ATSC 3.0 as a Use Case for Public Safety Communications

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Abstract. *Fire and EMS services across the United States still rely on paging technology to communicate emergency incident information. 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 serve the paging needs of public safety and uses North Carolina as a test case. This concept could lead to cost-sharing, greater collaboration across jurisdictions, and reduced response times for mutual aid requests. 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.*

Keywords. *Public Safety, Paging, Datacasting, Public Safety Answering Point (PSAP), ATSC 3.0, Digital Television. NextGen TV*

Introduction – The State of Public Safety Paging

Currently, paging is still widely used in the Fire and EMS disciplines for emergency call alerting. This can be true for both volunteer and staffed/career agencies. In these instances, paging is generally only a one-way page sent from fixed infrastructure to a device worn by a member of that agency. Call alerting can occur for agency members while they are at a station, at home, or even as they go about their daily jobs. A Public Safety Answering Point (PSAP), or 911 Center, sends the page to a voice pager with information about the location and type of emergency. This type of pager allows the responder to hear the dispatch. These devices are also known as a Tone & Voice Pager, Fire Pager, Voice Pager, and/or by the common vendor models such as the Motorola Minitor Pager, Unication G4/G5 Voice Pager, SwissPhone Voice Pager, or Apollo Voice Pager, just to name a few.

This voice pager has a speaker listening to a specific radio channel with 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 911 Center 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 911 Center that dispatches that agency. The criteria will often take into consideration such factors as the number of agencies served by the 911 Center, the operational nature of those agencies (career, volunteer, staffed stations, etc.), and the call volume of both the agency and 911 Center.

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 service for this type of mission critical communication and industry best practices do not recognize such systems[1], as they are not controlled by the agency or a governmental partner. In other words, commercial cellular or commercial paging services are not approved by organizations such as the National Fire Protection Agency (NFPA) and Insurance Services Office (ISO), who provide guidance on such communication systems. For this reason, each agency is likely to purchase (or lease) paging infrastructure and equipment to serve their response district, and multiple transmitters would be needed to serve a large area or a regional system. This is typically done in coordination with the 911 Center as the information originates there and is then sent out to responders.

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 911 Center 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 and waiting for the paging transmitter to become available.

For example, consider the fictitious city of Eloise. The Eloise Fire Department has 15 fire stations and 10 EMS stations. For a large building fire, there are 7 fire stations and 3 EMS stations that will be dispatched in order to get all of the appropriate equipment on scene. Even at only 2 seconds per station tone, this will take 20 seconds of tones being transmitted before the dispatcher can speak and provide information about the emergency. It will also take the dispatcher 25 seconds to say “Engine 1, Engine 2, Ladder 5, (etc.) respond to a building fire located at 123 Main Street on map grid 34 Bravo, respond on Tac channel 15, time is 14:22hours” which means that this particular dispatch will take a total of 45 seconds of transmission time. Any additional emergencies will have to wait until this dispatch is completed.

A paging system is generally designed to cover only an area for the specific jurisdictions that it will serve. A county 911 Center will commonly have a paging system that provides a coverage footprint for that county, and coverage beyond the county lines is typically not by design. This can leave a gap in the ability to dispatch a fire engine that is called to help staff a fire station in a neighboring county, or to contact responders that might be conducting business just outside the county.

Access to paging systems is generally only available to the 911 Center responsible for dispatching specific agencies. Every 911 Center has a jurisdictional boundary within which it receives emergency calls and dispatches responders. Although, emergencies do not adhere to these political boundaries and the closest responders may come from agencies that are dispatched by two or more 911 Centers. There are many fire departments that rely on automatic mutual aid from a neighboring department that is dispatched by a different 911 Center. When dispatching a unit or alerting responders of an agency from a different 911 Center, there are policy implications to consider. However, such a capability can enhance mutual aid responses and assist in backup and contingency planning for 911 Centers.

