ATSC 3.0 as a Use Case for Public Safety Communications – Development Milestones

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Abstract – Many fire and EMS services across the United States still rely on analog VHF paging technology to communicate emergency incident information to responders. The infrastructure for these paging systems is typically owned, operated, and maintained by the local government or agency to ensure coverage includes as close to 100% of the jurisdiction as possible. This paper proposes the use of datacasting technology to provide a redundant method for critical data distribution over a wide area to serve the paging needs of public safety and uses North Carolina as a test case. This concept could lead to cost-sharing, higher reliability, greater collaboration across jurisdictions, and reduced response times. The public deserve the best possible response from the public safety sector and therefore, public safety deserves the best technology available in order to achieve their mission.

PBS North Carolina, with the leading from the North Carolina Department of Information Technology First Responder Emerging Technologies Program (FirstTech), presented this concept at the 2019 NAB Broadcast Engineering and Information Technology Conference. Much progress has been made since then. Starting early 2020, a United States Department of Homeland Security Small Business Innovation Research contracted a prototype broadcast system has been developed including custom ATSC 3.0 paging receiver and miniature antenna, encoder, on a live broadcast in eastern North Carolina. This document will talk about the overall concept and current progress using ATSC 3.0 to address a critical emergency communications need.

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The State of Public Safety Paging

Currently, paging is still widely used in the Fire and EMS disciplines for dispatching emergency calls. This dispatch refers to the transmission of emergency information to the responders in the field from a Public Safety Answering Point (PSAP), which is the industry name for a 9-1-1 Center. The PSAP is the connection point between someone reporting an emergency need and the public safety agencies that will respond. This can be true for both volunteer and career agencies.

Today's voice pagers are tuned to a specific radio channel and messages filtered using a 'selective' call setting that will keep the speaker silent until a trigger (such as a specific set of tones) is heard on that channel. When a trigger is heard, the pager will then alert the user, either with a special beep and/or vibration, and unmute the speaker so that the dispatcher can be heard. There are a number of manufacturers of these voice pagers, each with a number of different features such as audio recording (stored voice), a display screen, customized audio alerts, etc.

The selective call feature allows responders to be alerted only for emergency incidents or for other information that is targeted for a specific group. The group being targeted can be a fire department, a particular station within a department, or even a specific fire truck or officer. The criteria used for determining how many groups is a mutual arrangement between the responding agency and the PSAP that dispatches that agency.

Fire and EMS services have to be assured that this information will be delivered to the responders in the field. It is not viable to rely on commercial paging or cellular services for this type of mission critical communication and industry best practices do not recognize such systems, as they are not controlled by the agency or a governmental partner and may rely on unsecured best-effort methods.

The Challenges with Pagers

The voice pager is based on outdated technology that is slow at delivering emergency information. This type of pager uses an analog radio channel, and the selective call feature relies on an audible set of tones. Each unique group's tone sent from the PSAP can be 2-3 seconds long (depending on setup). When multiple groups need to be paged, all of the tones have to be transmitted sequentially before any of the dispatch information can be delivered. Then, the actual voice dispatch can take 20-40 seconds depending on how much verbal information is provided. During all of this, other emergencies are queued waiting for the paging transmitter to become available.

Understanding Datacasting

In the late 1990's, television stations in the United States began broadcasting a digital transmission service. All analog broadcasts ended in 2009, making broadcast television digital only. This transition to digital television (DTV) uses the Advanced Television Systems Committee (ATSC) standard. DTV allows for more video (in the form of data) to be delivered using the same amount of spectrum as an analog transmission. This data stream can also be used to broadcast many other types of useful information besides video, such as TV program guides, emergency alerts, etc. Any portion of this data stream that is unused is a missed opportunity. Datacasting is a concept to transmit useful data utilizing the unused capacity of the DTV transmission signal. Datacasting is the ability to send data over digital broadcast television signals to specialized receivers. This data can include video streams, audio streams, pictures, documents, and other computer files. The nature of broadcasting is that it is a one-

to-many form of communication used to deliver a huge volume of data quickly to many receivers at the same time. It is not a two- way exchange of information.

Television stations use high power transmitters and antennas atop tall towers, buildings, and mountains. Their signals are in the VHF and UHF bands, and the coverage footprint and in-building coverage are unmatched by any other current technology.

