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Stereo Movies Here?

45 Seconds (plus Ten Minutes) from Broadway*

By David J. Weinberg



The Society of Motion Picture and Television Engineers (SMPTE) held its Fall 2007 technical conference and exhibition in the Marriott at the Brooklyn Bridge (Brooklyn, NY). SMPTE's Fall Tech was much more intimate an event than AES, CEDIA, or CES, but every bit as important, as SMPTE defines many of the video and audio standards that enable broad program distribution and relatively straightforward interconnection of multi-vendor systems. There were never more than two simultaneous conference sessions, plus technical committee meetings, and fewer than 50 exhibitors.

3D HERE TO STAY

Fall Tech opened in 3D, with an all-day pre-conference symposium on stereoscopic production and exhibition, sponsored by Sony and TI, with more than 150 attendees. SMPTE editorial VP Peter Ludé (Sony) reported that in SMPTE surveys 3D was identified as either the most or least important topic—very strong opposing opinions, no waffling.

Those involved in the symposium included Real D chief technical officer Lenny Lipton, Insight Media's Chris Chinnock, Lightspeed Design president Chris Ward, 21st Century 3D president

Jason Goodman, Lightstorm Productions 3D visual effect specialist Chuck Comisky, In-Three president David C. Seigle, Sony Pictures Imageworks stereographer/digital effects supervisor Rob Engle, DreamWorks Animation stereoscopic supervisor Phil McNally, Quantel strategic marketing manager Mark Horton, DreamWorks Animation head of production development Jim Mainard, Sony Pictures Imageworks senior VFX producer Buzz Hays, 3ality Digital Systems founder and CEO Steve Schklair, Warner Bros. VP for technology Wendy Aylsworth, Dolby senior director of image technology Dave Schnuelle, Real D chief scientific officer Matt Cowan, and MKPE Consulting president Michael Karagosian. That's quite a stellar group of individuals and companies committed to 3D movie production and exhibition.

Conceptually, 3D is to 2D movies as surround is to stereo—it can enhance the viewer's involvement in the experience.

Studios' interest in 3D is growing, as they search for ways to deliver a movie theater experience that can't be duplicated at home. Four recent movies have been released in 3D, but all were originally conceived as 2D films. Sony Imageworks' *The Polar Express* was released in IMAX 3D in November 2004. *Monster House* came out in D-Cinema 3D in July 2005. *Open Season*, another IMAX 3D movie, opened in September 2006. *Beowulf*, another Sony Imageworks production, was shown in IMAX 3D, D-Cinema 3D, plus D-Cinema and 35mm-film 2D, all starting simultaneously in November 2007.

YESTERDAY

3D imagery is claimed as early as the 1830s with stereoscopic pictures. 3D movies were tried about 75 years ago, and early technology was, obviously,

quite crude. Problems included drifting synchrony plus weave and jitter between two film strips running simultaneously, causing variations in the 3D effect, because perceived depth depends on the timing and spacing of the two images. Viewer discomfort results from image misalignment, divergence in the background, and editing that changes eye focus too quickly (for example, from in front of the screen to behind it, or wide focus to narrow). Modern 3D systems have overcome most of the technical problems.

... AND TODAY

Perception of motion in stereoscopic projection is especially sensitive to frame rate, because the left/right eye frames are projected sequentially, each at 24fps. Therefore, D-Cinema has the benefit that it isn't limited to the fixed film frame rate, potentially offering smoother motion by using higher frame rates.

There are creative issues including camera separation and convergence (it takes two cameras lock-synced and properly spaced to create the 3D effect; varying the spacing changes the object's distance in front of or behind the screen), depth of field (in 3D, the depth of field is not as thin front-to-back as in 2D films, making the image more immersive), and whether the film is being shot for the IMAX or a conventional movie screen. There are many optical tricks to produce the sense of depth, but care must be taken to minimize the distortion of objects' relative size.

It is difficult to translate a large real-life scene to a small editing screen and back to the movie theater screen. The effects as seen on a small screen might not translate to the large screen; this problem is exaggerated for 3D films. An additional problem is that the 3D

effect will appear different on various screen sizes. One possible solution is the creation of three "depth-graded" files—one for 60-80' screens, one for 35-45' screens, and another for television. I suggested a single file with metadata, set by the artists, for semi-automatic adjustment for screen size.