Let’s look at a fictitious example in which mutual aid is challenging due to jurisdictional boundaries. The Eloise Fire Department (EFD) is dispatched by the Eloise 911 Center while the Angelo Fire Department (AFD) is dispatched by the Angelo 911 Center. EFD and AFD jurisdictions are adjacent, and there are many incidents which require them to respond together. Currently, when Eloise 911 Center receives a call for an incident that requires EFD and AFD they are able to dispatch EFD directly, and then they make a call to Angelo 911 Center to have AFD dispatched. This relay of information can increase the likelihood of fragmented information reaching AFD and can also add minutes to the actual dispatch (and subsequently the response). Looking at a map, there are areas in the EFD district where the AFD fire station is actually closer. There are times when a cellular 911 call actually gets routed to the Angelo 911 Center for emergencies in Eloise. This common 911 call routing error also adds a delay in dispatching the correct units.

Though the Next Generation 911 (NG911) project will make the transferring of 911 calls and data much easier in the future, there are other challenges to meeting the general public's expectation that the closest help in an emergency will be dispatched in a timely manner. Collectively, the above examples show the very real situation existing within public safety in which agencies have "silos" of communications for dispatching and communicating with responders. These silos are closed systems, in which each agency has their own separate communication paths. Such silos are very prevalent throughout the country and impact the time it takes for responders to react to a public safety need.

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[2]. 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[3]. 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 on the horizon. The new standard, ATSC 3.0, will utilize a different delivery scheme that is far more robust and useful for mobile applications. It also has the added benefit of better building penetration, especially when using UHF 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 important requirement of this proposed concept.

The current ATSC 1.0 techology is limited to a 19.3 Mbit/sec payload and is a non IP based system utilizing MPEG2 video encoding technology. ATSC 3.0 is fully IP and utilizes High Efficiency Video Encoding (HEVC) to greatly reduce bandwidth needed for video and audio. ATSC 3.0 also provides a number of modulation/encoding combinations that could provide a higher data rate. With the improved encoding and higher capacity additional data space can be made available for datacasting.

Another feature of ATSC 3.0 is the ability to create “physical layer pipes”, essentially custom channels of data with modulation schemes developed for various robustness of delivery.

The following illustrations give a visual representation of the ATSC 3.0 transmission delivery:

Figure 1: Current ATSC 1.0 Technology Pipe

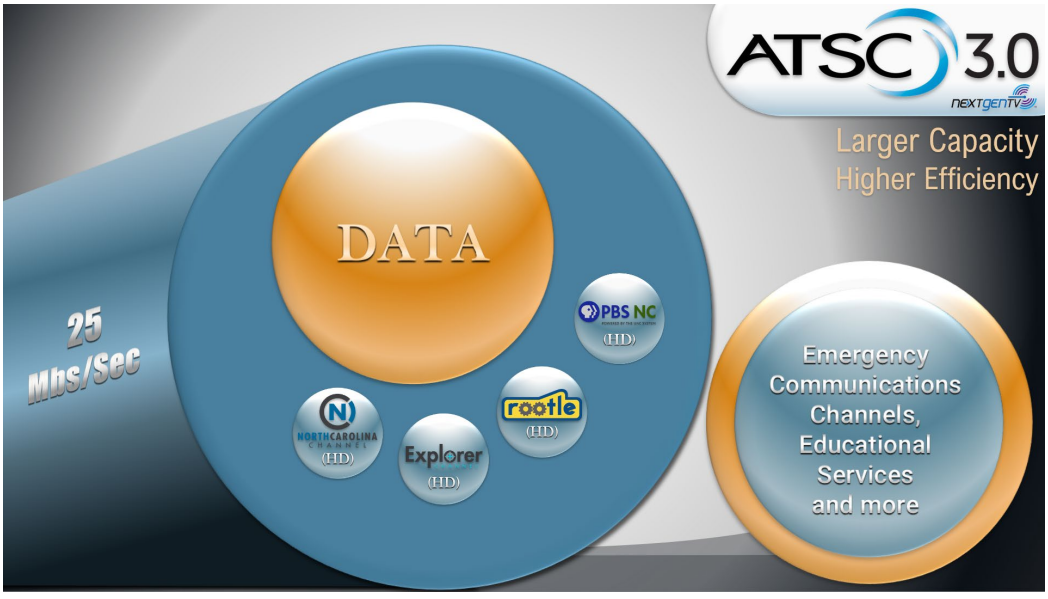

Figure 2: ATSC 3.0 – Increased capacity

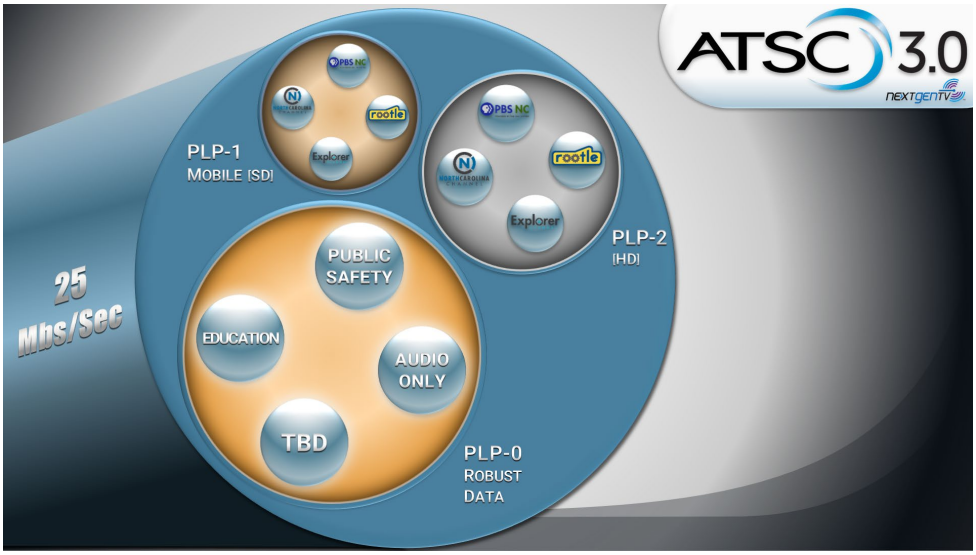

Figure 3: ATSC – Multiple Physical Layer Pipes

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 911 Centers, which provide the information needed by public safety responders, already support the export of such information to their existing paging system. Using datacasting for public safety paging is particularly timely as the association of America's Public Television Stations (APTS) announced that APTS members are setting aside 1 Mbps of their signal specifically for public safety use[4]. Having a centralized paging system available to several 911 Centers 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.

DATACAST PAGING IN NORTH CAROLINA

A favorable window of opportunity has recently opened that could make datacasting paging available for responders in North Carolina. The North Carolina 911 Board (NC 911 Board) is currently working to move the NG911 project forward in a statewide approach[5]. One aspect of NG911 effort in North Carolina is the work to better support PSAP outages. In particular, there is a need for backup 911 Centers to dispatch responders that they do not normally dispatch.

NC 911 Board is developing a statewide Emergency Services Information Network (ESInet) to provide a platform for all 911 Centers in the state to be connected via an IP network. This ESInet will allow for easier call transfers between 911 Centers, as well as support a higher degree of information sharing. The important aspect of Public Safety Datacast Paging in North Carolina is the desire to have a method for 911 Centers to not only receive 911 calls rerouted from another center, but to also have the ability to dispatch the emergency responders in the appropriate jurisdiction. Without the ability for another 911 Center to also dispatch units to an emergency incident, sending 911 calls to another 911 center is not as useful.