An enhancement to the current ATSC digital broadcast system is here. ATSC 3.0, utilizes a different delivery scheme that is far more robust and useful for mobile applications. Often referred to as “NEXT GEN TV”, it also has the added benefit of better building penetration, especially when using UHF broadcast television channels. Areas that may not receive a robust signal from the full power transmitter may be candidates for lower power transmitters to “fill in”. ATSC 3.0 allows for the development of a Single Frequency Network (SFN) for synchronized, on-channel transmitters to accomplish the fill. The ability of ATSC 3.0 to be reliably received by a device that is moving (mobile) is an added capability.

Using Datacasting for Public Safety Paging

Datacasting may present a perfect solution for the current challenges found with existing analog voice paging. TV infrastructure already exists, and the transmitting equipment, towers, antennas, power, and spectrum is already in use supporting broadcast television. The footprint of this Public Safety Datacast Paging system would be far greater than current paging systems, which would increase interoperability, reliability, and dependability. Similarly, many PSAPs, which provide the information needed by public safety responders, already support the export of such information to their existing paging system. Having a centralized paging system available to several PSAPs will also increase the ease of providing backup dispatch services between jurisdictions.

Datacasting may provide an opportunity to advance public safety paging to a new level for more timely public safety service delivery. The ability to alert multiple responders will only take milliseconds using a datacast digital format, which is literally a thousand times faster than today’s analog paging format. Datacasting is a one- to-many broadcast, similar to today’s public safety analog paging. The number of receivers is unlimited, unlike a cellular service which can only support a limited number of devices in a given area. By delivering the emergency dispatch information in a digital format over datacasting, the technology can support over 2000 dispatches during the same time frame that it would take an analog system to perform a single dispatch. At that rate of delivery, it may not seem important to prioritize the messages or dispatches, but a Public Safety Datacast Paging service could also support such prioritization.

Datacasting Paging Progress in North Carolina

As a result of evangelization efforts by PBS North Carolina and the North Carolina Department of IT FirstTech Program, the United States Department of Homeland Security authorized a Small Business Innovation Research (SBIR) grant opportunity in 2020. The grant was developed with three phases. The first phase was to identify small businesses who could prove their ability to address the issue. The second phase was to expand that work to develop prototypes to prove the concept. And the third phase is to bring the product to market.

Device Solutions Incorporated, Morrisville, North Carolina engineering firm qualifying as a small business, along with the Wireless Research Center (WRC) of North Carolina, won the Phase 1 SBIR award to describe how they would address this challenge. Device Solutions and the Wireless Research

Center advanced on to phase 2 to build a prototypes device and have partnered with PBS-NC and Triveni Digital to demonstrate a working broadcast solution system.

Phase 1 Goals included:

- Provide responders and incident commanders with improved pager coverage and capacity, quicker dispatching, and messaging content for increased situational awareness
- Develop a Proof-of-Concept digital paging system and receiver for emergency responders using public television (Figure 1 below)

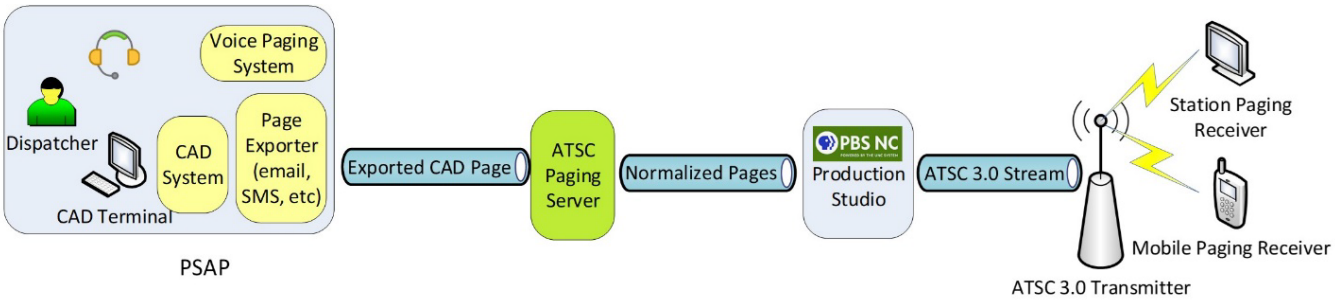

Figure 1- Proof of Concept

Phase 2 Goals included:

