



# Digital Television Broadcasting in the United States

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DIGITAL TELEVISION BROADCASTING IN THE UNITED STATES

In the September 2008 issue of the *Journal* I wrote a report on the condition of digital television broadcasting in the United States. At the point in time when I was writing that report, the analog shutoff date was February 17, 2009. There was a piece of legislation winding its way through Congress called “The Digital Television Border Fix Act” that was designed to allow television stations within 50 miles of the Mexican border to continue to operate their analog facilities. The National Telecommunications and Information Association (NTIA) administered coupon-eligible converter box program was operating at full speed after a rocky start. The proposed ATSC mobile/handheld (M/H) standard was making an extraordinarily rapid trip through the standardization process and was on track to become a standard in early 2009. What a difference a year makes.

## TERRESTRIAL DTV TRANSMISSION

In January 2009, I was attending the Consumer Electronics Show. I had two items on my list of things to see. The first was to see what home recording options were available for the consumer after the analog signals ceased operation the following month. The other item was to look at the new mobile devices that were being proposed to take advantage of the M/H standard. Before I even made it to the show floor I started hearing reports about a DTV delay bill that was being introduced in Congress, ostensibly to deal with the fact that a significant number of homes were completely unprepared for the end of analog. In the same time frame, the NTIA announced that the coupon program was out of money and that new applicants were being placed on a waiting list with the hope that more fund-

ing would be authorized. So at the eleventh hour, through an act of Congress, the mandatory analog television shutdown was delayed from February 17, 2009 to June 12, 2009. However, even the delay was a true mandate, because it allowed stations to cease analog operations before the June 12 deadline, and approximately one-third of the stations in the U.S. did, with the rest making the transition on June 12. So, analog television is gone and digital television is the standard and the great transition is over. We’re done, right?

Hardly! One of the fallacies of the “digital conversion” was that it took place on June 12, 2009. Iowa Public Television (IPTV) is a statewide television network of nine transmitters and eight translators. We turned on our first full-powered digital television transmitter in 1991. On June 12, the station shut down analog and found out the level of preparation of the over-the-air audience. Thus, one of the major ongoing jobs is educating the consumer about digital television reception. I have read many articles from leaders in the public sector, broadcasting, and the consumer electronics industry touting the 99%-plus awareness that was reached before the end of analog. However, there are numerous blogs, newspaper articles, and calls to IPTV and many others stations with complaints about digital reception. Confusing awareness with understanding is also an issue that requires attention. In a television program underwritten by the IEEE Broadcast Technology Society and produced at Iowa Public television ([www.iptv.org/video/detail.cfm/3328/dqa\\_20090131\\_receiving\\_digital\\_television](http://www.iptv.org/video/detail.cfm/3328/dqa_20090131_receiving_digital_television)), consulting engineer Gary Sgrignoli and I explained and demonstrated, in simple terms, why digital television reception performed differently from analog television. The program was distributed nationally to any station

