# PUBLIC SAFETY COMMUNICATION USER NEEDS: VOICES OF FIRST RESPONDERS

Shaneé Dawkins, Kristen Greene, Michelle Steves, Mary Theofanos, Yee-Yin Choong, Susanne Furman
National Institute of Standards of Technology, 100 Bureau Drive, Gaithersburg, MD 20899

Sandra Spickard Prettyman
Culture Catalyst, LLC

The public safety community is transitioning from land mobile radios to a communications technology ecosystem including a variety of broadband data sharing platforms. Successful deployment and adoption of new communications technology relies on efficient and effective user interfaces based on understanding first responder needs, requirements, and contexts of use; human factors research is needed to examine these factors. As such, this paper presents initial qualitative research results via semi-structured interviews with 133 first responders across the U.S. While there are similarities across disciplines, results show there is no easy "one size fits all" communications technology solution. To facilitate trust in new communications technology, solutions must be dependable, easy to use for first responders, and meet their communication needs through the application of user-centered design principles. During this shift in public safety communications technology, the time is now to leverage existing human factors expertise to influence emerging technology for public safety.

## INTRODUCTION

The public safety community performs the vital mission of protecting lives and property – from day-to-day operations to out-of-the-ordinary situations. Yet, the public safety community faces significant communications challenges including interoperability and network capacity, coverage, and service. To help address such challenges, a Nationwide Public Safety Broadband Network (NPSBN) is in development for public safety to take advantage of new technological innovations and enhance their communications and information sharing. The NPSBN will enable law enforcement officers, firefighters and emergency medical services providers to send data, images, video, and location information in real-time. These new capabilities should help first responders perform their life-saving mission more safely, efficiently, and effectively.

Traditionally in the public safety communications domain, systems have been tested and measured according to network factors such as capacity, coverage, service, and other public safety-grade features. As technologies mature, it is critical that all system factors be considered, including human factors. Careful consideration of user needs will enable significant improvements in overall public safety mission delivery, much more so than technology advancements alone will achieve.

As with many technological paradigm shifts, new opportunities also present new research and development (R&D) challenges. To facilitate this new R&D, the Public Safety Communications Research (PSCR) program was established at the National Institute of Standards and Technology (NIST). PSCR has recognized the need for usability research and enhanced user interfaces as one of several major priority research areas necessary to support new public safety communications technology. PSCR believes that, in order for first responders to execute operations successfully, technology must support their ability to efficiently and effectively complete their tasks without interference – success requires a "sound understanding of the user, their requirements, and the inherent features that make a system usable" (PSCR, 2018).

The recognition of the role that user interfaces play and the call for enhanced interfaces by PSCR presents a unique opportunity for human factors researchers and practitioners. The time is now to leverage this opportunity and contribute human factors expertise to influence new products and services for the public safety communications domain.

There have been notable pockets of human factors research in the public safety space—much of it by HFES researchers (e.g., Timmons & Hutchins, 2006; Lai, Entin, Dierks, Raemer, & Simon, 2004). However, public safety has not typically benefited from the same widespread human factors attention that other domains such as the military and aviation have received. With the upcoming technological shift and potential funding in the public safety communications space, the human factors community is well-poised to offer significant contributions and lessons learned from other relevant fields.

Unfortunately, research and development communities often propose communication and technology solutions for first responders without having a full understanding related to the characteristics of their work and the problems they face. However, understanding their user needs is a crucial first step towards successful technology design, deployment and adoption. There are roughly 4 million public safety workers in the U.S., composed of firefighters (FF), emergency medical services (EMS), law enforcement (LE), and 911 center communications (COMMS) personnel. Although it is a significant undertaking, this project set out to understand the wide range of first responders, their tasks, and contexts of first responder work. The research questions guiding this effort were: How do public safety personnel describe the context of their work, including roles and responsibilities as well as process and flow? How do public safety personnel describe

their communication and technology needs related to work? What do public safety personnel believe is working or not working in their current operational environment?

A goal of this research effort was to engage directly with first responders to understand their current user experience and what they need in order to communicate efficiently and effectively. Engaging with first responders captures their voices so that they become audible to a broader community.

## METHOD

There are two phases in this project's data collection; they are distinguished by the types of data collected. The first phase, the qualitative component, focused on interviews with 133 first responders across the U.S. The second phase will utilize a quantitative survey instrument to collect data to confirm and expand on the needs and problems related to communication and technology identified in the qualitative data. The qualitative and quantitative phases complement each other, providing a holistic view of first responders, their work, beliefs, and needs related to communications technology. The initial results for the FF, EMS, and LE disciplines of the qualitative component are described in this paper. (Note that few COMMS are included here, as they were part of a separate data collection effort.)

