

INTEGRATING ATSC M/H INTO A BROADCAST TRANSMISSION SYSTEM; OPTIONS AND CHOICES - WHAT YOU NEED TO KNOW

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ABSTRACT

ATSC M/H (mobile/handheld) is set to become a standard very soon, and broadcasters are understandably enthusiastic about the new business opportunities that it will provide to them. To ensure that they are able to take full advantage of this important new technology, it is essential that they have a clear understanding of the options and choices to convert their transmission facilities to incorporate M/H. This paper will seek to provide that understanding, covering such areas as exciter conversion, multiplexing, single frequency networks (SFNs), power level and coverage considerations for mobile vs. fixed reception, and all aspects of the transmission chain that are affected. While it is anticipated that most broadcasters will initially convert their existing single transmitter for dual service (fixed and M/H), the different coverage considerations for mobility and reception by a portable receiver may soon encourage the development of a network with multiple transmitters, possibly at different power levels. The paper will discuss this migration, and concepts to implement initially, while planning ahead for a multi-transmitter network. Overall, the paper will cover the major technical issues to consider now and in the future for ATSC M/H conversion.

HISTORY

The advent of digital television in the United States was primarily driven by the desire to deliver high-definition television (HDTV) programming to the home. In fact, the earliest working HDTV systems, such as the Japanese MUSE system, actually used analog transmission, which was not very bandwidth-efficient. So, the proposal of digital television systems ultimately showed the promise of delivering the highest quality HDTV signals and requiring the least bandwidth, while also providing the flexibility of including other services

as part of the television broadcast signal. Features such as data streaming, multicasting and even interactivity offered the attractive prospect of bringing new revenue streams to the broadcast industry.

The FCC created the Advisory Committee on Advanced Television Service (ACATS) to take on the task of selecting this new television system. By the early 1990s, several companies that had proposed various digital television standards ultimately joined forces, forming the "Grand Alliance" and proposing a single digital television standard that combined the best features of the individual proposals. Working closely with the Advanced Television Systems Committee (ATSC), ACATS subsequently recommended this single-carrier 8-VSB system, and it was adopted by the FCC. During this same time period, the beginning of a new digital standard called the Digital Video Broadcasting Project (DVB) was launched in Europe. By the late 1990s, the first ATSC systems were being deployed in the top 30 markets in the United States, while in Europe DVB had nearly completed a terrestrial version of its open standard, called DVB-T.

Early ATSC receivers had very little tolerance to multipath, which became a substantial limitation to reliable reception in the field. As a result, shortly after the top 30 market deployment, a group of broadcasters, led by Sinclair Broadcasting, started a movement to petition the FCC to reconsider its selection of ATSC as the US digital standard in favor of DVB-T. Proponents of a switch to DVB-T argued that it would provide much more reliable reception than ATSC. Proponents of the ATSC system pointed out that DVB-T had distance limitations and did not provide the necessary bandwidth for HDTV. Ultimately, the FCC upheld its decision to select ATSC. However, this exercise made

clear the shortcomings of the earliest ATSC receive equipment and encouraged receiver manufacturers to improve the equalization capability of their products.

Receiver manufacturers promised improved equalization algorithms, and they quickly made good on those promises. Equalizer windows were soon doubled to handle lagging echoes of 40µS, and leading-echo equalization was also added. These changes greatly improved reception capability, and also made it possible to consider implementation of multitransmitter on-channel networks to improve signal density throughout a market – a concept that was being implemented by DVB, but previously thought not to be practical with ATSC. Further improvements in receiver technology allow successful reception even with multipath interference that is equal in amplitude to the desired signal, and

leading and lagging equalization windows have been expanded to 50µS or greater, as shown in Figure 1.

DVB took the next step by introducing DVB-H (“H” for “handheld”), which optimized broadcasts for reception by portable and mobile devices such as cellular telephones and in-vehicle receivers. Seeing another revenue opportunity for broadcasters, the ATSC quickly responded with a fast-track selection and approval of a mobile technology – branded ATSC M/H for “mobile/handheld” - that is fully compatible with ATSC fixed service. As of this writing, ATSC M/H is a candidate standard scheduled for completion in May 2009.

