MINNESOTA

Public Safety Broadband Network Pilot Project

Final Report

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Executive Summary

Brief

The Minnesota Department of Public Safety's Emergency Communication Networks Division (ECN) managed a public safety broadband pilot network trial from 2014-2015. This project culminated in a full functional exercise in Elk River, Minnesota on a live, public safety LTE Band 14 network using public safety-specific devices and applications in November 2015.

This project demonstrated that a partnership with Minnesota-based entities can be successfully leveraged to provide public safety broadband service in the state. Furthermore, the project demonstrated the capabilities of a dedicated public safety broadband network to public safety stakeholders in the state. Finally, the project served as an excellent education and outreach opportunity for ECN's larger public safety broadband initiative.

This network was constructed in partnership between Emergency Communication Networks, Great River Energy, New Core Wireless, and the Elk River Fire Department. Equipment was donated to the exercise by a number of equipment vendors including Motorola and Sonim.

The network was turned down December 2, 2015.

Project Task Areas

The project included the following task areas:

Table 1: Project Task Areas and Tasks

Task Area	Tasks
Governance	Establish public-private partnership, develop project charter, kickoff project
Network Deployment	Construct LTE network, secure user equipment and test network
Industry Day	Plan and execute public safety broadband mini-conference at SECB[1] meeting
Tabletop Exercise	Plan and execute public safety broadband-themed tabletop exercise
Functional Exercise	Plan and execute functional exercise with live equipment

Accomplishments

Successful Implementation of a Band 14 Public Safety Broadband Network

This project marks the first successful deployment of an LTE Band 14 Public Safety Broadband Network in the Upper Midwest. LTE Band 14 spectrum is located in 758-768 MHz and 788-798 MHz and is reserved for a nationwide public safety broadband network to be deployed by FirstNet. By successfully

[1] The SECB, the Statewide Emergency Communications Board, is the Minnesota executive board who guide and statewide governance interoperable communications, including the adoption and implementation of the Nationwide Public Safety Broadband Network (NPSBN) within the state.

deploying the network, project personnel were able to build institutional knowledge about dedicated public safety broadband, and the stakeholders were able to experience firsthand new technologies operating on the network.

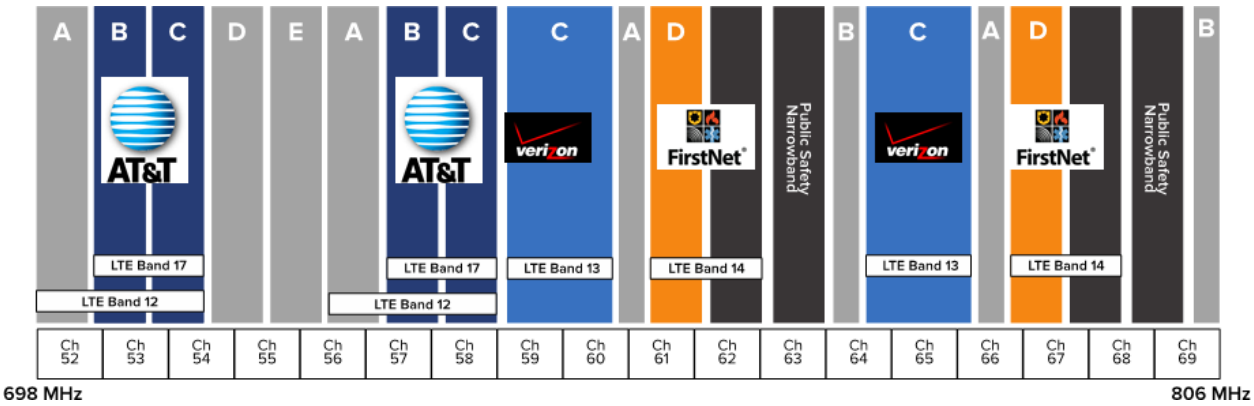

Figure 1: 700 MHz Spectrum

Extremely Successful Tabletop Exercise

We held a tabletop exercise in August 2015 where participants were presented with a major, multi-agency incident with a focus on broadband communications in Elk River, Minnesota. Participants were provided the parameter that commercial cellular networks were not available due to congestion, but a dedicated public safety broadband network was operational. Participants were then asked to discuss their ideal communications requirements and objectives with the understanding that they would have access to mission-critical, public-safety grade data communications throughout the incident.

The tabletop exercise was a major success. Participants identified a wide variety of new requirements for the future nationwide public safety broadband network (NPSBN), and had the opportunity to share their perspectives on mission critical broadband communications. Furthermore, based on thoughtful reasoning, the incident scenario participants identified a number of basic, foundational communications issues with their respective responder organizations, and a list of steps they can take to improve them.

Successful Functional Exercise on a Live Dedicated Public Safety Broadband Network

Program staff held a functional exercise in November that made extensive use of streaming incident video and push-to-talk voice over the broadband LTE network. The exercise was successful in demonstrating to participants the power of enhanced situational awareness via streaming incident video.

Outreach and Education about Public Safety Broadband

This project, and in particular its exercise activities, were an outstanding opportunity to further expose stakeholders to that state's public safety broadband initiative. The variety of activities surrounding broadband communications in Minnesota, including meetings, conferences, exercises and demonstrations all cumulatively contribute to growing interest and acceptance of the underlying technologies and the broader nationwide initiative. This level of interest will pay dividends in the future when State and FirstNet officials are encouraging adoption of the NPSBN throughout the state.

Extensive Support from non-Governmental Entities to make the Project a Success

All equipment for and services to construct the network were provided by private partners **at no capital cost to the State or local jurisdictions**—all hardware for the exercise was donated by private partners. The State's only cost for this event was staff and contractor time. Significantly, multiple competing vendors provided products and services to support the event in the interest of advancing public safety in the state of Minnesota and nationwide.

Extremely Successful "Industry Day" Showcase

Project partners including the State and private partners organized an "Industry Day" showcase at the October 2015 meeting of the Minnesota Statewide Emergency Communications Board (SECB). This event provided project partners with the opportunity to present the project to the SECB. This event doubled as a mini-convention, where vendors and partners presented new technologies and solutions to the SECB and meeting guests. This event was extremely well-received and was one of the key successes of the overall project.

Increased Institutional Knowledge in Deploying Broadband Service

Any project, whether successful in meeting its original objectives or not, is usually successful in developing institutional knowledge. This project is no exception. Through this project, the project team and stakeholders developed institutional technical knowledge about the hardware, software and network requirements to deploy broadband cellular service, organizational knowledge of each involved stakeholder group and strategic knowledge of the needs and expectations of the stakeholder community.

Shortcomings

Technical Difficulties at Functional Exercise

While participants at the functional exercise, on average, were generally satisfied with the exercise, the project team experienced significant technical difficulties at the exercise itself. End-user software was unstable, and a donor Wi-Fi network provided poor service that negatively affected throughput at field dispatch and command posts. As a result, the dispatch and command posts had spotty and unreliable live video feeds of the incident site.

Great River Energy Unable to Test Guaranteed Bitrate

A major objective of stakeholder Great River Energy was to test the LTE Guaranteed Bitrate (GBR) feature on a live network under a network capacity load. Due to challenges with project team resource availability, and a software license that was not procured prior to the end of the project term, Great River Energy was unable to test GBR on the network.

Lessons Learned

Extensive Regulatory Process can Slow Project Momentum

While this pilot project was originally conceived in mid-2013 and a formal project kickoff conducted in the summer of 2014, the State did not have authorization to operate on Band 14 frequencies until March 1, 2015. Band 14 frequencies, per federal law, are licensed on an exclusive nationwide basis to

FirstNet.[2] Securing temporary authorization to access FirstNet frequencies required several meetings between State and Federal Government officials prior to the State's application for Special Temporary Authority (STA) prior to the State submitting a formal application to the FCC to operate on Band 14. The application process then took six months to complete from beginning to end.

While it is not uncommon for an application for frequency authorization to take size months or more to complete, in this case, much of the initial excitement and momentum around the project from its initial kickoff subsided while the application was processing.

Consistent and Effective Project Management is Crucial

Management of the project transitioned from an initial project manager, to a new employee, and finally, back to the initial project manager 12 months after the first formal kickoff meeting. While staff changes are sometimes unavoidable, in the case of this project it introduced significant disruption.

Technology Solutions Demonstrated at the Functional Exercise Required Further Testing

The technology solutions used at the functional exercise, in some cases, performed extremely poorly and provided an inconsistent experience to exercise participants. While many factors contributed to the poor performance, it could have likely been mitigated with further testing from project partners and staff prior to the exercise. The exercise utilized a number of technologies that were new to exercise participants and, in some cases, pre-market beta software. If partners and staff had dedicated more effort to testing and setup prior to the exercise, the solutions used for the exercise might have performed better.

[2] P.L. 112-96 Sec.6206 (b) (1)

Project Overview

Mission

The project's mission is defined in its project plan as follows:

- Evaluate and demonstrate public/private partnership in public safety broadband network deployment
- Execute an MOA between the State and a private entity for network deployment in a way that will provide meaningful inputs into the State-FirstNet consultation process
- Allow public safety in Minnesota in a non-urban area to experience the benefits of public safety LTE, which will increase support for the Nationwide Public Safety Broadband Network and FirstNet in Minnesota
- Perform technical evaluations of public safety-grade band 14 LTE equipment

The project was centered in Elk River, Minnesota (see Figure 2), located about 20 miles northwest of the Twin Cities inner beltway metropolitan area. This location was chosen based on a number of significant factors. First and foremost, project partner Great River Energy (GRE) was willing to provide access to its Elk Hill site to support the project. This site would provide sufficient LTE coverage throughout downtown Elk River. Additionally, Elk River Fire Department was willing to provide comprehensive support to the project including providing work facilities, exercise program support, hosting meetings and directing the functional exercise.

