



What Futuristic Technology Means for First Responders: Voices from the Field

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Abstract. The public safety communication technology landscape in the United States (U.S.) is evolving to supplement the use of land mobile radios with a broader spectrum of communication technologies for use on the newly created Nationwide Public Safety Broadband Network. The goal of the multi-phase research study presented here was to understand the use of communication technologies by the population of first responders—Communications (Comm) Center & 9-1-1 Services; Emergency Medical Services; Fire Services; and Law Enforcement. The sequential, exploratory mixed methods study consisted of an initial exploratory qualitative phase followed by a larger quantitative phase. The qualitative data collection was via in-depth interviews with 193 first responders across the U.S.; the quantitative survey was completed by 7,182 first responders across the U.S. This paper presents the results of the study related to first responders' perceptions about the future of public safety communication technology. Discussed are the technologies first responders think would benefit their individual user populations, as well as communication technologies that would be useful across user populations within the public safety domain. Results show that first responders are open to new and exciting technologies, but their needs are utility driven; to have the biggest impact, their communication technology must be tailored to their needs and contexts. This paper will present the needs of first responders, in their own voices, to aid in the research and development of public safety communication technology.

Keywords: Usability · User survey · UX (user experience) · User requirements · Public safety · First responders · Incident response

1 Introduction

The public safety communication technology landscape in the United States (U.S.) is evolving. With the newly created Nationwide Public Safety Broadband Network (NPSBN), the public safety community is supplementing the use of land mobile radios with a broader spectrum of communication technologies. The public safety community has identified User Interfaces and User Experiences (UI/UX) as one of the key areas for research and development of these rapidly advancing technologies [1]. As such, the

Public Safety Communications Research (PSCR) Program at the National Institute of Standards and Technology (NIST) conducts research focusing on the end users – first responders [2]. Under this program, the NIST PSCR Usability Team performs research and provides guidance to ensure that communication technology in the public safety domain helps first responders achieve their goals and objectives with effectiveness, efficiency, and satisfaction in their specified contexts of use [3]. To this end, the NIST PSCR Usability Team has studied the public safety field to gain a better understanding of the user population of first responders—Comm Center & 9-1-1 Services (COMMS); Emergency Medical Services (EMS); Fire Services (FF); and Law Enforcement (LE). These four first responder disciplines, COMMS, EMS, FF, and LE, use different types of tools for different purposes; they experience different problems and have different communication technology needs. This is why it is crucial to understand the different public safety user groups and the communication technology they currently use, the problems they experience with current technology, and the technology they would like to have access to in the future.

NIST's PSCR Usability Team conducted a multi-phase, mixed methods research project in order to provide greater understanding of first responders, their experiences, and their communication technology problems and needs. The goal was to understand what first responders believe is necessary to facilitate communication and address their communication technology needs. Phase 1 of the project was a qualitative examination of first responder contexts of work [4]; interviews were conducted with first responders across the country from the four first responder disciplines—COMMS, EMS, FF, and LE. Phase 2 of the project utilized data from the qualitative interviews conducted in Phase 1 to create a large-scale, nationwide survey. The Phase 2 survey was designed to augment understanding of the types of communication technology first responders have, use, and want, and the problems they currently experience with their technology [5]. Understanding the use of communication technology by the four disciplines is critical to the success of the technology developed for the NPSBN.

Given the breadth and depth of the data collected, this paper focuses on a subset of the results from the Phase 2 survey related to the future of public safety and the NPSBN, presenting Phase 1 interview data throughout as appropriate. Previously analyzed results from the study are presented in [4–11]; additional data will be examined in future publications. The forward-looking communication technology needs of first responders presented here specifically focus on the potential usefulness of current devices first responders do not have, futuristic devices, and virtual reality (VR).

2 Methodology

2.1 Overview

The project consisted of a study with a sequential, exploratory mixed methods design, where an initial exploratory qualitative phase was followed by a larger quantitative phase. Phase 1 – the qualitative phase – examined first responders' communication technology use via in-depth interviews [4, 7]. The data from the interviews were the basis of the survey design used in Phase 2 – the quantitative phase [5]. In Phase 2, a large-scale, nationwide survey was conducted in order to gain a more comprehensive understanding

of communication technology in the public safety community [5]. Data from both phases was integrated for analysis to provide for a more holistic understanding of first responders and their communication. For ease of exposition, this paper will refer to the research phases as “interviews” and “survey” henceforth (for the Phase 1 qualitative interviews and the Phase 2 quantitative survey, respectively).

Overarching Sampling Goals. To provide a representative sample of first responders in the U.S., multiple variables were considered to develop the sampling strategy in both phases of the study. The sampling strategy included first responders in a variety of positions within the four public safety disciplines – COMMS, EMS, FF, and LE. Due to the varied public safety issues faced in different parts of the country, geographic and cultural diversity were also primary considerations. Across the U.S., urban (U), suburban (S), and rural (R) districts were sampled to ensure that cities and districts of different sizes and different economic realities were represented. Another consideration was jurisdictional diversity, including federal, state, county and local jurisdictions; however, local jurisdictions had higher priority, as incident response typically starts at the local level. Other variables considered in the sampling strategy were career and volunteer FF, public and private EMS, and civilian and deputized COMMS. With the wide range of different types of first responders, their roles and responsibilities, and their different communication and technology needs, this approach provided insight into the many different experiences of public safety communication across the U.S., ensuring coverage of both typical and unique experiences.

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

2.2 Interview Methodology

The interviews were conducted with first responders across the U.S. in 2017 and 2018. There were three research questions:

1. How do public safety personnel describe the context of their work, including their roles and responsibilities as well as process and flow?
2. How do public safety personnel describe their communication and technology needs related to work?
3. What do public safety personnel believe is working or not working in their current operational environment related to communication and technology?

