FirstNet in the Field

How the Nationwide Public Safety Broadband Network Is Impacting First Responder Operations and Supporting Innovations

Police Executive Research Forum

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FROM PERF'S EXECUTIVE DIRECTOR

When terrorists attacked the World Trade Center on September 11, 2001, the first responders to lower Manhattan – police officers, firefighters, emergency medical personnel, and others – faced an extremely unstable and dangerous situation. The danger was compounded by the fact that they could not easily communicate with one another.

Radio communication was spotty because critical infrastructure, including repeaters installed at the Twin Towers, was damaged or destroyed, and many police and fire communications systems were not compatible. Cellular networks were still in their infancy, and making a cell phone call was nearly impossible because the commercial networks that public safety personnel had to rely on were either inoperable or overwhelmed with callers trying to contact their loved ones.

As a result, critical information from the scene was not communicated to command personnel, and instructions from command centers were not reaching front-line responders. As the 9/11 Commission concluded in its final report, "Command and control decisions were affected by the lack of knowledge of what was happening."[1]

A Dedicated Network Was Finally Created

Even before 9/11, visionaries such as retired Ithaca, NY Police Chief Harlin McEwen had been warning about the precarious state of public safety communications and advocating a nationwide

communications network dedicated solely to public safety.

These experts argued that police officers, firefighters, and EMS personnel should not have to compete with businesses and individuals for limited spectrum owned and controlled by private carriers. They proposed that public safety should have a dedicated network providing secure, interoperable, and reliable access to critical voice and data communications, during emergencies as well as everyday operations.

Many of these public safety and industry leaders took part in a national meeting that PERF hosted in March 2010 to discuss allocation of the so-called "D Block." The D Block was 10 MHz of premium spectrum that police chiefs and others wanted the Federal Communications Commission (FCC) to set aside for public safety but which

1 "The 9/11 Commission Report." Available at https://www.9-11commission.gov/report/911Report.pdf.

the FCC was planning to auction to the highest bidders. The PERF meeting was seen as pivotal to the eventual decision by Congress to dedicate spectrum to public safety.[2]

It's a shame that it took a disaster like 9/11 to spur federal officials to act on the vision of Harlin McEwen and others, and that it took more than a decade of advocacy and hard work to iron out the details and make that vision a reality.

But on February 22, 2012, President Barack Obama signed a law that created the First Responder Network Authority and tasked it with overseeing creation of the Nationwide Public Safety Broadband Network (NPSBN).[3]

In 2017, following a competitive bidding process, the FirstNet Authority selected AT&T as the private-sector partner to build and maintain the FirstNet network. And in March 2018, FirstNet went live, essentially creating a new carrier that public safety agencies could select for their mobile broadband needs.

How Is FirstNet Working Today?

Three years after FirstNet went live, many public safety leaders – police chiefs and sheriffs, fire chiefs, EMS directors and others – still have questions about what FirstNet is and what makes it different from other mobile broadband networks:

- As public safety agencies began to adopt FirstNet, what pitfalls, opportunities, and successes did they encounter?
- What can be learned from the experiences of FirstNet "early adopters" that will help other agencies as they make decisions about whether to join the network and how they can use it?
- How is FirstNet evolving, and how are public safety agencies responding to these changes?

These are the types of questions that PERF set out to answer through this project.

Beginning in August 2018, PERF began interviewing and surveying dozens of public safety personnel about what they knew about FirstNet and how they were thinking about the network. To gather a range of perspectives and to facilitate the sharing of ideas, PERF hosted three in-person meetings that brought together agencies that had adopted FirstNet and agencies that had not, as well as leaders from the FirstNet Authority, the AT&T-FirstNet implementation team, third-party partners, and others interested in public safety broadband communications.

Working with subject matter experts in mobile communications technology, PERF also developed a protocol for testing the performance of FirstNet and commercial networks, and then we ran tests in various real-world settings and analyzed the results.

In our research on FirstNet, PERF made contact with hundreds of public safety practitioners and technology experts. Because FirstNet serves the entire public safety community, we worked with police, firefighters, EMS professionals, and other first responders.

3 Case Studies

As part of this project, PERF published three case study reports:

- The first described our performance testing protocol and presented the results of the field-tests we conducted.[4]
- Another case study focused on the experiences of one FirstNet early adopter, the Brazos County, TX Sheriff's Office.[5]
- The third report examined FirstNet's "deployables" program, which provides mobile communications assets when public safety agencies

2 *Subject to Debate*. Police Executive Research Forum. July 2010. https://www.policeforum.org/assets/docs/Subject_to_Debate/Debate2010/debate_2010_jul.pdf.

3 For more information about the First Responder Network Authority, visit https://firstnet.gov/about.

4 "Beyond Signal Strength: Measuring Performance of Public Safety Mobile Broadband Networks." Police Executive Research Forum. September 2019. https://www.policeforum.org/assets/FirstNetCaseStudy.pdf

5 "Brazos County, TX Sheriff's Office: A FirstNet Early Adopter." Police Executive Research Forum. January 2020. https://www.policeforum.org/assets/FirstNetBrazos.pdf

need additional capacity in response to a natural disaster or major event.[6]

This final report summarizes and synthesizes what we have learned from our research on the implementation of FirstNet over the past three years.

This report is intended for both public safety leaders and technical audiences.

- For agency leaders, the report provides an overview of what FirstNet is, including how and why it came into being, how it is being managed through a public-private partnership, and the current status of the network and its build-out. This background is important for police chiefs, fire chiefs, and other public safety executives who are trying to make informed decisions about their mobile broadband needs.
- The report also contains technical details about FirstNet operations and performance that should be valuable to an agency's information technology and emergency communications staff.

PERF's Findings

Four key findings emerged from our research:

1 **FIRSTNET IS PROVIDING PUBLIC SAFETY AGENCIES WITH RELIABLE, HIGH-SPEED ACCESS TO MOBILE DATA.**
In performance tests run during two large public demonstrations in Washington, D.C. (the March for Life on January 18, 2019, and the Women's March the following day), and during everyday police patrols in Camden, NJ, the PERF team found that mobile devices operating on FirstNet had faster data upload and download speeds, and experienced fewer service reliability problems, than devices operating on commercial networks (including AT&T's own commercial network).

2 **FIRSTNET PROVIDES CRITICAL SUPPORT DURING NATURAL DISASTERS AND MAJOR EVENTS.**
Throughout this project, PERF heard examples of how FirstNet helped public safety agencies respond to hurricanes, flooding, wildfires, and other natural disasters.

Often, one of the first casualties of these events is cell phone towers and other communications infrastructure, which can be damaged or destroyed. Through its nationwide deployables program, FirstNet has been able to get mobile communications assets – both land-based and airborne – to disaster locations to reestablish data and voice communications for first responders.

Over the past three years, FirstNet also has supported public safety at major events, like the Super Bowl, which attract large crowds that can tax or overwhelm cellular networks. And when the COVID-19 pandemic ravaged parts of the country, FirstNet deployables were brought in to support the medical community and first responders.

3 **FIRSTNET IS HELPING AGENCIES STREAMLINE OPERATIONS AND IMPROVE EFFICIENCY.**
FirstNet users reported being able to more easily access information in the field; complete and upload reports; transmit photographs, video and other large data files; and carry out other everyday tasks.

For police agencies, these efficiencies are allowing officers and deputies to remain out in the community, available to answer calls for service and engage in prevention activities, and not have to return to a police facility to access information or file a report. For fire and EMS personnel, reliable access to mobile data is speeding up dispatching and improving situational awareness when battling fires and tracking patients from incident scenes to hospitals.

6 "How FirstNet Deployables Are Supporting Public Safety." Police Executive Research Forum. October 2020. https://www.policeforum.org/assets/FirstNetDeployables.pdf

4 **FIRSTNET IS ENABLING AGENCIES TO EXPERIMENT WITH NEW WAYS OF DOING BUSINESS.**
For example, agencies are using FirstNet to conduct video roll calls; live-stream video of fires, accidents, or disaster scenes to improve situational awareness; provide TeleHealth services to first responders who come upon persons in crisis; and even remotely dispatch 911 calls during the COVID-19 pandemic, so that social distancing and other safety protocols could be maintained in the Emergency Communications Center. These and other innovations are made possible because agencies have access to a dedicated and secure mobile broadband network.

These findings are explored in greater detail throughout this report.

Acknowledgments

As I noted earlier, the First Responder Network Authority conducted a competitive bidding process and then selected AT&T to be the private sector partner on FirstNet. Shortly after FirstNet went live, AT&T leaders approached PERF about conducting a straightforward, unbiased examination of how the public safety community was adopting and using FirstNet. The AT&T-FirstNet team wanted to better understand the obstacles and opportunities that FirstNet presented in the real world, and AT&T Inc. awarded a grant to PERF to conduct a study. AT&T personnel did not direct PERF on how to carry out this project or what topics to examine or not examine, and they were not involved in writing this report or any of the earlier case studies.

Several AT&T-FirstNet leaders – including Jason Porter, President-Public Sector and FirstNet; his predecessor, Chris Sambar, who is now Executive Vice President of Technology Operations; Jim Bugel, Vice President-FirstNet; and Stacy Schwartz, Vice President of Public Safety, FirstNet and Education – attended our regional forums. At those sessions, Chris, Jason, Jim, Stacy, and their teams answered the often challenging technical and operational questions that attendees posed. Three members of the AT&T-FirstNet team were particularly helpful in explaining key aspects of the network and its implementation: Amy Huston, Lead Chief of Staff; Scott Agnew, Assistant Vice President; and Ryan Burchnell, Director.

This project also benefited from the assistance of the First Responder Network Authority. CEO Ed Parkinson and Director of Public Safety Engagement Dave Buchanan provided regular updates on FirstNet plans and activities, and they attended our regional meetings and provided helpful updates to meeting attendees and PERF staff.

Many PERF staff members contributed to this project and the final report. Chief Program Officer Kevin Morison guided the entire effort and was a hands-on leader involved in all aspects of our research, in-person meetings, and publications. Senior Principal Dave McClure was the day-to-day project lead. Dave organized the regional meetings, oversaw the collection and analysis of the performance test data, conducted surveys and interviews, and was the lead author of this report. Senior Research Associate Sarah Mostyn assisted with project management and drafting of the case study reports. PERF Research Associate Allison Heider and Research Assistants Jessica Calahorrano and Nora Coyne assisted with background research, case study drafting, and other project tasks.

Communications Director Craig Fischer edited this final report, and Assistant Communications Director James McGinty supported the communications needs at our in-person meetings. Dave Williams designed and laid out this report. And as always, my Executive Assistant, Soline Simenauer, kept me on track throughout this project.

I want to thank all the people who attended our meetings, responded to our surveys, and answered our interview questions. This project was a learning experience for PERF staff, and we are grateful to everyone who shared their knowledge, experiences, and insights.

Several people deserve special recognition for their insights and assistance: Harlin McEwen, retired Ithaca, NY Police Chief; Scott Edson, Executive Director of LA-RICS (Los Angeles Regional Interoperable Communications System); Dave Mulholland, Administrator of the Arlington County, VA Emergency Communications Center;

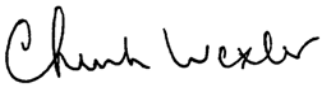
Rick Neal, of Government Strategies Advisory Group; Stephen Willoughby, Executive Director for Emergency Communications for Richmond, VA; and Kim Zagaris, Technology Advisor at the Western Fire Chiefs Association.

A special acknowledgment to Rick Keith of VisionNext, LLC. Rick has more than three decades of experience in the telecommunications field, and he was instrumental in designing the performance test protocol that PERF utilized and in helping PERF staff analyze the results of the field-tests that were run.

Our nation recently commemorated the 20th anniversary of 9/11. Over the past two decades, we have made great strides in combating terrorism, enhancing public safety, and improving communications. A key achievement has been the roll-out of FirstNet. It may have taken years to implement the vision of many public safety leaders, but today the country has a dedicated, nationwide broadband network that allows public safety to communicate more effectively during major events and everyday operations.

The United States is still in the early phases of rolling out and developing FirstNet. This report should not be considered the last word on FirstNet, but rather an early status report on where the network stands in late 2021. In the coming years, new devices, applications, and other technologies will be developed, and new use cases for FirstNet will emerge. And there will continue to be obstacles and challenges that the FirstNet Authority, AT&T-FirstNet, and the public safety community will need to overcome.

Whether particular agencies decide to adopt FirstNet or not, it is important for all public safety leaders to be aware of developments in public safety broadband, as they work toward the common goals of keeping their communities – and the public safety personnel who serve them – safe and healthy.



Chuck Wexler
Executive Director
Police Executive Research Forum
Washington, D.C.

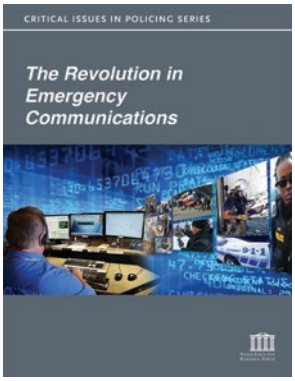
ABOUT THIS PROJECT

This project builds on PERF's previous work on critical issues in public safety communications.

- **D BLOCK ALLOCATION**
  In March 2010, PERF hosted a national meeting of public safety and telecommunications leaders to address the issue of radio spectrum dedicated to public safety. The so-called "D Block" was 10 MHz of highly valued spectrum that the Federal Communications Commissions was proposing to auction to the highest bidders at the time.[7]

  Public safety leaders at PERF's meeting laid out the rationale for public safety agencies to have access to the D Block and exercise control over it. The PERF meeting was seen by many as a turning point in the eventual decision by Congress to dedicate spectrum to public safety and establish a Nationwide Public Safety Broadband Network.[8]

- **NG911 AND FIRSTNET**
  In June 2017, PERF hosted another national meeting that examined two emerging technologies: NextGeneration 911 and FirstNet. At that time, the law creating the First Responder Network Authority had been enacted, and the Authority had recently selected AT&T as the private sector partner to build and maintain the network. PERF's publication, *The Revolution in Emergency Communications,* outlined the planned structure and operation of FirstNet, but because the network wasn't operational at the time, the report did not include any real-world experience with the network.[9]



March 2010 PERF meeting of public safety and telecommunications leaders

7 *Subject to Debate*. Police Executive Research Forum. March 2010. https://www.policeforum.org/assets/docs/Subject_to_Debate/Debate2010/debate_2010_mar.pdf.

8 *Subject to Debate*. Police Executive Research Forum. July 2010. https://www.policeforum.org/assets/docs/Subject_to_Debate/Debate2010/debate_2010_jul.pdf.

9 "The Revolution in Emergency Communications." Police Executive Research Forum. November 2017. https://www.policeforum.org/assets/EmergencyCommunications.pdf.

PERF's Early Adopter Forum on November 7, 2018

PERF began the current project in the summer of 2018, a few months after FirstNet went live with the initial build-out of the network and the launch of the FirstNet "core," a physically separate and secure infrastructure that supports the network.

While some police chiefs and other public safety leaders for years had been advocating a nationwide broadband network dedicated to public safety and had been following closely the development of FirstNet, others public safety leaders were unfamiliar with what FirstNet was, how it was different from the commercial networks that agencies were using, and how FirstNet could impact their operations.

This project is intended to address those issues in a straightforward, non-technical manner. This report summarizes our findings and observations.

For this report, PERF worked to assemble the questions, insights, and experiences of a wide range of public safety personnel. We reached out to "early adopter" agencies that were already using FirstNet; agencies that were in the process of adopting FirstNet; and those that were exploring whether FirstNet was an option for them. Because FirstNet is a public safety network, we included the perspectives of police and sheriffs' agencies, fire departments, emergency medical services, homeland security, and other departments.

Three Primary Information Sources

PERF used three primary approaches to gather information:

1. Online surveys and phone interviews
2. In-person discussion forums
3. Field-testing network performance

Online surveys and phone interviews

At the beginning of the project, PERF identified and interviewed a core group of individuals who understood mobile broadband technology and were exploring the adoption of FirstNet. Then, in preparation for in-person discussion forums, PERF collected online surveys and conducted phone interviews with approximately 100 PERF members and other public safety stakeholders.