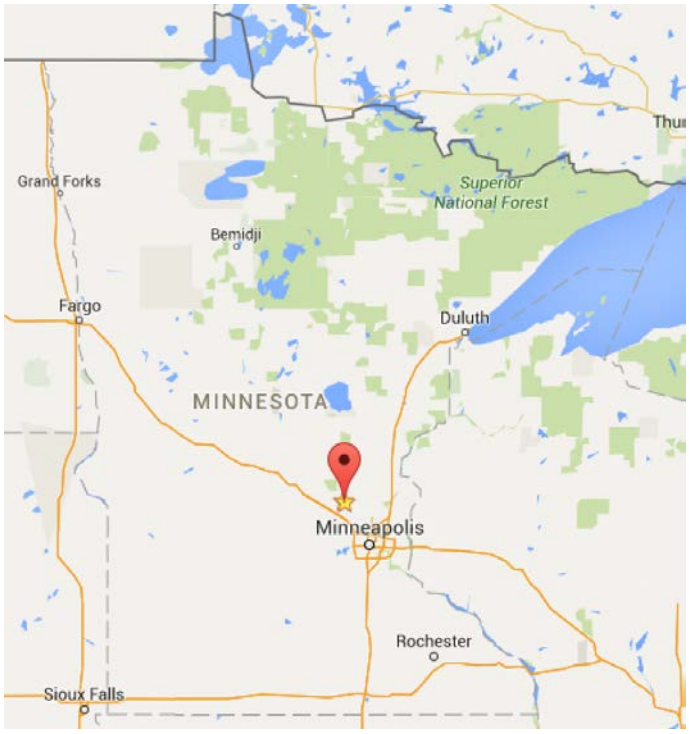

Figure 2: Elk River, MN

Stakeholder Register

Table 2: Stakeholder Register

Stakeholder	Role
ECN	Public safety project sponsor and provided overall project management for the pilot project. Holder of Band 14 STA.
Elk River Fire Department	First Responder agency sponsor. Provided facilities for planning and exercises, community outreach and coordination and exercise direction.
Great River Energy	Site infrastructure and tower access. Public Utility partner.
New Core Wireless	Hosted-core LTE switching services, LTE service, LTE technical support and device provisioning.
Motorola/ Ericsson	Donated site and user equipment including LTE eNodeB and mission-critical public safety LTE handheld. Provided access to WAVE push-to-talk service.
Sonim	Donated user equipment: mission-critical public safety handheld.
OnCall	Donated user equipment: body-worn camera.
nMotion	Provided access to demonstration aerial drone.
Lociva	Donated deployable LTE core and network for testing and evaluating.

Task Areas

Governance

The project's formal project plan was adopted July 1, 2014 and was authored primarily by Great River Energy. The plan went through a number of modifications over the following years, but for the most part, the project stayed fairly close to its original vision.

The project was originally envisioned to culminate in network tests and a full exercise on a live public safety broadband network in Elk River; however, specific details in terms of execution of the exercise were not in place until well into 2015.

The state of Minnesota made an original application for a license to access to Band 14 spectrum on 9/19/2014, which was dismissed by the FCC on procedural grounds,[3] and a second on 10/3/2014. The State sent a third application to the FCC on 10/16/2014, which was granted December 12, 2014 effective March 1, 2015. The State's second application was dismissed on 1/5/2015, as the State's second application had already been granted.

ECN was advised separately by the FCC and FirstNet to send its application to access FirstNet spectrum to the FCC Wireless Telecommunications Bureau (WTB) and to the FCC Office of Engineering and Technology (OET), respectively. Minnesota was ultimately granted Special Temporary Authority to

[3] The first application was signed by a contractor, which is inadmissible by the FCC rules.

access Band 14 spectrum by OET. Because accessing FirstNet's spectrum is a special case,[4] it is not covered by usual FCC rules and processes, and so it is not unexpected that ECN encountered issues and conflicting information about how to apply for access to the spectrum.

Network Deployment

Network Technical Description

The network utilized a single site with two sectorized antennas providing coverage due north and due south from the site. LTE eNodeB equipment and antennas were installed at the GRE Elk Hill site located about two (2) miles north of downtown Elk River. LTE switching services were provided at New Core's facilities in St. Cloud, Minnesota over the GRE-provided fiber OC-48 SONET backhaul. The network provided good coverage throughout downtown Elk River and for several miles north of the site.

The LTE core provided data service and access to the internet *only*. The network did not provide SMS/MMS, location, telephone or any other network services other than those required to provide internet access. Furthermore, the network did not provide 3G/2G fallback—devices on the pilot network had 4G data only. The network is depicted in the Figure 3 graphics below.

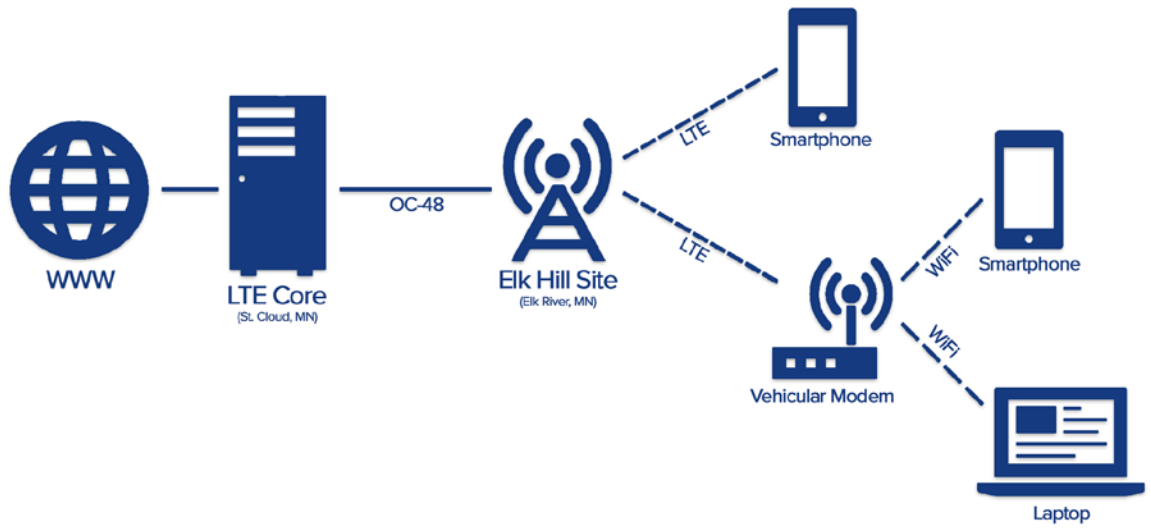

Figure 3: Pilot Network Basic Diagram

[4] FirstNet already holds a nationwide license for the spectrum under federal law, and so any access is granted to any other party is on a temporary basis only and under unique terms and rules.

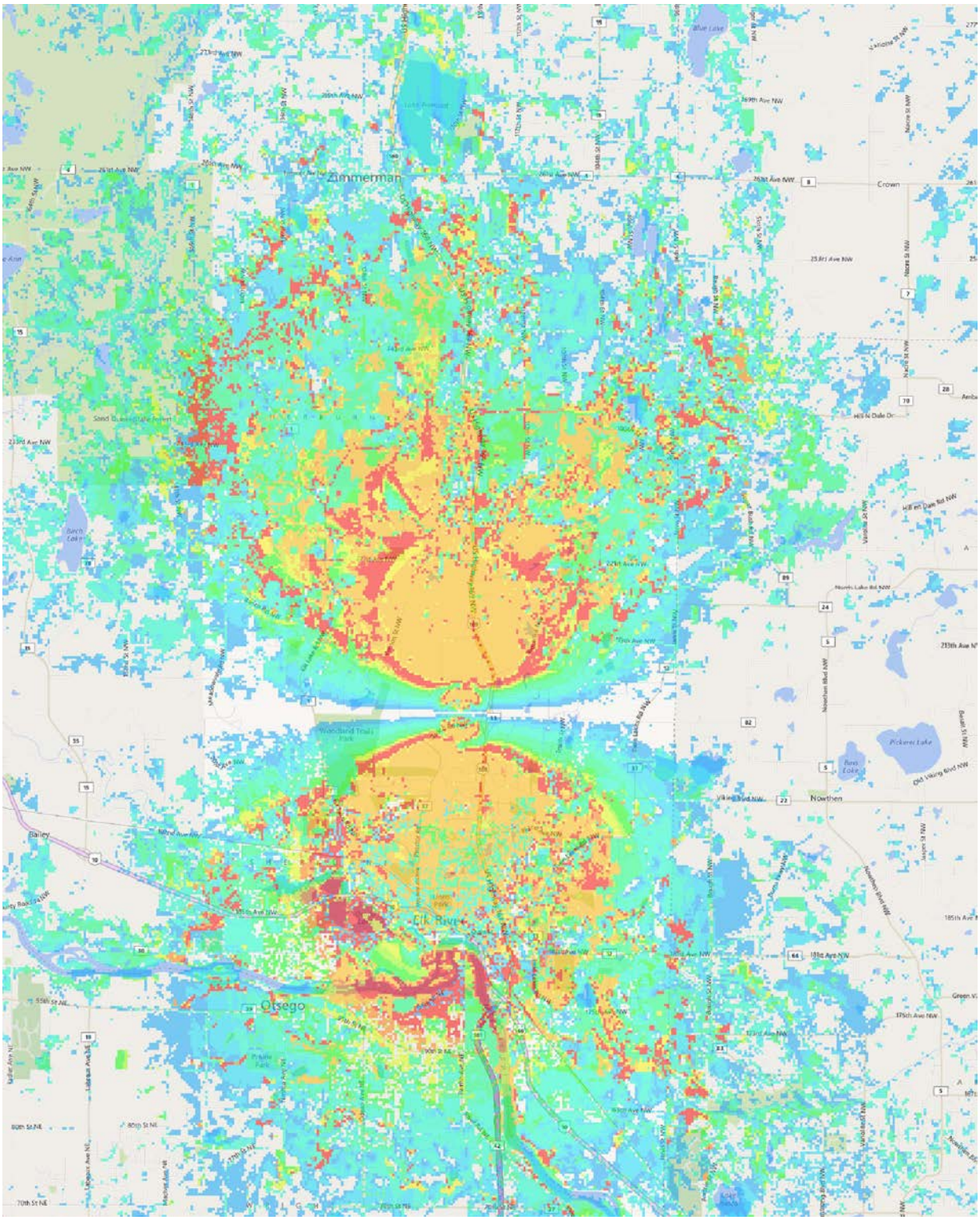

Figure 4: Expected Coverage and Throughput Simulation

Incumbent interference issues

Spectrum readings in Elk River were performed by New Core Wireless in March 2015. At that time, the project team noted emissions in the downlink upper portion (758-768 MHz) being emitted from the Metropolitan Area High Performance Data System ("HPD System") into *some* segments of the proposed operational area for the exercise, as well as from a licensed SCADA network (see Figure 5). This SCADA system was licensed for 757/758 MHz, but experienced out-of-band emissions in 758-760 MHz. The net effect of these interfering emissions was that downlink throughput (downloading files from the internet) was reduced substantially. Uplink throughput (sending files to the internet) was not affected.

