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Voices of First Responders

Public Safety Communications Research

Fire Service

Special Publication 1286pt3



NIST | NATIONAL INSTITUTE OF
STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

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Introduction

The goal of the National Institute of Standards and Technology's (NIST) Public Safety Communications Research (PSCR) program's Usability Team was to provide guidance on the usability of public safety communication technology. Toward that end, the PSCR Usability Team collected and analyzed data related to the contexts in which first responders work and their experiences with communication technology.

Data analysis of first responder needs for, and problems with, communication technology resulted in the development of six user-centered design guidelines. These guidelines serve as a set of best practices for technology developers working to develop and improve communication technology in the public safety domain.

This Special Publication is primarily intended for designers, developers, vendors, and researchers of public safety communication technology, as well as for public safety administrators and decision-makers. It is one of four in a special Voices of First Responders mini-series highlighting the experiences of first responders with communication technology, including their needs for, and problems with, communication technology. The special mini-series focuses on four first responder disciplines: Communication Center & 9-1-1 Services (COMMS); Emergency Medical Services (EMS); Fire Service (FF); and Law Enforcement (LE). Each presents discipline-specific data supporting the six user-centered design guidelines. This publication in the special mini-series focuses specifically on first responders in the fire service (FF).

In this publication, each of the six user-centered guidelines are discussed, along with supporting data, to provide a succinct view for how to optimize the FF user experience with communication technology. The results presented here are not exhaustive or comprehensive but provide a high-level summary of findings. Additional information can be found in the previous nine volumes of the Voices of First Responders Series which are cited on the final page of this publication. Ultimately, the goal is to provide guidance for ensuring an optimal user experience with communication technology for first responders in FF.

Communication Center & 9-1-1 Services

NIST SP 1286pt1

[https://doi.org/10.6028/
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Emergency Medical Services

NIST SP 1286pt2

[https://doi.org/10.6028/
NIST.SP.1286pt2](https://doi.org/10.6028/NIST.SP.1286pt2)



Fire Service (this Special Publication)

NIST SP 1286pt3

[https://doi.org/10.6028/
NIST.SP.1286pt3](https://doi.org/10.6028/NIST.SP.1286pt3)



Law Enforcement

NIST SP 1286pt4

[https://doi.org/10.6028/
NIST.SP.1286pt4](https://doi.org/10.6028/NIST.SP.1286pt4)



What We Did

The NIST PSCR Usability Team conducted an exploratory, sequential, mixed-methods study to gather data about the experiences of first responders in four public safety disciplines – COMMS, EMS, FF, LE. This multi-phase study consisted of in-depth interviews with 193 first responders about their views on communication technology (Phase 1). The results of these interviews informed a large-scale, nationwide survey completed by 7,182 first responders from across the United States (Phase 2). Respondents included first responders from all four disciplines and came from rural, suburban, and urban areas. The results of the study are reported across nine volumes in the Voices of First Responders series.

When quotes from the data are used in this publication, they are followed by a notation that shows where they are from in the data. Notations that begin with INT come from Phase 1 interviews, while those that begin with SUR come from Phase 2 open-ended survey responses. This is followed by the first responder discipline: COMMS; EMS; FF; and LE. Next is an indicator of whether the participant worked in a rural (R), suburban (S), or urban (Urban) area. The notation ends with a participant number. For example, INT-FF-R-200 refers to interview participant number 200 who was in FF and worked in a rural area.