These research questions guided the interview protocol design and analysis, as [4] extensively reported.

Interview Sampling. Since demographic factors such as age, years of service, and gender may play a role in participants’ views related to public safety communication, purposive sampling was applied in Phase 1. The sampling involved seeking participants who represented the full range of first responder experiences, as previously mentioned. Areas for in-person interviews were chosen that provided reasonable coverage of the

depth and breadth of geographic and cultural diversity in the U.S., as well as the broad types of incidents that first responders face, aligning with eight of the ten U.S. Federal Emergency Management Agency (FEMA) regions [12].

Data Collection and Analysis. The data collection and analysis followed a rigorous qualitative research process. First, the in-depth interviews with first responders in the COMMS, EMS, FF, and LE disciplines were conducted in 45-min sessions with first responders at their convenience (typically one-one-one at their station or department). These interviews were then audio recorded and transcribed. Two code lists were generated in order to label, or tag, participant statements: one for EMS, FF and LE, and one for COMMS, given the unique environment and primary tasks within that discipline. Then, the transcripts were coded according to the code lists, and the data were extracted (i.e., the data associated with a code from each transcript was exported into a separate document). Finally, themes were identified; relationships were examined among the codes, and between and within the four disciplines. This iterative process facilitated the identification of themes, trends, and outliers and provided an overall impression and understanding of the data. The themes, along with communication technology problems and needs findings, were used as the basis for the survey design in the second phase of the study.

2.3 Survey Methodology

The survey development began at the conclusion of the interviews; Greene, et al. extensively reported details about the survey instrument and survey methodology [5]. The following research questions served as guides for the development of the survey.

1. What are first responder needs related to communication and technology as they engage in their user-identified primary tasks?
 - a. What communication tools and technology do first responders believe currently work, or do not work, for them?
2. What are the problems that first responders experience as they use communication technology?

The survey collected a wide variety of data related to communication technology use by first responders, from their day-to-day technology use, problems, and needs, to the technology that would be more suitable for use in larger, out of the ordinary incidents. Survey questions and response options were grounded in research from the previously collected empirical interview data, as well as from content and survey expert reviews during survey development. One of the driving ideals in the design of the survey was to keep it short out of respect for first responders and their time, and to encourage survey completion.

Survey Instrument Design. After a rigorous design process that included content and survey expert reviews, and given the myriad of different types of communication technology utilized and needed for the individual disciplines, it became clear there would

need to be four different surveys, tailored for each discipline. The overall survey structure and flow were largely similar across the four survey versions: all began with a section on demographics, followed by a section on use of technology for day-to-day incident response (including questions on applications/software), and concluded with a section on use of technology in large events. The survey questions for EMS, FF, and LE were nearly identical, while differing somewhat more for COMMS, due to the different nature of their working environment [9]; for example, COMMS respondents were asked questions about call centers and Next Generation 9-1-1 (NG 911) [13, 14]. For all four disciplines, lists of technologies were used for questions about responders' use of day-to-day devices and devices used for large events. The lists of technologies used in the survey were catered to each discipline as the result of a thorough review of the problems and requested functionality identified in the interviews [7]. The goal was to not have first responders go through questions or lists of technologies that did not pertain to their work, as part of the effort to keep the survey short out of respect for first responders and their time. Greene et al. reported detailed descriptions of survey logic, branching, and all questions and response options [5].

As this paper focuses on a subset of the survey data, the remainder of this section describes the details of the survey design solely related to the questions from which results are discussed. These questions, related to the potential usefulness of futuristic technologies for day-to-day incident response, are: 1) futuristic technologies; 2) NG 911 (COMMS only), and 3) VR.

Futuristic Technologies Question. The futuristic technology question was framed with the text, "We know there is no such thing as a "typical" day in public safety. However, for this set of questions, focus on the kinds of things you use in your daytoday work." The question stem was "Which of the items below **would also be useful** for your **DAY-TODAY** work." Respondents were presented with a list of technologies and asked to "Check all that apply." The goal here was solely to identify those items that respondents believed would be useful in daytoday incident response, not to have them rank these items or indicate whether they were more or less useful than other items.

The list of technologies in this question was populated from two sources. The first source was a preset list of technology based on PSCR research priorities and derived from the results of the interviews. Note that as previously mentioned, different first responder disciplines saw different lists of futuristic technologies, because the survey was driven by the interview data and the technologies that first responders discussed as potentially important for their work. The second source was a list of items that were piped forward based on a participant's previous survey responses about their day-to-day technology use. On a previous question, participants were asked about how often or not they use existing technologies. Every device for which they made no selection or selected "do not have" was piped forward to the future technology list. The items that were piped forward allowed respondents to select items they thought would be useful even if they did not currently have them.

In addition to the "Check all that apply" question, respondents were also provided with an open-ended text box where they could list additional technologies they thought would be useful or provide additional information.

Next Generation 9-1-1 Question. NG 911 is a digital or Internet Protocol (IP)-based 911 system that has several key capabilities, including: the ability for voice, photos, videos and text messages to be sent from the public to the 911 network; the transfer of emergency calls, location information, and multimedia to another PSAP; and the exchange of voice and data with other state or federal entities involved in the response via internetworking technologies based on open standards [13, 14]. After the broader futuristic technology section, COMMS participants were asked two questions specifically about NG 911:

1. “Have you ever heard of Next Generation 9-1-1?”
2. “Next Generation 9-1-1 is a system that will allow the public to send texts, pictures, and video to 9-1-1 call centers. Do you think this will help you in your job?”

