Afterword

What We've Learned from the DTV Experience

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Before closing this book packed with over 600 pages of standards, figures, tables, and related details, it is perhaps appropriate to step back and consider, what have we learned from the DTV experience? I will try to concentrate my comments on our key experiences related to digital terrestrial broadcasting during the last fifteen years.

As this book goes to press, about 50 digital stations are on the air. In the understanding broadcasters had with the FCC back in April 1997, there were going to be only 24 or so. But there are many more. That is great news. Perhaps one thing we have learned from our DTV experience, contrary to what we seem to read in the newspapers, is that some broadcasters really do want to do something with digital broadcasting.

So, where are we now. What have we learned.

1. New standards are difficult to complete, especially when government regulations are involved.

Perhaps the most significant thing we have learned is that a totally new technical standard is exceedingly difficult to complete if the standard is regulated by the government. Terrestrial broadcasting is subject to strict technical regulation. Then, you have to add the fact that television broadcasting affects 100 percent of our citizens. Perhaps the wonder is that we were able to finish the standard during my lifetime.

This difficulty is not present in technical standards for pre-recorded media. Look at DVD as an example. That was not nearly so tough to complete. This difficulty is not present in technical standards for satellite broadcasting, or cable. Did you hear such long debates about DBS standards? Or digital cable standards?

Because of the technical regulation, more people have to be involved. That means more voices. Different opinions. Many different opinions. You have to get widespread agreement. General agreement. Consensus. Because of this, the standard came about very slowly. When a direction seemed to appear, new people became involved and they, of course, had new views. And so the direction changed many times.

And, as if the job was not already tough enough, national politics intervened. I mean politics with a capital "P". We all know that politics with a little "p" is involved in technical standards because different companies try to obtain an advantage over their competitors. But, in this case, national politics became a factor. The Advisory Committee was formed by a Chairman who expressed interest in HDTV. After a few months, a new Chairman was appointed, and he showed even greater interest in HDTV. Then the Administration changed from one political party to the other. A temporary Chairman was appointed. After some delay, another Chairman was appointed.

Most participants in the standardization process, especially at the beginning, had a goal of all media following one standard. That view seemed to persist for a long time, almost to the end. As we approached the end, though, I think too much time had passed. Digital satellite broadcasting

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had begun using slightly different technical parameter values. The DVD group released their standard with slightly different technical parameter values. Yet, the FCC still had not ruled on the digital terrestrial broadcasting standard.

Today we continue to see that kind of fragmentation. You still hear debates about "computers" and "broadcasting". Convergence. Convergence, to me, means convergence of the technology, not convergence of the products, or applications. I have a four wheel drive sports utility vehicle. It uses tires, four of them. They are big and fat. I have a motorcycle. It uses tires, two of them. They are not big and fat. All six tires are made of rubber, and they are all round, with a big hole in the center. But, they are not interchangeable. They all use the same technology, but they are not the same product. They are used in different applications. That's my view of convergence.

Back to the fragmentation. We still hear debates on progressive scan and interlace scan. And colorimetry. Different broadcasters will use different scanning formats. There continue to be debates on the number of pixels per line, for both standard-definition and high-definition. High-definition DBS may use still different scanning formats. It continues to be unclear what will happen with cable.

2. Bandwidth of 6 MHz is important, but NTSC compatibility is not.

Fifteen years ago, when the ATSC was formed, it was conventional wisdom that more than 6 MHz would be required for HDTV, that terrestrial broadcasters would not be able to broadcast HDTV, and that a new standard must be backward compatible with NTSC.

My how things changed in fifteen years. The earliest proposals were for satellite broadcasting only. And they required two channels. One channel carried the normal 525-line signal, the second channel carried an augmentation signal which, when added to the first signal, produced a high-definition picture. Some time later, there were proposals for satellite broadcasting that used wider bandwidth channels, and were not NTSC-compatible.