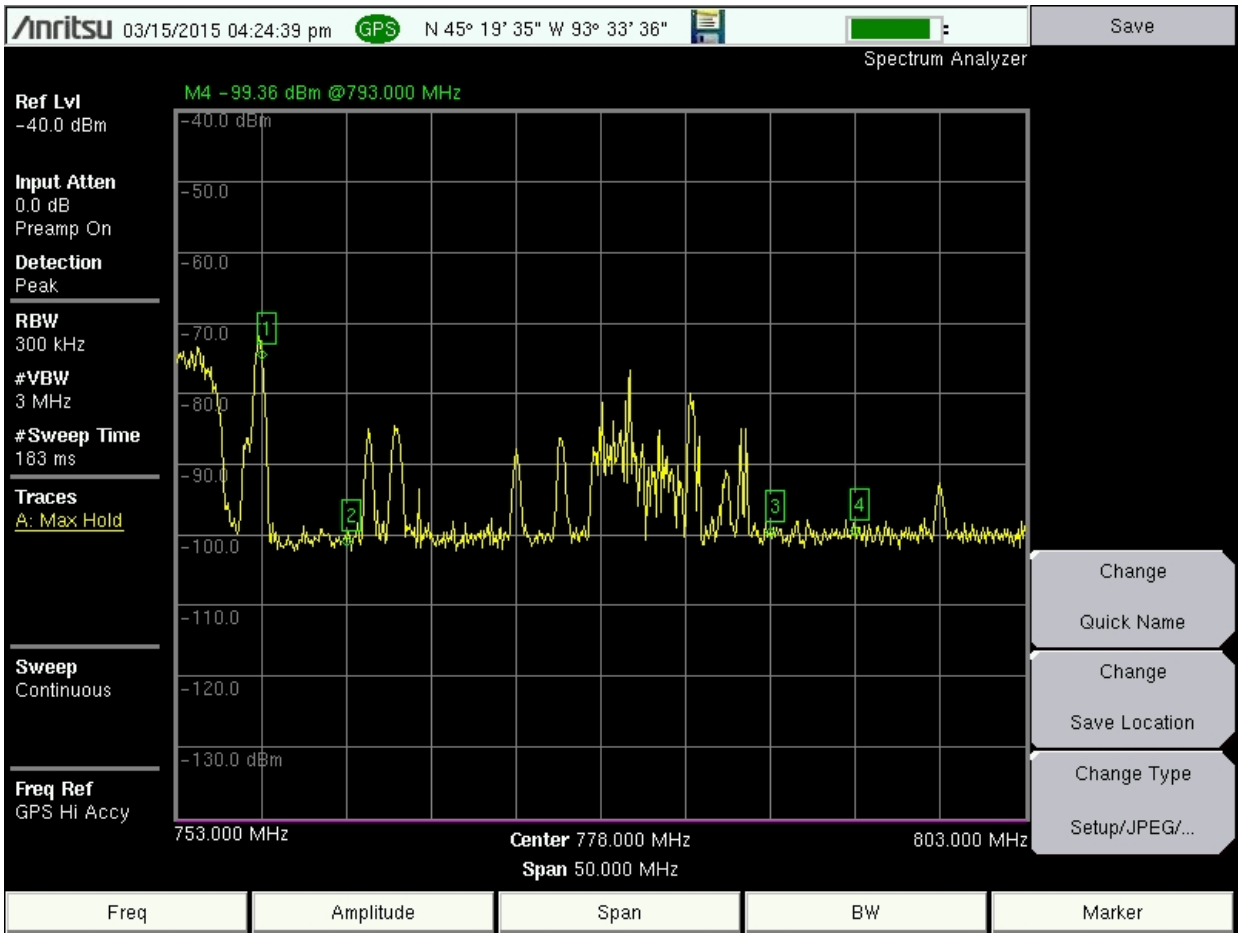

Figure 5: Emissions Observed in 763-768 MHz and Out-of-Band Emissions in 758-760 MHz

Historically, as public safety broadband spectrum was vacant, no operator encountered interference issues until the time of the exercise. However, SCADA operations are mission critical for the incumbent operator, and it is not an option for them to turn down their emissions to facilitate the pilot. The project team accepted that it would experience interference from the operator throughout the pilot. By the time the functional exercise was held, the HPD System had been turned down, was being decommissioned, and was no longer interfering with the public safety network.

It should be noted that at this time, the incumbent operator plans to make upgrades to their SCADA network. These upgrades should clear interference issues prior to FirstNet deployment in Minnesota.

Field Tests

The project team conducted field tests throughout October 2015. The team conducted tests including a variety of devices and channel configurations to measure the health of the network when accepting interference. Tests were conducted using an HTML5-based benchmarking tool[5] on a vehicular modem via a connected PC and web browser. The project team experienced the following average throughput results:

Table 3: Test Site Throughput Figures

Device	Channel	Downlink	Uplink
Vehicular Modem	758-763 MHz/+ 30MHz	9.83 Mbps	4.89 Mbps
Vehicular Modem	758-768 MHz/+ 30MHz	21.07 Mbps	7.53 Mbps

Downlink and uplink figures above are averages based on at least three (3) samples at multiple locations throughout Elk River, MN and represent average throughput throughout the downtown area.

The project team was able to determine that while throughput on the lower half of the downlink channel (758-763 MHz) was negatively affected by interference, downlink and uplink throughputs were still fairly good throughout most of downtown Elk River (nearly 10 Mbps downlink). By utilizing the full downlink LTE channel (758-768 MHz), downlink throughput was more than doubled to over 21 Mbps. The team was able to determine that while interference negatively affected network performance, it should still adequately support the project's needs for testing and the planned functional exercise.

User Equipment Fleet

The User Equipment (UE) fleet included devices and software was provided by multiple, and in some cases, competing vendors in support of the project. All devices and software services were provided in support of the program at no cost the government.

[5] https://speedof.me

Figure 6: Sonim XP7700 running Motorola WAVE PTT Software Client

Fleet components were as follows:

Table 4: Project Device and Application Fleet

Device/Service	Provider	Description
XP7700 Handheld	Sonim	Android-based handheld device. Essentially a ruggedized smartphone with a Push-to-Talk and Emergency button.
LX7 Handheld	Motorola	Android-based handheld device. Essentially a ruggedized smartphone with a Push-to-Talk and Emergency button. Functionally equivalent to the Sonim XP7700.
WAVE PTT	Motorola	A non-mission critical push-to-talk service provided by Motorola. Was provided as a hosted service by Motorola for this exercise. Not capable of scaling to mission-critical applications as it operates on an over-the-top basis and does not utilize LTE Multimedia Broadcast Multicast Service (eMBMS) or Mission-Critical Push to Talk (MCPTT).[6]
InstantEye	nMotion	An Unmanned Aerial video System (UAS) that provides streaming video from an unmanned aerial vehicle. The video feed is viewable on a handheld control deck as well as on client software at a PC computer.
OnCall Body Worn Camera	FireCam	Body or helmet-worn camera. Records video on device flash storage. Also capable of syncing with an iOS or Android-based smartphone software to publish video feed to a media server,

[6] See 3GPP Americas, SA-6 Mission Critical Applications workgroup. http://www.3gpp.org/specifications-groups/sa-plenary/sa6-mission-critical-applications

		which is then accessible remotely, live, at client software at a PC computer.
Toughbook	Panasonic/ St. Cloud	The City of St. Cloud provided Toughbook laptop computers to outfit field dispatch and command posts at the functional exercise.
Phoenix CAD	ProPhoenix/ Elk River	Elk River provided access to its training server on the ProPhoenix Phoenix CAD system. The CAD system was linked with a mobile application that allowed exercise participants to receive CAD alerts and respond on their smartphones.

Industry Day

Industry Day was a technology mini-conference held at the Minnesota SECB meeting in Otsego, MN on October 2015. This event included a technology mini-conference where participating project vendors demonstrated their technologies and services to attendees and SECB members. Additionally, members of the project team each prepared short presentations where they provided their perspectives on the project on a panel.

This event was extremely well-received by attendees and provided an excellent preview the upcoming November functional exercise.

Figure 7: Panel Seminar at Industry Day[7]

[7] Panelists are (from left to right) Albert Kangas (New Core Wireless), Dan Naylor (Motorola), Stephanie Court (New Core Wireless), Mike Koch (Motorola), John Cunningham (Chief, Elk River Fire Department), and Brandon Abley (contractor, ECN). Not pictured: panelists Jackie Mines (Director, ECN), Paul Christoforou (Lociva), Bob Escalle

The Industry Day seminar was not part of the original project scope, but was envisioned in early 2015 as an opportunity to educate the SECB about progress in the Minnesota Public Safety Broadband Initiative. This event was an important part of stakeholder management for the project, as the state's public safety broadband program is conducted specifically in accordance with SECB objectives and policies.

The town of Otego is located just south of Elk River, MN. While Otsego is located outside of the expected coverage footprint of the pilot network—particularly indoors—the project staff was pleased to discover that there was modest coverage inside of the event center that hosted Industry Day and the SECB meeting. Handheld devices were able to perform at 1-4 Mbps on the uplink and downlink inside of the facilities during the Industry Day technology demonstration. While this is a very small amount of throughput, it was enough for vendors to demonstrate their equipment live on the public safety broadband trial network.

Tabletop Exercise[8]

Overview

ECN requested assistance from the Department of Homeland Security (DHS) Office of Emergency Communications (OEC) Interoperable Communications Technical Assistance Program (ICTAP) to conduct a public safety communications Tabletop Exercise and provide an After Action Report (AAR) that identifies ways to improve public safety communications in Minnesota. The exercise was unique in that it focused on broadband communications and encouraged participants to provide insights and opportunities into the use of dedicated broadband communications in a future major interagency incident.

Exercise Description

The Exercise took place August 26, 2015 in Elk River and included 72 participants from 43 agencies, organizations, and private partner companies. For public safety, access to dedicated broadband networks can enhance situational awareness for response personnel, emergency management personnel, and, by extension, the public during emergency situations. This exercise allowed regional public safety and emergency management personnel to consider "the realm of the possible" when discussing emerging technologies and dedicated public safety broadband networks.

