ATSC Three and the SBE

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The relationship between broadcasting and technology is a deep one that defines us as broadcast engineers. The NAB convention almost always marks the week when some technology with associated hype turns out to be exciting but without legs. On the other hand, it's the week when a technology can show up in a corner of the NAB Show halls, where it is mobbed, and the next thing we know, physical media is dead and editing is done on a lap-top (or some other equally momentous change). Standards themselves rarely change the course of the industry -- unless they do -- and then they do in ways we could not have imagined.

When we started planning the Ennes Workshop for the NAB Show (Saturday, 16 April 2016), it looked to be about progress in the transition from SDI (serial digital interface for video and audio) to (video on) IP and from hardware to cloud. There is no lack of activity on this accelerating front. ATSC 3.0 (the Advanced Television Systems Committee that created the domestic digital TV standard and is now working on the next generation) looked to be a typical sterile standards process with lots of abstract details and few practical applications destined for slow adoption. We were wrong. In the process of putting the program together, it became clear that ATSC 3.0 had a great amount of momentum, was impossible to dismiss lightly, and was ready for its first roll-outs. But more than that, ATSC 3.0 fundamentally changes how TV works -- including how it makes money.

Why ATSC 3.0 Has Momentum

It's no secret that not every broadcast engineer thought the digital TV transition under the first ATSC went far enough, was flexible enough, or for that matter was targeted to the future. Still ATSC 1.0 largely digitalized TV, gave it higher resolution that some thought few would appreciate, program guides that few use and worked great on VHF to reach over the horizon to all those roof-top antennas and living-room TVs. ATSC did a great job of what it was preordained to do, but a realistic look at over-the-air (OTA) TV today reveals that the ATSC 1.0 standard simply can't do what the business of TV now needs to do. ATSC 3.0 has more to do with survival than sparkle.

The trillion-dollar question is, will the stakeholders; the viewers, the broadcasters, the regulators, the advertisers and the equipment manufacturers all benefit enough to invest in the transition. For ATSC 3.0 to be widely and quickly adopted, the new ATSC 3.0 standard has to be way beyond an incremental improvement – it has to be disruptive. One indication that this might be the case is how the ATSC 3.0 standards process has remained on track, on time, and has experienced very little controversy. Even more telling is that parties that fought DTV are supporting ATSC 3.0. Some of these are parties who rightly pointed out limitations in ATSC 1.0 that are finally now addressed. Many others are parties that have deep ownership in media. Yes, one can find articles mostly in the non-technical and non-media general press on how current TVs will need to be replaced and the new picture will be better ("but fortunately it's nothing to worry about for years to come"). I'm afraid it is easy and convenient to see ATSC 3.0 as an upgrade

in efficiency, quality and reach – all of which is true -- and completely miss or at least trivialize how deeply ATSC 3.0 will probably change the TV business.

Let's start with what ATSC 3.0 is and why the stakeholders will be motivated to adopt or reject the transition. But first, we have to look at the world as it has become since the DTV switch was flipped to full on June 13, 2009. What's on today's store display walls are large TVs that noticeably exceed broadcast HDTV's ability to support with the anticipated picture quality. What's in the store display cases are devices that are far more mobile than current OTA TV can reach. What's inside all of these is interactivity that ATSC 1.0's one-way string of packet identifiers (PID, a key part of the DTV data stream) and Program and System Information Protocol (PSIP, where things like the electronic program guide (EPG) is located) simply can't interact with. ATSC 3.0 is first the upgrading of broadcast TV to work in a world of multiple (often nomadic) screens, interactive experiences, with picture and audio quality once reserved for theaters.

The PHY (Physical Layer)

The easiest part of ATSC 3.0 to get your head around is the transmission standard. The RF waveform, or Physical Layer (abbreviated and frequently pronounces as the "PHY") is both capable of larger data payloads (~25Mb/s versus 19.54Mb/s) and greater mobility and penetration. Even as ATSC 1.0 was being adopted, a substantial number of participants argued that while 8-VSB (the waveform chosen by ATSC for version one) was a good duplicate of the old analog TV coverage, but if mobile devices and multiple screens became popular, it would simply collapse and couldn't be fixed without complexity and sacrificing already rather limited bandwidth. As you might recall, there were those who argued in favor of OFDM (Orthogonal Frequency Division Multiplexing, the alternative to 8-VSB chosen for most of the World's broadcast systems, and for ATSC 3.0). In the interim, the technology of digital modulation reached to within a hair of the theoretical maximum performance for such waveforms.