The earliest proposals for terrestrial broadcasting assumed NTSC compatibility. If the system required only 6 MHz, it really was an enhanced system, not a high-definition system. Early terrestrial proposals for high-definition assumed two channels, like the satellite example mentioned previously. The first channel was simply an NTSC signal, perhaps an enhanced NTSC signal. The second channel provided an augmentation signal which, when added to the first signal, produced a high-definition signal.

In my opinion, the big breakthrough came late in 1988 when Zenith proposed their "Digital Spectrum Compatible" high-definition system. This was a non-NTSC compatible 6 MHz system. For the first time, people began to seriously consider a non-compatible system. There seemed to be a recognition that NTSC was terribly bandwidth inefficient, and that carrying an NTSC signal forevermore would be a terrible waste of bandwidth.

3. Digital broadcasting is a winner.

Fifteen years ago we thought that digital broadcasting would not be possible for many, many years into the future. Even ten years ago it was conventional wisdom. That changed in 1990, when General Instrument proposed a 100 percent digital system to the FCC. Within six months, all proposals, save one, were modified to be all-digital. The one remaining analog system was dropped two years later.

Let me make a clarification for people who have not been involved in this area. Digital television is not new, not by any means. I began my digital television career in 1970. The IBA in Great Britain designed a digital standards converter around 1970. The first commercial digital time base corrector was available around 1972. The first commercial digital television frame store was available around 1974 or 1975. Broadcast quality digital tape recorders were being demonstrated around 1980. This form of digital television is not new.

Digital bit rate reduction, on the other hand, is new. Or, let me say, bit rate reduction to the degree that permits digital broadcasting to use less bandwidth than analog broadcasting is certainly much newer. The work of MPEG in the late 1980s and early 1990s made this happen.

Broadcasting bits, rather than broadcasting an analog signal, also is newer technology. This development, more or less, coincides with the bit rate reduction development. Finding techniques to broadcast more bits per second, coupled with reduction of the number of bits required to represent pictures, proved to be a powerful combination.

This change in technology also affects how companies use other technologies. Consider, for example, my own company, the Sony Pictures High-Definition Center. Our biggest business is converting movies to high-definition video. As I am sure you know, there is not an overwhelming demand for HD software today. So, we downconvert the movies to standard-definition for broadcasting and for VHS and Laserdisc releases, and for DVD releases. Because of the great amount of bit rate reduction that is needed for DVD, other elements of the process begin to take on greater importance than ever before. Some of these important items are elimination of weave, low noise, and proper maintenance of the 3:2 pulldown. And this will be just as important for digital broadcasting, whether standard-definition or high-definition. Weave and noise gobble up bits.

Think for a moment just how important bits are. If you start with 1920 x 1080 pixels, 24 times each second, with a 4:2:2 representation, meaning 16 bits per pixel, you have almost 800 million bits per second. For HD broadcasting, this must be reduced to about 18 million bits per second. Or, about 0.36 bits per pixel. We go from 16 bits per pixel to only 1/3 of a bit per pixel. You certainly do not want to waste bits under such constraints. So, we use pin registration to remove the weave and low noise full-frame cameras to minimize the noise. We have designed our own telecine equipment and have transferred around 350 movies with it, gaining an Emmy in the meantime.

4. Material shot on film should be posted and broadcast at 24 frames per second.

Fifteen years ago we did not think of broadcasting film-originated programming at 24 frames per second. Today, it is becoming the rage.

About 75 percent of prime time programming is shot on film. That means 24 frames per second. Generally, each film shot is transferred to video, and then treated as if it were 60 Hz interlaced video rather than 24 frames per second film. Edit timing is based on 60 Hz fields, not 24 Hz frames. This means that the 24 frames per second character of the film probably is maintained within the shot, but there is a 3 out of 4 chance that it is broken between shots. And, when the length of the show is changed by dropping or repeating a field, it is lost within the shot. This wastes those precious bits. If the 24 Hz character is maintained, fewer bits are required for a given level of quality.