- Develop a prototype ATSC 3.0 paging receiver which displays the CAD information normalized and sent from the ATSC paging server to the ATSC 3.0 transmitter or forwards it to other Bluetooth capable devices
- Optimize ATSC 3.0 delivery chain for delivery of emergency pages
- Deliver results from performance modeling and testing of ATSC 3.0 receptibility in a controlled environment for anticipated paging receiver design (for example, body worn small device on a belt)
- Prototype two different paging receiver designs, one based on a stand-alone model and the other based on a smartphone integration with the ATSC 3.0 information passed along to a smartphone application
- Provide a practical demonstration of the capability with at least 10 receivers located with different first responder organizations from different jurisdictions within a state. The organizations should represent different types of jurisdictions from urban to rural, career to volunteer, mountainous to coastal

To fully appreciate the benefits and requirements it is helpful to review how emergency calls are handled in many jurisdictions. When someone dials 9-1-1, it is automatically routed to the nearest PSAP or 9-1-1 call center. Once sufficient information is received from the caller, the operator alerts the first responders via a VHF transmitter and belt worn audio pagers. (Figure 2 below) The received audio quality is often limited by the low quality of the device speaker, poor use of the microphone by the dispatcher, dispatcher speech accents, local noise at the receiver etc. If the first responder does not clearly hear and remember all the relevant details, the pager may have limited ability to replay the message and the responder may have to use a cell phone or two-way radio to request details from the PSAP. Furthermore, in many jurisdictions, updates are not always transmitted over the paging channel – resulting in delayed responses and responders arriving at the incorrect address.

Most PSAPs utilize a Computer Aided Dispatch software to input all of the details of an emergency and track the status of responding units, among other features. This software is simply referred to as CAD and each PSAP may have their own vendor and instance of CAD in use for their operation. In many cases, the CAD data is also exported and sent, often via email and SMS, directly to users or to third party application servers for delivery to the first responder. Third party application servers work to normalize the data from multiple PSAP/CAD feeds and deliver it in consistent formats, sometimes decreasing the usability of the message. Adding to the complexity of handling these exported CAD messages – each dispatch center formats their exported data uniquely – and therefore for a statewide deployment we propose a normalization function to be integrated into the ATSC paging server to ensure consistent broadcast format and content and potentially augment with additional GIS content. These issues are particularly problematic in rural, volunteer-oriented departments which cannot afford to equip the majority of their responders with modern, digital radios, which can cost $3,000 or more.