DreamWorks is focusing on training and education regarding 3D—how to shoot it and knowing what it will look like on the big screen, particularly since they anticipate parallel 2D and 3D production on a given film. They gave their artists visual stereo acuity tests, on which they performed quite well. DreamWorks also gave their artists stereo still-cameras to experiment with—take whatever pictures they wanted, and see how the stereo effect works on the big screen. This improved their ability to produce convincing 3D effects.

Jim Mainard reminded attendees that the story needs to drive the project, not the technology. For best results, it is necessary to consider 3D from the beginning (what role will depth play in telling the story? Will 3D enhance the emotional experience? How will 3D scenes affect the sound design and the script? Will stereo staging be different than for 2D? What are the depth cues?). The creative rules for 2D might not apply in 3D. You must be careful not to produce a beautiful image that distracts viewers from the story.

Technically, 3D changes the production process, plus asset management issues increase.

There is no production pipeline, yet. There are some stereoscopic production and post-production tools available, but they are limited. For 3D filmmaking to become cost-effective, many more tools are needed to fix problems and to speed up the creation/production



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978-281-7708
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Advertising/Account Coordinator
Janet Hensel

Multi Media Manufacturer
PO Box 876
Peterborough NH 03458
603-924-7292
Fax – 603-924-6230

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tion processes.

There is a feeling that 3D is not yet good enough for long-term success, but there are very good individual scenes. More collaboration and sharing of 3D creative experiences will help improve 3D's consistency and effectiveness.

There is no standard approach to handling subtitles. Wendy Aylsworth said that the 3D release of *Beowulf* will be the first D-Cinema movie with subtitles. *The Polar Express* had subtitles, but that was in IMAX format. Warner studios tested several locations for the subtitles, to minimize their distracting viewers from the 3D effect—above and below the image, and using 3D imagery to place the subtitles at the screen, behind it, or in front of it. They decided to put subtitles at the screen and above the image. They also are leaning toward using a warm white color for the subtitles, which will be on the black background (bright white on the black background is stark and attracts the viewer's eye).

Over the past century of filmmaking, part of its success has been the vagueness of space when needed. With 3D, there seems to be a move toward knowing exactly every object's placement. Will that take away from the involvement of the experience?

Regarding 3D delivery formats, the Digital Cinema Initiative (DCI) is working on specifications (www.DCIMovies.com), with an eye toward integrating 3D into approved and draft filmmaking practices.

IMAX 3D advantages over D-Cinema 3D include a larger screen, film versus digital, and more uniform viewing distance relative to image size (which affects perception of depth effects).

The D-Cinema approaches, which use one digital projector, offer a more stable double-image than IMAX's two film projector heads. For the two images to be psychovisually fused into one 3D image, D-Cinema doubles the overall frame rate by alternating left-eye/right-eye frames sequentially, with a polarizing LCD filter that with each new frame alternates polarization (by 90°, such as horizontal then vertical, or in some other way such that each eye sees only the image it's supposed to see). In this way, an ex-

isting D-Cinema projector can be used for conventional and 3D movies, if it's able to handle the higher frame rates, just by shifting the filter/processing in-and-out of the light path. Since 3D movies require a separate film for each eye, overall movie file sizes are double those for 2D movies. With the image coming from a single projector, the color-space, gray-scale, and light levels are identical for each eye's image, whereas even the best film processing cannot prevent some differences between two prints.

With the two files running at a total 48fps, the system then triple-shutters the frames, bringing the total to 144fps, in an alternating left-eye/right-eye frame sequence repeated three times for each movie frame.

3D FORMATS

There are three major players in 3D:

- Real D (www.RealD.com), which uses ZScreen® LCD switching-polarizing filter on the front of the D-Cinema projector, with a curved aluminized screen (optical gain of 2.4), while the viewer wears passive polarized glasses that are cheap enough to be throwaways
- Dolby and Infitec™ (www.infitec.net), which uses one D-Cinema projector with a special colorwheel that contains two sets of RGB primaries (one set for each eye's image), while the viewer wears passive filter glasses
- NuVision (www.NuVision3D.com), which uses LCD shutter-glasses with an IR link to sync their polarization shift with the film frame. There is a battery and circuitry in the glasses, which cost more than the passive glasses.