The response items for these questions were: Yes, No, or Not Sure. Interview data drove the design of the survey and indicated that some first responders did not know what NG 911 was or how it would apply to their work. The survey intentionally used a simplified definition of NG 911 in the second question listed above; content expert reviewers of the survey believed it better captured how COMMS participants would define and understand it.

Virtual Reality Question. Given its importance to PSCR’s initial research agenda [15], all participants were asked specific questions about the use of VR for training and for other purposes. The two questions asked were:

1. “Do you think VR (virtual reality) would be useful for training in your work?”
2. “Do you see VR as useful in other ways for your work?”

The response items for these questions were: Yes, No, or Not Sure. An open-ended text box was also provided to give participants the opportunity to respond with additional details about their answers to the VR questions listed above.

Survey Sampling and Dissemination. In order to reach a large number of first responders, outreach occurred at the department/agency level. The sampling frame consisted of an online database with contacts in all 10 U.S. FEMA Regions [12] and a variety of first responder departments and agencies. Other means of outreach were via public safety organizations and through previous points of contact within the public safety community. Individuals contacted were asked to forward the survey to their first responder communities and colleagues in order to reach as many departments and agencies as possible, and through them to reach first responders, in order to have broad representation. The survey was disseminated to first responders across the U.S. for approximately 5 months between 2018 and 2019.

3 Participants

The first responder population sample for the interviews and survey accounted for geographic and cultural diversity; different area types (urban, suburban, and rural); and various levels in the chain of command within the COMMS, EMS, FF, and LE disciplines. The participants in the interviews represented 13 states in eight FEMA regions; the survey had representation from all 50 states and Washington D.C. Other demographic variables of interest—such as jurisdictional level (local, county, state, federal), years of service, and age—also showed good variability in both the interview and survey data. 193 first responders participated in the interviews; 7,281 first responders completed the survey.

The 193 first responders interviewed resulted in 158 interview transcripts. Some interviews included multiple participants; five participants opted to not be recorded [4]. Each of the four disciplines was represented in the sample; Fig. 1 below shows a breakdown of interview participants by discipline and area type.

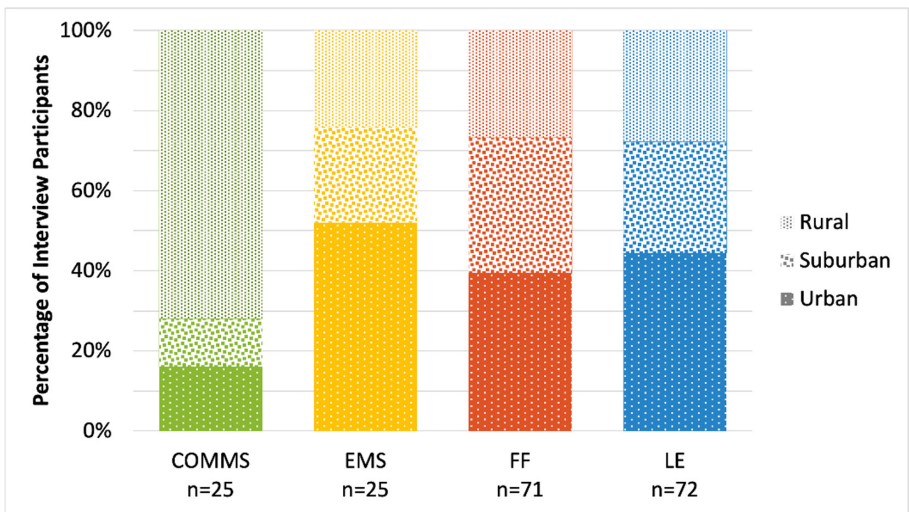


Fig. 1. Interview participants by area type

Likewise, the survey sample included diverse representation of the first responder population in all four disciplines. Figure 2 shows a similar breakdown for the survey data – participants who completed the survey by discipline and area type.

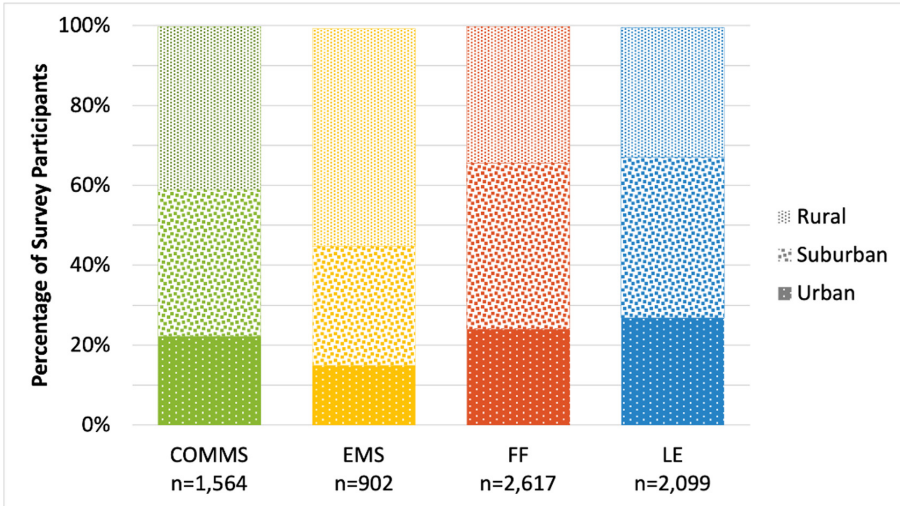


Fig. 2. Survey participants by area type (Color figure online)

4 Results

The results presented here are quantitative survey data supported by qualitative data from both the survey (from open-ended survey questions) and interviews. Quotes from the qualitative data are verbatim and are indented in blue text with a reference notation following each quote. The reference notation represents a particular participant response and is composed of three parts: the first represents the discipline of the response (COMMS; EMS; FF; LE), the second represents the area of the response (Urban = U; Suburban = S; Rural = R), and the third is the record ID number. Interview quotes are distinguishable from survey quotes in their notations; “INT” precedes the three-part notation for interview quotes. For example, (FF:U:1234) represents the survey responses for record ID #1234, from a fire service respondent in an urban area; (INT-LE-U-006) refers to an LE interview, from an urban location, who is law enforcement interviewee number 006. It is important to highlight that these notations are not connected to specific participants, as survey and interview data are anonymous.