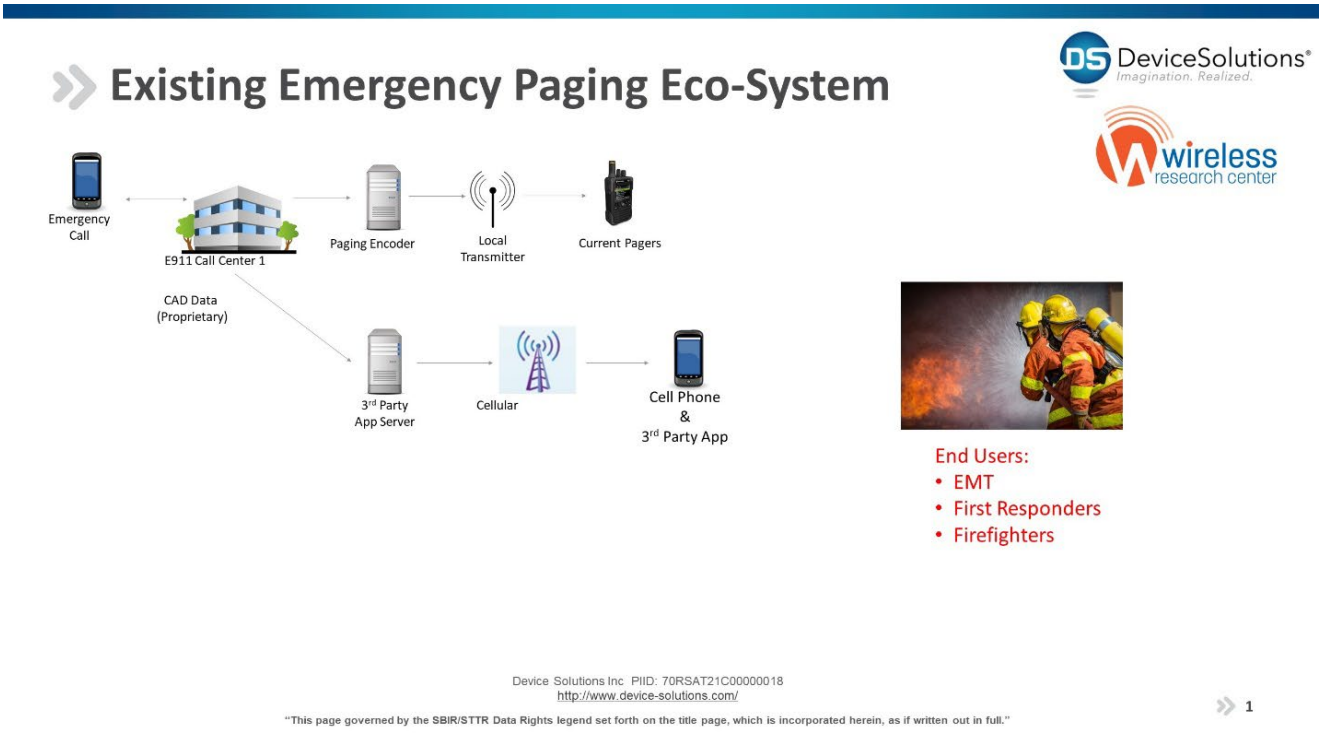

Figure 2 - Existing Emergency Paging Eco-System

In the prototype system a custom page normalization function has been developed as part of the ATSC Paging Server which transfers standardized messages to the ATSC 3.0 broadcast system with a few simple APIs, implemented by Triveni Digital (a business partner), over secure IP connections. (Figure 3 below)