Qualitative research is iterative in nature and focuses on the importance of participants' perspectives throughout the research process. Our research process consistently returned to our research questions to inform elements of the process: instrument development, data collection, and data analysis. Further, data collection and initial data analysis were conducted in tandem and occurred iteratively.

### Instrument Development

The research team developed a semi-structured interview protocol. Pilot interviews were conducted with several first responders in each discipline to determine face and construct validity as well as assess language appropriateness for the user population. The pilot interviews demonstrated that a generalized instrument worked well across all disciplines. The final protocol included questions on work-related tasks, relationships, and communication and technology tools, and a short demographic form. The demographic questions focused on gender, age, years of service, and participants' ease and comfort with technology.

### Sampling Strategy and Participants

*Sampling strategy.* There is a wide range of different types of first responders with different roles and responsibilities, as well as different communications and technology needs. The initial sampling strategy focused on FF, EMS, and LE in urban, suburban, and rural locations. In addition to discipline and location representation, the sampling strategy addressed first responders with various levels of experience as a responder, from rookie to senior, as well as responders from multiple jurisdictional agency levels, and a mix of station types, both volunteer, career, and combined.

*Participants.* 133 participants were interviewed in 105 interview sessions. Table 1 shows the distribution of participants by discipline and location type.

**Table 1: Participant distribution by discipline and location**

| | FF | EMS | LE | COMMS | PS* | *Total* |
|---|---|---|---|---|---|---|
| Urban | 35 | 11 | 26 | 1 | | *73* |
| Suburban | 25 | 6 | 12 | 1 | 2 | *46* |
| Rural | 5 | 3 | 5 | 1 | | *14* |
| *Total* | *65* | *20* | *43* | *3* | *2* | *133* |

*PS are cross-trained in FF, EMS, and LE.

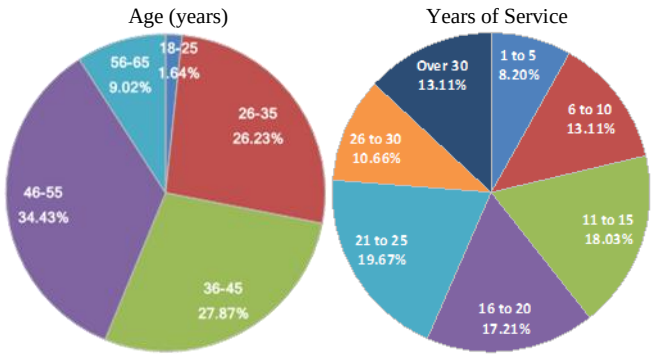


**Figure 1. Participant Demographics**

Figure 1 shows basic demographic characteristics. For these participants, their years of service ranged from less than a year in the field to 40 years of service (mean=18.89, *SD*=9.38). With respect to gender, there were very few women in our interview sample, just 9.84 %; however, this is representative of the first responder community in general. Women make up approximately 13 % of LE (U.S. Department of Justice, 2013) and less than 5 % of FF (National Fire Protection Association, 2018). Note that the demographics in Figure 1 are from *n*=122 first responders, as some participants did not complete all questions on the demographic questionnaire.

### Data Collection

Most interviews took place in the workplace (a police, fire, or EMS station) typically in either a group gathering area, a private office, or conference room. Some interview sessions had more than one participant. Each participant was provided with a copy of the study information sheet and verbally given a summary of its content. Participants were asked for permission to audio record the session.

The data consist of interview transcripts of the recordings, demographics, field notes, and analytic memos. All interview recordings (a total of 5 627 minutes) were transcribed by an external transcription service and the transcripts form the major dataset for analysis (1 807 pages). In addition, research team members wrote field notes related to interviews they conducted, that served as additional data for analysis.

**Data Analysis**

Data analysis involved both individual and research team coding and analysis sessions. Qualitative data analysis included coding, data extraction, and analytic memoing. Coding is a process of tagging data that allows for data reduction at the start of the analysis process. In the coding sessions, an initial code list was constructed and revised as the data were explored more fully. In these sessions findings were also discussed, ideas and concepts in and about the data were explored, and concepts and variables were ultimately identified to address as part of our analysis. Finally, data extraction was performed, which is the process of pulling (extracting) all data associated with a particular code from the source data to help identify relationships and themes that might exist across codes during analysis.

