Broadcast Acquisition and Post

By Mark Schubin

Very few countries (the U.S. not among them) mandate any amount of high-definition television (HDTV) programming. Nevertheless, broadcasters are shifting to HDTV production in the same way that they have always shifted to higher quality.

As recently as ten years ago, the cost of a single HDTV camera, recorder, and lens combination was close to a million U.S. dollars. Solid-state-imager technology, which was by then all but universal in standard-definition cameras, was just being introduced to HDTV. Camcorder technology had not yet been introduced to HDTV. Whereas imager size for broadcast cameras was near universally 2/3-in., those for HDTV were near universally 1-in.

Today, HDTV camcorders are available from many manufacturers, and all broadcast HDTV cameras use solid-state imagers. Imager type, resolution, and size, however, have been changing. Although the changes have been in progress for some time, they have been most apparent in the past year.

Imagers may be divided into different types, based on their signal transport mechanisms and color-separation mechanism. The traditional form of signal transport in camera imagers has been charge-coupling. In a charge-coupled device (CCD), free electrons are passed across the imaging chip in a manner similar to that used in a human bucket brigade. The newer technology uses complementary metal-oxide semiconductor (CMOS) imagers that transport current from active photo-sites.

There have been advantages and disadvantages to each, such as a greater signal-to-noise ratio for CCD and lower cost and less power consumption for CMOS. As the younger technology, CMOS imaging may be expected to improve faster than CCD. CMOS imagers are now used in cameras available from such traditional sources as Ikegami and Sony, as well as in cameras from newer brands.

Most broadcast color television cameras use a prism-based color-separation system to divide incoming light into its red, green, and blue components. The technology is mature and does not significantly affect image sharpness or sensitivity (though it may limit the maximum aperture of the camera). The big disadvantage is that the length of the optical path through the prism prevents the direct use of film-based motion-picture-camera lenses without some form of relay optics.

One technology developed to avoid prism-based color separation is that of the Foveon X3 image sensors, in which layers sensitive to different wavelengths are stacked as they are in color film. That technology does not yet offer HDTV resolution at television frame rates.

Much more common is the use of imagers with on-chip color filters. In the Panavision Genesis digital-cinematography camera, these take the form of vertical stripes of red, green, or blue. In other cameras, ranging from the high-end Dalsa Origin digital-cinematography camera to the low-end Sony HVR-A1U, a grid pattern called a Bayer mosaic is used, in which one imager row will alternate between green and red filters over photo-sites and the next will alternate between blue and green.

There is a trade-off between resolution and color-detail aliasing in these filtered imagers. They do, however, like the Foveon X3, allow direct use of film-based motion picture lenses without need of relay optics.

Standard-definition solid-state cameras have long used oversampling in the horizontal direction to provide increased image sharpness. Until recently, however, HDTV camera imagers have had either 1920 x 1080 or 1280 x 720 imager resolutions.

The ARRI D20 and Panavision Genesis digital cinematography cameras have used imagers with higher resolution to deliver HDTV signals (the Dalsa Origin digital cinematography camera also uses higher-resolution imagers but does not directly deliver HDTV). There has been a recent trend in lower cost cameras, however, toward lower resolution imagers, with the green imager offset from the red and blue imagers to increase resolution.

Sony's HVR-Z1U, for example, uses 960 x 1080 imagers with a half-pixel horizontal offset. Panasonic's AG-HVX200 uses 960 x 540 imagers with a half-pixel diagonal offset. A half-pixel diagonal offset is also applied between two green imagers in both the Olympus Octavision (3840 x 2160) camera and the NHK Super Hi-Vision (7680 x 4320) camera.

As in the use of on-chip color filtering, offset imagers

can lead to fine-detail color aliasing or reduced resolution. They offer the advantage of increased sensitivity and dynamic range, however, and, in the case of the extremely high-resolution Olympus and NHK cameras, ease of imager manufacture.

In addition to these varied signal transport, color-separation, and resolutions, another area in which cameras have become differentiated is in imager size. An HDTV camera, recorder, and lens package ceased to cost a million dollars when the imager shifted from 1-in. format (16mm image diagonal) to 2/3 in. (11mm image diagonal). There was, however, an associated slight reduction in image quality.