Unlike almost any other broadcast waveform, ATSC 3.0 can be adjusted for various levels of quality versus robustness. The original ATSC 1.0 is a one size fits all, constant bit rate solution. Attempts to fix this with a backward compatible adaptation (M/H or mobile/handheld) came at great cost in payload and didn't perform well enough to implement. In the same way broadcasters can adjust the quality versus quantity of services in today's DTV, they will be able to adjust the robustness of various services to address more hostile environments.

8-VSB as implemented in North America has one other Achilles heel; it does not support a single-frequency-network design well. Qualcomm's MediaFLO took this on in a big way, rethinking how the distribution network is designed. If your goal is to have the same kind of reach that the cellular and wireless data networks have, your broadcast distribution network has to look like a lot more like a radio access network (RAN) than a big-stick TV transmitter. MediaFLO used a boomer-booster-and DAS architecture. Traditional TV of course is built around a boomer with maybe a few translators to reach communities the main transmitter RF cannot see. With an ATSC 3.0 single-frequency network (SFN), the distribution network usually starts with a traditional tall-tower boomer that can be considerably more powerful than the 25kW ERP horizontal and 25kW vertical that MediaFLO was limited to in order to carpet bomb the coverage area. SFN

boosters are used to push the signal into high population density buildings from close-in sites and DASs (distributed antenna system) that push the signal into subways and venues. Buildings, even at UHF, can present an average 20dB of attenuation to signals from outside. The power required from a traditional TV transmitter outside of the city to penetrate the buildings where people live and work isn't just impractical, it is impossible to reach with current technology. While ATSC 1.0 wouldn't work in even a slow-moving car, ATSC 3.0 networks can be designed to reach into moving trains and busses in transportation corridors, not to mention garden restaurants and game side seats, apartments, home kitchens, and backyard pool sides.

The IP Piece

The hardest part of ATSC 3.0 to get one's head around is probably the IP transport piece. Over the air TV, as it stands, might have its distribution network issues, but they pale compared to the Internet's limitations. The simple fact is that we watch a lot of television -- something on the order of five hours a day per person. This is order of magnitudes more bits per person than the entire Internet's current capacity. About half of that is OTA television viewing, of which 50 percent in some southern states is received directly off-air, but only 5 percent of viewers in the New York City DMA (Dominant Market Area) watch OTA, the other 95 percent watch via an MVPD (multichannel video program delivery; for example; cable, satellite or telco). While there may be hundreds of cable networks, and other video sources, only a bit more than half of programming consumed comes from sources other than OTA broadcast.

While the bulk of all Internet traffic is video by a wide margin, it is a very small amount of the total video consumed. Courtesy NetFlix, PBS, the nets doing next day catchup, YouTube and the like, combined with devices that can be used nearly anywhere (including a lot of places OTA TV doesn't reach) Internet access and capacity is growing, consuming more RF wireless spectrum and reaching farther into the corners of the world. This is the gap. Only a sliver of TV viewing is delivered via IP and the IP networks are a long way from having the capacity to deliver all of the TV people watch with the quality they expect. Right now, IP TV is a bit of a miracle. IP TV is a bundle of buffers, sparingly supported multicast protocols, switches, edge servers, and best effort adaptive streaming techniques. It is well understood that watching an Internet video may or may not be a good experience. Reflect on how the far rarer rain fades on direct-to-home satellite are considered by many viewers as an insufferable impairment.

The obvious way to fix IP distribution is make a lot more of it. The other way is to broadcast the highly universally consumed video directly to gateways in the IP network that combine the regular Internet traffic with the broadcast high-capacity pipes. Like most people, you probably have in the last decade or so purchased and replaced a series of faster better and more wireless routers that connect your home local area network (LAN) to the wider world via an internet service provider's wide area network (WAN). Your local network probably supports an ever-growing world of wired Ethernet devices and both a 2.5GHz and 5GHz WiFi local wireless network that pretty much covers your home or apartment. Your home is filling with Internet of things (IoT) devices like thermostats and security cameras that connect via WiFi. Add printers and scanners. You also have tablets, smart phones, DVRs (digital video recorders), games, smart TVs,

and even early generation TV appliances like SiliconDust's HDHomeRun, Dish's Slingboxes, etc., so that your devices can view OTA TV at home and sometimes away.