Phase 1 In-Depth Interviews

1 Goals

- Problem
- Purpose
- Research questions

2 Protocol

- Develop protocol
- Identify sample
- Pilot protocol

3 Data Collection

- Recruit participants
- Conduct interviews
- Have data transcribed

4 Analysis

- Create initial code book
- Code interview data
- Identify emergent themes
- Analyze data/codes

5 Results

- Develop relationships
- Identify variables

Phase 2 Nationwide Survey

1 Goals

- Problem
- Purpose
- Research questions

2 Survey Instrument

- Survey items and scales
- Reviews: content and survey experts, pseudo-participants
- Refine instrument

3 Data Collection

- Disseminate survey
- Send reminders
- Monitor responses

4 Analysis

- Perform data analysis
- Quantitative
- Qualitative

5 Results

- Describe sample
- Draw inferences
- Identify usability requirements

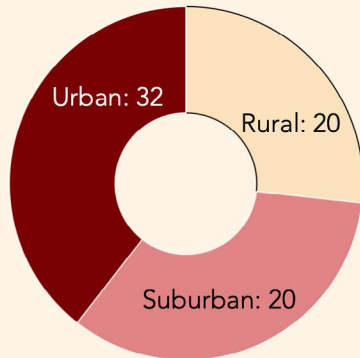
The Voices We Heard

Fire Service Participants

71

First responders interviewed

Average
20 years
experience

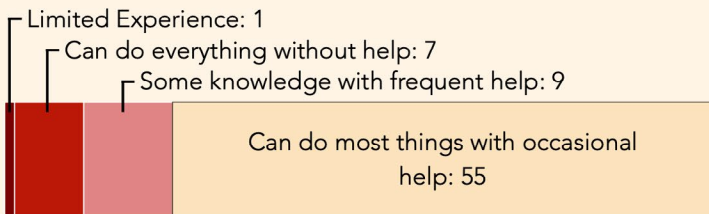


Non-Frontline
Responder: 6

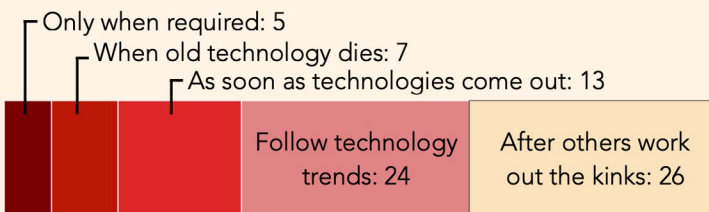
Supervising Responder: 19

Frontline Responder: 20

Chief / Management: 22



Experience with Technology

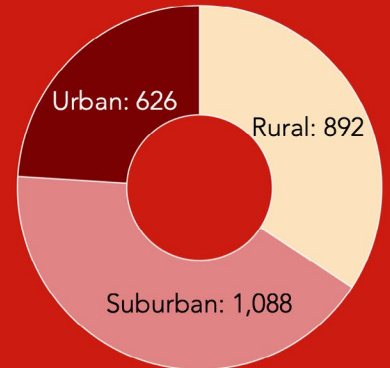


Technology Adoption

2,617

Survey respondents

Average
26 years
experience



Non-Frontline
Responder: 86

Supervising
Responder:
418

Frontline
Responder: 465

Chief / Management: 1,592

Federal: 22

County: 534

Local: 1,996

State: 49

Jurisdiction

Volunteer: 835

Career: 1,771

Fire Department Type

What We Recommend

User-Centered Design Guidelines



Guideline #1: Improve current technology

Improve functionality of what first responders currently have, make technology more affordable and more reliable. It is not necessarily new technology that first responders want, but the improvement of current technology that they believe is most important.



Guideline #2: Reduce unintended consequences

Develop technology that does not interfere with first responders' attention to their primary tasks. Technology interference can cause distraction, loss of situational awareness, cognitive overload, and over-reliance on technology.



Guideline #3: Recognize "one size does not fit all"

While there are similarities across the first responder disciplines and standardization is important for consistency, compatibility, and quality, technology must accommodate the wide variety of public safety needs—across disciplines, personnel, departments, districts, and contexts of use. All are different, requiring easy adaptability and configurability.



Guideline #4: Minimize "technology for technology's sake"

Develop technology with and for first responders driven by their user characteristics, needs, requirements, and contexts of use.