As previously stated, this paper focuses on a subset of the survey data that are the results of the analysis of three survey questions: 1) futuristic technologies; 2) NG 911 (COMMS only), and 3) VR. Due to the relationships between the responses to these questions and the complexities in the data, the presentation of the results is structured as follows. Examined first is the usefulness of existing devices to which first responders do not have access (deeming them “futuristic”), both across and within the four disciplines (see Sect. 4.1). Second, technologies that are typically considered futuristic both within the public safety domain and externally (e.g., VR) are explored across disciplines (see Sect. 4.2). Finally, the paper presents the discipline-specific communication technologies that first responders think would be most useful for incident response, including, for COMMS, NG 911 (see Sect. 4.3).

The analyses yielding these results was performed on unweighted survey data (see Appendix). Survey responses are representative of the first responders who completed the survey; weighting of the data should be applied prior to making any generalizations about the results to the broader public safety population. The full dataset from the interviews and survey are available online [16].

4.1 Access to Existing Technologies

As noted in the survey methodology section, some devices currently used for public safety communication are not used universally; while many devices currently exist for first responders use, not all first responders use or even have access to the same types of technology. Those devices that survey participants indicated that they did not have were piped forward in the survey to the list of technologies for the futuristic technology question. As expected, these devices varied across disciplines and demographic measures, including technologies that are often considered to be more mainstream in the public safety domain today. Perhaps of most importance here are all the basic items that respondents still do not have, but that they believe would be useful, e.g., radios and mobile data terminals (MDTs).

Across the four disciplines, survey respondents consistently identified work-issued smartphones as something that would be useful in their day-to-day work; 21.08% of COMMS thought they would be useful, 31.11% of EMS, 30.41% of FF, and 39.34% of LE. While smartphone technology exists, many first responders do not currently have access to work-issued smartphones. In contrast to the usefulness of work-issued smartphones, much lower percentages of participants thought personal smartphones would be beneficial; 8.96% of COMMS, 13.40% of EMS, 19.34% of FF, 8.05% of LE. Dawkins, et al. posited that the concerns over the cost of smartphones could explain the discrepancy between work-issued and personal smartphones in the perceived benefits of their use [11]. The interview data mirrored these findings, showing the lack of access is often due to the cost of the devices as well as the additional costs beyond the technology itself, such as maintenance and data plans.

At this point, I would love to buy officers smart phones, but I don't have the funding for it. So right now the only communication device that the department supplies is the radio. (INT-LE-U-029)

In addition to cost, particularly for personal smartphones, research findings suggest that major detractors from smartphones' usefulness to first responders were due to the necessity for personal data plans, the lack of adequate (if any) subsidies, and the possibilities for the subpoena of a first responder's personal smartphone [11].

Aside from smartphones, the only other technology existing in the public safety domain that crossed all four disciplines in a similar manner was desktop computers. Desktop computers are not typically considered a futuristic technology, yet like work-issued smartphones, are a technology that not all first responders currently have access to in their day-to-day work. While the percentages of EMS and FF who chose this item were somewhat low (EMS—11.65%, FF—9.58%), far more LE and COMMS respondents chose this item (19.39% of LE and 38.46% of COMMS).

Several other technologies were included in the list for three of the four first responder disciplines—EMS, FF, and LE—those public safety disciplines that are in the field. At least 20% of participants in each of these three disciplines thought the following devices that they do not currently have would be useful for their work:

- Laptop computer
- Mobile Data Terminal (MDT) or Mobile Data Computers (MDCs)
- Portable radio
- Tablet
- Vehicle radio
- Work-issued wireless earpiece

These devices, particularly MDTs and radios, represent critical public safety communication devices – something identified in the interviews as very important to first responders [4]. Again, these do not represent new or especially futuristic technology, but they are items that many first responders do not currently have but identify as potentially useful for their day-to-day incident response.

In addition to these cross-cutting technologies are those discipline-specific technologies to which first responders do not currently have access. These discipline-specific items were often those chosen by the largest percentage of respondents within the disciplines who use them. Fingerprint scanners (45.59%) and license plate readers (46.11%) were the top two devices chosen by LE respondents, with body cameras also chosen by a large percentage (31.96%). Thermal imaging cameras (TIC) for FF (27.15%) and headsets (32.47%) for COMMS also represent discipline-specific items that were selected by large percentages of their corresponding respondents. While these represent discipline-specific needs, large percentages of respondents who did not have access to them identified them as useful for their day-to-day work.

As public safety looks toward the use of more cutting-edge technologies, it is important to consider ways to make the existing technologies presented to this point more accessible to first responders in order to appropriately address the needs of the public safety community.

4.2 Technologies Useful for All

The majority of the technologies listed for the futuristic survey question were predetermined during survey development (see Sect. 2.3). Several of the technologies listed for all four disciplines – COMMS, EMS, FF, and LE – were selected by high percentages of respondents. The one item that over 50% of respondents in each discipline chose was “one login” (instead of many different usernames and passwords). While not yet ubiquitous, the use of one login, or single sign-on (SSO), is becoming increasingly widespread for the general public, but is still uncommon in public safety—for first responders, one login is still “futuristic” technology. One login was the top overall item checked for FF and LE, and the second overall item for COMMS and EMS, demonstrating its importance across all four disciplines (see Fig. 3). This mirrors the findings from the interview data – a major source of frustration for many first responders was the requirement to use

multiple logins and passwords on their devices [4, 11]. The open-ended survey responses also indicate that SSO would be of tremendous benefit for first responders.

