Booting Analog TV, Pt. 1

Technology in Support of Creativity

By David J. Weinberg

[Video technology is complicated and complex, from lens issues through compression choices to display compromises. For the filmmaker with a limited budget, whether creating for the theater or TV, understanding the technology can greatly help increase the effectiveness of the message.—DJW]

The mandated over-the-air analog-television broadcast cutoff deadline is less than 13 months away. Much has been accomplished, yet much remains to be done.

Digital television is a special application of computer science and information technology. The digital television (DTV) transition brings to the broadcast community new Society of Motion Picture and Television Engineers (SMPTE) and Advanced Television System Committee (ATSC) standards, new technologies, plus a need for different knowledge and skills.

HDTV BOOT CAMP

SMPTE's mission includes educating through seminars and communicating the latest technology developments, as well as promoting interaction among members and others in the community.

In concert with this objective, plus broadcast professionals' needs resulting from the DTV transition, SMPTE's Washington DC section and the Association of Washington Executive Broadcast Engineers (WEBE) produced, managed, and held an intensive two-day HDTV boot camp for broadcast and program-production personnel in September.

The event drew 100 attendees, and registrations for at least 40 other interested professionals had to be reluctantly declined due to space limitations.

The topics were split between HDTV program creation/processing and DTV broadcasting/reception, to attract a broader audience and provide a more comprehensive curriculum.

First day topics: Studio Technologies Basics—DTV foundations, Video basics, DTV image basics, Video compression basics, Audio for DTV, Dolby Digital (AC-3) audio compression basics, Practical surround sound; ATSC transport protocol and program multiplexing: Datacasting basics; Station Scenarios.

Second day topics: Production—Introduction, HD versus SD, Aspect ratio issues, Audio, Concatenation (multiple sequential encode/decode cycles); HD versus SD optics; Test and measurement; 1080p60; Active Format Description; Audio metadata; Final comments, Q&A.

PRESENTERS

James Snyder (Communications Engineering, Inc.) is a SMPTE-DC section manager, and had been a part of the Harris/PBS DTV Express team. Snyder is a member of the AES, IEEE, NATAS, and president of WEBE, as well as being the DC region broadcast frequency coordinator.

Karl Kuhn (senior application engineer, Tektronix) is the SMPTE-DC section chair. Kuhn was the lead video test engineer in IBM's Digital Video Development Lab. He holds four patents—three US and one Japanese—that cover in-service testing of digital broadcast video.

Michel Proulx (chief technical officer, Miranda Technologies) crafts Miranda's long-term strategies and individual product road maps. Formerly, he was with Pixstream, an IPTV head-end solutions provider. Prior to that, he was a design engineer, and ultimately Director of Engineering for Routing and Distribution products, at Leitch. He started in broadcasting as a co-op student for the Canadian Broadcasting Corporation.

Laurence J. Thorpe (national marketing executive, Broadcast and Communications Division, Canon USA) is a renowned expert on cameras, optics, and digital television.

VIDEO FORMATS

Snyder's knowledge of NTSC and DTV systems' heritage seems encyclopedic, providing an edifying and entertaining context to many parameters ensconced in standards and to some real-world problems he has encountered. He reminded attendees that in many ways digital *is* analog—transferring digital audio and video data over wires at even SD bit rates involves frequencies up through RF, meaning such cable-related issues as termination, signal attenuation, and phase shift must be addressed. He pointed out that *digital* doesn't automatically mean high quality—that digital can only deliver whatever quality is in the program, minimizing most of the analog artifacts while introducing the potential for new ones unique to the digital world.

Snyder also gave context to HDTV as a subset of DTV (the FCC standard does not *require* HD programming, only an over-the-air (OTA) broadcast of higher quality than NTSC), plus that multicasting and datacasting are supported by the DTV standard. He included discussion of the European OTA, DBS and cable/telco DTV systems, comparing their modulation technologies and video/audio formats.

Covering SD and HD, Snyder explained the various professional and consumer video formats (NTSC, PAL, 4:2:2, 4:2:0, YUV, YPbPr, YCbCr, and so on), the different color spaces (601 versus 709; for example, you can't get real purple in NTSC), the various recording and broadcasting video compression formats, DTV-related SMPTE image scanning format standards (274M, 293M, 296M, 125M), the total video data area versus the displayed image area (for example, 2200 × 1125 versus 1920 × 1080 pixels) and what metadata is passed in the non-visible-image bits, frame rates, progressive versus interlaced scanning, bit rates (for example, 1125 × 2200 pixels × 30 fps × 2 samples-per-pixel × 10 bits-per-sample = 1.485Gbps). He also

covered compression ratios (such as 1920 × 1080i29.97 with 10-bit video compressed to 18Mbps is a compression ratio of almost 70:1; with 8-bit video it is still about 55:1), the FCC DTV standard A/53's "lost" Table 3, SMPTE digital interface standards (259M, 292M, 294M, 305M, 310M), plus the differences and similarities between analog and digital image construction and waveforms. He also talked about how different lighting and camera techniques are needed for best results in HD versus SD, and some of the other artistic decisions that are available during program creation.

