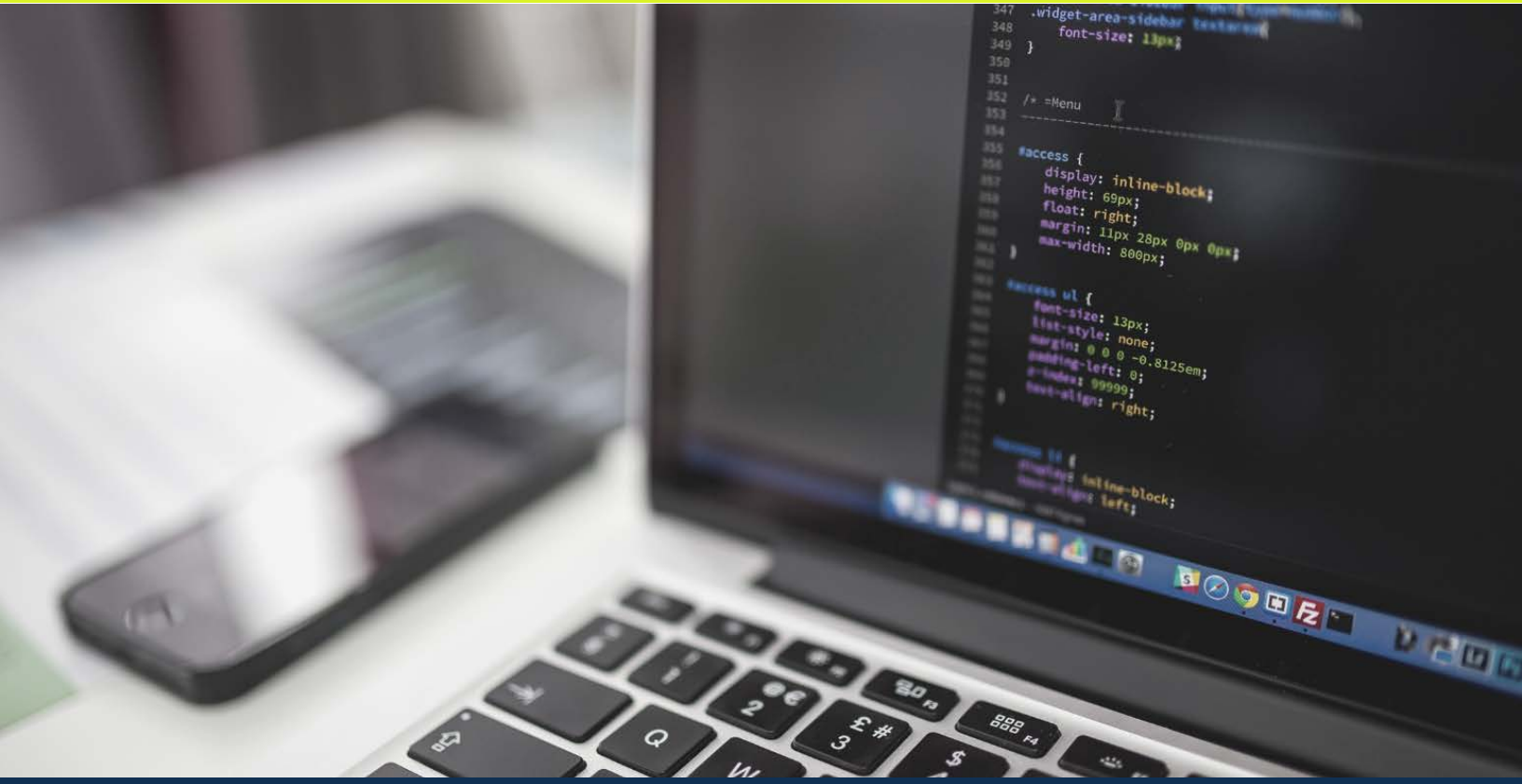

LIFE-SAVING INNOVATION: ATSC 3.0 IN PUBLIC SAFETY COMMUNICATIONS

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EXECUTIVE SUMMARY

Many emergency services across the United States, including fire, medical, and law enforcement, rely on analog VHF paging technology to communicate emergency incident information to responders in the field. However, the current paging system involving voice pagers and analog radio channel relies on outdated technology that is slow at delivering emergency information and can hinder response by public safety agencies.