The prospect of a new mobile-based revenue stream has energized broadcasters to consider the possibilities

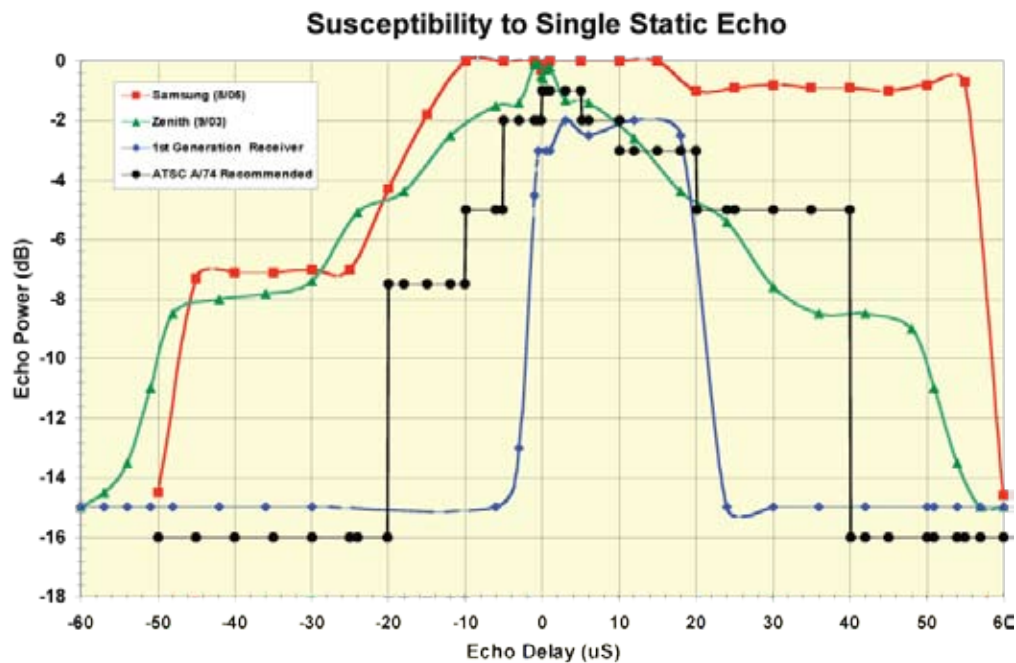


Figure 1

and plan to add this capability to their facilities. But what does this mean for a station that has already built a brand new digital transmission plant? What can be reused and what will be scrapped? How much will this cost and how will it affect HDTV and other fixed programming? These are some of the questions that this paper will attempt to answer.

MAJOR COMPONENTS OF A DIGITAL TELEVISION TRANSMISSION FACILITY

There are three general blocks that can be associated with the transmission facility signal flow of most

digital television stations. While the quantity, quality and implementation of each might vary from station to station, the basic functionality remains the same for each block. These general blocks are shown in Figure 2 and include:

ATSC Fixed Program Headend Equipment – multiplexers, encoders, PSIP generator, etc.

Studio to Transmitter Link (STL) – Fiber, microwave, etc.

Digital Transmitter – Modulator, upconverter, power amplifier, mask filter, etc.

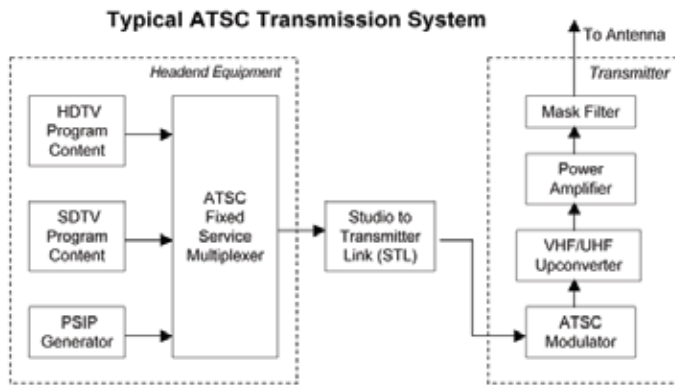


Figure 2

Each of these blocks is critical to a successful M/H transmission system. The desired broadcast content will dictate what is required for some of this equipment. Terminology Note: Throughout the remainder of this paper, there are two terms that will be used to describe ATSC services. One is “ATSC fixed” service, which describes the primary ATSC service that is currently deployed and delivering SDTV and HDTV programming to fixed television receivers. The other is “ATSC M/H” service, which describes the mobile ATSC service that is described in ATSC candidate standard A/153. For clarity, ATSC fixed service will continue to be used to deliver broadcast television to fixed receivers, even in cases when broadcasters choose to implement a mobile component to their signal. When mobile is implemented, ATSC M/H is added to the ATSC fixed signal, allowing both fixed and mobile receivers to be served.

