Public Safety Broadband Special Event Report
2016 Houston Livestock Show and Rodeo

Harris County, Texas Public Safety Broadband Program
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## Contents

I. Executive Summary .......................................................................................................................... 2  
   A. Successes ................................................................................................................................. 2  
   B. Major Lessons Learned .......................................................................................................... 3  
II. Event Overview ................................................................................................................................ 3  
   A. Event ......................................................................................................................................... 3  
   B. Location ..................................................................................................................................... 4  
   C. Participating Organizations .................................................................................................... 4  
   D. Vendor Participation .................................................................................................................. 5  
III. Setup ......................................................................................................................................... 6  
    A. Operational Support .................................................................................................................. 6  
    B. Network Setup .......................................................................................................................... 6  
IV. Implementation .............................................................................................................................. 8  
    A. Operations Support ................................................................................................................... 8  
    B. Device/Hardware Performance ................................................................................................ 8  
    C. Application Performance ......................................................................................................... 9  
    D. Harris County LTE Network Performance .............................................................................. 10  
    E. Commercial Network Performance ........................................................................................ 11  
V. Lessons Learned ............................................................................................................................ 11  
    A. Network ................................................................................................................................. 11  
    B. Support Operations and Logistics ........................................................................................... 12  
    C. Human Factors ....................................................................................................................... 13  
    D. Devices, Accessories, and Applications ............................................................................... 15  
VI. Summary ...................................................................................................................................... 16
I. Executive Summary

Harris County, Texas is one of five early builders authorized by FirstNet and the FCC to operate a public safety Long Term Evolution (LTE) network in advance of the Nationwide Public Safety Broadband Network. In exchange for use of the public safety LTE spectrum, each early builder must satisfy certain Key Learning Conditions (KLC). This evaluation report, which is part of the Special Events KLC for the State of Texas, covers the network implementation, impact assessment and lessons learned from the deployment of Harris County’s public safety LTE network during the 2016 Houston Livestock Show and Rodeo at NRG Park in Houston, TX.

The Houston Livestock Show and Rodeo (HLSR) is one of the largest rodeo and live entertainment events in the world, with activities that last nearly a full month. All told, the event generates over $130 million in revenue and draws in close to 2.5 million visitors. Approximately 30,000 volunteers and 1,000 public safety personnel are needed to facilitate HLSR operations and maintain security. Like many large scale events, the HLSR poses significant challenges for first responder communications.

To help address some of these communications challenges, Harris County’s Central Technology Services elected to deploy its public safety broadband network (PSBN), including dedicated devices and applications, from the pre-show World Championship Bar-B-Que Cook-Off starting on February 25th through the end of HLSR on March 20th.

Based on planning meetings with Harris County Sheriff’s Office (HCSO), Houston Police Department (HPD), and Rodeo staff, the team agreed to two primary objectives for the deployment:

1. Remove as much non-essential voice traffic from the Land Mobile Radio (LMR) security channel as possible
2. Quickly identify officers and their location during a distress situation

The purpose of this report is to analyze the results of the deployment, identify strengths to be maintained and built upon, as well as highlight areas for further improvement.

A. Successes

The major strengths identified during this event were as follows:

- Users enjoyed greater bandwidth and faster speeds on the Harris County LTE network compared to commercial carrier networks
- Location services provided enhanced situational awareness and faster response for incidents
- The cellular push-to-talk (PTT) application proved popular, allowing flexible communications and successfully offloading non-essential traffic from the LMR security channel
B. Major Lessons Learned

During the month-long deployment, the team identified a number of areas for improvement, falling broadly under the following subject areas:

- The Band-14 devices, accessories and applications markets are still immature, which resulted in many reliability, interoperability and functionality issues.
- Expectation management is crucial; many officers still expected “mission critical” performance out of the devices, despite the Harris County team’s repeated assertions that the deployment of the technology was more of a test.
- Device management and technical support were very time-intensive tasks, requiring constant attention to maintain user engagement.