One login would be at the top of everybody's list here. It is ridiculous the number of passwords and log-ins that have to be used and waste the time of first responders in their preparation and continuous log-in status. (LE:R:5075)

I need to purchase an app just to remember all of the id's and passwords I need for each program I need to use. This is very frustrating and time-consuming. Where is the fob that allows me to log into anything I want? Biometrics? Bring it! (FF:S:4460)

ONE LOGIN!!! Gosh, I spend an inordinate amount of brainspace and time tracking all my logins. (COMMS:U:3213)

These open-ended survey responses highlight the quantitative survey data about the importance of having one login, showing that first responders believe SSO would save time and lead to less frustration.

Three other technologies garnered relatively high percentages from first responders in all four disciplines, making them the desired future, in part, of the broader public safety domain: real-time on-scene video, indoor mapping, and voice controls for hands-free input (see Fig. 3).

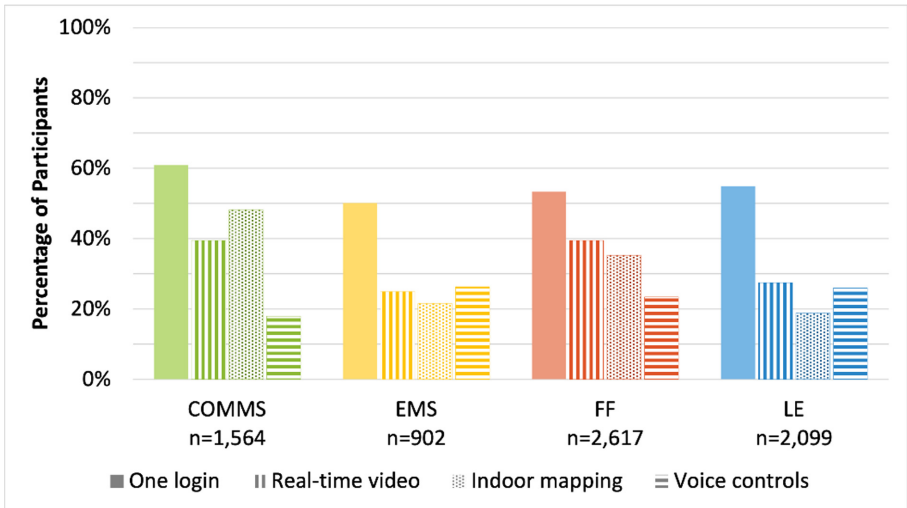


Fig. 3. Top futuristic technologies across all four disciplines

While these technologies were identified by all four disciplines as potentially useful for their day-to-day work, there were some differences amongst the disciplines. For example, COMMS and FF respondents chose indoor mapping and real-time on-scene video more often than their EMS and LE colleagues, while there was greater consistency across disciplines for voice controls for hands-free input.

As with the data presented in the previous section, some technologies cut across the three disciplines for which first responders work in the field —EMS, FF, and LE. When asked if drones would be beneficial in their day-to-day work, large percentages of FF and LE thought they would, while fewer EMS thought drones would be beneficial (see Fig. 4). However, in each of these three disciplines, including EMS, drones were one of the technologies that intrigued first responders during the interviews. First responders expressed how both aerial drones (e.g., to give “a live feed 360 view of [the scene]” (INT-FF-S-033)) and ground drones (e.g., “the BB-8 character from Star Wars...get that little ball with the camera... [for] reconnaissance.” (INT-LE-U-013)) would be useful for incident response [7].

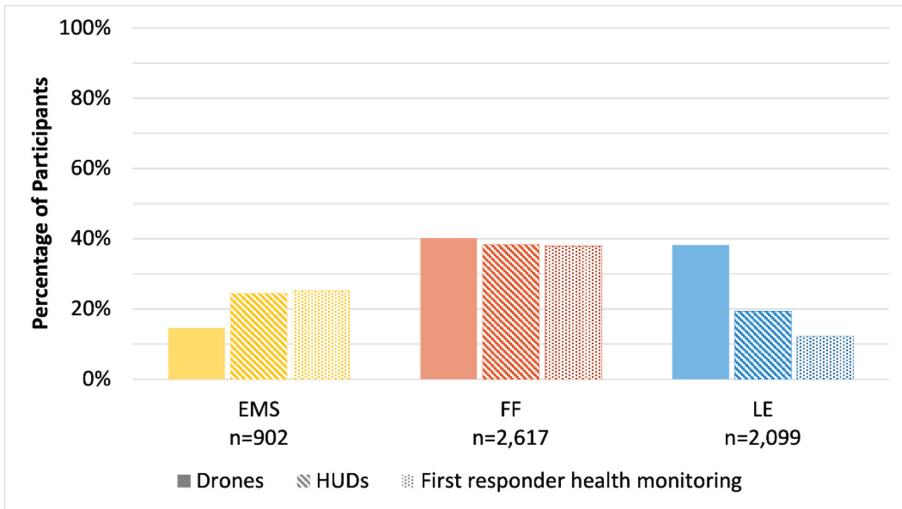


Fig. 4. Top futuristic technologies across EMS, FF, and LE

The highest percentage of participants who thought heads-up displays (HUDs) would be beneficial were in FF. Interview data show that FF envision HUDs built-into their face pieces, where they “can glance down at that HUD and look through the thermal imager if the smoke is too thick [to] be able to see through otherwise” (INT-FF-S-040). The status of first responder health and vitals is also a critical piece of information in high-risk environments; many FF and EMS respondents thought the health monitoring of first responders would be beneficial to their work. EMS and FF first responders’ priority is preservation of life, but this information would also be especially helpful for incident commanders managing an incident.