Today, there are at least three branches of imager-size philosophy. One continues to use 2/3-in. imagers for HDTV, maintaining 1920 x 1080 imager resolution (albeit with on-chip color filtering in the case of the Silicon Imaging SI-1920 HVDR); a sub-branch uses imagers with less resolution, either without spatial offset (as in most of Panasonic's cameras) or with (as in Grass Valley's Infinity). Another branch seeks to recover or even surpass the quality of the 1-in. imager format and to achieve 35mm motion picture depth of field by moving to 35mm film-frame-sized imagers, as in the ARRI, Colorspace, Dalsa, Panavision, and Red cameras. The third seeks to continue the cost-cutting by moving to even smaller imagers, as in Sony's XDCAM HD (1/2-in.), HDV-format offerings from Canon, JVC, and Sony (1/3-in.), the Iconix HD-RH1, Panasonic's AG-HVX200 (1/3-in.), and Sanyo's VPC-HD1 (1/2.5-in.).

In the case of the Iconix HD-RH1, the motivation to use 1/3-in. imagers was based not on reduced cost, but on camera size. The three-chip HDTV camera is smaller than 2 in. in its longest dimension.

Differentiated by imager type, size, and resolution and by color-separation technique, camcorders are also differentiated by their bit-rate reduction techniques and storage media. Although Panasonic introduced its Professional Plug-in (P2) flash-memory storage system in 2004, in 2006 the company nevertheless introduced a tape-based HDTV camcorder, the AJ-HDX900. Most new broadcast camcorders record on some form of flash memory or disk, and, in some cases (Grass Valley Infinity, Ikegami Editcam, Red One), both.

The drop in flash-memory prices has led to either a reduction in cost or an increase in capacity at the same cost. With the Sanyo VPC-HD1 recording on single secure digital (SD) cards and the Grass Valley Infinity recording on compact flash cards, serious consideration must be given to labeling issues.

Sony's XDCAM HD records on blue-laser optical disks. Other non-tape, non-flash-memory camcorders record on magnetic-disk drives. Grass Valley's Infinity uses a version of Iomega's Rev drive called Rev Pro. It has sufficient transfer speed to allow dual-stream playback for dissolves or other effects from a single-disk pack. Although it does not yet seem to be used in any HDTV camcorder, Hitachi's iVDR disk pack has a similar small size.

For bit-rate reduction (or compression), current Panasonic HD products continue to use DVCPRO HD compression, intraframe at 100 Mbits/sec. The company did show a hardware-based encoder, however, for intraframe AVC (MPEG-4 Part 10, H.264) compression at 50 Mbits/sec.

All of the HDV-format camcorders use MPEG-2 compression. The 1080-line versions use a 15-frame group of pictures (GOP) at 25 Mbits/sec. JVC's 720-line HDV camcorders have used MPEG-2 with a 6-frame GOP at under 20 Mbits/sec; in 2006 they announced an improved encoder with a 12-frame GOP at the same bit rate for recording 60-frame HDTV signals.

In XDCAM HD, Sony offers 18 or 35 Mbit/sec MPEG-2 recording with a somewhat variable bit rate and a 25 Mbit/sec constant-bit-rate-mode matching that of HDV. Ikegami's HDN-X10 Editcam uses Avid's DNxHD intraframe encoding at 145 Mbits/sec, with 220 Mbits/sec said to be available in the future. Grass Valley's Infinity camcorder records either JPEG 2000 or, optionally, MPEG-2. Perhaps surprisingly, among newly introduced products, only the Sanyo VPC-HD1, considered more a consumer camcorder than a broadcast product, uses AVC bit-rate reduction.

MPEG-2 and AVC compression are based on discrete cosine transforms in small picture blocks. JPEG 2000 is wavelet based. Wavelet-based variable-bit-rate compression could also be found this year in the Red One (Redcode) and Silicon Imaging SI-1920 HVDR (Cineform RAW). Those camcorders might be considered digital-cinematography models, but their prices are well inside the range of broadcast HDTV camcorders.