In the analysis sessions, the research team explored initial ideas about the data and the codes, and began to identify any relationships and themes. Analysis included thematic, negative case, values, and descriptive exploration of the data and the codes (Saldaña, 2013). Team members used analytic memoing to document the relationships of the data and the codes. The iterative process of reviewing the data and codes, the full data set and extracted files, facilitated the identification of themes, trends, outliers, and an overall impression and understanding of the data.

## RESULTS

This section presents the results of the initial analysis of the qualitative interview data, including how first responders' work influences their communication and technology needs, the challenges they face using their current technology, and their vital need for usable solutions. Participant quotes are presented to serve as exemplars of key concepts, ideas, and themes identified in the analysis rather than as just singular examples of data. All participant responses in blue text are verbatim and come directly from participant transcripts. The participant responses are followed by a notation that is comprised of three parts: discipline (FF, EMS, LE, COMMS, PS); city type (Urban=U, Suburban=S, Rural=R); and interview number. Thus (FF-R-009) refers to a FF interview, from a rural location, who was fire interview number 009.

**Public Safety Communication and Technology Needs**

First responders in fire, law enforcement, and EMS require unique skillsets to respond to incidents in their respective disciplines. They are responsible for handling the most extreme incidents, utilizing the highest levels of specialized training, as well as the more routine day-to-day tasks. In their work environments, first responders are expected to know it all:

> Pretty much, we're going to go help anybody that needs help, whether it's medical, fire, anything like that. If they need something, just call the fire department, we'll come and help them… So if it was really coming down to, "What do we do?" just be anything for the citizens we work for, pretty much. (FF-R-009)

> We're multi-faceted. We're teachers, doctors, nurses, medics, moms, dads, coaches, counselors is a big one, mental health specialists, which is what we get a lot of in [city redacted]. We're jack of all trades. We do everything. Report takers, problem solvers, crime fighters. I mean, we do everything in [city redacted]. (LE-U-013)

When responding to incidents, first responders have to expect the unexpected. While the extreme range of incident types in their work is overwhelmingly consistent across all three disciplines, first responders' communication and information needs and practices during incident response have very distinct differences. These differences heavily depend on their discipline, their position, and especially their role in the chain of command.

The differences among and within the various disciplines of FF, LE, and EMS imply that there is no easy "one size fits all" communications technology and data solution. Participant responses clearly show that not all first responders need access to all types of communication tools, nor to the same communication tools—everyone does not need everything. However, there are some important similarities across disciplines; for instance, FF, EMS, and LE all need to know the location and nature of incidents, and traffic patterns while en route to a location. Despite these similarities across disciplines, it is critical that technology developers and data providers know that even within a single discipline, communications technology and information needs differ based on both individual first responder roles as well as the scale and nature of the incident to which they are responding.

For FF, incident commanders need a much more holistic view of the incident in order to monitor and direct all teams involved, whereas the firefighters under their command are often completing very specific tasks and communicating only with their immediate crew. Likewise, information and communication needs for a single-family home structure fire differ from a high-rise fire or a large-scale hazmat incident. For EMS, information and communication needs of an EMS squad supervisor responsible for directing multiple crews are different from an individual paramedic and his/her partner. Coordinating and providing patient care for a mass casualty incident (MCI) is different than dealing with a single cardiac arrest patient. In LE, information and communication needs for a single patrol officer during a simple stop for a traffic violation are very different than those of an incident commander in charge of coordinating police response to an ongoing active shooter event. Shorter duration incidents require different information and communication needs than more extended incidents, such as active shooters, public protests and sporting events. Across these disciplines, the challenges in using communications technology are heightened due to first responders' unique environments, tasks, and needs.

**User-Centered Design of Public Safety Communications Technology**

As the human factors community is well aware, the design of new technology should focus on the user rather than be designed in a vacuum, absent of user needs. To have a positive impact on the work of first responders, meaningful improvements to their current technology and research and developments of new technology must be designed with and for them.

> The idea of [a button used only for] emergency alerting on radios is absolute crap. It's a theory and a concept that was created in an air-conditioned room on a whiteboard, but when you're scared to death, you're going to do what you do 99.9 % of the time… hit the side button [used for normal radio transmissions]. (FF-R-008)

First responders spoke of what is working or not working in their current operational environments. Universally, participants all wanted better, faster, and cheaper technology. They also emphasized the needs to improve their current technology, reduce unintended consequences, lower product/service costs, and make technology easier to use. The user-identified needs and requirements provide a blueprint for the public safety communications R&D community to develop solutions for solving the "right problems." From the first responders' interviews, six user-centered governing principles emerged that should guide all development of public safety technology.