Similarly, it's timely and opportune that the Public Television Network in North Carolina, PBS NC, is well- established and is already capable of supporting datacasting. PBS NC has a network of transmitters and translators that provide almost 100% geographic coverage throughout the state of North Carolina. This includes extensive coverage in the mountainous areas, lakes, sounds, and several miles out into the Atlantic Ocean. The footprint of this coverage also includes hundreds of square miles in neighboring states. Public Television also has an enviable record for system reliability, as well as a long history of supporting public safety voice radio communications using PBS NC towers and microwave communications network. PBS NC is also perfectly situated to provide such a paging service to public safety, as it is not a commercial entity.

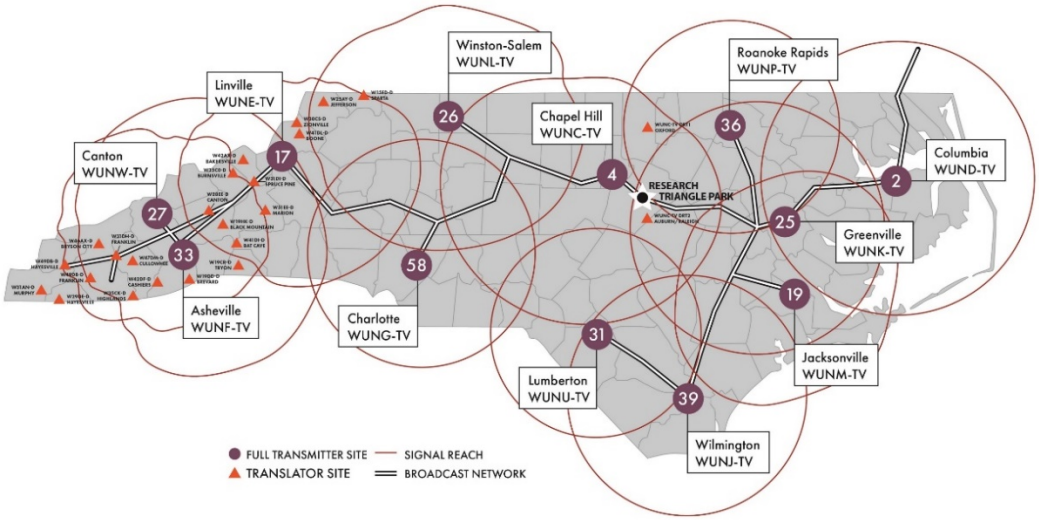

Figure 4. PBS North Carolina Network

Datacasting coverage can be provided to the entire state using this network of transmitters. If a datacast needs to be kept more local, the separate transmitters and translators can also be partitioned in the network to provide coverage in a smaller segment of the state.