Finally, the survey asked participants about the use of VR in multiple ways. First, VR was included in the list of technologies for the futuristic question. Second, the survey asked if VR would be useful for training. Lastly, participants were asked about the potential use of VR for other purposes. Results show that the usefulness of VR to first responders was tied to the way it would be used in their work contexts.

When asked about general VR benefits in their day-to-day work and about other uses for VR, respondents either did not think it would be helpful or were unsure about its usefulness. A very low percentage of respondents selected VR in the list of futuristic technologies; less than 7% in each discipline thought VR would be useful in their day-to-day work (4.92% COMMS, 3.33% EMS, 6.84% FF, 5.81% LE)¹. In comparison with the other futuristic technologies listed, these data suggest that there are far more technologies that first responders think would be useful in their day-to-day work than VR (see Appendix). This is demonstrated further in the results of the question asking participants if VR would be useful in their work for purposes other than training. Over 50% of respondents in each discipline responded, “Not sure,” indicating that first responders were unsure if VR would be useful in other ways for their work. In fact, more respondents in all four disciplines chose “No” than “Yes” in response to this question.

While respondents had difficulty imagining other situations in which VR might be useful, when asked to think specifically about VR and training, they were more able to recognize its potential utility. Responses on the use of VR for training show more than 50% of respondents from EMS (50.28%), FF (51.54%), and LE (58.83%) said they believe VR would be useful for training in their discipline (see Fig. 5). For COMMS, this percentage was slightly lower at 33.78%, but still higher than the percentage of COMMS respondents who indicated they did not see VR as useful for training in their work. While high numbers of respondents supported the use of VR for training in their discipline, it must be noted as well that over 30% of respondents from all four disciplines indicated they were not sure if VR would be useful for training in their work. These data show that many first responders need additional information about the potential capabilities and value of VR to their work if VR is to be used in public safety.

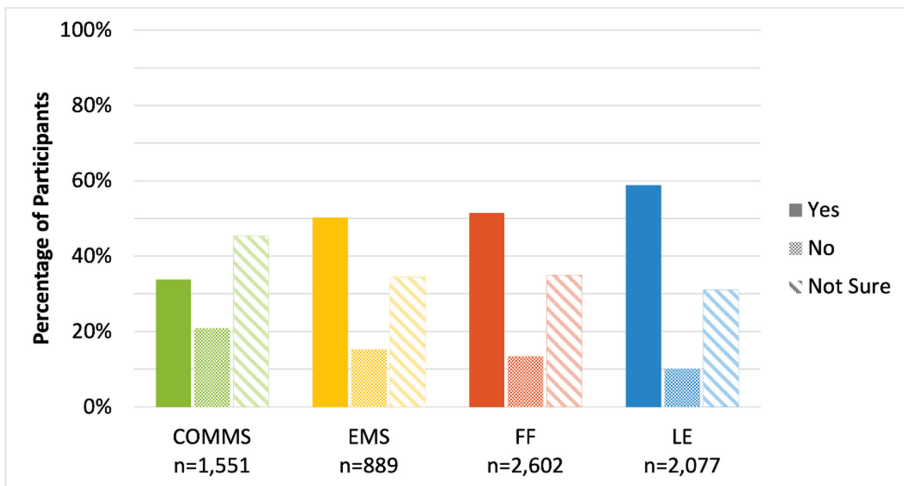


Fig. 5. Usefulness of VR for training

¹ Similarly, low percentages of respondents thought augmented reality (AR) would be useful in their day-to-day work: 4.80% of COMMS, 4.55% of EMS, 5.88% of FF, 4.95% of LE.

The higher percentage of LE respondents who saw VR as useful for training may be due to their familiarity with simulation-based training in general, while the COMMS percentage may be lower since their work is often based on audio rather than video or in-person interaction. While some first responders see the benefits of VR for training, there are others who feel VR would be a hinderance to the work of first responders, especially in an operations capacity.

Training, but I am not yet able to see the applicability of VR in the day-to-day operations. (EMS:S:2482)

I do not see its practical application. (FF:S:250)

So far, everything I've seen about VR seems gimmicky - more of a toy than a useful technology. (LE:R:4511)

VR, to me, seems to be a system for gaming and entertainment... I unfortunately see little practical application it could be used for in 9-1-1 dispatch at this time. (COMMS:S:46)

Overall, the quantitative survey data related to VR show support across all four first responder disciplines for the use of VR for training in public safety. However, as these quotes show, the open-ended data are somewhat more qualified, with first responders noting other factors that affect VR's utility, even for training.

4.3 Discipline-Specific Technologies

For the futuristic survey question, some of the technologies listed were discipline-specific due to the various types of needs of first responders (see Sect. 2.3). These technologies provide specific functions and support for first responders and are of tremendous importance to the disciplines that use them. The subsequent sections here are centered around a single discipline in presentation of these data.

COMMS. First responders in Comm Center & 9-1-1 Services have unique roles in unique environments within public safety. As such, the communication technology used in COMMS is quite different than the other disciplines, which is reflected in the survey design as well as the results. 71.23% of COMMS respondents thought automatic caller location would be useful in their day-to-day work, far more than the other futuristic technologies listed for the futuristic survey question. A key component of the day-to-day work in COMMS is interacting with 9-1-1 callers and relaying their information to first responders in the field. With the ever-increasing number of 9-1-1 calls from mobile devices, accurate location of callers is essential to their work. Another technology that a high percentage of COMMS thought would be useful is first responder tracking; 60.55% of respondents selected this technology. As COMMS represents both call taking and dispatching responsibilities, first responder tracking would have a major impact on the day-to-day work of COMMS dispatchers.