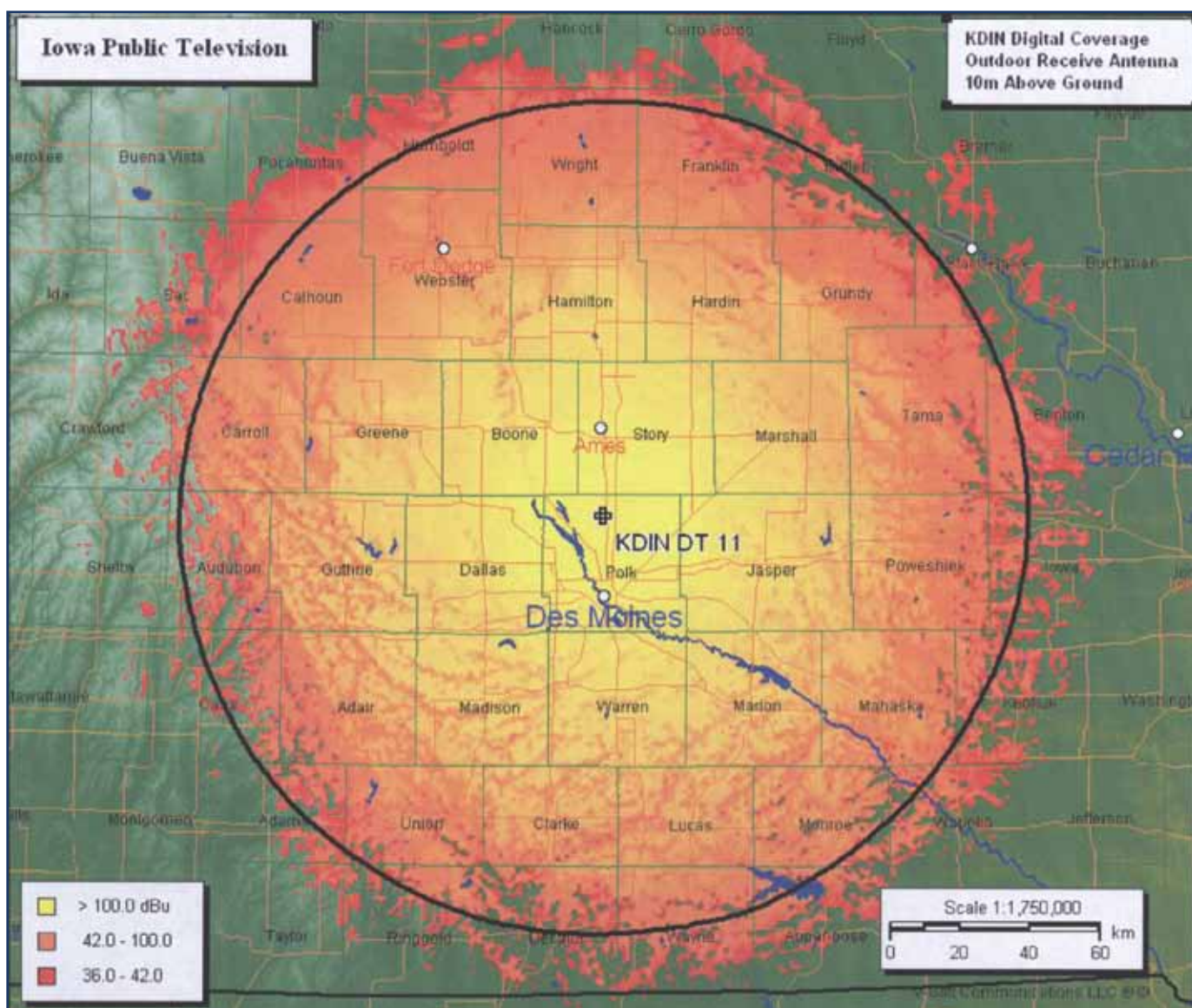
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that wanted it with the intention of providing a tool for local stations to educate their viewers about reception, which, although not glamorous, is the key to success for over-the-air broadcasting. Stations are still answering these questions and will continue to do so for some time to come. Unfortunately, many stations are opting to suggest to their over-the-air viewers that a subscription-based service such as cable or satellite is the best answer, when in reality, if these viewers wanted to pay for service, with very few exceptions, they already would.

Reception is not the only problem, however; there are transmission issues as well. Most can be traced back to the planning factors and assumptions made by the Federal Communications Commission (FCC) when developing the original channel plan for the nation

and determining appropriate signal levels. The FCC was looking for a plan to replicate every station's analog coverage. They based the radiated power assignments on the same antenna parameters that were used in the 1950s to determine coverage. One of those assumptions was that the antenna would be mounted outside approximately 30 ft above the ground. **Figure 1** shows the predicted coverage of IPTV's digital station, KDIN, Des Moines, using the FCC planning factor of an outdoor antenna mounted 10 meters above ground. The black line represents the FCC service contour of 36 dBu. The yellow to red color wash represents the predicted coverage using the Longley-Rice methodology and the two predictions are fairly close. Since central Iowa is relatively flat, both models actually tend to be a little conservative in predicting coverage.