Multiplexing

There are various types of multiplexers available for ATSC fixed service to address the features required by each broadcaster. These features include SDTV and/or HDTV capability; number of programs; static or dynamic multiplexing; etc. All digital television stations that generate local program content use a multiplexer for their current ATSC fixed service. These multiplexers can remain in service after converting to ATSC M/H, however they will continue to handle only the fixed ATSC programming. Additional equipment is required for the ATSC M/H programming. The addition of an ATSC M/H multiplexer, which includes an ATSC M/H pre-processor, is required in order to incorporate the ATSC M/H content into the ATSC bit stream. This unit is placed downstream of the ATSC fixed service MUX and accepts inputs from the ATSC fixed service MUX and the ATSC M/H encoder(s), as shown in Figure 3. The ATSC M/H MUX will typically include an ASI

and/or SMPTE 310M input for the ATSC fixed content, as well as an IP input for the ATSC M/H content.

The ATSC M/H pre-processor adds the forward-error correction (FEC) and training sequences to ensure that the M/H signal is robust enough to provide reliable reception by mobile receivers. Most ATSC M/H exciter manufacturers also offer an ATSC M/H multiplexer. This is an advantage for broadcasters since it ensures that one company takes full responsibility for the complete transmission system.

The implementation of ATSC M/H requires that a portion of the signal bandwidth be dedicated to mobile programming. This bandwidth is scalable based on the number of mobile programs and quality required for each. Generally speaking, each mobile video program will consume between 1.5Mb/s and 2.0Mb/s, while each fixed SDTV program requires about 3Mb/s to 4Mb/s, and a fixed HDTV program requires between about 12Mb/s and 15Mb/s, depending upon format and quality. As a result, broadcasters can choose the services that are most applicable to each market based on the total available bandwidth of their ATSC stream, which is 19.39Mb/s. Figure 4 gives just two examples of what bandwidth partitioning might look like, one with HDTV and the other with multiple SD programs.

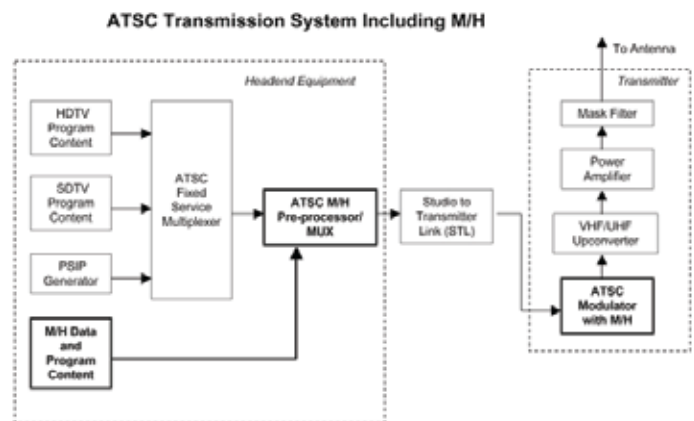


Figure 3

Studio to Transmitter Link

In most cases, the addition of ATSC M/H to a broadcast facility will not require replacement of an existing digital STL. This, of course, assumes that the current digital STL is capable of handling the current ATSC fixed signal. Most digital STLs are capable of transmitting more than enough bandwidth to pass the digital signal. An ATSC broadcast channel is limited to 19.39 Mbps bandwidth regardless of the content of the signal, so existing STLs will not be affected by the