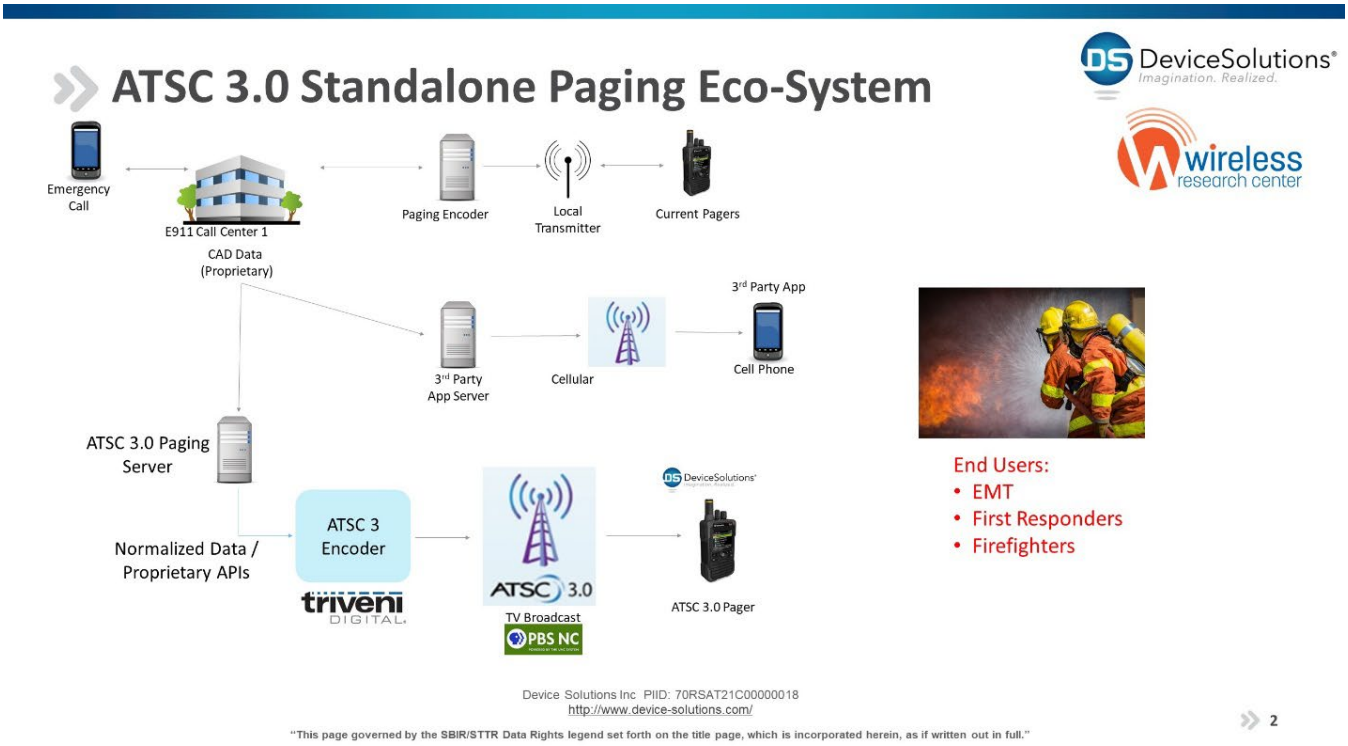

Figure 3 - ATSC 3.0 Standalone Paging Eco-System

Additionally, as shown below, the paging receiver can be further minimized by connecting to a standard cell phone over Bluetooth to provide all the user interface functionality and providing a redundant data path to existing phone applications. (Figure 4 below).

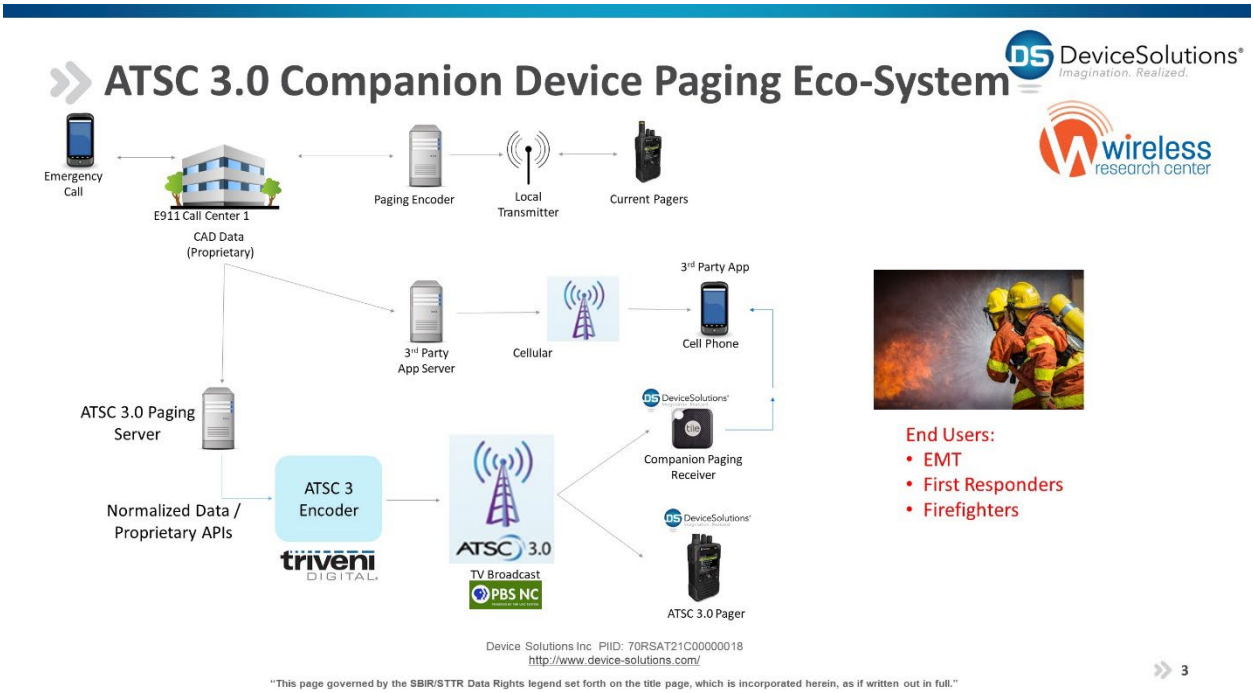

Figure 4 -ATSC 3.0 Companion Device Paging Eco-System

This next section will look at more of the technical details of the ATSC 3.0 broadcast.

The ATSC 3.0 standard is based on IP protocols meaning that all the connections from the video encoders to the transmitter are all IP based. The only coax cable in our lab is used in conjunction with the inputs to the video encoders and the RF output of the exciter modulator.