MKPE Consulting (www.MKPE.com), a media-entertainment-market analysis firm, sees trade-offs among the three systems, and believes all of them will remain active competitors in the 3D market.

Dave Schnuelle said that for 3D to succeed:

- it must be a good investment for studios and exhibitors;
- it must offer a high-quality visual experience;
- it must integrate easily into theater

operations;

- there must be a hands-free switch-over between 2D and 3D projection; and
- 3D retrofits for existing projectors must be simple and relatively inexpensive.

The 3D images require a different gamma and color saturation level to compensate for the lower light output plus enable a single file-master and single projector/screen setup for 2D and 3D movies. Aylsworth believes a lookup table could be constructed to make the conversion automatically in real time.

Effective light levels are an issue. There is a 50% loss because each eye sees alternate frames, so there is time-division multiplexing. While placing the LCD filter in the lamp house—instead of in front of the projection lens—reduces the stress on the light engine, wherever it is located it will cause another 50% light loss. Triple-shuttering causes another 40% light loss. Multiplying these results in a net of 12-15% of the projector lamp's light getting to the viewers' eye, regardless of the 3D projection technology used.

Thus, if the projector can throw 30-35fL in 2D mode, a 3D movie will yield 3-5fL through the 3D-glasses to the eye. The SMPTE standard for 35mm film projection center-screen luminance is nominally 16fL with open gate (no film), which results in about 12fL with film running. Thus 3D is quite dark in comparison. Responses to my question to the panel about this lower light level was that the audiences don't seem to notice. I wondered whether it isn't the fact that so many movie theaters run their projectors at much lower than 12fL, or the newness of seeing 3D, that distracts the customers from this issue.

Matt Cowan spoke about the Real D system, which was used for the stereoscopic digital projection demonstration during the symposium, and requires a curved aluminized screen with an optical gain of 2.4, leading them to claim about 30-35% light efficiency through the glasses. Because of the Real D aluminized-screen gain (versus normal movie theater screens that have a gain of 1), I asked about

spectral uniformity versus horizontal viewing angle. I was told that over the range of $\pm 55^\circ$ "it is quite uniform, and the curved screen mitigates the problem." My perception was that the image seemed slightly yellow toward the right, slightly blue toward the left, but I didn't have a true reference to compare it with, because the demo was an animated film.

The Real D system's polarization is not horizontal/vertical, but left and right circular, to minimize crosstalk (ghosting) between the left/right images when the viewer tilts his head to the side. Their glasses cost <\$1 each in quantity. The Real D system works with screens from two providers and projectors from three manufacturers. They recently signed a contract with Odeon to install their system in 500 theaters in Europe. Cowan said that as of March 2007 there were about 700 systems in operation for about 500,000 hours cumulative, with no failures.

A presentation created by Michael Karagosian claimed that of the roughly 4000 D-Cinema screens in the US, 1000 are 3D screens. The rest of the world has about 800 3D screens (the Real D contract brings that up to 1300 accounted for outside the US).

Rob Engle classified typical projects for 3D treatment as CG films conceived entirely for 3D, 3D live-action, live-action/computer-graphics/animation hybrid shot for 3D, legacy 2D movies repurposed for 3D, and correction of "bad" 3D movies. There will be a mix of 2D and 3D in a single film.

IN REVIEW

The program and proceedings for this pre-conference Symposium on Stereoscopic Production holds a wealth of information about the technology and the business of 3D movies. 3D is here to stay if the quality and the story, not the special effects, drives the work. As Lenny Lipton said, "Creativity is in the hands of the filmmakers."

I have monocular vision—I can see an object with only one eye at a time. Therefore, I can't psychovisually fuse two images into one, and cannot see the 3D effect regardless of the technology. I've had this affliction my whole life, so I don't run into

objects. . . too often. Thus I can't report on my perception of the demonstrations. However, many attendees seemed impressed.