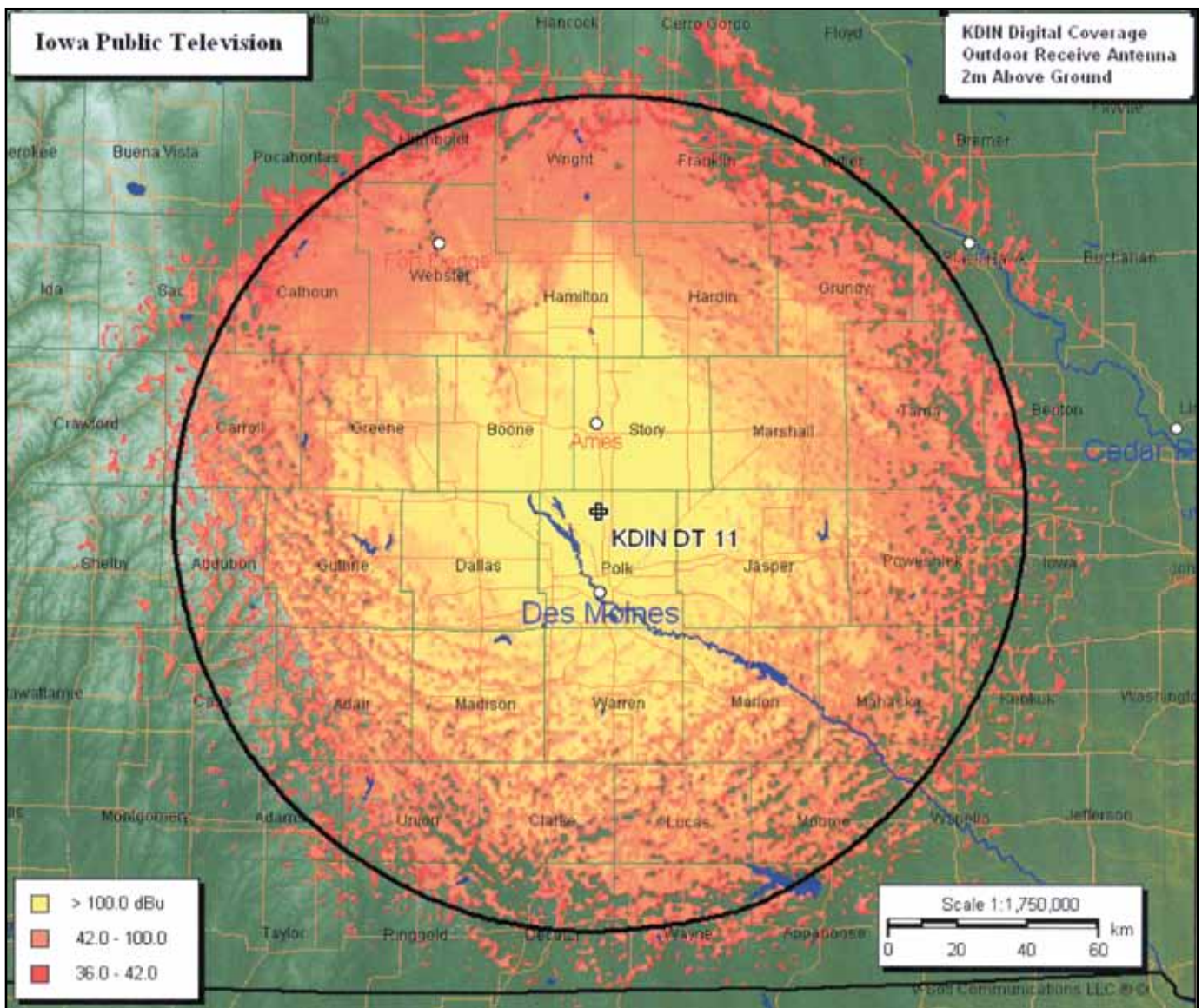


**Figure 1.** KDIN digital coverage outdoor receive antenna 10 m above ground.

My experience in Iowa is that with an antenna mounted outside at 30 ft above the ground, digital performance actually exceeds analog performance. Although this antenna metric may be good for predicting signal propagation, very few over-the-air viewers use it and as a result there are problems.