The questions focused on how agencies were using mobile data technology, their primary considerations and expectations for a mobile broadband network, and their anticipated future uses and integration of mobile technologies into their operations. These surveys and interviews aimed to capture a wide range of agency insights and experiences, as opposed to being a representative snapshot of the overall experiences of the entire public safety community.

Several themes and issues emerged from the interviews and surveys. These included the growing importance of mobile data to public safety agencies, questions about coverage and capacity, and how FirstNet might impact day-to-day agency operations and the handling of major events.

In-person discussion forums

For this project, PERF conducted three in-person issues forums. The purpose of these meetings was to hear directly from public safety personnel about how their agencies are using FirstNet and to hold peer-to-peer discussions about a range of FirstNet issues among representatives of agencies that had adopted FirstNet, as well as agencies that had not done so.

Early Adopters Forum

PERF convened a national **Early Adopters Forum** in Washington, D.C. on November 7, 2018. Approximately 55 people representing 32 agencies and public safety stakeholder groups participated. It focused on identifying and understanding early FirstNet users' experiences during the first few months of the network's operations, as well as common issues or challenges those agencies had encountered.

LEFT TO RIGHT: The Southeast Regional Forum on March 28, 2019; the Western Regional Forum on October 3, 2019.

FirstNet in the Field Forum, Atlanta

The Southeast Regional Forum was held March 28, 2019, in Atlanta. Approximately 100 people representing more than 70 agencies and other public safety stakeholder groups participated. The forum focused on broad issues related to FirstNet implementation, as well as mobile data issues that were specific to the Southeastern United States.

For example, the meeting included first-hand accounts of using mobile data devices in response to Hurricane Michael, as well as the role of mobile data in managing public safety during the 2019 Super Bowl in Atlanta.

FirstNet in the Field Forum, San Jose, CA

The Western Regional Forum took place on October 3, 2019, in San Jose, California. Approximately 90 people representing more than 40 agencies and other public safety stakeholder groups participated. As with the Atlanta regional forum, this meeting covered a combination of general and region-specific issues. Agency representatives discussed FirstNet's role in the responses to Western wildfires, TeleHealth applications, and coverage issues in large expanses of remote and unpopulated areas, such as the desert Southwest.

Field-testing network performance

In addition to gathering ideas and experiences from a cross-section of public safety professionals, PERF worked to develop a way for public safety agencies to test the performance of FirstNet in the field. The goal was to develop a testing protocol that agencies could easily replicate in their jurisdictions.

Working with experts in mobile broadband communications, PERF created a methodology for testing the performance of mobile devices running on both the FirstNet network and major commercial carriers. PERF then conducted three sets of field-tests using this protocol during different real-world conditions that public safety officials encounter.

Two of the field-tests took place during major events when large numbers of people were trying to connect to mobile data networks at the same time in a relatively small geographic area. The other field-test took place under more typical operating conditions – that is, there were no exceptional pressures on the mobile data networks. This test was designed to replicate what a police officer might experience on a typical shift.

Additional details about the testing protocol and the test results are presented on page 24. More information and complete testing results are available in PERF's case study report.[10]

In addition to these primary sources of information, PERF monitored continuing developments with the implementation of FirstNet and conducted additional research for the case study reports. All of these sources informed this final report.

10 "Beyond Signal Strength: Measuring Performance of Public Safety Mobile Broadband Networks." Police Executive Research Forum. September 2019: https://www.policeforum.org/assets/FirstNetCaseStudy.pdf.

FIRSTNET EXPLAINED

Prior to 2018, public safety agencies had few options for mobile broadband services beyond those available to the general public.[11] To get the benefits of mobile voice and data access, agencies had to operate alongside business and individual customers using the same commercial networks.

When FirstNet was launched in March 2018, it established a new option for public safety agencies: a nationwide mobile broadband network created exclusively for police, fire, emergency medical services, and other public safety personnel, along with key public- and private-sector partners.

While the basic concept of FirstNet is fairly straightforward, how the network operates isn't necessarily well-understood by public safety leaders or front-line personnel. This chapter provides an overview of FirstNet – how it came into being, how it operates, and how the network has evolved in the three years since it went live.

FirstNet's Formation and Organization

In 2004, the final report of the 9/11 Commission identified shortcomings that affected public safety's response to the terrorist attacks.[12] One of those critical failures was the inability of first responders to communicate effectively with one another. Most communications networks were destroyed, overloaded, or otherwise not operating as needed.

The 9/11 Commission recommended that Congress enact legislation providing for the increased and expedited assignment of radio spectrum specifically for public safety purposes.[13] In 2012, Congress passed legislation authorizing the formation of the First Responder Network Authority (commonly known as the FirstNet Authority) to oversee creation of FirstNet – the first-ever Nationwide Public Safety Broadband Network (NPSBN).[14]

The newly created FirstNet Authority consulted with public safety stakeholders and other government leaders across the country to identify the needs and requirements for the NPSBN. That information provided the basis for a competitive

CONTINUED ON PAGE 11

11 A small number of public safety agencies had formed regional collaboratives that operated their own mobile broadband networks. For example, the Los Angeles Regional Interoperable Communications System (LA-RICS) has connected more than 30 jurisdictions in Los Angeles County on a common radio and broadband communications network. In 2018, LA-RICS began transferring its network to AT&T for integration into FirstNet. For more information about LA-RICS, see https://www.la-rics.org/.

12 "The 9/11 Commission Report." Available at https://www.9-11commission.gov/report/911Report.pdf.

13 For more information about the history of FirstNet, see https://firstnet.gov/about/history.

14 The Middle Class Tax Relief and Job Creation Act of 2012 designated 20 MHz of premium radio wave frequencies for the NPSBN and allocated $7 billion for building, operating, and maintaining the network. See https://www.congress.gov/112/plaws/publ96/PLAW-112publ96.pdf.

THE TWO SIDES OF THE FIRSTNET PUBLIC-PRIVATE PARTNERSHIP

The term "FirstNet" is often used to describe both the Nationwide Public Safety Broadband Network itself and the entity that manages the network. That entity is actually a public-private partnership consisting of two partners.

The Public Side of FirstNet

The First Responder Network Authority (also referred to as the "FirstNet Authority" or "FirstNet.gov") is an independent government authority within the U.S. Department of Commerce's National Telecommunications and Information Administration (NTIA). The FirstNet Authority is responsible for ensuring the development, construction, and operation of the Nationwide Public Safety Broadband Network.

The FirstNet Board is the governing body that leads the FirstNet Authority.[15] Its members are selected by the Secretary of Commerce for their expertise in public safety, technology, telecommunications, and financial management. The FirstNet Board also includes permanent membership seats for representatives of the Secretary of Homeland Security, the Attorney General, and the Director of the Office of Management and Budget. Day-to-day operations of the FirstNet Authority are directed by an appointed CEO and a team of professional staff.

The Public Safety Advisory Committee (PSAC) provides the FirstNet Authority with assistance and advice from frontline stakeholders in carrying out its statutory responsibilities. The PSAC includes representatives from approximately 40 associations representing 6 million public safety personnel, as well as local, state, tribal, and federal government.[16]

The Private Side of FirstNet

AT&T Inc. is a diversified, global company providing telecommunications, media and entertainment, and technology services. Consumers and businesses have more than 225 million monthly subscriptions to AT&T services. AT&T Communications provides more than 100 million U.S. consumers with communications and entertainment services across mobile and broadband platforms. In addition, the company has nearly 3 million business customers.

FirstNet Built with AT&T (also called "AT&T-FirstNet" or "FirstNet.com") is the private sector component of the FirstNet partnership.[17] It is responsible for building, managing, and maintaining the Nationwide Public Safety Broadband Network, as well as providing voice and data services to first responders using the network.

The Research Element of the FirstNet Partnership

The Public Safety Communications Research (PSCR) Division is part of the U.S. Department of Commerce's National Institute of Standards and Technology (NIST). The same legislation that authorized the creation of the FirstNet Authority and the NPSBN also directed NIST to allocate up to $300 million on research and development to advance and transform public safety communications capabilities.

As a result, the PSCR Division conducts research, development, testing, and evaluation of public safety communications technologies. PSCR also invests in addressing the critical public safety needs identified by practitioners in the field (see page 19 for more information).[18]

15. See https://firstnet.gov/about/board.
16. See https://firstnet.gov/about/psac.
17. See https://www.firstnet.com/.
18. See https://www.nist.gov/ctl/pscr.

CONTINUED FROM PAGE 9

Request for Proposals to deploy the network. The FirstNet Authority opened the RFP for bids in January 2016, and 15 months later announced that AT&T had won the 25-year contract to build and run the FirstNet network.[19]

FirstNet is structured as a public-private partnership, and the agreement between the FirstNet Authority and AT&T provides for the following:

- The FirstNet Authority is providing 20 MHz of high-value telecommunications spectrum to AT&T to operate the network. When project milestones are met, AT&T will receive payments of $6.5 billion over the first five years to support the network build-out. (FirstNet's funding was obtained from FCC spectrum auctions.)
- AT&T will spend about $40 billion over the life of the contract to build, deploy, operate, and maintain the network.
- AT&T will connect FirstNet users to the company's telecommunications network assets.

The full agreement includes 16 objectives that Congress and the FirstNet Authority expect AT&T to accomplish. In addition to building, operating, and maintaining the network, these objectives include developing device and application "ecosystems," building and maintaining systems for cybersecurity, integrating FirstNet with existing infrastructure, and customer service.[20]

Next, the FirstNet Authority developed customized plans for all 50 states, 5 U.S. territories, and the District of Columbia, which described how FirstNet would be deployed. Jurisdictions had 90 days to decide whether to opt-in with their state plan or develop their own dedicated mobile broadband network for public safety. All 56 jurisdictions decided to accept their plans for the FirstNet network. Those opt-in decisions did not mean that individual public safety agencies had to select FirstNet as their mobile broadband carrier. But they did make it easier and faster for FirstNet and AT&T to deploy a nationwide broadband network for public safety.

AT&T then began the process of building out the network. This involved readying cell towers, acquiring mobile communications assets called "deployables" and making them available to FirstNet subscribers (see page 13 for more information on deployables), and designing and deploying the FirstNet "core." The core is the highly secure infrastructure on which FirstNet operates. It ensures that public safety voice and data traffic is separated from commercial traffic and supports critical FirstNet functions. In March 2018, AT&T launched the FirstNet core, which provided public safety agencies with a new option for their voice and data communications.[21]

How the FirstNet Network Operates

In terms of basic technology, the FirstNet network operates in much the same way as other cellular networks. A cell phone or other mobile device emits a radio signal that is picked up by the nearest cell tower antenna. The signal is transmitted to a switching center that can route the request – either voice phone call or data request – to the requested device or network.

This basic process works smoothly when there's a limited number of people trying to access a cell tower at a time. However, when traffic increases, users are essentially queued-up to download and upload their data over the wireless connection to the antenna. The more people and data in the queue for a single antenna, the longer it takes for the data to travel to and from each user's mobile device.

19. "FirstNet Partners with AT&T to Build Wireless Broadband Network for America's First Responders." First Responder Network Authority (News Release). March 30, 2017. https://2014-2018.firstnet.gov/news/firstnet-partners-att-build-wireless-broadband-network-americas-first-responders.
20. For details on the 16 objectives spelled out in the FirstNet-AT&T agreement, see https://docplayer.net/23400960-Solicitation-no-d15ps00295-section-c-statement-of-objectives-c-statement-of-objectives-c-1-c-1-background-c-1.html.
21. "FirstNet Core Delivers on the Promise of a Dedicated Network for Public Safety." First Responder Network Authority (News Release). March 27, 2018. https://firstnet.gov/newsroom/blog/firstnet-core-delivers-promise-dedicated-network-public-safety.

If pressure on the network becomes too great, the service will slow or stop altogether. This is what can happen in an emergency when everyone in a small geographic area is trying to use their cell phone at the same time. Often, these are the very times – like on 9/11 or during natural disasters – when it is critical for public safety agencies to be able to access voice and data communications.

The FirstNet network has four key features that distinguish it from other networks:

- **Band 14, a special band of radio frequencies;**
- **Priority and preemption for public safety requests;**
- **The specially built FirstNet "core," or physical infrastructure; and**
- **Dedicated deployable equipment, such as trucks and airborne assets, that can bring additional wireless communications capacity to locations where it is needed.**

These features help to ensure that public safety personnel can get on and stay on the mobile broadband network, especially when it would be difficult or impossible to do so on other networks.

Band 14

Band 14 refers to a special range of wireless frequencies that the Federal Communications Commission (FCC) licensed to the FirstNet Authority specifically for use by public safety personnel using FirstNet. Band 14 resides in the 700 MHz band which, according to the FCC, is high-quality spectrum that can carry more data over larger geographic areas and penetrate buildings more easily. As PERF's field tests uncovered, mobile devices running on Band 14 had faster upload and download speeds and fewer service reliability issues than devices running on commercial networks (see page 24).

Priority and Preemption

FirstNet users have access to both Band 14 and AT&T's existing allocation of wireless spectrum for its commercial subscribers. By default, FirstNet subscribers will access Band 14 if it is available. But if for some reason Band 14 cannot be accessed or it's more efficient to use AT&T's commercial network, the FirstNet user is switched to the commercial network.

In this situation, public safety customers' voice or data requests move to the front of the line through the concepts of *priority* and *preemption*.

Priority allows a FirstNet user to skip past everyone else waiting to get on the network and become the *next* person in line. Priority allows public safety users to avoid the connection delays they might experience if there were a long line of people ahead of them trying to connect.

If, however, a large number of people are already on the network, then *preemption* comes into play. With *preemption*, a public safety user does not have to wait for another user to leave the network and free up space. Instead, that other user's connection may be slowed down or set aside to make room for the public safety user.

"It is important to test for Band 14 coverage in your jurisdiction with various devices. AT&T commercial coverage is a must-have to adopt FirstNet, but Band 14 enhances the experience along with the best priority and preemption. Your local AT&T network team should demonstrate Band 14 tower locations and coverage to ensure the best performance. The devices you use day to day also need Band 14 capabilities. Bottom line, Band 14 is a must-have, not just a nice-to-have."

— Interoperability Communications Manager Andy Smith San Jose (CA) Police Department

Priority and preemption are not at issue with Band 14, because Band 14 is a dedicated network for public safety. But these concepts are important when public safety users are accessing commercial networks along with everyone else.

The FirstNet Core

The "core" is the physical infrastructure that supports FirstNet. It can be thought of as the brain and nervous system of the network. The physical core runs on its own separate hardware. This allows public safety communications to be segregated from traffic on the commercial networks that consumers and businesses use.

The FirstNet core is also customized to address the public safety community's unique needs, such as end-to-end encryption and 24/7 security monitoring.

Deployables

To augment its permanent infrastructure of cell towers, antenna, and other hardware, FirstNet has a dedicated fleet of more than 100 mobile and airborne assets that are available on demand to FirstNet subscribers. These temporary cell sites are known as "deployables." They are strategically located throughout the country and can be dispatched to areas that do not have enough mobile data access at a time when first responders need it.

With all broadband networks, extra capacity can be needed for several reasons. Cellular infrastructure may not exist in a particular area, such as a remote mountain area experiencing a wildfire. In other locations, existing cell towers may be disabled or destroyed by fire, hurricanes, or earthquakes. Or existing cell towers may lack sufficient capacity because many users are simultaneously trying to connect to that same cell at the same time (such as an urban area hosting a large event).

Deployable cell sites typically connect back to the main network *via satellite* and can quickly establish new or additional mobile access almost anywhere.