Guideline #5: Lower product/service costs

Develop technology at price points that departments can afford, lowering costs for technology. The goal should not only be to design the tool, but to design it at a price-point that makes it feasible and scalable for use.



Guideline #6: Require usable technology

Know thy user and develop 'Fisher-Price' solutions – simple, easy to use, light, fast, and not disruptive. Technology should make it easy for the user to do the right thing, hard to do the wrong thing, and easy to recover when the wrong thing happens.



GUIDELINE 1:

Improve Current Technology

Designers, developers, vendors, and researchers of public safety communication technology need to focus their efforts on addressing the issues, including price, that first responders continue to face with the devices they use the most for day-to-day incident response.

- Improve the current technologies FF first responders continue to experience significant problems with, including with the devices they rank as most useful for their day-to-day incident response listed on the right.
- FF survey responses show that “price: too expensive” is the top problem that FF first responders “Always” experience with communication technology. Both qualitative and quantitative data show that the top problems across the most used devices for FF are coverage and connectivity, device batteries (including battery life), reliability, and price.
- Improving their current technology is more important to FF participants than having access to futuristic forms of technology. When asked about futuristic forms of technology on the survey, the one “futuristic” technology that over 50% of FF survey respondents said would be useful is one login (single sign-on or SSO), which is widely used in other domains and generally not considered an advanced technology.
- Technological improvements should be prioritized by what is most useful to FF first responders in their day-to-day incident response. Although used a lot, certain devices may not be as useful as others to FF responders. For example, while thermal imaging cameras were frequently used by more than 80% of FF survey respondents, they were only ranked in the top 5 most useful devices by 30% of FF.

Devices Ranked Most Useful

1. Portable radio
2. Personal smartphone
3. Desktop computer
4. In-vehicle radio
5. Work-issued smartphone
6. Mobile Data Terminal
7. Pager

“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.”

(INT-FF-U-042)

“if everybody in the globe has the technology to find their phone, why can't they find me based on my radio?”

(INT-FF-U-002)

*Top problems
across devices*



price



coverage &
connectivity



reliability



batteries



GUIDELINE 2: Reduce Unintended consequences

In both Phase 1 and Phase 2 data, FF first responders note that new technology often comes with, or can create, unintended consequences. This is often the case with new radios. While new radios bring additional capabilities or coverage, it is important to consider whether these are necessary for FF as they engage in their primary tasks, especially since new radios also come with an increased price.

Designers, developers, vendors, and researchers of public safety communication technology need to make sure that there are no unintended consequences with the technologies they develop for first responders that might interfere with their attention to their primary tasks.

"But we do have the capability to talk...if everybody moves to these certain channels. But they're so rarely used that a lot of our guys, they have to search for them. They're literally going bank to bank in the radio to try to find it."

(INT-FF-R-024)

1 in 2

FF survey respondents had channel issues with their radios at least "Sometimes"

75% of FF survey respondents had problems with the coverage and price of their radios at least "Sometimes"

Case: Radios

Radios are a lifeline for FF — they rely on them working effectively, efficiently, and consistently. Changes and upgrades to FF radios can create both problems and benefits. New radios can bring benefits, such as greater interoperability. However, many times the negatives outweigh the positives. For example, new radios can come with additional channels—but more channels may not be something that FF need, want, or will use. New (and more) channels may just cause frustration for FF, as well as additional expense. Likewise, the switch from low frequency to new 800MHz radios can provide for better range and coverage in some cases, but it can also create problems when trying to communicate in many indoor locations. For many FF, older radio systems offered better overall communication.

"A knife can either be a weapon or it could be a cooking tool. It's just on how you use it. And with every new whatever, new fire truck, new gadget, new app, new everything, there's always that double edge of both negative and positive of whatever it is."

(INT-FF-R-019)

"Constant coverage concerns!!! Numerous deadzones! Channels that switch at the slightest touch. Being forced to use 800mghz radios that DO NOT WORK ON INTERIOR INCIDENTS."