FirstTech, a program within the North Carolina Department of Information Technology that helps public safety agencies utilize advanced technology, is leading government, nonprofit, and industry partners to research the delivery of emergency dispatch paging information over digital television signals. This method called datacasting can meet the challenges of analog voice paging and provide a redundant method to distribute critical public safety paging data over a wide area. Datacasting public safety paging can speed emergency response by delivering more than 2,000 dispatches in the same time that an analog system can perform a single dispatch.

FirstTech and its partners have developed a prototype broadcast system with a custom paging receiver and miniature antenna encoder that uses the new digital broadcasting standard, Advanced Television Systems Committee (ATSC) 3.0. The emergency paging system over ATSC 3.0 utilizes a different delivery scheme that is far more robust and useful for mobile applications, can carry significantly more data, and can be reliably received by mobile devices, even when moving.

A paper describing this development milestone in the use of ATSC 3.0 in public safety communications received the co-best paper award at the 2022 National Association of Broadcasters Broadcast Engineering and Information Technology Conference. The prototype has since entered field testing of emergency paging dispatches over a public broadcaster's ATSC 3.0 signal in North Carolina. Leveraging the significant advantages of the digital broadcast spectrum over the current VHF paging system, this datacasting prototype for emergency services paging has the potential to establish a national model that can lead to cost-sharing, higher reliability, greater cross-jurisdiction collaboration, and reduced response times.

IDEA

First Responder Emerging Technologies (FirstTech), a program housed within the North Carolina Department of Information Technology (NCDIT), aims to assist all public safety agencies throughout North Carolina to seamlessly and securely communicate using advanced technology. In collaboration with government, industry, and nonprofit partners, FirstTech explores emerging technological solutions and promotes their adoption across public safety disciplines, from law enforcement and emergency dispatch to fire and emergency medical services.

FirstTech and its partners, PBS North Carolina, the Wireless Research Center (WRC) of North Carolina, Device Solutions, and Triveni Digital, are researching digital broadcasting applications as a solution to meet the challenges of analog voice paging for public safety response. Many fire and EMS services across the United States still rely on analog VHF paging technology for public safety answering points (PSAP) to communicate emergency incident information from 911 callers to responders in the field. Local governments or agencies typically own, operate, and maintain these paging systems'

infrastructure. It is not viable to rely on commercial paging or cellular services for this mission-critical communication, and industry best practices do not recognize such systems because they are not controlled by the agency or a governmental partner and may rely on unsecured, best-effort methods.

> *"It's not often you can read a paper where the technology described could actually save lives. This is one of those times."*
>
> 2022 NAB BEIT Conference Co-Best Paper Award Citation

However, the current paging system involving voice pagers and analog radio channel presents significant drawbacks. The voice pager is based on outdated technology that is slow at delivering emergency information. When multiple groups of responders need to be paged, each group's audible tone, up to 2 to 3 seconds long, must be transmitted sequentially before any of the verbal dispatch information, which can also take 20 to 40 seconds. Throughout all of this, other emergencies are queued, waiting for the paging transmitter to become available. Other disadvantages of this system include low-quality audio, a restricted ability to replay messages, a lack of updates sent over the paging channel, and the complexity of sending data via computer-aided dispatch software and third-party servers. These issues are particularly problematic in rural, volunteer-oriented departments, which cannot afford to equip the majority of their responders with modern, digital radios costing $3,000 or more.

FirstTech, along with its partners, is developing and testing the delivery of emergency dispatch information over the new digital broadcasting standard, Advanced Television Systems Committee (ATSC) 3.0, often called Next Gen TV, which has features and capabilities far beyond the current digital television system. ATSC 3.0 utilizes a different delivery scheme that is far more robust and can be reliably received by mobile devices, even when moving. Digital television can deliver more data using the same amount of spectrum as an analog transmission. The delivery of emergency paging services over these digital TV signals – called datacasting – can provide a redundant method for critical data distribution over a wide area to serve the paging needs of public safety.

The infrastructure for datacasting – transmitting equipment, towers, antennas, power, and spectrum – is already in use by broadcast television and offers a coverage footprint and in-building footprint unmatched any other current technology. Many PSAPs can export the data to their existing paging system. A centralized paging system available to multiple PSAPs will have a far greater footprint, increasing interoperability, reliability, and dependability, and supporting PSAPs' ability to provide backup dispatch services between jurisdictions.