FIRSTNET DEPLOYABLES

FirstNet has several types of deployables that are designed to meet the needs of public safety agencies in different situations:[22]

COWs (Cell on Wheels)

COWs are land-based deployables that can range in size from a "Compact Rapid Deployable" (small enough to roll through a doorway) to trailers that are towed to a site. These deployables broadcast Band 14 and WiFi to the surrounding area; the distance of their reach varies by size of the COW. Because they are compact, COWs can be maneuvered into some locations where larger deployables cannot be driven. During an early surge of COVID-19 cases in northern California, a FirstNet COW was deployed to a medical center to provide additional communications capacity and help keep physicians, ER nurses, and remote staff members connected.

SatCOLT (Satellite Cell on Light Trucks)

SatCOLTs are larger deployables, built on truck frames, that provide more extensive coverage than COWs. SatCOLTs are often used to support large pre-planned events, such as sports championships, or unplanned events such as natural disasters.

SatCOLTs can be loaded onto C-130 transport planes and flown to distant locations. AT&T-FirstNet provided this service following back-to-back hurricanes in Puerto Rico in 2018.

Micro SatCOLTs

These are small land-based vehicles that can be deployed and operated by a single technician. Micro SatCOLTs combine the agility of COWs with the coverage of larger SatCOLTs, making them particularly useful on the front lines of dynamic natural disasters like wildfires.

AT&T-FirstNet stationed the four Micro SatCOLTs in the Western United States to support the 2021 wildfire response.

Communications Vehicles

These are ruggedized, multi-purpose vehicles that provide connectivity to Band 14 and WiFi and can also serve as command vehicles during emergencies, training exercises, or other planned events. The vehicles have multiple monitors, a large exterior screen and speakers for conducting briefings, and sleeping and eating accommodations for longer term deployments.

Flying COWs

FirstNet has airborne deployables as well. Flying COWs are essentially aerial cell towers that use a pair of tethered drones that can broadcast Band 14 and

LEFT TO RIGHT: Cell-on-Wheels (COW), Satellite Cell on Light Truck (SatCOLT), and Communications Vehicle.

22. Further details and use cases of FirstNet deployables are available in PERF's case study report: "How FirstNet Deployables Are Supporting Public Safety." October 2020. https://www.policeforum.org/assets/FirstNetDeployables.pdf.

other signals. The drones can fly as high as 400 feet while receiving power and data through their tethered connections to a satellite-connected trailer on the ground. Flying COWs can operate for about 23.5 hours at a time before needing to be brought down for maintenance.

Aerostat

Dubbed "FirstNet One," this 55-foot blimp can operate from a height of about 1,000 feet, allowing the aerostat to cover a much wider area than other airborne or land-based deployables. (AT&T-FirstNet officials estimated that it would take 3 to 5 SatCOLTs to cover the geography of FirstNet One.)

FirstNet One is tethered to a deployable on the ground that supplies power and connectivity. This allows the blimp to operate for up to three weeks before it needs to be brought down for maintenance.

Following Hurricane Laura, which made landfall in Louisiana in August 2020, FirstNet One provided first responders with connectivity to support public safety activities and the restoration of normal operations.

How Deployables Are Managed

The deployables program is managed by the Response Operations Group of AT&T-FirstNet. This provides for a coordinated, nationwide response to the many requests for deployables that are received each year. The deployables are housed at more than 40 secure locations around the United States, which allows for the assets to be dispatched quickly and efficiently.

Deployables are available to FirstNet subscribers 24 hours a day, seven days a week. There is no charge to agencies requesting these assets. FirstNet deployables are supporting approximately 500 operations a year, including natural disasters and planned events.

Some Agencies Are Building and Using Their Own Deployables

To ensure availability of extra coverage and capacity in their jurisdiction, some FirstNet users have acquired their own deployables that can be connected to the FirstNet network. The Los Angeles Regional Interoperable Communications System (LA-RICS) used grant funds to purchase and outfit nine Cells on Wheels (COWs) that can be deployed to incidents where extra capacity is needed or areas where broadband coverage is spotty.

Scott Edson, Executive Director of LA-RICS, said the COWs are especially valuable for responding to fires. "When we have a fire in a remote area where FirstNet coverage may be limited, we can roll the deployables," he said. "They arrive right behind the firetruck, and we can set them up quickly. Since LA County Fire is a FirstNet user, we can have our FirstNet service available almost immediately." Edson said these additional assets are key in mutual aid responses.

AT&T-FirstNet's Customer Owned And Maintained (COAM) program allows agencies to purchase and operate their own deployables. However, all independent (non-FirstNet) deployables must undergo testing at the FirstNet Authority's Innovation and Test Lab in Boulder, CO.[23] And use of these deployables needs to be coordinated with AT&T-FirstNet to ensure that the mobile assets don't interfere with the existing FirstNet infrastructure.

LEFT TO RIGHT: Cell on Wings (Flying COW) and Aerostat (FirstNet One).

23. For more information about the FirstNet Innovation and Test Lab, see https://firstnet.gov/network/innovation-and-test-lab.

FIRSTNET BUILD-OUT

During PERF's regional meetings and other discussions with public safety leaders, probably the most frequently asked question was, "How good is the FirstNet coverage in my area?" Public safety agencies won't consider a new broadband network if it does not provide adequate coverage.

Status of the Build-Out

AT&T's contract with the FirstNet Authority requires the company to complete the build-out of the entire network by March 2023. When complete, the network will cover 2.74 million square miles, or 76% of the continental U.S. land mass, reaching more than 99% of the population.

It is likely that this goal will be met ahead of schedule. In September 2021, AT&T-FirstNet reported that 95% of its contracted build-out of the Band 14 network had been completed.[24] In many areas, Band 14 is being installed on new or existing AT&T cell sites, which provides additional coverage in densely populated areas. Officials also reported more than 2.8 million connections to FirstNet, representing approximately 18,500 public safety agencies.[25]

As the FirstNet build-out continues, emphasis is being placed on expanding coverage in rural areas. AT&T-FirstNet is installing more than 1,000 new cell sites as part of the initial FirstNet expansion to connect rural, remote, and tribal areas, which include locations without a strong cellular infrastructure. FirstNet is collaborating with local telecom providers in these areas to address rural coverage needs.

FirstNet also is working directly with individual agencies to identify and address coverage issues. Some agencies contacted by PERF said they regularly notify FirstNet of specific areas where greater coverage is needed.

5G and Other Network Enhancements

5G represents the 5th generation of mobile data technology. Though still in its early stages – most areas across the United States are not yet fully outfitted with 5G – its announcement has generated considerable interest among individual, business, and public safety users.

5G can handle data 10 times faster than 4G, and its latency – the lag time between initiating a command and the network responding – is almost imperceptible to the human senses. The biggest limitation of 5G, especially for public safety users, is that its radio waves can travel only short and unobstructed distances. The signals can have a hard time penetrating walls and other obstacles, and during inclement weather. What this

24. Jackson, Donny. "FirstNet buildout more than 95% complete, AT&T exec says." *ICWE Urgent Communications*. October 5, 2021. https://urgentcomm.com/2021/10/05/firstnet-buildout-more-than-95-complete-att-exec-says/.
25. Jackson, Donny. "FirstNet tops 2.8 million connections and 18,500 agencies after best quarter ever, AT&T says." *ICWE Urgent Communications*. October 21, 2021. https://urgentcomm.com/2021/10/21/firstnet-tops-2-8-million-connections-18500-agencies-after-best-quarter-ever-att-says/.

"There are areas where we don't have radio connectivity through our 800 MHz system. In some of the areas, we've lost coverage even with FirstNet. There's an app that we have on our phones. When an officer is in an area like North Duck where we might lose signal, they mark the spot on their phone, and the app lets FirstNet know that's an area that needs to be addressed."

— Chief (ret.) John Cueto
Town of Duck (NC) Police Department

means in practical terms is that 5G can provide fast data speeds over relatively short, open distances. So 5G networks will require larger numbers of small cellular base stations.

FirstNet is currently deployed over a 4G LTE (long-term evolution) network. 4G networks remain the primary broadband networks in the United States. Most voice, text, and data traffic is transmitted over 4G networks, a trend that is expected to continue for the next several years. Even as 5G becomes more prevalent, it will not entirely replace 4G LTE but will instead anchor to and build upon the existing network.[26]

FirstNet has begun making investments to ready the network for the next generation technology. In June 2020, the FirstNet Authority Board approved more than $200 million in network investments in two areas: expanding the fleet of deployables and funding the initial phase of a multi-year project to enable 5G services for FirstNet subscribers.[27]

An initial focus is upgrading FirstNet's dedicated core to enable 5G connections from FirstNet users. In addition, in April 2021 FirstNet users were given access to AT&T's mmWave 5G spectrum in parts of 38 cities and 20 venues across the United States.[28] In August 2021, AT&T announced that FirstNet subscribers in an additional 10 U.S. cities will have access to 5G.[29] In these areas, FirstNet users will continue to use the 4G LTE network for voice communications with priority and preemption. For data traffic, the FirstNet network will determine the better option, either 5G or 4G LTE spectrum.

5G has the potential to make smartphones faster and more powerful. 5G is also expected to drive major innovations in other types of connected devices for FirstNet and other mobile broadband networks, including drones, autonomous vehicles, and sensor technology.

FirstNet Devices

To take full advantage of FirstNet, mobile devices must be able to receive and transmit voice and data through the dedicated FirstNet core. Individuals cannot simply take a smartphone or other mobile device and "program" it to access FirstNet. Rather, devices must be outfitted with special FirstNet SIM cards, which give the devices access to the FirstNet network and the priority and preemption that come with the network. FirstNet SIM cards are provided only to verified public safety personnel.

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26. Tibken, Shara. "No, 5G isn't going to make your 4G LTE phone obsolete." *CNET*. July 12, 2019. https://www.cnet.com/tech/mobile/no-5g-isnt-going-to-make-your-4g-lte-phone-obsolete/.
27. "FirstNet Authority Board Approves Network Investments for 5G, On-Demand Coverage." First Responder Network Authority (News Release). June 17, 2020. https://www.firstnet.gov/newsroom/press-releases/firstnet-authority-board-approves-network-investments-5g-demand-coverage.
28. Parkinson, Edward. "FirstNet Partnership Kicks Off Fifth Year, Brings Initial 5G Investment to FirstNet." First Responder Network Authority (Blog Post). April 1, 2021. https://www.firstnet.gov/newsroom/blog/firstnet-partnership-kicks-fifth-year-brings-initial-5g-investment-firstnet.
29. Hill, Kelly. "AT&T extends 5G access to FirstNet customers in 10 more cities." *RCR Wireless News*. August 17, 2021. https://www.rcrwireless.com/20210817/5g/att-extends-5g-access-to-firstnet-customers-in-10-more-cities.

There are two classes of FirstNet devices:

- "FirstNet Ready" devices are capable of accessing the network right out of the box, once the FirstNet SIM card is installed.
- "FirstNet Capable" devices require software updates and may need to be "unlocked" before the FirstNet SIM can be installed.

As of August 2021, there were nearly 300 types or models of devices certified by FirstNet.[30] However, not all devices perform equally on all networks. For example, an iPhone XR specifically made to run on one network's service may not include the antenna required for a different company's network. As public safety agencies are making decisions about mobile broadband networks, they should keep in mind whether devices are able to access FirstNet and Band 14 if they are considering switching to FirstNet in the future.

While smartphones are the most common device that runs on FirstNet, the network supports many other types of mobile data devices, including tablets, laptops, smart watches, and other connected devices. Peripheral devices – such as automated license plate readers, drones, gunshot detection systems, mobile fingerprint scanners, and security cameras – become more useful when they can be connected remotely through a mobile broadband connection.

PERF's research found that some public safety agencies are using mobile routers running on FirstNet to turn their vehicles into mobile WiFi hotspots. This allows a wide range of mobile devices to run on FirstNet, even if those devices don't have a built-in connection.

FirstNet App Ecosystem

Under its agreement with the FirstNet Authority, AT&T-FirstNet is required to provide an applications (app) ecosystem that supports the Nationwide Public Safety Broadband Network with capabilities and services for public safety. Among other things, the FirstNet app ecosystem must include a portfolio of mobile and enterprise applications, as well as cloud services; an applications development platform and third-party applications developer community; an applications store; and security and privacy compliance for all users.[31]

Although most apps available through commercial app stores will work on FirstNet devices, the FirstNet App Catalog is a curated collection of mobile applications designed and vetted specifically for public safety users. As of August 2021, the App Catalog had approximately 175 apps for law enforcement, fire and rescue, Hazmat, emergency management, and other disciplines.[32]

Apps featured in the Catalog include the following:

- **Mapping tools** (including in-building and 3D visualizations);
- **Push-to-Talk** solutions;
- **Secure and encrypted messaging** and emergency alerts;
- **Remote fleet management** (automated vehicle locaters);
- **Remote access to records management** and other systems; and
- **Workforce management tools** that, among other things, allow personnel to submit paperwork remotely.

Other apps provide more specific functionality. For example:

- One app accesses a thin **sensor within an officer's body armor** to detect any time the armor is pierced (shot, stabbed, shrapnel) and report the officer's location.
- Another app allows a first responder to take a photo of an unconscious person and use facial recognition to help **determine the victim's identity** and emergency contact information.
- An app provides first responders with information about the **contents of specific freight railcars** in case there is a derailment or other incident.

30. See https://www.firstnet.com/content/dam/firstnet/white-papers/firstnet-certified-devices.pdf.
31. For details on the contractual requirements of the FirstNet Applications Ecosystem, see https://docplayer.net/23400960-Solicitation-no-d15ps00295-section-c-statement-of-objectives-c-statement-of-objectives-c-1-c-1-background-c-1.html.
32. For a link to browse the online App Catalog, visit https://www.firstnet.com/apps/featured-apps.html.

- Another app maintains a **registry of Automated External Defibrillators** (AEDs) in a community, along with other lifesaving resources such as bleeding control kits and naloxone, that are accessible to public safety personnel.

All apps in the FirstNet App Catalog go through a rigorous review process that includes checks for malware and other security vulnerabilities and assurances that the apps will meet the needs of the public safety community. These apps are "FirstNet Verified," meaning they have met a four-part test during review and evaluation. FirstNet Verified apps must:

- Be relevant for public safety use;
- Have garnered a high level of confidence that the app is highly secure;
- Use industry best practices for protecting access to, and sharing of, app data; and
- Have demonstrated a performance history of being at least 99.9% available.

Approximately 20% of the apps in the FirstNet App Catalog have achieved a more stringent designation of "FirstNet Certified." In addition to meeting or exceeding the criteria for being "FirstNet Verified," apps that are FirstNet Certified must also:

- Garner a higher level of confidence the app is highly secure;
- Demonstrate a performance history of even higher availability (99.99% versus 99.9%);
- Demonstrate an ability to be resilient in times of other system failures; and
- Demonstrate an ability to be scalable in times of peak demand.

Having public safety mobile apps listed in one place and reviewed for their reliability and performance helps to make the FirstNet app ecosystem useful to public safety agencies and attractive to app developers.

USING COMPETITION TO SPUR APP INNOVATION

FirstNet is helping to drive innovations in the mobile broadband technologies available to first responders and others in the public safety community. One example is the "Tech to Protect Challenge," which was hosted by the Public Safety Communications Research (PSCR) Division within the National Institute of Standards and Technology in 2019-20. This event was an innovations contest held online and in-person at 10 cities across the United States.

Each session brought together teams of entrepreneurs, technologists, students, programmers, designers, and public safety experts to create innovative mobile data solutions for first responders. Contestants were competing for nearly $500,000 in prize money. The PSCR named approximately two dozen Tech to Protect winners.[33] The winning projects included mobile tools for:

- High-quality evidence collection;
- Maintaining chain of custody using a block chain;
- Mobile triaging to improve the efficiency of EMS teams in the field during emergencies;
- Biometric monitoring and alerts using wearable devices, for public safety individuals and teams in the field;
- Verifying whether an app is sufficiently secure for sending sensitive medical information;
- Combining real-time resource mapping/tracking and push-to-talk communications;
- Hands-free voice assistance in the field.

Several of the projects developed through the competition are becoming commercially available.