If you desire Ultra High Definition TV (UHDTV), the limitations on your system is the connectivity via your Internet Service Provider (ISP) and OTA. If you and a few million others want to watch the Super Bowl in UHDTV, the Internet would collapse and current OTA TV is of no help because it lacks the requisite bandwidth and support for the high quality, high efficiency codecs required.

This is the era of first adopters when it comes to home LANs (local area networks) supporting video, multiple screens, remote DVRs, and the like. One can do a lot, but the integration of all of the pieces and the still clumsy and disparate user interfaces makes this more of a science experiment than the friendly convenient standard universal platform that anyone can use. ATSC 3.0 would move this forward dramatically simply because the platform would need to be easy to install and use and is universal.

With current OTA TV, you connect rabbit ears or a coax from an attic or outdoor antenna to each TV set. With ATSC, 3.0 you connect your new ~$250 household gateway/router that probably includes some storage and DVR features to that OTA antenna. Now every IP device in your home LAN coverage area has access to everything OTA and Internet. The 80-inch media room TV has something to watch, the portable devices do too, and you can control DVRs and big screens from the devices that allow you to interact with things like the electronic program guide, saving programs, sending programs to friends, watching programs, searching for something to watch.

Certainly, there will be ATSC 3.0 dongles with an F-connector on one end and an HDMI connector on the other end that will allow those older flat screens to continue to receive basic OTA TV. In that respect, converting grandma from an OTA TV to ATSC 3.0 is fairly inexpensive and easy. Clumsy at first with maybe yet another remote control to deal with. This is nothing like 2009 where we replaced glass CRTs, gave out $20 converter coupons and encouraged millions to migrate to MVPDs basic service to avoid the effort and investment that DTV required. In this case, the digital transition has already happened, we already have flat screens and devices and all that is missing is a means to connect broadcast TV to them.

Devices that can only receive ATSC 3.0 will exist in the same way that you can still get a cell phone that is just a cell phone, without any data or display. For most people, ATSC 3.0 is replacing that gateway router and watching as new devices mysteriously have ATSC 3.0 features.

Regulation – The FCC

While ATSC 3.0 is the natural progression of improved technology, it also makes a fundamental change to the traditional business model that over the last century caused manufacturers to make TVs, caused us to buy them, and caused the broadcasters to create content that we wanted to watch, so that advertisers would buy access to that audience. Let's walk through what the stakeholders get from ATSC 3.0 and what they have to give up or invest to get there.

The most common business model for the United States broadcaster is the one above. We the people give the broadcaster exclusive use of some finite RF spectrum in return for serving the public interest convenience and necessity. It's certainly not the only working model in the world. Some governments tightly control and own broadcasting and its messages. It is also true that wireless providers, MVPDs, and some Internet programmers are broadcasters with a subscription, pay-per-view and/or data fees supporting the arrangement. Domestically, much of maybe the more uplifting goals of broadcasting have faded, but buried in our broadcasting experience are three notable directives for free-to-air broadcast. First; the poorest, most feeble, least interested in paying among us should have access to broadcast TV. All but the poorest among us can expect to have free TV to watch. Second; emergency warnings and life- and property-saving information is to be distributed on that platform. Thirdly, to the degree that education is a goal of our society and TV is the most economical and wide reaching platform for learning, we expect that TV will support some level of arts and education. From the viewpoint of the least interested in TV among us, ATSC 3.0 poses a small price and likely will allow some ATSC 1.0 lighthouse stations to operate for some time. The FCC which regulates on behalf of the public continues to meet its mandates with ATSC 3.0 actually making some improvement in public safety and warning communications as ATSC 3.0 represents a step forward in this field. Most of all, ATSC 3.0 has a bigger reach than ATSC 1.0 which increases the population free to air TV can reach.

Regulators are not being asked for anything, in particular spectrum, for the transition. The FCC will have to first approve the transmission of ATSC 3.0 before anything can happen, but there is little chance that the FCC will object. There is more of a chance that they move to expedite the transition as a way to ease the impact of the present-day spectrum reallocation process.