AccessIT (www.AccessIT.com) and TI sponsored a special after-hours event, treating about 150 conference attendees to 3D demo clips from a U2 concert and *Beowulf* in AccessIT's Pavilion Digital Showcase Theatre (also in Brooklyn NY). This was followed by a 2D D-Cinema presentation of *The Godfather*. I haven't seen *The Godfather* in many years, but the image appeared to have problems. The image didn't seem to match the original's 1.85 aspect ratio—it seemed slightly squeezed (the women seemed anorexic). There was a very high level of film grain, and the image seemed a bit soft. In the scene with fires in 55-gallon drums, the fire looked fake. I got a sense of green-screening around the actors in certain scenes, and slightly colored edges (particularly red) in others. Still, it was good to see the movie again.

ADVANCED IMAGING

Bill Hogan (Sprocket Digital; www.SprocketDig.com) and Nelson Meacham (principal engineer, Walt Disney Imagineering) chaired this session.

Luigi Tamontana (CTO, Craft Animations and Entertainment AB; www.CraftAnimations.com) explained how they sped up the animation creation processes and improved quality. Craft Animations uses simulation software instead of traditional animation techniques and programs. They add real-time input-driven actions. The system acts like a very sophisticated game controller to produce the animation. The structure is highly modular, enabling relatively simple addition or replacement of modules.

They have developed an extensive suite of specialized Craft Director Tools™ that can be built into assemblies, primarily for moving or flying vehicles. Their website has demos.

Rodney Grubbs, Carlos Fontanot, and Kevin Hames (NASA) discussed the difficulties in "Producing a Live HDTV Program from Space." A most interesting problem is that CCD arrays—image sensors in cameras—deteriorate rapidly in space. HD cameras can

become unusable within weeks, due to sensor damage from cosmic rays and x-rays. This is less of a problem with SD video and still cameras because of the lower detail (fewer pixels) and sophisticated image correction software, which can fix some of the image flaws caused by dead pixels. There is at least one HD camera manufacturer that will not ship its cameras by air because they see some deterioration even at 40,000'.

I asked for a date/time stamp of origination to be added to all video on the NASA channel, but was told that they were not allowed to do so, that it was difficult enough getting permission to place the NASA logo in the upper-right corner so it doesn't conflict with the logo of any station reusing the video.

Rod Sterling (Chief Engineer, JVC ILA Technology Group) spoke of their 4096×2400 D-ILA™ projection technology. Their image engine offers higher resolution than DCI's 4096×2048 , but there is a problem getting enough light output.

EXTENDED COLOR GAMUT

Chris DuMont and Thomas Maiers (Kodak) described some of the characteristics and bases for the various color gamuts specified:

- The DCI Digital Cinema Distribution Master (DCDM) xvYCC color gamut (IEC 61926-2-4) is non-CRT-related and is based on the 1931 CIE standard observer and related theory. Kodak's research shows that the 1931 standard observer data is still valid. The R-G-B primary coordinates and D6500 white are the same as in ITU-R Rec 709. Some of the xvYCC color gamut isn't allowed in Rec 709. xvYCC supports Rec 709, but supports a larger color gamut. The xvYCC Y/Cb/Cr covers digital 1-254, while Rec 709 allows 16-235.
- For D-Cinema theater viewing, DCI recommends a white level of 48 nits (14fL) with a theater-black off-the-screen measurement of <0.024 nits (<0.007fL). For TV viewing, SMPTE RP166 recommends a white level of 120 nits (35fL) with an ambient light level <12 nits (<3.5fL).
- Because of human optical char-

acteristics, perceived color gamut changes with luminance.

- The ITU-R Rec 709 is a recording standard; there is no display standard.
- The electro-optical (display) transfer function (gamma) is not the direct inverse of the optoelectrical (camera) transfer function. This is, in part, because colorimetry calculated is not equal to appearance perceived.

For post-production facilities to see what their customers will see, they need to color-grade images on displays that have characteristics matching those of their customers.