The deployment was successful in that it demonstrated the network’s value as a supplement to LMR voice traffic, providing enhanced situational awareness as well as communication flexibility. The rest of this report details the operational planning and implementation process, as well as challenges observed and lessons learned.

II. Event Overview

A. Event

The Houston Livestock Show and Rodeo, which takes place annually at NRG Park in Houston, consists of several pre-show events, a three-week carnival and livestock show, daily rodeo activities, and nightly concerts featuring artists such as Kid Rock, Pitbull, Brad Paisley, and Keith Urban. Harris County deployed its LTE network to cover all associated HLSR events, beginning with the World Championship Bar-B-Que Cook-Off from February 25th-27th.

The contest is a three-day event which draws nearly 250,000 visitors to a parking lot area covering less than 25% of the entire NRG Park (see Figure 1). Commercial cellular service during this portion of HLSR is particularly congested, with cell phones virtually unusable during much of the event.

The contest is followed by the HLSR, a 20-day event which ran from March 1-20. In 2016, HLSR brought in 2,214,539 cumulative visitors and over 30,000 volunteers.

![Figure 1: NRG Park, with location of World Championship Bar-B-Que Contest highlighted in red.](image)
B. Location

NRG Park is a large sporting event complex located at the intersection of Kirby Drive and Interstate 610 in Houston, TX. It consists of NRG Stadium (home of the Houston Texans), NRG Center (a 706,000 square foot convention center), NRG Arena, and the Astrodome (currently closed). NRG Park is owned by Harris County but operated by a private sports authority. See Figure 2 below for overview of NRG Park.

C. Participating Organizations

Harris County CTS

Harris County Central Technology Services (CTS) planned, deployed, and supported the operation of the Band-14 network and associated devices during HLSR. Harris County CTS provided network and operations support under the Director of Public Safety Technology Services, Shing Lin. The CTS network team was led by Jim McMillan with support from Matt Barna, Edgar Centeno, Gary Herzog and John Chaney. Operational aspects of the event were led by Niki Papazoglakis with significant support from Joe Jasso and other CTS staff.
Security Operations

Security operations at the HLSR are segregated between inside the stadium and the rest of the park. Stadium security is provided by NRG Park which consists of a combination of private security companies and off-duty officers from various agencies throughout the region. Outdoor security is provided by HCSO and HPD with 60% HCSO and 40% HPD. These officers are considered off-duty, working secondary employment paid directly by HLSR. Security Operations used a joint command staff under the direction of HCSO Chief Skip Oliver and HPD Chief Don McKinney, with HCSO Sergeant Doug Thomas and HPD Lieutenant Spencer Coker serving as the onsite Incident Commanders. At any given time, there are between 150 to 250 personnel working security operations out of a pool of approximately 700 officers. Approximately 80 of the 120 Band-14 handheld devices used during HLSR were dedicated to security operations.

Safety Committee

The HLSR Safety Committee is responsible for providing minor first aid and medical care to guests, conducting inspections for fire and other hazards as well as the investigation of medical incidents throughout the course of the event. Staff consists of off-duty fire and EMS professionals working in a volunteer capacity. The Safety Committee assists in the management and operation of various first aid stations and mobile units throughout the event grounds. Committee members also serve as liaisons between the HLSR and the Houston Fire Department.

The 2016 Safety Committee consisted of approximately 300 volunteers, with most assigned four shifts each during the course of the rodeo. Of the 120 devices issued, 20 were issued to the Safety Committee.

Directions and Assistance

The Directions & Assistance (D&A) Committee is responsible for assisting attendees and exhibitors with information and directions around the HLSR grounds. They are also responsible for locating, caring for and reconciling lost children, which is a significant effort every year. The 2016 D&A Committee consisted of 953 volunteers. The team issued 10 Band-14 devices to D&A volunteers tasked with reuniting children with their guardians.