Whether there will be legislation that requires cellphones to be able to view free OTA TV, or FM radio for that matter is yet to be played out. Voters pushed Congress and thus the FCC to regulate loud commercials, they may also demand their free TV.

CE – Consumer Electronics Industry

The consumer electronics industry has historically been asked or required to make products with capabilities that didn't have an intrinsic monetary value to the manufacturer. Take into account the All Channel Receiver Act of 1962, a.k.a., the UHF mandate, which required television sets to include UHF channels 14-69, even though there were few UHF broadcast stations and most consumers had little interest in what they had to offer. The CE industry is international and very price sensitive, but they are also very opportunity oriented. In this case, the CE industry is ahead of the curve, already delivering televisions and peripherals that would benefit from ATSC 3.0 which will enable features that they can monetize. For the CE world, ATSC 3.0 represents opportunity with minimal mandates or risks.

Stations

Within the television stations, ATSC 3.0 in its simplest form is just a change in the transmission system – the same linear video programming goes in to the new transmission system. There is no requirement that any broadcaster take any further advantage of ATSC 3.0, or at this point that they do anything at all with it. But let's say that a broadcaster does want to improve their bottom line. As mentioned above, the station's distribution network can be improved markedly with the addition of SFN boosters and DAS systems. More viewers on more devices is a profitable broadcast mantra. The transmission system represents a small piece of many station's operating and capital costs. Still, ATSC 3.0 will come with far less expense than the DTV transition of 2009, but it is easy to spend more on SFN boosters with ATSC 3.0 than the single transmitter many ATSC 1.0 stations employ.

This also requires a transition plan for all of the stakeholders. The most likely scenario is that stations cooperate to operate some legacy ATSC 1.0 lighthouse stations to avoid obsoleting the current OTA TVs in the field. Throughout the world, the amount of UHF spectrum for broadcast TV is being reduced in favor of more spectrum for wireless service providers. The VHF spectrum is not so hotly contested, so a likely scenario is for lighthouse stations to set up temporary ATSC 1.0 condos where upwards of six or so stations occupy a given ATSC 1.0 multiplex, even if only at standard definition levels. Clearly the FCC is predisposed to the idea as part of the spectrum repacking we spoke off earlier. It seems likely that regulations will allow this kind of transition without penalties in the must-carry environment, etc. In any case, a market can start with one or a few ATSC 3.0 stations, converting and building out additional facilities and boosters over time, without interrupting the current programming or business. Stations and markets will determine the specifics and potentially each one is different.

It needs to be said also that ATSC 3.0 offers larger payloads and has more efficient video coding. If that was all there was to it, ATSC 3.0 would seem the answer to the demand for more spectrum for the carrier's RANs. One could issue a bunch of converter boxes and dongles and restructure OTA TV broadcast to occupy half the channels it now does. Certainly any number of people contemplate the efficacy of this scenario. It's not ridiculous, but currently the FCC doesn't seem inclined to use this bullet, but to simply encourage ATSC 3.0 as an option that broadcasters can employ. Timing might be an issue. Repack, at least this round, isn't going to wait for ATSC 3.0 to be available.

Advertising and Revenue

The other part of ATSC 3.0's IP piece that it is difficult to grasp and internalize is that it can materially change the advertising business model. Internet advertising has slowly and not so obviously leveraged big data and an advanced advertising ecosystem, to connect sponsors with consumers that will buy their products, without wasting bandwidth (and thus money) advertising to people who will not. This is what makes Internet advertising so powerful, efficient and lucrative, even with its limited reach. current broadcast TV is by comparison low efficiency and less effective, but has incredibly better reach. What ATSC 3.0 does, is carry the same kind of messaging power that Internet advertising has into the TV experience. There is an incentive for viewers to participate that is similar to a loyalty card. As a consumer, you'd expect special

bargains and offers, not to mention special content, all in exchange for allowing your TV to know who is watching what when and accepting the specialized content. In time the ATSC 3.0 TV will morph into a more interactive device in conjunction with your handheld devices. If the technology grows as fast as smart phones with their array of applications and sensors, it is hard to predict where this goes. Gateways, TVs, devices, and the ecosystem will certainly become smarter and more able with time. Broadcasters are obviously interested in what ATSC 3.0 can do their bottom lines.

