Are You Seeing the HD You Paid For?

The Importance of Display Design and Calibration

By David J. Weinberg

[This report is for a special event presented by the SMPTE—Washington DC section at the AFI Silver Theater, Silver Spring, Md., on October 20, 2007. Invitations were extended to other eastern US SMPTE sections, plus DC-region custom home theater installers and display calibrators.—DJW.]

Program production and transmission (via any path) through to the consumer's display is all about the art of storytelling through audio and video—making sure the intentions of the program originator can be properly seen and heard.

Thanks to a number of SMPTE standards, image creation, monitoring, and display are much more quantified and standardized processes than is the case for audio.

DISPLAYS

Directors, cinematographers, and videographers work hard to create specific image characteristics in support of the story they are telling. If you want to best experience that vision, or help in its formation, you need displays that match those on which the images were monitored during creation. For the consumer to see an image that closely reflects what was created by the director and cinematographer/videographer, a properly designed and calibrated display is required; any deviations compromise the artistic integrity of that vision, sometimes severely reducing the effectiveness of the message.

With this in mind, I devoted two years to arranging a SMPTE—DC section special event: a presentation from industry video consultant Joe Kane (JKP Productions; www.VideoEssentials.com) to discuss and demonstrate the need for and benefits of proper display design and calibration, and to show attendees the image quality reasonably priced display devices can be capable of delivering. During this four-hour seminar (intended primarily for production and post-production professionals, home-theater retailers, display calibrators, and custom installers), Kane addressed in technical depth the science of electronic imaging and accurately reproducing video signals on all types of displays:

- Film and video, the canvases on which the story is painted, define the limits of what can be presented, with video often being shy of film's capability. The canvas of high definition video is much larger than standard definition. As much as consumers are often wowed by HD images, getting it right makes involving the viewer that much more effective.
- During production and in many post-production facilities, the image is monitored on expensive CRT-based video displays that are carefully designed and fastidiously calibrated in accordance with SMPTE and other relevant standards, to help ensure consistency and high image quality. Transmission of the image to local stations and consumers typically maintains that image quality, within the limits of the modulation scheme and data reduction algorithms used.
- The greatest divergence in characteristics from the image as originally created occurs in the consumer display. Pixelated displays, whether LCD-, DLP-, or plasma-based, exhibit substantially different visual characteristics from the CRT, which is the reference to which all current image quality standards have been designed.
- With the migration to digital video—SD and HD—a new issue arises: the need to monitor digital transmission and MPEG-2/MPEG-4 AVC/VC-1 data reduction artifacts. Because a calibrated CRT display was assumed in design of these video codec algorithms, an uncalibrated display will be more likely to hide certain artifacts and enhance others, distorting perception of the video datastream quality.

BACKGROUND

Since the 1970s, Joe Kane has professionally been committed to helping provide viewers with the opportunity to experience storytelling as it was created and intended to be seen. A basic story idea can come across on any TV set, but it takes a really good system to draw you into the events unfolding on screen. Kane wants to help make sure that you have the opportunity to see the creation of the film or video artist—experience their idea of how the story should be told. He delivers display device calibration seminars throughout the industry, consults for manufacturers on video product quality, and assists the professional world in achieving better technical quality in program production.

In 1973, Kane joined Eastman-Kodak, becoming involved in their research effort to determine how to make film look good on television, resulting in the flying-spot scanner designs of that era. They started by studying the NTSC broadcast standards established in 1953.

He has been involved in raising public and professional awareness of image quality issues since the early 1980s, when he founded Joe Kane Productions. In 1986, he became chair of the SMPTE working group on studio and professional monitors. In the mid-90s, he was a cofounder of the Imaging Science Foundation, and has since separated from there and concentrated on his work as a consultant.

Kane's laserdisc *A Video Standard* (released in 1989) represented the first time anyone had tried to use video to describe video—the first video reference for video. Part of his motivation came from the production community, which was being asked to spend money and effort standardizing their monitors, and sought improvement in consumer displays so they didn't believe their efforts were wasted.

With the advent of the DVD, Kane went on to create *Video Essentials*, followed by *Digital Video Essentials*. He has now released a professional version of *Digital Video Essentials* and an HD DVD version, with a Blu-ray version nearing release.

He has been a consultant to Samsung, developing a series of single-chip DLP front projectors that met his performance criteria, first the 1280 × 720 models, and now a 1920 × 1080 model, the SP-A800 ($7000srp).

He has also consulted with Stewart Filmscreen, the result being two generations of the Studiotek 130 and the Greyhawk Reference Standard screen materials. The latest generation of each has a smoother surface, because as 1920 × 1080 projection became available, moiré interaction between the pixelated projection and the screen texture became a problem.

I have been following the development of each of these products for several years, and have always found the most film-like and satisfying images in his exhibits at CEDIA and CES.

Kane was one of the industry experts to whom Microsoft, during its development of the Windows Media video codec, sent draft decoders and encoded material for evaluation. Kane would peruse them on his Samsung projector and screen, and feed back to them the flaws he detected. They kept telling him they couldn't see the problems on their displays, so several of their project engineers visited Kane, who showed them the problems. They ended up borrowing his personal projector and screen for three months until they could get their own. To their credit, Kane says they fixed every codec problem that he reported.