As discussed in Sect. 2.3, the COMMS survey was uniquely positioned to include questions about NG 911. Figure 6 depicts results showing that COMMS respondents overwhelmingly said they had heard of NG 911 (89.72%) and believed it will be helpful in their work (74.47%). The fact that almost 20% of respondents (19.55%) said they were not sure that NG 911 will be helpful in their work may demonstrate a lack of clarity about NG 911 and the ways in which it might benefit COMMS workers.

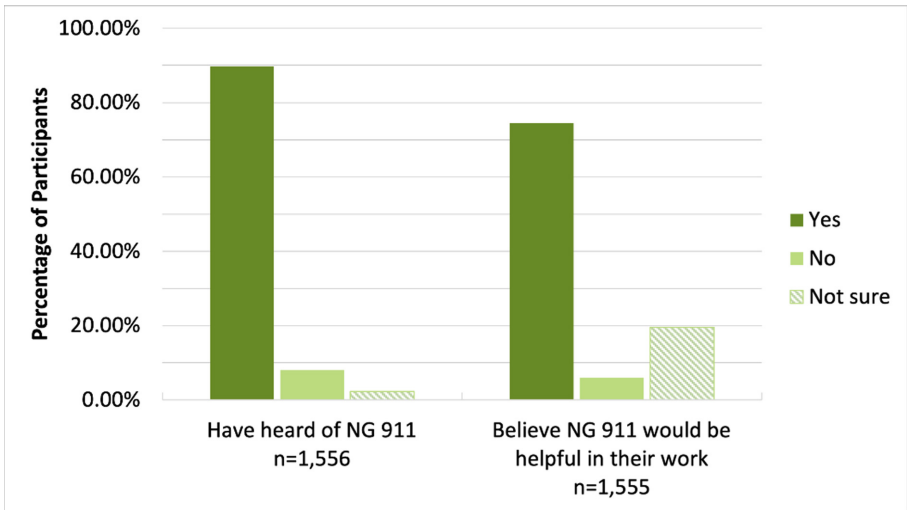


Fig. 6. COMMS survey responses to NG 911 questions

EMS. For EMS, more than half of respondents thought automatic transmission of patient vitals and information to the hospital would be useful in their day-to-day work (56.43%). Nearly 40% also thought health/vitals monitoring of patients and automatic vehicle location (AVL) would be useful (39.47% and 39.36%, respectively). The primary task for day-to-day work in EMS is treating patients. It is understandable that improvements to the health monitoring of EMS patients, as well as automating their communication tasks while treating those patients, are desirable technologies for the future of EMS.

FF. The fire service is unique in that many of FF first responders are cross-trained in EMS – their responsibilities include both fire-related and health-related service. As a result, there is some overlap in the future of communication technology with EMS and FF. This is reflected in the discipline-specific survey results, where nearly half of FF thought AVL – technology that enables COMMS to dispatch the closest vehicle to an incident, rather than just the closest station – would be useful in their day-to-day work (49.41%); a high percentage of EMS also thought AVL would be useful.

LE. Two discipline-specific technologies were selected by nearly 40% of LE – facial recognition and thermal imaging. In their day-to-day work, first responders in LE regularly need to identify persons of interest. Results suggest that first responders think technology may help in this task, as 38.69% of LE respondents thought facial recognition software would be useful in their day-to-day work.

As previously stated, some technologies listed for the futuristic survey question are more commonly used by the general public, but not as widely used in public safety; other technologies are used by some agencies and departments in public safety, but their use is not universal. Thermal imaging falls into the latter category of technology – TICs are more common in FF (but still not universally used), but not as prevalent in LE. First responders in LE think it may be beneficial for this to change, with 38.40% indicating that thermal imaging would be useful in their day-to-day work.

5 Conclusion

First responders were asked about their vision of the future of communication technology for incident response. While some of the futuristic technologies used in the survey may not be considered futuristic in some arenas, these items have often not made their way into the world of public safety. One of the best examples of this is single sign-on (SSO). Across all four disciplines – COMMS, EMS, FF, and LE – over half of participants indicated that SSO for their devices would be most useful in their everyday work. While SSO is commonly used in industry, it addresses a universal pain point in public safety, where its use is less common.

Other, more futuristic technologies first responders thought would be useful include real-time on-scene video, indoor mapping, and voice controls for hands-free input. In addition to these technologies, first responders also envisioned the usefulness of futuristic technologies specific to their individual disciplines. COMMS thought automatic caller location would be the most beneficial for their work, while also recognizing the potential of NG 911 as the future of 9-1-1 technology. EMS saw technology to automatically send patient vitals to a hospital as the most potentially useful. Automatic vehicle location (AVL) was considered by FF as the futuristic technology with the most benefit. Lastly, LE thought drones, thermal imaging, and facial recognition to identify a person of interest would be equally beneficial in their day-to-day work.

While the survey results generally showed favorability towards futuristic technologies, the open-ended survey data revealed that first responders consistently emphasized that an obstacle to the use of futuristic technologies was cost [11]. In the interviews as well, many participants cited issues of cost and price as prohibitive factors related to the adoption of new forms of technology.

...throw in the fact that most of us have inadequate funding (FF:S:5094)
 ...the technology is there, it just costs so much. (INT-LE-U-010)
 Technology is very expensive. You don't just buy it and you're good.
 You've got to maintain it... You've got to upgrade it. (INT-EMS-R-008)

As noted by the EMS interviewee quoted above, it is not just the initial cost of technology that makes it unattainable, there are often auxiliary costs beyond the technology itself, such as associated maintenance, certification, technical support and training. Cost may be one reason that respondents did not see some of this technology as useful for their day-to-day incident response. Improving current technology and meeting current needs rather than buying into (literally and figuratively) totally new technology was an important consideration for the first responders who participated in both the interviews and the survey. The best technology in the world is not useful if those who need it cannot afford it.