Many over-the-air viewers use indoor antennas, which in their view worked fine for their analog reception, but are now unreliable or completely failing for digital reception. In one experiment performed at my home, I placed a set of rabbit ears outside on my deck and used a spectrum analyzer to measure the signal level of all the television stations in the Des Moines market. I did this before

the analog shutoff so that I had both digital and analog services. My home is only about 13 miles from the television tower farm. With the antenna outside, I was able to measure good to excellent signals from all of the stations, without any adjustments to the antenna, and image quality on both the analog and digital services was fine. I measured the antenna height on the railing of my deck at about 2 m and applied this to the Longley-Rice model in **Fig. 2**. If you compare the strong signal areas in yellow between **Figs. 1 and 2**, there is some degradation to the strong signal because of the lower antenna, but the flat terrain minimizes the impact close in. The impact is greatest at the contour edges. The reason is that by lowering the receive antenna, the effect of minor terrain irregularity-

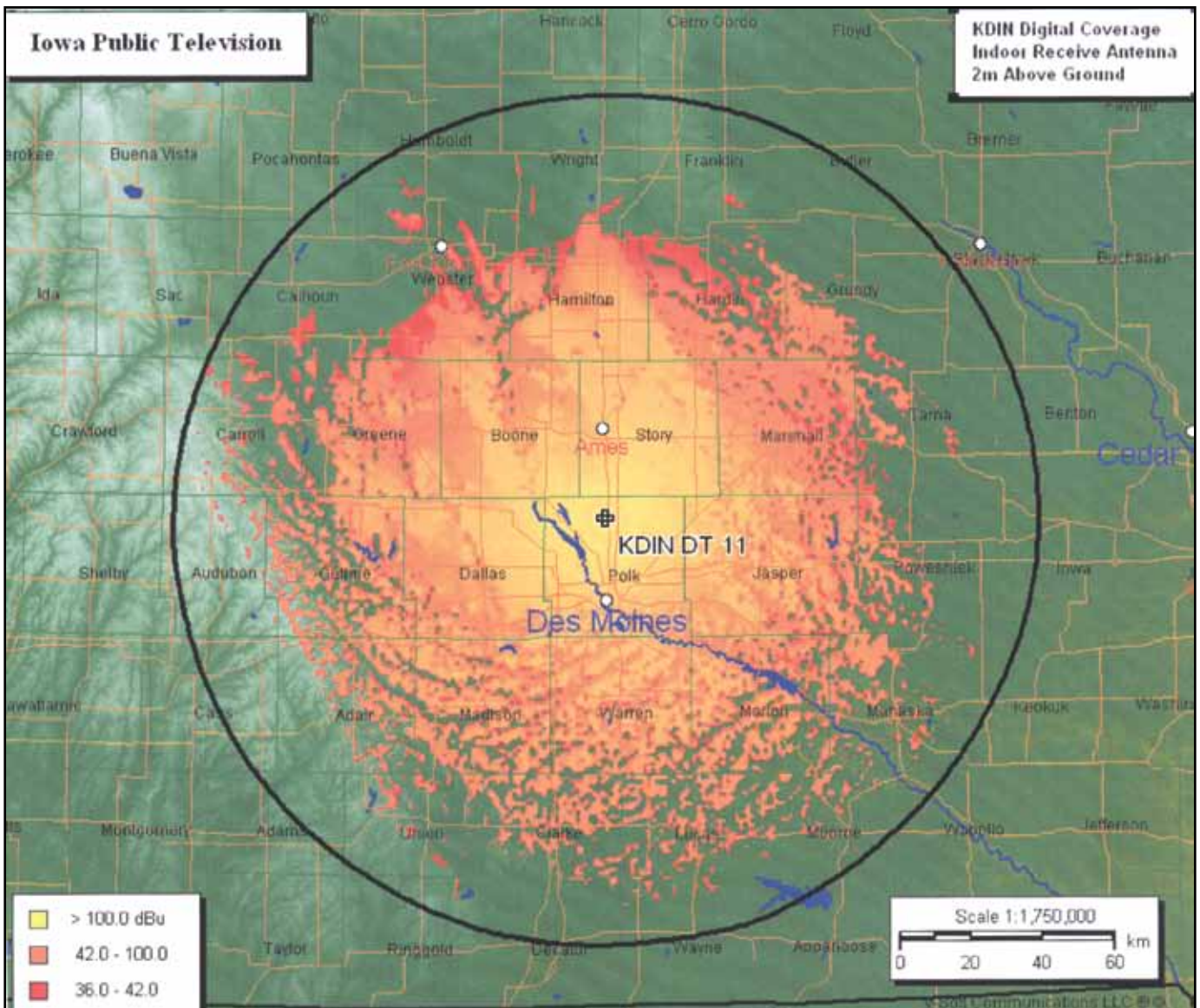


**Figure 2.** KDIN digital coverage outdoor receive antenna 2m above ground.



ties and the curve of the earth become more significant closer to the transmitter site. Bringing the antenna indoors and placing it on top of my television caused problems for both the analog and digital services. The analog services had ghosts and noise, and the digital services macro-blocked or failed completely. Measuring the signals with the antenna indoors revealed approximately 20 dB loss in signal level. In **Fig. 3**, I applied attenuation of 20 dBu to the Longley-Rice model and the effects are significant at all distances. It is also important to keep in mind that my computer models are only considering the receive antenna elevation changes and the loss of signal strength due to building penetration. Complex reflections and other signal impairments were not factored into the models. At that time, most of the analog stations were VHF and all of the digital stations were UHF. For example, at the KDIN station we operated on channel 11 analog with an effective radiated power of