This exercise focused on a commuter train derailment near US Highway 10 in Elk River, Minnesota. The exercise scenario was developed locally in collaboration with an exercise planning team consisting of Minnesota public safety officials. The exercise was unique to Elk River, Minnesota and involved regional personnel, agencies, locations, and environmental factors. Exercise planners incorporated critical voice and data communication elements into the exercise to spark productive discussions among Players

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(Sonim) and Kathy Shaft (Great River Energy). Chair Mark Dunaski (Assistant Commissioner of Public Safety) and Carol Salmon (ECN) in foreground.

[8] A comprehensive After-Action Report (AAR) is available upon request to ECN an a controlled unclassified basis. For contact information visit https://dps.mn.gov/divisions/ecn/contact/Pages/default.aspx. Note that substantial portions of this section are excerpted from the AAR.

regarding the various mechanisms at their disposal, both in the present day response environment and in the foreseeable future.

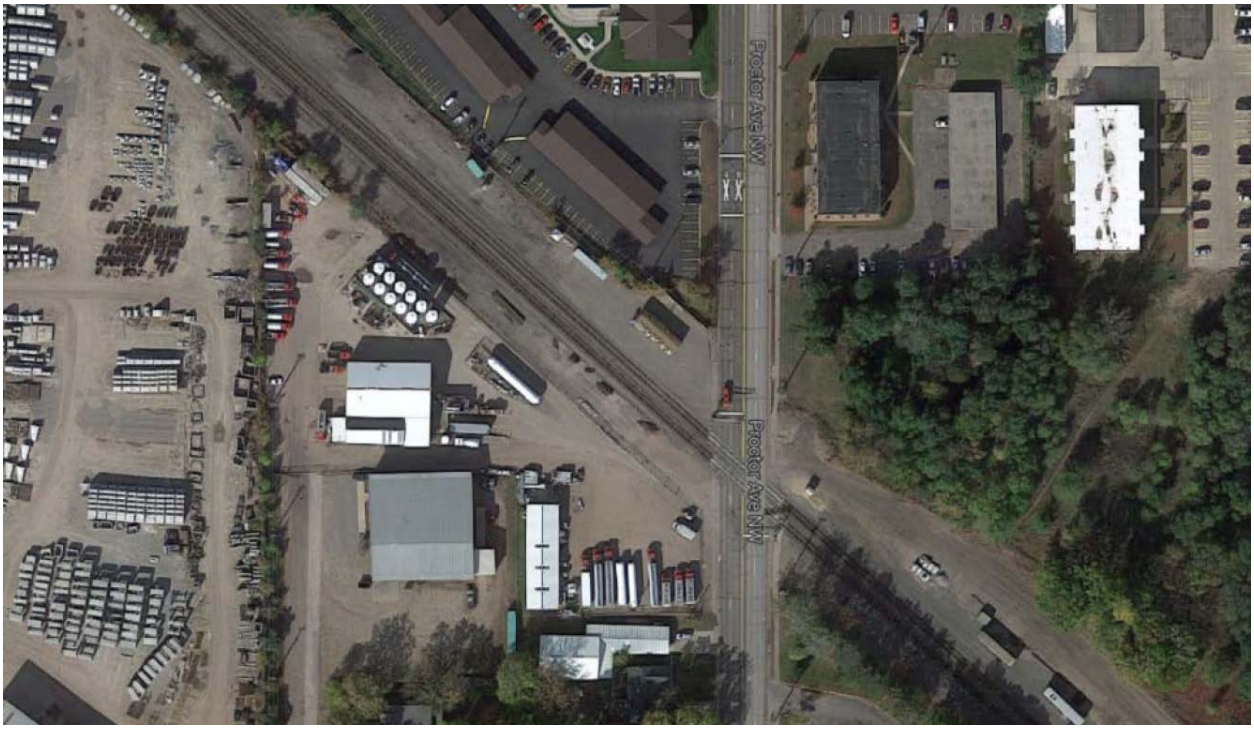

Figure 8: Train Derailment Site, Proctor Ave Crossing, Elk River MN

Participating Agencies

- Andover Fire Department
- Becker Police Department
- City of Elk River
- City of Maple Grove
- City of Milaca
- City of St. Cloud
- Elk River Fire Department
- Elk River Police Department
- FirstNet
- Hennepin Co. Emergency Management
- Hennepin County Sheriff's Office
- Metropolitan Emergency Services Board
- Metro Transit
- Mille Lacs Ambulance
- Mille Lacs County
- Mille Lacs County Sheriff's Office
- Minnesota Department of Corrections
- Minnesota HSEM
- Minnesota DOT
- Minnesota DPS
- MnIT
- Minnesota National Guard
- Otter Tail County Sheriff's Office
- Scott County Emergency Management
- Sherburne County
- Sherburne County Sheriff's Office
- St. Cloud Fire Department
- St. Cloud Metro Bus
- St. Cloud Police Department
- St. Paul Police Department
- Stearns County
- Stearns County Sheriff's Office
- Washington County Sheriff's Office
- Wayzata Police Department

Private Entities in Attendance

- Alpha Wireless
- Century Link
- Charter Communications
- Connexus Energy
- NewCore Wireless

Recommendations

OEC provided a number of recommendations as an outcome of the tabletop exercise. These recommendations are detailed into the following categories:

Education and Awareness

1. Promote more widespread access to and readership of existing public safety broadband awareness materials (see Appendix D). Consider adding a current materials "library" with links to research and other publications on the Interoperable Data Committee (IDC) website.
2. Expand Minnesota DPS-ECN and IDC outreach efforts statewide to ensure that responders from the executive level to the line level across the state are abreast of developments in the state's access to dedicated public safety broadband networks and emerging technologies on those networks.
3. Focus statewide outreach discussions on the tasks public safety agencies need to perform in order to ready their organizations to best utilize broadband technologies as network access emerges. Include targeted discussions on developing required policies, training programs, staffing requirements, and other activities designed to enhance stakeholder awareness and preparation for broadband communications.
4. Solicit support from Minnesota agencies that currently use broadband data technologies to help mentor peer agencies statewide, which do not use broadband technologies currently or are just beginning to adopt these technologies.

Enhancing Data Capabilities

1. Evaluate all new technologies for effectiveness, need, and usability. Solicit inputs from all levels of an agency, from the line level responder up through executive leadership.
2. Utilize available expertise across Minnesota to carefully and thoroughly test new technology acquisitions in the light of long term public safety needs. Avoid selecting overly complex platforms or products that are prone to frequent (and costly) upgrades, as these solutions take their toll on public safety in terms of training requirements, device downtimes, tactical implementation.
3. Identify the types of information that dispatch, command, and emergency management personnel desire to share and receive directly from front-line public safety personnel. Investigate technologies that allow those front-line responders to serve as "sensors," collecting that information in active and/or passive ways and transmitting it to dispatch centers, command posts, and/or EOCs as required.
4. Incorporate managing broadband or other data communication technologies into the policies, practices, procedures, and on-going training efforts of Communications Unit (COMU) personnel statewide. Work to establish strong working relationships and trust between traditional voice communication experts and data communication experts.
5. Verify and eliminate the impact of harmful radio interference on future broadband network deployment and implementation.

Policy and Governance

1. Encourage public engagement and collaborative discussions when developing policies governing public safety data use. Provide awareness of and/or obtain consensus on how data will be captured, stored, shared and used.
2. Evaluate Minnesota public record laws in light of emerging public safety broadband technologies. Ensure that these laws protect the privacy of individuals while furthering the data gathering, assessment, and retention needs of public safety agencies.
3. Expand the outreach efforts of the IDC to ensure that stakeholders statewide have a "one stop shop" access point for information related to public safety broadband governance. Provide links to the IDC charter, bylaws, and membership requirements. Identify the constituencies of all IDC members such that members know who they represent and stakeholders know who represent them. Clearly define information pathways between stakeholders and the IDC as well as between the IDC and the SECB.
4. Establish a working group of the IDC dedicated to reviewing public safety data sharing requirements and desired capabilities against available new technologies. Utilize this working group to help synthesize and solidify statewide public safety data-sharing policies, to develop best practices and financial guidance for departments looking to procure new data technologies, etc.
5. Develop data capture, sharing, use, and storage protocols both within agencies and statewide. Ensure that policies established at one agency integrate smoothly with the policies in place in other agencies to enable data to flow properly between each organization when needed, on demand, in real time, and as authorized. Consider key elements such as:
    a. File naming protocols
    b. Data access protocols
    c. File creation, distribution, editing, and deletion protocols
    d. Desired file types
    e. File sizes or other limitations

Staffing and Training

1. Identify key existing staff members in each agency with the interest, capacity to learn, and commitment level necessary to spearhead the adoption of broadband technologies into that agency. Ensure that these staff members are well respected in the organization, work well both with their immediate peers and with peers in other agencies and disciplines, and can present technical or complex information readily and simply to others.
2. Consider the professional capabilities each agency may desire in future hires as it relates to more thoroughly integrating data sharing technologies into their operations. Include those skill sets in future hiring profiles.
3. Investigate opportunities to work with universities and colleges to provide internship and/or mentorship slots for students who can support public safety organizations as they expand their social media-based (and other data) capabilities. Leverage their expertise, education, and enthusiasm to obtain the maximum benefit from publicly available data streams.
4. Incorporate existing voice and data communication mechanisms into every public safety exercise. Ensure that responders from all levels experience using available communication pathways and learn to do so in accordance with local and statewide policies. Identify ways to

incorporate emerging communication technologies into exercises alongside legacy communication technologies to ensure that responders maintain skills in one area while acquiring skills in another area.

5. Broaden the scope of existing public safety training and exercise programs to include information sharing requirements and interoperable applications with public and private partners, as well as to include emerging broadband technologies.
6. Provide training opportunities for traditional IT support personnel to enable them to better support first responders in the field. Consider basic training offerings such as Incident Command System (ICS) courses. Provide these staff members with experience during planned events or other reduced intensity operations.

Functional Exercise

Overview

The project team conducted a functional exercise using the live Band 14 LTE network on November 24, 2015 at the Elk River Senior High School. This exercise was designed as the culmination of all project efforts up until this point: a public/private partnership had been leveraged to build the network and supply a fleet of devices, and now Minnesota's public safety practitioners would be able to utilize the equipment live and on the air.