Additionally, when asked about futuristic technology, first responders often cited the need to focus less on cutting edge technology, like VR, and more on basics and current technology needed by first responders rather than on new technology.

Until rural areas have a comms infrastructure that can support BASIC communications the rest is a fantasy. (EMS:R:2434)

None of [the futuristic technologies] sound particularly useful and some could be disruptive to our normal work processes in dispatch. (COMMS:S:1545)

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 first responders are going to accept and adopt new technologies, they need to have a better understanding of how those technologies will help them accomplish their primary tasks and provide better efficiency, effectiveness, and satisfaction than what they currently use. As reported in the findings from the interview data, “New technology is exciting, and the possibilities for it are endless. While new technology may sound good and make sense to researchers and developers, adoption requires buy-in from first responders” [4].

As technology for the NPSBN is being developed, researchers, designers, and developers alike need to focus on the needs of the users – the first responders. As we learned in our interviews, there is no room in public safety to develop “technology for technology’s sake” [4]. The interviews and survey both suggest that “one size does not fit all” – first responders are open to new and exciting technologies, but their needs are utility driven; to have the biggest impact, their communication technology must be tailored to each discipline’s needs and contexts.

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Appendix

Table 1 and Table 2 show the results from the responses to the survey question on futuristic technology. The number of respondents, *n*, for each technology and the corresponding discipline is the following, unless otherwise noted: COMMS, *n* = 1,564; EMS, *n* = 902; FF, *n* = 2,617; and LE, *n* = 2,099.

Table 1. Participants who selected preset futuristic technology

Futuristic technology	COMMS	EMS	FF	LE
AR (augmented reality)	4.80%	4.55%	5.88%	4.95%
Automatic caller location	71.23%			
Automatic transmission of patient vitals and information to hospital		56.43%		
AVL (automatic vehicle location)		39.36%	49.41%	
Drones		14.52%	40.20%	38.21%
Facial recognition software	16.05%			38.69%
First responder tracking	60.55%			21.30%
Health/vitals monitoring of first responders		25.17%	37.87%	12.15%
Health/vitals monitoring of patients		39.47%	19.07%	
HUDs (heads-up displays)		24.39%	38.29%	19.39%
Indoor mapping	48.15%	21.51%	35.27%	18.87%
One login (instead of many different usernames and passwords)	60.93%	50.11%	53.31%	54.88%
Real-time on-scene video	39.51%	24.94%	39.47%	27.49%
Remote sensing (by aircraft or satellite)			10.58%	
Robots		2.00%	4.93%	7.86%
Self driving cars		6.21%	3.97%	3.53%
Smart buildings		6.98%	12.99%	7.58%
Smart glasses		8.98%	8.06%	7.86%
Smart watch	7.23%	16.41%	12.95%	15.39%
Thermal imaging				38.40%
Vehicle tracking				26.39%
Voice controls for hands-free input	17.90%	26.27%	23.42%	25.96%
Voice recognition for identification		15.52%	13.11%	16.77%
VR (virtual reality)	4.92%	3.33%	6.84%	5.81%

Table 2. Participants who selected existing technology

Existing technology	COMMS	EMS	FF	LE
Body camera				31.96%; n = 1214
Computer: desktop	38.46%; n = 26	11.65%; n = 103	9.58%; n = 240	19.39%; n = 196
Computer: laptop		31.62%; n = 136	35.93%; n = 501	38.66%; n = 476
Dash camera				25.43%; n = 1266
Earpiece: wireless (self purchased)		3.03%; n = 661	9.32%; n = 1931	4.67%; n = 1799
Earpiece: wireless (work issued)		21.67%; n = 812	28.95%; n = 2297	34.74%; n = 1802
Earpiece: with cord		4.47%; n = 694	4.81%; n = 1890	6.63%; n = 1147
Fingerprint scanner				45.59%; n = 1349
Flip phone: work issued		2.66%; n = 788	1.77%; n = 2369	2.47%; n = 1906
Foot pedal	10.87%; n = 276			
Headset	32.47%; n = 231			
License plate reader				46.11%; n = 1644
MDT/MDC (mobile data terminal/computer)		32.95%; n = 516	38.98%; n = 1116	28.46%; n = 615
Microphone: desktop	7.16%; n = 433			
Microphone: handheld or clip-on	9.08%; n = 859			
Mic: wireless		15.04%; n = 791	19.50%; n = 2251	19.40%; n = 1696
Mic: with cord		4.33%; n = 393	3.46%; n = 752	3.08%; n = 746
Monitor (at your personal workstation)	25.00%; n = 56			
Monitor (for shared viewing)	20.46%; n = 391			

(continued)

Table 2. (continued)

Existing technology	COMMS	EMS	FF	LE
Pager	1.33%; n = 1125	6.27%; n = 383	2.97%; n = 1178	0.55%; n = 2002
Phone: landline	16.67%; n = 42			
Radio	11.94%; n = 67			
Radio: in-vehicle		21.62%; n = 111	35.68%; n = 213	24.38%; n = 320
Radio: portable		32.79%; n = 61	34.88%; n = 43	11.83%; n = 93
Smartphone: personal	8.96%; n = 201	13.40%; n = 97	19.34%; n = 331	8.05%; n = 410
Smartphone: work issued	21.08%; n = 887	31.11%; n = 601	30.41%; n = 1391	39.34%; n = 816
Tablet		36.50%; n = 326	33.88%; n = 856	23.33%; n = 1380
TIC (thermal imaging camera)			27.15%; n = 291	

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