316 kW and on channel 50 digital with an effective radiated power of 968 kW. After analog shutoff, the digital service was moved from channel 50 back to channel 11 with a maximized effective radiated power of 22.5 kW. What this means to reception depends on the receiver antenna location. Measuring service and observing performance with an antenna 30 ft in the air, at 90 to 100 miles across flat terrain, showed a reliable signal. However, with indoor antennas, in urban areas, or in more challenging terrain, analog reception outperforms digital, in part because of the graceful degradation analog and, in part because there was just more power and therefore more fade margin. Many VHF stations, both high and low band, are looking at ways to increase effective radiated power—not to increase distant coverage but to improve close in, indoor reception. It is expected that the FCC will authorize some changes to improve the situation but digital reception will still be a challenge



**Figure 3.** KDIN digital coverage indoor receive antenna 2m above ground.

indoors because of the cliff effect. Again using my home and KDIN DT 11 as an example, I measured a signal about 21 dB lower than the FCC predicted level with antenna indoors. In order to overcome that loss, the effective radiated power of KDIN DT 11 would have to increase from 22.5 kW to approximately 173.5 kW, which is unrealistic. It is more likely that power increases will be in the range of 3 to 6 dB, which will add to the receive margin and improve the situation but will not eliminate the cliff.

As an added challenge, low-band VHF, in addition to having even lower effective radiated power than high-band VHF, must also deal with environmental electrical noise or impulse noise. Power line insulators arcing, vacuum cleaners, blenders, and any device with a switching power supply increases the noise floor. Although the vast majority of these devices meet FCC requirements for interference compliance, the planning factors did not account for the quantity of these devices that are now in the room with the antenna attempting to receive a weaker signal. It is not clear to me that low-band VHF stations will be able to radiate enough power to overcome the environment without causing unacceptable interference to other stations and services. Dealing with these issues and trying to explain them to the average consumer will be an ongoing challenge for terrestrial broadcasters for some time to come.