33. "Tech to Protect Challenge Winners." Public Safety Communications Research Division, National Institute of Standards and Technology. https://www.nist.gov/ctl/pscr/tech-protect-challenge-winners.

GOVERNANCE: THE RULES OF HOW FIRSTNET WORKS

FirstNet is accessible to a range of public and private sector personnel beyond first responders – for example, parole and probation offices, emergency management agencies, and utilities in some instances. In addition, individual first responders can sign up to get FirstNet on their personal cell phones, even if their agencies are not FirstNet subscribers.

Even though the Band 14 network is broad and robust, it is still a finite resource. Setting up policies and procedures to establish who has priority access to the network, especially during large-scale emergencies when network usage will spike, is critically important, according to the experts that PERF consulted.

Who Is Eligible to Use FirstNet?

There are three types of FirstNet subscribers that must be accounted for when jurisdictions are planning their FirstNet implementation.

PRIMARY USERS are the core public safety personnel who act as first responders in emergencies and routine day-to-day public safety matters. These primary users are:

- Law enforcement officers,
- Firefighters,
- Emergency medical services personnel, and
- Emergency dispatch personnel.

EXTENDED PRIMARY USERS are public safety individuals, agencies, organizations, or for-profit companies that may be called upon to support public safety personnel (Primary Users) during an emergency. These personnel may be called in for mitigation, remediation, clean-up, or restoration during and immediately after a natural disaster or other emergency. Examples of FirstNet's Extended Primary Users include the following:

- Emergency Support & Private Security
  - Law Enforcement Civilian Personnel
  - Private Security
  - Courts
  - Corrections
  - Probation & Parole
- Broadcasting
  - Emergency Broadcasting
  - Amateur Radio Emergency Service (ARES)
- Utilities & Energy
  - Electric & Gas
  - Telecom
  - Water
  - Sewer/Waste
- Education – K-12/Higher Ed
- Hospitals/Public Health (non-EMS)
- Transportation
  - Public Transportation (Trucking, Bus, Rail, Air & Wheelchair Vans)

- Transportation Services (Departments of Transportation & Towing)
- Internet of Things (Devices & Alarms)

EXTENDED PRIMARY USERS WITH CRITICAL INFRASTRUCTURE RESPONSIBILITIES include a wide range of entities that may be called upon on a temporary basis to assist with different types of emergency situations. Because it is difficult to predict which roles could become critical when responding to a particular emergency, it is also difficult to define eligibility rules for Extended Primary Users with Critical Infrastructure Responsibilities. FirstNet uses a flexible approach in which local jurisdictions request that particular roles be given FirstNet access.

Who Gets Priority Access to FirstNet in an Emergency?

As more users and more devices join FirstNet, and as users find more ways to push more data over the network, it becomes necessary to prioritize among FirstNet users to ensure network access for the most critical personnel during major incidents or emergencies. Depending on the nature of the emergency, some people will need priority connections to the network. Others who may have little or no role in responding to that situation will not need privileged access to the network, especially if it comes at the expense of other first responders who are actively engaged in the response.

SETTING UP FIRSTNET GOVERNANCE AND PRIORITIZATION

Scott Edson is Executive Director of LA-RICS, the Los Angeles Regional Interoperable Communications System, which connects more than 30 jurisdictions in Los Angeles County on a common land mobile radio and broadband communications network. He has years of experience in managing public safety communications networks and is a strong advocate for strong governance of these networks.[34] He spoke at PERF's Western Regional meeting:

"You need to create policies, procedures, and guidelines that everyone follows. This already exists and is well-established for land mobile radio systems. Now you need to do the same thing for mobile broadband.

"When you have multiple agencies on a scene and everyone is trying to stream video, you're going to have issues. You need to have policies in place to dictate what should happen in this situation. In LA County, we have a mutual aid policy where the sheriff is in charge. We met with different cities to pre-plan responses and what should happen. Figure out what fits your jurisdiction and map it out.

Scott Edson

"Through FirstNet, you can set users at the highest priority of level 1 all the way down through levels 2, 3, 4, and 5. I recommend that governance needs to be set so that all new FirstNet users default to priority level 4, which is one level above commercial users.

"Priority levels also depend on the nature of an incident. For example, firefighters may get a higher priority, maybe level 2, when the emergency is a major fire. To make that happen, someone either needs to change those priority levels in a way that makes sense for the incident, or you can use an automated 'uplift' tool to assign the right people to higher priority levels."

(See "The FirstNet Uplift Tool," page 22.)

34. For an overview of LA-RICS governance, visit https://www.la-rics.org/governance-overview/.

To address these governance issues, FirstNet allows local jurisdictions to set the rules for who should have priority access to FirstNet under different circumstances. When they first join the network, all FirstNet users are assigned a priority level from 1 (highest priority) to 5 (lowest priority). This system helps to ensure that the individuals with the greatest need can connect to the network, especially when traffic on the network surges.

The experts PERF consulted agreed that it is critical for jurisdictions to establish their local governance structures and procedures ahead of time, before an emergency occurs. As one police chief said, "You don't want to be handing out your business cards on the day of an emergency."

The FirstNet Uplift Tool

While new FirstNet subscribers are initially assigned a priority level, FirstNet allows jurisdictions to make changes to priority levels "on the fly" to meet the unique needs of any situation. This is accomplished through a device called the Uplift Tool.

For example, firefighters would be given highest priority when battling a high-rise fire. If the situation also involved a gas leak explosion, personnel from the local gas company may also have their priority lifted.

The Uplift Tool can be especially helpful when FirstNet users from outside the jurisdiction arrive on-site to assist, or when an otherwise low-priority user is a primary responder to an emergency situation. In these situations, it is especially important that these users' priority levels get raised quickly to ensure they are able to stay connected to the network.[35]

> "Snowplows can be mission-critical when a city has three feet of snow."
>
> — **Assistant Chief Mike Baltrotsky Montgomery County (MD) Fire and Rescue Service**

Individual First Responder Subscriptions

One unique aspect of FirstNet is that individual first responders who are part of the Primary Users category can subscribe to FirstNet on their personal mobile devices, even if their agency has not subscribed to the network.

To qualify, these "subscriber-paid users" must:

- Be current employees of, or active auxiliary volunteer personnel affiliated with, a qualified public safety entity;
- Provide services or perform functions in the areas of law enforcement, fire protection, emergency medical services, emergency (9-1-1) call dispatch, or emergency management for the qualified public safety entity; and
- Subscribe to the service under individual FirstNet accounts.

These individual subscriptions expand the number of front-line personnel who have priority access to FirstNet on an ongoing basis. This can be beneficial, provided the first responder is permitted to use his or her personal device for work. (See page 38 for a discussion of using personal devices for work-related activities.)

This setup also creates some governance issues that jurisdictions need to address. For example, should individual first responders be required to "register" their FirstNet devices with their agencies? What types of official business are first responders permitted to carry out on their personal devices? And if an individual is off-duty but near the site of a major event that is generating a lot of network traffic, how can the jurisdiction adjust that person's priority level, since they aren't part of the response? Or if they are responding off-duty, how can their priority level be increased?

Experts told PERF that jurisdictions need to consider these types of issues related to subscriber-paid users when developing their FirstNet governance plans.

35. For more information about the FirstNet Uplift Tool, see Kerr, Randy. "FirstNet Uplift Request Tool Provides Support During Extreme Network Congestion." First Responder Network Authority (Blog Post). June 29, 2021. https://www.firstnet.gov/newsroom/blog/firstnet-uplift-request-tool-provides-support-during-extreme-network-congestion.

THE FIRSTNET AUTHORITY ROADMAP

In addition to overseeing the initial rollout of the FirstNet network, the FirstNet Authority is also charged with managing the growth, evolution, and advancement of the network. To help guide this process, the Authority published its "Roadmap," a 32-page report that serves as a FirstNet strategic plan for the next five years.[36]

Initially released in 2019 and updated in 2020, the Roadmap was developed with input from public safety agencies, industry and government representatives, and AT&T-FirstNet. The FirstNet Authority held more than 1,600 engagements with the public safety community in 2019 and 2020 and conducted industry outreach and research to better understand technology trends and advancements. The Roadmap provides a broad view of public safety's operational needs and technology trends for mobile broadband communications.

The Roadmap is structured around six "domains," which represent network capabilities that are critical to police, fire, and other public safety agencies. These domains are designed to help the FirstNet Authority prioritize future programs, resources, investments, and partnership activities.

1. **THE CORE:** The services and capabilities of FirstNet's physical backbone, or core.
2. **COVERAGE:** FirstNet's coverage and performance to meet public safety needs in their communities.
3. **SITUATIONAL AWARENESS:** Combining and analyzing data from multiple sources to provide real-time information about what is happening.
4. **VOICE COMMUNICATIONS:** Supporting easy and effective conversations among public safety officials within and across different public safety agencies, jurisdictions, and technological platforms.
5. **SECURE INFORMATION EXCHANGE:** Securely and conveniently accessing, exchanging, and managing data within and across different public safety agencies, jurisdictions, and technological platforms.
6. **USER EXPERIENCE:** Tailoring FirstNet's capabilities, features, devices, and applications to meet the unique needs and requirements of first responders and other public safety officials.

The 2020 version of the First Responder Network Authority Roadmap identifies updated priorities for each of the six domains.

36. "First Responder Network Authority Roadmap." First Responder Network Authority. www.firstnet.gov/system/tdf/Roadmap_2020_nocompress.pdf?file=1&type=node&id=1612.

TESTING NETWORK COVERAGE AND PERFORMANCE

While FirstNet is the nationwide mobile broad-band network dedicated to public safety, there is no requirement that individual agencies subscribe to the network. Police, fire, EMS, and other agencies have a choice of which mobile broadband carrier they use – either FirstNet or a private commercial carrier.

When PERF asked public safety officials to define their most important factors in selecting a mobile broadband carrier, they almost universally identified two issues: network coverage and performance. Officials said that factors such as security, network management, access to mobile applications, and other issues were important considerations, but knowing that their mobile devices could consistently connect to the network and that they could upload and download data quickly and reliably were the paramount concerns.

Testing Performance from the Perspective of the User

How do public safety agencies test the coverage and performance of broadband carriers in their jurisdictions? There are some common ways that agencies can answer that question, but PERF's research found shortcomings in many of them.

Coverage maps

Coverage maps provide a broad overview of the extent to which a broadband network is built out in a particular geographic area. Coverage maps tell you whether your devices *should* be able to connect to the network from a particular location. But these maps cannot guarantee that a device will be able to connect from that location, nor can they indicate how well the device will perform.

Signal strength

This measurement, often depicted as the number of "bars" displayed on a smartphone or tablet, provides some indication about whether a device *will connect to the network*. But unlike land mobile radio networks, where the strength of the radio signal is the determining factor, PERF's research found that more bars on a mobile device did not necessarily translate into better *performance* on a mobile broadband network. Having a strong connection does not necessarily mean that a device will be able to send or receive large quantities of data quickly and efficiently. This is especially important when first responders want to share video footage or other content that requires large amounts of data.

Network tests

Agencies can commission testing of broadband services using sophisticated equipment and methodologies, but these approaches can be expensive

"For our FirstNet testing, we took something seemingly complex and just made it easy for our first responders. We brought FirstNet to the department, sent it to those on the front lines and said, 'Let us know what you think.' We empowered our people to tell us what they experienced using FirstNet. I would encourage decision makers to roll it out to your people and just see what they think and how it performs for them."

— Chief (ret.) Sylvia Moir
Tempe (AZ) Police Department

and time-consuming, and the results can be overly complicated for key decision-makers.

In addition, these tests may not be able to account for all of the ways that public safety personnel use their devices, which can influence the results. For example, a smartphone may lose its signal because of how it is situated on an officer's belt while they're driving.

The key to obtaining simple and useful test results is to focus on the perspective and experiences of the end-users – the police officers, firefighters, EMTs, and other first responders who use the network.

Straightforward tests that closely mirror an agency's real-world, daily use patterns will produce results that reflect what that department should experience if it subscribes to a particular mobile broadband provider. Some agencies have found that simply using the same types of devices from different carriers and using mobile apps to measure certain indicators can sufficiently test coverage and performance in most circumstances. However, it is important that the tests measure the right things, or else the results will not be helpful and may even be misleading.

As it was evaluating the suitability of FirstNet, the Tempe, AZ Police Department empowered its employees to conduct straightforward performance tests designed to mirror the everyday experiences of its personnel. Using an app called Speedtest on devices operating on FirstNet and another carrier, personnel went to various locations around the city to see how fast data could load on the devices.[37] This provided the department with real-time results that were easy to capture and analyze.

It's important to test coverage and performance at many different locations, and to conduct testing for every public safety agency in a jurisdiction. Two agencies in the same jurisdiction can have completely different experiences based on where and how they typically operate. That is what the police and fire agencies in the Modesto, CA area discovered when they conducted side-by-side tests of FirstNet and the carrier they had been using, using the Speedtest app.

In Modesto's case, FirstNet had better connectivity and performance within the city limits where the police department operates. However, the county's Consolidated Fire Protection District covers both the city and areas of the Central Valley, which include mountains and low-lying hills. At the time of the tests, FirstNet did not perform as well as the existing carrier in those more remote areas. So the police department signed a contract to adopt FirstNet, while the Fire Protection District decided to stay with its current provider and monitor the FirstNet build-out in the area.

PERF's Testing Protocol

While the simple side-by-side tests using apps such as Speedtest can provide jurisdictions with basic information for comparing carriers, that approach may not be sophisticated enough for some jurisdictions that want a more detailed examination of broadband network coverage and performance.

For this project, PERF sought to develop a robust, accurate, and easy-to-use protocol that public safety agencies could employ for testing coverage and performance in their own jurisdictions.

Given the technical nature of this work, PERF enlisted the help of subject matter experts in telecommunications and mobile broadband operations.[38] The rest of this chapter summarizes our findings.

37. See https://www.speedtest.net/apps.

38. More detailed information about the testing procedures and specific results from the test sites can be found in PERF's case study report: "Beyond Signal Strength: Measuring Performance of Public Safety Mobile Broadband Networks." September 2019. https://www.policeforum.org/assets/FirstNetCaseStudy.pdf.

How to structure a coverage and performance test

PERF followed a few key principles in designing the testing protocol:

- All tests should adhere as closely as possible to the conditions that police officers, firefighters, EMS personnel, and others experience in the field. To get useful results, you have to mirror the real-world operations of public safety personnel.
- Tests should use only equipment or services that are available for a department to deploy in the field. Test results for a service or application that you cannot purchase or use on a regular basis are not useful in making decisions about broadband networks.
- Similarly, performance can vary widely across types of devices, so testing should be conducted only with devices that your agency uses. If your agency uses iPhones, tests should be conducted using iPhones.

Use devices that your agency already has

The first step in conducting a test is to obtain samples of the types of devices the agency will be using in the field. This could include one or two models of smartphones, tablets, and possibly an in-vehicle router. These will need to run on each of the service options the agency is considering – mostly standard commercial carriers, possibly any restricted or special alternative services from those providers, and FirstNet (for either the Band 14- or non-Band 14-capable devices).

For its performance tests, PERF used a combination of Samsung S9 phones and Apple XR iPhones. These were relatively current models at the time the tests were conducted in 2019. Two of the devices – one Samsung, one Apple – ran on FirstNet. The other six devices operated on three major commercial networks.

Screenshot of NetMonitor Pro

Off-the-shelf apps can support rigorous testing

After obtaining the devices and services, the next step is to assemble the apps needed to collect the data to be analyzed.[39] There are three important metrics included in PERF's protocol.

NETWORK CONNECTION. PERF wanted to measure various aspects of each device's connection to the network, including signal strength, the radio frequency band being accessed, GPS location, and more. PERF wanted to know which radio band the devices were accessing in order to assess (1) how often FirstNet devices were accessing Band 14 (the spectrum that FirstNet dedicates to public safety) and (2) how devices operating on Band 14 performed when compared to devices on other bands.