(Figure 5) - Going left to right across the diagram, the signal flow starts with video sources feeding an HEVC video encoder system that generates IP video streams. This output, using the DASH protocol, feeds a signaling server.

The signaling server is an IP signal aggregator. It can receive a variety of data feeds from various sources such as the output from the video encoders, the programming guide information, and other data feeds such as those from emergency services, Emergency Alert System (EAS), and other sources. This is where the paging data is input into the transmission path. The signaling server assembles the various IP streams and uses the Route protocol to send that data to the Gateway.

The Gateway then packages the data and creates an IP output using the STL TP protocol that is then used to send the data to the exciter modulator. The STL TP protocol allows several things to happen including the ability to introduce forward error correction to minimize data loss during transport to the transmission site. It also imbeds the mod cod information so the transmitter's exciter can create the RF signal with the desired Physical Layer Pipe (PLP). Security signing is also part of the STL TP protocol. This prevents man in the middle attacks from being successful against the station. In other words, your transmitter will only broadcast what you send it and not something from someone else.

In our lab, the exciter modulator is a transmitter exciter that was donated by GatesAir. The output of that exciter feeds a multi-port RF splitter that feeds a wide variety of receivers as well as other RF test devices.

PBS NC NextGen TV Research Lab

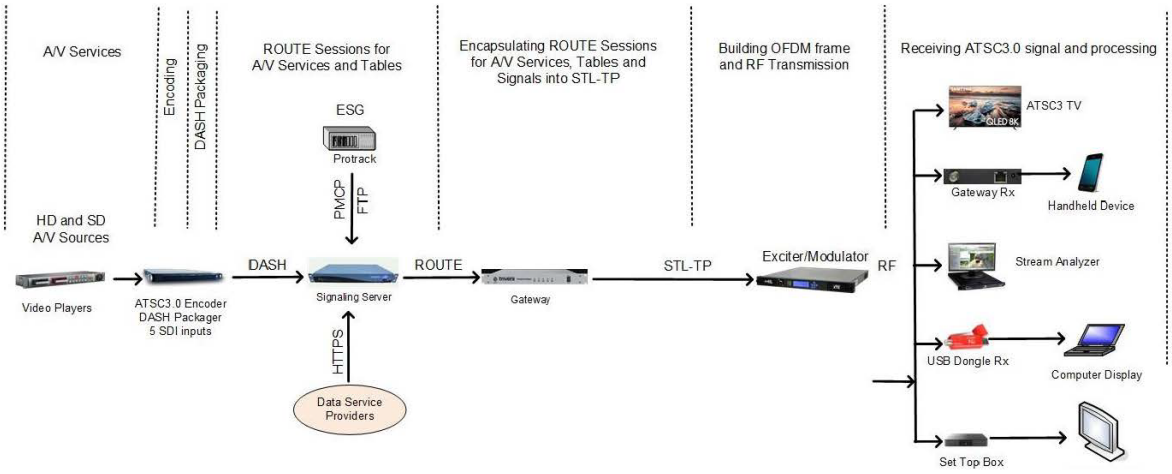

Figure 5 - PBS NC ATSC 3.0/NEXT GEN TV Research Lab

PBS North Carolina operates 12 full power, UHF stations (see Figure 6 below). All facilities are ATSC 3.0 capable. All of the transmit antennas are also elliptically polarized. We currently have two stations that are operating with an ATSC 3.0 broadcast signal.

The first station is WUNC-TV Chapel Hill. It began operation as a guest station on Capitol Broadcasting's host station WNGT-CD. This signal is also shared by Capitol's other 2 Raleigh stations WRAL-TV, an NBC affiliate, and Fox 50, WRAZ. The signal is on channel 23 with a power of 15 kW ERP using a circularly polarized directional antenna at a height of 1040 feet and it serves the Raleigh Durham area.

The other station is our over the air research lab station, WUNK-TV Greenville North Carolina. There are no guest stations currently sharing the WUNK signal. The station operates on channel 25 with 1000 kilowatts ERP using an elliptically polarized nondirectional antenna. That antenna provides a 500 kilowatt vertically polarized signal as well as the 1000 kilowatt horizontally polarized signal. The antenna height is 1142 feet, and the station serves the Greenville-Washington-New Bern area of eastern North Carolina.