That Windows Media Video codec became the basis for the SMPTE video codec standard VC1, which is one of the two most efficient video codecs in commercial use for DBS and for Blu-ray and HD DVD releases (the other is MPEG4 part 10, also known as H.264 or AVC).

THE PRESENTATION

Kane cited many examples from movies and television program creation experiences that provided real-life context to the issues.

Throughout his lecture, he put industry decisions in perspective (for example, explaining why the specific phosphors were selected for red, green, and blue in 1953, and the SMPTE C phosphors in 1979) and provided the history behind some of the earliest broadcasts.

He presented an introductory tutorial on light and visual perception, how that fit into the design of the TV color system, and why certain supermarket-products' packaging colors couldn't be properly reproduced on TV. He even explained why the green phosphor standard for the PAL TV system would not work for the NTSC system (at 50 fields/sec the phosphor persistence didn't cause image motion problems, whereas at 60 fields/sec it did).

He reminded the audience that video and film do not have the same image capabilities, and that reviewers need to remember that the video of a movie might—but might not—have image characteristics similar to the film. Converted from film to video, a movie undergoes a transformation, producing a new look. For example, James Cameron is well known for adjusting the look of his movies for video release, taking into account the strengths and weaknesses of that medium versus film, plus taking the opportunity to improve the believability of certain effects. Filmmaker James Ivory never had enough money to color-time his films as he desired, but when it came time to master the video, he had made enough money to produce the image he wanted; thus the video versions of Ivory's movies are the definitive versions. Kane's point was that the post-production community must be very careful how it sets up its canvas (the display)—display calibration is critical.

From its inception up through today, the entire video communications system—camera to display—is based on the characteristics of a CRT, and to see the image as created, the display—regardless of the technology—must mimic the CRT's characteristics.

Throughout the 1960s through 1990s, during which display calibration wasn't considered particularly important, TV manufacturers included circuits that tried to compensate for image errors, making the problems worse. Finally by the mid-1990s production and post-production facilities had become fairly diligent at keeping their monitors properly calibrated.

The situation is becoming worse now that content is being created on computers, with no color-space standardization in most PC monitors, potentially leading to chaos.

Kane described many of the display parameters that are important to ensure a properly performing and calibrated display, including single-pixel transitions between black and white in the vertical and horizontal direction.

The SD and HD math are different relating to how red, green, and blue are combined to produce gray. The SD system is based on the math from the 1931 CIE diagram, while the HD system math is based on the 1976 version. This means every HD display must have two decoders. Most consumer HD displays lack the ability to properly perform HD math. Kane used his Samsung SP-A800 projector, employing some of the test patterns he has created to evaluate the performance capabilities of any display, to demonstrate and explain what to look for to see the difference between SD and HD color decoding.

The gamma curve and the need to adjust the transfer function of non-CRT devices to match that of CRTs is critical to produce the correct image characteristics. The inverse gamma incorporated into professional video cameras enables the system to act as a compressor/expander, reducing video noise in the displayed image—a great benefit in early color TV broadcasts, and still helpful even though equipment performance has substantially improved.

PICTURE QUALITY

Manufacturers use focus groups, viewing displays set up with various image characteristics, to determine what consumers are more likely to buy, thus determining how to factory-adjust displays. Kane once changed only the test room background, and demonstrated that changing the environment substantially changes perception.

He talked about LED backlighting for displays and projectors, the dynamic iris (severely compromises picture quality), screen gain (hot-spot issues) and materials (the screen and the projector are an integrated system) including the need for uniform relative spectral balance versus viewing angle (many screens don't exhibit this important characteristic), the need for a very fine-grained screen surface (with 1920 $\times$ 1080 projection, many screens exhibit a moiré interference between the image's pixel structure and the screen grain), plus many other display characteristics that affect picture quality.

Several years ago, Kane ran tests using the JVC D-VHS D-Theater HD tape format at a peak video bit rate of 24Mbps, and saw that a perforated home theater screen masked the difference between MPEG-2 and WMV encoding and hid image details, while on a non-perforated screen, the difference was obvious to all observers. The Digital Cinema Initiative ran similar tests at the USC processing lab in Hollywood, and found that a perforated movie screen mostly masked the difference between 2k and 4k projected images, yet the difference was obvious with a non-perforated screen.

For the first time, I saw the same source material shown in sequence—one in 1080p24 frames/sec, the other in 1080i30 frames/sec—and observed the effect of 3:2 pulldown on image motion.

He spoke about the low-pass filtering used in MPEG-encoding 1080i program material that results in image detail that's often less than that found in a 720p program.

He discussed the image-quality compromise from use of an anamorphic lens in consumer projectors (even as expensive as these lenses are, he sees chromatic aberrations and geometric distortion, however slight).

This synopsis doesn't do justice to the amount of valuable information presented. The attendees paid rapt attention, and seemed a little overwhelmed with the facts and concepts that most of them had never realized they needed to consider, or how much their display affects their job performance.

It is impossible to present the full impact of his lecture without seeing the slides and images, which prove beyond doubt the ability with current technology to realize the image quality promised by the HD format.

A report of this seminar has been scheduled to appear in the *SMPTE Motion Imaging Journal*.

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