D. Vendor Participation

Several vendors loaned devices, accessories, and application demo licenses during Harris County’s LTE deployment. Select equipment and applications are listed below.

Mobile Devices

- Bittium Tough Mobile
- Motorola LEX-10
- Sonim XP-7
Mobile Applications

- ESChat: a push-to-talk (PTT) app for 1:1, group, and ad-hoc communication
- STING Suite: a suite of web and mobile situational awareness applications that includes a common operating picture with live location mapping and photo and note sharing

III. Setup

A. Operational Support

Event Support Process

A cadre of personnel from HCSO, HPD, HLSR Safety Committee, and HLSR Directions & Assistance Committee were equipped with PSBN handheld devices, which were pre-loaded with applications designed for public safety use. The applications allowed users to see each other’s locations, as well as communicate with PTT and messaging features. These devices were also connected to the private NRG analog LMR system, allowing users on Band-14 to communicate via PTT with LMR users on their respective channels (Security, Safety and D&A). The team took the following steps to achieve operational Band-14 devices on the PSBN:

1) Pre-launch activities
2) User outreach
3) User adoption
4) Device adoption
5) Application selection
6) Ecosystem testing- device application, operational testing, friendly user testing
7) Coverage augmentation
8) Environmental approval from FirstNet
9) Backhaul configuration and installation
10) End-to-end testing
11) Coverage verification

B. Network Setup

Cellular on Wheels

Harris County’s existing 18 public safety LTE sites did not adequately cover NRG Park. The team therefore leveraged a cell on wheels (COW) from the Texas Department of Public Safety to provide temporary coverage. The team deployed the COW at the county-owned Child Protective Services facility .5 miles west of NRG Park (see Figure 3, below). This site was selected due to its access to both power and fiber backhaul over the county’s IP network. The team further added a 4x2 MIMO array to improve service. While locating the COW at NRG Park would have provided better coverage for the event, this was not a viable option due to the lack of a place to park the COW with available power and backhaul.
**Indoor Coverage**

Due to both the distance of the COW and signal loss from buildings, the COW did not provide coverage in the Command Center in Room 100 of NRG Center creating the need for an indoor coverage solution. The first small cell solution that the team tried continuously rebooted itself due to the inability to handle the large number of devices attempting to connect, rendering it unusable. A second small cell solution worked, but could not support more than eight devices. With a large cache of devices and users centered in Room 100, this was not an acceptable solution. As a last resort, the team pulled a macro eNodeB from the Harris County CTS mobile command unit and installed it inside Room 100 at 10% power with the antenna pointed toward a wall. This proved to be a workable solution.

**Drive Testing**

The team used a Test Equipment Management System (TEMS) platform on a golf cart to conduct a drive test of the area. The results showed a strong outdoor signal throughout most of NRG Park (see Figure 4). The results predictably showed that the signal was somewhat obstructed in the eastern portion of the park by NRG Stadium and the Astrodome.

![Figure 4: Results of drive test. The team used 4xRX MIMO to aid with uplink in the area east of the Astrodome, shown in yellow.](image-url)
IV. Implementation

A. Operations Support

The Harris County CTS Team provided end-user and network support during the entire month-long operational period. The operations team provided ongoing end-user training and technical support on devices and applications. They also continuously performed speed tests throughout the park to monitor network performance. Due to inclement weather, the mast on the COW had to be lowered and then raised numerous times throughout the operation. The engineering team regularly tested signal strength and performed network monitoring to optimize system performance. They also provided troubleshooting during system outages.

Operational Use Cases

The team noted officers and volunteers using their devices for the following operational uses during HLSR:

1) Security during cash transport
2) Locating missing persons/lost children
3) Security in the bus tent
4) Sharing information about a possible domestic terror threat
5) Picture sharing used for detecting fake parking tags
6) Identifying banned people or vehicles returning to premises
7) Sending broadcast messages or instructions

B. Device/Hardware Performance

The devices and applications which were deployed during the event are different than what is used on a daily basis on the Harris County public safety broadband network. Currently, only in-vehicle-routers (IVRs) supporting vehicles with mobile data terminals are deployed, but this event used borrowed devices, application demo licenses and accessories to support voice centric services. The deployment of these devices and applications for this event created a number of issues which were not surprising, due to the inability to test many items prior to the event.