## CONTENT ISSUES

Not all is gloom and doom in the terrestrial environment, however. The number of broadcast stations embracing HD for their local productions continues to increase and broaden, so that it is no longer just the major markets. I am not old enough to remember, in any great detail, the transition of local television productions from black-and-white (B&W) to color. However, I do vaguely recall watching shows such as "Bonanza" in color and then seeing the local news in B&W on our new color television and wondering why all programming was not in color. Although the B&W technology was not broken, the transition between the two was fairly startling for the audience and detracted from the local content. The early adopters of color television were fairly knowledgeable and understood the different technologies employed. As color television sets became more common, however, an increasingly larger percentage of the audience was subjected to the local versus national transition (B&W vs. color), and their understanding of the reasons, and their desire to understand, was much less. The wow factor may get the audience's attention, but it will not hold them if the content is not compelling, and substandard technology (real or perceived). Coupled with more sources of similar content, this will contribute to audience loss. Local HD is now undergoing this transition but in addition to other local broadcasters, the audience has cable, satellite, broadband, Blu-ray and such; even their own home digital cameras produce content in HD. Flat panel TV prices continue to drop, and despite a tight economy, sales appear to be fairly strong,

so an increasing number of viewers are going to see the national (HD) versus the local (SD) transition. In an August 4, 2009, interview with Cnet News, Consumer Electronics Association president Gary Shapiro stated that he thought "broadcasters blew it in that HDTV was their one opportunity to get ahead of cable and satellite in the sense that it was cheaper for them to go to HDTV because they could just send out (an HD) broadcast signal." While I am not advocating Gary's views on how the digital conversion was managed by the various entities involved, I believe there is some validity in this observation. Terrestrial digital broadcast began in the late 1990s and a concerted effort by the broadcast community might have provided a competitive advantage for free terrestrial broadcasting and improved the bargaining position for the carriage and placement of HD and multicast content on digital television stations.

A stronger commitment early on might have also helped ensure a smoother transition, especially in the fine details with which we are currently struggling. Consider aspect ratios. The current display environment is extraordinarily challenging. We are dealing with an increasing number of new displays using the wide-aspect ratios and different imaging technologies that perform differently in their display of both color and luminance. We are also dealing with a colossal number of old displays using the traditional 4 x 3 aspect ratio. This has become a very thorny issue since the end of analog broadcast. In the days of simulcasting, the broadcaster had direct control over the display format and made intelligent decisions on whether to center-cut or letterbox for a 4 x 3, based on the content. At IPTV the digital HD stream went out as 16 x 9 with pillar box for legacy content and on the analog stream we made the decision of letterbox or center-cut so each stream was individually tailored for the primary type of display. A single stream is now being used to feed all display types, which results in a mixture of complaints regarding letterboxing, pillar-boxing, and postage stamping. In theory, the active format description (AFD) standard will address this, however, there have been many implementation issues associated with it, that cable and satellite providers have been slow to adopt it. Consequently, broadcasters now must deal with aspect ratio complaints from all areas. Explaining to terrestrial service viewers that their converter box or DTV provides them with display control is fairly easy; however, explaining to viewers using cable or satellite service that their analog television does not offer these controls is less simple, and there are no answers that satisfy everyone. It would have been easier if these issues were resolved when analog was still online, as fewer viewers would have been affected.

Audio loudness is another issue that is still being addressed. This is more inexplicable in the eyes of end users because this is not a new problem and the conversion to digital actually seems to have made it worse. In the days of analog, there were loudness issues, however, they were more a function of audio processing and compression. The great level equalizer for terrestrial broadcasters was that whether the transmitted audio used amplitude or frequency modu-



lation, over-modulation resulted in a condition that violated FCC rules and could result in a monetary fine, so very few broadcasters actually over-modulated. Unfortunately, many content creators and broadcasters over-processed so even though they did not exceed 100% modulation, they spent an inordinate amount of time near 100%. In the digital broadcast world there is no direct connection between audio loudness and over modulation, so in addition to the aforementioned audio processing issues there is also the potential that one facility's perception of 100% may be different from another's and switching between the two can be extremely difficult. In June 2008, Representative Anna G. Eshoo (D-CA) introduced the Commercial Advertisement Loudness Mitigation Act (CALM Act) as a method to deal with loud commercials, and a companion bill was introduced in the Senate by Roger Wicker (R-MS). Concern over this issue is high and although no congressional action was taken last year, clearly this will continue to be a hot topic, which will be fixed either voluntarily or by law.