The exercise was held during a holiday week at a public high school, so school was not in session, so exercise participants and planners had full access to the school grounds and facilities. Dozens of agencies were in attendance, including representatives from state and local government, first responders in law enforcement, fire and EMS; the US Army and FirstNet. Local media was present, and the exercise was featured in the local newspaper.[9]

[9] http://www.sctimes.com/story/news/local/2015/11/24/1st-responders-test-wireless-network-elk-river/76304220/

Figure 9: Minnesota Statewide Interoperability Coordinator Jim Stromberg (left) briefs Exercise Participants

Technical support was generously provided by the City of St. Cloud, Washington County, Douglas County and Sherburne County who provided command vehicles that were used for mobile command posts. Washington County installed a Band 14 vehicular modem with WiFi hotspot which provided service to laptops at the field command post, EOC and dispatch center over Band 14 LTE.

Exercise Description

The exercise was structured as a scavenger hunt. Participants were told that there was the threat of an imminent threat of an attack somewhere within Elk River, and that the attacked had left a series of clues throughout the school grounds. Participants were given two restraints in terms of communications: first, that radio communications were banned, and second, that all communications must occur over the Band 14 pilot network.

Participants had a number of communication vectors available to them over the broadband network:

- Push-to-Talk over Broadband
- Streaming video via a body-worn camera
- Streaming video via an aerial drone
- CAD Messaging
- Email

The exercise was divided into 4 stations. These stations are as follows:

- Field Personnel
- Field Dispatch
- Field EOC
- Field Incident Command Post

The field command post, EOC and command center all had access to video feeds from the aerial drone and body-worn camera.

Figure 10: An Exercise Facilitator Launches an Unmanned Aerial System ("drone")

Successes

The exercise was successful in demonstrating public safety broadband technologies to exercise participants. They were able to use streaming incident video from the body-worn cameras and aerial drones to increase situational awareness and to guide field personnel from the command post. Further, participants were able to manage all communications over the band 14 dedicated public safety broadband network, including voice push-to-talk.

Challenges

The exercise experienced a number of technology challenges that negatively impacted exercise outcomes. However, these challenges provided valuable lessons learned to the participating community.

Most significantly, there was very low data throughput at the exercise site throughout the duration of the exercise. Though field tests prior to the exercise had recorded downlink speeds at over 20 Mbps, on exercise day, individual users reported downlink throughputs of below 1 Mbps. Although this was adequate to support exercise activities—compressed audio from push-to-talk and low bitrate video streams from field cameras—the multimedia quality of streaming video was much lower than the project team had anticipated. The low bitrates were likely a product of wireless interference.

Figure 11: Al Fjerstad of Mille Lacs County communicates via push-to-talk over the band 14 public safety LTE network while viewing a video stream from a body-worn camera

Streaming video feeds from the aerial drone and body-worn camera were sporadic. During testing the day prior to the exercise, video feeds were reliable and came in clearly. However, video feeds during the exercise were highly compressed and client applications on user laptops at the exercise site frequently lost connection to the drone and body-worn camera. While the multimedia quality was minimally sufficient to demonstrate the technology to participants, it was not sufficient to meaningfully support exercise activities. Almost all meaningful exercise communications occurred over the broadband push-to-talk service over Band 14 public safety smartphones.

Feedback Survey

The project team released a feedback survey after the exercise. Out of 98 total individuals that were either exercise participants, facilitators, vendors or technical support, 28 people, or about 29% of all individuals involved with the exercise responded to the survey.

In this survey, the project team asked the following questions:

- On a scale of 1-5, where your expectations for the exercise met?
- On a scale of 1-3, do you feel like you learned something useful or beneficial at this exercise?
- What did you like MOST about the exercise?
- What did you like LEAST about the exercise?
- Which exercise modules did you have an option to interact with?
- What additional user devices and applications would you like to see in the future that would leverage a dedicated public safety broadband network that were not featured at the exercise?

- Based on your experience at the exercise, please describe what you think MOST needs further exploration by the regional and/or state communications board, or your agency.
- Please provide any additional comments, such as feedback on your user experience with devices or applications, accommodations or exercise planning, below.

Participants reported that they were satisfied with the exercise. About 93% of responses were positive, with only two respondents reporting that the exercise "fell short of" their expectations. About 14% of participants reported that the exercise "greatly exceeded" their expectations, while none reported that the exercise "greatly fell short". The average value for all responses was 3.71, which means that, on average, respondents were somewhere between "met my expectations" and "generally exceeded my expectations".

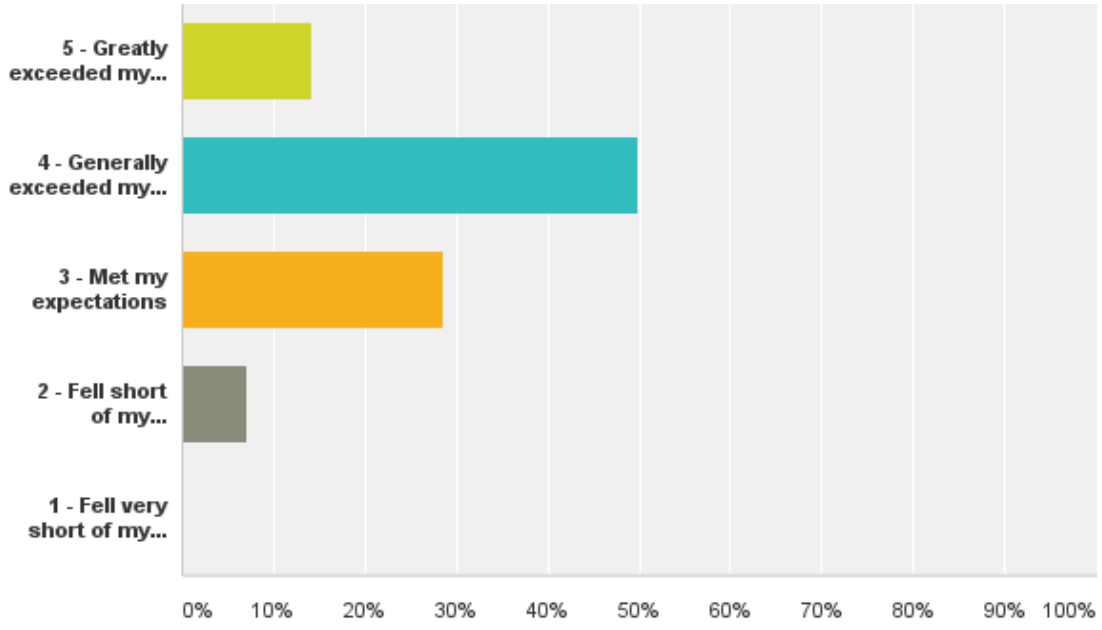

Figure 12: User Satisfaction on a Scale of 1-5

Additionally, all users reported that they had either learned something, with most reporting that they "learned a great deal", and the remaining reporting that they "learned something useful".

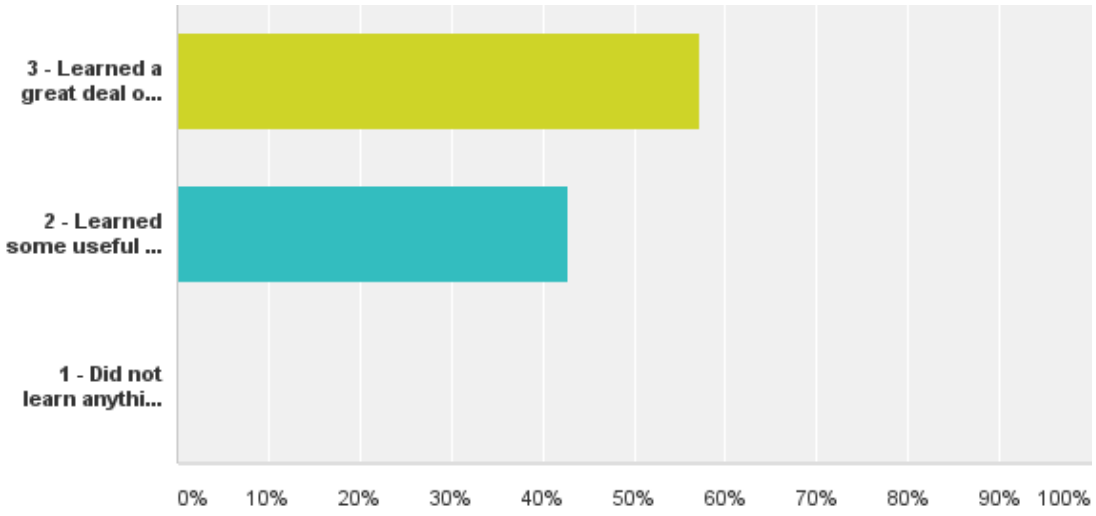

Figure 13: Responses to question: "Did you learn something useful or beneficial from this exercise?"

Participants had a fairly even exposure to all technologies on display at the exercise. However, due to the structure of the exercise rotations, no one participant had the opportunity to interact with every station.

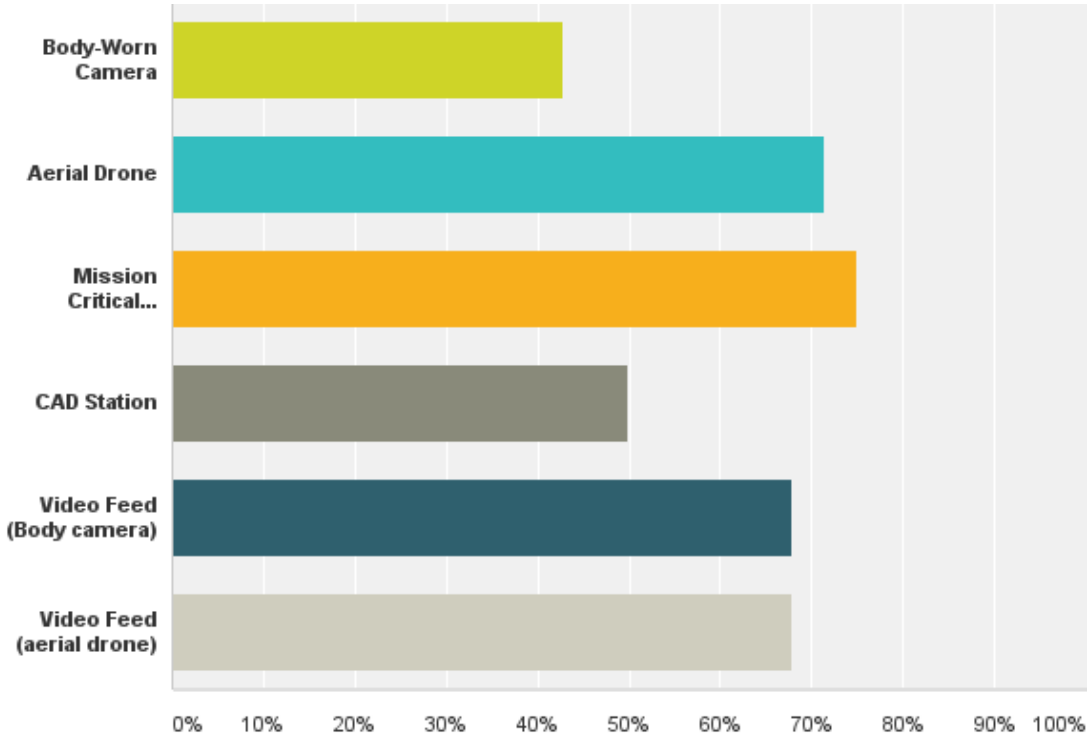

Figure 14: Responses to question, "Which exercise modules did you have an option to interact with?