There were a variety of challenges integrating the existing LMR system within the covered areas. Initially, it was observed that devices differ in compatibility of applications, hardware and accessories. Without appropriate testing, perception from end users was that handheld devices unfavorably differed in radio frequency performance and sensitivity. The testing that was performed showed all devices operated on the LTE network.

Rodeo Security Operations had a talk group radio channel on the NRG LMR Radio System that was bridged to Band-14. The PTT application was originally configured to have lower priority than transmissions originating from an LMR radio. After the first busy Saturday night when end-users on the Band-14 devices were unable to "key up" to
initiate a transmission, it was discovered that the Security channel was configured with a 3-second hang time on the repeater. The radio traffic was so heavy that night, the application viewed the repeater as busy the entire night thus not allowing any outbound transmissions from the Band-14 devices on the Security channel. This problem did not exist on the Safety channel or transmissions to users/groups only within the app. The issue was later resolved by setting the priority on transmissions from the app to the same as those on the radios. The LMR gateway also exacerbated another issue, by amplifying any static heard on LMR radios.

C. Application Performance

The most used applications were ESChat’s PTT app and Intrepid Networks’ Sting situational awareness and messaging app. The team installed ESChat as the PTT application on all three types of mobile devices tested. ESChat application had previously not been tested on the Lex-10 Motorola phone.

ESChat and Sting seemed to work well on two of the three handheld devices. Most users found the PTT app to be convenient and easy to use. Some elements of Security Operations did not normally have LMR radios issued to them during HLSR. For these users, the Band-14 devices with PTT capabilities provided a useful way to communicate. The most popular feature was the ability to contact individuals and small groups quickly and easily. On the other hand, officers found it difficult to navigate to the individual or group quickly and efficiently when in a large crowd situation. This issue was addressed by setting the default key on the device to a specific group based on the user role and/or preference. This was an adequate solution for most users; however, many officers stated their preference to change talkgroups from a simple knob on the radio as opposed to the process in the app of 1) un-holstering the device, 2) entering the PIN, 3) opening the app and 4) scrolling to the person or group they wanted to contact.

ESChat also created a “man down” feature in which an officer could simply press the red button on the side of the device to immediately notify the dispatcher of their identity and location in the event of a distress situation and open a call between the officer and dispatcher. Although this feature was successfully tested, it was luckily not needed.

The Sting application was used on several occasions to locate other users, and in one instance, to locate a phone that had been misplaced and reported lost. Many users reported how convenient it was to see other personnel, their associated job description, and their call sign, moving around in real time on the digital map.

Officers also used Sting to share images of fake parking placards that were encountered at NRG Park entrances, as well as to share information about missing children. With extra time and training, units may have been able to take better advantage of a situational awareness application.
D. Harris County LTE Network Performance

Several short “outages” occurred throughout the rodeo. These outages were typically very short, and could never be properly isolated. There were many suspected issues, non-controlled backhaul, application server disruptions, differences in backhaul paths from indoor eNB vs the outdoor eNB, general application issues presenting as network issues, and general user errors.

The applications in general typically use some type of tunnel across the internet back to a server based off site somewhere. We had trouble determining if there were problems related to QoS over the internet back to these servers. Vendors always report no issues with this, but very difficult to know for sure.