Datacasting paging can enable more timely public safety service delivery. Whereas cellular service supports only a limited number of devices in a given area, datacasting serves an unlimited number of receivers and can alert multiple responders in only milliseconds, literally a thousand times faster than analog paging. Datacasting paging can deliver more than 2,000 dispatches in the same time that an analog system can perform a single dispatch.

FirstTech approached PBS North Carolina, which has North Carolina's largest wireless network covering nearly the entire state, to explore applications using the public broadcaster's ATSC 3.0 signal for an emergency dispatch paging service. FirstTech and its partners have developed a prototype system with a custom ATSC 3.0 paging receiver and miniature antenna encoder for use on the public broadcaster's NextGen TV signals. Initial field testing with live dispatches transmitted by PBS North Carolina's ATSC 3.0 channels has begun to determine the optimum performance configurations and will continue throughout 2022.

Leveraging the significant advantages of the digital broadcast spectrum over the VHF paging system,

this datacasting prototype for emergency services paging has won national recognition as a model for public safety, which can lead to cost-sharing, higher reliability, greater cross-jurisdiction collaboration, and reduced response times. A paper, "ATSC 3.0 as a Use Case for Public Safety Communications - Development Milestones," coauthored by FirstTech, PBS North Carolina, Device Solutions, and WRC, received the 2022 Broadcast Engineering and Information Technology (BEIT) Conference Proceedings Co-Best Paper Award at the 2022 National Association of Broadcasters (NAB) BEIT Conference.

IMPLEMENTATION

FirstTech joined with PBS North Carolina and the WRC in 2019 to develop and operate a public safety research center, initially evaluating and analyzing the potential of innovative applications for Next Gen TV to improve public safety response. FirstTech focused on public safety initiatives and government interactions, WRC on research design, execution and data science, and PBS North Carolina on strategy, operations, technical talent and training.

The partners presented a white paper on the concept of an emergency services paging system using ATSC 3.0 and a public broadcaster at the 2019 NAB BEIT Conference. In 2020, the U.S. Department of Homeland Security FirstTech awarded a Small Business Innovation Research (SBIR) grant for the development of a new emergency digital paging system over public television. The grant has enabled work to identify small businesses that could prove their ability to address the issue and develop prototypes to prove the concept. Future work will aim to bring the product to market.

WRC and Device Solutions, a Morrisville-based engineering firm, won the award to plan for work on the project, including:

- 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 responders using public television

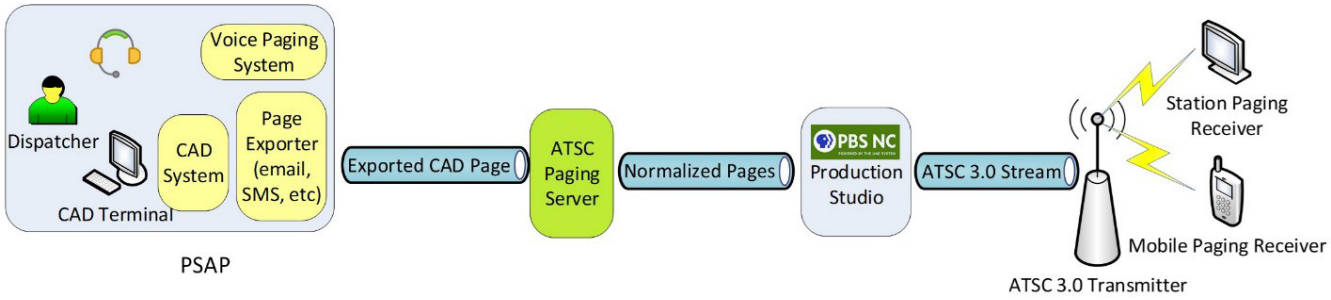

Figure 1. Proof of Concept

Device Solutions and WRC built a prototypes device and partnered with PBS North Carolina and Triveni Digital to demonstrate a working broadcast solution system. This work involved:

- 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 the ATSC 3.0 delivery chain for the delivery of emergency pages
- Deliver the results from performance modeling and testing of ATSC 3.0 receptibility in a controlled environment for anticipated paging receiver design (e.g., a small, body-worn device on a belt)