(SUR:FF:R:5257)



GUIDELINE 3:

Recognize “one size does not fit all”

Communication technology is paramount to all first responder disciplines, however, the contexts of use, needs, and problems vary across disciplines. Designers, developers, vendors, and researchers of public safety communication technology need to make sure that technology they develop attends to the specific contexts of use and needs of first responders, rather than providing “generic” technology that may or may not address their needs and problems.

- Survey responses show that, while similar to EMS, FF first responders use different devices and software/apps than first responders in COMMS and LE disciplines. For example, more FF and EMS used pagers, personal smartphones, and tablets than their counterparts. FF first responders used corded mics more frequently than the other disciplines.
- The contexts of use, needs, and problems also vary amongst FF first responders. For example, rural FF have very different needs than their suburban and urban counterparts, lacking many basic resources and desiring existing technology solutions (e.g., computer-aided dispatch (CAD), electronic patient care records (EPCR), records management system (RMS)) as shown below.

Considering Fire Service Environments

Rural vs. Urban and Suburban

- Rural FF are *more* likely to:
 - frequently use pagers
 - have radio coverage problems
 - have problems with the price of radios and desktop computers
- Rural FF are *less* likely to:
 - frequently use mobile data terminals (MDTs)
 - have CAD, EPCR, language translation, and RMS

Volunteer vs. Career

- Volunteer FF are *more* likely to:
 - use pagers
 - view pagers as useful futuristic technology
 - have problems with the price of radios and desktop computers
- Volunteer FF are *less* likely to:
 - use MDTs and desktop computers
 - have MDTs, work-issued smartphones, in-vehicle radios, and tablets
 - have RMS, CAD, language translation and EPCR

Chief/Management vs. Frontline Responders

- FF chiefs are *more* likely to:
 - frequently use pagers, work-issued smartphones, and laptops
 - have problems with the price of radios
- FF chiefs are *less* likely to:
 - frequently use TICs, corded mics, and MDTs
 - have TIC, personal smartphone, MDTs, and flip phones
 - have problems with the sufficiency of smartphone subsidies



GUIDELINE 4: Minimize “technology for technology’s sake”

Designers, developers, vendors, and researchers of public safety communication technology need to recognize that just because we can, doesn’t mean we should—just because technology exists, does not mean it will be helpful for first responders. Focusing on what they see as useful is a better strategy for optimizing the user experience and encouraging adoption and usage.

Both qualitative and quantitative data show that first responders did not see most forms of futuristic technology as something they would find “useful for [their] day-to-day work.” On the survey, respondents were asked which futuristic technologies they thought would be “useful for your day-to-day work.” Participants could select from a technology list, which consisted of futuristic technology as well as more current devices that participants did not already have.

- Of all the futuristic technology listed in the survey, one login (single sign-on or SSO) is the only technology selected by more than half of FF respondents.
- More than 1 in 4 FF survey respondents did not already have the technologies shown on the right, but thought they would be most useful for their work.

Make “Good, Basic Technology”

- Existing technology many FF respondents did not have, but thought would be useful:
 1. Mobile Data Terminal
 2. Laptop
 3. In-vehicle radio
 4. Portable radio
 5. Tablet
 6. Work-issued smartphone
 7. Wireless earpiece (work-issued)
 8. Thermal Imaging Camera

“I’m carrying usually two 800 radios, a VHF, and two cellphones when I’m running an incident. And that’s ridiculous... It’s also too much information... When someone’s talking, I can’t process all that information. So to fix that problem... consolidate it down, but then, somehow, have it manageable.”

(INT-FF-R-019)

Least selected futuristic technology

Over half of the futuristic technologies listed on the survey were selected by less than 20% of FF. Some of the most futuristic technology in the list, like those shown here, were selected by less than 10% of FF.