NEXT GENERATION MEDIA: ENGINEERING THE MULTI-PLATFORM FUTURE

Bob Ross (CBS senior VP for East coast operations) proclaimed that there are far too many file/program distribution formats, and that CBS has no capability designed into their system to handle 1080p60. Last year CBS distributed 72,000 hours of programming to international TV broadcasters in 234 territories (countries and groups of countries); this does not include the Internet and cell phones. They have a core group of client recipients, but the majority of the list is volatile—dynamic—and changes often and rapidly (turnover can occur within weeks). In addition, content rights ownership and management is extremely complicated, and can prevent distribution of a given program to certain media due to lack of rights; as an example, not having the rights to the music in an episode of *Gunsmoke* prevents its delivery to cell phones.

Pat Griffis (Microsoft senior director, Media Interoperability Entertainment and Services Division) identified four service spaces—communications, gaming, music, and video. Programming will be personal, with one custom channel versus the hundreds we now surf. Entertainment will be interactive. The individual will have real-time connections with content and the world community, getting access to new experiences.

Craig Cuttner (HBO senior VP for advanced technology) perceives storage

as becoming a commodity. HBO has structured its workflow to permit easy addition and replacement of modules, such as a transcoder, a storage device, or a format.

Ross interjected that no storage devices marketed for general-purpose IT applications were reliable enough to be used in broadcast servers; specially designed and constructed units are needed to keep the server online sufficiently close to 100% of the time.

Regarding HBO program distribution, Cuttner said that they are using MPEG-4 up/downlinks, transcoded to MPEG-2 at the local cable system's head end. This transcoder is critical to the image quality delivered to the home.

As I learned in a SMPTE seminar in Washington, DC, earlier this year, with concatenation of encode-decode cycles, during each encode process, careful consideration must be given to the additional image deterioration that will occur from concatenation, especially when the algorithms are different.

Gary Traver (Senior VP and COO, Comcast Media Center) reported that there are about 36 million MPEG-2-only STBs in homes, so a transition to MPEG-4, or any other codec, will be slow. Comcast is building a switched cable system:

- Thousands of channels are delivered to the local system head end;
- Some channels are always delivered to all customers' homes;
- Other channels will only be delivered to specific neighborhoods or homes when asked for (STBs tuned to them);
- It's easier to add channels to this switched system without enlarging the cable home-delivery system;
- It's also easier to deliver higher quality of distributed channels without overloading the cable distribution system;
- Because delivery to the home is personalized, there is more opportunity for focused advertising.

MAINTAINING QUALITY IN HDTV SYSTEMS

Wes Simpson (Telecom Product Consulting) discussed their custom fil-

ter IC that "produces dramatic performance improvements" in up- and down-conversion between SD and HD. One of his slides erroneously referred to odd and even video "frames," when it should have been "fields." I had questions, including: Was their pixel averaging weighted? If so, was the weighting based on image scaling factor and source/destination pixel location on the screen? For them to claim 10-bit performance, what is the bit-depth of their math inside the processor (since more bits are needed during multiplication/division to maintain a given bit-depth accuracy in the result)? Does their processing incorporate video dither? I received no answers.

David Bancroft (Thomson Grass Valley manager, advanced technology) declared that "television technology should be a medium to pass the creative's message to the viewer without change." Bancroft is chair of the SMPTE study group on display technologies, and a member of the EBU ITU/R SG6.

Mike Richardson (Harris Broadcast Communications Division) advised that the conventional eye-pattern test [which is being widely used in consumer advertising to market HDMI cables] does not show level- or frequency-related jitter problems. Other tests, such as a flat-field test, can reveal a DC offset and other data transmission problems.

Peter Putman (ROAM Consulting) reminded his audience of professionals that the consumer market is driving sales and product development—the pro market is an afterthought. There are still image display problems that need to be fixed, including 480i-to-1080p scaling, de-interlacing, and motion artifacts. Black-frame insertion at 120 frames/sec improves the images on TFT LCD displays, plus their black levels are better than from previous generations. All the display technologies are improving, but there are many factors and characteristics that must be considered to ensure accurate reproduction of the source images.

DIGITAL TV AUDIO CHALLENGES

Tom Scott (Onstream Media; SMPTE

Engineering Director—Motion Pictures; and renowned film sound mixer) chaired this session.