Open-Ended Questions

About half of the responses were open-ended. Notable responses are transcribed below, however, there were a few common themes between all of the open-ended responses.

Participants were overall positive about the exercise. Most of the general comments were positive in nature, stating that the exercise was interesting, that participants learned something, that they felt like they were part of the "cutting edge", or that they were exposed to a unique technology. The open-ended responses, in this regard, accurately reflect the quantitative responses (e.g., user satisfaction on a scale of 1-5).

Negative comments carried an almost universally consistent message: the technical issues significantly detracted from the exercise. Some negative comments reflected an understanding that participants were still able to see the value of the technology despite the poor user experience. However, all participants responded to the question, "what did you like least?" and the majority of those responses commented on issues with WiFi connectivity through the donor modem, unreliable user client software, poor video feed quality, or technical issues in general.

A small number of participants recorded complaints about the weather—temperatures were mild for the season, but near-freezing throughout the day with a strong wind.

Notable responses to: What did you like most?

Seeing the connection between the technology and IC (incident command).

Hands on use off devices and what UAV's[10] can do for all of public safety if used with a "closed" FirstNet type network

The hands on experience. I always enjoy that type of learning over sitting in a classroom.

Seeing the different ways to interact with various entities.

The exposure to the next big thing. Being on the cutting edge.

Having people from all the different types of public safety departments working together for one goal. Also having the technology staff as part of exercise, so they could see firsthand how we needed the technology to work for us.

Vision into the future for what interactions may look like with regard to communications and data transfer.

Getting people thinking about the future and new technology and new problems and challenges that will occur.

Real world scenario, using tech to solve it.

Complete cooperation between all participants.

The interworkings between EOC, mobile ICC, and a CP[11].

Opportunity to test the PTT and the set-up of the trailers. The field testing was very beneficial!

The ability to see what the future holds for the public safety sector.

The various backgrounds of participants, the organization of the exercise, the location and the various types of technology that was used.

Notable Responses: What did you like least?

I spent a little too much time getting familiar with the drones and missed out on gathering clues and the technology used by my team at the time.

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[10] "UAV" means "Unmanned Aerial Vehicle", which is synonymous with UAS or "aerial drone"

[11] "EOC" means "Emergency Operations Center", "ICC" means "Incident Command Center" and "CP" means "Command Post"

Appeared to be under organized.

Nothing...all was excellent

I understand that a lot of this stuff was BETA but it was frustrating at times to have programs crash and not always work well.

The glitches took up valuable time, so everyone wasn't able to do all stations in a timely fashion. But it was good to see the problems and know what they were up front, real life comes with glitches

The Cold.

The Wind.

A little unorganized and the failure of some of the equipment.

[Technical support] was pulled in many directions it could have benefitted each trailer to have [this person] or someone with [their] capabilities to stay in each trailer- although this helped us to identify certain gaps.[12]

The failures of the systems, but that was expected because of the BETA status

Limited broadband capabilities. Freezing up of hand held devices.

In order to prove our use of true cell connection with devices interacting to it, we needed to assure all modules could connect and transmit data back to each group. The only way to prove it works is to take the time to make it work.

Notable Positive General Feedback:

More of these exercises need to be planned and can't loose[sic] the momentum of this exercise. The SECB needs to keep this on forefront.

It's nice to see a preliminary version of the equipment and how it's used. I hope that the technology evolves with the next exercise.

It would be great to do some testing of the smartphone in rural MN.

If an emergency manager could use this phone to communicate in all ways in the field if needed it would be awesome: fillable forms, notifying elected officials, communicating with the IC via a talkgroup, monitoring/scanning the talkgroups for situational updates, emailing situational updates and the fillable

[12] Note: original comment referenced person by name, which is redacted in this transcription.

IAP's from Command to the EOC and be able to text dispatch from the phone if ARMER[13] is down. One additional thing would be to have an emergency alert button that we could activate at the local level if needed (orange button on the top of a portable currently).

Nice work by all. The vision is awesome and the technology is there today to do it all. Our culture may be the biggest challenge at this point. Nice work!

[We should explore] more similar exercises so more of our partners can gain exposure.

[. . .] The need for a public safety broadband is clear. What will that be and who/what can connect?

Notable Negative General Feedback:

The handheld was cool as a push to talk, but either needs to be redesigned (mic vs volume control) or it will not be a valuable asset like the 800 radios currently in use. Also would not be able to be used in an operation needing stealth - too noisy.

The smartphone was scratchy (unclear) sounding at times.

If we could have had the aerial drone and body camera feed show up on the phone that would have been beneficial. The EOC could have used 3 additional laptops.

It would be good to test a speaker mic on the smartphone and if there could be some connection or screen on the mic that would show what talkgroup the radio is on and/or a way to limit the officer or fire person from having to pull the phone form their chest pocket or pouch- whatever is created to secure the phone- if not in a pocket.

I would like to see more discussion on the problem we solve with FirstNet. Good discussion there will build more use cases and educate the decision makers better than demonstrating the technology.

Work towards getting better voice quality in the push to talk area. What we had worked but it was most certainly and likely will never be as good as our LMR networks.

We need to come up with ONE standard for Lat and Long that is the same across ALL types of industries, public and private sector both - this was an issue right off the bat during the exercise, taking valuable time in real life we may not have had.[14]

I would like to see greater focus on how this is part of the roadmap for public safety communication. Right now it still has a novelty feel, instead of a first look at the next evolution.

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[14] Note: Exercise planners intentionally designed clues that were misleading or difficult to interpret, including non-standard geolocation notation.

Outcomes

Despite technical issues, the exercise was successful in meeting its goals to demonstrate the capability of a dedicated public safety broadband network to exercise participants. Participants were generally satisfied and all reported that they learned something. As reflected in some of the open-ended comments, frequent exercises—including this one—all contribute to a strong culture that values interoperable communications in the state of Minnesota.

Conclusion

The Minnesota Public Safety Broadband Pilot Project was generally successful in achieving its objectives.

The project allowed project team members to evaluate and demonstrate public/private partnership opportunities in public safety broadband through managing a successful partnership between a public utility, private cellular carrier, and multiple governmental organizations. This partnership culminated in a live Band 14 LTE network and multiple successful exercises, including a functional exercise using live equipment.

The project team did not execute a formal MOA between a public and private entity per its original objectives. However, the team adopted a formal project plan that clearly defined desired outcomes and stakeholder responsibilities. For public-facing activities including weekly project meetings and the Industry Day, public and private partners presented a united and cohesive team.

While the project team was able to meet most project objectives, the team experienced some significant challenges. Namely, the Functional Exercise, while generally successful, would have had a better impact on stakeholders had it not experienced technical difficulties. However, over 90% of participants reported they were satisfied, or that their experience was better than satisfactory, with the exercise and all reported having learned something.

Overall, the Minnesota Public Safety Broadband Network Pilot Project was a success.

Final Report

Minnesota Public Safety Broadband Pilot Project

Brandon Abley Televate, LLC, *for*

Emergency Communication Networks, Minnesota Department of Public Safety

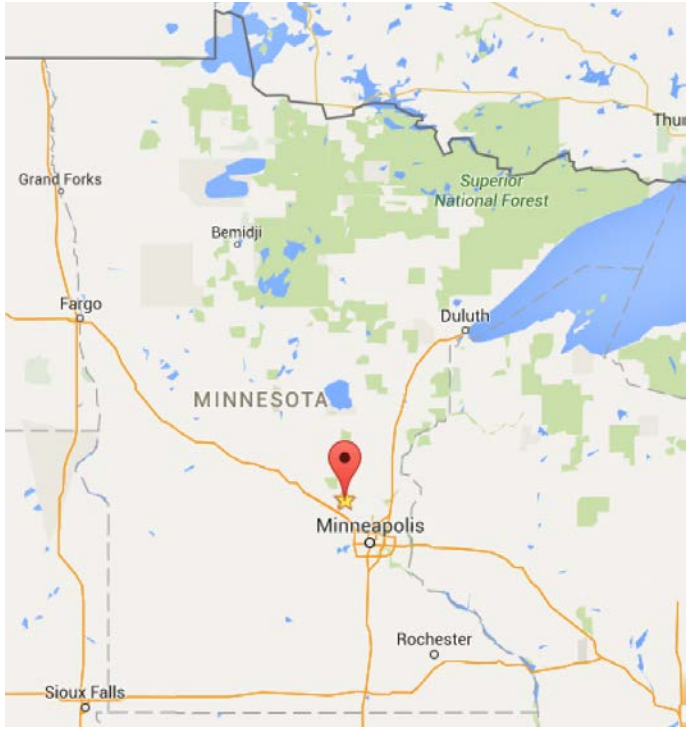
December 2015

Brief

- ECN managed a public safety broadband network trial from Summer 2014-Fall 2015

- Demonstrated:
  - A partnership with Minnesota-based entities can be successfully leveraged to provide public safety broadband service in the state.
  - Some of the capabilities of public safety broadband technologies to Minnesota stakeholders.