For these measurements, PERF used an app called NetMonitor Pro. One benefit of this app is that it can take measurements at short intervals, which can provide more detailed data for analysis. PERF set up NetMonitor Pro to capture signal strength and other network connection data every five seconds on each phone.[40]

DATA UPLOAD AND DOWNLOAD SPEEDS. A key measurement of network performance is data upload and download speeds – in other words, how fast a data file could be uploaded from a mobile device to the Internet and how fast a file could be downloaded from the Internet to the device. For this protocol, PERF used an app called SpeedCheck Pro to measure upload and download speeds by megabits per second (Mbps). Conveniently, the app can be set to run tests automatically in the background on a

39. The apps used in PERF's testing protocol were selected because they are readily accessible and inexpensive (or free) and have been found to perform well. There are other apps that can provide similar functionality.
40. Signal strength was collected on the Samsung S9 devices only; automated signal strength tests were not available for the Apple iPhones at the time of the tests.

set schedule of intervals, which makes testing much easier. For its field tests, PERF set up SpeedCheck Pro to run automated upload and download samples on each smartphone at five-minute intervals.

For these tests, PERF established a "pass rate" threshold. Any tests that did not achieve 5 Mbps download or 2 Mbps upload were considered to be unreliable, as they failed to meet a basic level of what public safety personnel would expect in the field.[41]

IMAGE TRANSFER. Another important measure of network performance is how long it takes to transfer an image to a mobile device, something that public safety personnel routinely do in the field. For this protocol, PERF downloaded a 20MB file from a website at 15-minute intervals and tracked how long it took to fully render the image on the smartphone. A 20MB file generally aligns with the typical file sizes first responders work with, such as building floor plans or photos of a missing person.

When mobile devices download the same file multiple times, the device typically provides a shortcut to the website so that the file loads much faster on the second and subsequent downloads. To mitigate this issue, PERF used the DuckDuckGo Privacy Browser, which makes it easy to clear the shortcut after each download. As a result, each file download in the PERF tests mirrored the file being downloaded for the first time, as it would be for public safety personnel in the field.

Three sets of field-tests were conducted

Using this testing protocol, PERF conducted three separate field-tests in early 2019. The tests involved simultaneously monitoring multiple smartphones running on different networks – both commercial and FirstNet – to collect data on various performance measurements in different locations and under different conditions.

These field-tests were designed to simulate working conditions and scenarios in which first responders would need access to a mobile data network. Importantly, all of the tests were designed to gather information from the perspective of the user – the police officer, firefighter, or EMS technician operating in the field.

TWO LARGE DEMONSTRATIONS: The first two field-tests took place in January 2019 in Washington, D.C., during two large-scale marches: the annual March for Life on January 18, and the Women's March on January 19. Each of these demonstrations attracted tens of thousands of people to areas along the National Mall, the U.S. Capitol, and downtown Washington, D.C. They provided a laboratory for testing the performance of FirstNet and commercial networks during periods when large numbers of people were trying to connect to mobile data networks at the same time in a relatively small geographic area.

For both for these events, two teams of testers were deployed; each team was equipped with a selection of the devices being tested. One team was embedded in the middle of the crowds, to replicate the experience of a police officer, firefighter, or EMS worker responding to an incident in the middle of a large event. The second team stayed on the immediate periphery of the marches, outside the densest parts of the crowds but close enough to the primary activity. This was designed to mirror the experience of first responders who might be monitoring events but not fully embedded in them.

EVERYDAY OPERATING CONDITIONS: PERF's third field-test took place under more typical operating conditions – that is, there were no exceptional pressures on the mobile data networks. This test was designed to replicate what a police officer might experience on a typical shift.

On March 11-12, 2019, PERF staff members rode in a patrol vehicle with members of the Camden County, NJ Police Department. Over the course of the two days, the vehicle traversed the vast majority of the city's streets and a number of alleys. The routes were aligned with Camden's police districts, so that data would reflect how and where officers patrol. In addition, separate tests were run on highways and interstates within the

41. The download speed of 5 Mbps represented a threshold for successfully streaming relatively high-resolution video (such as from a fixed security camera); the upload speed of 2 Mbps represented a threshold for successfully streaming lower-resolution video (such as from a dash-camera).

UPPER LEFT: March for Life, Washington, D.C., January 18, 2019

UPPER RIGHT: Women's March, Washington, D.C., January 19, 2019

LEFT: Drive-Test Data Example, Camden, NJ, March 11-12, 2019

city where patrol vehicles would travel at higher rates of speed, posing additional challenges for broadband systems.

As with the two field-tests in Washington, D.C., the PERF team ran the same tests and collected the same types of data by monitoring the various smartphones accessing FirstNet and the commercial networks. It's important to note that the purpose of these tests was not to evaluate individual carriers, but rather to validate the testing protocol and to see how FirstNet performed in relation to commercial networks generally. In the analysis, results for the three major commercial carriers that were tested were aggregated into overall averages.

Summary of Testing Results

In all, PERF collected and analyzed approximately 118,000 test samples: 80,000 during the two days of drive-testing in Camden and 38,000 during the two large-scale marches in Washington, D.C. A summary of the analysis follows.

It is important to note that these results represent what PERF documented at these particular locations at these specific times. Running similar tests at different locations – or even the same locations at different times – would not necessarily produce the same results. That is why it is critical for agencies to conduct performance tests in their own jurisdictions that mirror the conditions under which their public safety personnel operate.

Camden, NJ Drive-Test Results

PERF examined five key metrics from the two days of drive-tests in Camden:

SERVICE RELIABILITY. This was a simple assessment of whether a device was connected to its network during each five second-interval test. If a device was unable to receive or send data during a test, it was considered non-operational for that sample and the result was recorded as a service reliability failure.

All of the devices in the drive-tests had service reliability measures of 95% or greater (see Figure 1). One of the FirstNet phones and one of the commercial carrier phones each had 100% service reliability. There were relatively few service outages on any of the devices during the drive-tests.

DOWNLOAD AND UPLOAD PASS RATES. As noted earlier, PERF assigned a minimum threshold or "pass rate" of 5 megabits per second (Mbps) for data downloads and 2 Mbps for data uploads. On this metric,

the FirstNet devices generally outperformed the commercial network devices combined. FirstNet phones met the download threshold 95% of the time and the upload threshold 87% of the time. The commercial devices met the thresholds in 82% of the download tests and 76% of the uploads.

DOWNLOAD AND UPLOAD SPEEDS. On average, FistNet devices had faster download and upload speeds than the devices operating on the commercial carriers. The download speed was approximately 46 Mbps on the FirstNet phones and 38 Mbps on the commercial network devices. Upload speeds were approximately 12 Mbps on FirstNet and 10 Mbps on the other networks combined (see Figure 2).

IMAGE TRANSFER SPEED. Devices operating on FirstNet were able to download the 20 MB file almost twice as fast as the commercial network phones: just over 11 seconds, vs. approximately 20 seconds.

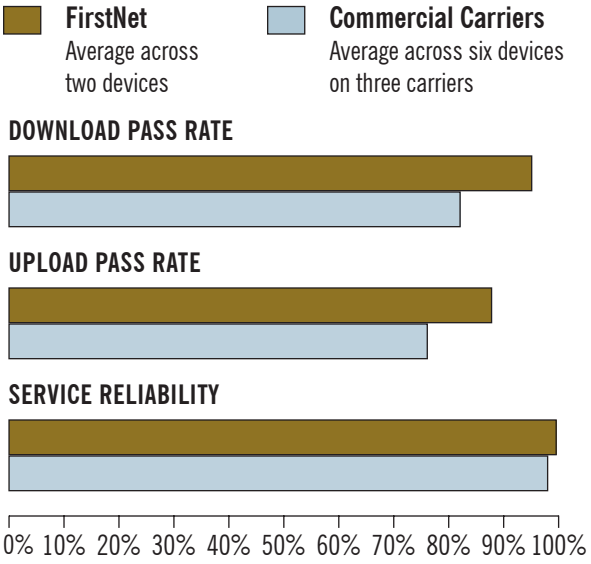
BAND 14 DETECTION. Band 14 was detected in only about 32% of the samples taken on the FirstNet phones over the two days. (In large part, this reflected the extent to which the FirstNet network had been built-out in the Camden area in March 2019.) In the other 68% of the samples, the FirstNet phones accessed the AT&T commercial network with priority and preemption. Even though these devices were hitting Band 14 less than one-third of the time, they still generally outperformed the commercial networks on data upload and download speeds and image transfer rates.

Washington, D.C. Major Event Test Results

PERF examined the same key metrics for the tests run at the two major events in Washington, D.C. Because the two marches were both high-capacity events that shared the same basic characteristics – that is, large crowds in a concentrated area for a defined period of time – PERF analyzed the data from the two events in tandem.

Figure 1. Performance and Service Reliability

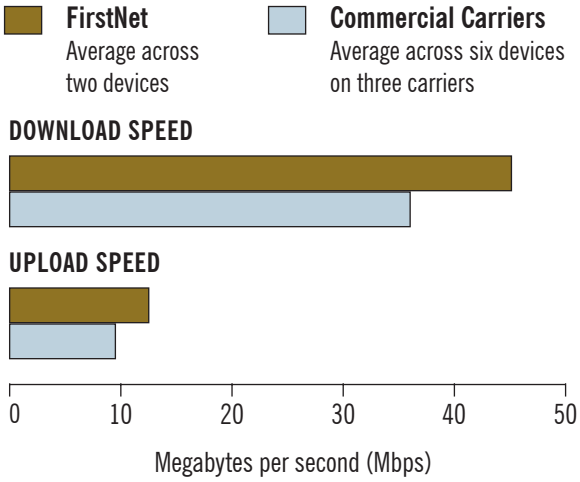
Drive Testing, March 11-12 – Camden, NJ



Notes: The pass rate thresholds were a minimum of 5 Mbps for data downloads and 2 Mbps for uploads. Service reliability measures the percentage of sample tests in which a device was able to receive or send data.

Figure 2. Download and Upload Speeds

Drive Testing, March 11-12 – Camden, NJ



SERVICE RELIABILITY. Unlike the drive-tests in Camden, NJ, where all devices – FirstNet and commercial networks – had high service reliability marks of 95% or greater, the devices tested during the two major events experienced more numerous reliability failures (i.e., the device was unable to receive or send data during the tests run every five seconds).

On average, the commercial devices passed just 37% of the service reliability tests, an indication of the pressure these events put on cellular networks. The FirstNet devices passed 88% of the reliability tests over the two days (see Figure 3).

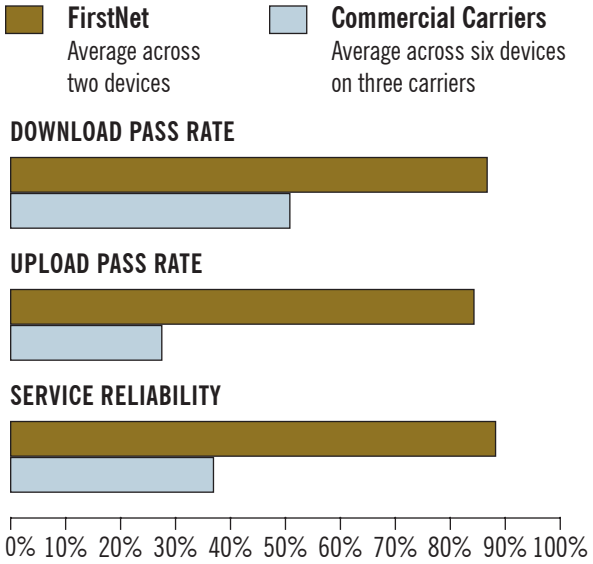
DOWNLOAD AND UPLOAD PASS RATES. The FirstNet devices also met the thresholds for data downloads (5 Mbps) and uploads (2 Mbps) at much higher rates than the commercial networks combined. For both data downloads and uploads, the FirstNet phones met the thresholds more than 85% of the time. The commercial devices met the download thresholds in about 55% of the tests and the upload threshold in fewer than 30% of the tests (see Figure 3).

DOWNLOAD AND UPLOAD SPEEDS. For both events, download and upload speeds were faster on the FirstNet devices than on the average of devices running on commercial networks. Given the size of the two events, all of the networks, including FirstNet, experienced some variability in upload and download speeds during the two days of testing. Overall, downloads and uploads on FirstNet were approximately two times faster than on the commercial networks (see Figure 4).

IMAGE TRANSFER SPEED. The FirstNet devices were also significantly faster at being able to transfer an image file. During the Women's March, for example, FirstNet phones averaged less than 10 seconds in transferring the 20 MB image file.

Figure 3. Performance and Service Reliability

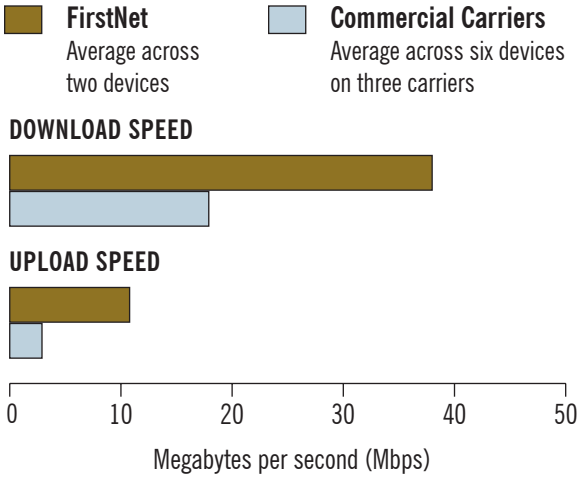
March for Life, January 18, 2019 and Women's March, January 19, 2019 – Washington, DC



Notes: The pass rate thresholds were a minimum of 5 Mbps for data downloads and 2 Mbps for uploads. Service reliability measures the percentage of sample tests in which a device was able to receive or send data. For the Women's March, only five devices on the three major commercial carriers were tested.

Figure 4. Download and Upload Speeds

March for Life, January 18, 2019 and Women's March, January 19, 2019 – Washington, DC



Note: For the Women's March, only five devices on the three commercial carriers were tested.

Combined, devices running on the commercial networks were about 3.5 times slower.[42]

BAND 14 DETECTION. Band 14 was detected in 46% of the samples on the FirstNet phones during the March for Life and 84% of the samples during the Women's March. The Women's March covered a much smaller geographic footprint than the March for Life, and Band 14 was more prevalent in that part of downtown Washington, D.C. At the March for Life, most of the Band 14 detections occurred at the beginning of the event, when people were gathered at the main stage on the National Mall. To boost coverage and capacity at this location, AT&T-FirstNet had placed a Cell on Wheels (COW) deployable. (See page 13 for more information about FirstNet deployables.) Again, when Band 14 was not detected, FirstNet devices had to access AT&T's commercial network. Even then, FirstNet phones were consistently more reliable and faster than the phones on commercial networks, which were experiencing extremely high traffic during these events.

It's About More Than Signal Strength

These three field-tests produced another significant finding: A stronger signal – more bars on a smartphone or other mobile device – does not necessarily translate into better performance on a mobile broadband network.

For example, during the drive tests in Camden, NJ, the Samsung S9 device operating on FirstNet generally had a weaker signal than the S9 devices operating on commercial networks. However, the FirstNet device had generally faster data upload and download speeds and was able to transfer images faster and more reliably. Throughout the two marches in Washington, D.C., PERF found that all devices (both commercial network and FirstNet) had generally strong signals. However, the FirstNet devices were found to have faster throughput and greater service reliability. These findings were especially pronounced when the FirstNet devices were operating on Band 14.

AS THEY ADDRESS COVERAGE ISSUES, SOME AGENCIES RUN DUAL NETWORKS

In our research, PERF heard from several agencies that were maintaining their existing mobile broadband carrier even as they began implementing FirstNet. Some agencies wanted to ensure redundancy in case there were issues with either network. Other agencies found coverage and performance varied by location within their jurisdiction: one network may work better in a more urban area, while the other network excels in more remote areas.