Wind storms caused the team to lower the mast of the COW for safety concerns, which drastically affected coverage during that timeframe in certain areas. The onsite macro tower will resolve needing to have a COW on site.
E. Commercial Network Performance

Verizon and AT&T connectivity was often unreliable during busy events at HLSR. Both commercial carriers deployed additional capacity via a new outdoor DAS system (oDAS), multiple frequency carriers, multiple technologies across many outdoor DAS sectors. Many public safety users commented that they had difficulty using their personal cell phones on the commercial networks, often times voice and data became unusable. Congestion was very apparent on the commercial system, unusable in areas of high concentrations of humans. (High concentrations of cattle had no problems)

V. Lessons Learned

A. Network

While the network itself performed well, the maintenance and monitoring proved to be challenging. Whereas the network was available and stable, getting connected to it via the venue’s provided network was problematic. In this situation, the use of venue provided commercial backhaul as a means to connect back to the Harris County core for an indoor small cell was a problem. It is recommended that anything connecting back to the core be on dedicated backhaul.

In addition to this, the small cell did not provide X2 handover capability; thus causing problems at the network border between small cell and macro network. It was also noted that the small cell could not handle high number of users attached at the same time.

Ultimately, due to all the small cell problems – Harris County decided to replace it with a macro eNB, but not over a dedicated connection. We connected to the core via the commercial telco provided by the venue, no QoS.

Outage alarms were challenging in the beginning because there was often no indication that end-user devices had detached from the network. This was primarily due to connectivity back to the core. Because of unplanned outages, devices were prohibited for use on Friday and Saturday nights due to lack of reliability. Early in the process, Harris County was able to communicate the sense of urgency to the venue, and the connectivity issues improved, due to swapping to another less congested commercial backhaul connection.
Lessons learned from the network deployment:

- **Verify coverage and have physical access to entire network:** Small coverage holes and in-building coverage have a big impact on user operations. Part of this can be addressed by working with the venue and event executives. This includes verifying the coverage and finding means to cover the holes. Small cells can be used, but they should be vetted and fully operational on the network first.

- **Deploy a COW on the venue premises:** Due to the lack of availability of power and affordable backhaul on premise, Harris County CTS was not able to stage a COW inside NRG Park, which made coverage of the area more challenging. Future events can see improvement from dedicated COW deployment on site with dedicated fiber backhaul. Microwave is not recommended at this venue due to high interference in the area.

While special event planning involves including contingency options, back up plans were limited since the COW would normally be an additional asset to a built network. With so many variables, it was time consuming to narrow down the issue causing any communication instability. Because Harris County was leveraging network transport from multiple providers, the team did not have visibility into all aspects of the network to troubleshoot and isolate “outages”.

Numerous reports of “outages” were not long enough to determine if the issue was with the applications, one of the Internet Service Providers (ISP) being used or the actual RAN. It is suspected the primary cause of the outages were due to lack of QoS over the commercial shared fiber connection. It is noted that the shared backhaul also has a primary function, which would be considered critical for the venue operations; the COW would have never been given priority over this connection. Again – critical that dedicated connection be in place ahead of time.

### B. Support Operations and Logistics

Strong support roles are required to properly manage new technology deployments. The team did a great deal of outreach during the special event by making daily customer service calls, collecting feedback and managing the devices. This month-long special event showed that the level of support required may be overwhelming for a small staff to sustain for steady state operations. Below are support/logistics recommendations:

- **A network operations center (NOC) of some sort should be activated, and a Mobile Device Management (MDM) system should be used:** The NOC should be able to support all PSBN technologies utilized, and possibly act as an applications administrator. It should also be capable of bulk tasks such as device re-flashing, swap-outs, and issuing spare equipment, including chargers. Onsite support should have authority to view any usage report at any time and additional
login access for troubleshooting. The staff should also have the ability to add, change and delete user profiles. The use of an MDM would have significantly reduced the time, complexity and errors associated with initial device configuration as well as ongoing configuration changes. If any interference issues come up, the NOC can deal with and investigate right away.

- **Support starts well ahead of the event:** Device provisioning is time consuming and should be resolved far in advance of deployment. Software processes and compatibility issues should be resolved, with backup solutions in place. Information management processes, prior checks and SIM assignments should all be completed before the start of any event.