A second reason that 24 frames per second post production is becoming so popular is because of the different scanning formats that different broadcasters plan to use. In Hollywood, it is clear that post should be performed at the highest resolution that any client will want the product delivered. Then you downconvert to lower resolution formats. Posting film-shot productions at 24 frames per second with 1920 x 1080 resolution makes sense. You can easily extract a 1920 x 1080 60I signal, or a 1280 x 720 60P or 24P signal, or a 480P signal, or a 480I signal. Perhaps equally important, you can easily extract a 50 Hz signal by running the 24 Hz tape at 25 Hz. This makes a PAL tape that is identical to what you would have if you used a 50 Hz high-definition telecine and ran the film 4 percent fast at 25 frames per second.

The HD Center has been aware of this issue for some time. We have been maintaining proper 3:2 pulldown in our transfers from the beginning. This has been important to us because of our downconversions to a DVD master, and because of our downconversions to PAL. To make a PAL tape, we simply drop the redundant one-out-of-five 60 Hz field, downconvert from 1920 x 1080 pixels to 576 x 720 pixels, and record at 48 Hz. Then we play back that tape at 50 Hz. As described before, this produces a flawless PAL tape.

We also are interested in 24 Hz electronic shooting. We want to be able to seamlessly mix material shot on film and material shot electronically. This is for material which will end up as video, and for material which will end up as film. We believe the easiest way to accomplish this is to shoot video at 24 frames per second.

5. The distinction between high-definition and standard-definition has blurred.

Fifteen years ago, the ATSC formed three different technology groups. The first group was dedicated to improved-NTSC systems. The second group was dedicated to enhanced 525-line systems. The third group was dedicated to HDTV systems. Around 1990, the ATSC changed that organizational arrangement. It had become clear that the more important breakdown was production and distribution.

Today, we continue to see this as a continuum, not three different standards, or sets of standards. Yes, the ATSC Digital Television Standard incorporates three quality levels, 480 lines, 720 lines, and 1080 lines. But we also believe receivers should decode and display a picture regardless of which quality level was broadcast. This is consistent with my earlier comments that productions will likely be done at the highest quality level, then distributed at whatever quality level seems appropriate for that show at that time on that service.

This approach that we took in America is different from the approach that has been taken in Europe. In America, we have embraced HD and SD in the original standard, and we have encouraged the manufacture of all-format receivers. In this approach, viewers select the resolution they desire when purchasing a television set. The highest quality will cost the most. Even the lowest resolution television set, though, will be able to display pictures from a high-definition broadcast. The European approach has been to incorporate only SD in the original standard. Then, whenever HD is desired, HD broadcasts can be made to HD receivers. I am an advocate of the American approach because I am concerned that it will be too difficult to take that second step up to HD broadcasting. This means two transitions, not one. I am afraid that one transition is difficult enough!

Today we do not know if the American approach is a winner or a loser. As I have said, I believe it is the right approach. But, only time will tell.

The future

What do I see for the future. Or, what might I have written if these comments were published five or ten years from now?

I am sold on quality. That's why I am a big advocate of HD. I believe our standard of 1920 x 1080 will be able to stand the test of time. Let me give you an example of what this quality level means. The HD Center is involved in digital image restoration. Often this means scanning a 35 mm film that has been damaged, repairing the scanned images, then replacing the damaged images. A project we have been working on for several months is the restoration of the 1969 Columbia Pictures classic "Easy Rider." We are replacing two missing negative reels. We are accomplishing this by scanning, at 1920 x 1080, black and white separation prints that were made from the original negatives back in 1969. Then we are combining the three black and white images to make a color image, repair any damage with computers, then make a 35 mm negative from the HD master. The two replacement reels will then be included in the movie, along with the other original reels.

So, what will I say five or ten years from now? All those pesky little issues I mentioned at the beginning of this essay will go away. At some point, we will stop worrying about the number of pixels, the colorimetry, the scanning formats; yes, even progressive and interlaced scanning. All forms of "open" media will use the ATSC Digital Television Standard. And the all-format receiver approach will be seen as the appropriate manner to have begun the new service. And consumers will embrace HD. They will love it just as I do.

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