Such was the case with the Santa Clara County, CA Fire Department when it began using FirstNet in 2018. Fire Chief Tony Bowden explained their thinking during PERF's Western Regional meeting:

> *"We serve seven of the 15 cities in Santa Clara County, and the areas are quite different. We have urban areas such as the city of Campbell, and very rural and mountainous areas. So coverage has always been an issue with us, regardless of carrier. We have some areas where we have difficult coverage issues.*

> *"We began implementing FirstNet, and right now, about 60% of our fleet has transferred over. But a lot of our fleet is running two carriers – FirstNet and another major carrier – for redundancy, because we still have some spots that have coverage issues.*
>
> *"Our litmus test is always the experience of the crews. It's always going to be the officers or the firefighters that are using it daily. They rely heavily on a lot of web-based applications."*
>
> **— Chief Anthony Bowden**
> **Santa Clara County (CA) Fire Department**

42. At the March for Life on January 18, 2019, PERF used a 40 MB file for the image transfer tests. Across networks, this file size produced a larger-than-expected number of failures (downloads that exceeded two minutes). For subsequent tests, PERF used a 20 MB file, which is more in line with typical files sizes that first responders deal with in the field.

HOW FIRSTNET SUPPORTS DISASTER RESPONSE AND MAJOR EVENTS

When major incidents such as natural disasters, major demonstrations or attacks, or large-scale planned events occur, wireless communications in general, and public safety communications specifically, are often disrupted. Congress authorized the creation of FirstNet in order to establish a dedicated system that allows police, fire, EMS, and other first responders to communicate with each other during critical incidents.

Throughout this project, PERF heard from public safety agencies about how FirstNet helped them restore data and voice communications following natural disasters and maintain communications during large-scale planed events. In many of these situations, a key element in maintaining communications was the FirstNet deployables program, which can send mobile communications assets to an area experiencing network outages. (See page 13 for more information about FirstNet deployables.)

Following are a number of early case studies of events in which FirstNet supported disaster response.

Severe Weather Events

Hurricanes, tropical storms, and tornadoes often interrupt or disable cellular communications. For individuals and businesses, these disruptions can be annoying and costly. For public safety users, communications failures can be dangerous and interfere with their efforts to protect the public.

Over the past three years, FirstNet has been called on to assist in the response to numerous severe weather events. In most instances, FirstNet deployables have been dispatched to support the voice and data communications needs of police, fire, and other first responders. Two examples were discussed at PERF's meetings for this project.

Hurricane Michael in October 2018

Hurricane Michael was the first Category 5 hurricane to hit the continental United States since Hurricane Andrew in 1992, making landfall on the Florida Panhandle on October 10, 2018. The town of Mexico Beach, Florida (population 1,500 at the time) took a direct hit. Of the nearly 1,700 buildings in the city, approximately 800 were destroyed and another 800 were damaged.[43]

Mexico Beach Police Chief Anthony Kelly sent his officers out of town to ride out the storm, and they planned to meet at a designated location

43. Beven, John; Berg, Robbie; and Hagen, Andrew. "Tropical Cyclone Report: Hurricane Michael." National Hurricane Center. May 17, 2019. https://www.nhc.noaa.gov/data/tcr/AL142018_Michael.pdf.

five hours after impact. For the next 48 hours, in-person communication was the only option for the officers.

Chief Kelly contacted the county Emergency Operations Center, which was able to provide the Mexico Beach Police Department with cellular phones operating on FirstNet, even though the department was not a FirstNet subscriber. Chief Kelly said the phones allowed his officers to communicate and keep track of one another. In addition, the phones enabled officers to take and share photos and video that could be used for situational awareness and documentation of the damage. Officers also had access to mapping applications, which enabled them to conduct search-and-rescue efforts more accurately and effectively.

Mexico Beach and other communities hit by Hurricane Michael were able to regain communications after FirstNet-dedicated SatCOLTs (satellite cell on light trucks) were deployed to several parts of Florida and Georgia. In addition, a Flying COW (cell on wings) was deployed over the ground in Mexico Beach and other parts of the Panhandle to support communications.

Hurricane Florence in September 2018

A month before Hurricane Michael, Hurricane Florence made landfall on September 14, 2018, as a Category 1 storm along the southeastern coast of North Carolina. The large, slow-moving storm dumped huge amounts of rain as it pushed inland. Officials in Whiteville, NC, a city of 5,400 people located almost 50 miles west of Wilmington, recorded up to two feet of rain.[44]

The flooding caused extensive damage to much of Whiteville's infrastructure. The storm knocked out its land mobile radio system, which left Whiteville first responders without their primary means of voice communications.[45]

Three months earlier, in June 2018, Whiteville had become the first municipality in North Carolina to sign up for FirstNet, and the network remained operational throughout Hurricane Florence and its aftermath. To maintain voice communications, police and other public safety personnel used the enhanced push-to-talk service on their FirstNet smartphones.

While the FirstNet devices worked well for voice, data transmissions over the network were initially slow. Hal Lowder, Whiteville's Director of Emergency Services, said he contacted AT&T-FirstNet, which sent a SatCOLT to boost capacity and coverage in the area. "It was like flipping on a light switch," Director Lowder said at PERF's Early Adopter Forum. "Everything on the data side started to work."

Western Wildfires

In recent years, the number of wildfires in the United States has been fairly constant, but the intensity of the blazes and the number of acres burned have increased dramatically.[46] These fires, especially those in California and the Pacific Northwest, have required large numbers of personnel from multiple agencies. For example, more than 1,000 first responders were deployed to the 2021 Bootleg Fire in Oregon.

Because many of the largest fires occur in remote areas, the existing cellular infrastructure – either commercial networks or FirstNet – is often limited. Capacity on commercial networks is often used up by local residents and businesses trying to connect with the outside world.

PERF's research found that today's fire agencies are relying more on smartphones, tablets, and other mobile devices to share data (including video) and support other needs such as virtual briefings. Applications such as Geographic Information System mapping (GIS), resource allocation and tracking, and situational awareness generate large amounts of data. And personnel on the scene want to be able to stay in touch with their families.

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44. Stewart, Stacy R., and Berg, Robbie. "Tropical Cyclone Report: Hurricane Florence." National Hurricane Center. May 30, 2019. https://www.nhc.noaa.gov/data/tcr/AL062018_Florence.pdf.

45. Unlike most jurisdictions in North Carolina, Whiteville was not part of the statewide LMR system, which remained operational during the hurricane. Rather, Whiteville used a county-owned system that runs on proprietary software.

46. "Climate Change Indicators: Wildfires." U.S. Environmental Protection Agency. April 2021. https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires.

As a result, broadband coverage and performance are critical when fighting wildfires.

For the past four wildfire seasons, FirstNet has sent deployables and other resources to support personnel battling the major fires on the West Coast.[47] In most cases, these efforts involved strategically deploying SatCOLTs near command centers and on the front lines. One advantage of having mobile communications assets during a wildfire is that as the fire line moves, so can the deployables be relocated, thus enabling a more consistent level of coverage.

In addition to accessing deployables, California public safety officials have worked with AT&T-FirstNet to increase capacity in areas that are prone to having fires.

> "We worked closely with AT&T and the U.S. Forest Service to build FirstNet LTE sites in the Angeles National Forest. We identified areas where we know we have fires, and we're building LTE sites in the forest. That was a huge accomplishment."
>
> — **Executive Director Scott Edson LA-RICS**

At PERF's Western Regional meeting, fire officials from California described the types of communications that front-line firefighters rely on and why reliable access to mobile broadband networks is so important.

RESOURCE REQUESTS. Santa Clara County Fire Chief Anthony Bowden said one of the biggest needs at a fire scene is the ability to request resources from other agencies. In California, fire agencies use the Interagency Resource Ordering Capability (IROC) system to request resources from other departments. Chief Bowden said that having reliable access to that system is critical for incident commanders when they first arrive on the scene and as conditions change.

"When that first command post gets set up and you have that first team come in and start setting up, the incident commander needs to start communicating resource requests with multiple agencies and jurisdictions, not just locally, but across the state. That requires data. You need to be able to access that system and transmit data up and back," Chief Bowden said.

GIS DATA. Fire leaders discussed the importance of being able to collect and share Geographic Information System mapping during a large-scale

FIRSTNET MEGARANGE BOOSTS CONNECTIVITY IN REMOTE AREAS

A new resource available to firefighters battling Western wildfires is FirstNet MegaRange.

This is a High-Power User Equipment (HPUE) solution that can boost connectivity in remote areas and increase device transmission power by up to six times.[48] The increased signal with FirstNet MegaRange can be transmitted only on Band 14, the spectrum reserved for FirstNet.

When fighting wildfires, improved connectivity and signal strength are especially important in remote areas that may be at the edge of existing networks. Because HPUE operates at a higher power class on Band 14, uplink data speeds are faster, and coverage is more reliable.

47. Nida, Kevin, and Baker, Chris. "FirstNet – Helping Firefighters Face Historic Wildfire Season During the Pandemic." First Responder Network Authority (Blog Post). August 5, 2021. https://www.firstnet.gov/newsroom/blog/firstnet-helping-firefighters-face-historic-wildfire-season-amid-pandemic.

48. HPUE is a special class of user equipment for LTE cellular networks that meets both 3GPP and FCC standards. See https://www.getwirelessllc.com/2020/05/hpue for additional details.

fire. These systems typically use large data files that require considerable bandwidth.

Chief Bowden described his agency's GIS platform as "Google maps on steroids." It stores several layers of data, including the location of hydrants and other critical infrastructure such as communications, electricity, and natural gas. For structure fires, the system stores building plans and related information. For wildfires, it includes topographical layers, which allow personnel to see geographic contours that helps them to predict which direction a fire is likely to travel, and street layers showing buildings and other structures. "They can adjust what they see in real time to help them gain better situational awareness of the area that they're coming into," Chief Bowden said.

The system also provides real-time automated vehicle location (AVL) capabilities, allowing crews to see the locations of every other unit on the scene.

Super Bowls and Other Major Events

Unlike hurricanes, wildfires, or other natural disasters, major events such as the Super Bowl are scheduled years in advance and require considerable up-front planning. These high-capacity events also attract large numbers of people using their mobile devices to talk, take and share photos and video, and post to social media. All this activity can put tremendous strain on cellular networks.

To ensure that public safety personnel have access to voice and data communications, FirstNet has supported recent Super Bowls by enhancing the network infrastructure in advance of the games and staging deployables to provide extra coverage and capacity if needed. AT&T-FirstNet has also supplied FirstNet Ready mobile devices to public safety personnel.

For example, in advance of Super Bowl LIV in February 2020 in Miami, AT&T-FirstNet deployed Band 14 across the area and staged three SatCOLTs outside Hard Rock Stadium, where the game was played. To address any communications issues that might arise, technical staff from AT&T-FirstNet were stationed in various command posts in the week leading up to and during the game.

Improving Situational Awareness and Officer Safety at Super Bowl LIII

The experience at Super Bowl LIII in Atlanta in February 2019 demonstrated how mobile broadband connectivity can support a variety of public safety needs.

At PERF's Southeast Regional meeting, Warren Shepard, a Manager with the Georgia Emergency Management and Homeland Security Agency (GEMA), discussed security planning for the Super Bowl and how FirstNet supported operations throughout Super Bowl week. The Atlanta Police Department was the lead agency on security planning. GEMA was one of several partners responsible for monitoring the events taking place in the run-up to the Super Bowl and the game itself, and then providing support as needed.

GEMA was an early adopter of FirstNet when it joined the network in April 2018. The agency had approximately 100 FirstNet devices by the time of the Super Bowl, which were allocated to GEMA personnel and selected partners.

While there were no major security incidents at Super Bowl LIII, Mr. Shepard described three instances where FirstNet connectivity proved helpful:

- **MAINTAINING VIDEO FEEDS FROM DRONES:** Several Super Bowl events took place in and around the Georgia World Congress Center, the city's main convention center. The GWCC Authority hired a private contractor to fly four tethered drones in the area to enhance situational awareness. But there were issues with keeping a stable video link from the drones back to the command center; the video was "jumpy" and pixelating.

  Because the drones were being used for a public safety purpose, the GWCC received authorization to install FirstNet SIM cards in the drones. Once these devices were connected to the FirstNet network, Mr. Shepard said the video images from the drones remained stable and clear throughout the event.
- **MANAGING STRIKE TEAMS:** The security plan called for 10 strike teams to be deployed throughout the Super Bowl event. These teams included a Canine and Bomb Detection officer, an explosive ordnance technician, a National Guard

representative, and others. Each strike team was given a FirstNet device for both communications and tracking. The location-based system on the FirstNet devices allowed the command center to keep track of where the strike teams were located. And if something happened, commanders would know which teams could respond fastest based on their location.

- **TAKING FULL ADVANTAGE OF EXISTING HARDWARE:** FirstNet supported other video capabilities. For example, officials were able to take feeds from some of the fixed video cameras that are permanently installed throughout downtown Atlanta and push those images out to the strike teams and others equipped with FirstNet phones. In the event of a critical incident, the video feeds would provide clear, real-time situational awareness.

"The camera feeds were perfectly clear – no pixelation, no delay. Without FirstNet, you'd see someone walking across the entrance of the crosswalk, then a blip, and they'd be on the other side of the street. With FirstNet, we were able to monitor the activity throughout that zone," Mr. Shepard said.

AT&T-FirstNet had staged a SatCOLT near the Mercedes-Benz Stadium, but it was never activated. The existing network provided sufficient coverage and capacity throughout the event.

COVID-19 Pandemic Response

The COVID-19 pandemic has increased the communications needs of public health and public safety personnel. FirstNet was called upon to support patient transports in COVID hot spots, mass testing and vaccination sites, and the needs of emergency operations and 911 dispatch centers.

Early in the pandemic, FirstNet deployables were used to boost coverage and capacity in several areas where COVID cases were surging. For example:

- FirstNet deployables were sent to ports in New York City and Los Angeles to ensure interoperable connectivity among military personnel, nurses and physicians, and first responders at temporary hospitals established onboard two U.S. Navy medical ships.
- In northern California, a FirstNet COW (cell on wheels) was deployed to a medical center to provide additional communications capacity and help keep critical-care physicians, ER nurses, and other staff (including remote workers) connected.
- As the pandemic spread among the Navajo Nation, FirstNet deployables were sent to locations in Arizona and New Mexico to resolve connectivity and communications issues among first responders in remote areas.
- At a COVID testing location in Conyers, GA where officials were conducting 1,200 tests a day, a FirstNet SatCOLT was brought in to enhance data and voice communications.

In some areas, FirstNet-connected devices and apps were used for COVID testing, treatment, and contact tracing. For example, jurisdictions in New York State used FirstNet and RumbleUp, a peer-to-peer texting app, to trace COVID infections. In Massachusetts, Baystate Medical Center and American Medical Response used FirstNet and the e-Bridge telemedicine app to help process a surge in patients.

In Alexandria, VA, FirstNet allowed some personnel in the emergency communications center to work remotely, so that the call-takers and dispatchers who were working in the physical center could socially distance and follow other COVID-safety procedures. The city already had CommandPost kits – consisting of a phone, headset, laptop, mobile router, and second monitor, all housed in a ruggedized case – that telecommunicators could set up at their homes.

To provide reliable and secure connections, Alexandria established FirstNet hot spots to connect their remote workers. This allowed staff to access any open "position" in the emergency communications center and operate with full functionality, as if they were physically located at the center. Initially, the remote workers answered only non-emergency calls, but after a month, they began receiving and dispatching 911 calls as well.

HOW FIRSTNET AND MOBILE DATA TECHNOLOGY ARE HELPING AGENCIES TO BECOME MORE EFFICIENT AND EFFECTIVE

FirstNet offers protection for times when networks are under significant or potentially crippling pressures. Fortunately, such extreme circumstances are relatively rare. Most of the time, public safety agencies rely on access to mobile data to support their everyday operations.

To get the full benefits of FirstNet, agencies should do more than just sign up and begin using the network. Greater benefits can be realized if agencies are more strategic and consider how high-speed and reliable mobile data access can improve their operations and make their agencies more efficient.