- **Ensure a strong liaison support presence:** Users need to have a proactive feedback loop, and there needs to be a process for finding spare devices for unannounced VIP guests. Ensuring user engagement with the apps and devices required regular dialogue and visits throughout the day by Harris County CTS staff. Significant technical support for HLSR was provided by software and hardware companies free of charge as a demonstration of their products. Devices were provided as a temporary loan only. This level of support will likely not be available in the future without additional cost.

- **Deployment should be well-planned:** Having devices in advance, with provisioning, training material on applications, and ample time given to programming will contribute to a successful deployment. Local and regional communications plans should also be included and followed in any deployment.

![Figure 7: Harris County CTS team managing devices in the command center.](image)

C. **Human Factors**

The commissioned officers working the HLSR seem to enjoy the job, and several have worked it for many consecutive years. That said, HLSR still has many of the same challenges that officers face in their on-duty department jobs, such as: car theft,
assaults, breaking up fights, fence jumpers, nuisance complaints, drunk and disorderly behavior, and random acts of violence. Despite the similarities; however, it is important to reiterate that, for these officers, the HLSR is still a form of secondary employment, which changes the attitude that many have regarding the voluntary adoption of new devices and applications.

Noteworthy human factor observations from HLSR include:

- **“One more device” is not welcomed:** Officers were warned that the Band-14 devices were not yet ready as mission critical communications devices that could replace their radios. The prospect of carrying a secondary communications device proved unwelcome for many officers, however, who pointed to their already-full duty belt before asking, “What comes off?” If the equipment works well, officers would prefer to carry just one communications device. For this reason, and despite the team’s earlier warnings, several of the law enforcement officers unloaded their bulkier public safety radios enthusiastically. Other users were not ready to carry a Band-14 device, preferring to rely on their more familiar and reliable radio.

- **The utilization will prove itself:** Once a user has a device on a reliable network, and it provides a higher level of situational awareness the first few times, first responders will start to expect this service on a regular basis. Adoption of new devices is always challenging and users are often unwilling to take on another piece of equipment, until it proves to have a desirable use. Unfortunately, there were not enough devices to deploy to the entire security staff of HLSR, so it may prove to be even more useful if more than a fraction of staff used the same applications. While Band-14 devices were initially met with some criticism, as routines stabilized, some users became more enthusiastic about using them and incorporating them into regular operations. Usage increased as users become more comfortable in knowing how to use the devices, and trusting that the devices worked.

- **Training is needed.** Applications are used more when they are friendly and easy to navigate, with as few steps as possible. Training on applications, to know how each will be used, is necessary to successfully integrate devices into daily operations. With more familiarization of applications, and practice on how to route messages and attach pictures, for example, time and frustration is saved in the field. Adequate time for training is needed, and resource documentation for reference can be helpful.

- **Devices with location tracking may feel invasive.** There was a surprising level of concern from users who were uncomfortable that their locations were able to be tracked. Several officers returned the devices due to unwanted personnel tracking, and others opted to turn GPS off on their devices. Other officers were just reluctant to send messages via the messaging application, because they were unsure who was receiving and reading them.
As a reliable network is built out, realistic expectations must be set for the end users that will use the network. As much as first responders appreciated the situational awareness that was provided, there is still an expectation to keep things as simple as possible, and potentially make it work like a radio. Manufacturers have upgraded LMR equipment over the years by listening to user feedback, and may experience déjà vu with Band-14 devices. A PTT application that ties into a radio talk group is useful, until the accidental pushing of buttons becomes a distraction and compromises safety. While radios typically have a simple means of changing a channel or talk group, navigating the touch screen of a smartphone-like device requires more attention from the user.

D. Devices, Accessories, and Applications

Preparations and planning are necessary to a successful deployment of any public safety data device on a broadband network. Various HCSO, HPD, and Safety Committee users forwent their radios, and decided to carry only the handheld Band-14 devices, even though they were advised the devices were not yet intended for mission critical communications.