Carriers

One stakeholder that might not be so excited about ATSC 3.0 is the RAN carriers (the providers of wireless data services) and MVPDs.) ATSC 3.0 essentially bypasses their networks, or more appropriately, limits the dream of having all of TV carried on their revenue producing networks. MVPDs offer triple plays and quad-triple plays in an effort to earn all of your TV, data, phone, and wireless business, with some buying spectrum and others making agreements with carriers to provide all of your needs at home and away. Some set-top boxes even incorporate WiFi nodes to supply video to your at home wireless devices. For the same reason that smart phones rarely have their internal receivers and apps for FM receiver use activated and MediaFLO saw so few devices manufactured that were capable of receiving the MediaFLO programs; if receiving an OTA signal reduces a carrier's revenues, there is good reason to keep the devices on their network from receiving those broadcasts.

While carriers and MVPDs benefit from selling connectivity, there may be other profits in ATSC 3.0. In the same sense that computers didn't create a paperless world, but instead created demand to print even more – a more compelling TV offering with a high degree of interactivity might open more revenue opportunities for the carriers. The data traffic generated from advanced advertising and the convenience of cloud services in support of a more interactive TV experience will demand a lot of connectivity. A look at the ownership of media reveals that many, if not most, of the significant ownership firms have made investments in many of the pieces of media distribution that ATSC 3.0 addresses. Still, for a while, the carriers will almost certainly use OTA TV reception as a pawn in some ways. Some will use it as a value add to attract customers from carriers who prevent OTA reception. Some will bargain over the emergency alerting functions with the government. Others will look to make deals with broadcasters for valuable mutual exclusivities. While it is important for broadcasters to have OTA TV built into smart phones, it is not necessary that it happens fast or completely. Handheld portable OTA TVs will likely and quickly be comparably less expensive than an AM transistor radio was in the 1960s or a first-generation Walkman, Watchman, or iPod.

Ultra-High Definition TV

ATSC 3.0 supports high efficiency video codecs (HVEC) and Ultra-High Definition TV (UHDTV). Already, most high end content producers, cameras, video processing, and production manufacturers are making and using UHDTV equipment. Interestingly, while new technology is always expensive, much of UHDTV is state of the art and not

equipment waiting to be invented. Even now, from monitors to cameras, the cost of UHDTV equipment is coming down as the quantity of the gear ramps up. It seems likely that UHDTV is the new HDTV, with a public that is buying bigger-screen UHDTV, who will in turn favor programming in UHDTV from wherever they can get it. ATSC 3.0 allows broadcasters to compete in this arena as desired.

Broadcast Transmission Equipment

Broadcast equipment manufacturers will need to provide products also. ATSC 3.0 studio-transmitter-links (STLs), multiplexers, modulators and transmitters need to be built. They are more complex and expensive, but not by that much. ATSC 3.0 is based on flexible, all the way though transmission, physical layer pipes (PLP) rather than PIDs in ATSC 1.0's fixed 19.54Mb/s stream.

Currently, it looks like an ATSC 3.0 transmitter will need to handle a dB or two of peak-to-average power that ATSC 1.0 doesn't require. Hence, transmitters will be bigger for the same power. Prototype ATSC 3.0 exciters are in the field. GatesAir has demonstrated Futurevision in several test situations.

There are roughly half the transmitter manufacturers supplying domestically that there were six years ago for the DTV transition. Each of the standing companies is claiming to be ready for ATSC 3.0. This stakeholder offers no opposition to ATSC 3.0 and it appears all wish to supply the market.

There are complications however. SFNs demand much heavier monitoring and control systems, as well as a higher level of management. MediaFLO discovered that it was even advantageous to have remote receiver locations in the market to accurately track the performance of the distribution network. SFNs that fall out of timing, something as simple as loss of GPS of a few minutes or hours, can become interferers rather than boosters. The monitoring and control (M&C) system necessary for this kind of distribution is a lot more complex than that of a single transmitter on a mountain. It can also be done rather well if a system can reconfigure to deal with the loss of one of the boosters or even the main.

Summary

The ATSC 3.0 transition is very different from the DTV transition in that it bonds the Internet with broadcast in a way that changes where and how one can watch TV and how profitable it can be. By historical standards, the conversion to ATSC 3.0 is considerably less challenging than the digital transition was and the rewards are much greater. The support for ATSC 3.0 comes not from ATSC 3.0 being a better broadcasting standard, but because it has the potential to make broadcasting a better business.