Augmented reality (AR)



Robots



Self-driving vehicles



Smart glasses



Virtual reality (VR)



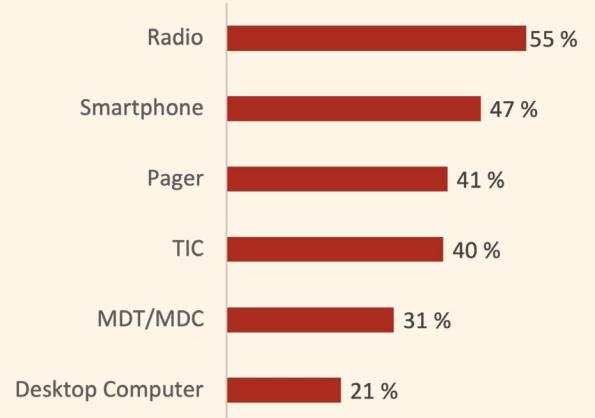
GUIDELINE 5: Lower product/service costs

The cost of technology was a major issue identified by FF participants in the Phase 1 interview data. Likewise, survey data show that “Price: too expensive” was the top problem “Always” experienced by FF respondents with nine of the ten devices listed on the survey, often by a ratio of at least 2:1 — twice as many FF survey respondents had problems with price than any other device problem. Cost issues were wide-ranging, and not only refer to the initial cost of purchasing the technology, but also auxiliary costs such as maintenance, upgrades, IT support, training, and data plans. Participants reiterated time and time again that technology must be developed at price points they can afford. This was especially true for rural participants whose funding sources were often woefully inadequate to support their work and the tools they need to accomplish it. FF first responders also see changes with technology as happening so quickly that they find it difficult to keep up, financially and technologically.

Designers, developers, vendors, and researchers of public safety communication technology need to address this major pain point for first responders, recognizing the important role that budgets and finances play in the usage and adoption of new technology. When designing new or improving current technology, it needs to be affordable, with scalability for widespread distribution whenever possible.

Problems with Cost

Top FF ranked and FF-specific devices:
Percentages of FF who had problems with price all or most of the time.



“Cost of useful apps prevents us from making or using any that could really assist us... We carry pagers and our smart phones could take the place but cost is the issue.”

(SUR:FF:S:7583)

“The price of [laptop] software that would be truly useful to the department is prohibitive.”

(SUR:FF:R:1781)

“We currently are on 460 MHz radios, which are sufficient, but with the current trend towards the [statewide] system, I anticipate problems with... the expense of monthly subscriptions.”

(SUR:FF:R:2741)

\$\$\$

Our survey data show that COST was the top problem across devices and public safety disciplines



GUIDELINE 6:

Require Usable Technology

Many problems with communication technology faced by first responders are in some ways a usability issues. Both interview and survey data show that participants repeatedly identify usability issues with their communication devices as major problems they face during incident response. First responders are not opposed to technology, but they want technology that makes sense to them within their contexts of use. The goal is for technology to make it easier for them to accomplish their primary tasks. Ultimately, first responders require technology that is easy to use, easy to learn, and easy to integrate into their contexts of use.

Designers, developers, vendors, and researchers of public safety communication technology need to recognize that usability and usefulness figure heavily into decisions about adoption and usage. Listening to and taking into consideration the voices of first responders could go a long way in helping them trust (and thus be willing to use) improved and newly developed technology.

- FF first responders experience significant problems with their ability to efficiently and effectively access and use the devices they rely on every day for incident response, like radios, smartphones, and MDTs.