Intraframe coding need not present problems for compressed-domain cuts-only editing. Long-GOP editing can present problems, as can the common field assignment

for mapping 24-frame material onto 60-field recordings. Major editing-system manufacturers offer long-GOP HDV support, and they also support so-called 24pA (24-frame progressive advanced) 2:3:3:2 mapping, which provides four temporally coincident frames and only one redundant-field frame in every five, simplifying compressed-domain editing.

Although many HDTV camcorders operate at 24 frames/sec, there have also been moves in the opposite direction. Silicon Imaging's SI-1920 HVDR can capture up to 72 frames/sec. A number of companies offer ultra-high-speed high-resolution (if not quite HDTV) cameras capturing as many as 1000 frames/sec. Sony has now introduced a triple-speed HDTV slow-motion system based on the HDC-3300 camera to join earlier double-speed versions from Grass Valley and Ikegami.

The prices of the small-format (1/2-in. and smaller) HDTV camcorders pose a quandary for lens manufacturers, whose 2/3-in. HDTV lenses often cost more than the entire camcorders. Canon has responded by introducing a new low-cost line of HDgc (general class) HDTV lenses. Fujinon similarly introduced a series of lower cost lenses for Sony's 1/2-in. XDCAM HD imagers.

Curiously, the smaller the imager, the greater the demands on lens quality. A 1920-pixel-per-line 2/3-in. imager has a maximum of 100 line pairs per millimeter (lp/mm); for a 1/2-in. imager capturing the same resolution, it is 138 lp/mm and for a 1/3-in. imager 184 lp/mm. Thus, the lower-cost lenses should, to maintain equivalent sharpness, provide higher quality. With HDTV being more demanding of proper focus, Canon has now joined Fujinon in demonstrating a focus assist system for HDTV lenses.

Fujinon introduced a 16 x 6.3 mm lens for 2/3-in. imagers that can be considered both wide angle and normal. They also introduced a wider range 27 x 6.5 mm studio lens.

By using a Bayer-mosaic color filter on its 2/3-in. imager, Silicon Imaging's SI-1920 HVDR camcorder can use film lenses directly, without relay optics. It accepts, C, F, and PL (positive-lock) lens mounts. In the case of 35mm motion-picture film camera lenses, however, the lenses were designed for an image diagonal of approximately 31mm, but the 2/3-in. imager has an image diagonal of just 11mm. That means that the image is taken from roughly the central third of the lens, where the quality is usually highest. Unfortunately, it means the shots will also be much tighter than those of the same lens on a 35mm motion-picture film camera, and depth of field will be much greater.

Although shallow depth of field is considered a positive characteristic for dramatic programming, as it allows direction of the viewer's attention to that which is in focus, greater depth of field could be considered beneficial for news. The smaller the imager, the greater the depth of field.

Where 35mm motion-picture film-like depth of field is desired, relay optics may be used with 35mm motion-picture film lenses. Redrock Micro has introduced a new, lower cost version of relay optics using a spinning ground-glass screen. JVC has also introduced the HZ-CA13U, a relay system—for 16mm motion picture film lenses—without a spinning screen and with image inversion. The company's GY-HD200U HDTV camcorder offers an image-inversion mode to restore the picture to a right-side-up configuration.

Many associate 5.1-channel surround sound with HDTV. The Holophone H4 SuperMini is a small, lightweight, camera-mountable microphone head that can capture all 5.1 channels at one point and allows zooming. For applications requiring closer microphone placement, Ricsonix has applied Bluetooth technology to wireless microphones for an exceptionally small and lightweight transmitter; the company plans to combine the transmitter with its previously introduced Pin-Mic technology to eliminate all wires, including the one from the microphone to the transmitter.

Small HDTV camcorders and camera-mounted surround-sound microphones enable single-person crews to operate in the field. New prompter developments can assist them.

Portaprompt's Nano-Prompt is a small, lightweight computer with reversible screen, light enough for camera mounting. A small, easily concealed, wireless transmitter allows the talent to control the speed of the text scrolling.

For applications where such control is impossible or inappropriate, Autoscript's Voice Plus software offers an alternative. It uses voice recognition to advance the text without manual control.

Rushworks' Newsrush continues the one-person operation theme into the studio. It allows a reporter to write robotic camera moves and color-replacement keying cues into a script.