- Prototype two paging receiver designs: a stand-alone model and 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 used by first responder organizations in different jurisdiction types, from urban to rural, career to volunteer, mountain to coast

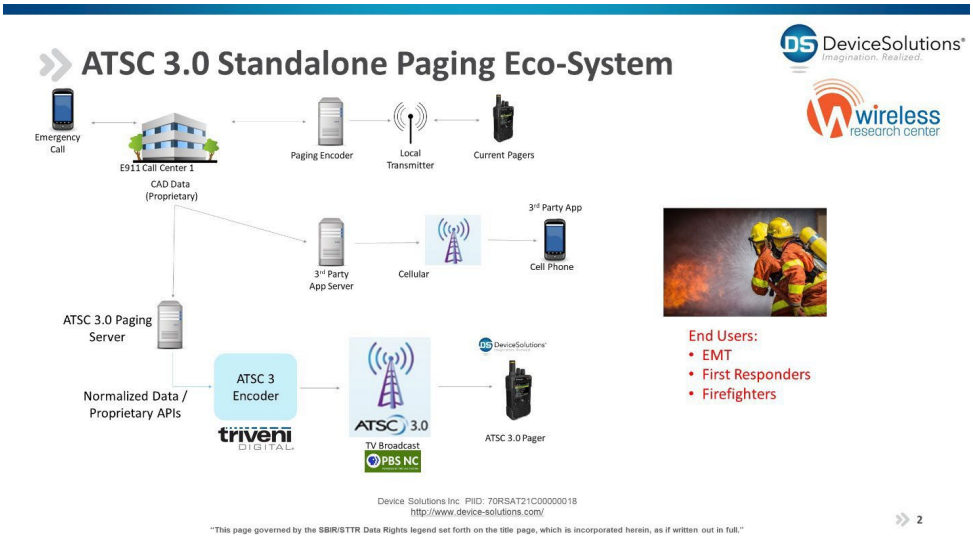

Figure 2. ATSC 3.0 Standalone Paging Eco-System

Field testing is underway to bring the product to market and is expected to continue throughout 2022.

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

The paging receiver can be further minimized by connecting to a standard cell phone over Bluetooth to provide all the user interface functionality and a redundant data path to existing phone applications.

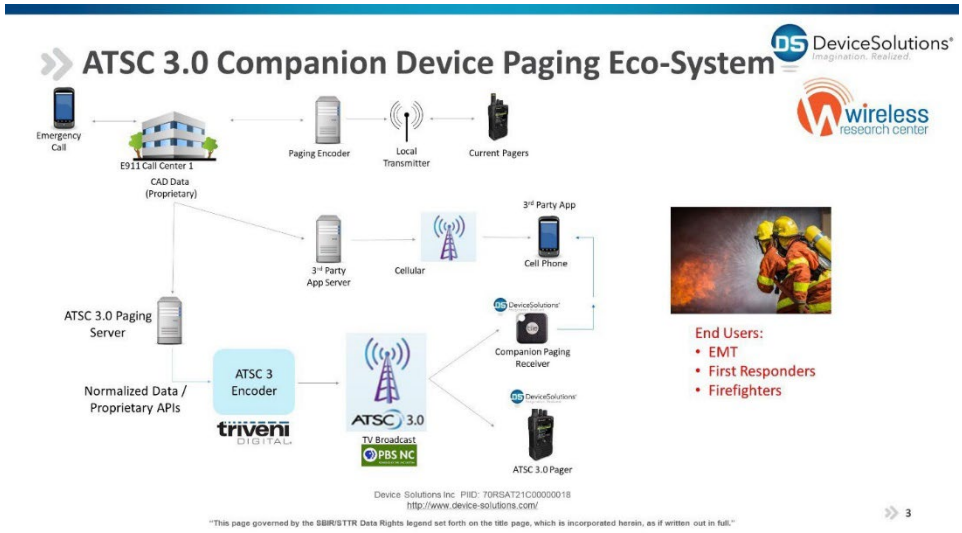

Figure 3. ATSC 3.0 Companion Device Paging Eco-System

The prototype has entered initial field testing with partners FirstTech, PBS North Carolina, WRC, Device Solutions, and Triveni Digital. Live emergency dispatches are being broadcast on an ATSC 3.0 signals from PBS North Carolina's stations.