As part of this project, PERF examined how agencies were using FirstNet to increase their operational efficiency and effectiveness.

In examining how different public safety agencies improved their operations through FirstNet, PERF found they generally followed a three-stage process:

1. Gather information and assess current operations.
2. Identify opportunities for operational improvements.
3. Implement a revised concept of operations.

Working through these steps will do more than prepare a public safety agency to take advantage of FirstNet. It will also prime those agencies to consider ways that mobile data technologies can enhance their day-to-day operations.

"All of this is not just about changing your broadband carrier or getting a different cell phone plan. The question is, 'How do we use all these data streams to obtain more actionable information?' "

— **Information Services Manager Maximilian Pop Richmond (VA) Police Department**

1. Gather Information and Assess Current Operations

Determining FirstNet's local coverage and performance is a critical first step for any agency deciding on a mobile broadband carrier and looking to improve its operations. As detailed in pages 24-31, PERF developed a straightforward protocol that agencies can use to test coverage and performance in their jurisdictions. It is essential that these tests be conducted from the perspective of the user. That is, agencies need to replicate as closely as possible the circumstances under which police officers, firefighters, EMS technicians, and other public safety personnel would access data in the field, using the same types of devices they are currently equipped with.

In addition to assessing the functionality of the network itself, agencies need to understand how they are currently using mobile data and how they plan to use it in the future. As part of this analysis, agency decision-makers need to answer three key questions:

- Who has mobile devices?
- What kinds of mobile devices do personnel have?
- Are the devices compatible with FirstNet?

Who is issued a mobile device?

As smartphones and other mobile devices have proliferated in recent years, many public safety agencies now issue devices to at least some of their members. However, this practice is not universal or consistent across all agencies, and there is wide variation in who has a work-provided mobile device. PERF's research found that some agencies issue smartphones to all their sworn personnel, while others reserve agency-issued devices mostly for command staff members, supervisors, detectives, and personnel in other specialized assignments (see Figure 5).

The data in Figures 5, 6, and 7 are based on responses to questionnaires that PERF sent out in advance of the two regional meetings in Atlanta and San Jose. There were a total of 71 responses, although not every respondent answered every question.

As mobile devices become more powerful and more types of devices become available, it is likely that public safety agencies will equip more of their front-line personnel with smartphones. Among agencies that told PERF they do not currently issue smartphones to all their staff, many mentioned that they were planning or in the process of issuing tablets instead.

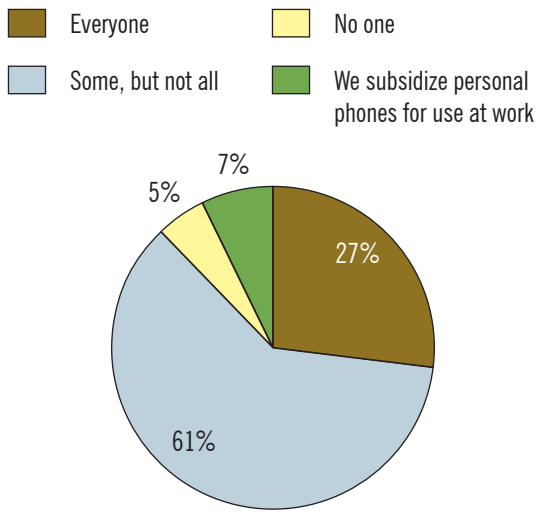
How many staff use their personal devices for official work business?

Where members of an agency are not equipped with official department-provided devices, it is common for many of them to rely on their own personal devices to assist them in their official work (see Figure 6).

Allowing personnel to use their personal devices for work-related activities can create significant efficiencies but also some problems. Public safety agencies have less control when employees are using their personal devices, and managing security and preventing the spread of computer viruses and malware become more difficult.

Mixing an officer's personal information and communications with work-related information

Figure 5. Who is issued a work-provided smartphone in your agency?



on a single smartphone or other device can cause other problems. For example, news media or others may make Freedom of Information Act (FOIA) requests for video footage or other information about an incident, and officers' personal information may be compromised if they are forced to turn over their devices to investigators or public information officers. Several public safety officials told PERF that as soon as officers have to turn over their phones for a FOIA inquiry, they no longer want to use their phones for job-related tasks.

Understanding how many people are likely to use their personal devices for work activities is especially important for FirstNet. In addition to contracting with public safety agencies to provide mobile data services, FirstNet offers subscription service to individual employees and auxiliary personnel of public safety agencies, even if their agencies are not FirstNet customers (see page 22). As a result, individual first responders may have FirstNet devices and access to the network even if their agency has not signed up (see Figure 7).

What kinds of mobile devices do personnel have?

In assessing their broadband capabilities and goals, public safety agencies also need to catalog what kinds of mobile devices they have. As noted earlier, smartphones are the most commonly used mobile devices in public safety, and agencies seem to have a mix of Android and Apple devices. However, as TeleHealth, situational awareness, and other video-based applications become more common, it is likely that agencies will begin incorporating more tablets and laptops into their operations. And, of course, the use of drones, license plate readers, body-worn cameras, and other specialized technologies that can be connected to the Internet is likely to grow significantly in the future.

In determining how a mobile broadband network can improve their operations, public safety agencies need to consider both the mobile devices they are using today and the devices they hope to utilize in the future.

Figure 6. How likely are members of your organization to use their personal smartphones for official work?

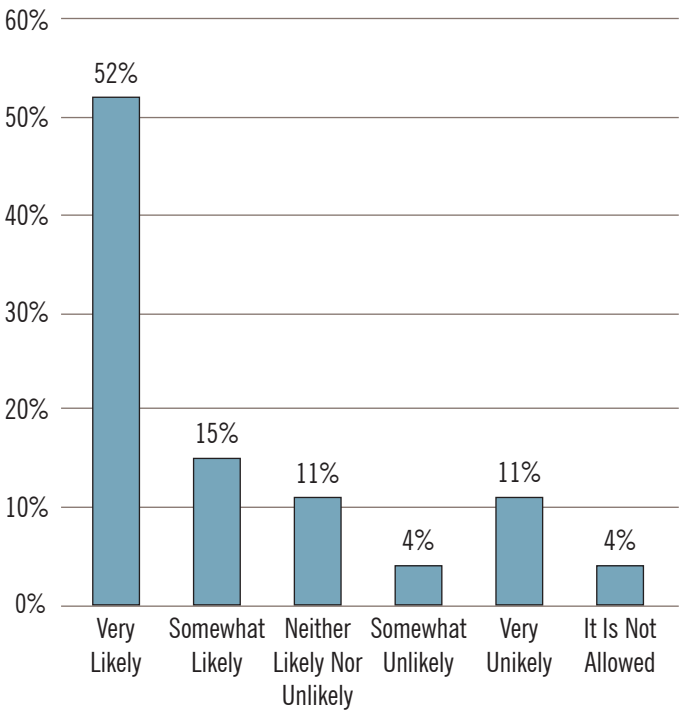
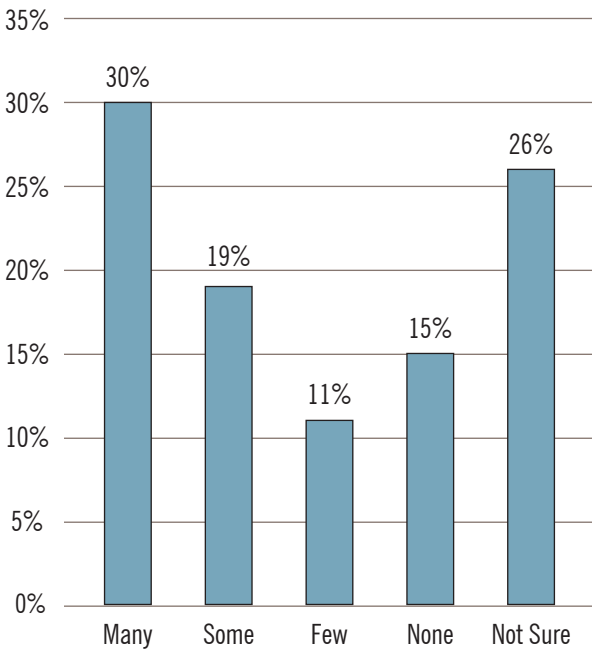


Figure 7. How many of your agency staff have FirstNet on their personal devices?



Are the devices compatible with FirstNet?

As detailed on page 17, for agencies to take full advantage of FirstNet, their mobile devices must be able to receive and transmit voice and data through the dedicated FirstNet core. As of August 2021, there were approximately 300 types or models of devices that have been certified as either FirstNet Ready or FirstNet Capable, and that list is growing.

As agencies think about moving to FirstNet, they need to consider whether their current devices are compatible with FirstNet and, if they are not, what the costs of replacing devices may be. Some officials told PERF that if an agency is due for updating its devices, that can be a good time to consider possible changes to their network too.

2. Identify Opportunities for Operational Improvements

Once an agency has developed an understanding of which employees are using what kinds of devices, the agency can begin to consider different and more effective ways of incorporating mobile data into their operations. Key factors to consider are how the devices are used, under what types of circumstances, and what they are intended to accomplish.

In emergency situations, understanding which users have the greatest need for mobile data access and at what priority level is important for improving emergency response. The ideas and experiences of other public safety agencies can be a valuable resource for finding ways to improve agency operations during both emergencies and everyday work. Agencies also should look internally, especially to personnel who understand current operations and how technology can help improve them.

> "Today's public safety employees understand technology. So bring them into the room at the beginning of the process. Don't wait to tell them about it until after you have made all the decisions, or you will fail."
>
> — **Assistant Chief Mike Baltrotsky Montgomery County (MD) Fire and Rescue Service**

The process of integrating a new information technology system can sometimes prompt agencies to re-examine procedures that have accumulated over the years and become "the way things are done," even if those approaches are inefficient or no longer serve their intended purpose. Agencies have found that implementing a new technology can help them rethink and improve operational procedures.

3. Implement a Revised Concept of Operations

Once an agency has identified what mobile devices it has and will need, and after it has identified opportunities for operational improvements, the next step is implementation.

PERF's research found that when agencies transition to FirstNet, they often need to replace at least some of their existing mobile devices. And if an agency has decided to change aspects of its operations to make better use of mobile data, this will also require some transitions.

PERF found there are three basic approaches agencies to making this transition:

1. Simultaneous use of the old and new approaches
2. Gradual transition from old to new approaches
3. All-at-once transition to new approaches.

PERF examined how a number of agencies went about implementing FirstNet, and collected information and advice from public safety officials who have used these three approaches.

Simultaneous use of old and new approaches

Several agencies reported that, at least in their initial transition to FirstNet, they were currently running dual networks simultaneously. This approach provides greater redundancy and resiliency.

This is especially true in areas where one service option may not be clearly superior to another. For example, at the time of PERF's Western Regional meeting, the San Bernardino County, CA Sheriff's Office reported that while

FirstNet coverage was good in the urban parts of the 20,000-square-mile county, coverage in desert locations was spotty. That prompted the Sheriff's Office to operate on two networks, to help ensure coverage and provide greater redundancy.

Some agencies have managed to deploy "dual-SIM" options that allow a single smartphone or other mobile device to easily toggle between FirstNet and another carrier's network. Others have achieved a degree of redundancy by providing staff with department-issued devices that run on one carrier while many have a different carrier on their personal device.

While this approach provides benefits of redundant coverage, it often carries the greater expense of additional devices and multiple service plans. Additionally, simultaneously maintaining an old and a new approach to operations can create complications and confusion for agencies that are trying to implement operational changes.

Gradual transition from old to new approaches

Outfitting large numbers of personnel with mobile devices can be expensive, especially in larger agencies and those that provide most or all their members with devices. In our research, PERF heard from numerous agencies that were considering changes to their mobile data approaches based on the scheduled replacement dates for their devices or the expiration of their existing service contracts. These milestones provided a natural opportunity to consider changes in service while upgrading their devices. Some agencies reported having a two-year replacement cycle for smartphones, a five-year cycle for mobile data terminals, and contracts of one or more years with service providers.

At PERF's Western Regional meeting, Chief Anthony Bowden of the Santa Clara County, CA Fire Department described how his agency has gone about the transition to FirstNet. His department started rolling out FirstNet devices to support staff first, and then to mission-critical staff. This approach also allowed the agency to spread the cost over several budget cycles.

> "Members of a fire department can be skeptical about new technology, and that skepticism is good. You want to be 'leading edge,' not 'bleeding edge.' Our jurisdiction covers seven different cities, and is very diverse geographically with urban and rural areas. So we took a step-in approach, knowing that it's going to be several years before we are fully on FirstNet. We started with our support staff – our deputy fire marshals. They're out in the field, and they'll be actively testing coverage every day. If they drop a call, it's not mission-critical. We have been very methodical moving into this and looking at how this will impact the organization.
>
> "Second to that, as a chief, you're always fighting budget issues, and this was a significant budget concern. We have about 400-500 devices throughout the organization. It's a pretty big number for us.
>
> "We also are a large participant in the state mutual aid system. We have our own Type-3 strike team that we send all over the state of California. I know that members of that team and our battalion chiefs are going to be carrying devices from multiple providers for quite some time. I have to think globally, not just locally."
>
> **— Chief Anthony Bowden**
> **Santa Clara County (CA) Fire Department**

All-at-once transition

For agencies that have access to FirstNet coverage and do not have an existing mobile broadband plan or much digital infrastructure, there can be significant benefits to making a complete transition to FirstNet all at once. This was the case for the police department in Signal Mountain, TN.

Signal Mountain is a community of approximately 8,500 people north of Chattanooga. Until 2018, the town's 15-officer police department relied entirely on manual processes for collecting and reporting data.

"When I took over, we were basically in the 1970s. Everything was still hand-written. There was literally no technology. We had no RMS (Records Management System), no computers in our patrol cars, and very little internet accessibility for officers to use," Chief Mike Williams said at PERF's Southeast Regional meeting.

Chief Williams previously served as Deputy Chief of Operations responsible for technology in the Chattanooga Police Department, which has more than 500 officers. So he understood the opportunities and the challenges presented by new technology. And he had an officer in Signal Mountain, Troy Kennedy, who was well-versed in technology and adept at research.

A priority for Chief Williams and Officer Kennedy was to ensure that their technology adoption was seamless and that all systems worked together. "Coming from a bigger department, I learned to start by making everything work from the beginning," Chief Williams said. "None of the systems talked to each other in our big department. We were constantly having to buy interfaces and pay for software so the different parts of our technology could work with each other."

Officer Kennedy conducted almost two years of research before Chief Williams began implementation. In 2018, Signal Mountain became the first community in Tennessee to subscribe to FirstNet. The Police Department used this as an opportunity to transform how it uses technology to perform many of its functions. All 12 of the department's patrol vehicles are equipped with mobile tablets connected to FirstNet, and except for issuing traffic citations, all processes are now paperless.

The Department's plans for technological growth outpaced the rest of the local government in Signal Mountain. Chief Williams said that the town's IT Department regularly told him, "No, we can't do that – it won't work." But once the department completed its research and developed its plan, Chief Williams decided to effectively build the Police Department's own technology platform.

How Agencies Are Improving Their Operations

PERF's research uncovered ways in which access to mobile data has helped public safety agencies make operational improvements, both for responding to emergencies and in their day-to-day activities. Following are some examples.

Brazos County, TX: Virtual roll calls keep deputies in the community

An early adopter of FirstNet, the Brazos County, TX Sheriff's Office (BCSO) has used the network to support a variety of video applications. One of them is the "virtual roll call," an approach that allows deputies to meet and share information before their shifts while remaining in the community.

As in most agencies, BCSO deputies in the past traveled to agency headquarters for briefings at the start of their shift, and then drove out to their assigned patrol zones after roll call. Given the size of Brazos County – nearly 600 square miles – that process was time-consuming and kept deputies away from the community. With virtual roll calls, deputies drive directly to their patrol areas at the

"We were the first agency in Tennessee to sign on with FirstNet as the hub for all our communications. All the cars have in-car computers, and we all have body cameras. We instituted it the same time as our Records Management System, so the officers are doing reports in the cars now and are sending them back to our RMS. We are also up and running with our Mobile CAD dispatched through the Hamilton County 9-1-1 center.