Jim Starzynski (NBC/Universal) reported that NBC/Universal generated a document defining delivered-program characteristics, including a specific dialog level such that the correct Dolby DialNorm setting is -23dBFS(LeqA) . Their network systems cannot handle agile metadata (it cannot make dynamic adjustments between programs or program segments based on different DialNorm settings). Their testing shows a comfort range of about -5.5dB to $+2.5\text{dB}$ around the nominal dialog level.

They check their program levels with the Dolby LM100. However, ITU-R BS.1770 specifies use of Leq(m) , an algorithm for loudness perception that works better than LeqA when there is no isolated normal-level dialog.

NBC uses an Aphex compressor to reduce the highly variable levels of locally submitted material, including commercials.

The North American Broadcasters Association's (www.NABAnet.com) "Managing DTV Station Loudness Using Audio Metadata" stated that using fixed metadata is not as good as reading the program levels and making adjustments in near-real-time, but it is a good start.

Ioan Allen (Senior VP, Dolby) discussed "Commercial Trailers and the Feature—How Loud Was Your Evening?" The ITU-R 468 weighting curve (originally defined in CCIR recommendation 468), compared with the A-weighting curve, is slightly less sensitive to fundamental voice frequencies and lower harmonics, but is as much as 12dB more sensitive over $3\text{-}10\text{kHz}$, peaking in the $6\text{-}8\text{kHz}$ range. Thus it more accurately reflects "annoyance value." Leq(m) is a program loudness measurement using the ITU-R 468 weighting curve that can help balance inter-program levels, such as among trailers and the feature, to maintain a relatively constant annoyance level.

The Trailer Audio Standards Association (TASA) has defined 85dB Leq(m) as the maximum level allowed for TASA trailer certification. This measurement is designed for short (<3 minute) programs. For longer programs,

a Leq(m10) measurement uses a sliding ten-minute window measurement. This should not be used for movies in theaters or on home-theater media, because a movie's entire soundtrack dynamics is part of the film creator's package.

Allen is vehemently against legislation or regulation that limits peak film loudness, but if a metric is mandated, Leq(m10) could provide a *relative* measure of annoyance.

TRENDS IN CONTENT DISTRIBUTION AND BROADCAST

SMPTE eastern region governor Graham Jones (Director of Communications Engineering, National Association of Broadcasters; www.NAB.org) was session chair. Jones said that broadcast stations and the Advanced Television System Committee (ATSC; www.ATSC.org) are considering direct broadcast to mobile devices, which satellite and cable systems can't do.

C. Scott Birdwell (SES Americom; www.SES-Americom.com) expressed the belief that the future of broadcasting is temporal and spatial independence along with customized content.

Mark Aitken (Sinclair Broadcast Group's director of advanced technology; www.SBGI.net) is chair of the ATSC working group on mobile/handheld augmentation of the ATSC DTV standard. ATSC 2.0 will define new services for home reception, and likely will include the advanced common application platform (ACAP), facilitating simpler application development across vendors' product lines. ATSC-M/H addresses delivery to mobile/handheld devices. These are additional applications for part-through-full-time use of the 19.39Mbps 6MHz -channel bandwidth.

CONCLUSION

Contact SMPTE at www.SMPTE.org to purchase the technical session papers CD-ROM.

This report is a mere sampling of the many informative presentations, demonstrations, and discussions that make attendance so valuable. Perhaps I'll see you there next year.

* Thanks and apologies to Neil Simon.



David J. Weinberg (Tobias Audio, Silver Spring, Md.; (301) 593-3230; WeinbergDJ@BostonAudioSociety.org) is an engineering consultant and technical journalist on audio, video, and film technology. He provides audio and home theater engineering consultation and professional on-location digital audio recording services to companies, radio stations, and individuals. He brings to his work an MSEE, a First Class Radiotelephone license, and over 40 years of continued study and active involvement in the audio, video, and computer industries. He is Chair of the Audio Engineering Society's DC section, and a manager in the Society of Motion Picture and Television Engineers' DC section. David has authored articles on various phases of audio for video and film, is Associate Editor of *Multi Media Manufacturer* (www.MultiMediaManufacturer.com), Contributing Editor to *Widescreen Review* (www.WidescreenReview.com), plus serves as Membership Officer for the Boston Audio Society (BAS, www.BostonAudioSociety.org) and Editor of its journal: *The BAS Speaker*.