- Pilot was executed in Elk River, MN



Stakeholders

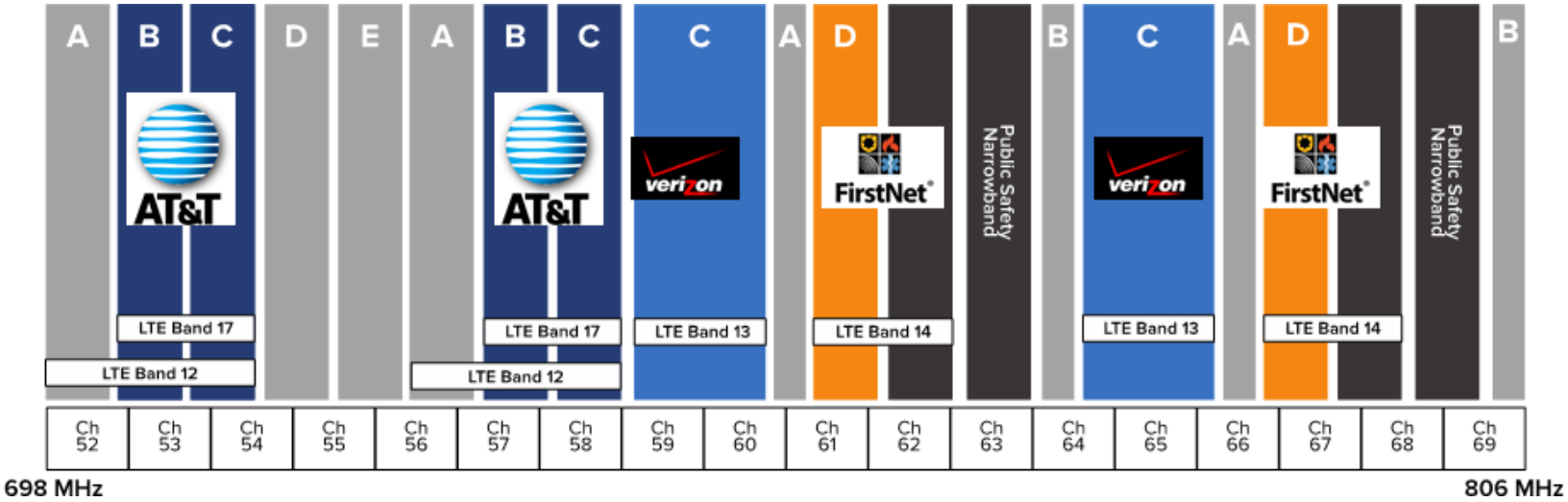
- ECN
- Elk River Fire Department
- Great River Energy
- New Core Wireless
- Motorola/ Ericsson
- Sonim
- OnCall
- nMotion
- Lociva

Task Areas

Task Area	Tasks
Governance	Establish public-private partnership, develop project charter, kickoff project
Network Deployment	Construct LTE network, secure user equipment and test network
Industry Day	Plan and execute public safety broadband mini-conference at SECB meeting
Tabletop Exercise	Plan and execute public safety broadband-themed tabletop exercise
Functional Exercise	Plan and execute functional exercise with live equipment

Accomplishments

- Successful Implementation of a Band 14 Public Safety Broadband Network



Accomplishments

- Extremely Successful Tabletop Exercise
- Successful Functional Exercise on a Live Dedicated Public Safety Broadband Network
- Outreach and Education about Public Safety Broadband
- Extensive Support from non-Governmental Entities to make the Project a Success
- Extremely Successful “Industry Day” Showcase
- Increased Institutional Knowledge in Deploying Broadband Service

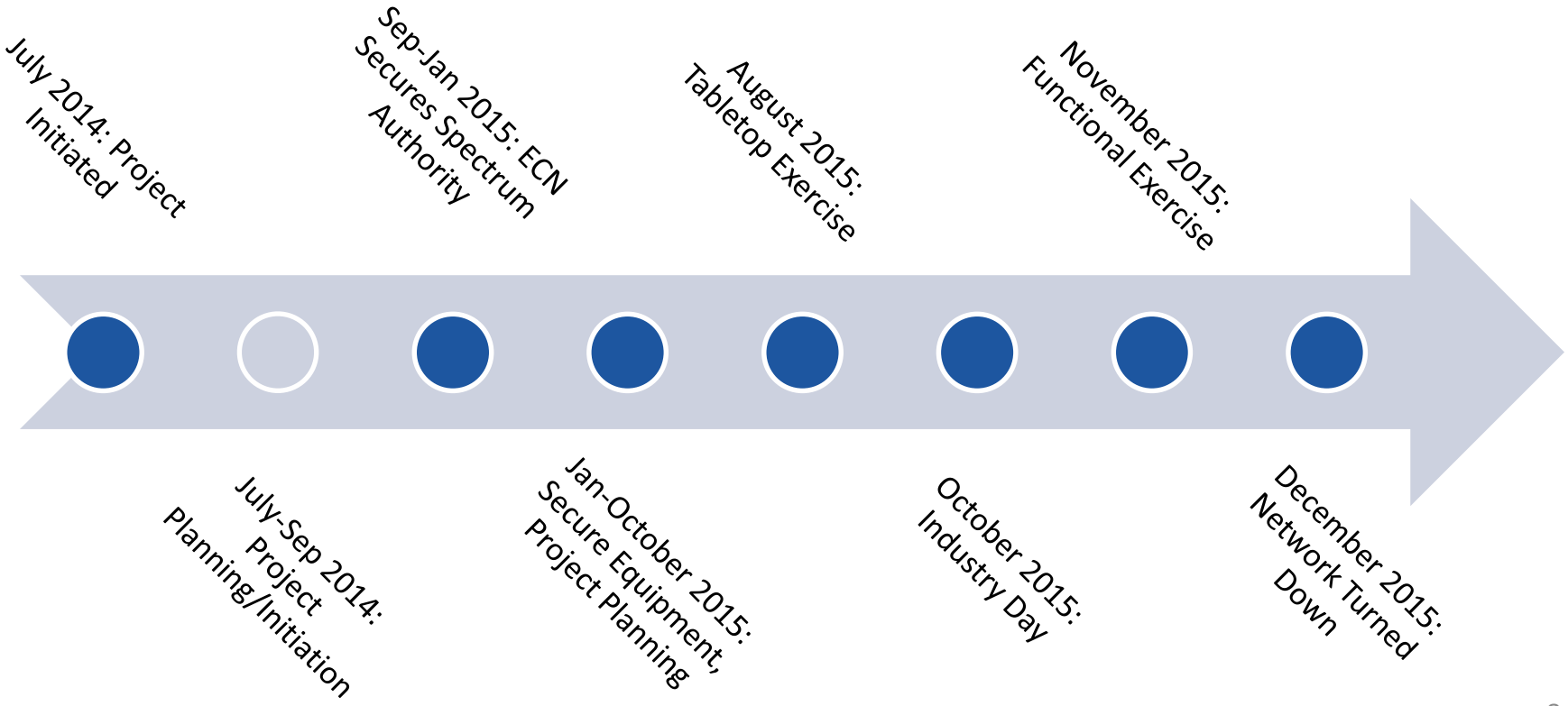
Shortcomings

- Technical Difficulties at Functional Exercise
- Great River Energy Unable to Test Guaranteed Bitrate

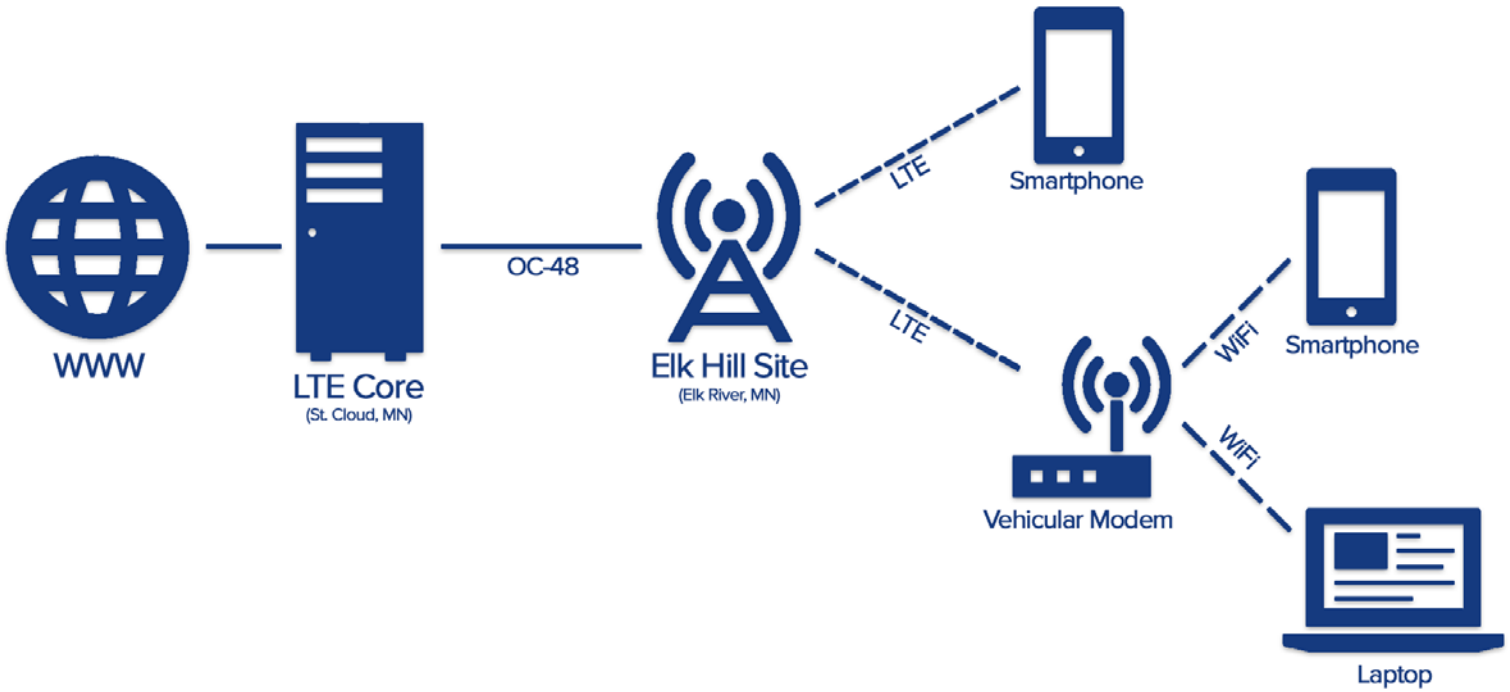
Lessons Learned

- Extensive Regulatory Process can Slow Project Momentum
- Consistent and Effective Project Management is Crucial
- Technology Solutions Demonstrated at the Functional Exercise Required Further Testing