Fixed / Mobile Bandwidth Examples

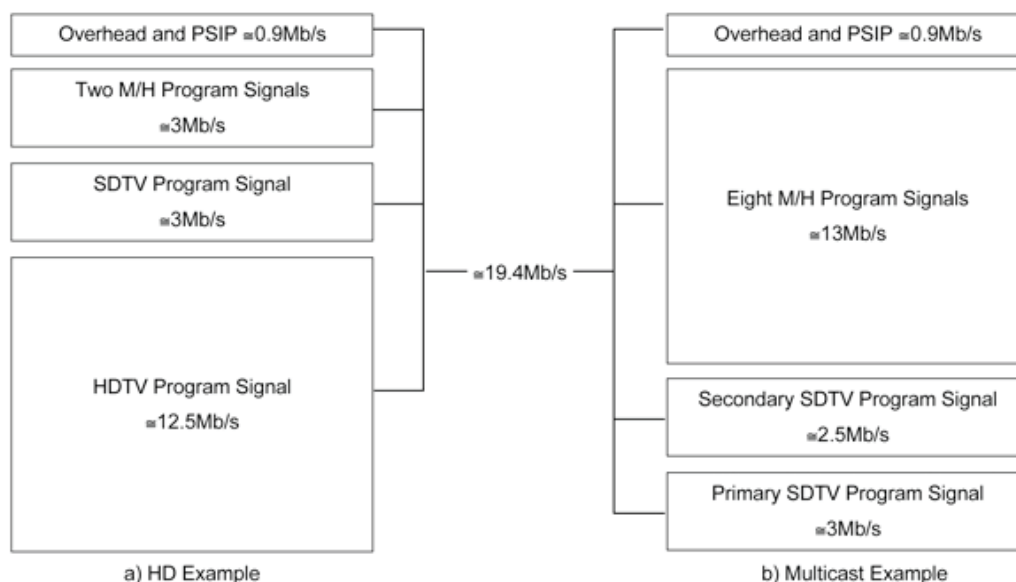


Figure 4

incorporation of the ATSC M/H content. However, broadcasters that choose to operate multiple transmitters in a distributed transmission system (DTS), which will be addressed later in this paper, will require a dedicated STL for each transmitter in the network. Each transmitter in the network must receive identical content, including timing and synchronization information, in order to operate as a single frequency network (SFN) without causing destructive interference within the coverage area.

ATSC Exciter

All existing ATSC transmitters include, of course, an ATSC exciter that is capable of operating in ATSC fixed mode to deliver 8VSB signals to fixed receivers. An ATSC exciter typically consists of two to four components:

ATSC modulator – Accepts an ATSC-compliant baseband ASI or SMPTE 310M bitstream and modulates the bitstream to an 8VSB signal at an intermediate frequency (IF), typically 44MHz

Upconverter – Up-converts the IF signal to the desired VHF or UHF RF channel

Pre-amplifier – Amplifies the RF signal to the necessary level required to drive the final high power amplifier(s) (HPA); the pre-amplifier can be a separate module, it can be integrated into the upconverter, or it can be part of the HPA chain

Downconverter – For systems that employ automatic or adaptive pre-correction, downconverts a sample of the RF output signal to IF for comparison with the IF

output signal from the modulator. Distortions in the amplifier chain and filter can then be calculated and precorrection applied to compensate for these distortions

Except for the modulator, all of the legacy ATSC exciter components are capable of passing an M/H or DTS signal, so for the purposes of this paper, the discussion will be limited to the modulator.

Most legacy ATSC modulators cannot be updated to operate in M/H mode or to operate as part of a DTS. However, some newer digital signal processing (DSP) based designs, such as Axcera's "Axciter" Intelligent Modulator, are capable of being upgraded to M/H and DTS operation with a firmware update from the manufacturer. For M/H operation, the firmware update allows the modulator to recognize the incoming M/H packets that were created by the M/H pre processor. It also adds a post processor block that manipulates the M/H packets of the stream to ensure backwards compatibility with ATSC fixed receivers.

For operation in a DTS, the firmware update allows each modulator in the network to broadcast identical data streams and allows adjustment of timing delay between all transmitters. This is done in conjunction with another piece of equipment called a Distributed Transmission Adaptor (DTxA) which is added to the signal path prior to the STL(s). The DTxA provides a common data stream for delivery to all of the transmitters in the DTS network. The DTxA adds the necessary timing and synchronization information

to this signal to allow control over the timing of the signal from each transmitter in the network and to ensure that all transmitters in the network broadcast identical signals. DTS can be employed as part of an M/H system provided that the DTxA includes an M/H enhanced channel-coding model. A block diagram of a transmission system that includes both DTS and M/H is provided in Figure 5.

If the current ATSC modulator is not capable of being upgraded to M/H and/or DTS with a software update, the modulator and possibly the upconverter will need to be replaced. This requirement varies by transmitter brand and model. The control system, protection circuitry, required signal levels and even the physical design of the existing transmitter will affect which components can be reused and which cannot. The manufacturer of the M/H-DTS exciter that will be installed in the existing transmitter can determine what changes are required.