***1) Improve current technology.*** Designers should make what first responders currently have better, more affordable, and more reliable. For example, better radios – coverage, durability, clarity; better microphones and cords. It is not necessarily new technology that first responders want, but the improvement of current technology that they believe is most important.

> let's slow our horses a little bit, and let's back up and… Instead of introducing all this extra new stuff let's, one, make sure what we have actually works better. And then, two, let's not rely on it so much. (FF-U-042)

***2) Reduce unintended consequences.*** Develop technology that does not take away first responders' attention from their primary tasks–causing distraction, loss of situational awareness, cognitive overload, and over-reliance on technology. Consider the social, political, policy, and legal implications of technology.

> With all the different [technology] functions, it makes actually seeing what's going on in the neighborhood harder. And somebody's looking at this box to tell them what's going on as opposed to actually looking at the surroundings and figuring out what's going on. (LE-U-024)

***3) Recognize 'one size does not fit all'.*** While standardization is critical for consistency, compatibility and quality, technology development must accommodate a variety of different public safety needs–across disciplines, personnel, departments, districts, contexts of use–all requiring adaptability and configurability.

> So that's the challenge [for developers]. Whatever you come out with, it's not going to be one size fits all. (EMS-U-001)

***4) Minimize 'technology for technology's sake'.*** Develop technology with and for first responders driven by their needs, requirements, and contexts of use.

> I can't make any of my employees do anything. Okay. They're here 24 hours a day. I've done their job. It's not easy. If you throw all kinds of harder stuff to make their job harder on top of it, it's not going to work. I mean, I can put all of the sanctions and rules and everything I want on it, but I have to motivate people to want to use this technology and show them the advantage of using it… We can post statistics that show us what we're really doing, how it's useful. But if it's not [useful] to them, what's in it for them? (EMS-R-008)

***5) Lower product/service costs.*** Develop technology at price points that departments can afford to purchase and maintain to reduce monetary barriers.

> [Technology] has to be affordable, and that's the challenge. Of course, they're loosely related. I mean, there are companies out there that sell all this stuff, but it's never achievable for us. We'll never be able to spend $10 000 on a radio. We have a hard enough time spending-- right now, I mean, our radios are costing almost 4 grand for radio. And that's why we have older radios because we can't afford the new stuff. (FF-R-019)

***6) Require usable technology.*** Develop 'Fisher-Price' solutions – simple, easy to use, light, fast, and not disruptive. Technology should make it easy to do the right thing, hard to do the wrong thing, and easy to recover when the wrong thing happens.

> But when you're in a dynamic environment, you need relatively simple what I call "Fisher-Price technology." Big shapes, big buttons, colors, things like that so that I don't have to scroll down menus and things like that… (FF-S-035)
>
> In the police world, if you want somebody to use something, it has to be simple. The more complicated it is, it's very seldom getting used. (LE-R-001)

Participants were not opposed to technology, but they want technology that makes sense to them and makes their work easier to accomplish. They don't want technology to sever and replace the human connection they see as so important. Technology must also work with first responders' other equipment and tools, and be affordable. Adhering to these guiding principles will promote first responders' trust with new technology, a requirement for successful adoption.

**Trust in Public Safety Communications Technology**

Early in the data analysis, the concept of trust emerged as an overarching element in public safety communications technology. The relationship of trust to many of the problems identified by the first responder participants was prevalent in the data. Although it was not specifically asked during the interviews, trust cut across the data, irrespective of discipline, geography, city type, rank, age, years of service, and other variables.

Trust is built over time and requires good experiences. Unfortunately, many participants' experiences with new technology have predisposed them not to trust technology. As a result, often participants did not see the need for new technology.

> I mean, the big thing is everything we use, I mean, we don't have time to mess with it, or tweak it, or play with it. It has to work the first time, every time, or people will just stop using it. They will just refuse to use it and go back to the old way of talking on the radio. (EMS-U-003)

Users' first impressions of a new technology heavily influences trust of that technology, adoption, and continued use. Building trust requires that the technology development community 'solve the right problems' – problems identified by first responders that impact their work.