Ideally, customized profiles with actual names are preferred. Device sharing on a large scale without auto profile is not ideal, as generic IDs do not generally work well. However, vendors generously lent several devices, and in order to maximize user feedback, each device was handed to the position it was designated for rather than the individual working a particular shift. That meant that no device was attached to one individual for the event’s duration. This made configuration and troubleshooting quite cumbersome. A single sign-on or other profile mapping capability would have been preferred.

While many enjoyed the benefits of the LTE devices, user comments created a “wish list” of features that they would have liked to have on the device and the applications to make them better suited for public safety use.

Noteworthy feedback given by law enforcement officers on the devices, accessories, and applications used includes:

- Additional reporting capabilities are needed, including near real-time information, user location and utilization levels.
- Devices still need to improve audio quality via noise cancellation or loud environment settings. The dynamic range of audio was significant in using the PTT application.
- Current Over-The-Top PTT applications are not advised for operational use for uniformed, front-line officers. Latency, interop, device integration, maturity of devices and accessories, were all important considerations that officers
expressed. In particular, they mentioned that PTT functions cannot have any delay.

- Accessories must have stronger port connections than a simple 3.5mm headphone jack.
- If different devices are used, learn how the applications may set up or interface differently.
- Manufacturers must make devices and accessories extremely durable for highly active first responders. First responders will only deal with flimsy construction for so long before reverting back to more familiar equipment. The future of portable devices in a mission critical role has to consider that first responders need to be hands-free. Accessories are an integral part of the solution for public safety grade communications, and will be expected to provide the best audio quality, with greater durability than current commercial accessories on the market. Regular jacks and adapters will need to have a stronger plug, or screw-on attachment, to keep up with the demands of first responders’ active needs.

The team had some difficulty in supporting and isolating issues observed during the event. There was good visibility in the monitoring of LTE elements, but a lack of visibility in troubleshooting, by not having access to every single step in the network, as well as unreported outages at night. Therefore, it was often difficult to tell if it was a LTE network issue, LMR bridge issue, device issue, accessory issue, application issue, etc.

Because of these challenges of monitoring the network’s service status, it was a continued effort to troubleshoot issues. End users do not care if the problem lies with the network, the application or the device. They expect the technology to work when, where and how they need it. As the industry evolves, tools to help isolate and quickly notify administrators and end-users of network, application and device issues will go a long way towards troubleshooting and resolving issues more quickly for improved end-user experience.

**VI. Summary**

The Harris County Public Safety LTE deployment at HLSR met its goal of reducing traffic on the main radio channel by providing a flexible supplemental PTT capability. Command staff and officers also recognized the valuable situational awareness that dedicated broadband provided.

While the network met its objectives overall, many challenges surfaced during the event, highlighting the fact that the current public safety broadband ecosystem is still in a developmental phase. One of the chief lessons from the month-long deployment at HLSR is that support can be very labor-intensive with this new capability. The interoperability of every link in the public safety communication chain, from the core network to the end user, is critical, particularly for the Nationwide Public Safety Broadband Network to enjoy rapid user adoption.
As public safety broadband evolves, it will be important to continually manage the expectations of end users, while also continuously seeking their feedback. Although we cannot anticipate what the next big public safety application will be, we know that the public safety broadband network must be capable of supporting it in such a way that can be considered “public safety grade”. End users have the expectation that things just work, the first time, every time, and as we all know technology is not always that simple. Onsite support during deployments is a key factor of success and must not be overlooked. Not all issues are technical and can possibly be resolved easily with a few quick changes or explanation, if the right people are onsite to assist. Simply having key personnel available when things are not working as expected can quickly de-escalate an issue and give a positive perception of the overall deployment – even in the event that it wasn’t working properly. It is very important to remember to make a conscious effort to hear what the end users are communicating back, as they are the boots on the ground and the ultimate customer – we take those lessons back and improve where we can.