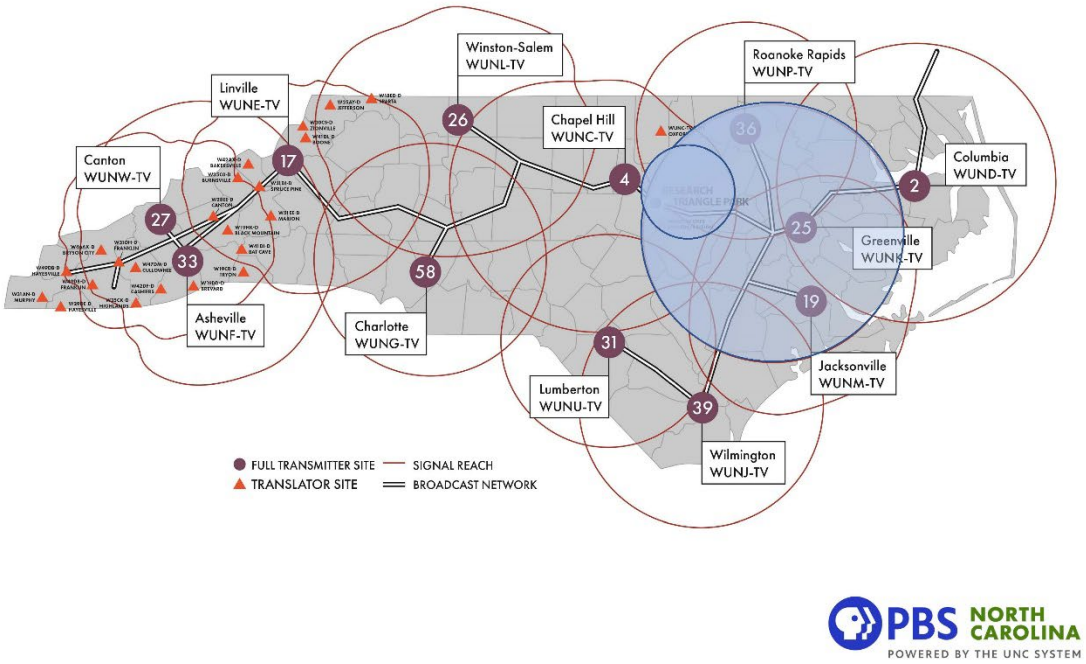

Figure 6 - WUNK-TV Coverage Map

In cooperation with our partners (WRC, Triveni Digital), Device Solutions and PBS-NC are in the initial phases of field testing with the WUNK transmitter and live dispatches from multiple counties, using second generation prototype paging receivers, shown below. We are continuing to optimize the RF performance and battery life of these devices and survey signal propagation with a dedicated, highly robust PLP. These pagers will be deployed with multiple departments for end user testing later this year (2022).

Figure 7 - Device Solutions Prototype Paging Receiver

Summary

Tone and voice paging has been used by public safety for decades. This technology delivers emergency notification information at a slow pace compared to today's digital world. The advent of datacasting presents a unique opportunity to serve emergency notifications to first responders in a more efficient manner, over a greater distance, and with better coverage than ever before. The timing is perfect for further development of this concept. The following highlights the key ideas presented in this paper:

- Digital delivery of information will greatly increase the speed of reception, thus decreasing response times.
- Datacasting capacity allows for dozens of separate dispatches within seconds.
- A centralized paging system serving a large region will decrease mutual aid requests.
- A larger coverage footprint will allow departments to notify members outside their jurisdiction.
- Transmitting infrastructure is already in place.
- Receivers could also support live audio streaming, video, data files, maps, and sensor data.

Open and Public Knowledge of Datacast Paging

The contributors of this paper acknowledge that this concept is part of the public domain. The concept and further development of such products supporting this concept should be openly available for all to use without formal, informal, implied, or explicit restriction or permission. The desire is to prevent a proprietary implementation which could cause interoperability issues, increase costs, and decrease quality incentives. Regardless of what is developed or where the industry takes this concept, it is time to upgrade the paging and call notification technology for public safety personnel. This should be done as an open standard-based approach that enables the technology to support different manufacturers, eliminating dependency on any single manufacturer.

References

(1) Sadwoski, Allan; Grasso, Red; Engel, Fred; Woodlief, Adam; Public Safety Datacast Paging, 2017.02.13