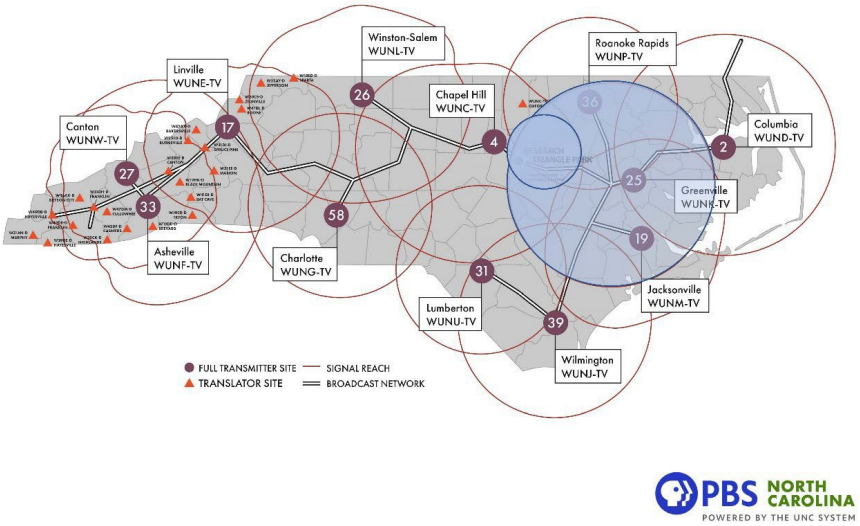

Figure 4. PBS North Carolina Coverage Map

The live emergency dispatches on the public broadcaster's ATSC 3.0 signal are being received by second-generation prototype paging receivers. The field testing includes optimizing the performance and battery life of these devices and their survey signal propagation with a dedicated, highly robust PLP. These pagers will be deployed with multiple departments for end user testing later in 2022.

IMPACT

Public safety has used tone and voice paging for decades, but this technology delivers emergency dispatches at a slow pace compared to today's digital world. Datacasting presents a unique opportunity to send emergency notifications to first responders in a more efficient manner, over a greater distance, and with better coverage than ever before. It is not viable to rely on commercial paging or cellular services for this 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.

FirstTech has led its partners in developing an emergency digital paging system prototype that uses a custom ATSC 3.0 paging receiver and miniature antenna encoder to broadcast live dispatches on a public broadcaster's NextGen signal in eastern North Carolina. This system overcomes many technological disadvantages of the analog VHF paging technology that emergency services across the United States often still rely on to communicate emergency incident information to responders. These disadvantages include slower delivery of emergency information and low-quality audio, which can

create queues of emergency notifications awaiting transmission and delay adequate response by public safety agencies.

The emergency paging system over NextGen TV utilizes a different delivery scheme that is far more robust and useful for mobile applications, can carry significantly more data, and can be reliably received by mobile devices, even when moving. The digital emergency paging system enables more timely delivery of public safety notifications to first responders. The datacasting formatting serves an unlimited number of receiving devices and can alert multiple responders in only milliseconds – literally a thousand times faster than analog paging. Digital datacasting can deliver more than 2,000 dispatches in the same time that an analog system can perform a single dispatch.

This prototype, now under live field testing, can deliver the following benefits that improve first responders' ability to ensure public safety in both North Carolina and throughout the United States:

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

The prototype has gained recognition as a national model for the use of ATSC 3.0 broadcast signals in public safety communications, as demonstrated by the 2022 BEIT Conference Proceedings Co-Best Paper Award received at the 2022 NAB BEIT Conference. Leveraging the significant advantages of the digital broadcast spectrum over the current VHF paging system, FirstTech has demonstrated that an emergency digital paging system in partnership with a public broadcaster can provide a redundant method to serve public safety paging needs over a wide area. The prototype leverages infrastructure for datacasting that is already in use by broadcast television, can be used by many PSAPs to export data to their existing paging systems, and offers a coverage footprint and in-building footprint unmatched any other current technology.

This technology trial shows how ATSC 3.0 can replace paging systems for public safety communications more robustly and with faster delivery times than other methods. This use case can be easily replicated for many wide-area, secure, emergency notification applications, which can sit on a local, trusted public broadcaster's ATSC 3.0 transmission signal. Use of this prototype datacasting system for emergency dispatch paging service can lead to cost-sharing, higher reliability, reduced response times, and greater collaboration across jurisdictions.