"If I have my radio up too loud and my officer's next to me, we get feedback... then if your radio is down too low, then [you can't hear]." (INT-FF-S-022)

"Most firefighters use the... strap, which puts the radio at your waist with the cord coming up and across the chest. Stupidest set up ever!! Entanglement issues, cant reach the radio if its under the coat, have to plug in and unplug the earpiece cord, possibility of melting it if its on top of the coat, In my mind this is a huge safety issue." (SUR:FF:S:6590)

Human factors & Ergonomics (HFE)

HFE considerations

- Perceptual
- Cognitive
- Physical
- Environmental
- Social & Organizational

Usability considerations

- Efficiency
- Effectiveness
- Satisfaction

"But for firemen, it needs to be built by Fisher-Price. It's got to be bacteria resistant. It's got to be waterproof. You've got to be able to throw it in the dishwasher. It's got to go through high temps, got to go through low temp. It can't have thin wires. It's got to have big buttons because I'm wearing gloves. It's got to be built for a three-year old. Because this is how we use it. We use it in the water. We use it in the cold. We use it in the heat. We use it with calls..."

(INT-FF-R-019)

"When you're in a dynamic environment... I need it very simple because I don't have the time or the mental capability or the bandwidth to be looking at a lot of different things. When you're under stress, you want something that will do simple things quickly."

(INT-FF-S-035)

VOICES OF THE FIRE SERVICE

Urban
24%

Suburban
42%

Rural
34%

2,617 Respondents



Radio
Portable 99%
Vehicle 92%

Audio Quality
Price
Coverage
Battery Life



Desktop Computer
91%

Login/Passwords
Software Updates
Outdated
Price



Personal Smartphone
88%

Battery Life
Price
Coverage
Glare



Thermal Imaging Camera
83%

Price
Battery Life
Small Screen
Size/Bulkiness



Laptop
78%

Internet Connection
Price
Battery Life
Login/Passwords



Corded Mic
70%

Audio Quality
Cord
Price
Placement on Body



Email
99%



Mapping
86%



Hydrant Location
80%



Computer Aided Dispatch
75%



Emergency Response Guide
75%

Apps Used

Devices Used & Top Problems

Drones
40%



Real-time on-scene video
39%



Heads-up Display
38%



Automatic Vehicle Location
49%



One-Login
53%



Deployable
82%



Mobile Command Center
74%



Drones
71%

Tech. Needs for Major Disasters

Futuristic Technology Needs

Voices of First Responders Publications

Voices of First Responders, Phase 1: Findings from User-Centered Interviews

- Volume 1 - Identifying Public Safety Communication Problems (NISTIR 8216)
- Volume 2 - Examining Public Safety Communication Problems and Requested Functionality (NISTIR 8245)
- Volume 3 - Examining Public Safety Communication from the Rural Perspective (NISTIR 8277)
- Volume 4 - Examining Public Safety Communication from the Perspective of 9-1-1 Call Takers and Dispatchers (NISTIR 8295)
- Volume 5 - Applying Human Factors and Ergonomics Knowledge to Improve the Usability of Public Safety Communications Technology (NISTIR 8340)

Voices of First Responders, Phase 2: Nationwide Survey

- Volume 1 - Methodology: Development, Dissemination, and Demographics (NISTIR 8288)
- Volume 2 - Mobile Devices, Applications, and Futuristic Technology (NISTIR 8314)
- Volume 3 - Day-to-Day Technology (NISTIR 8400)
- Volume 4 - Statistical Analysis Results (NISTIR 8444)
- How to Facilitate Adoption and Usage of Communication Technology: *An Integrated Analysis of Qualitative and Quantitative Findings* (NISTIR 8443)
- PSCR Usability Results Tool: <https://publicsafety.nist.gov/>

Other relevant publications from NIST's PSCR Usability Team

- Incident Scenarios Collection for Public Safety Communications Research: Framing the Context of Use (NISTIR 8181)
- Usability Handbook for Public Safety Communications - Ensuring Successful Systems for First Responders (NIST Handbook 161)

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<https://www.nist.gov/ctl/pscr/user-interface-user-experience-publications>

<https://www.nist.gov/programs-projects/usability-and-public-safety-communications-research>



NIST Research Protections Office reviewed the protocol for this project and determined it meets the criteria for "exempt human subjects research" as defined in 15 CFR 27, the Common Rule for the Protection of Human Subjects.

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