Disc(s), 6-Track Dialogue Stem Masters, 6-Track Music Stem Masters.

6-Track Effects Stem Masters, 6 + 2 Track Music & Effects (M&E) Master, 6-Track DD/MM/EE Master, LTO Pre-dubs, Dubbing (Rerecording) Cue Sheets, Original Production Sound Dailies, All Original Sound Dailies, All Original Sound Reports of Dailies.

International Elements—Subtitling Disk and Spotting List, Subtitling Disk and Spotting List for English subtitles, Optical Sound Track Negative, Dolby MO Disc, Dolby SR-D/ 6+2-track Dub Discrete Printmaster, 6-track Dub Dialogue Stem (MAG, LTO, DVD), One complete set of Dub dialogue recordings only (raw stems).

Trailer Material—Pro-Tools Session, MO Disc ProTools Session of all mix elements, 2K Final Output Digital Files on Firewire Drive, 35mm Timed Interpositive, 35mm Timed IP of the final version negative of the trailer, 35mm color reference print, MO Disc Pro-Tools Session of all mix elements.

TV/Airline Material

Videotape Master Material

Digital Streaming/Downloading

Music Materials

Publicity Materials – Press Kit Materials, EPK Materials

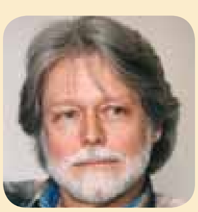
Foreign Language Tracks

DVD Bonus Materials – EPK, All available bonus material.

Clearance Documents—Interviews/ Featurettes / Documentaries, Music cue sheets, Commentaries, QC Delivery Masters, Photo Galleries.

Legal Materials—Short Form Assignments, Chain-of-Title Documentation, Final Shooting Script, Laboratory Access Letters, Laboratory List, Residual Documentation, Credit Documents, Contracts, Clearances, Consultation and Approval Obligations, IATSE Seal, MPAA, Negative Cost Statement, Dolby or Ultra Stereo License/ D.T.S., License/S.D.D.S. License, Certificate of Origin, Insurance, Security Interest Documentation, Adam Walsh Child Protection and Safety Act Documentation.

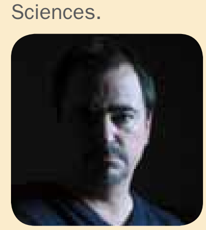
Clearly, the task of an efficient metadata schema would be to automate the collection and preservation of all of these important pieces of the media puzzle for each product the studio creates, but also to make them accessible on a day-to-day basis. The principal value of metadata in this case is to enable us to quickly and efficiently find the elements that we have invested so much time and money into creating.



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. Clark's feature film credits include such critically acclaimed narrative films as *The Draughtsman's Contract*; *Dominick and Eugene*; *Alamo Bay*; *Extremities* and *Triumph of the Spirit*. He started shooting television commercials in the early 90s, which put him on the forefront of the digital/film frontier. He continues to add to his hundreds of commercial credits working with cutting-edge directors and ad agencies.

Clark is a member of the American Society of Cinematographers and is chairman of the ASC Technology Committee, an important motion picture industry forum that both investigates and influences the development of emerging digital technologies that impact filmmaking practice. Since its inception in 2003, The ASC Technology Committee has achieved a series of notable successes including its collaborative work with Digital Cinema Initiatives (DCI) to produce standardized test material for evaluating the performance of digital projectors and other elements of digital cinema systems. Among its multiple initiatives, the ASC Technology Committee has been developing a groundbreaking project to create cross platform data exchange for primary RGB digital color correction referred to as the ASC CDL (Color Decision List). Broad-based Industry implementation of the ASC CDL is well advanced. Prominent among the ASC Technology Committee's recent achievements is the ASC-PGA (Producers Guild of America) Camera Assessment Series, which evaluated the performance of seven digital cinematography cameras compared to film. Clark and the ASC Technology Committee have been active participants in the development and implementation of the revolutionary new AMPAS color management workflow architecture known as the Image Interchange Framework (IIF)—Academy Color Encoding Specification (ACES).

Clark is also a member of the Academy of Motion Picture Arts and Sciences.



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.