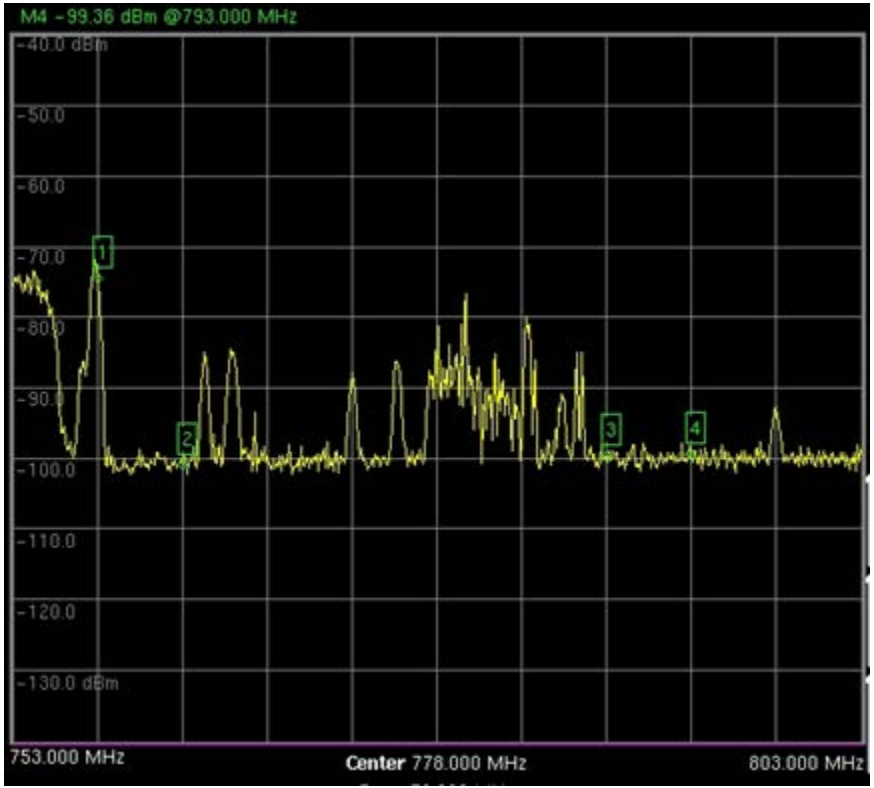
Timeline


July 2014: Project Initiated
July-Sep 2014: Project Planning/Initiation
Sep-Jan 2015: ECN Secures Spectrum Authority
Jan-October 2015: Secure Equipment, Project Planning
August 2015: Tabletop Exercise
October 2015: Industry Day
November 2015: Functional Exercise
December 2015: Network Turned Down

Pilot Network



Interference



- Network experienced interference
  - Metro Area HPD
  - GRE SCADA
- Unrelated to this project, metro HPD turned down
- GRE could not turn down its SCADA network for pilot
  - Project team accepted that there would be interference from GRE
  - GRE interference reduced downlink throughput by about 5-10%

Fleet

Device/Service	Provider
XP7700 Handheld	Sonim
LX7 Handheld	Motorola
WAVE PTT	Motorola
InstantEye	nMotion
OnCall Body Worn Camera	FireCam
Toughbook	Panasonic/ St. Cloud
Phoenix CAD	ProPhoenix/ Elk River

Industry Day

- Held in Otsego, MN October 2015
- Panel presentation @ SECB meeting
- Vendor/provider mini-conference
- Some coverage from pilot network at event
  - Made technology showcase more effective
- Event was extremely well-received by attendees

Tabletop Exercise

- August 26, 2015
- Support from US DHS
- Premise:
  - Train derailment near Elk River, MN
  - Cellular networks down
  - First responders have a dedicated broadband wireless network
- Well-attended
  - 72 participants
  - 43 agencies

Tabletop Exercise

OEC provided several recommendations including:

- Expand outreach efforts related to public safety broadband
- Solicit support from agencies that use broadband to mentor other agencies as they adopt it
- Establish a working group to develop data sharing standards
- Include technical proficiencies to support broadband in future hiring profiles
- Investigate opportunities to work with educational institutions to mentor students who can support public safety broadband in the future
- Provide training opportunities to IT so that they can better understand responders in the field

Functional Exercise

- Held in Elk River, MN November 24, 2015
- Live functional exercise using the pilot network and demo technology
- Designed as culmination of all other project efforts
- Dozens of agencies in attendance, including law, fire, EMS the US Army and FirstNet
- Technical support provided by Washington Co, Douglas Co, Sherburne Co and St. Cloud

Functional Exercise

Participants were not allowed to use radios. They could communicate via:

- Push-to-Talk over Broadband
- Streaming video via a body-worn camera
- Streaming video via an aerial drone
- CAD Messaging
- Email

The exercise was divided into four stations:

- Field Personnel
- Field Dispatch
- Field EOC
- Field Incident Command Post

Functional Exercise

Successes:

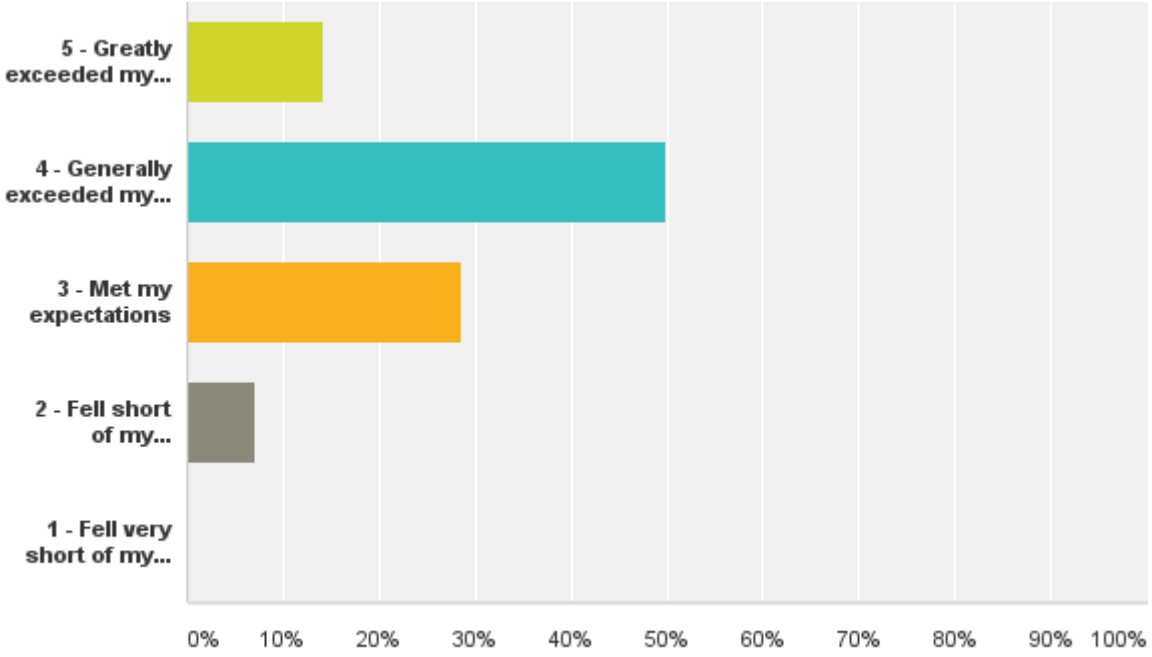
- Demonstrated a dedicated broadband network to participants
- Demonstrated technologies unfamiliar to most participants
- Participants completed two exercise rotations communicating only over the broadband network

Challenges:

- Low throughput on exercise day, especially in the command posts
- Video feeds from body-worn camera and drone were sporadic (frequent software freezes/crashes)
- Video feeds were low-quality

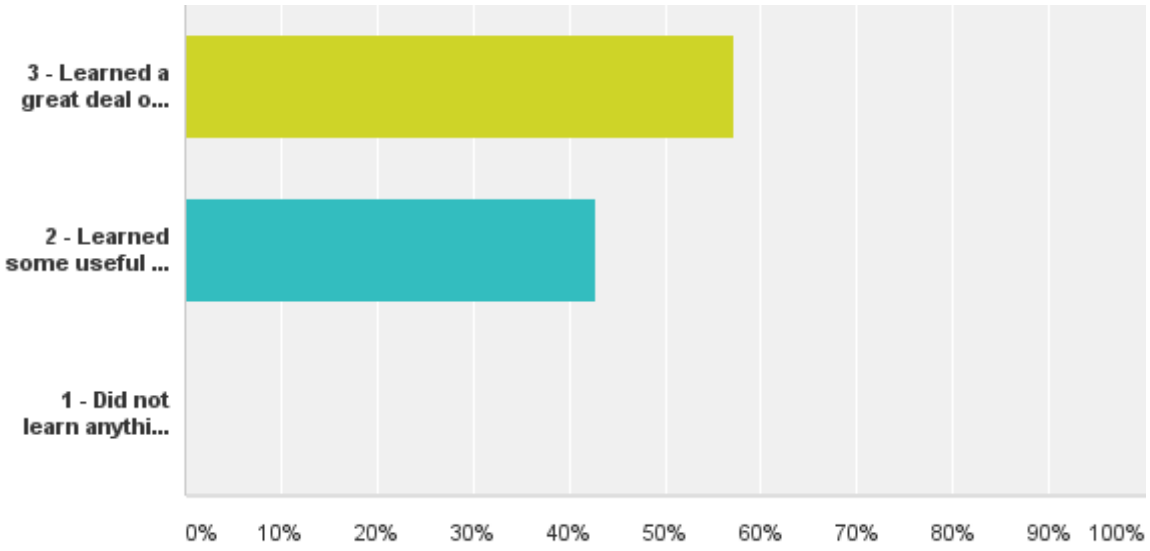
Functional Exercise

Feedback: Rate exercise 1-5



Functional Exercise

Feedback: Did you learn anything?



Conclusion

- The project was generally a success
- Allowed project team members to evaluate and demonstrate public/private partnership opportunities
- The project team did deploy a Band 14 public safety broadband network
- Industry Day and tabletop exercise were extremely successful
- Despite technical challenges, functional exercise participants rated the exercise fairly well
  - Over 90% of participants reported they were “satisfied” or better and 100% had learned something