Most high power transmitters use adaptive precorrection, while most low power transmitters use fixed pre-correction. However, most M/H modulators will include at least an automatic setup option, if not continuous adaptive pre-correction. Again, the M/H DTS exciter manufacturer can provide information

on what is required to implement an automatic setup or continuously adaptive system when using the new exciter in an existing transmitter.

SINGLE TRANSMITTER VS. DISTRIBUTED TRANSMISSION SYSTEM (DTS)

As broadcasters deploy ATSC M/H, it will be necessary to decide whether to take a single transmitter approach or a multi-transmitter approach. While a single transmitter approach is the simplest, and may be the most sensible approach for initial deployment since the transmitter facility is already in place, it has some drawbacks. Two of the most obvious drawbacks are terrain-shielded areas and lower signal levels as the distance from the transmitter increases.

While terrain shielding is somewhat of a problem for fixed receivers, this problem will be much more evident with mobile receivers. With fixed receivers, viewers in shadowed areas are aware that reception is poor in their location, so they generally accept the fact that they cannot receive an over-the-air signal. However, with mobile receivers the population of potential viewers who experience each shadowed area becomes much greater since mobile is a transient service (i.e. many more people travel through an area than live in

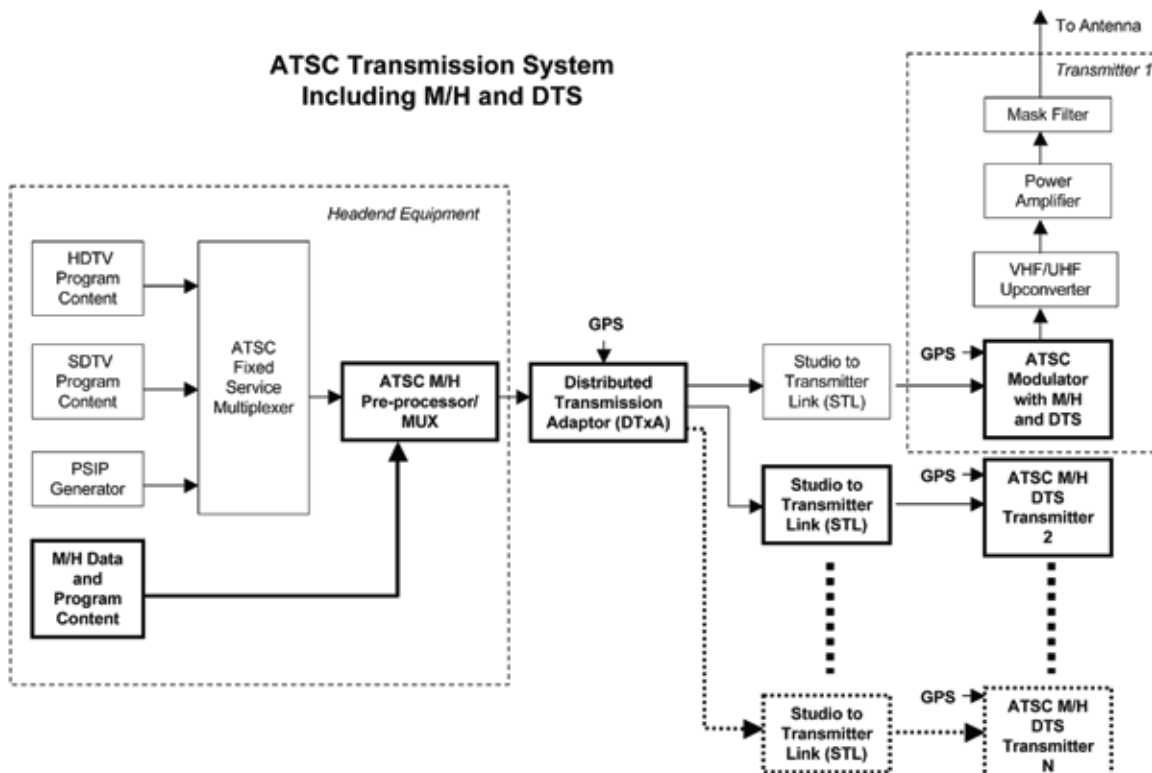


Figure 5

that area). Too many shadowed areas within a market can cause an unreliable signal that will likely cause viewers to become frustrated and stop trying to watch the M/H signal.