Although well intentioned, the CALM Act only deals with a part of the problem, which is the change in loudness (real or apparent) when a content source changes within a stream, such as going from a program to a commercial break. It does not really address the issues associated with switching between channels. Because terrestrial broadcasting uses Dolby AC-3 encoding, the proprietary Dolby dialog normalization is included in the audio stream. There has been much debate within the broadcast community regarding the appropriate value to set, but progress is being made so that there is increasing consistency in levels between stations and within streams. Unfortunately, not all of the services are Dolby-encoded on a cable or satellite system, or even on a DVD. The cable audience in general does not make a distinction between a cable-only channel and a broadcast channel, so switching between channels continues to show considerable differences in levels.

Audio/video synchronization is another old problem that seems to have become worse with progress. I suspect that this is partly because the quality of the sound systems and displays used by the home viewer has increased to the point at which barely noticeable problems have become visible. It also does not help that the timing relationship specifications for acceptable performance are so broad that a even a well-planned multihop system using only devices that meet specification can easily exhibit unacceptable A/V synchronization. This issue is not limited only to the U.S. terrestrial broadcast service, but is a problem for all digital services globally; it is the focus of an ad-hoc SMPTE committee chaired by Graham Jones of the National Association of Broadcasters.

## TRANSLATORS/LOW-POWERED TELEVISION

In last year's report I noted that there has yet to be any definitive FCC deadline for the conversion of translators and low-powered TVs (LPTVs). At this point, there is still not much movement re-

garding a mandate for the conversion of these services to digital, but the FCC is now accepting applications to allow existing translators and LPTV stations to apply for flash cut digital conversion. This means that a station can apply for a switch to digital transmission using its existing channel. I am not sure there ever will be a mandate for these services. It appears with this latest action that the FCC wants to let the marketplace determine the time and rate at which these services convert. At IPTV, the decision was made that the transition to digital would include all service budgeted for the conversion. Construction permits have already been received for digital conversion at three of the station's eight translator sites. However, there are other translator sites for which there is no plan or funding available for the conversion. There is hope for people relying on these services, mostly in rural areas. On May 12, 2009, the National Telecommunications and Information Administration announced the start of the Low Power TV and Translator Digital Upgrade Program to reimburse licensees of analog LPTV-eligible stations for eligible costs associated with the upgrade of their analog facilities to digital broadcast capacity. One caveat is that to apply, a station must be on the air with a licensed digital signal. Many organizations that operate translators are unable to generate the funds for the purchase of the equipment needed. If they can obtain the funds and meet the other eligibility requirements, they can recover most of the costs for their digital upgrade. More information can be found at the NTIA's website ([www.ntia.doc.gov/lptv/index.html](http://www.ntia.doc.gov/lptv/index.html)).

## CONCLUSION

In last year's report, I noted that the transition to digital broadcasting was at time very convoluted, and now after a brief delay the digital conversion stills has some twists and turns that need to be navigated. Broadcasters are continuing to struggle with diverse audiences and methodologies for acquiring and consuming content. We are struggling with some of the fine details of supplying digital service to our core audiences. We are looking at rapidly emerging technologies such as M/H, and deciphering our role in that environment, and even future technologies such as 3D TV. This is taking place against a backdrop of hard economic times and increasing competition. Broadcasting was the first successful wireless technology that could deliver content to consumers virtually anywhere. How can we have that as our heritage and still wonder if we have a role to play in the future when the focus seems to be on delivering content wirelessly to consumers everywhere? As stated in last year's report, no one tool can do every job; it is a matter of using the right tool for the job at hand, and in many instances, terrestrial broadcasting will be the right tool.