## DISCUSSION AND CONCLUSIONS

The voices of first responders should be at the forefront when considering the design, development, and adoption of public safety communications technology. According to participant responses collected in our interviews, researchers and developers should focus on technology that facilitates first responders' primary tasks and improves the user experience. During the interviews, participants noted the huge costs that occurred when technology was mandated or "pushed" upon first responders. Even if new technology is adopted at the administrative level, it will be impossible to convince end users to use it if they do not see immediate and tangible benefits for themselves. The components of usability, i.e., effectiveness, efficiency, and satisfaction, (ISO, 2010) must be fulfilled in order for successful public safety technology development and deployment. For the public safety space:

- Effectiveness – how the technology will be useful in first responders' primary task of protecting lives and property while preserving or enhancing situational awareness,
- Efficiency – how the technology will be easy to use and save first responders' time,
- Satisfaction – how the technology will promote first responders' comfort and confidence in use.

When designing for usability, it is important to consider the finding that communication and technology needs differ by first responders' roles and operating environments. This finding—that user characteristics and contexts of use influence user needs—is not unique to the public safety domain. However, it is often the case that technology designers in this space may assume that similarities among first responders outweigh their differences. Additionally, although many assume public safety is very similar to the military, first responders often have different training and experiences than do military personnel. For example, in the fire service, where 70 % of first responders are volunteer (Haynes & Stein, 2017), military-grade technology is neither designed to be cost effective, nor built to withstand the extreme environment of a fire ground (Hamins, et. al., 2015).

Differences such as those between career and volunteer in the fire service, as well as age, rank, position, or city type in the other public safety disciplines, are avenues for future exploration of the existing qualitative data results. Together with the quantitative survey results in phase two, this analysis will provide a more holistic view of challenges in the field, as well as implications for public safety technology designers and evaluators.

As human factors researchers, we need to challenge the assumption that, with new technology, public safety first responders will simply be able to 'communicate' with one another as long as their radios or devices are on the same network. There are many other non-technological factors involved: for example, differences in standard operating procedures (SOPs), communication styles, and whether first responders have trained and worked together before.

Just because devices can 'talk to each other' on a national broadband network, does not necessarily mean that first responders can do so as easily. Trust in technology is not built in a day, and it is much easier to destroy trust than it is to build it. New communications technology must be dependable, easy to use for first responders, and meet their communication needs. With the forthcoming NPSBN, the time is now for human factors professionals to partner with public safety researchers to improve public safety communications technology.

## DISCLAIMER

Any mention of commercial products or reference to commercial organizations is for information only; it does not imply recommendation or endorsement by the National Institute of Standards and Technology nor does it imply that the products mentioned are necessarily the best available for the purpose.

## REFERENCES


Hamins, A., Grant, C., Bryner, N. P., Jones, A. T., & Koepke, G. H. (2015). Research Roadmap for Smart Fire Fighting. NIST Special Publication 1191. DOI: http:/dx.doi.org/10.6028/NIST.SP.1191

Haynes, H. J. G., & Stein, G. P. (2017). U.S. Fire Department Profile – 2015. *National Fire Protection Association*. https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics/Fire-service/osfdprofile.pdf (Accessed Feb, 2018).

ISO 9241-210. (2010). *Ergonomics of human-system interaction -- Part 210: Human-centred design for interactive systems*.

Lai, F., Entin, E., Dierks, M., Raemer, D., & Simon, R. (2004). Designing simulation-based training scenarios for emergency medical first responders. In *Proc. of the Human Factors and Ergonomics Society Annual Meeting*, vol. 48, 15: pp. 1670-1674.

Middle Class Tax Relief and Job Creation Act of 2012, Public Law 112–96, 126 Stat. 156, February 22, 2012. http://www.gpo.gov/fdsys/pkg/PLAW-112publ96/pdf/PLAW-112publ96.pdf (Accessed Feb, 2018)

National Fire Protection Association. Firefighting occupations by women and race. http://www.nfpa.org/News-and-Research/Fire-statistics-and-reports/Fire-statistics/The-fire-service/Administration/Firefighting-occupations-by-women-and-race (Accessed Feb, 2018)

Public Safety Communications Research. (2018). https://www.nist.gov/ctl/pscr/research-portfolios/user-interfaceuser-experience (Accessed Feb, 2018)

Saldaña, J. (2013) *The Coding Manual for Qualitative Researchers* (2nd ed.). Thousand Oaks, CA: Sage.

Timmons, R. P., & Hutchins, S. G. (2006). Radio interoperability: There is more to it than hardware. In *Proc. of the Human Factors and Ergonomics Society Annual Meeting*, vol. 50, 4: pp. 609-613.

U.S. Department of Justice (2013) Women in Law Enforcement, in *COPS – Community Policing Dispatch*. https://cops.usdoj.gov/html/dispatch/07-2013/women_in_law_enforcement.asp (Accessed Feb, 2018)