The fact that signal levels drop as distance from the transmitter increases is also something that has been dealt with for many years with fixed television service, but is much more likely to be a problem for mobile service. With fixed installations, over-the-air television viewers located far from the transmitter site have dealt with low signal levels by utilizing directional rooftop antennas. These suburban or rural viewers simply expect to use a rooftop antenna and accept this. However, for handheld receivers, which are typically only a few feet off of the ground, can be indoors or outdoors and use relatively small omni-directional antennas that can be oriented in any plane, reception in weak signal areas can be much more challenging.

A multi-transmitter network, such as a DTS, can solve both of these issues. By strategically placing synchronized on-channel “gap fillers” to cover shadowed areas, signal levels can be increased in these areas to ensure reliable reception by portable and handheld devices. Similar results can be achieved through the use of translators, which rebroadcast the signal on a different channel. But the use of translators is less desirable than on-channel systems since it requires FCC licensing of the translators as a secondary service, and it requires receivers to change frequency during the handoff as a viewer travels between signal areas. The issue of low signal levels at greater distances from the transmitter can also be mitigated through the use of DTS by taking more of a “cellular” approach when building out a market. By installing multiple lower power transmitters in a cellular single frequency network, more consistent signal levels can be achieved throughout the noise-limited contour, ensuring more consistent fixed and mobile reception, both indoors and outdoors.

A single full service DTV transmitter may be licensed up to 1MW effective radiated power (ERP). This is the power out of the antenna, which takes into account transmitter power, RF system and transmission line loss, and antenna gain. As previously described in the “gap filler” approach, a DTS can use a large transmission facility like this along with multiple lower power synchronized transmission sites, each likely operating

below about 10kW ERP – some well below this power level, depending upon the size of the shadowed area.

The previously described cellular approach to building a DTS is likely to utilize more transmitters than the gap filler approach, at power levels that will generally be higher than the gap filler transmitters. However, this approach does not require a single large transmitter, so the overall efficiency can be better than a system that requires a single large transmitter. With a cellular approach, ERPs are more likely to be in the 50kW range, although they can vary substantially based on terrain, location of population centers and desired coverage contour.

Deploying a reliable DTS requires significant coverage planning to ensure that good signal strength is achieved throughout the desired coverage area and that cochannel interference is minimized. This allows the optimal transmitter sites and power levels to be selected, and also helps to estimate the initial timing settings between the transmitters in the network.

A DTS system takes advantage of the multipath equalization capability of modern ATSC receivers. To do this, each transmitter within the network must broadcast an identical signal that is synchronized in time with the other transmitters in the network. In the areas where signals from multiple transmitters overlap, the interfering signals must be timed so that they arrive at the receive locations within the equalization window of the receivers. If this is done properly, the receivers will see the two signals as multipath and successfully demodulate the signal.

Since a DTS requires a parallel distribution system (i.e. an original, identical signal feed is delivered directly to each transmitter in the network), a signal transport is required to feed each transmitter in the network. This is most commonly a microwave or fiber STL.

For optimal ATSC M/H coverage, it is highly desirable to use a multiple transmitter network. However, as mentioned previously it is much simpler to convert an existing single transmitter to M/H, so many broadcasters will take this approach for their initial launch. This brings up the question of what it would take to upgrade a single-transmitter system to M/H and then add DTS capability in the future. Fortunately, most DSP based M/H equipment can be upgraded with a firmware

update to add DTS capability. ATSC M/H modulators, like Axcera's "Axciter", can easily be upgraded to DTS slave mode in the field. A DTxA can easily be installed in line after the M/H MUX, and in some cases a DTxA mode can even be added to the M/H MUX, further minimizing hardware requirements. This signal can then be distributed to the slave transmitters in the network, including the existing high power transmitter, which also becomes a slave.

SUMMARY

Digital television transmission arose from the desire to deliver high definition television pictures to viewers across the country. This opened the door for new and exciting broadcast offerings, including interactivity, datacasting and now highly robust mobile television service. Mobile television brings great new revenue opportunities for broadcasters, but can also be a technical challenge to implement. Fortunately, this challenge can be minimized with forethought and planning when building or modifying a transmission facility.

ATSC M/H can be incorporated into most any existing DTV transmitter plant with the modification of existing equipment, the addition of new equipment, or a combination of both. Likewise, DTS networks can incorporate existing transmitter facilities with minimal changes. Planning can make it possible to transition from a single transmitter approach to a multi-transmitter approach and even to a cellular transmission approach, ultimately maximizing coverage to mobile devices.