"It's just been amazing how seamlessly everything has worked, and it wasn't that expensive. Of course, we only have 12 marked patrol cars, but for a small agency, obviously the budget's small as well.

"We also have a lot of ideas we can expand on. One is to integrate the body cameras with FirstNet and to stream video from our schools and some of our businesses."

— Chief Mike Williams
Signal Mountain (TN) Police Department

"People like to see police cars in their neighborhoods. It's great that the deputies can sit in a neighborhood in their patrol zone and basically go to the shift briefing, without having to physically go to the office."

— **Sergeant Josh Hearen**
Brazos County (TX) Sheriff's Office

beginning of their shift, park in a safe location, launch the videoconferencing feature on their tablets, and participate in the daily briefing. Then, throughout their shifts, deputies use the same technology to participate in other meetings or impromptu briefings, while still remaining in their patrol zones.

This approach not only saves time and fuel previously spent in transit to and from headquarters; it also allows for effective information-sharing. Deputies can upload live feeds from their in-vehicle cameras and share documents with colleagues over the network. For planned briefings, supervisors can preload information that the deputies will need during their shifts, including recent crime trends, scheduled home checks, and other assignments.

Mesa, AZ: Capturing and uploading information more efficiently and accurately

The Mesa, AZ Police Department recently implemented a new Records Management System (RMS) that includes mobile applications for patrol officers to use on their FirstNet smartphones. These functions are making data collection during traffic stops faster and more accurate.

SCANNING DRIVERS' LICENSES AND REGISTRATION INFORMATION: In the past, officers had to manually key information from motorists' driver's licenses and registration cards into the RMS. With their FirstNet smartphones, offices can now scan those documents, which are instantaneously uploaded to the RMS. The system also gives officers the flexibility to run inquiries directly from their smartphones.

VOICE-TO-TEXT REPORTS: Mesa Police are also investigating other efficiencies that save time and improve accuracy. For example, voice-to-text functions will make it easier for officers to dictate reports and transfer them automatically to the RMS. Under the old system, officers responding to traffic accidents frequently had to enter the same information multiple times, which took time and increased the chances of errors.

CRIME SCENE PHOTOS: The department is also phasing out point-and-shoot cameras that officers previously used to document minor crimes. This system required officers to go into the station at the end of their shift and upload the images from the cameras to the evidence management system. With their FirstNet phones, officers can take the images and immediately upload them in the field.

Santa Clara County, CA: Giving firefighters situational awareness

For firefighters battling a wildfire or a large structure fire, real-time situational awareness is critical. Responding units need to know where to go – and sometimes where not to go – when they arrive on scene.

In the past, the Santa Clara County, CA Fire Department relied largely on radio communications to coordinate units responding to a large fire. Today, the department is using iPads connected to FirstNet to share up-to-the-minute, easy-to-understand geographic information among responding units.

Here is how the system works: The first incident commander to arrive pulls up a map of the location on an iPad. The commander can use his or

her finger to draw where the incident is, the location of command posts, and other relevant data, including suggested entry routes. That information is automatically updated in the system and transmitted to the tablets of all units responding to the scene. These GIS files can be large, so it is important that fire personnel have the bandwidth to share them.

> "The units coming in can get a real-time visual perspective of what the scene looks like, rather than trying to discern that over the radio. They can see where they're going."
>
> — **Chief Anthony Bowden**
> **Santa Clara County (CA) Fire Department**

Duck, NC: Streamlining property checks during the off-season

Duck is a tourist community on the Outer Banks of North Carolina. The town has fewer than 400 permanent residents, but its population swells during the summer months. Approximately 2,100 of the town's 2,500 homes are rental properties, and the police department, which has 11 officers, conducts property checks on the rental homes throughout the off-season to look for burglaries, vandalism, or property damage. In the past, the agency used a largely manual system for recording which properties were checked and when. This led to inaccuracies and redundancies.

The police department found a mobile app to streamline the process. Officers can bring up a map on their FirstNet smartphones that shows the locations of all properties, and when they have been checked. The app uses a specific color to indicate the properties that were checked in the current week. This information is also sent to the department's CAD system.

INNOVATIONS MADE POSSIBLE BY FIRSTNET AND MOBILE DATA TECHNOLOGY

Once mobile data devices and applications are in the hands of public safety professionals, they often find creative and innovative ways to incorporate them into their agency's operations. As this project revealed, these innovations not only allow agencies to make existing processes more effective and efficient; the technology can also enable agencies to develop new approaches that were not possible before.

PERF's research uncovered numerous examples of innovations made possible by FirstNet and mobile data technology.

Volusia County, FL: Streaming Video to Improve Situational Awareness at the Daytona 500

The Daytona 500 typically attracts 200,000 NASCAR fans each February. For local law enforcement – including the Volusia County Sheriff's Office (VCSO) and the Daytona Beach Police Department – the event is a massive security operation that involves other local, state, and federal partners. The Sheriff's Office alone stages multiple bomb squads and places about 40 plain-clothes detectives into the crowds.

Communications was always the biggest challenge that public safety agencies faced. Agencies generally had to rely on voice communications – radios, cell phones, and push-to-talk – but these communications channels were not always reliable or interoperable across agencies.

The Sheriff's Office had already been using an application developed by a local software company, Callyo, to support its Internet Crimes against Children and Narcotics units. VCSO asked the company to discuss how they could utilize the app for domestic security purposes. At the 2019 race, the VCSO used the Callyo app on FirstNet devices to enhance situational awareness among personnel.

> "At our Tactical Command Post, I was able to see where all my teams and all my undercover detectives were. I was able to push out information to them and track them on the map around the Speedway and see where everybody's going.
>
> "I had a team respond to a suspicious package. I was able to have my detectives in the crowd go live on the app and post it. Anybody can go into this channel with the right password from anywhere in the world. Our sheriff could be miles away from the Speedway and still watch each incident that we were working.
>
> "We were also able to bring feeds from multiple cameras to our command post, which also had ATF, FBI, and Department of Homeland Security. All this information was being provided to us live. With the help of FirstNet, we were able to do all this because we had priority on the network, even though there were 200,000 people at the event."
>
> **— Lieutenant Kurt Schoeps**
> **Volusia County (FL) Sheriff's Office**

LEFT TO RIGHT: Lt. Kurt Schoeps, Volusia County (FL) Sheriff's Office and Sheriff (ret.) Christopher Kirk, Brazos County (TX) Sheriff's Office

For future races, the Sheriff's Office is looking to incorporate drones and other feeds into its video network.

Coweta County, GA: Using TeleHealth to Provide On-Site Assessments of Individuals in Crisis

For public safety personnel who frequently encounter individuals in a mental or behavioral health crisis, being able to access expert mental health resources can be critical to resolving these situations safely and get the person the help they need.

It's impractical to expect doctors or other professionals to be able to respond to locations in the field where these encounters take place. But what if first responders could bring that expertise to the field through a mobile data network?

That is what Coweta County, GA is doing with its "Coweta Cares" program, which includes a Tele-Health component geared toward persons in crisis. The program pairs a paramedic with a licensed clinician from a private care provider. Working in an unmarked SUV that purposefully doesn't look like a public safety vehicle, the team makes regular checks with behavioral health and stroke patients. The team also responds to calls for service involving individuals in crisis.

The vehicle is equipped with a camera, monitor, and keyboard. When the team encounters a person in crisis, they can videotape the person's actions or even conduct an interview, if the individual is stable enough. The live video is then transmitted over the network to a doctor at the local hospital.

The doctor can evaluate the person and advise the Coweta Cares team on next steps, including possible placement in a treatment facility, if necessary. Making these diagnoses remotely gives the Coweta Cares team more options than taking the individual to the emergency room or having police bring them to jail.

Brazos County, TX: Using Public and Private Camera Feeds to Provide Real-Time Intelligence

As an early adopter of FirstNet, the Brazos County, TX Sheriff's Office has experimented with numerous mobile broadband applications. With the bandwidth provided by FirstNet, the agency has focused extensively on making use of video.

In addition to supporting "virtual roll calls" for its deputies (see page 42), the sheriff's office has worked on a drone project that allows video feeds to be pushed not only to personnel in a command center, but also to deputies in their squad cars. The agency is also looking to live-stream body-worn camera video of deputies involved in critical incidents. Both these applications allow supervisory and command personnel to monitor and help direct ongoing incidents, while providing other responding units with the situational awareness they need to approach dynamic incidents safely and effectively.

One other video application the sheriff's office is exploring is connecting video cameras from schools and other public agencies, as well as from private entities.

> "With any place that has an IP (Internet Protocol) camera system, public or private, we could develop an MOU to access their camera feeds. That way, when deputies are responding to alarm calls, a mass gathering, or anything, we'll have a heads-up and be able to have a plan in place, with real-time intelligence."
>
> **— Sheriff (ret.) Christopher Kirk**
> **Brazos County (TX) Sheriff's Office**

Biloxi, MS: Allowing Supervisors to Fine-Tune the Response to Fire Emergencies

The dispatch center in Biloxi, MS uses standard protocols for determining how to code and assign a call requiring a fire response, based on the initial information the center receives. These standardized procedures are helpful for ensuring a consistent response to most alarms or other emergencies.

But some incidents call for a more customized response than the one suggested by the protocol. The Biloxi Fire Department is using tablets connected to FirstNet to provide firefighters with more detailed information before they arrive on scene – sometimes before they even leave the fire station. The system also allows supervisors to monitor dispatches in real time and adjust the response, if needed.

At PERF's Southeast Regional meeting, Biloxi (MS) Fire Chief Joe Boney explained how the network is empowering supervisors and improving the response to some calls:

> "We have a dispatch app on our tablets. A lot of times, as the dispatcher is typing the information in, the firefighters are seeing that information before they get the call over the radio. When supervisors see the same information, they are able to change the dispatch call.
>
> "That's really helpful when you have a lot of standard responses for different kinds of alarms or emergencies. The supervisor can catch any issues with the preset response and adjust it as needed, often before the units even leave the station."

Collier County, FL: Using Mobile Data Technology to Access Trained Community Help in a Medical Emergency

When someone suffers a heart attack, a near drowning, or other life-threatening emergency, getting medical attention as quickly as possible is critical. But EMS resources are often stretched thin. Collier County, FL has developed a way to use mobile technology to tap into trained community resources that can help.

The county is using an app that maps individuals in the community who are trained in CPR. When a cardiac arrest or similar call is dispatched, the app notifies community members near the location of the incident. If they're available, the trained citizens can respond and provide initial CPR until first responders arrive.

Duck, NC: Using License Plate Readers to Help Manage Traffic and Fight Crime

Located on the Outer Banks of North Carolina, the tourist town of Duck has one entry point from the north and one from the south, along State Highway 12. Knowing in real time how many vehicles are in the town helps the police department to manage routine traffic, and also to evacuate residents during a hurricane or other natural disaster.

The police department has invested in automated license plate readers (ALPR) that are connected to FirstNet. "By connecting our ALPRs to FirstNet, we're able to know when every vehicle has entered and exited our town, in real-time," Police Chief John Cueto said at the PERF Southeast Regional meeting.

The system is helpful on "changeover days" – the Saturdays and Sundays in the summer when tourists who rent homes are leaving in the morning, and new tourists are arriving in the afternoon.

The police department also relied on ALPRs to help evacuate people in advance of Hurricane Florence in 2018. The system allowed the police to know how many vehicles were still in the town and needed to be evacuated as Florence advanced. Chief Cueto said the ALPR system has also helped his department solve a series of burglaries, recover stolen vehicles, and arrest suspected opioid traffickers.[49]

Fire Chief Joe Boney, Biloxi (MS)

49. Griffith, David. "More than Just License Plate Readers." POLICE. October 7, 2020. https://www.policemag.com/577493/more-than-just-license-plate-readers.

CONCLUSION: FIRSTNET REMAINS A WORK IN PROGRESS

Public safety communications have come a long way since September 11, 2001, when communications failures hampered the response to an unprecedented terrorist attack on the United States.

Thanks to the vision and persistence of a committed group of public safety professionals, the United States now has a Nationwide Public Safety Broadband Network dedicated to police, fire, and other first responders. Under a unique public-private partnership, that network is up and running, and expanding. Public safety agencies are achieving operational efficiencies and creating innovative ways of managing information. And the public safety community is beginning to see what's possible with mobile data technology.

This report documents the development and implementation of FirstNet during the first three-plus years the network has been in operation. Using in-person meetings, surveys and interviews, and ongoing monitoring of FirstNet developments, PERF researchers have identified key issues facing public safety agencies as they consider adoption of FirstNet. This report also catalogues numerous efficiencies and innovations that agencies have achieved through the use of FirstNet and mobile broadband technology.

In addition, the report presents a testing protocol that public safety agencies can use to measure the coverage, performance, and reliability of different mobile broadband networks, including FirstNet. Having an easy-to-use and accurate testing regimen is critically important as agencies decide which mobile broadband network is best for them.

PERF's research found that FirstNet is impacting operations in public safety agencies of all sizes and types.

- After implementing FirstNet, the 15-officer Signal Mountain, TN Police Department went from all-manual operations to a robust, integrated technology platform that allows officers to access data and file reports while remaining in the community.
- Another small police department, in the tourist town of Duck, NC, is using FirstNet to support the property checks that officers make during the off-season and improve traffic and emergency management during the peak summer months.
- The much larger Mesa, AZ Police Department is relying on FirstNet to automate and improve the collection of drivers' information during traffic stops and to streamline the collection of photo evidence at the scenes of crimes and traffic crashes.
- With the increased bandwidth and priority access that come with FirstNet, the Brazos County, TX Sheriff's Office is implementing a number of video-based applications, including "virtual rolls calls" and other meetings that allow deputies to remain in the community. The video-sharing technology also provides

real-time situational awareness, as in-car camera footage is fed to a command center or to other deputies responding to an incident.

- FirstNet is also supporting innovations in firefighting. The Santa Clara County, CA Fire Department is using iPads connected to FirstNet to allow the first commander on the scene of an incident to pull up a map of the area, add important details such as the command post location and entry and egress routes, and instantly push that information to all other responding units.
- Emergency medical services agencies are using FirstNet to support applications such as Tele-Health and the real-time sharing of information about patients with hospital and doctors.
- Jurisdictions that are called upon to manage major incidents – both planned events like sports championship games and unplanned incidents such as hurricanes – are relying on FirstNet assets to improve their response. Many have used FirstNet's fleet of "deployables" – land-based and aerial temporary cell sites – to provide coverage and capacity when networks are overloaded, damaged, or in remote areas, nonexistent.

While this report covers a lot of ground regarding the implementation of FirstNet, it represents only a snapshot in time. New applications of mobile data technology are emerging rapidly. For example, agencies are finding new ways of using video to enhance situational awareness and improve the safety of their personnel. A growing number of mobile apps are being designed specifically to make the jobs of first responders easier, more effective, and safer.

This process will accelerate in the future as more types of mobile devices are connected to FirstNet, including drones, wearable sensor technology, Internet of Things (IoT) solutions, artificial intelligence-based systems, and more. The continued development of NextGeneration 911 systems will also increase the amount of data (especially video and photos) coming into emergency communications centers and, in turn, being pushed out to police officers, firefighters, EMS personnel, and other first responders.

FirstNet remains a work in progress. Over the past three years, there have been implementation and operational challenges, and there will likely be more in the future, especially as severe weather events and other natural disasters make it challenging to maintain network communications under unusual and adverse conditions.

As FirstNet continues to evolve, it will be crucial for public safety agencies to stay on top of new developments in mobile broadband technology. By continually learning from one another and applying new technologies with efficiency and imagination, public safety agencies of all types can help keep their communities safe and be better prepared for the next major threat or catastrophe.

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