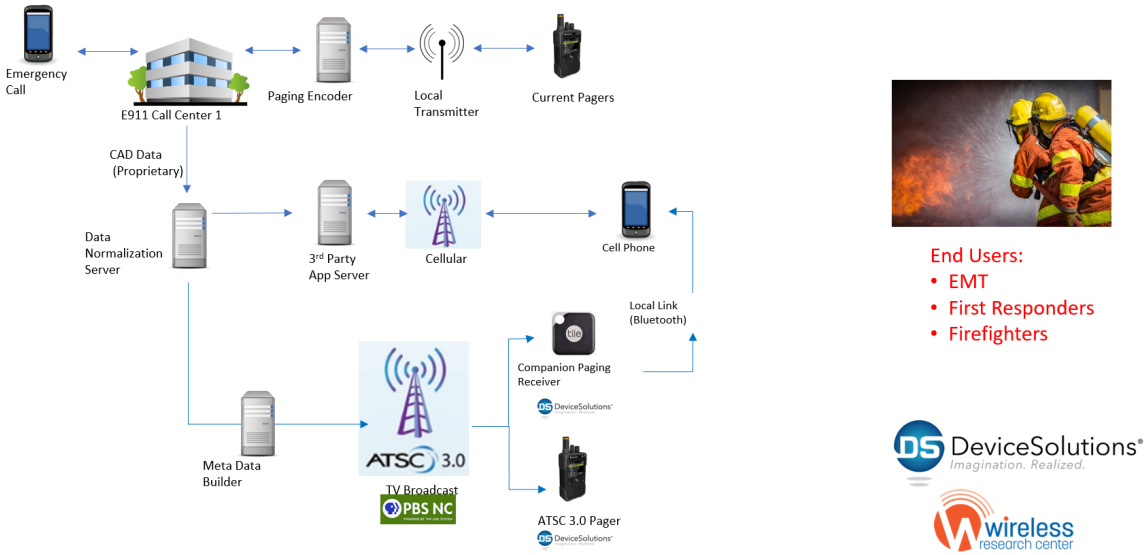

Figure 5: ATSC 3.0 proposed paging system

OTHER CONSIDERATIONS

There would have to be a centralized collection point for 911 Centers to send paging requests. The connection between such a centralized point and each 911 Center would have to be government-controlled in order to provide the robust and resilient service that is required to handle public safety grade information. An ESInet represents the ideal type of network to handle such a connection.

Due to the mobile nature of public safety personnel, the concept of using Datacasting to provide a paging solution would be dependent on transmitters operating in the ATSC 3.0 standard. The current DTV standard is designed for receivers that are not moving. The new ATSC 3.0 standard supports a receiver that is moving. This concept is meant to support individual emergency responders carrying a small receiving device throughout their normal day, which includes driving.

Today's public safety agencies have the ability to program their own equipment. The only thing that is needed to be programmed is the frequency that the pager needs to listen to, and the tones that will trigger an alert. It is possible to accomplish the same thing on such a Public Safety Datacast Paging system. One possible method would be to assign each 911 Center a unique character code, leaving another set of characters to be managed by the 911 Center (an

equivalent of today's various groups or tones). For example, a prefix of NC001 could designate Alamance County in North Carolina (using the same standard as the US Census Bureau[6]).

Using an 8-character code would leave Alamance County another 3 characters for a total of 1000 other triggers. This would maintain the independence of each 911 Center's ability to manage how their various departments are dispatched and alerted. It would also keep the programming of the receivers the responsibility of each department, in coordination with their 911 Center. Since current pagers can be configured at the device level for which trigger(s) to use by each department, any new device developed for a Datacast Paging System should have the same configurability. The datacast stream would contain all of the information and the local device would be programmed to trigger or monitor any parts of the stream.

The receiving device itself could take many forms. Manufacturers would need to develop a device that is appropriate for the public safety industry. Such a device could follow the same form as today's tone and voice pagers. Using software to deliver text-to-speech will still allow for a device with a speaker to be utilized. Such a digital device would also allow for a visual display to relay the information. A receiver is also being developed as a smartphone case that would integrate this public safety pager function, allowing for enhanced applications such as navigation, response updates, and messaging. Such a smartphone case would allow an app to receive the datacast paging information even when the phone is out of range of the cellular network.

A greater look at the policy implications and operational impact will have to be conducted. 911 Centers would have to develop policies for units that are requested to multiple incidents. If a centralized system allows any 911 Center to send a page to any unit, what happens if a unit is dispatched to two different incidents by two different 911 Centers? The centralized paging system could be configured to alert a 911 Center when their paging prefix is used by another 911 Center, which would close the loop on mutual aid requests.

A datacast paging receiver in the 911 Center could provide a confirmation that the appropriate dispatch has occurred by monitoring and decoding the datacasting stream. This level of transmission confirmation is not widely used today and would add another level of system integrity monitoring.

This would require an investment in new devices for departments. The roll out and adoption could be slow, but the benefits are great. As many radio systems are looking at converting to digital, new paging receivers may already be on the horizon.

While the promise of greater LTE coverage in rural areas is a common goal, it is known that the there maybe gaps for first responders who may need to be notified of emergencies. A datacast paging system could provide the needed coverage in rural areas.

Conclusion

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 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 milliseconds;
- 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.

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