His coverage of MPEG2 was comprehensive and clear, and made the point that the signal being encoded needs to be as clean as possible, because the MPEG encoder will try to process everything in the image, including noise, which will take away from the bits available to carry image data, thus reducing image quality. He said that NTSC composite video is roughly equivalent to 2.8:0.6:0.2 versus MPEG2-encoded video's 4:2:0 and the professional video camera's 4:4:4 sampling. He talked about how human visual perception limitations are considered in MPEG video compression algorithms, and proceeded on to a thorough explanation of how MPEG2 data-reduces video content. A critical issue raised was the cumulative effects of concatenation, since in almost all cases, a program goes through a series of compression/decompression cycles, sometimes including changing the compression algorithm, between program creation and the home viewer; this means that at each stage in the production/broadcast process, image data compression must not be so severe that one or two successive cycles will cause visible image degradation.

Snyder also made recommendations regarding inter- and intra-studio and broadcast facility data distribution technologies.

"Would you like audio with your video?" was Snyder's introduction to Dolby Digital, during which he explained the audio data capabilities supported by Dolby Digital for DTV transmission, and the Dolby DialNorm and DynRng parameters, each of which is required to be decoded in all DTV receivers.

His description of the ATSC transport format and PSIP (Program and System Information Protocol) were, again, thorough and exemplary.

Snyder's discussion of station and facility scenarios was applicable to any point-to-multipoint program distribution system, not just OTA broadcasting, and included network distribution, local branding and pass-through, examples of network implementations, plus suggested resources.

Overall, Snyder made clear that engineering enables the creative process. DTV (and digital in general) increases the number of parameters that can be more easily, accurately, and precisely adjusted as part of that creative process. "SMPTE tends to focus on quality. Consumers are going in opposite directions simultaneously—many viewers want better quality; however, many others just want to see and hear the programs, even on small, low-quality mobile devices. A higher-quality source results in better mobile image/sound quality as well as meeting the needs of the quality-oriented consumer. All of this DTV hardware and software is enabling technology. We in the program production, processing, and broadcast community need to keep *all* the distribution channels in mind. Either we deal with it during program creation, or someone else will do it for us, with unpredictable results. Broadcasters also need to be keenly aware of all the distribution possibilities, or others will take away parts of their markets."

OTHER SEMINARS

Larry Thorpe discussed the role of the lens in maximizing HDTV camera performance, making clear that lens quality is at least as important as the pixel count of the image sensor. He talked about the basic optical requirements for HD imaging, perceived image sharpness, differences between SD and HD lenses, compared studio versus ENG lens requirements, all the while emphasizing that the lens and camera must be recognized as an integrated system.

Karl Kuhn demonstrated how to monitor HD and SD image/sound characteristics and transport bitstream data using Tektronix test equipment (although certainly other manufacturers make products that can do the job). Kuhn also emphasized that a digital bitstream includes radio frequencies. However, unlike analog, the waveform itself provides severely limited information about problems. Using examples, he explained that there is a huge amount of detailed data and metadata in the transport bitstream, which when decoded can lead to a clearer understanding of a problem's cause.

Michel Proulx spoke of the near-term "holy grail"—1920 × 1080p60 (3Gbps data rate), talking about camera capabilities, up/down conversion of video resolutions, data rates, and the benefits of keeping video in a progressively scanned format as long as possible through the production, post-production, and broadcast chain. He also talked about aspect ratio problems, plus Active Format Description's history and SMPTE standard set (SMPTE 2016, parts 1-5) (he represented Miranda as part of the committee that developed this SMPTE standard set).

Attendees received a 1200+ page binder with the presenters' PowerPoint slides, plus tutorials and technical reference guides from Tektronix, Miranda, and other manufacturers. The seminar information was also provided on a USB memory stick (supplied by Sony), to facilitate searching for information when needed.

Additional handouts included the two-page announcement "The switch to digital television is coming" from www.DTVAnswers.com, Miranda's 2′ × 3′ Digital Television and Production Standards poster, and from Tektronix, three of their 2′ × 3′ posters ("MPEG-2 Transport Streams," "Understanding High-Definition Video," and "Understanding Colors and Gamut"), two application notes ("Physical Layer Testing of Serial Digital

Signals" and "Monitoring Surround-Sound Audio"), plus two of their tutorial booklets ("MPEG Fundamentals and Protocol Analysis" and "A Guide to Standard and High-Definition Digital Video Measurements") and their "Digital Video & Audio" pocket reference book. Lunch and snacks were included for all attendees.

Reaction to the seminar was universally positive, with lively discussions involving the presenters and many of the attendees throughout the sessions.

A report of this seminar has been scheduled to appear in the *SMPTE Motion Imaging Journal*. SMPTE-DC section officers can be contacted through their website (www.SMPTEDC.org) for more information. M³

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